31-8-2022

Bachelor thesis

UNIVERSITY OF TWENTE.

AUTHOR
Keur, J. H. J. (Jesse)
S2003511
j.h.j.keur@student.utwente.nl

FACULTY
Behavioural, Management and Social Sciences (BMS)

PROGRAMME
Industrial Engineering and Management (IEM)

UNIVERSITY SUPERVISOR
W. J. A. van Heeswijk
w.j.a.vanheeswijk@utwente.nl

UNIVERSITY SUPERVISOR
M. C. van der Heijden
m.c.vanderheijden@utwente.nl

DHL SUPERVISOR
Operations Systems Owner
Anna Horbeek
Anna.horbeek@dhl.com

Management Summary

Introduction

This research started off by DHL wishing to improve the efficiency of their return shipment process over at the hub in Utrecht. The return shipment process could be divided into two separate processes: i) the automated sorting process and ii) the manual sorting process. As the name suggests, the automated sorting process is performed by a machine sorter that pushes packages to the chute of their corresponding customer, whereas the manual sorting process requires manual scanning, handling and sorting of the packages. In the current situation, DHL employees are not able to handle the increasing number of shipment that require manual handling in the prescribed hours. Resulting in employees having to work in the manual sorting department for more hours or delaying the shipments towards next day. Therefore, this research will focus on the manual sorting process, because the manual sorting process is fully controlled by the company DHL, whereas the automated sorting process is influenced by other companies. The overall research question in the thesis is:

How can the efficiency of handling return shipments in the manual return sorting process be improved at DHL Parcel (E-Commerce)?

The efficiency of the process is made measurable by calculating the total distance that employees walk while distributing the shipments over all the customers.

Current situation

The return shipment process is responsible for making sure that return shipments will be send back to the right original retailer, referred to as customers of DHL. Approximately 80% of the shipment can be returned to the customer through the use of the automated sorting process, which leaves the manual sorting department with an average of 5000 packages daily. These packages require manual handling because the machine is not able to read or process the label on the package. Due to the COVID-19 restrictions and the natural growth of E-Commerce, the manual sorting department is having a hard time keeping up with the daily workload. The manual sorting department was set up in the early days of E-Commerce and did not change it working method ever since.

A Gemba Walk is performed to find wastes in the current manual sorting process. A Gemba Walk is a way to gather information through observation and interaction with employees. The problems found during the Gemba Walk through the manual sorting process, such as the unclear locations of customers and crossing walking paths of employees, suggested an improvement regarding the layout of the manual sorting department. The manual sorting department is set up like a manual sorting belt with roll containers and pallets all around the sorting belt. Each roll containers/pallets corresponds to a certain customer that uses DHL's service to transport goods. The number of customers is growing at the same rate as the number of packages do, implying that there are more and more roll containers/pallets added to the layout.

Improvement plan

The problems found in the current situation serve as input for the improved layout plan. A tool that generates the optimal layout based on walking distance will be created. The layout consists of every customer that can receive return shipments through the service of DHL. This tool creates the layout according to the following performance indicators and characteristics:

1. Average number of return packages that the customer receives
2. The type of storing (roll container versus pallet storing)
3. If the customer has its own chute during automated sorting (own chute versus collection chute)

The first indicator implies that the customer with the most return packages should be located closest to the sorting belt, while customers that receive little to no packages should be placed at the end of an aisle, minimizing the total walking distance from the sorting belt. The second characteristic makes sure that the customers will be made accessible. Placing pallet customers and roll container customer next to each other makes it harder to navigate through the aisles, because of the difference in space occupation. Lastly, the third characteristic is responsible for an exception in the manual sorting process. During the automated sorting process, DHL is unable to assign a single chute to every customer. Therefore, small customers are sometimes assigned to the same chute. At the end of the automated sorting process, these packages require manual handling since these packages need to be divided over the customers that are assigned to that particular chute. This is done at the manual handling department, but does not require an additional scan at this department. Placing the customers that are assigned to the same chute next to each other in the manual sorting layout optimizes the time it takes to divide these packages.

Two different layouts are created with the use of this input and Systematic Layout Planning. A tool that automatically divides the customers over the available slots in the layout is created within Excel. Two different layouts are created, one layout that does not take any space restrictions into account and one layout that uses the same space as the current situation. DHL also wants to investigate a layout without any space restriction, because the hub in Utrecht is expanding and extra space could be made available for the manual sorting department.

Results and evaluation

The results of the new situations are made quantifiable by calculating the walking distance of the employees at the manual sorting department. The walking distance of employees effects the throughput rate of shipments and, therefore, the efficiency of the manual sorting process. The goal is to improve the walking distance by 20%. The impact of the newly created layouts can be found in Table 1: Impact of improved layout plan.

Table 1: Impact of improved layout plan

Situation	Total walking distance	Improvement in percentages	In-Aisle distance	Improvement in percentages
Current situation	196,898 units	-	98,709 units	-
New situation without space restrictions	147,454 units	25.11%	51,235 units	**48.09%**
New situation with space restrictions	141,360 units	**28.21%**	60,841 units	38.36%

The goal that was set prior to the design of the new layout was accomplished. The table shows that the new situation with space restriction scores best when taking total walking distance into account, whereas the new situation without space restriction outperforms in terms of In-Aisle distance.

Preface

Dear reader,

You are about to read the bachelor thesis: 'Improving throughput rate of handling return shipments at DHL Parcel (E-Commerce)'. This research is conducted at DHL Parcel, as the final assignment of my bachelor Industrial Engineering and Management. The goal of my research is to improve the efficiency of the manual sorting department within SVC 1 in Utrecht.

First of all, I would like to thank Wouter van Heeswijk for always being available as main supervisor and for helping me by giving critical, clear and supportive feedback. Furthermore, I would like to thanks Matthieu van der Heijden for being my second supervisor.

Also, I want to thank Anna Horbeek, internal supervisor at the company, for learning me the best way to tackle such big projects and providing feedback.

Enjoy reading the thesis!

Jesse Keur

Contents

1. Introduction

In Section 1.1 a general introduction of DHL is given which gives the reader an idea about the company where the research is taking place. This section is split into the history of the company that can be found at 1.1.1 and the mission and strategy of DHL at 1.1.2. Furthermore, section 1.2 gives a general description of the return process in which the research will be done. Lastly, section 1.4 summarizes the most important information of this introduction chapter.

1.1 Company background

1.1.1 History

DHL is the world's leading and the largest company that provides domestic and international pick-up, delivery and e-commerce for individuals and business customers across the globe. DHL was founded in 1969 in the United States, the company was named after the founders Adrian **D**alsey, Larry **H**illblom and Robert **L**ynn. DHL started off as DHL Worldwide Express with the transport of documents through airplanes. In 2002, DHL became part of the German logistics organization Deutsche Post. Currently, DHL offers logistic solution to more than 220 different countries across the world with the help of more than 500.000 employees.

In the Netherlands, Deutsche Post DHL consists of the following business units:

- DHL Post – eCommerce – Parcel: The packages and pallets that are being transported by cars and trucks
- DHL Express: worldwide, quick express deliveries and courier services through planes
- DHL Global Forwarding – Freight: air and sea cargo
- DHL Supply Chain: warehouse solutions and logistics service provider
- DHL Solutions: for every type of transport that does not fit in the one mentioned above

1.1.2 Mission and Strategy

DHL's mission is connecting people and business while trying to improve lives and businesses. The company's phrase is "*Excellence. Simply Delivered"* and its vision is having "*the logistics company for the world".* The main goal is offering excellent services for every customer worldwide. This process start off with the sorting and scanning of materials that are being transported to domestic DHL hubs. At these DHL hubs, the shipments are being set on the final mile of delivery through DHL Parcel and DHL Express. The company ensures that the delivery is done safely with extra checks through signatures and reaching the destination within time frames. DHL's primary strategy is focus, connect, and growth.

1.2 Return process

This bachelor thesis will take place at SorteerVoorbereidingsCentrum (SVC) 1 in Utrecht, one of DHL's three sorting buildings in the Netherlands. Two different types of processes are done in SVC 1 every day. The first process is the regular sorting process, this process is responsible for dividing all packages over the DHL cityhubs that are spread around the country. Secondly, the return process of packages within the Netherlands also takes place in SVC 1. This process is responsible for all return shipments that take place in the Netherlands and the process will divide all these different return shipments over the corresponding DHL customers. Every day, approximately 100.000 packages are being sorted during the regular process and approximately 30.000 packages are being sorted during the return process. The goal

of this bachelor assignment is to improve the throughput rate of return shipment at DHL Parcel, the regular process will be left out and we will only focus on the return process.

SVC 1 is the only place in the Netherlands where return shipments are being processed. All return packages get transported to the SVC 1 and are being divided over more than 150 different customers of DHL (webshops such as Wehkamp, ZARA, etc.) The number of customers is expected to keep on rising with the increasing number of new internet retailers. A graphical, detailed view of the return process can be found in appendix A, while a short version is described in words within this paragraph. The return process starts when the packages are being put on an automated machine, the sorter. The package will be forwarded by the machine and will arrive at the scanning machine in the sorter. The barcode of the package will be scanned. This barcode contains data about the customer and private purchaser, and in the ideal situation, the machine finds a so-called “shipper number”. This “shipper number” is connected to one of DHL’s customers. The sorter will, according to the “shipper number”, make sure that the package will be put in the corresponding customers’ chute (English term DHL uses for “goot”). However, the machine is often unable to identify the correct data for a variety of reasons. This will be further explained in the problem identification part of this project that is stated in section 2.1.

Whenever the machine sorter is not able to identify the retailer, the package will be moved to the manual return process. At the manual return process the packages, of which the machine was unable to identify the original customers, are being sorted manually. A team of approximately 10-12 employees with a lot of knowledge about the customers of DHL will take a look at the packages again and are, most of the time, able to tell to which customer it belongs. By scanning certain specific characteristics of the label, information about the customer can be found that cannot be seen by the machine sorter. The information on the package that the employees are looking for are for example the senders details on the original label. Furthermore, DHL uses RC-codes (RC= roll container) for certain customers. These RC-codes are part of the label that the customers use to send their packages. The employees of the manual sorting team are able to connect RC-codes to the correct customer. The manual return processing team performs the same task the machine sorter does, but it takes some more handling, which will result in more time for each package. Also, mistakes can be made while putting the package in the right roll container or pallet and while determining to which customer the package belongs.

Full roll containers and/or pallets are stored throughout the SVC-building and will eventually be transported to the corresponding customers. Each customer has made agreements with DHL about the frequency and time of loading the return shipments the customers. The big customers are being transported throughout the whole day, some every day at a pre-set time and some once or twice a week. The transport of these roll containers and/or pallets towards the customer is being outsourced to other transporting companies.

1.3 Problem

DHL is struggling to keep up with the increasing number of return shipments. Due to the growth of E-Commerce during the last couple of years the manual sorting department is responsible for four times the number of shipment compared to two years ago. The current working method of the manual sorting department is outdated and DHL wishes to improve the efficiency of handling return shipments manually, since the department will not be able to process the return shipments if the number of shipment follow its natural growth.

1.4 Conclusion

In short, the return process can be divided into the machine sorter part and the manual sorting part. The return process prefers sorting the packages via the machine sorter part. However, when the machine sorter is not able to recognize where the return package belongs to, the manual sorting part comes into play. The manual sorting team is able to retrieve information about the original customer through certain specific characteristics on the package, like original label or RC-codes. The manual sorting team is not able to keep up with the current number of return shipments that require manual handling and DHL wants to improve the efficiency of the manual sorting process within the hub in Utrecht. Detailed information about the problem, such as reasons for manual sorting and the problem cluster, will be stated in the next chapter.

2. Problem identification

The problem identification chapter takes a closer look at the problems that occur in the return process. Section 2.1 complements the introduction with extra information about the actual problem and giving the causal relation between the machine sorting and manual sorting. Section 2.2 shows the problem cluster that is connected to the actual problem. Section 2.3 states the central research question that will be answered in the research. Section 2.4 brings scope to the research. This section will in- or exclude different factors in the research. Section 2.5 mentions the deliverables that will be delivered at the end of the research. Lastly, Section 2.6 concludes this section and mentions the most important information about problem identification within the research.

