Improving the receiving processes at Hamifleurs

Master Thesis

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UNIVERSITY OF TWENTE.

HAMIFLEURS

Flowers with a personal touch

Management Summary

Hamifleurs is a wholesaler for flowers and one of the largest cut flower exporters in the Netherlands. Hamifleurs buys their products from several growers and auctions. This research is about creating a more efficient flow at the receiving points of Hamifleurs.

Problem description and research objective and question

Currently there are six points at the production street of Hamifleurs were flowers can be received and where the flowers will be processed through the receiving processes. Every employee is responsible for a receiving point. Depending on the moment and receiving point, the supply can be very high or low, which results in an unequal workload for the employees. With a high supply it is possible that there is not enough free space as required in the production street, which results in an unsafe work place for the employees. When the workload is high for the employees, the chance of mistakes is bigger and with a low supply, the employees are waiting for the next supply. This results in a flow that is not always as efficient as wanted. This brings us to the research objective: to get an efficient flow at the receiving points. The corresponding research question is:

'How to create a more efficient flow at the receiving points of Hamifleurs, which takes the corresponding logistical costs into account while maintaining the quality control of the flowers?'

This question is answered through a literature review about the receiving processes, followed by a description and analysis of the current situation. Thereafter we made a simulation model to test several interventions, where after the results are analyzed and conclusions and recommendations are given regarding to the receiving processes of Hamifleurs.

Current situation

At the moment, each supplier delivers their trolleys for Hamifleurs separately and each delivery can contain a different amount of trolleys. One of the agreements that is currently used is that there is a maximum amount of time available for the suppliers to deliver their products after the products are bought.

The average supply for a week is 3,065 trolleys, divided over each weekday with 925, 567, 512, 369 and 692 trolleys from Monday to Friday respectively. The average utilization and costs of the employees are 36% per day and €6,576 per week respectively and the average waiting time per employee is 04:18:35 per day.

Simulation model

With help of a simulation model several interventions are tested. The used interventions are:

- Changing the amount and/or location of receiving points combined with the amount of employees per receiving point and process step.
- Allowing employees to execute both of the process steps and at multiple receiving points.
- Use separate breaks for the employees.
- Limiting the number of trolleys at the production street.

We tested these interventions on two different locations, the current and the new location. The current location contains the same location that is used within the current situation. This location is

located at the production street of Hamifleurs and unlike the current situation, involves the current location a maximum amount of trolleys at the production street. The new location is located at Flora Holland Naaldwijk and does not include a maximum amount of trolleys at their location. Within both of these locations several collection/storage strategies and agreements are used and included. For both locations, the first experiments are executed based on changing the amount of receiving points, amount of employees and the flexibility of employees to execute both process steps and at multiple receiving points. These results are sorted on the amount of employees, the average lead time and the average time finished after last arrival. The average time finished after last arrival, is the time that is needed to finish the day after the last trolley has arrived. More experiments are performed with separate break groups for the employees on the best results according to the logistics manager.

Results

The obtained results through the simulation model are presented in Table 1 through percentages and factors that are calculated by comparing the new situations with the current situation. The current location contains most of the time two receiving points and the new location only contains one receiving point.

The utilization and the waiting time both have a better performance when the new location is used compared to the current location. The labor costs are better in the current location and will almost be half of the current labor costs. The new location is manned by more employees, especially in step 2 of the receiving processes because the travel time is enlarged with eight minutes compared to the current situation and around six and seven minutes with the current location. The travel time is enlarged, because the new location of the receiving processes is further than the current location and within the current location, the trolleys needs transport from the buffer to the receiving points which costs time.

Depending on the lead times and amount of employees, that are chosen for both locations by the logistics manager, the lead times increase. Only for the Monday, the lead times will decrease in both new situations. When using separate breaks for the employees the lead time decreases compared to the lead time of the new situations without separate breaks, except for the Wednesday in the new location.

Table 1: Percentage and factorial differences for the new situations compared with the current situation

	Current location	New location
Labor costs	-46%	-31%
Utilization employees	1.99	2.10
Waiting time employees	-42%	-48%
Lead time of the trolleys	43%	52%
With separate breaks (lead time)	-7%	-10%

Conclusion

Concluding, a more efficient flow can be created when one of the new situations will be used. The utilization of the employees improves and the labor costs decreases. The downside is the increased lead times in both new situations, but the new lead times are chosen by the logistics manager and therefore accepted. Depending on the labor costs, the current location is a better fit with a reduction of 46% in the labor costs (Table 1). The labor costs will reduce from €6,576 to €3,551 when the current

location is used and from €6,576 to €4,537 when the new location is used. Probably the extra costs when using the new location are higher than when using the current location, but to ensure this further research should be executed to the extra costs.

Recommendations

Depending on the outcome of the costs of the current and new location, several recommendations are given:

- Change the amount and/or location of the receiving points, amount of employees, tasks of the employees and use separate break groups.
- New agreements have to be made with the supplier, regarding to the delivery location of the trolleys, buffer or location space needed at the supplier, the information on the trolley and the changing costs.
- Put only information that is necessary on the batch sticker.
- Communicate the ETA (Estimate Time of Arrival) at the receiving processes, this improves the communication with the buyer.
- No use of dedicated storage and family grouping while executing step 2 at the refrigerated and conditioned areas.
- Change the collection/storage strategies depending on the new situation.

Further research

Further research is recommended to the following aspects:

- The extra costs of the current and new location, to know which location does give the best result.
- Photo boxes and the correct use, so that the quality of the photo can be assured.
- The resistance of the employees when changes are happening.
- Pros and cons of using dedicated storage and family grouping at the refrigerated and conditioned areas.

Preface

This master thesis is written to finish my student time and to complete the master Industrial Engineering and Management, with the specialization in Production and Logistics Management at the University of Twente. With help of this master thesis, I will become a Master of Science and shall I never return to this amazing time.

First, I want to thank Hamifleurs but not only for the opportunity to execute my graduation project here. Through a benchmark during my bachelor thesis, I did get the first knowledge of Hamifleurs. Which made me partly decide to continue my studies within the logistics. Without Hamifleurs, I maybe did not continue my study and therefore I was very pleased to do my graduation project at Hamifleurs, so thank you Bob de Vette. Further I want to thank Stella van Holsteijn, for supervising my master thesis. Thank you for your time, feedback, support and pleasant talks.

But only a company to perform your graduation project at is not enough. So, I especially want to thank Martijn Mes for the great feedback and help with my project. I really enjoyed the meetings and feedback, so thank you very much.

I also want to thank Peter Schuur, for the feedback that he delivered and his quick responses when I had further questions.

Last but not least, I want to thank my family and friends for their support during my study.

Let the 'real life' begin.

L.C. Korpershoek

University of Twente, April 2018

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1 Introduction

To complete the master Industrial Engineering and Management at the University of Twente, I had to perform a graduation project. This graduation project is executed at Hamifleurs regarding to the receiving processes.

This chapter introduces the project about the receiving processes at Hamifleurs. Firstly, a description of the company and the internal logistical processes are given. Thereafter, the problem description of this research is given, followed by the scope and the objective of the company and the research. For finding a solution to this problem the research questions are mentioned with their method of approach. Concluding, the research design is stated with the construction of the report.

1.1 Company description

Hamifleurs is a wholesaler for flowers and one of the largest cut flower exporters in the Netherlands. In 1999 Dutch Flower Group arose from several family companies as the biggest player within the cut flowers in the world. Since then, Hamifleurs is a part of the Dutch Flower Group. In 2013 Hamifleurs became the owner of Ed de Groot, this company is on the other side of the production street of Hamifleurs.

Every day, hundreds of different types of fresh harvested flowers are delivered at Hamifleurs through several purchasing channels. With the help of highly automated and mechanized sophisticated logistical processes, orders are processed. Hamifleurs distinctiveness is based on three factors: motivated employees, a broad product range and consistently innovative solutions offered to customers. The people focus of Hamifleurs gives attention to the development, well-being and competence of their staff. The mission of Hamifleurs is: “to be the best Dutch supplier of cut flowers to wholesale importers in Europe by continuously offering high quality and reliability, and by taking a personal approach to both customers and employees”. The core values of Hamifleurs are:

- Focus on wholesale importers
- Innovation
- Superior quality
- Service orientation
- Broad product range
- Personal approach: people first!

Hamifleurs buys their products by several growers and auctions. The sale of these products goes together with the buying. The sales people make an overview for the buyers of the products which are already sold to customers. These products are bought by the buyer at the growers or auctions. Next to these products, the buyer buys some products at the growers or auctions that have a good offer, which are sold by the sale people. The bought products go through a logistical process, such that the products meet all the customer requirements.

After merging Hamifleurs and Ed de Groot in 2013, the logistical area of Hamifleurs was too small to also manage the logistics which is arranged by Ed de Groot. For this reason, the logistical area of Ed de Groot also became property of Hamifleurs. For this reason, one refrigerated area (G: Lilies and chrysanthemums) and one of the packages area (Hami 2: Package) is on the other side of the production street as shown in Figure 1.

Internal logistical process

The areas where products arrive in the internal logistical process of Hamifleurs are briefly described here. The areas are: receiving points, refrigerated and conditioned areas, package, repackage and assembly. Within these areas, 100-120 people are working. The warehouse lay-out of Hamifleurs is shown in Figure 1. Trolleys can contain several batches and batches can contain several collies with flowers. A big batch with many collies and flowers can also be stored on several trolleys.

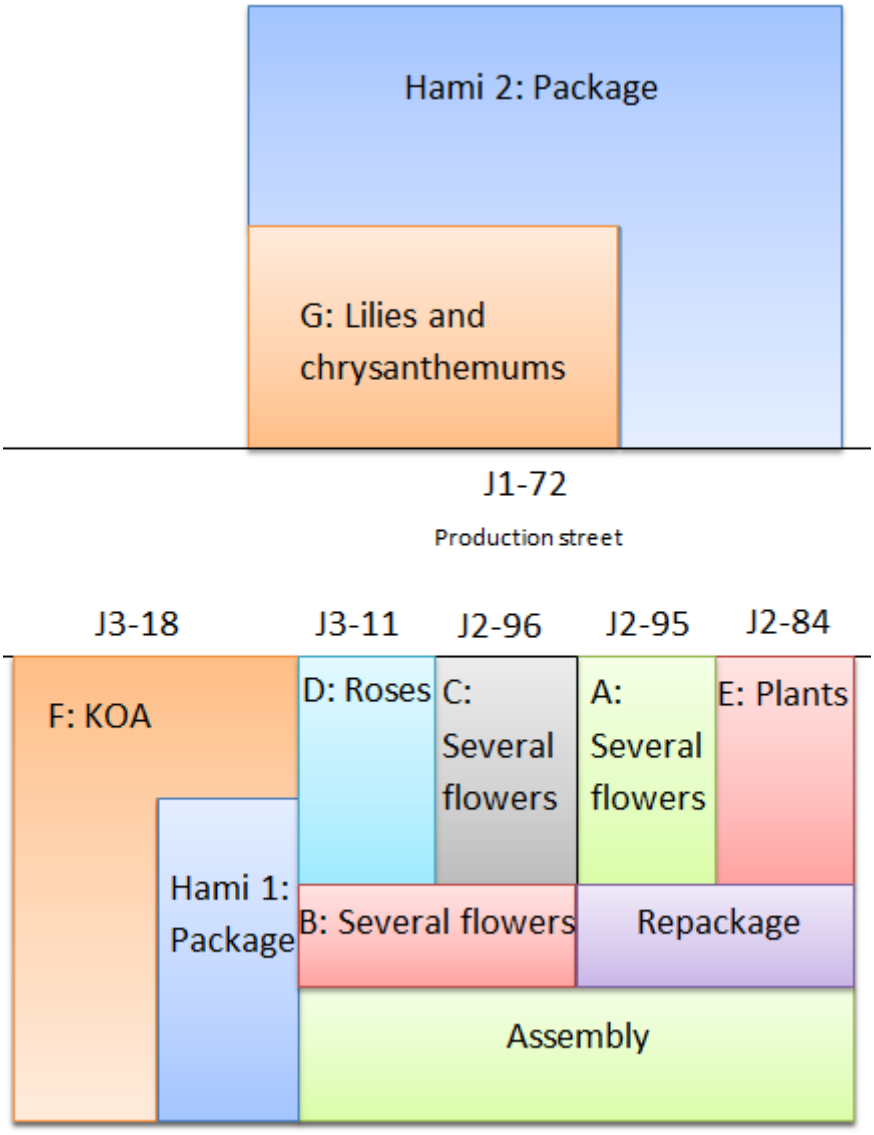

Figure 1: Warehouse lay-out Hamifleurs

Receiving points

Products from growers and auctions arrive at trolleys at the receiving points at the production street through electrical vehicles. The receiving points are J1-72, J2-84, J2-95, J2-96, J3-11 and J3-18. Each of these six receiving points has their own product groups, because the storage of these product group is directly near his receiving point. Over the years storage is added to the warehouse of Hamifleurs and therefore receiving points where added. At the receiving points, purchased batches are collected and checked on quality, right amounts and sometimes a picture is made of the flowers for the webshop of

Hamifleurs. Every trolley that arrives contains a barcode or a note with some details of the content of the trolley, for example, the name of the grower. With this information, the batch is found in the system and the batch stickers that belong to that trolley are printed. After the check, each batch receives a batch sticker and with this sticker the batches can be transported further in the logistical process to the refrigerated and conditioned areas with help of electrical vehicles. Before this transport, the content of the trolley is sorted even more specific on product groups and lengths so that the trolley is used efficiently.