2.1 Actual problem

With the rise of internet shopping, the number of packages keep on increasing. One year ago, a total of nearly 10.000 packages were being returned daily. Right now, more than 30.000 packages are waiting to be returned to the original retailer every day. The highly increasing number of return shipment are a result of the combination of natural growth of E-Commerce and the extra shipments due to closing physical shops because of the COVID-19 restrictions. The return process is at an all-time high and even more daily packages could result in volume problems for the return process. Within the return process, a distinction could be made between two different processes, namely (i) the machine sorting process and (ii) the manual sorting process. Approximately 20-25% of the total number of packages requires manual sorting for diverse reasons. A graphical and detailed overview of the manual sorting process can be found in appendix B. The following reasons make it that the package needs manual sorting:

- There are two labels (retour label and original label) on the package and the machine cannot decide which one to use
- The barcode is (partly) missing
- The barcode is damaged
- The barcode is unreadable due to folding error
- Data is missing, no “shipment number” or other criteria of data do not match with “shipment number”
- No retour label added, only label to private purchaser
- Preferences of customer, for example a customer wants an excel file with all return packages
- Warmlopers (wrongly transported roll-containers) need to be handled at manual sorting

Most of these problems can only be resolved by adjusting the mechanics of the machine sorter. However, the settings of the machine are out of scope for this research. The machine is out of scope during this research because changes to the machine sorter are made by another company. Therefore, the problem is the efficiency of the manual sorting process. As mentioned before, the manual sorting process is ran by 10-12 employees. The goal of this research will be improving the manual sorting process in terms of walking distance of the employees, efficient layout across the customers and the throughput rate of packages. The layout of the current situation can be found in Figure 1.

Figure 1: Current layout of manual sorting [adapted from DHL (2020)]

2.2 Problem cluster

In order for DHL to handle the increasing number of return shipments, an efficient return process handling is necessary. The problems that occur in the current return process, their relationship with each other and the consequences are derived from employee interviews and observation. They are stated in the problem cluster that can be found in Figure 2: Problem cluster.

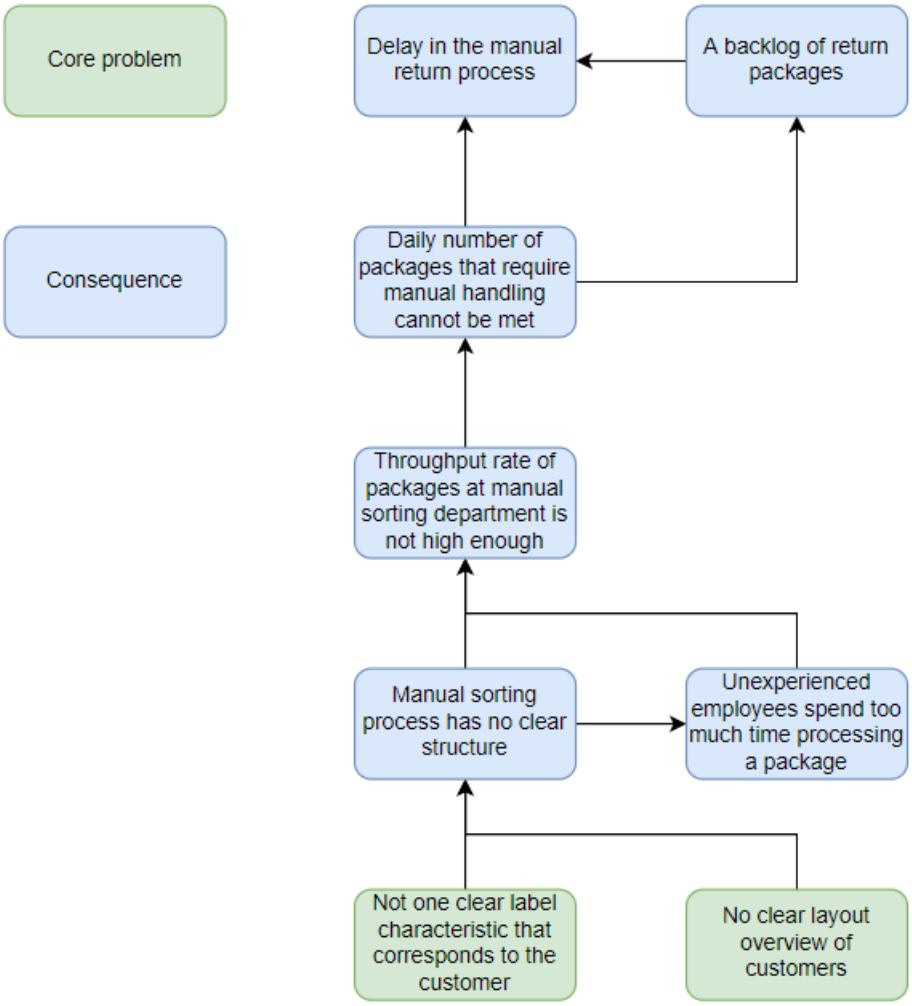

Figure 2: Problem cluster

The core problems are problems that occur in the current manual return sorting process. The layout of the manual return process is not updated since the start of manual sorting and improving this process can result in a higher throughput rate at the manual sorting department. The goal of the new layout is decreasing the total walking distance needed to sort every single package. A lower total walking distance results in a shorter time needed to process the packages, which results in a higher throughput rate. Currently, the total walking distance needed to process the packages of one week is 196.898 units. Together with DHL, the norm is set to decreasing this number by at least 20%, which means that the maximum walking distance is 157.518 units. However, another interesting expression will be the In-Aisle walking distance. In-Aisle walking distance is the distance that is walked within an aisle, so from along the sorting belt at the aisle of the specific customer to the pallet/roll container of the specific customer, neglecting the distance that is walked along the sorting belt in Cross-Aisle direction. The In-Aisle distance

is more important, because of the fact that the Cross-Aisle distance can be neglected if the packages will be forwarded along the sorting belt. The In-Aisle distance of the current situation is 98.709 units and the goal of the new situation is decreasing this number by at least 20% again.

2.3 Research question

Based on the problem cluster and the core problems that can be found in this cluster, the central research question is formulated as follows:

How can the efficiency of handling return shipments in the manual return sorting process be improved at DHL Parcel (E-Commerce)?

This research question matches the wishes of DHL Parcel and also covers the two core problems found in the problem cluster. The efficiency of handling return shipments can be made measurable by looking at the throughput rate of the return shipments. Throughput rate of packages at the manual sorting department is highly influenced by the travel distance of a package. Minimizing the walking distance of employees will result in a higher throughput rate. Sub questions to the main research question are mentioned in Section 3.3 of the this and are resolved in separate chapters.

2.4 Scope of research

The scope of this research will be within the borders of the SVC 1. The process of return shipments starts way before the arrival of packages at SVC 1. However, to prevent the research becoming too broad, the movement of the packages before arriving at the SVC 1 will be left out of the research. The foremost reason for leaving the movement of packages before arriving at SVC 1 out is the fact that it is will not be realistic to approach the service-points and cityhubs of DHL. We will not be able to influence the choices made at a service-point or cityhub, let alone the private purchaser that returns packages.

Furthermore, the automated machine process is hard to improve. Improving the machine sorting process requires a lot of knowledge about the settings of the sorter machine. Because of the fact that this knowledge is not possessed by DHL, the machine processing part of return shipments is also left out of scope. The machine sorter, its settings and its maintenance are outsourced towards another company that is specialised in this field.

Since the route of the shipments before arriving at SVC 1 and the mechanics of the machine sorter are out of control, the focus will be on the manual sorting process at SVC 1. The manual sorting process is in full control of the terminal manager and supervisors at SVC 1. This makes it that all data and information that is relevant towards the manual sorting process can be found in the SVC 1. The manual sorting process will be optimized by improving the current process. The theory that we will use is mentioned in the solution method part of this report. This can be found in Section 0 of the thesis. Optimization will take place on the following criteria: walking distance, throughput of a single employee per hour and total throughput of the process.

2.5 Deliverables

The purpose of this research is to present improvement for the manual sorting process at DHL Parcel. In the end, the knowledge gained throughout the research will result in valuable outcomes that can be used to improve the current manual sorting process at DHL Parcel. The following outcomes will be made available for DHL Parcel:

- Improvement (and recommendation) plan
- Overview of new situation (floor map of layout and/or flowchart of adjusted working method)
- List of bottlenecks (ranking from biggest to smallest problem)
- End report

2.6 Conclusion

In short, the core problems of this research are related to the efficiency of the manual return sorting process at DHL Parcel. Not being able to process the increasing number of return shipment can result in serious problems, such as backlog and delay in the process, and by improving the throughput rate of this process, these problems could be prevented. Therefore, the research question of this thesis is *"How can the manual return sorting be improved regarding their efficiency in handling return shipment at DHL Parcel (E-Commerce)?"* Problem-solving will only take place within the manual handling process, other outside factors will be left out of this research. This will result in an improvement plan regarding the manual return sorting process of DHL Parcel.

3. Theoretical framework

In the theoretical framework section functions as a manual during the research. This section starts off with section 3.1 that mentions the criteria for the solution planning method that will be used in the research. Section 3.2 explains the solution planning method Managerial Problem Solving Method (MPSM). Section 3.3 formulates the needed research questions that need to be answered for every phase of MPSM. Section 3.4 will explain the research design. This includes for every knowledge question the type of research that will be done, the research strategy, the research population and the method of data gathering. In order to answer the knowledge questions about improving the return process, a theory is needed that is able to improve the return process. The theory that we will be using is explained in section 0. Other theories that could help our research will be considered in section 3.6. The validity and reliability of the research will be mentioned in section 3.7. Finally, section 3.8 will summarize the most important information regarding the theoretical framework.

3.1 Requirements

A brief planning of all activities that need to be taken into account when conducting a research is valuable. A proper solution planning method makes sure that everything that is necessary to get to a valuable outcome is being covered. The solution planning method will function as an instruction manual during the thesis period. For our research, the solution planning method should be able to:

- Create a view of the current return process at DHL Parcel
- Analyse the current return process
    - Find problems
    - Find bottlenecks
- Search for solutions regarding process optimization
- Be able to implement a solution in the process (so not outside of the organization)

3.2 Managerial Problem Solving Method

The solution planning method we are using for this bachelor thesis is the Managerial Problem Solving Method (MPSM). MPSM refers to the book Solving Managerial Problems Systematically by Hans Heerkens & Arnold van Winden (2017). MPSM consists of the following seven phases:

1. Defining the problem
2. Formulating the approach
3. Analysing the problem
4. Formulating (alternative) solution
5. Choosing a solution
6. Implementing the solution
7. Evaluating the solution

The first phase was already done in the second chapter of this report, therefore, within the theoretical framework, the first phase will be left out. Phase 7 is added to the plan, however, this phase will not be done in our research. The evaluating phase is set up for the company so that they know how the new situation can be evaluated, what the important criteria/KPIs are. This will make the evaluation easier and also increases the chances of DHL Parcel implementing the solution.

3.3 Research questions

In order to find solutions for the problems, research questions should be formed that cover the problem. For every phase of MPSM (except for phase 5), research questions can be formulated. The research question and sub-questions of MPSM Phase 3 and MSPM Phase 4 are knowledge questions, because it requires knowledge that is not available already. The combination of all research questions will help answering the central research question that is stated in Section 2.3. The following research question should help answering to corresponding phase in the MPSM:

MPSM Phase 2 'Formulating the approach'

In the current stage of the research, the research plan should be stated. By answering the following questions, the formulation of the approach can be answered.

- What information is needed in order to improve the current return process?
    - What knowledge questions can be formulated to answer the central research in the end?
    - How will this information be obtained (research design)?

MPSM Phase 3 'Analysing the problem'

In order to get a clear view of the biggest problems in the current process, a problem analysis is required. This problem analysis should be able to review the current situation around the manual handling process and should highlight the current problems that the process is facing. The answer to the following questions should be able to bring the current process into view and mention the important factors.

- What is the current situation regarding the manual return process at DHL Parcel?
    - How are the return shipments divided over the customers?
    - What are the bottlenecks of the current process?

MSPM Phase 4 'Formulating (alternative) solution'

When the problems and other important data are acquired, solution to these problems should be found that can help improving the current situation. Depending on the found data, theories, found in literature, should be applied. These theories will contribute towards finding solutions to the earlier found problems and bottlenecks. The variety of solutions will be compared to one another and the best solution will be chosen. The following questions and their answers combined will answer phase 4 of MPSM.

- What is the best possible solution that will improve the throughput of the current process?
    - What theories can be of use when trying to improve the handling of packages within a process?
    - What are the possible options for process improvement?

MPSM Phase 6 'Implementing the solution'

In our research, phase 6 of MPSM will function as a conclusion and recommendation chapter. The solutions found in phase 4 are compared to each other and one or more found solutions should be implemented. These solutions will be mentioned and a plan will be written on how to implement the solution and what the new situation will look like.

- What changes should be implemented to improve the current process?
    - How can the solution be implemented?
    - What are the major bottlenecks?
    - What is the layout of the new situation?

MPSM Phase 7 'Evaluating the solution'

To increase the chances of DHL using our new situation, the evaluation of the solution is also set up. However, this part will only be discussed with the DHL stakeholders in our research. The evaluation part of the research is not of great importance for all readers.

- What is the impact of the solution on all the different criteria? (criteria= required number of employees, costs, walking distance, number of shipments processed)

3.4 Research design

Every knowledge question requires a research design. Depending on the type of questions, data gathering will be the first step in this research design.

The method of gathering data depends on the type of knowledge question. Interviewing employees will cover a lot of data gathering for this research. With the help of semi-structured interviews we want to gain information about the return process and discover the bottlenecks of the current situation. Besides interviewing, observation will also be a helpful data gathering method. Observing employees performing their tasks in the manual sorting process will give an overview of all activities that are involved in the process.

The research questions of phase 3 and phase 4 of MPSM can be classified as knowledge questions. These knowledge questions will be solved using the research design that can be found in **Error! Reference source not found.**.

Table 2: Research design

Knowledge question	Type of research	Research strategy	Research population	Method of data gathering	Method of data processing
How are the return shipments divided over the customers?	Explanatory	Quantitative	Customers in the return process	Data from documents	Graph overview / excel data
What are the bottlenecks of the current process?	Descriptive	Non-experimental research	Manual return process	Observation	List of bottlenecks

What is the current situation regarding the manual return process at DHL Parcel?	Descriptive	Qualitative and non-experimental research	Employees at manual handling department and data from sub-questions	Observation and communication	Visual representation
What theories can be of use when trying to improve the handling of packages within a process?	Evaluative	Action-oriented research	Manual return process	Literature study	Theory will be chosen that supports improving throughput of products
What are the possible options for process improvement?	Explanatory	Quantitative	Manual return process	Data from earlier knowledge questions	List of possible changes and their impact on the process
Which of these found options will have the most impact on the current process (considering the impact and the time it will take to implement)?	Descriptive	Action-oriented research	Possible changes found	Literature study	A listing of the changes in order of biggest impact to smallest impact, taking time it takes into account
What is the best possible solution that will improve the throughput of the current process?	Explanatory	Quantitative	Manual return process	Data from sub-questions	A solution will be chosen that will have the best value for DHL

3.5 Solution method

The solution method is a theory found in literature that functions as a manual for finding different solutions to certain knowledge problems. The goal of this research is to improve the manual return process of DHL Parcel. The commonly used and familiar solution method at DHL that we will be using for this research is Lean Management. Lean Management focuses on continuously improving work processes, purposes and people while respecting the people it affects. Lean Management is found to be the most appropriate theory for this research. The manual return process of DHL Parcel is the work process that requires improvement in this case. Wilson (2010) states that Lean Management consists of five principles:

1. Identify value – define the value for the customers
2. Map the Value Stream – map the workflow, including all actions and people involved, of the process
3. Create Flow – make sure the workflow remains smooth
4. Establish Pull – the process should only take place if there is an actual need
5. Continuous Improvement – keep on looking for improvement, strive for perfection

This cycle can be repeated until perfection, it is a 'journey' which constantly strives for perfection. According to Wilson (2010), the definition of Lean is: "Lean is a set of 'tools' that assist in the identification and steady elimination of waste, the improvement of quality, and production time and cost reduction." Examples of Lean tools are Kanban and Poka Yoke. Kanban is a lean tool that supports managing and improving work across human systems. This is done by balancing demand over the available capacity and improving the handling of bottlenecks. Poka Yoke is Japanese for "mistake-proofing", it is a mechanism in a process that helps avoiding mistakes defects. According to Robinson (1997), this is done by preventing, correcting or drawing attention to human errors as they occur.

During the analysing phase of this research, the Gemba Walk will be used to find problems, bottlenecks and wastes in the current manual return process. A Gemba Walk is a way to gather information through observation and interaction with employees. The Gemba Walk is characterized by four distinctive elements (Romero, et al. 2020). The first important element is the location. In order for the Gemba Walk to be successful, the Gemba Walk should be done at "the actual location". In our research the location is the manual sorting process. Secondly, observing the location is of importance, watching the team perform their tasks in person. Thirdly, in order for the researcher to be able to get a full understanding of the process, interaction with the team is necessary. This is done by respectfully asking questions regarding their working performance. Lastly, after watching at and listening to employees the reflecting phase is important. Reflecting what actions serve as solutions to the found problems, bottlenecks and types of wastes. The reflecting part is most important for the Gemba Walk to be successful. Furthermore, Gemba Walks are an important Lean tool, because it engages managers with the employees at the actual workplace. Performing a Gemba Walk shows appreciation for the work of the employees. It creates value, boosts morale and can result in gaining trust of the employees. In the long run, these values can result in employees giving more useful information about their working process.

3.6 Alternative/following solution methods

Production process layout is a crucial factor that affects the efficiency of a handling system. Improper layout planning may lead to higher costs for the organization. Redesign of the layout of the manual sorting process might take place if the outcomes of the Gemba Walk suggest major changes. Whenever this is the case, the current layout will be analysed. In our research, the positioning of roll containers, employees and materials will become very important. The number of packages per customer will be a key decision factor, the workload should be divided equally over the total process and the biggest customers should be easily reachable since these receive the greatest number of packages throughout the day. Also, putting these roll containers/pallets close to the line will reduce the overall walking distance of the employees, which is another factor that influences the throughput of packages at the manual sorting department.

Despite of the type of organisation that is having a redesign of their layout, there are certain factors that should always be taken into consideration when redesigning a process. Sharma et al (2016) state the

following key performance factors: space utilisation, ease of management and control, flow of material, internal household and employee satisfaction, ease of maintenance, preferred closeness and attractiveness of layout. Sometimes the layout flexibility is also considered as an important factors during the redesign of production layouts. The framework that we will be using, if redesign is necessary, is the Systematic Layout Planning (SLP) method. According to Suhardini et al (2017), the SLP technique is expected to make the fastest material flow with the lowest costs and least amount of material handling. The procedure of Systematic Layout Planning can be found in Figure 3: Systematic Layout Planning (SLP).

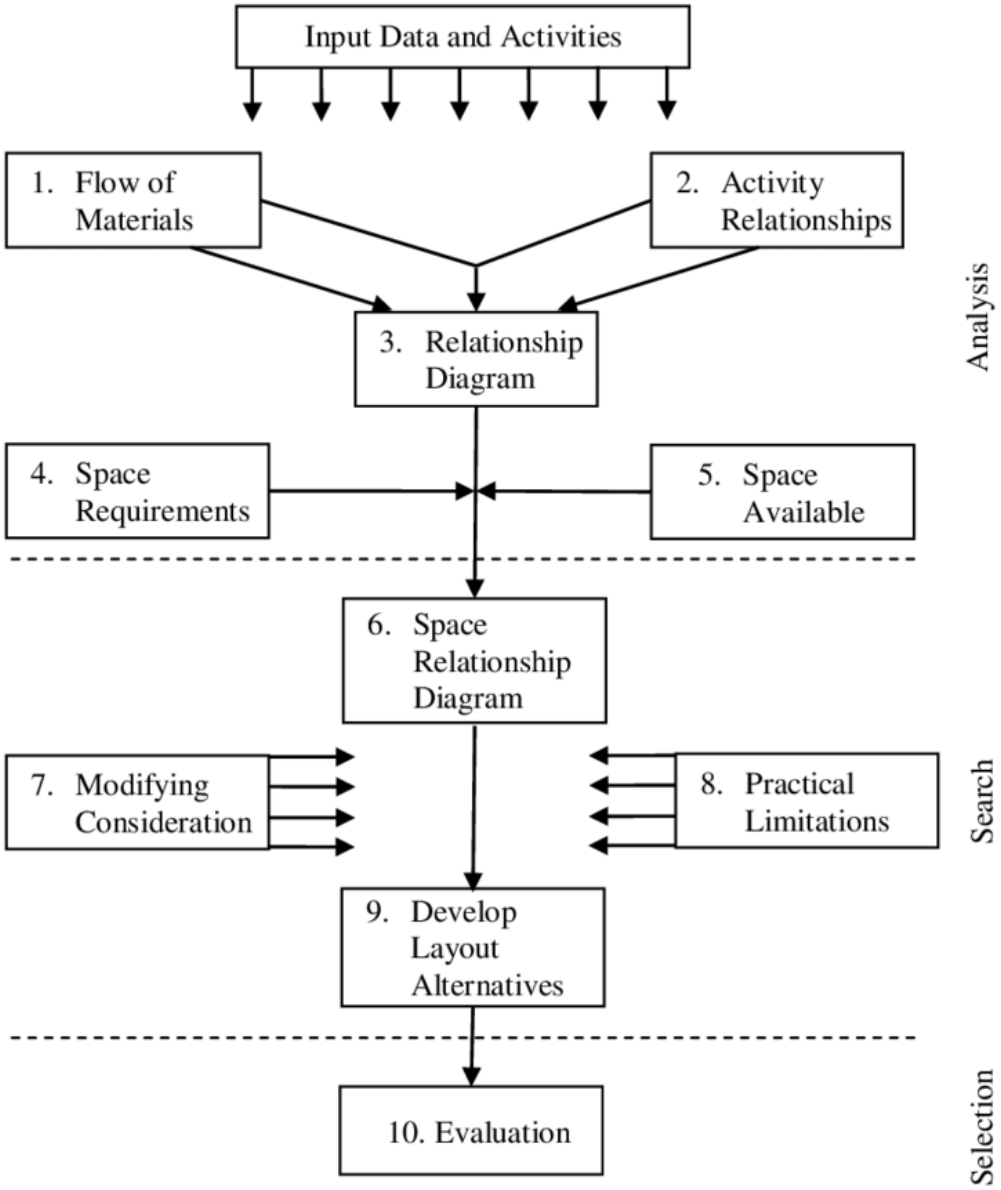

Figure 3: Systematic Layout Planning (SLP)

3.7 Validity and reliability

According to Cooper and Schindler (2014), the three major characteristics of a measurement tool are reliability, validity and practicality. The reliability of our research regarding the observation of the

manual sorting process has to do with consistently receiving the same results. Observations can be made more reliable by observing the same situation repeatedly. Therefore, in order to increase the reliability of the research, observation on the manual sorting process will be done regularly. Furthermore, another important measuring tool during our research is the use of interviews. The reliability of interviews is negatively influenced because we are not interviewing everybody that has something to do with the manual sorting process. However, the experienced employees will be interviewed and the results of these interviews are available for the rest of the employees. This way the employees that were not interviewed can still give their opinion if they want to.

Another important measurement of quality in a research study is the validity. The validity is the extent to which a concept is accurately measured in the study. To ensure that the data gathering is done accurately, the research is based on a theoretical framework. The data gathering methods consist of interviews with experienced employees, observation of the manual sorting process and historical and fixed data of the manual sorting process.