Refrigerated and conditioned areas

After the receiving points, the batches are transported to their corresponding refrigerated and conditioned areas (Table 2). The transport of the batches is executed on trolleys and with electrical vehicles. The conditioned areas are B: Several flowers and E: Plants, the other areas are all refrigerated. The batches are stored on trolleys within the storage areas. At the moment there is a combination of a dedicated storage and closest open location storage. An explanation of these storage strategies is mentioned in Section 2.3. The products are stored at a dedicated location, namely at one of the refrigerated or conditioned areas that stores their product group. Family grouping is mostly used within the refrigerated and conditioned areas at their product group. This means that in the refrigerated and conditioned areas where multiple product groups are stored, the flowers are still sorted on their own product group. Within this kind of grouping, closest open location storage is used. In the storage area of the right product group, the employee decides the location where the trolleys will be stored. This is mostly the location that is closest to the conveyor or by the wall. While storing the trolleys, the barcode of the location is scanned and thereafter the batch stickers of that trolley on that location are scanned so that the system knows exactly where each product is located. In these areas, order picking is executed by employees. When an order comes available, this order can be picked. Every colli of this order will receive a sticker to make sure that all the collies of that customer will go to the right collection place of the order. With the help of conveyors and trolleys and electrical vehicles, the collies are brought to the right collection area where further processes take place or where the collies will be collected for transport.

Table 2: Receiving points corresponding refrigerated and conditioned areas

Receiving point	Refrigerated and conditioned areas
J1-72	G: Lilies and chrysanthemums
J2-84	E: Plants
J2-95	A: Several flowers
J2-96	B: Several flowers and C: Several flowers
J3-11	D: Roses
J3-18	F: KOA

All the processes for storing the trolleys are the same at the refrigerated and conditioned areas, except for the KOA. KOA is an abbreviation for ‘Kopen Op Afstand’ which means that customers buy their own products at the growers or the auction but wants Hamifleurs to take care of the logistical processes. The logistical processes of Hamifleurs differ for each customer. Some customers use Hamifleurs only as a storage company, while other customers for example, want Hamifleurs to bundle their bought products on their sub customers. These processes at the KOA are also called: ‘small Hamifleurs’. In

small Hamifleurs all the logistical processes for the KOA customers only take place at area F, while the logistical processes of the other customers take place at several areas at Hamifleurs.

Package

Hami 1 and Hami 2 (Figure 1) are both package areas. At Hami 2, the package contains the packaging of the lilies and chrysanthemums, which will go mainly to Russia. At Hami 1, the package contains the rest of the packaging of Hamifleurs. Here the products are sorted on customer. The sorting is executed by checking the sticker which is on the product. Thereafter the products are packed in boxes how the customer wants it. When a box is finished packing, the box gets a collection sticker that describes all the products that are packed in that box. When the collection sticker is scanned, an overview is given over all the products in that box. At the end, the boxes are put on the right pallets and trolleys.

Repackage

Repackage contains the orders of customers who want their products, for example, with a different wrapping or sticker. Depending on the amount of products per customer, the repackaged products go with the help of a conveyor or a trolley to the right collection area of that customer with help of the sticker of the order picker.

Assembly

At the assembly, the products, which are divided over the customers in the refrigerated and conditioned areas, arrive with help of the conveyor or trolleys. Also, products from the repackage area arrive here. For each customer, the right trolley is filled with their products how the customers want it. Every order leaves with a form that includes all the products that are on the trolleys.

1.2 Problem description

Currently there are six points were flowers can be received and where the flowers will be processed with all the activities mentioned in the previous section about the receiving points. As mentioned before, over the years storage is added to the warehouse of Hamifleurs and therefore receiving points where added. Each of the six receiving points is employed by one to three employees. The flowers are bought at growers or through the auction. Within the auction there are several auction clocks. Each receiving point is linked with several clocks of the auctions and product groups. Flowers that are bought at a certain auction clock, needs delivery at the receiving point that belongs to that auction clock. Each batch arrives at the receiving point of their product group and is noted in the system. The batches are placed in specific conditioned and refrigerated areas according to their own product group and are put on location.

According to Hamifleurs, the chance on mistakes increases in the peaks where high supply occurs because of the high workload. The safety of the employees is also a point of attention in these peaks. The supply of flowers from several purchasing channels, like auctions and growers, shows a fluctuating progress during the day. This is dependent on the amount of flowers that are purchased per clock and the auction where the flowers are bought. Because of these fluctuations, peaks and valleys arise in the supply.

Six points for the receiving of flowers also means that there are six flows that have to be sorted. Besides this, all these six receiving points have to be manned. Each receiving point has its own conditioned or

refrigerated area where the flowers will be put on location. Each of the receiving points does have its own system to process the received products. By changing systems, like photo cameras, printers and scanners, these systems have to be bought for each of the receiving points.

In Figure 2, the problem cluster of the receiving processes is given. The blue boxes are the causal problems, the green boxes are the main problems, the orange boxes are the effects of the main problems and the red boxes are included in the scope and are the core problems of this research.

There are several main problems at the receiving processes. The unequal supply results in several problems. One of those problems is that there are no agreements about the arrival times of the trolleys. The first main problem is that there is no information of the ETA (Estimated Time of Arrival) of batches and this leads to an unsure amount of trolleys per period. Because there is no ETA of the batches, the employees at the receiving points cannot communicate with the buyer that the supply is too late and the employees are waiting for supply without knowing when the supply arrives. When the employees do know when supply arrives, they could help somewhere else in the processes of Hamifleurs. The absence of agreements with the suppliers and the unsure supply delivery of suppliers, leads to an unequal supply. Within the unequal supply, suppliers of Hamifleurs bring their trolleys to Hamifleurs at the moments they want or prefer within their agreed lead time. For example, at one moment twenty trolleys will arrive at a receiving point, while at the other moment only two trolleys arrive at one of the receiving points. A low supply will not lead to other problems, except a low utilization and so unnecessary costs. However, a high supply does. Because of the unequal supply, sometimes a low supply occurs and sometimes a high supply, which results in a low and high workload respectively. It is possible to have an unequal workload with an unequal supply or to have an unequal workload with an equal supply.

The second main problem that results from the unequal supply, is that in case of a high supply there is not enough free space as required at the production street. This leads to an unclear overview over the production street, which is unsafe for the employees. Other reasons for not having enough free space as required in the production street is that arriving batches are incomplete, and batches have to wait at the street until the rest of the batch arrives. The second reason is that the batches arrive at the production street without a batch sticker available, because the buyer did not book the batch through yet. The third reason is that the batches on the trolleys from Aalsmeer already have their batch sticker. Even though these trolleys are put at the production street instead of directly moved to the storage. The last reason that the production street is full is that trolleys arrive with a large amount of different batches. Every batch of the same product needs their own batch sticker, so the trolleys have to be split, to get a clear overview over the batches. This result in more trolleys at the production street, while there is not enough free space to maintain an overview over the production street and the safety of the employees.

Another main problem that results from the unequal supply, is that photos are missing or having a low quality. Mostly during the peaks of high supply there is a high workload. Due to this high workload, photo stickers can be pulled off without making a picture and the protocol for making a picture is not followed exactly. This leads to no photo or a low quality of the photo. Some photo boxes are not the same as the other photo boxes, which also results in a low quality of the photo. A missing photo or low photo quality is seen as a mistake. So, when there is a high workload, the chance on mistakes is higher.

The fourth main problem is that there is no flexibility to switch receiving points, but the employees only switch receiving points when instructed to do so by their coordinator. When there is a low supply, so a low workload and the employees are waiting for the next supply, they could move to another receiving point where the workload is high or to another workspace where is work to do. However, they are usually not doing that, because they are responsible for their own receiving point. The amount of receiving points is originated because the product and clock groups are sorted per receiving point. When products arrive at the wrong receiving point, transport is needed to the right receiving point. In this case several people observe the same trolley. Each receiving point contains products and clock groups and each receiving point has to be manned according to Hamifleurs. Employees do not have the flexibility to switch receiving point (only when sent by their coordinator). Therefore, when the productivity will not be optimal at the receiving points, there are too many employees for the workload and employees are waiting for the next supply at their receiving point.

The last two main problems are that the product description is not totally clear on the products at the trolley and that the batch sticker includes more information than relevant. The effect from these problems is that it is hard to put the right sticker at the right batch. The products and product groups are sorted and received at the same receiving point. For example, when the product at one receiving point is roses, it could be hard to see the difference between the several kinds of roses like Avalanche and Adalonia, when knowledge is not available about these flowers. Because of the small differences between the flowers at the receiving points, it is hard to see differences between batches per receiving point and to put the right sticker at the right batch. Another reason that it is hard to put the right stickers at the right batch is that sometimes there is no correct information what is exactly on the trolley. The barcode or product note could be missing. That leads to a product description that is not totally clear and so it could be hard to find the right batch in the system and put the right sticker at the right batch. Also, when a batch sticker includes more information then relevant, it is hard to put the right stickers at the right batch. Because it is harder to find the right information and it is easy to get confused with the extra information that is not relevant.

To summarize, the main problems are:

- No information of the ETA of the batches
- Not enough free space as required in the production street
- No or low quality of the photo’s
- No flexibility for employees to switch receiving point
- Product descriptions are not totally clear
- Batch stickers include more information than relevant

The effects of the main problems are:

- Unsafety for employees
- Higher chance on mistakes
- Employees waiting for the next supply
- Difficulty of putting right stickers at the right batch

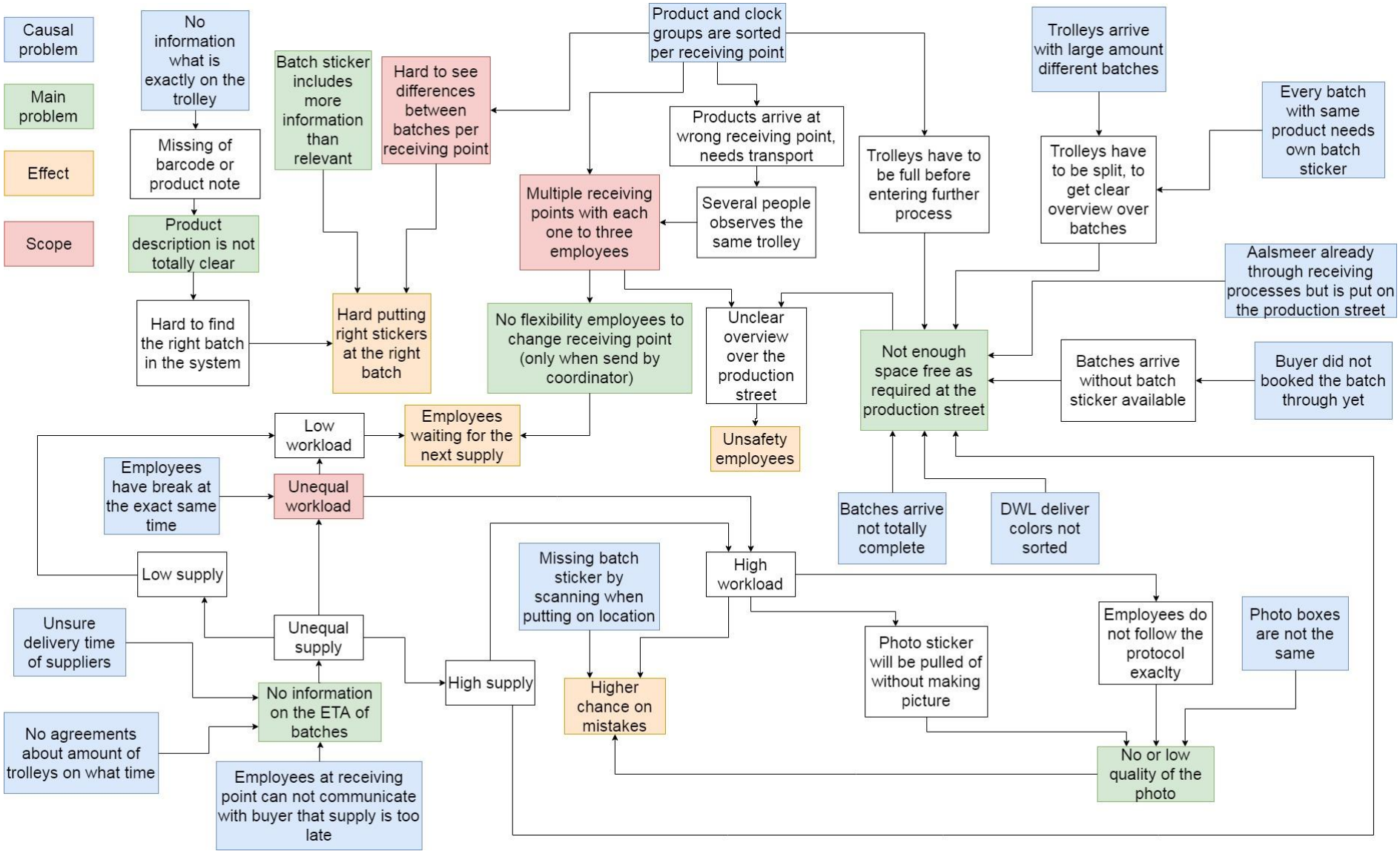

Figure 2: Problem cluster receiving processes

1.3 Scope

The scope of this research is the receiving processes of Hamifleurs. The receiving processes start with the supply delivery at the production street and end when the trolleys are put on the right location. The processes after these receiving processes are out of scope for this research. According to the main problems and effects resulting from the main problems as defined in Section 1.2 and also represented in the green and orange boxes in Figure 2, the scope is chosen according to these main problems. Research will be executed to the following problems, see also the red boxes at the problem cluster in Figure 2:

- Unequal workload
- Multiple receiving points with each one or two employees
- Hard to visually distinguish differences between types of flowers per receiving point

The waiting time of a batch at a receiving point is not taken into consideration when the batch is waiting because of incompleteness or when there is no batch sticker for the batch. The unsafety of the employees is taken into consideration. When there is not enough space as required at the production street (Section 3.3), the safety of the employees is not guaranteed. The fullness of the trolley and the way of storage on the trolley before entering the next step of the receiving processes is out of scope even as the resistance of the employees which could occur when changing the work situation of the employees. The transport deadlines of the customers are also out of scope within this research.