3.8 Conclusion

This chapter mentions the different theories that will be used to support the research. In order to make sure that the setup of this research will be correct, we will use the MPSM approach. This guarantees that all important factors that can help tackling a problem, will be taken into account. Furthermore, Lean Management will be used for the process improvement. Lean Management is a set of theories that helps optimizing working processes. The research will start off with a Gemba Walk that is able to find the problems, bottlenecks and wastes in the current process. The follow-up theory that will be used is not known yet and depends on the outcome of the Gemba Walk. The results of the Gemba Walk are mentioned in the next chapter, after reviewing the results, a follow-up theory can be chosen.

4. Current situation

This chapter creates a view of the current situation and the problems that currently occur. The process is already explained in earlier chapters. Therefore, this chapter will focus on the certain important factors that influences the efficiency of handling return shipment. Section 4.1 brings the current layout of the manual return process into view. With the help of a floor map, the distribution of all customers is shown, as well as the pathway of the shipments. In section 4.2 the Gemba Walk will be conducted. The procedure of the Gemba Walk and the findings will be explained. Section 4.3 highlights the indicators that have been mentioned in section 2.3 or have been found during the Gemba Walk. These indicators need to be expressed for the current situation, because these will function as a benchmark for the new situation eventually. Section 4.4 will analyse the found problems that occur in the current situation and a solution approach that is able to solve the most problems will be determined. Lastly, Section 4.5 will conclude this chapter by stating the most important points regarding the current situation.

4.1 Current layout planning and package distribution among customers

In this section, a step-by-step procedure of the manual return process will be explained with the help of a floor map that is displayed in **Error! Reference source not found.**. The process starts by getting the packages out of the roll container and putting these on the sorting belt. The arrival of the roll containers at the storage within the manual sorting process is left out of scope. The sorting belt is not automated, the packages that are being put on the sorting belt should be manually forwarded. Whenever the package arrives at the scanning stations, one of the two scanning employees scans the package and has to decide to which group of customers it belongs. The groups are divided into three sections namely, section A, section B and section C. These different sections are highlighted by the use of different colouring in the floor map. The decision that has to be made by the scanning employee depends the section where the package belongs to. If the packages belongs to one of the customers that can be found in section A or B, the package should be forwarded in the vertical direction. Otherwise, when the package belongs to section C, the scanning employee should move the package in horizontal direction to the left. Next up, if no mistake was made by the scanning employees, the package will be taken from the sorting belt. The employee takes a look at the label(s) on the package and is able to connect a customer to the package. In the case of section A and B, the employees leave the package on the sorting belt if the customer is not part of their section. If the package does belong to one of the section's customer it will be brought to the corresponding roll container/pallet, and this is the end of the manual sorting process for the employees.

Another important factor of the layout planning is the distribution of employees over the process. An adequate distribution of employees in workspaces helps the company increase the efficiency in processes (Arista, 2021). Therefore, the current distribution of employees should be brought into view.

- Employee 1: setting up packages at begin sorting belt (opzet)
- Employee 2: scanning station
- Employee 3: scanning station
- Employee 4: section A
- Employee 5: section A
- Employee 6: section A

- Employee 7: section B
- Employee 8: section B
- Employee 9: section B
- Employee 10: section C
- Employee 11: section C / extra opzet (depends on busyness)
- Employee 12: coordinator

Equally important is the current layout of the manual sorting department. The current situation is displayed in Figure 4: Floor map of the current situation.

Figure 4: Floor map of the current situation [adapted from DHL (2020)]

4.2 Gemba Walk findings

While conducting the Gemba Walk, a better understanding of the current process is gathered. By asking questions about certain actions made by the employees, the idea behind choices within the process is getting clearer. The Gemba Walk started off at the beginning of the manual sorting process, where one or two employees (depending on busyness) put packages on the sorting belt, a simple task that can be performed by every employee within the manual sorting department. However, taking the efficiency into

account, there were a few specific roll containers that might result in higher efficiency if handled differently. These specific roll containers are the roll containers that are coming from the machine sorting process and are known as roll containers from “collection chutes” (verzamelgoten in Dutch). DHL has more customers than available chutes at the machine sorter, therefore some small customers are set up to the same chute number. This results in roll containers that consist of packages that need to go to different customers. These roll containers require extra handling at the manual sorting process, because the packages of the different customers need to be divided correctly and the single roll container can only be found in the manual sorting process (machine process has no space). Right now, these roll containers are handled the same way as all other roll containers. While it might be more efficient to cluster the customers that are connected in a “collection chute” and scan the packages from the roll containers with a mobile scanning device close to this cluster with the corresponding customers.

Next up in the process is the scanning of packages. The packages that were put on the sorting belt in the earlier mentioned step arrive at the two employees that scan the packages so that the system registers every package that is being processed at DHL. This scan results in a red, orange or green screen and every type of screen means something different. The different meanings of the screen can be found in Appendix B: Flowchart of manual return process. After determining to which customer the return package belongs, the employee at the scanning station needs to determine where the roll container or pallet of this customers is placed and then the package should be moved in the correct direction. The fact that the scanning employees need to determine the customer and think about the location of this customer in the layout can be seen as a waste in the current situation. This is considered a waste, because the exact same thing also needs to be done by the employees in section A, B and C. Performing this task at the scanning station needs to be done, because of the split between the different sections in the layout. Therefore, this will be an important factor that should be considered when coming up with solutions. Also, because it requires extra time to determine the corresponding customer, which can result in another waste, namely waiting time for the next step(s).

Lastly, the tasks of the employees at the different sections. Every sections fulfils the same tasks, the only difference is the customers that are located in the section. The employees are responsible for getting the packages from the sorting belt and putting them in/on the roll container/pallet of the correct customer. In order to successfully transfer the package to the roll container/pallet, determining to which customer the package belongs is of the biggest importance. However, there is not one good way to determine the correct customer. The following characteristics can all have influence on finding the correct customer:

- RC-code
- Sender details
- Receiver details
- Abbreviation under barcode
- Packaging
- Scanning screen
- Content of the package (only if the characteristics above did not result in finding the customer)

There is not one characteristic that is always able to find the correct customer. The high number of characteristics results in a difficult process that cannot be performed by every employee and, therefore, requires experienced employees.

Furthermore, the employees in section A and B are both together responsible for each complete section. This results in employees walking same paths and crossing each other constantly. Every employees in these sections is getting the packages from the beginning of the sorting belt and bringing them to the corresponding location of the customer. This results in employees walking to the same customer at the same time and a lot of crossing between employees. Also, since the packages pile up at the beginning, the walking distance becomes longer than necessary.

Also, questions about the layout of the manual sorting department sections were asked. The employees said that they have learned the layout by heart and do not need any indication to find certain customers anymore. This contributes to the earlier mentioned problem about needing experienced employees. There is a floor map at the end of the sorting belt, but this map is not totally up-to-date and needing to walk to the end of the sorting belt results in much longer processing times.

Finally, to conclude this section, an overview of the most important findings will be given.

- Handling of “collection chutes”
- Wastes scanning employees
- Lot of characteristics on label for determining the right customer
- Walking paths and distance of employees in sections
- Employees need to learn layout by heart

4.3 Value indicators

In order to make the impact on efficiency quantifiable the value of the solution should be measurable. For DHL, the most important indicator is the number of packages sorted per hour per employee. Being able to increase the number of packages that a single employee processes has the biggest impact on the throughput rate of the manual sorting department. The throughput rate of a single employee is only important for employees that are located in one of the sections. However, the consequences of the new layout cannot be fully expressed in the throughput rate. The throughput rate is also influenced by other factors that are improved due to a new situation.

An interesting indicator that expresses the value of a new layout is the total walking distance of the employees that divide the packages over the sections. Decreasing walking distance helps decreasing the cycle time of a single package, a lower cycle time means that more packages can be processed and this results in an improvement in the throughput rate of packages. The current walking distance can be calculated with the help of the current layout and the division of packages over the customers. Considering that this warehouse has only the In-Aisle and Cross-Aisle dimensions (no height), the Total Distance Traveled for any order (DT) can be split up into two separate parts: Travel in the In-Aisle direction (DA) and travel in the Cross-Aisle direction (DC), where DT = DA + DC. The Expected Total Distance Traveled can then be stated as E(DT) = E(DA) + E(DC) (Jarvis, 1991). The Expected Total Distance Traveled will be calculated for the new situations and compared to the total walking distance of the current situation.

The total walking distance of week 25 in the current situation is 196,898 units, while the In-Aisle distance is 98,709 units. Calculations on the total walking distance can be found in Appendix D: Calculations on the walking distance.

4.4 Solution to problems

4.4.1 Collection chutes

Considering the handling of “collection chutes” roll containers, the problem lies within the fact that the customers within these roll containers are known beforehand, but are processed the same way as roll containers that could contain every single possible customer. With the use of a mobile scanning device and grouping the customers that can be found in the “collection chute”, the procedure of putting the packages on the sorting belt and the double determination of to which customer it belongs will be eliminated. Resulting in a shorter processing time, due to the shorter path the package will follow and the shorter walking distance of the employee that handles the roll container in the section. On the other hand, the roll container has to be navigated towards the right aisle and the employee that is responsible for that aisle will not be able to process the other packages that are coming from the sorting belt. This could be solved be making an employee responsible for the handling of “collection chute”, the employee distribution and their tasks can only be given when all other factors are also known. More about the distribution of personal along the sorting belt is mentioned in section 4.4.4 of this chapter.

4.4.2 Scanning employees

In the current manual sorting process, two scanning employees are needed in order to forward the return packages in the right direction without causing a delay in the process. If this would be done by only one person, the packages will pile up at the scanning station, because scanning the package and identifying to which path it belongs takes more time than only putting the packages on the sorting belt at the beginning of the process. Especially the need to identify to which customer the package belongs and where in the layout this customer is located can be seen as a waste of time, because this action also has to be performed later in the process, by the employees that are dividing the packages over the roll containers or pallets. Right now, this splitting pathways of the sorting belt is done because of the available space. Together with DHL, we decided to create a situation in which there is no split between different sections and the sorting belt will be one (bit longer) line instead, as well as a situation that does take the current available space into account. Being able to sort the packages along one straight line resolves the need of two different scanning stations. The task of a scanning employee in at a straight sorting belt will only be scanning the packages, no distinction has to be made regarding to follow-up pathway towards the customers, since all customers are located along one line. Scanning the packages can be done at the same pace as putting the packages on the sorting belt, therefore two scanning employees are not necessary anymore.

4.4.3 Lot of characteristics on label

As mentioned above, there are a lot of different steps that could be considered when finding out to what customer a package belongs. All different characteristics on the label that could lead to finding out the original customer result in a longer time to determine the customer, which results in longer processing times and delay in the process might occur. Focussing on the most common characteristics that are able to clearly show the original customer should result in the quickest throughput in identifying the original customer. Right now, the RC-codes are the easiest way to derive to what customer a package belongs. RC-codes are numbers that are connected to a customer (for example, RC-120 belongs to Zalando). Every customer has its own, original number. Making sure that every customer has a corresponding RC-code and that the customer puts its code on the label clearly visible, is out of scope of our research. However, an interview with the Customer Operations Support Manager of DHL Parcel showed that providing every

customer with its own RC-code is possible. The current RC-code can even be changed to another number if this would be beneficial for the throughput rate of packages at the manual sorting department.

4.4.4 Walking paths and distance of employees

Employees in section A and B do not receive any instruction regarding what part of the section they are responsible for. The, on average, three employees in section A are responsible for the complete section A and the employees in section B are, likewise, responsible for their complete section. The consequence of not distributing the employees over the section is that the packages pile up at a point just after the scanning station and all employees are getting their packages from this point. The employees take a (few) package(s) out of this pile and start distributing the packages over the corresponding customers. Every now and then, two employees pick a package that belongs to the same customer and follow each other towards the roll container in which the package belongs. Following another employee when dividing the packages is a waste in the current situation. This could be solved by making an employee responsible for a smaller part of the section, for example, one or two aisles. The employee responsible for the part closest to the scanning station will also be responsible for forwarding the packages that do not belong to his/her aisle(s). This results in the packages not piling up at the start of the sorting belt and decreases the walking distance of employees that are responsible for aisles that are located further away from the scanning station. When choosing for a distribution of employees along the sorting belt, the average number of packages per aisle should be divided equally. Furthermore, the customers with the most average packages should be placed at the beginning of the aisle. This way the workload of the employees will be the same and walking distance is decreased.