Besides the current location of the receiving processes, a new location is also into scope. A new location of the receiving processes means that the receiving processes are executed somewhere else instead of the receiving processes at Hamifleurs. In this case a location will be rented at Flora Holland Naaldwijk. While using the current location, an extra location could also be rented at one of the suppliers. A more defined explanation between these locations is stated in Section 4.2.1.

1.4 Objective

The company objective is to get an efficient flow at the receiving points, which takes the corresponding logistical costs into account while maintaining the quality control of the flowers.

The research objective is to find out how to obtain an efficient flow at the receiving points. One part of this research is to answer the question how to obtain a more evenly workload at the receiving points, which flats the peaks and valleys while maintaining the quality of the processes and the flowers. The other part of the research is to get insight into the bottlenecks such that an efficiency improvement can take place.

1.5 Research questions

The main research question is as follows:

'How to create a more efficient flow at the receiving points of Hamifleurs, which takes the corresponding logistical costs into account while maintaining the quality control of the flowers?'

To come to the main goal of this project, several research (and sub-) questions have to be answered:

- What does the literature say about the receiving processes?
    - Which operations occur at the receiving processes?
    - What are performance indicators?

- What kind of collection/storage strategies exists?
- Which results are obtained at similar problems considering the receiving processes?

Approach
These questions will be answered through a literature review.

- What is the current situation at the receiving processes?
  - What are the current operations at the receiving processes?
  - What are the current agreements with the suppliers?
  - What are the current collection/storage strategies at the receiving processes?
  - What is the current data of the receiving processes?
  - What are the current indicators of the receiving processes?

Approach
An answer to these questions will provide insight into the current operations at the receiving processes. This insight will be gained through observations and interviews at the production street where the products arrive at their receiving points and with the employees working at the receiving processes. The information about the current agreements with the suppliers will be obtained by asking the logistic and operational manager about the agreements that are made with the suppliers. To know what is happening with the products before they arrive at the production street, appointments are made with the suppliers to observe their processes. The third question will be answered with help of the collection/storage strategies found in the literature by checking the current situation at Hamifleurs regarding to their collection/storage strategies. The fourth question is about the current data of the receiving processes. To create a clear overview at the receiving processes, data of the supply, processing times and costs is obtained. This data is obtained through suppliers, measurements at the receiving points and from the database. Besides this data, indicators are calculated with the help of the performance indicators found with the literature review. This leads to the last question about the current indicators of the receiving processes.

- How can the receiving processes be modelled?
  - Which interventions are applicable and how can these be modeled?
  - What does the conceptual model look like?
  - What does the implemented model look like?
  - Does the simulation model accurately represents the conceptual model and reality?

Approach
At first, the interventions of the receiving processes and how these interventions can be modeled are obtained. Interventions are changes in the current situation, to improve the situation. For the translation of the current situation to a conceptual model, the next question is answered through making assumptions, gathering data and setting performance indicators by discussing them with the logistic and operational manager. To create an overview of the conceptual model, flowcharts have to be made and the type of simulation has to be defined with their assumptions, even as the number of replications. Based on the conceptual model, the model can be implemented in a program. With help of verification and validation, it is checked whether the implemented model accurately represents the conceptual model and reality.

- What are the effects of the proposed interventions in the receiving processes?
    - Which experiments originate from the proposed interventions and what are these results, when using the *current* location of the receiving processes?
    - Which experiments originate from the proposed interventions and what are these results, when using a *new* location for the receiving processes?
    - What is the impact of adding and reducing the supply when executing a sensitivity analysis?

Approach

Firstly, the experiments that originate from the earlier proposed interventions are defined for the current location of the receiving processes, followed by their results. Within these experiments, the same experiments are firstly executed for each weekday for the current location, after which the results are analyzed and extra experiments are executed for each weekday to obtain the optimal solution. Choosing the optimal solution also depends on the weights of the performance indicators, so this also has to be included in the final comparison. After this, the same is executed for the situation where a new location is used for the receiving processes. A sensitivity analysis will be performed over the supply data on the best configurations for each weekday. With help of this sensitivity analysis, we can conclude if the amount of employees is still enough at the receiving processes when the amount of supply will be raised or reduced.

1.6 Research design

According to Figure 3, there are several ways to study a system. For this research an experiment with an actual system would be too costly. When changing, for example the amount of employees, the effects of the experiment can be huge. Namely with a too small amount of employees, it is impossible to fulfill the orders within the agreed time. Physical models are not the kind of models that are mostly used for operations research and system analysis, because making a physical model would be too time consuming. Within a simple model, an analytical solution could work. With a high complexity, simulation models have to be used (Law, 2007). This research contains a high complexity, so a simulation model is used for this research.

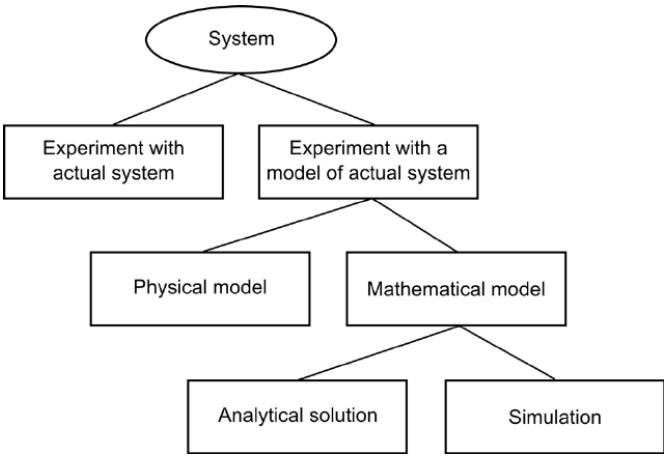

Figure 3: Ways to study a system (Law, 2007)

Concluding from the several ways to study a system, this research will be studied with help of simulation. This research is too complex to obtain an analytical solution. With a simulation model several statistics can be gathered, while the organization details are still flexible (Abdulmalek &

Rajgopal, 2006). For this research, we follow the steps as proposed by Law (2007) for simulation studies, see Figure 4.

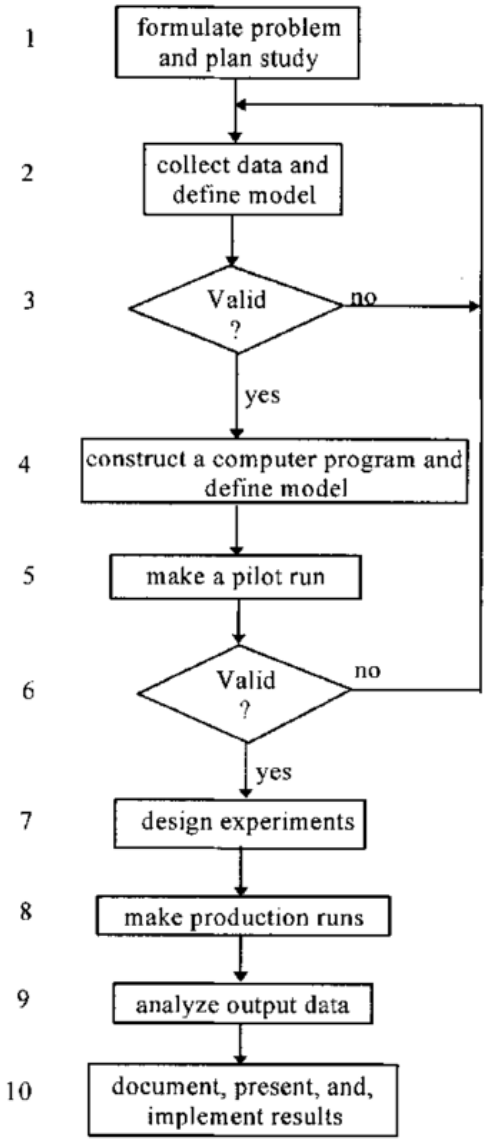

Figure 4: Steps in a simulation study (Law, 2007)

In Chapter 1, the problem is formulated and the approach of the study, how we can obtain a more efficient flow at the receiving points, is mentioned. Between step 1 and 2 a literature study is executed about the logistical processes at receiving, which is presented in Chapter 2 and answers the first research question. Step 2 is stated in Chapter 3 and 4. Chapter 3 represents the collected data of the current situation and answers the second question. Chapter 4 defines the model and answers question 3. Step 3-8 are directly checked and mentioned in Chapter 4. Chapter 5 contains step 9 where the current data and the experimental results will be compared with each other, whereby the last sub question will be answered. Step 10 is Chapter 6 and contains the conclusions and recommendations and answers the main question of this research.

2 Literature review

In the literature review we will answer the first question with help of the sub questions. The main question of this chapter is:

'What does the literature say about the receiving processes?'

The literature about the operations which occur at the receiving processes is mentioned firstly, followed by performance indicators and collection/storage strategies. The last sub question is about earlier achieved results at similar problems at the receiving processes. Finally a conclusion is given to answer the main question of this chapter briefly.

2.1 Operations

'Which operations occur at the receiving processes?'

Several operations occur during the processes from the receiving points until the products are put on the right location. The kind of warehouse for this research is a distribution warehouse. In a distribution warehouse, products are collected and sometimes assembled from different suppliers for the delivery to a number of customers (van den Berg & Zijm, 1999).

Within this distribution warehouse several activities occur in the receiving processes, which are also called material handling. According to the Institute of Industrial Engineers (2000) material handling is "the process and systems that transfer and manage the transfer of goods from one place to another". According to (Siddhartha, 2017) "the essential requirements of a good materials handling system may be summarized as:

- Efficient and safe movement of materials to the desired place
- Timely movement of the materials when needed
- Supply of materials at the desired rate
- Storing of materials utilizing minimum space
- Lowest cost solution to the materials handling activities".

Gu, Goetschalckx & McGinnis (2007) state that the receiving processes includes the operations that involve the assignment of trucks to docks and the unloading of the products. The storage processes include the materials movement from the unloading area to the place where the product belongs and how these products have to be stored (Section 2.3).

The operations at the receiving points are verifying quantities, random quality checks on the supply arrivals and are preparing the loads for the transportation to the storage area, for example with a label (van den Berg & Zijm, 1999).

According to Green, Lee & Kozman (2010) the focus of lean manufacturing assessment is on the material handling process: the flow of the materials and what is expected of the operational group. The two most effective ways of lean manufacturing assessment are value stream mapping, which is an overview of the process with all actions including the time in queue, transport etc. The other most effective way of lean manufacturing assessment is analyzing the facility layout, which includes the logistics used for moving the products from their current location to their destination.

The steps in the value stream map of the current state include which waste will be identified and eliminated (Rother & Shook, 1999). For making a value stream map for future state process flows, simulation is a good solution to perform several statistics while the organizational details are still flexible (Abdulmalek & Rajgopal, 2006).

2.2 Performance indicators

'What are performance indicators?'

This research is about how to create a more efficient flow at the receiving points from arrival until the products are put on location. For getting a more efficient flow, it is important which performance indicators occur at these processes. We explain the meaning of efficiency and will relate this with help of the literature to measurable performance indicators.

According to Farrell (1957), economic efficiency consists of two main components, namely technical and allocative efficiency. Technical efficiency involves getting the maximum possible output from a given set of resources, while allocative efficiency wants to maximize profits by equaling the marginal revenue of the product with the marginal cost of inputs. Another definition of technical efficiency is: 'a producer is technically efficient if an increase in any output requires a reduction in at least one other output or an increase in at least one input and if a reduction in any input requires an increase in at least one other input or a reduction in at least one output.' (Koopmans, Armen Albert Alchian, & Cowles Commission for Research in Economics, 1951).

According to Frazelle (2002), the amount of the in- and output of the logistical processes can be influenced by logistics managers and analysts. Figure 5 represents a common input-output perspective on logistics productivity.

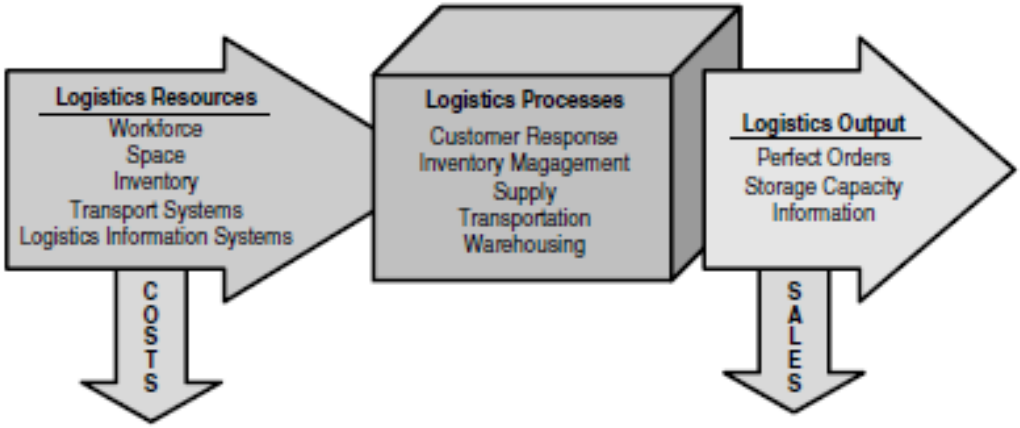

Figure 5: An input-output perspective on logistics productivity (Frazelle, 2002)

The difference between productivity and efficiency is that productivity is a ratio between in- and outputs and efficiency is the distance between the quantities of in- and outputs where the quantities define the frontier (Thiry & Tulkens, 1989).

According to Staudt, Alpan, Di Mascolo & Rodriguez (2015) there is a difference between direct (the 'hard' metrics) and indirect (the 'soft' metrics). The direct indicators are quantitative and possible to measure in numbers like cycle time and costs. While indirect indicators are qualitative measures like

customer satisfaction and loyalty and require more sophisticated tools of measurement. According to (Symbol B.V., 2010) there are several process performance metrics:

- The cycle time: the time it takes the operator to go through all the processes of the product until repeating them with the next product.
- The lead time: the time that is needed for one product to go through the processes from start to finish.

Throughput is the amount of items per hour which are leaving the warehouse, or in this case the receiving processes (Staudt et al., 2015). Productivity is a quantitative performance measurement. Productivity is mostly measured in 'units' handled per hour work of an employee (Hackman, Frazelle, Griffin, Griffin, & Vlasta, 2001). Utilization is a measure of the percentage of the actual amount of input used to some norm value, for example the amount of labor hours used divided by the amount of budgeted labor hours (Caplice & Sheffi, 1994).

2.3 Collection/storage strategies

'What kind of collection/storage strategies exists?'

Following Riopel, Langevin & Campbell (2005): "The design of receiving and shipping areas of the warehouse deserves special attention and depends on the transportation modes utilized, the material handling fleet mix, the unit loads, the mission and functions of the warehouse and the packaging design. Additional information on the characteristics of the products being handled at the docks, loading and unloading times, and the safety of employees is also used". The facility layout design can have a large impact on the effectiveness and efficiency of manufacturing operations (Negahban & Smith, 2013).

For putting the products on location, several storage methods exist according to De Koster, Le-Duc & Roodbergen (2007):

- Random storage: every incoming product or car is assigned a location in the warehouse from all empty locations with equal probability.
- Closest open location storage: order pickers can choose the location for storage themselves, at the first empty location will the products be stored.
- Dedicated storage: products are stored at a fixed location. Disadvantage is that if there are fewer products, the space is still reserved for that kind of product.
- Full-turnover storage: products with the highest sales rates are located at the easiest accessible locations.
- Family grouping: similar products are located in the same region of the storage area.
    - Complementary-based method: clusters the items into groups based of strength of joint demand, locates the items within one cluster as close to each other as possible.
    - Contact-based method: uses contact frequencies to cluster items into groups.
- Zoning: each order picker is assigned to pick the part of the order that is in his assigned zone.
    - Progressive assembly: one order picker starts with order in his zone, the next picker continues within his zone (pick-and-pass).
    - Parallel (or synchronized) picking: number of order pickers start on the same order and after that the partial orders are merged.

According to Goetschalckx & Rafliff (1987) is block stacking one of the most common storage methods for warehousing large quantities of palletized or boxed products. Items are stored on, next and behind each other. Within shared storage policies, the storage can be used by items of all kind of batches. Examples of block stacking are showed in Figure 6.

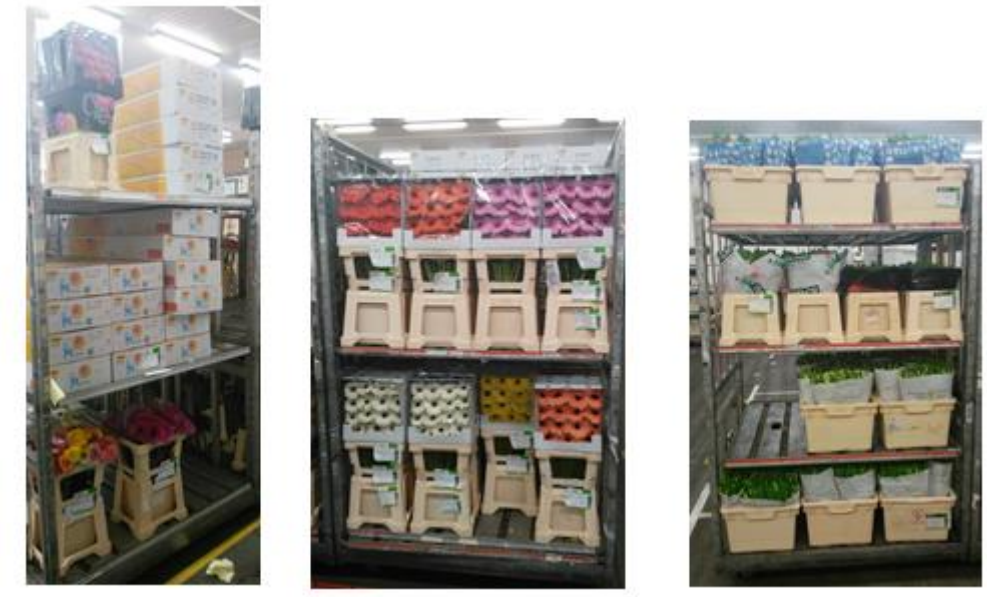

Figure 6: Examples of block stacking

Related to the planning of the arrivals at the receiving points, Larbi et all. (2010) did a research. This research was for situations where information about the sequence of the arrivals was full, partial or not available. The conclusion from this research was that knowing far future information does not improve the solution of the schedule.

By each new arrival, new information is retrieved. After each new arrival, a new schedule is made with help of the new information. Another approach is to make a new schedule after each time interval. Making a new schedule after each new arrival is no worse than making a new schedule after each time interval (Larbi et all., 2011).

2.4 Obtained results at similar problems

'Which results are obtained at similar problems considering the receiving processes?'

Several results are obtained at similar problems considering the receiving processes. These problems are about improving and optimizing the inbound logistics and the delivery planning. In each of the problems, the focus is on different performance indicators.

The research executed by Boeve (2016) focusses on the optimization of the inbound process. Boeve (2016) concludes that when an employee can focus on one activity, for example checking the quality of the product, he/she will make fewer mistakes. Another result of this research is that when employees are trained for several activities, they are more flexible in performing their activities. When using an equal workflow by the planning of the incoming deliveries, a reduction in the dock to stock time from 14:25:49 hours to 12:22:26 hours can be realized.

The research of Fontijn (2016) is about the internal delivery planning of materials. The goal of this research is to minimize the delays caused by waiting for materials. With taking into consideration the mentioned assumptions, the waiting time in one of the situations reduces from 128.7 hours to 0.3 hours and for the other situation the waiting time reduces from 137.5 hours to 0.5 hours. This is a saving of waiting time of 128.4 and 137.2 hours respectively.

The research obtained by de Graaff (2016) is about an effective layout design and improved inbound logistics. De Graaff (2016) concludes that out of several alternative layout designs and logistic organizations, one layout design and logistic organization is the best. So, improvements can be made when changing, for example, the collection/storage strategies.

A result of the research from Klaassen (2012) about improving inboud logistics, is that when the amount of problems at the incoming goods is reduced, this leads to a substantial performance improvement. Because in this research it takes 9.2% of the time of the employees to solve these problems.

2.5 Conclusion

The main question of this chapter is what the literature says about the receiving processes. The main objective of this research is to create a more efficient flow at the receiving points. Relating this question and objective with each other, several conclusions can be made.

The operations that occur at the receiving processes are the transfer of goods from one place to another (Institute of Industrial Engineers, 2000), verifying the quantities, performing random quality checks and putting for example a label on the goods (van den Berg & Zijm, 1999). Within these activities the research of Boeve (2016) states that an employee will make fewer mistakes when they are only responsible for one activity. But when the employees are trained for several activities, they are more flexible in performing several activities. Either of these decisions can lead to a more efficient flow, when choosing for just one decision or combining these decisions. This also relates to one of the main problems in our research where there is no flexibility under the employees to switch from receiving point, when they are not sent by their coordinator. With this research, the right zoning for the employees will be found.

Useful performance indicators according to the literature are throughput, productivity and utilization. When using an equal workflow, the time from arriving at the receiving point until the product is located in the storage can be reduced significantly compared with an unequal workflow (Boeve, 2016). This increase the safety of the employees, because the trolleys will be a shorter time at the production street and therefore the amount of trolleys in the production street at the same time can be reduced. Fontijn (2016) has found a strong correlation between minimizing the delays and the waiting times. At our research, the waiting time of the trolleys will not decrease by definition when the waiting time between the arrivals of the trolleys is reduced, but it would decrease the waiting time of the employees when there are no trolleys that have to be handled. This could relate to a higher utilization of the employees.

Several collection/storage strategies exist according to the studied literature. When using the right layout design and logistic organization, improvements can be made and so the flow at the receiving processes can become more efficient (Klaassen, 2012). Because only the same kind of products are received at a receiving point, it is hard to see differences between the batches and so hard to put the

right sticker at the right batch. For example, when a combination of roses and tulips arrive and the batch sticker includes a type of roses, it is not hard to put the sticker on the roses instead on the tulips. This is one of the main problems, from which the efficiency can be improved by changing the collection strategy in this example according to de Graaff (2016). When the collection is executed through random storage, this would make it easier to spot the differences between the batches.

Concluding the main question of this chapter, it is possible that several changes like responsibility of the employees, training, equal workflow, less waiting for new arrivals and the right collection/storage strategies in the logistical organization of the receiving processes can lead to improvements and to a more efficient flow at the receiving points.

3 Current situation

The second question is about the current situation of this research. The main question is:

'What is the current situation at the receiving processes?'

At first the results of the process analysis are given including the current operations at the receiving processes at Hamifleurs. Followed by the current agreements with the several suppliers and the current collection/storage strategies used. After this a data analysis is executed that represents the current indicators. At the end a conclusion is given about the current situation at the receiving processes.

3.1 Current operations

'What are the current operations at the receiving processes?'

Trolleys arrive at the receiving processes with help of electrical vehicles and each of these trolleys can contain multiple batches. The current operations at the receiving processes are presented in Figure 7. The blue boxes are operations that occur during the receiving processes, but which are not executed by the employees at the receiving processes. The green boxes include documents that are used to fulfill the processes in the orange boxes. The orange boxes are the processes that belong to the operations at the receiving processes. The purple boxes include the decisions that have to be made and the yellow box presents the used computer files. Step 1 includes the receiving processes, which are the receiving of the products, the specifications, and amount and quality check of the products. These processes are partly executed with help of the information presented on the batch sticker. The batch sticker is printed after the receiving of the batch. After these processes, each batch of the trolleys will be provided with their batch sticker. When the batch have their batch sticker, step 2 starts with making a picture if this is needed for that batch and putting the batch on the right location with help of electrical vehicles.

The products arrive at trolleys at the production street at their corresponding receiving point according to Table 2. Depending on the size of the batches, a trolley can contain one or multiple batches. When there is no receipt available at the trolley, the batch is checked with the system information. After this, the batch will be signed up or scanned. When the batch is also not present in the system information, the batch will be put on hold and will be checked once in a while in the system. After the batch is signed in, a batch sticker is printed and with help of this batch sticker the specifications, numbers and buckets are checked. When this is not correct, the buyer and/or correction office will be informed after which the correction will be performed and the batch is adjusted. The batch will be provided with a batch sticker and a picture is made of the batch when this is needed. The processes at the receiving points are now finished and the trolley, which includes the batches with the right batch stickers, will be put on the right location with a distribution truck. To know exactly where the batches are, the location of the trolley is scanned as well as the batches that are on that trolley.

In Aalsmeer there is an employee of Hamifleurs who is responsible for the receiving processes of the flowers bought at the auction in Aalsmeer. The receiving processes at Aalsmeer include quality check, checking the right numbers and making a picture for the web shop when needed. After these processes, the batch receives a batch sticker from the employee. After transport to Hamifleurs by De Winter Logistics, the trolleys could directly be put on location by the employees at Hamifleurs in Naaldwijk when the batches are complete.

Also, products from growers are delivered at Aalsmeer. Sometimes the receiving processes of the batches delivered from the grower at Aalsmeer are also executed by the employee in Aalsmeer, but mostly this is not the case.