4.4.5 Layout should be learned by heart

Right now, a floor map of the manual sorting department is printed and can be found at the end of the sorting belt. For new employees, finding the location of the roll container/pallet of the customer takes a lot of time if it is necessary to take a look at the floor map for every package. Putting a sign with all customer that are located in the aisle above every aisle will decrease the extra time it takes to walk to the back and search for the customer on a floor map (that is not completely up-to-date). Complete names of customers might make it hard to find the customer in one glance, therefore mentioning the RC-code on the signs makes it easier to find the location an employee is looking for. Especially, if the RC-code can be ordered low to high, so RC-code 1-20 in the first aisle and 21-40 in the next aisle. As mentioned in section 4.4.3, according to the Customer Operations Support Manager, the current RC-codes can be changed around and put into order. This will create a better overview of the location of customer that is easily understandable for new employees and decreases the difference in processing time between an experienced and new employees, which results in higher flexibility for DHL Parcel.

4.5 Conclusion

This chapter took a closer look at the current situation and especially the current layout of the manual sorting process. With the help of the Gemba Walk the biggest wastes and problems are highlighted, the following problems were found most important: the handling of collection chutes, the scanning employees, the labels with lot of characteristics, the walking paths and distance of employees and the unclear floor map of the layout. Except for the problems with the label, every problem is somehow connected to the current layout at the manual sorting department. Therefore, the solution should focus on the redesign of the layout of the manual sorting department, while taking all problems into

consideration. The new situation should cluster the “collection chutes”, desirable will be one straight line, having an equal workload for each aisle and indications about locations of customers should be given. Together with DHL Parcel, an agreement was made about delivering two different situations. The first one with no restrictions on space utilization and the second one that is limited by the current available space. The design of and methodology behind the new layout creations will be explained in the next section.

5. Design layout planning

The design of the new layouts will take place in this chapter. The chapter starts with section 5.1 mentioning the inputs for the Systematic Layout Planning and how this data is obtained. Section **Error! Reference source not found.** explains how the input and SLP turn into an Excel file that creates a new layout, while trying to minimize the walking distance of employees within the manual sorting department. The new layout are introduced in section 5.2, starting off with an explanation of the Excel coding that will be used. Followed by both the new layout without space restrictions, as well as the new layout with space restrictions. The results regarding walking distances will be mentioned in section 5.3 and the chapter will be concluded in section 0.

5.1 Input

To start redesigning the layout of the manual sorting department, all relevant data should be collected and processed. In order to get a good overview of the number of packages that one customer receives on average, the total of a whole week is taken. With the help of SVInfo, a tool that processes all information regarding packages that are being handled in SVC 1, data about Week 25 (21-06-2021 t/m 27-06-2021) is obtained. The relevant information of the complete dataset can be found in Appendix C: Dataset week 25. The information obtained in SVInfo is divided over the customers as we know them from the floor map. Some customers are known by a different name in SVInfo or are the parent company of several smaller companies, for example Termeer Schoenen is part of Sacha & Manfield. Therefore the 290 different results received from SVInfo, can be divided over the 128 customers at the manual sorting department. In Appendix D: Calculations on the walking distance, together with the calculations on the walking distance, the ranking of the customers with the most average packages can be found. This ranking is of importance when making a new layout for the manual sorting department. The customers that receive the most packages should be located closest to the sorting belt, in order to achieve the smallest walking distance possible.

However, the new layout should not only be based on this ranking, there are more factors that should be taken into account. First of all, collection chute customers. Collection chute customer packages arrive at the manual sorting department after receiving a scan at the machine sorter and being put in a collection roll container. Since these packages have already received a scan, it has been registered that the package is located at SVC 1 and has been sorted. Therefore, the package does not require an extra scan at the manual sorting department and it could directly be divided over the customers. Locating the customers from each collection chute next to each other will make it possible to bring the packages to the location of the corresponding customers and divide the packages without putting these on the sorting belt first. This will eliminate the scanning part of the process and improve the throughput rate. Processing the collection chute roll containers can best be done in idle or low volume times, since it requires an employee that normally takes place at the sorting belt. Furthermore, a distinction between pallet and roll containers has to be made while designing a new layout. Pallets require more space than roll containers and are harder to replace when full. Right now, pallets are mostly located at the beginning of the sorting belt. In the new situation this will still be the case, putting pallets at the end will result in more challenges while replacing the pallets due to space utilization and the location of new pallets. Also, exclusively for the new situation with space restrictions, the customers that are currently located in section C will stay in section C within the new situation. Together with DHL, a consideration of changing around with these customer was made. The effect of changing around these customers will probably result in difficulties for the scanning employees since they are known with the current situation. It will

result in a higher mistake rate and changing in section C will have a small impact on the walking distance because of the few customers that are located in this section. This decision was made because of the fact that delay at the scanning station will have a big impact on the throughput rate. Lastly, in the current situation several customers have more than one roll container or pallet that can be used to put the packages in. Together with the coordinator and supervisor that are responsible for the manual sorting department, we looked at the amount of packages for each of those customers. The result can be found in

.

Table 3: Number of pallets/roll containers per customer

Customer	Number of units
Amazon	3 pallets
Algemeen retour	2 roll containers
ASOS	2 pallets
BAX	2 boxes
BCC	2 pallets
Bon a Parte	2 pallets
Depot Dordrecht	2 roll containers
DP Optie 4	2 boxes
Hunkemoller	2 pallets
iBood	2 roll containers
JVGL Kwaliteit	2 roll containers
Lidl	3 pallets
Omoda	3 roll containers
Pionhoek	2 roll containers
Wehkamp	4 roll containers (3 normal and 1 recycle)
Zalando	2 pallets
Zooplus	3 pallets
Every other customer	1 pallet/roll container

5.2 New situation

5.2.1 Methodology

The new layout will be created with the help of Excel and its programming feature Visual Basics. The Excel file automatically fills in all spots in the layout based on the criteria mentioned in section 5.1. Two different layouts will be generated, the first layout has no restrictions in terms of space. This results in choosing for a sorting belt that follows a straight line, instead of the current split of sections after the scanning station. Eliminating the split into different sections after the scan results in only being responsible for scanning the barcode instead of also identifying its corresponding customer and forwarding it into the right section. Furthermore, only one scanning employee is required in the no space restriction layout, because scanning can be done at an pace that is equal to the rate of putting packages on the sorting belt at the beginning. The second layout does take the current space utilization into account. Therefore, this layout uses the same structure as the current layout. As mentioned above, section C will contain the same customers as of the current situation, due to preference of DHL concerning standardization of the current scanning employees' decisions.

5.2.2 Situation without space restriction

The situation without space restriction will have a different structure compared to the current situation. The structure of the sorting belt in the new situation will be a straight line. A straight line will create an easier task for the scanning employees. In the current situation, the scanning employees have to decide which path the package should follow after the scan. If the customer that belongs to the package located in section A or B, then the package should be forwarded on the sorting belt that run through the middle of section A and B. Otherwise, if the customer is located in section C, the package will be directed towards this section on another sorting belt. In the new situation, this step is not necessary because of all customer being located along one straight sorting belt. Not only will the task of the scanning employee be much simpler, a second scanning employee is not even necessary in this case. Scanning the packages can easily be done at the same pace as putting the packages on the sorting belt at the beginning. Therefore, this new situation without space restriction does not only positively influence the walking distance, and consequently the throughput rate, it also requires one less employee to fulfil the tasks at the manual sorting department. Furthermore, customer BAX will keep its place at the beginning of the sorting belt. This is the case because of the personal needs of BAX. BAX would like a file with all barcodes that are going to be delivered that day. Therefore, every morning before the start of the actual process, the packages from BAX receive an extra scan that registers the barcodes in an Excel file. Whenever new BAX return packages are being scanned during the day, DHL temporary stores them in large blue cages until these packages receive the extra scan on the next day. These large cages cannot be placed in the middle of the layout and are therefore located at the beginning of the sorting belt. The same applies to 8x3 sorteerfout (SF) and DP Optie 4. These customers are also stored in bigger cages and do not fit somewhere in the middle of the layout. Currently, these are located in section C. However, in the new situation without space restrictions, there is no section C. Therefore, these two customers will, just like BAX, be located in the first aisle of the new layout. Lastly, the aisles behind BAX, SF and DP Optie 4 on both the left and right side are filled with pallets, these can also be recognized by the brown filling. The rest of the customers are stored in roll containers. The new situation without space restrictions is displayed in Figure 5: Floor map of new situation without space restrictions.

Figure 5: Floor map of new situation without space restrictions

5.3.3. Situation with space restriction

The situation with space restriction will be structured the same way the current situation is structured. Due to preferences of DHL and the employees at the manual sorting department, the customers that are located in section C will remain the same. However, these customers can be changed around within section C if this will positively influence the walking distance of the employees. For customers that are originally located in section A or B, swapping between sections is possible. Furthermore, BAX will also keep its place at the beginning of the sorting belt. The reason for keeping BAX at the beginning of the sorting belt is explained in section 5.2.2. The new situation with space restrictions can be found in Figure 6: Floor map of new situation with space restrictions.

Figure 6: Floor map of new situation with space restrictions

5.3 Walking distance results of new situations

Two different types of walking distance results are reviewed in this section, the first type is the total walking distance that is needed to divide all packages over their pallets/roll containers, while the second type only looks at the In-Aisle distances. In an ideal situation, the employees are spread over the layout and made responsible for a single aisle. If this is the case, the packages should be forwarded by the employees until the package reaches the aisle where it is located. The In-Aisle distance of this customer will be the only distance that will be walked by the employee at the sorting belt. Therefore, the In-Aisle distance is important when trying to reach the ideal situation.

Right now, the total walking distance needed to process every package is 196,898 units, of which 98,709 units are In-Aisle direction. As mentioned in section 2.2, the goal is set to decreasing these numbers by at least 20%. The new situation without space restrictions resulted in a total walking distance of 147,454 units, which is a 25.11% improvement, and an In-Aisle distance of 51,235 units, which is a 48.09% improvement. The other new situation, with space restrictions, resulted in a total walking distance of 141,360 units, an improvement of 28.21%. While the In-Aisle distance is 60,841 units, an improvement of 38.36%. An overview of the results can be found in Table 4: Walking distance results.

The new situation without space restrictions scored better at the In-Aisle distances, while the new situation with space restrictions had a better result regarding the total walking distance. The improvement of the In-Aisle distance at the new situation without space restriction can be explained by the fact that all customers are located along one sorting line. The other situation has to take a group of pallet customers into account when arranging spots in the layout, while this situation can clearly locate the pallet customers according to their number of packages in descending order.

The new situation with space restrictions scoring better on the total walking distance can be explained by the fact that the total area covered by customers is smaller than the situation without space restrictions. The space restricted new layout outperforms the new layout without space restrictions on total walking distance, but does require the extra scanning employee which is explained in more detail in subsection 4.4.2. Personally, we prefer the new situation without space restrictions over the new situation with space restrictions. The reason for choosing the new situation without space restrictions is mainly the fact that it resolves more problems that are stated in section 4.2. The situation solves 4 out of the 5 problems mentioned, while the space restricted layout only solves 3 out of 5 problems. Being able to decrease the number of scanning employees from 2 to 1 and locate every customer along the same sorting line is the main difference between the two layouts. In the current situation the two scanning employees need to have a lot of knowledge about the return shipments, while in the non-space restricted layout the task of the scanning employee becomes very simple. Right now, the customer has to be recognized and the package should be forwarded in the right direction. The scanning employee has to know the characteristics of every single customer. In the new situation without space restrictions the scanning employee's only task is to scan the barcode of the package and push it forward on the sorting belt. The first benefit is being able to do all tasks of the scanning employee by one person, which results in an extra employee available for distribution the packages over the pallets/roll containers. Additionally, the one scanning employee does not require all knowledge that is currently needed. Scanning packages in the new situation without space restrictions can be done by everybody, which means that the knowledge of the 'experts' that are scanning the packages in the current situation can be used in the final part of the process, that is the division of package over the customers. The current scanning employees are quick and great at recognizing to what customer the packages belong, using these

employees at the sorting belt instead of scanning station will increase the quality and speed of handling return shipments.