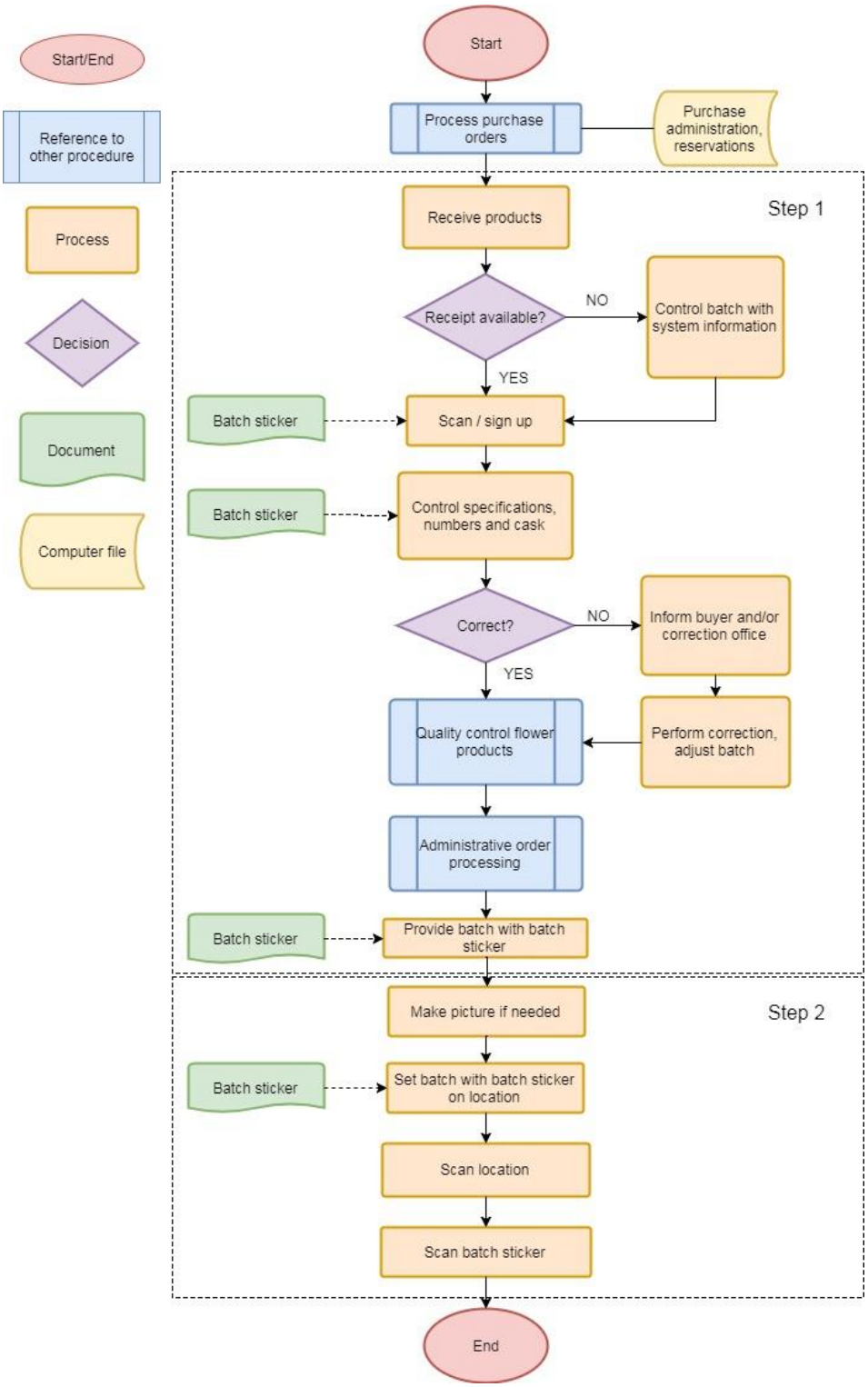

Figure 7: Flowchart receiving processes

3.2 Current agreements

'What are the current agreements with the suppliers?'

To answer this question, the agreements of every supplier of Hamifleurs are mentioned.

Auction Flora Holland Naaldwijk

An agreement with the auction at Flora Holland Naaldwijk is that when flowers are bought, there is a certain amount of hours within batches may be send back in case of poor quality. Flora Holland Naaldwijk sorts the products on product groups at the trolley and takes care of the delivery at the right receiving point. These agreements always count at the auction at Flora Holland Naaldwijk, except for the products bought in the pre-sale of the auction. The products bought in the pre-sale of the auction are not put on the right receiving point.

Connect

The agreement with Connect is that they take care of the delivery of the products from the growers. Every day before 6 am (especially on Monday) the products which are already delivered by growers are delivered at the empty spots at the receiving points of Hamifleurs. Connect does not sort the products on product groups and receiving points. During the day growers still deliver to Connect and these products are then transported to Hamifleurs.

De Winter Logistics

De Winter Logistics (DWL) is responsible for the supply from the auctions in Aalsmeer and Rijnsburg. When the buyers of Hamifleurs buy products at the growers close to Aalsmeer and Rijnsburg, the growers deliver their products at those locations. DWL is also responsible for this supply from the growers that are delivered at Aalsmeer and/or Rijnsburg. At these locations the products are collected and sorted on the receiving points at Hamifleurs.

For the auctions in Aalsmeer and Rijnsburg, DWL sorts the different product groups on their clock group. Each clock group has a color and several clock groups belong to the same color. Each color belongs to one of the receiving points at Hamifleurs. By filling the trolleys for transport, the trolleys first have to be filled with their own clock group. When the trolleys are not full with only their own clock group, other clock groups that belong to the same color will be packed on the same trolley. Most trolleys are only filled with their own clock group and mixing clock groups is only the case when trolleys are half full. When trolleys have a colored paper on their trolley, the trolleys are put on a location of DWL.

In Aalsmeer there is an employee who is responsible for the receiving and quality check of the products at Aalsmeer. When the batches of the auction have their batch sticker, the trolley can go further in the process of DWL and be transported to Hamifleurs. Sometimes the receiving processes of the batches delivered from the grower at Aalsmeer are also executed by the employee in Aalsmeer, but mostly this is not the case.

In Rijnsburg there is no employee of Hamifleurs to do the receiving processes. Different from Aalsmeer the transport to Hamifleurs is directly possible. In both cases, Aalsmeer and Rijnsburg, the trolleys are brought to the right receiving point at Hamifleurs.

Growers

The agreement with the growers is that they sort their products per batch. This is the only sorting that is executed by the grower. When the growers deliver their products, the trolleys can mostly go directly through the right receiving point. The products of the grower are mostly from the same product group.

3.3 Current collection/storage strategies

'What are the current collection/storages strategies at the receiving processes?'

For the receiving points, a combination of family grouping and dedicated storage is used. Each product arrives at their dedicated receiving point and family grouping is used to sort the products per product group. At each receiving point, except for J2-84 and J3-18, the employees are using progressive assembly zoning, each employee stays at its own receiving point to complete the receiving processes of their products. Only when a coordinator will sent the employee to another receiving point, they will switch receiving point. At the receiving points J2-84 and J3-18 zoning is used, because the employees at these receiving points execute both processing steps. After executing step 1, closest open location storage is used before executing step 2.

To put the products on the right location, products are placed to their corresponding refrigerated and conditioned areas as mentioned in Table 2. In these areas again, family grouping and dedicated storage is used. Within the family grouping and dedicated storage, closest open location storage is used so that the trolleys are as closed to the conveyor or wall as possible in their area.

Within these storage strategies, block stacking is used. The batches are stored on trolleys during the first step of the receiving points. The collies of these batches are sorted on same lengths and depths, so that the trolley is used most efficiently. During and after receiving processes step 2, trolleys are combined with each other when trolleys are half empty to optimize the use of lanes. This storage strategy is mainly used within the distribution area and is out of scope, even as the exact way of how the products are stored on the delivered trolleys.

Within the current collection/storage strategies, the location of the collection is also important. The current situation is explained here and the new situations are explained in Section 4.1.2 with their collection/storage strategies.

In the current situation, the collection of the trolleys is executed at the production street of Hamifleurs. To have a safe environment at the production street, there is a maximum amount of trolleys that can be stored at the production street. The current space allows a maximum of 40 trolleys for each of the receiving points J2-95, J2-96, J3-11 and J3-18. For receiving point J2-84 the maximum amount of trolleys is 20 and for receiving point J1-72 the maximum amount of trolleys is 50. This leads to a maximum amount of trolleys of 180 trolleys on the downside of the production street and 50 on the upside of the production street (Figure 1) and a total of 230 trolleys at the production street. However, in the current situation this maximum amount of trolleys at the production street is not regulated and thus safety of the employees is not guaranteed.

3.4 Current data

'What is the current data of the receiving processes?'

The current data are the supply of the products, the processing times per step of the receiving processes and the amount of hours needed to execute the receiving processes. In these data differences between weekdays is taken into consideration and the weekend days are excluded.

3.4.1 Supply

For the supply, the average amount of trolleys that arrive per quarter per weekday per supplier is obtained. The amount of trolleys that arrive directly from the grower at Hamifleurs is minimal and will not be taken into consideration.

Flora Holland Naaldwijk

The average amount of trolleys per receiving point per weekday from Flora Holland Naaldwijk is displayed in Figure 8. The table of this figure is presented in Appendix A, as well as the graphs with the average amount of trolleys per quarter for each receiving point and weekday from Flora Holland Naaldwijk. One day of data is deleted, because this was a day where the data was not collected in the right manner and gave a wrong vision on the averages.

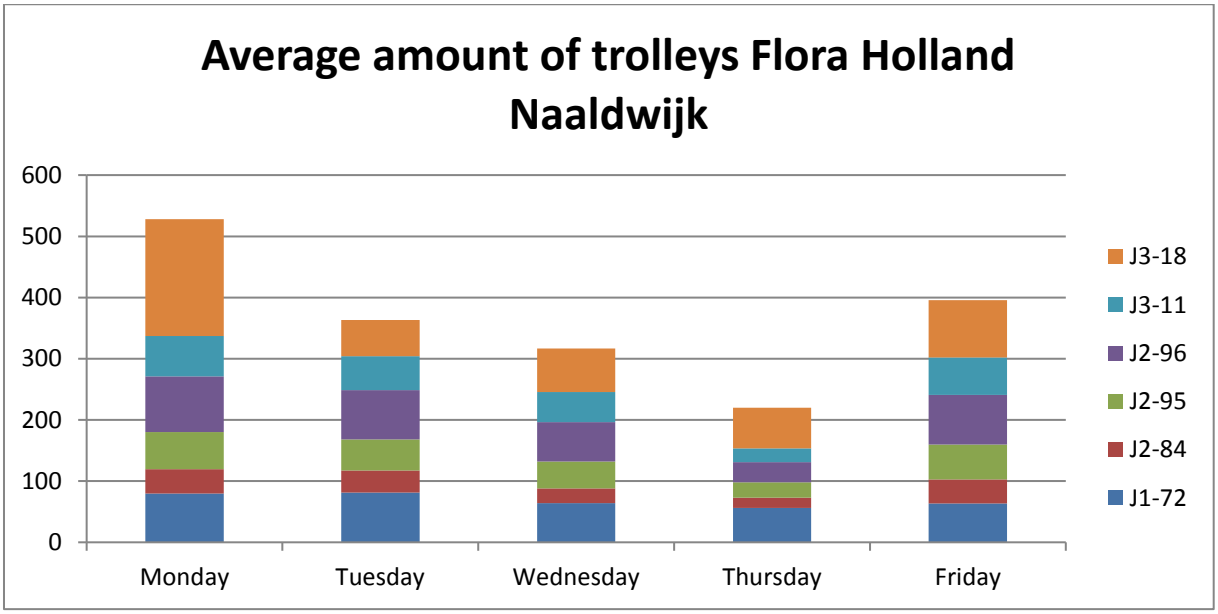

Figure 8: Average amount of trolleys from Flora Holland Naaldwijk

Connect

On the basis of the grower, the amount of trolleys at each receiving point is obtained. The amount of trolleys delivered from Connect for the KOA (J3-18) is only a few percent and negligible according to the purchasing manager. The average amount of trolleys per receiving point per weekday from Connect is displayed in Figure 9. The table of Figure 9 is presented in Appendix B, together with the graphs with the average amount of trolleys per quarter for each receiving point and weekday from Connect. Here we can see that Connect usually delivers between 18:00 and 06:00 o'clock.

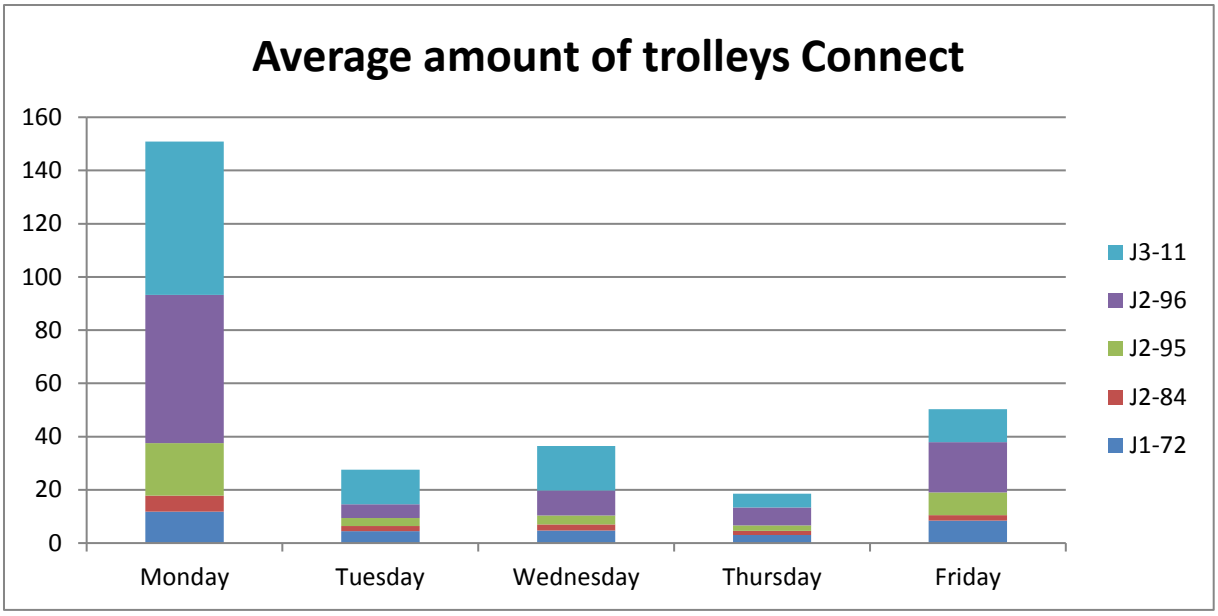

Figure 9: Average amount of trolleys from Connect

DWL

DWL is responsible for the supply from the auctions in Aalsmeer and Rijnsburg. The data gathered from DWL includes the amount of trolleys that are delivered on each date and time. The data of the trolleys, to which receiving points they have to go, is not included. The average amount per weekday of the bought flower steals per receiving point at Aalsmeer and Rijnsburg is used to gather the amount of trolleys per receiving point. The average amount of trolleys for each weekday per receiving point is displayed in Figure 10. The table with the average amount of trolleys per receiving point and weekday from the locations at DWL is displayed in Appendix C, together with the graphs with the average amount of trolleys per quarter for each receiving point and weekday from DWL.

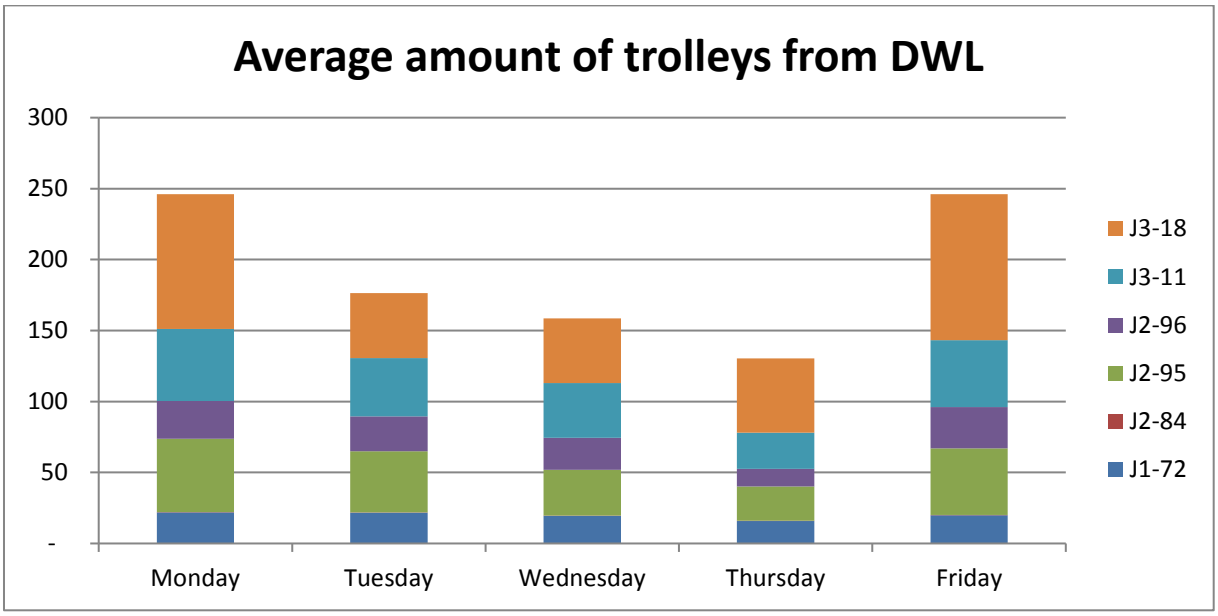

Figure 10: Average amount of trolleys from DWL

Total supply

The average amounts of trolleys arriving at Hamifleurs are represented in Figure 11 for each receiving point and weekday. The table of this figure is presented in Appendix D, as well as the graphs with the average amount of arriving trolleys per quarter for each receiving point and weekday.

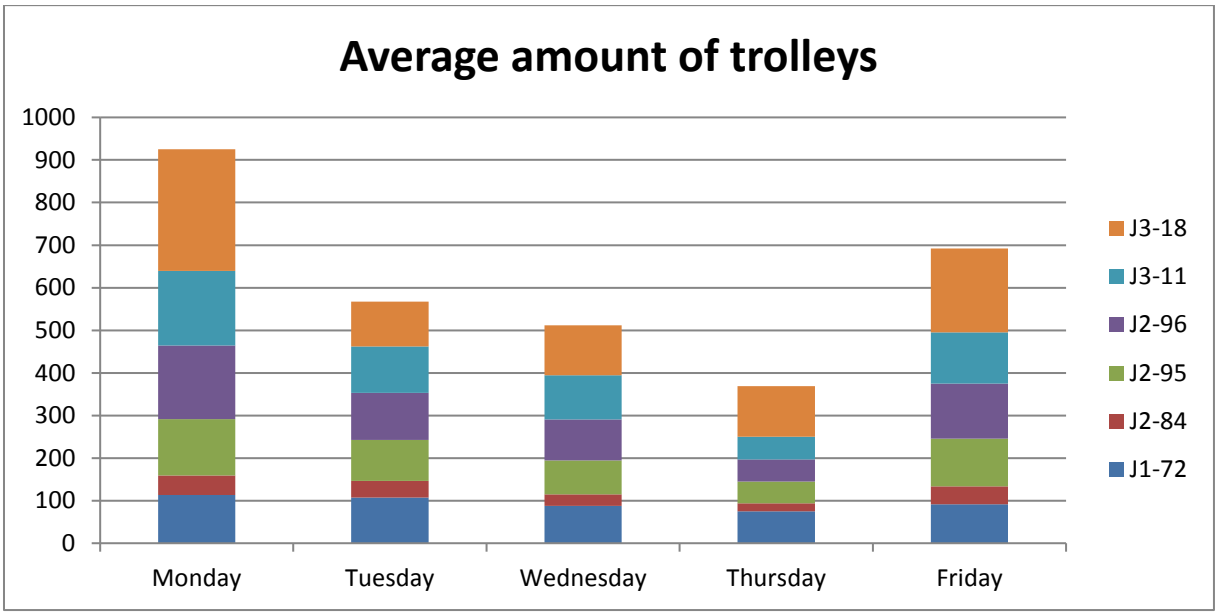

Figure 11: Average amount of trolleys from all suppliers

3.4.2 Processing times

The processing times that occur at the receiving processes are split in two steps. Which processes occur at which step is shown in Figure 7. For each of these steps the average processing time of one trolley is obtained.

Step 1

Within this step there are two different processing times. One of the processing times is where the trolleys have a barcode and the other one is where they do not have a barcode. The trolleys with barcode are mostly from the auctions and the other trolleys are mostly from the growers and are delivered through Connect.

Trolleys with barcode

The batch stickers of the trolleys with barcode take less time. When the trolley with the barcode is scanned, the batch stickers are directly printed.

Trolleys without barcode

Finding the batch stickers of the trolleys without barcode takes more time. The trolleys without barcode have to be searched in the system to find the right batch sticker.

The trolleys delivered from Connect are mostly more chaotic than the trolleys delivered by the auction, because the growers just put all the orders on the trolley without sorting on length or other characteristics. The amount of trolleys that cannot be scanned at the receiving points J1-72, J2-84 and

J3-18 is negligible. For these receiving points there is only one processing time for step 1 of the receiving processes.

For calculating the average processing time of step 1 for a trolley per receiving point, the processing times are timed at each receiving point. The procedure for calculating the processing times for step 1 is to do several measurements for each receiving point where the times are noted. Within the noted time, the amount of trolleys, the amount of batches on the trolleys, and if the trolleys could be scanned, are also noted. With this data the average processing time per batch is calculated by dividing the measured time with the amount of batches within that measured time. The standard deviation of the processing times of a batch for each receiving point is also calculated and both, the average and the standard deviation of the processing times are presented in Table 3. With a significance of 5% we can state that for each receiving point that the processing times can be described by a lognormal distribution. The histograms of the receiving points with their fitted distribution are presented in Appendix E, as well as the chi-square test and the Q-Q plot.

Table 3: Summary statistics per receiving point and supplier for the processing times of step 1 per batch

Step 1	J1-72	J2-84	J2-95		J2-96		J3-11		J3-18
Supplier	All	All	Connect	Auction	Connect	Auction	Connect	Auction	All
Mean	00:00:38	00:00:47	00:00:40	00:00:29	00:00:27	00:00:23	00:00:21	00:00:17	00:00:09
Standard deviation	00:00:23	00:00:20	00:00:29	00:00:13	00:00:14	00:00:09	00:00:09	00:00:08	00:00:01

The processing time per trolley for step 1 depends on the amount of batches on the trolley, which can be different for each receiving point and supplier. When there are many batches on a trolley, more sorting has to be executed which takes more time than when there is only one batch on a trolley. The amount of batches arriving at each receiving point is data that is not available. The amount of batches on a trolley also depends on the supplier of the trolleys, through the auction or from growers through Connect. Therefore a distinction is made between the average amount of batches on a trolley per supplier, except for the receiving points J1-72, J2-84 and J3-18. By these receiving points, the amounts of trolleys that cannot be scanned are negligible and so do the amount of trolleys that are received through Connect. In the procedure to calculate the processing times for step 1, the amount of batches that are measured at an amount of trolleys is known. With the help of this data, the average amount of batches on a trolley per receiving point and supplier, auction or Connect, is presented in Table 4.

Table 4: Average amount of batches on a trolley per supplier and receiving point

Receiving point	Connect	Auction
J1-72	1.5	1.5
J2-84	2.4	2.4
J2-95	5.2	3.8
J2-96	4.8	3.8
J3-11	10.3	3.5
J3-18	5.4	5.4

With the help of data from Table 3, that presents the average processing time per batch, and Table 4, that presents the average amount of batches on a trolley, the average processing time and standard deviation of step 1 for a trolley for each receiving point can be calculated and is presented in Table 5.

Table 5: Summary statistics per receiving point and supplier for the processing times of step 1 per trolley

Step 1	J1-72	J2-84	J2-95		J2-96		J3-11		J3-18
Supplier	All	All	Connect	Auction	Connect	Auction	Connect	Auction	All
Mean	00:00:57	00:01:53	00:03:30	00:01:52	00:02:09	00:01:28	00:03:40	00:01:00	00:00:49
Standard deviation	00:00:29	00:00:32	00:01:06	00:00:24	00:00:32	00:00:17	00:00:28	00:00:16	00:00:03

Step 2

The processing time of step 2 does not depend on the average amount of batches on a trolley. Here the amount of trolleys processed in the measured time is used. For the receiving point of J2-84, the times are not measured in this process step. The employee at this receiving point executes all the receiving and distribution processes by himself. The receiving processes are executed in different order, where process step 1 finds place during process step 2. Before step 1 of J2-84 is executed, the trolleys are moved to the distribution storage, because process step 1 is executed there and not at the production street like the other receiving points. After step 1 is executed, step 2 continues with putting the trolleys on the right location, this is executed all by the same employee.

Appendix F shows for the other receiving points with a 5% significance, if there is a difference between the averages between the receiving points at step 2. Here we can see that the data of the receiving points J1-72, J3-11 and J3-18 do not have a significant difference in the processing times, so this data is taken together. The data from the receiving points J2-95 and J2-96 is also taken together. Group 1 represents the receiving points J1-72, J3-11 and J3-18, while group 2 represents J2-95 and J2-96. According to the operational manager, the processing time of step 2 of J2-84 would be the same as the processing time in group 1. For this research we execute step 1 of J2-84 at the production street together with the other receiving points. For the processing time of step 2 of J2-84, J2-84 will be added to group 1.

The histograms of the receiving points with their fitted distribution are presented in Appendix F, as well as the chi-square test and the Q-Q plot. For group 1 and 2 of step 2, we can state with a significance of 5% that the lognormal distribution and the exponential distribution fit the data. As the lognormal distribution fits better, this distribution is used for both groups. Table 6 represents the average processing time and standard deviation per group of receiving points of step 2 of the receiving processes. The differences between the two groups are not surprising. At the receiving points J2-95 and J2-96 (group 2), more photos have to be made of the products than at the receiving points at group 1. The making of photos do cost more time, than when no photos have to be made of the products.

Table 6: Summary statistics per group for the processing times of step 2 per trolley

Step 2	Group 1 (J1-72, J2-84, J3-11, J3-18)	Group 2 (J2-95, J2-96)
Mean	00:00:46	00:01:18
Standard deviation	00:00:02	00:00:05

While performing the procedure, to calculate the summary statistics per trolley per receiving point for the processing times of step 2, the amount of trolleys treated in the measured time is also noted. The average of the amount of trolleys that goes through process step 2 once a time, is 4 trolleys.

Flexibility of the employees to work at a different receiving point

When introducing flexibility of the employees to work at a different receiving point, the processing times of step 1 will change. This because the amount of travel time from a receiving point to another receiving point is not taken into consideration. Therefore, when the last executed step of the receiving processes taken place on another receiving point as the next processing step, the processing time of step 1 will count 30 extra seconds for each switch in the location. When the employee first did process step 1 at a certain receiving point, there is no time added when the same employee executes step 2 at the same receiving point.