Table 4: Walking distance results

Situation	Total walking distance	Improvement in percentages	In-Aisle distance	Improvement in percentages
Current situation	196,898 units	-	98,709 units	-
New situation without space restrictions	147,454 units	25.11%	51,235 units	**48.09%**
New situation with space restrictions	141,360 units	**28.21%**	60,841 units	38.36%

5.4 Conclusion

This chapter explains the design of and methodology behind the new layouts for the manual sorting department. All data was obtained through a tool that DHL uses to register every package in SVC 1. With the use of SLP, the input and Excel, a new situation without space restrictions and a situation with space restrictions was created. The situation with space restrictions resulted in a 28.21% improvement regarding the total distance walked by employees at the manual sorting department and the new situation without space restrictions decreased the In-Aisle distance by 48.09%. An overall conclusion, discussion and recommendation will be given in the next chapter.

6. Conclusion, discussion and recommendation

This chapter briefly explains the conclusion, discussion, recommendations and any further research that could be done at DHL Parcel. With the help of the answers to all sub-research questions, the main research question will be answered in section 6.1. A discussion of the result will be given in section 6.2 and the chapter will be concluded with a recommendation and further research in section 6.3.

6.1 Conclusion

The manual sorting department of DHL Parcel in Utrecht is having problems regarding the handling of the increasing number of return shipments. The throughput rate of return shipment requires improvement if the department wants to keep up with the daily number of return shipment. The goal of this research is to answer the following research question:

How can the efficiency of handling return shipments in the manual return sorting process be improved at DHL Parcel (E-Commerce)?

The current situation was brought into view in order to find out what parts of the manual sorting department could be improved. After the Gemba Walk and taking a closer look at the problems that were found, the current layout of the manual sorting department is acknowledged as the major bottleneck at the manual sorting department. Efficiently dividing customers over the available space will positively influence four out of the five found problems during the Gemba Walk: handling of “collection chutes”, wastes scanning employees, lot of characteristics on label for determining the right customer, walking paths and distance of employees in sections and the fact that employees need to learn layout by heart. Re-arranging the division of customers over the layout according to the number of packages each customer receives, will decrease the walking distance of the employees at the manual sorting department. Decreasing walking distances results in shorter processing times for the return packages and the shorter processing times improves the throughput rate of the return packages, resulting in the manual sorting department being able to sort their return packages at a higher pace and giving DHL more flexibility regarding the use of their employees.

The new layout is based on locating the ‘biggest’ customers closest to the sorting belt, where ‘biggest’ means the customer that receives the most return shipments. This solution is focused on the practical improvement of the manual sorting department. The data is obtained through the tool SVInfo, which registers every package that receives a scan at the manual sorting department. This data consists of all number that can be found in Appendix C: Dataset week 25 and are divided over the corresponding, existing customers at the manual sorting department. This converted data and characteristics of the customer are used to create two new designs of the layout. One layout that uses the exact same structure as the current situation and one layout that has no restrictions regarding space utilization. In order to express the improvements of the new layouts compared to the current layout, the In-Aisle walking distance is the main indicator of improvement. Further recommendations towards DHL and results about the layouts will be stated in section 6.3.

6.2 Discussion

Some limitations due to the method and provided data will be addressed in this section. First of all regarding the provided data, the provided data was not the ideal data and had to be transformed into workable data. This had to do with the way SVInfo registers the data, SVInfo connect names according to the ‘verladernummer’ that can be found within the data. This results in certain names appearing more

than once and certain customers appearing under a different name than known for at the manual sorting department. Assigning the data from SVInfo to the customers at the manual sorting department may have raised some inaccuracy with regards to the reality. Some names in the SVInfo file could not be assigned to any of the known customers and the number of packages that these names received were neglected when designing the new layouts. Concluding, using the same name for the customers in the manual sorting department and the customer in the SVInfo dataset will result in an easier transition of data into Excel and create a better representation of the reality.

Another limitation of this research is new customers that start using DHL's services. In our research a data set of a single week is taken, which consists of the customers that are currently partner of DHL. However, new customer keep entering while others leave DHL's services. Therefore, in order for the layout to be efficient, the dataset should be updated frequently. Otherwise, new customers will be missing in the layout while others are still located and not receiving any packages. Once again, adding and deleting customers will be easier when the customer is registered under one and the same name only, instead of differences between the names that SVInfo uses and the names of the customers in the manual sorting department. After implementing the solution, adding new customers to the layout might become very difficult if not familiar with the Excel file and certain Excel-functions that are in use.

Furthermore, the layout cannot completely be designed by Excel, an exception takes place when assigning a position to customers that are set to a "collection chute" in the machine process. Customers from a collection chute require different handling than customer that have their own chute at the machine process. Collection chute customers have already made their way over the machine sorter and arrived at the collection chute. The roll containers from these collection chutes do not require an additional scan at the scanning station from the manual sorting department. These packages can directly be divided over the corresponding customers and locating these customers next to each other would be necessary. Therefore, these collection chute customers are left out of the automatic assignment of customers and added manually when every other customer has received a location.

6.3 Recommendation and further research

Due to the often changing customers that make use of DHL's service it is recommended that the layout receives updates whenever big changes have happened. Keeping customers that no longer send and receive through DHL is a waste and adding new customers to the end of aisles instead of based on the number of packages they receive results in longer walking distances than necessary.

The assumption was made that packages will be forwarded along the sorting belt until that package reaches the aisle its customer is located in. In reality this might not always be the case, for a variety of reasons the employee might not be able to forward the package along the sorting belt. This results in an extra walking distance in Cross-Aisle direction for the employee that is supposed to put the package in the roll container or on the pallet. Because this risk was known beforehand, the extra indicator that is the total walking distance is also expressed. This indicator assumes that every package will be picked up at the start of the sorting belt just after it has received a scan at the scanning station. The total walking distance is equal to the Cross-Aisle and In-Aisle walking distance summed up. However, it is recommended to forward the shipment along the sorting belt until it reaches the aisle of the customer. Pushing shipment along the sorting belt eliminates walking distance and improve the throughput rate. However, this can only be successful if employees are distributed along the sorting belt and assigned to certain aisles.

For further research, it is recommended to extend the scope of the research. By extending the scope of the research, the process of packages before arriving at SVC could be taken into account. Resolving problems that occur in this phase regarding mistakes with labels and data transferring, can result in a lower percentage of packages that requires manual handling. Attacking the problem at the cause will have a greater impact on the complete return shipment sorting process of DHL.

Next to that, when starting this research, the manual sorting department was also handling return shipments that did not necessarily require manual handling. When the manual sorting department was out of roll containers that require manual sorting, normal return roll containers were processed in order to be productive in idle time. A recommendation would be to keep processing the packages that are able to be sorted by the machine on the machine sorter and only take care of the no-info packages at the manual sorting department. This way the productivity is better, since the machine sorter is quicker than manual sorting. Moreover, the machine sorter also guarantees quality and does not make any mistake while dividing the packages over the customers. In manual sorting, this quality cannot be ensured because every single person can make a mistake while dividing the packages. Combining this and the previous suggestion should result in considerably lower working load for the manual sorting department, resulting in more flexibility for DHL in how to use the manual sorting department employees. The hours that are not needed anymore could be used to let the employees help at the machine sorter and save costs for temporary workers that are currently responsible for the machine process.

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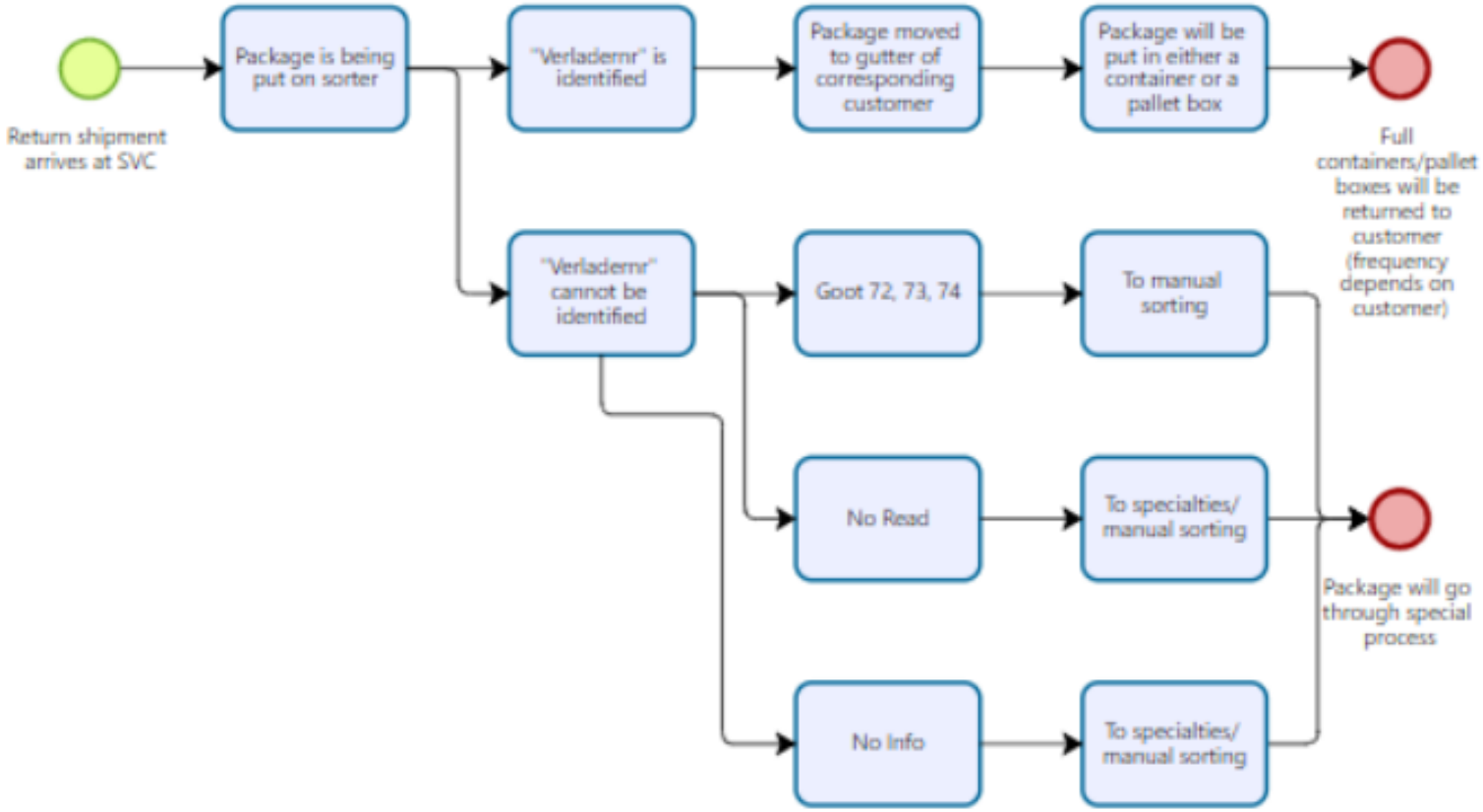
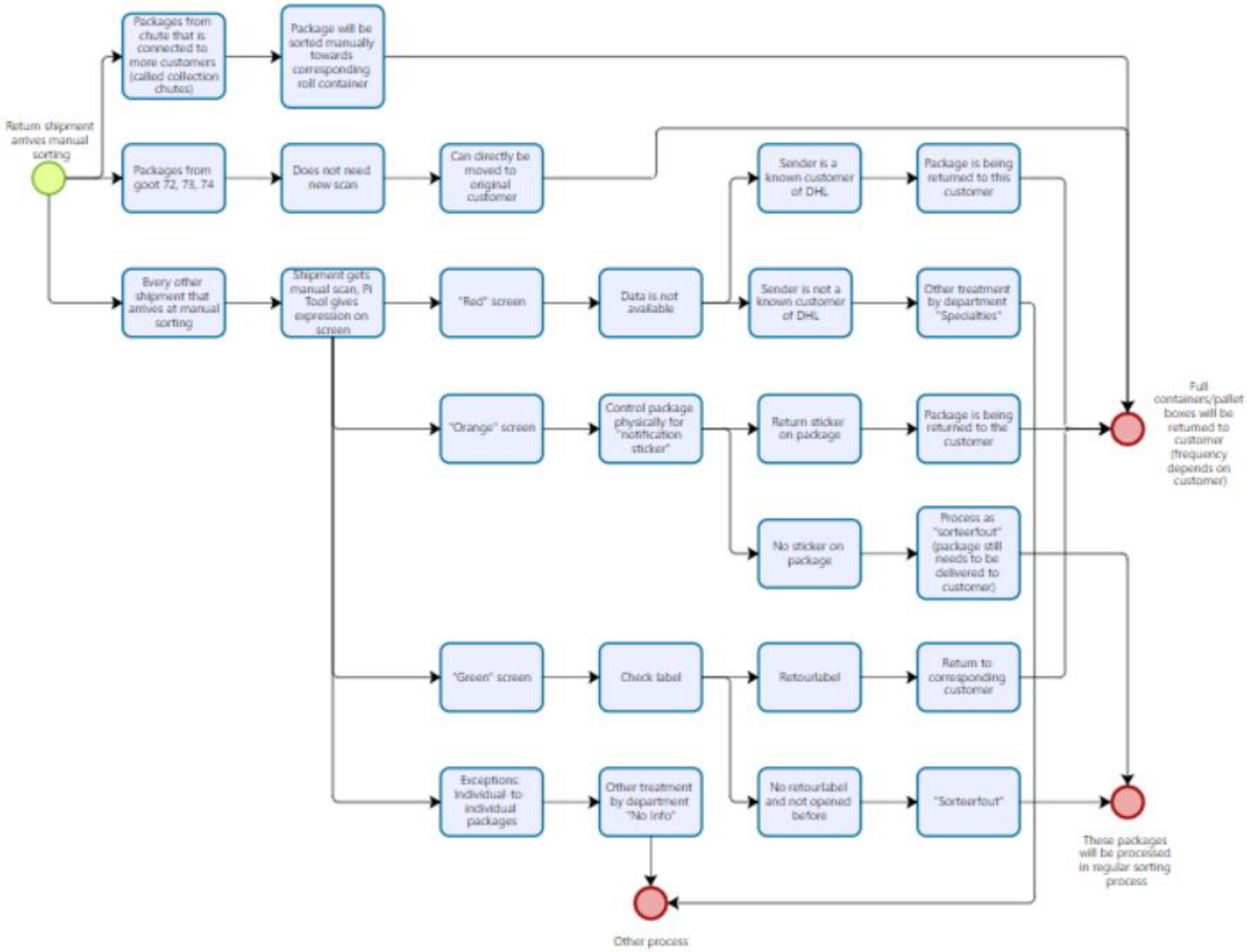
Appendix A: Flowchart of machine return process