Changing the amount and/or location of the receiving points

The processing times of step 1 will stay the same when changing the location of the receiving point of that trolley. The processing time of step 2 will change by changing the location of the receiving points. The traveled distance for the trolleys from the receiving point to the right storage area will become larger and this could take more time. When changing the amount and/or location of the receiving points. At some places at the production street there could not be a receiving point anymore. At these places trolleys can be buffered, for the still existing receiving points. Bringing the trolleys from this buffer area to the receiving point, also takes time. According to the logistical manager, the time to travel these distances will take 10 seconds per trolley. When the amount and location of the receiving points change, the trolleys could be delivered at different receiving points then they are used to be. The processing times of step 2 will add 10 seconds per trolley to their mean processing time when the receiving processes are still executed at the production street of Hamifleurs. When the location of the receiving processes changes to a location at Flora Holland Naaldwijk, the extra processing time of step 2 will be eight minutes per batch. A batch will be between 6 and 16 trolleys, except when a trolley is waiting longer than 30 minutes to form a complete batch.

3.4.3 Amount of hours needed

The needed amount of hours for each day and step 1 and 2 is calculated by multiplying the amount of trolleys with the amount of time needed to accomplish the operations and is presented in Table 7 for step 1 and in

Table 8 for step 2. The total amount of hours needed per receiving point and weekday is presented in Table 9.

Table 7: Amount of hours needed at step 1 per weekday and receiving point

Receiving point	Monday	Tuesday	Wednesday	Thursday	Friday
J1-72	01:47:32	01:42:06	01:23:38	01:11:16	01:27:00
J2-84	01:27:00	01:12:40	00:50:42	00:35:14	01:19:05
J2-95	04:38:51	03:04:22	02:33:33	01:38:43	03:43:38
J2-96	04:51:57	02:45:55	02:27:38	01:21:06	03:21:46
J3-11	05:28:20	02:23:52	02:28:44	01:07:12	02:33:45
J3-18	03:53:09	01:25:35	01:35:36	01:36:51	02:40:31

Total	22:06:49	12:34:30	11:19:52	07:30:22	15:05:44

Table 8: Amount of hours needed at step 2 per weekday per receiving point

Receiving point	Monday	Tuesday	Wednesday	Thursday	Friday
J1-72	01:26:47	01:22:24	01:07:29	00:57:30	01:10:12
J2-84	00:35:25	00:29:35	00:20:38	00:14:21	00:32:12
J2-95	02:51:45	02:05:01	01:43:02	01:06:27	02:26:02
J2-96	03:45:03	02:23:55	02:05:14	01:07:48	02:47:26
J3-11	02:13:57	01:23:47	01:19:52	00:40:57	01:32:31
J3-18	03:38:52	01:20:20	01:29:45	01:30:55	02:30:41
Total	**14:31:50**	**09:05:02**	**08:06:01**	**05:37:57**	**10:59:04**

Table 9: Total amount of hours needed per weekday per receiving point

Receiving point	Monday	Tuesday	Wednesday	Thursday	Friday
J1-72	03:14:18	03:04:30	02:31:07	02:08:46	02:37:12
J2-84	02:02:25	01:42:15	01:11:20	00:49:35	01:51:16
J2-95	07:30:36	05:09:23	04:16:36	02:45:10	06:09:40
J2-96	08:37:01	05:09:51	04:32:53	02:28:54	06:09:12
J3-11	07:42:17	03:47:39	03:48:36	01:48:08	04:06:17
J3-18	07:32:01	02:45:55	03:05:21	03:07:46	05:11:11
Total	**36:38:38**	**21:39:32**	**19:25:53**	**13:08:19**	**26:04:49**

3.5 Current indicators

'What are the current indicators of the receiving processes?'

There are several indicators of the current situation. Namely the productivity, utilization and waiting time of the employees and the labor costs per week. In the current situation, the utilization and productivity are expressed per weekday and process step, because the more specific data on which employee did exactly what is not available.

3.5.1 Productivity

As described in the literature review, productivity is mostly measured in 'units' handled per hour work of an employee (Hackman, et al., 2001). The productivity of the employees is calculated for each weekday and step of the receiving processes, with help of the average amount of employee hours per step per weekday (Table 10) and the amount of trolleys per weekday (Figure 11). The amount of employee hours per step is not totally correct. In the data that is used to gain these data, the breaks that are paid by Hamifleurs are also included in the amount of employees' hours. These hours are paid, but there is not worked in these hours. It is almost impossible to retrieve the right data exactly of the working hours of the employees. So, we will work with this data. The productivity should be a little bit higher, because of the break hours that are paid by Hamifleurs are not taken into consideration as break, but as time that is needed to pay the employees.

Table 10: Amount of employee hours per step

Amount of hours per step	Monday	Tuesday	Wednesday	Thursday	Friday
Step 1	59:05:58	42:57:03	36:22:01	17:25:46	40:52:32
Step 2	38:04:34	29:41:35	22:19:19	14:34:41	27:25:22
Total	**97:10:32**	**72:38:38**	**58:41:20**	**32:00:27**	**68:17:55**

The hours that are used for both processing steps are divided under the processing steps 1 and 2. This is calculated by multiplying the average processing time of both steps with the amount of trolleys on that receiving point. The total processing times of the trolleys of each process step are compared with each other for each receiving point, which leads to a percentage of how the time is divided between step 1 and 2 of the receiving processes of that receiving point. Which is 71% of the time of the employee at receiving point J2-84 goes to step 1 and 29% of the time of the employee goes to step 2. For J3-18 this is respectively 52% and 48%.

The average productivity is the amount of trolleys processed per employee per hour, is presented in Table 11 per weekday and process step.

Table 11: Average productivity per process step per weekday

Productivity	Monday	Tuesday	Wednesday	Thursday	Friday
Step 1	16	13	14	21	17
Step 2	24	19	23	25	25

3.5.2 Utilization

The utilization in the current situation represents the amount of hours needed divided by the amount of hours used. The utilization for the current situation is presented in Table 12 for each step and weekday. As mentioned in Section 3.5.1, the hours that Hamifleurs paid for the break are not reduced from the actual work hours. For this reason, the utilizations are a little bit lower than they have to be. The average utilization of an employee for a whole week is 35.57%.

Table 12: Utilization for each process step and weekday

Utilization	Monday	Tuesday	Wednesday	Thursday	Friday
Step 1	37%	29%	31%	43%	37%
Step 2	38%	31%	36%	39%	40%
Total	38%	30%	33%	41%	38 %

3.5.3 Waiting time of the employees

By minimizing the current amount of hours per step for each weekday with the total amount of hours that are needed for step 1 and 2, the waiting time of the employees is calculated and presented in Table 13. This is the difference of the amount of employee hours needed (summing Table 7 and

Table 8 and the amount of employee hours that are currently used (Table 10). Thereby the amount of hours that the employees spend at the distribution center is also taken off. Similar to Section 3.5.1 and 3.5.2, the current amount of hours are lower than they have to be because of the breaks that are paid by Hamifleurs. Therefore, the waiting times have to be a little bit lower than they are now. The average waiting time of an employee is 04:18:35 hours per day.

Table 13: Average waiting time

Average waiting time	Monday	Tuesday	Wednesday	Thursday	Friday
Step 1	36:59:09	30:22:33	25:02:09	09:55:24	25:46:48
Step 2	23:32:44	20:36:33	14:13:18	08:56:44	16:26:18
Total	**60:31:54**	**50:59:06**	**39:15:27**	**18:52:08**	**42:13:06**
Per employee	05:26:50	04:46:18	03:52:04	02:28:14	04:24:33

3.5.4 Labor costs

To calculate the average labor cost per weekday, several data is needed. Figure 12 presents the average amount of employees per weekday, and Figure 13 the average amount of hours per employee per weekday. In both figures there is a distinction between the employees who execute step 1, step 2 or who executes both steps of the receiving processes, that is indicated by 'Both'. For some days there is a large difference in the amount of employees per weekday and the amount of hours per employee per weekday. This is because the amount of work is different per weekday. For example, the average amount of trolleys that arrive on a Monday is more than 900, while the average amount of trolleys that arrive on a Thursday is less than 400. The amount of hours, and so the amount of employees, needed to execute the receiving processes for the 900 trolleys is more than the amount of hours needed to execute the receiving processes for the 400 trolleys. This explains the difference in the average amount of employees per weekday in Figure 12 even as the average amount of hours per employee per weekday in Figure 13. In this industry it is normal that the workdays on Thursday are a lot shorter than on a Monday for example.

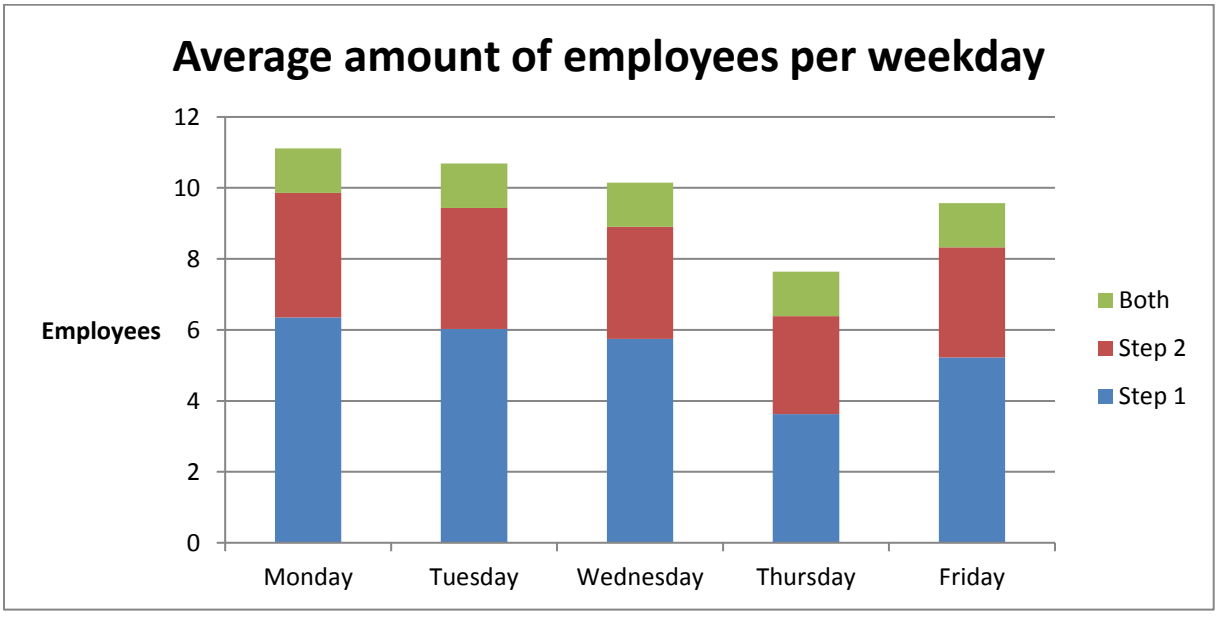

Figure 12: Average amount of employees per weekday

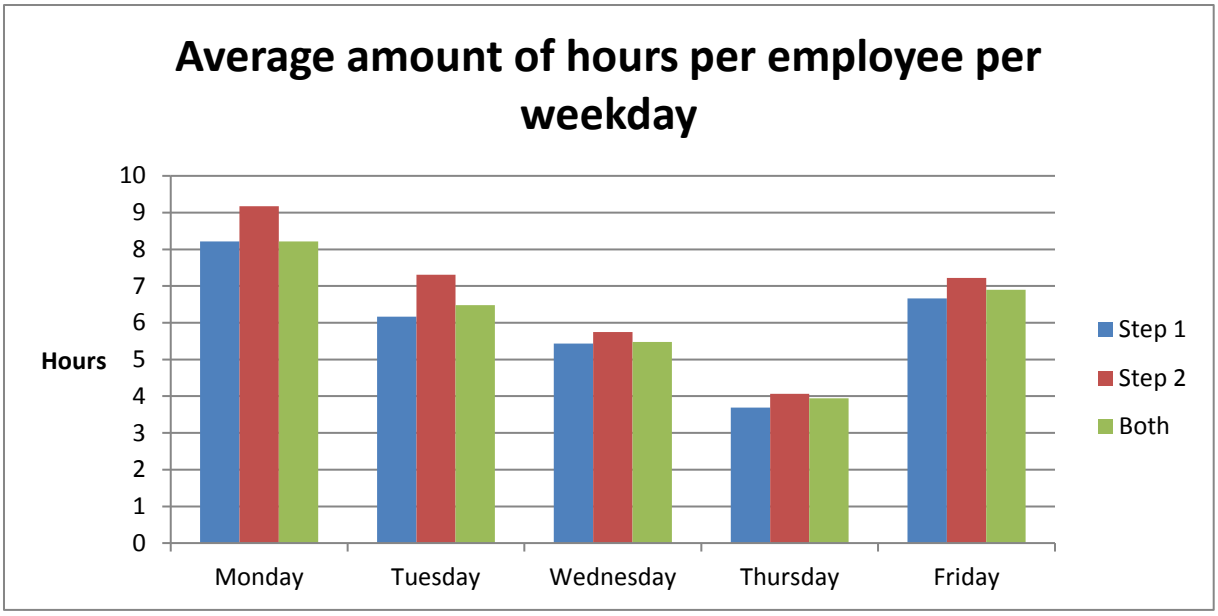

Figure 13: Average amount of hours per employee per weekday

The average cost per employee is defined to be 20 euros per hour. With the help of the data from figure 11 and 12, the average cost per weekday is calculated and presented in Table 14. The total average costs for a week for employees of the receiving processes are €6,576.29. When in a theoretical situation the waiting times in Table 13 could be fully reduced, this leads to a cost saving of €4,237.23. In this situation the utilization of each employee has to be a 100% and nothing may go wrong, which is desirable but not possible.