Appendix B: Flowchart of manual return process



Appendix C: Dataset week 25

Name	Retour PI-scans
123BestDeal B.V.	17
123INKT.NL	16
7 days jobwear	0
ACE & TATE	8
ACTIVE	44
Active Ants b.v.	389
ACTIVEANTS	355
AFHALEN OP	213
AGRADI BV	16
ALIBABA	176
ALL4SPORT	9
ALL4SPORTS	0
AMAZING	11
AMAZON	1280
AMAZON	569
Amazon EU Sarl	6
ASOS	123
ATLAS4MEN	0
Attitude Holland	3
AUDAX	2
AVADO	0
B.C.C.(Elektro-Speciaalzaken) b.v.	36
B2C	0
B2C Europe Netherlands B.V.	143
Bader Postorders	26
Bader Verteil Zentrum	2
Badge Direct B.V.	8
BAX MUSIC	80
BCC	13
BEEKMAN	23
Beerwulf B.V	33
BERSHKA	109
BIJENKORF	122
Bitiba	4
BITIBA	0
BOEKEN	0
Boekenkraam.nl	0
Boekwinkeltjes.nl	6
BOL Nederland 5 en 6 nummers	494
BOL.com	74
Bomont	68
BPOST	0
BPOST BPAC	206
BPOSTSHOW	26
Brandunit b.v.	11
CAST IRON	1
CHASIN'	25
COBRAXL BV	7
COOKING	52
DANTUMA MS	4
De Nederlandse B.V.	5
De ScoutShop	4
DECATHLON	24
DENLFASH	34
Desk Services B.V.	4
Deutsche Post AG	797
Deutsche Post AG	109
Deutsche Post AG	27
Deutsche Post AG	4
DHL FOR YOU	238
DHL Parcel (e-Commerce)	143
DHL Parcel (e-Commerce) DE	377
DHL Parcel (e-Commerce) FI	0
DHL Parcel (e-Commerce) H	0
DHL Parcel (e-Commerce) PL	56
DHL Parcel (e-Commerce) SE	13
DHL Parcel (e-Commerce) SP	4
DHL Parcel (Netherlands) BV	29
DHL Parcel (Netherlands) BV	2
DHL Parcel Nederland M de Hoon	91
DHL Parcel Netherlands	41
DHL Parcel Nordic	55
DHL Parcel Nordic	34
DHL Parcel Nordic	9
DHL Parcel Nordic	7
DHL Parcel Nordic AB	353
DHL Parcel(e-Commerce) CZ	1
DHLFORYOU	122
DHLFORYOU	23
DHLFORYOU	18
DHLFORYOU	0
DHLFORYOU.	81

DHLFORYOU.nl C2C	470
DKCOMP	52
Docdata - Livera	27
DPGM France SAS	55
DPGM France SAS	3
Drogist.nl	53
Drogisterij.net	225
DUTCH BRAN	1
E-Care Reverse Logistics B.V.	68
E-COM TEST	0
Edel Collecties B.V.	6
ETRIAS BV	39
EUROPAKET	0
Europaket Gmbh	131
Europaket Gmbh	21
EUROPLUS	64
eWarehousing BV	10
GEBRS	102
GOODIEBOX	5
G-STAR RAW	79
H&M	272
Handyman b.v.	12
HAPPY SIZE	1
HBL	23
HEMA	8
HEMA b.v.	108
HOME PARTS	0
Hunkem◆ller International BV	125
Indicator B.V.	5
ING PUNTEN	21
Ingram Micro CFS Benelux BV	48
Ingram Micro CFS Benelux BV	13
Intersko	101
INTRAPOST	36
IXO	2
IXO Concept	2
IXO Concept	0
IXO GROUP	2
JANVDSTORM	0
JASI	11
JBFO	0
Je MAppelle B.V.	64

JEANS	5
Jeans Centre BV KIOSK	2
Jeans Centre BV WEB	17
JUST	0
JUSTBRANDS	3
KBV	10
KBV BV	13
KEQ	77
Kin Netherlands b.v.	31
Koter Kado VOF	1
Landmark Global (Netherlands) BV	2
Landmark Global (UK) Limited	79
LG SHOW	4
LIDL	254
LIDL E-Commerce Intern GmbH & Co KG	243
LOAVIES	26
LUCARDI	21
Mailmission Solutions b.v.	2
Make or Buy B.V.	16
MAKEORBUY	24
MAMALOES	38
MANFIELD	63
Maron Opslag	0
MASSIMO	59
MATHOT MS	23
MEDPETS	103
Misi Fulfillment	13
MMCORE	0
MNFLD BV	17
MOBILE	0
MONA	2
MONDIAL	29
MONTA	260
MONTA	38
MONTA	28
MONTA	19
MONTA	13
MONTA	8
MONTA	8
MONTA	1
MONTA	1
MONTA	1
MONTA-	2

MONTA-	0
MONTAPACKI	9
MONTAPACKI	2
Montapacking Gorinchem BV	2
Montapacking Gorinchem Fulfilment	10
Montapacking Gorinchem Fulfilment	4
Montapacking Molengraafs BV	37
Montapacking Molengraafs BV	21
Montapacking Molengraafs BV	5
Montapacking Molengraafs BV	4
Montapacking Oosterhout BV	16
Montapacking Oosterhout BV	4
Montapacking Oosterhout BV	0
Montapacking Roosendaal	175
Montapacking Waspik BV	5
NA-KD	521
NATALIS	3
N-BRANDS	51
NEDERLANDS	0
NELSON	224
NELSON	59
NELSON	6
NELSON	1
NELSON	1
NESPRESSO	117
NESPRESSO	3
Nespresso NK	6
Nespresso NK	3
Nespresso NQ	0
Nestl Nederland dolce gusto	6
NEW	0
Nic Oud Direct Mail	3
NINE & CO	118
NORAH B.V.	72
NV Landmark Global (Belgium)	58
NV Landmark Global (Belgium)	34
OMODA	1430
OMODA	190
OMODA	28
OYSHO	21
Pakketdienst QLS	10
PARCEL	1205
Parfumerie Douglas Nederland B.V.	113
Parfumswinkel.nl	19
PARRET	0
PDC WEB	0
PDCWEB	0
Perfect Direct Mail BV	2
Pluto Sport Europe B.V.	206
PME LEGEND	11
Post & Mail Stellinwerf VOF	0
PRIMAVIERA	3
PULL&BEAR	88
QLS	274
QLS	230
QLS	0
RADIAL PL	23
Rapaat Logistics B.V.	133
RITUALS	43
RM Netherlands	10
ROTAFORM	13
ROYAL MAIL	9
S&H ProductFulfilment	9
SACHA	50
SANS	11
Sans-Online B.V.	62
SCHUURMAN	1
Schuurman Schoenen	26
SCORE	21
SEVEN	12
SEVEN	9
SEVEN	6
SEVEN	5
SEVEN	4
SEVEN	0
SHOEBY	70
Shoppartners	15
SIERKUSSEN	2
SIRA	2
SISSY BOY	92
Sports Unlimited Retail BV	55
SPRWINKEL	24
State of Art I-store B.V.	5
Stichting Opkikker	4
STRADI	35
SUPER	1

Termeer Schoenen B.V.	8
THE BADGE	62
TIMARCO	4
TLogistics	23
TOM BV	113
TRAVEL	2
TWI B.V.	0
UTERQUE	1
VAKANTIE	108
Van Tilburg Mode & Sport	127
VANGUARD	0
VENDOR	1
VRIJBUITER	6
VSN I.O.V.	0
WEHKAMP	18
Wehkamp B.V.	180
Wehkamp B.V.	170
Wehkamp B.V.	143
Wehkamp B.V.	5
Welmer Logistieke Dienstverlening	0
WORLDTECH	0
WPR	1
WSSN B.V.	24
YourSurprise	72
YUNEXPRESS	1208
Zaadhandel van de Wal BV	0
ZALANDO	51
ZALANDO	19
ZALANDO	17
ZALANDO SE	724
ZARA	1226
ZARA HOME	150
ZES GOES	15
Zooplus AG	52
ZWO VP	46

Appendix D: Calculations on the walking distance

Customer	Pallet/rolco	Cross-aisle	In-aisle	Distance	Average packages	Rank	Total distance
123 Bestdeal	Rolco	8	9	17	17	99	289
24 MX	Pallet	0	9	9	71	53	639
8x3 sorteerfout	Start	0	1	1	122	38	122
ABC mail	Rolco	12	1	13	143	31	1859
Active Ants	Rolco	7	2	9	814	8	7326
Agradi	Pallet	0	8	8	16	100	128
Ajax Docdata	Rolco	7	2	9	61	59	549
Algemeen retour	Rolco	5	1	6	217	22	1302
ALL4Running	Rolco	10	6	16	9	112	144
Amazing Kids	Rolco	4	2	6	11	108	66
Amazon	Pallet	4	6	10	1855	1	18550
ASOS	Pallet	0	2	2	1705	2	3410
Atlas for men	Rolco	10	2	12	55	61	660
Attitude	Rolco	7	6	13	3	999	39
Audax Gilze	Rolco	4	5	9	2	123	18
Bader	Pallet C	6	7	13	28	81	364
Bax	Start	0	2	2	213	23	426
BCC	Pallet C	6	9	15	49	67	735
Beerwulf	Rolco	13	2	15	33	999	495
Bol.com	Rolco	7	5	12	1083	6	12996
Bomont	Rolco	10	7	17	68	56	1156
Bon a Parte	Pallet C	6	6	12	52	64	624
B-post	Rolco	0	1	1	432	16	432
Brandunit	Rolco	1	7	8	11	999	88
CLD/MPK Oud Gastel	Rolco	4	2	6	175	26	1050
Coltex	Rolco	10	4	14	40	70	560
De Bijenkorf	Rolco	7	7	14	122	39	1708
Decathlon	Rolco	4	9	13	24	89	312
Defshop	Rolco	1	5	6	6	999	36
Depot Dordrecht	Rolco	6	1	7	514	13	3598
Digital Revolution 123	Rolco	7	8	15	16	999	240
Douglas	Rolco	5	1	6	113	41	678
DP Optie 4	Box	6	1	7	797	10	5579
DP Prio/Non Prio	Rolco	11	1	12	140	33	1680
Dpc Undeliverable	Rolco	4	6	10	165	27	1650
Drogist.nl	Rolco	4	3	7	53	63	371
Drogisterij.net	Rolco	7	2	9	225	21	2025
E-Care	Rolco	10	5	15	68	57	1020
Edel collectie	Rolco	4	4	8	6	999	48
Etrias	Rolco	10	2	12	39	72	468

Ewarehousing	Rolco	7	10	17	10	110	170
G-Star Raw	Rolco	1	6	7	79	49	553
H&M	Rolco	7	10	17	625	11	10625
Handyman	Pallet	0	11	11	12	106	132
HBL Gereedschap	Rolco	1	2	3	23	92	69
Hema	Pallet	4	11	15	116	40	1740
Hunkemöller	Pallet C	6	5	11	125	37	1375
Ibood	Rolco	7	3	10	38	73	380
ING	Rolco	7	6	13	21	96	273
Intersko	Rolco	7	5	12	101	46	1212
Intrapost BV	Rolco	7	9	16	36	999	576
IT retour	Rolco	13	5	18	261	19	4698
Ixo Concept	Rolco	1	6	7	6	999	42
Jan v. d. Storm	Rolco	4	7	11	12	107	132
Janssen	Pallet	0	10	10	157	29	1570
Je M Appelle	Rolco	4	3	7	64	58	448
Jeans centre	Rolco	10	5	15	24	999	360
John Beerens	Rolco	4	8	12	23	93	276
JVGL Kwaliteit	Rolco	8	1	9	143	32	1287
Klingel	Pallet C	6	4	10	32	78	320
Lege toners	Pallet	13	7	20	0	125	0
Lidl	Pallet C	6	3	9	497	14	4473
Lillydoo	Rolco	4	8	12	4	117	48
Livera	Rolco	7	8	15	27	84	405
Lucardi	Rolco	7	3	10	52	65	520
M+ Groep	Rolco	4	6	10	24	91	240
Make or Buy	Rolco	7	9	16	40	71	640
Mamaloes	Rolco	1	6	7	38	74	266
Mathot	Rolco	4	4	8	27	85	216
Medpets	Rolco	7	7	14	103	45	1442
Misi Fulfilment	Rolco	10	3	13	13	999	169
MPK Breda	Pallet	4	3	7	260	20	1820
MPK Gorinchem Edison	Rolco	4	4	8	28	82	224
MPK Gorinchem Weide	Rolco	4	5	9	26	87	234
MPK Molanaarsgraaf	Rolco	7	8	15	81	48	1215
MPK Oosterhout	Rolco	7	3	10	28	83	280
MPK Papland	Rolco	4	6	10	22	95	220
MPK Waspik	Rolco	13	4	17	10	111	170
Na nomi	Rolco	13	6	19	3	121	57
NAKD fashion	Pallet	4	4	8	874	7	6992
Natalis	Rolco	10	9	19	3	122	57
Nelly	Pallet	0	7	7	34	76	238
Nelson schoenen	Pallet	0	6	6	291	18	1746

Nespresso	Rolco	4	2	6	126	36	756
No Data Relabelband	Rolco	4	9	13	31	79	403
Norah	Rolco	10	8	18	72	51	1296
OB UTX	Rolco	0	1	1	163	28	163
Omoda	Rolco	1	3	4	1648	3	6592
Opkikker	Rolco	4	5	9	4	999	36
Paardendrogist	Rolco	7	7	14	0	126	0
Paradigit	Rolco	1	3	4	23	94	92
Parfumwinkel	Rolco	10	8	18	19	999	342
Perfect DM	Rolco	1	3	4	2	124	8
Perrysport/Aktiesport	Rolco	4	8	12	55	999	660
Pionhoek	Rolco	8	1	9	470	15	4230
Plutosport	Rolco	3	1	4	206	24	824
PME Legend	Rolco	10	5	15	16	102	240
POM Logistiek	Rolco	10	8	18	29	80	522
Promese	Rolco	13	3	16	51	66	816
Rituals	Rolco	10	7	17	43	69	731
Royal Mail	Rolco	10	3	13	19	98	247
S&H	Rolco	10	2	12	9	113	108
Sacha & Manfield	Rolco	10	4	14	138	34	1932
Sans online	Rolco	1	4	5	73	50	365
Sapph	Rolco	10	6	16	0	999	0
Schuurman & Sooco	Rolco	1	7	8	104	44	832
Score/ Chasin	Rolco	10	7	17	46	68	782
Scout Shop	Rolco	4	3	7	4	119	28
Shoeby	Rolco	10	3	13	70	54	910
Shoppartners	Rolco	10	6	16	15	103	240
Sissi Boy	Rolco	1	8	9	92	47	828
Spedimex	Pallet			0	406	17	0
Superwinkel	Rolco	10	9	19	25	999	475
T.O.M.	Rolco	7	5	12	113	42	1356
The Badge	Rolco	1	5	6	70	55	420
Tilburg Online	Rolco	1	5	6	127	35	762
Undeliverables	Rolco	7	4	11	183	25	2013
Vakantie Veilingen	Pallet	4	2	6	108	43	648
Waschbar	Rolco	10	4	14	27	86	378
Wehkamp	Rolco	7	6	13	568	12	7384
Wehkamp recycle	Rolco	7	8	15	0	999	0
Worldtech	Pallet	1	8	9	1208	5	10872
Your Surprise	Rolco	7	4	11	72	999	792
Zalando	Pallet	4	9	13	811	9	10543
ZARA	Pallet	6	6	12	1227	4	14724
ZARA HOME	Pallet	0	4	4	150	30	600

Zes Goes	Rolco	9	1	10	15	104	150
Zooplus	Pallet C	6	2	8	56	60	448

For every customer, the distance is calculated by adding the Cross-Aisle distance and the In-Aisle distance. The total distance is calculated by multiplying the distance towards the customer and the total average number of packages that this customer receives.

Appendix E: Results new situations

Cross-aisle NS without rest.	In-aisle NS without rest.	Distance without rest.	Total distance without rest.	Cross-aisle NS with rest.	In-aisle NS with rest.	Distance with rest.	Total distance with rest.
7	6	13	221	7	6	13	221
4	7	11	781	4	9	13	923
0	1	1	122	0	1	1	122
10	2	12	1716	10	2	12	1716
6	1	7	5698	1	1	2	1628
0	9	9	144	0	10	10	160
10	4	14	854	7	4	11	671
12	1	13	2821	7	1	8	1736
4	7	11	99	1	7	8	72
4	6	10	110	1	6	7	77
0	2	2	3710	0	2	2	3710
0	1	1	1705	3	1	4	6820
7	5	12	660	7	4	11	605
13	8	21	63	1	8	9	27
7	7	14	28	7	7	14	28
1	8	9	252	6	8	14	392
0	2	2	426	0	2	2	426
0	6	6	294	6	6	12	588
10	7	17	561	7	7	14	462
4	1	5	5415	0	1	1	1083
10	4	14	952	10	4	14	952
1	6	7	364	6	5	11	572
7	1	8	3456	6	1	7	3024
13	9	22	242	10	9	19	209
13	1	14	2450	12	1	13	2275
4	4	8	320	1	4	5	200
4	2	6	732	1	2	3	366
13	5	18	432	10	5	15	360
13	9	22	132	10	9	19	114
7	1	8	4112	6	1	7	3598
10	8	18	288	7	8	15	240
4	3	7	791	1	3	4	452
0	5	5	3985	6	1	7	5579
10	2	12	1680	7	2	9	1260
13	2	15	2475	13	2	15	2475
10	4	14	742	4	4	8	424
10	1	11	2475	9	1	10	2250
13	4	17	1156	7	4	11	748

13	10	23	138	10	10	20	120
4	5	9	351	1	5	6	234
4	6	10	100	1	6	7	70
13	3	16	1264	7	3	10	790
4	1	5	3125	3	1	4	2500
1	9	10	120	0	11	11	132
13	6	19	437	13	6	19	437
4	5	9	1044	0	8	8	928
1	5	6	750	6	4	10	1250
7	5	12	456	1	5	6	228
10	6	16	336	10	6	16	336
10	3	13	1313	4	3	7	707
13	7	20	720	10	7	17	612
9	1	10	2610	8	1	9	2349
10	8	18	108	7	8	15	90
4	6	10	120	4	6	10	120
0	4	4	628	4	7	11	1727
10	4	14	896	10	4	14	896
4	8	12	288	4	8	12	288
13	6	19	437	10	6	16	368
10	2	12	1716	10	2	12	1716
0	8	8	256	6	7	13	416
4	9	13	0	4	11	15	0
1	4	5	2485	6	2	8	3976
4	7	11	44	4	7	11	44
10	5	15	405	7	5	12	324
7	4	11	572	7	4	11	572
13	5	18	432	13	5	18	432
4	5	9	360	1	5	6	240
4	5	9	342	4	5	9	342
10	5	15	405	10	5	15	405
7	3	10	1030	7	3	10	1030
4	8	12	156	4	8	12	156
1	4	5	1300	0	7	7	1820
10	5	15	420	4	5	9	252
10	5	15	390	10	5	15	390
10	3	13	1053	7	3	10	810
7	5	12	336	7	5	12	336
13	6	19	418	7	6	13	286
4	7	11	110	1	7	8	80
7	7	14	42	7	7	14	42
4	2	6	5244	0	4	4	3496
10	7	17	51	4	7	11	33

4	8	12	408	4	10	14	476
4	4	8	2328	4	6	10	2910
7	2	9	1134	1	2	3	378
7	5	12	372	4	5	9	279
13	3	16	1152	10	3	13	936
13	2	15	2445	10	2	12	1956
4	2	6	9888	1	2	3	4944
13	10	23	92	10	10	20	80
10	7	17	0	10	7	17	0
10	6	16	368	10	6	16	368
13	8	21	399	10	8	18	342
10	7	17	34	7	7	14	28
13	7	20	1100	10	7	17	935
9	1	10	4700	4	1	5	2350
9	1	10	2060	9	1	10	2060
10	7	17	272	4	6	10	160
7	5	12	348	7	5	12	348
4	4	8	408	4	4	8	408
4	4	8	344	1	4	5	215
10	6	16	304	7	6	13	247
7	7	14	126	1	7	8	72
7	2	9	1242	7	2	9	1242
10	3	13	949	10	3	13	949
4	9	13	0	4	9	13	0
4	3	7	728	4	3	7	728
7	4	11	506	1	4	5	230
7	7	14	56	4	7	11	44
13	4	17	1190	13	4	17	1190
7	6	13	195	7	6	13	195
7	3	10	920	7	3	10	920
4	3	7	2842	4	5	9	3654
13	8	21	525	10	8	18	450
7	3	10	1130	1	3	4	452
13	4	17	1190	10	4	14	980
4	2	6	762	4	2	6	762
12	1	13	2379	10	1	11	2013
4	6	10	1080	0	9	9	972
13	5	18	486	7	5	12	324
7	2	9	5112	4	2	6	3408
7	4	11	0	4	4	8	0
3	1	4	4832	4	4	8	9664
13	7	20	1440	1	8	9	648
1	2	3	2433	0	5	5	4055

1	1	2	2454	4	3	7	8589
0	5	5	750	4	8	12	1800
7	6	13	195	4	6	10	150
1	8	9	504	6	3	9	504