Table 14: Average cost per weekday

Average cost per weekday	Monday	Tuesday	Wednesday	Thursday	Friday
Step 1	€ 1,181.99	€ 859.02	€ 727.34	€ 348.59	€ 817.51
Step 2	€ 761.52	€ 593.86	€ 446.44	€ 291.56	€ 548.46
Total	**€ 1,943.51**	**€ 1,452.88**	**€ 1,173.78**	**€ 640.15**	**€ 1,365.97**

According to Table 7 and Table 8, a minimum amount of employees for each day and step is presented in Table 15 and is rounded above to whole numbers. The amount of hours per day is defined from Figure 13, which represents the average amount of hours per employee per weekday. These amounts of employees are the amount of employees in the theoretical situation, where nothing can go wrong and the employees are continuously working. As mentioned before, this is desirable but not possible.

Table 15: Average amount of employees needed per step per weekday (rounded above)

Average amount of employees needed per step per weekday	Monday	Tuesday	Wednesday	Thursday	Friday
Step 1	3	2	2	2	2
Step 2	2	2	2	2	2
Total	**5**	**4**	**4**	**4**	**4**

3.6 Conclusion

The current situation at the receiving processes contains several operations, which are presented in Figure 7. Several agreements are made in the current situation with the suppliers consisting of auction Flora Holland Naaldwijk, Connect, DWL and the growers. At the moment, each supplier delivers their trolleys for Hamifleurs separately and each delivery can contain a different amount of trolleys. One of the agreements is for example that there is a maximum amount of time available for the suppliers to deliver their products after the products are bought. There are three different supply flows with no agreements on the amount of trolleys and time per delivery, which results in an unequal supply. The current collection/storage strategies at the receiving points are a combination of family grouping, dedicated storage and closest open location storage. Within these storage strategies, block stacking is used for a most optimal utilization of the trolleys and lanes. For the current indicators, data is obtained regarding the arrival of the supply, processing time of the steps in the receiving processes, amount of hours needed, the productivity and utilization of the employees, the waiting time and the labor costs.

The average supply for a week is 3065 trolleys, divided over each weekday with 925, 567, 512, 369 and 692 trolleys from Monday to Friday respectively. The average utilization of an employee for a week is 35.57%, whereby the average waiting time of an employee is 04:18:35 hours. The average weekly labor costs for the receiving processes are €6,576. In a theoretical situation where the utilization of the employees can be 100% and no mistakes occur and the waiting times can be fully reduced, a cost saving of €4,237 per week on the labor costs can theoretically be realized.

4 Simulation model

In this chapter the third question will be answered:

'How can the receiving processes be modelled?'

At first the interventions are defined and modelled. Secondly, the conceptual model is made, followed by the implemented simulation model. Through verification and validation, correctness of the simulation model is ensured and it is checked whether the reality is represented well enough. The chapter ends with a conclusion of how the receiving processes can be modelled.

4.1 Interventions

'Which interventions are applicable and how can these be modeled?'

The current situation contains six receiving points, with for each step an amount of employees working. For the current situation the optimal occupation, according to the operational manager, is used. The start and break time (group 1) are presented in Table 16 in Section 4.2. The end time of the weekday is when all the trolleys went through both steps of the receiving processes. Looking at the main problems and the scope of this research, the interventions are defined. Through the experiments, the defined interventions could be modeled on their own, but the interventions could also be combined with each other. Within the interventions, the assumptions made in Section 4.2.3 are taken into consideration.

Changing the amount and/or location of the receiving points combined with the amount of employees per receiving point and process step

The first intervention is the amount and location of the receiving points combined with the amount of employees per receiving point and process step. When changing the location of the receiving points we can choose the current and new location (Section 4.2.1). When changing the amount of the receiving points and with that the amount of employees per receiving point and process step, it is possible that the workload for the employees becomes more equal through risk pooling. Because the amount of work per receiving point, could become more the same when product groups are flexible to arrive at a receiving point. When reducing the amount of receiving points, more product groups arrive at a receiving point. This could make it less difficult to visually distinguish the differences between the types of flowers per receiving point. When for example a combination of roses and tulips arrive and the batch sticker includes a type of roses, it is not hard to put the sticker on the roses instead on the tulips.

According to the warehouse lay-out of Hamifleurs that is presented in Figure 1, there are two sides of the production street where step 1 of the receiving processes could be accomplished namely the upside with receiving point J1-72 and the downside with the other receiving points. We want a high utilization for the employees and therefore it is preferred that there are almost always trolleys waiting at the production street to be executed by the employees. When using both sides of the production street in the current location as storage, a maximum amount of 230 trolleys can be buffered, while maintaining the safety of the employees. At the new location, there is practically no maximum amount of trolleys that can be stored at the location.

Allowing employees to execute both of the process steps and at multiple receiving points

Another intervention is to let the employees execute both of the process steps instead of one and to let them be flexible to work at more receiving points (without being sent by their coordinator), the workload between the employees could get more equal between the receiving points and steps with this intervention. If for example one and a half employee are needed to execute process step 2 per receiving point and there are two receiving points, there can be chosen to let three employees executing process step 2 at both receiving points, instead of one or two employees that are only executing step 2 at one receiving point.

Use separate breaks for the employees

The third intervention is to let the employees have separate breaks. For the current situation applies that there is a break for everyone at the same time. When using separate break groups for the employees, the employees are divided over break group 1 and 2 (Table 16 in Section 4.2.4). When they have separate breaks, the amount of trolleys at the production street will probably not get as high when all the employees have break at the same time. Depending on the arrival times of trolleys, the lead time could also get lower when using separate breaks.

Limiting the number of trolleys at the production street

Within the earlier mentioned interventions, it is of interest that the safety of the employees is maintained, which brings us to the last intervention. When the safety of the employees is brought in danger, while experimenting with the earlier defined interventions, a check at the supply delivery has to take place. While limiting the number of trolleys at the production street, we can ensure that the maximum amount of trolleys at the production street will not be reached and the production street will not become unsafe for the employees. When there is no space to safely store the trolleys, the supplier is not allowed to deliver trolleys at the production street. When this happens, the supplier needs to put the trolley in their own buffer.

As mentioned before, in the current situation by the current collection/storage strategies (Section 3.3) there is a maximum amount of 230 trolleys that can be stored at the production street. This maximum amount is not taken into account in the current situation, but to have a safe environment for the employees, this maximum amount should be taken into account when using the current location of the receiving processes.

This means that there are no more than 230 trolleys at once at the production street. This can be accomplished by setting an agreement with the supplier. The suppliers will create an extra buffer for Hamifleurs together at the location of one of the suppliers. Having this buffer at one of the suppliers could include extra costs. At this buffer they collect all their trolleys. When there are 16 trolleys in this buffer and there is space at the production street of Hamifleurs the trolleys will be brought to the production street. The amount of 16 trolleys is chosen, because this is the maximum amount of trolleys that can be transported at once. The maximum time in this supplier buffer is 45 minutes for the trolleys, which is decided by the logistics manager. This means that when a trolley is waiting more than 45 minutes at the supplier buffer to form a batch of 16 trolleys, the trolleys in the buffer will be brought to the production street with the amount of trolleys that is in the buffer at that moment. When there is no space at the receiving points, the trolleys will be put in the buffer of Hamifleurs and when there

is space at the receiving points, the trolleys will be moved to the right receiving point. The buffer of Hamifleurs is stored at the locations of the receiving points at the production street that are not used for the receiving processes. The trolleys will also be moved from the buffer of the supplier to the production street, when the last trolley is arrived. With help of these restrictions, there could be a check on the supply and the safety of the employees can be maintained.

When the trolleys are not dedicated to a specific receiving point the trolleys are divided over the receiving points while taking into account the maximum amount of trolleys per receiving point. When there is space available at receiving points, the trolleys are divided per receiving point, starting with the ones that have the least amount of trolleys at their buffer and receiving point for step 1.

To summarize, the interventions are:

- Changing the amount and/or location of the receiving points combined with the amount of employees per receiving point and process step
- Allowing employees to execute both of the process steps and at multiple receiving points
- Use separate breaks for the employees
- Limiting the number of trolleys at the production street

4.2 Conceptual model

'What does the conceptual model look like?'

The conceptual model includes the used collection/storage strategies and the agreements with the suppliers. To translate the current situation to a conceptual model, assumptions have to be made, because it is impossible to create the exact same situation as reality. The input and output data that is needed to accomplish the interventions are described next, followed by the schemes and flowcharts of the model. The schemes and flowcharts represent the design of the simulation model, to model the interventions with the right data. Also, the type of simulation is defined, together with the run length. The number of replications that is needed to let the confidence interval be satisfactory is defined at last.

4.2.1 Collection/storage strategies

For the current and the new location of the receiving processes, decisions are made according to the collection/storage strategies. A more detailed explanation what each collection/storage strategy means can be found in Section 2.3. In both, the current and the new location of the receiving processes, progressive assembly zoning is used for the employees when it is not stated otherwise. Each employee works in their own zone. The employees are assigned to receiving points and process steps. When the employees finish their step, the trolley is mostly moved to another employee that executes the next step which is in their employment. The used collection/storage strategies for the new situations are mentioned below, unless clearly stated otherwise in Section 5.1.

Current location receiving processes

The current location presents a new situation and uses the same collection area of the current situation, which is the production street of Hamifleurs. In comparison with the current situation, the current location does take the maximum amount of 230 trolleys at the production street into account to maintain the safety of the employees and therefore a buffer at the supplier is needed. Within the current location a maximum amount of two employees is allowed to work on a process step per

receiving point. The lay-out of the receiving processes when the current location is used is presented in Figure 14.

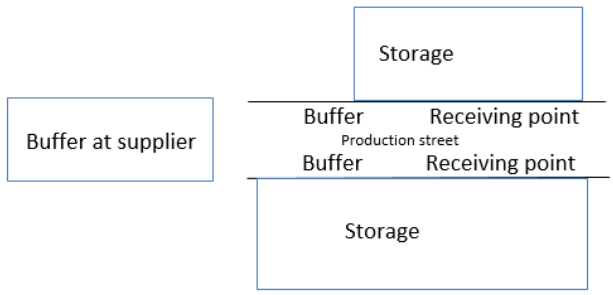

Figure 14: Lay-out using current location

When the trolleys arrive at the current location of the receiving processes, trolleys are brought to the emptiest receiving point buffer. When there is no space in these receiving points' buffers, the trolleys are first stored in the buffer of Hamifleurs at the production street through closest open location storage. Within the receiving points, the trolleys are collected through closest open location storage. In this way the trolleys are most closed by the employee that execute process step 1. When this step is finished, the trolley is moved to the next step and stored also through closest open location storage. While executing step 2, the trolleys are moved to the refrigerated/conditioned areas while combining dedicated storage, family grouping and closest open location storage. To which refrigerated/conditioned areas the trolleys have to go is dedicated. Family grouping is used to set the same product groups together. Within the dedicated, family grouping area, closest open location storage follows so that the trolleys are as closest to the conveyor or wall as possible.

New location receiving processes

Within another new situation, namely the new location, the collection of the trolleys and the receiving processes will be executed at a location at Flora Holland Naaldwijk. Therefore, new space should be rented for this location to collect the trolleys and execute the receiving processes. At this location, there is practically no maximum amount of trolleys that can be stored at the location. For this location there is also no maximum amount of employees that is allowed to work on a processes step and receiving point. For each product group a buffer is created for step 2 of the receiving processes. The lay-out of the new location is presented in Figure 15.

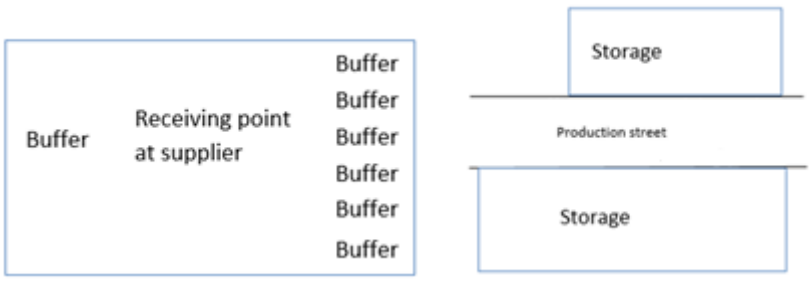

Figure 15: Lay-out using new location

When the trolleys arrive at the new location of the receiving processes at Flora Holland Naaldwijk, the trolleys are collected, while using closest open location storage. The trolleys will be put most closed to

the employees that execute process step 1. After performing process step 1, the trolleys will be stored in the buffer of step 2 using family grouping. Family grouping is executed to sort the trolleys the same as they have to be stored eventually. While performing step 2 of the receiving processes, a combination between dedicated storage, family grouping and closest open location storage is used. The refrigerated/conditioned areas where the trolleys have to go are dedicated and within these areas family grouping is used to set the same product groups together. Within the dedicated, family grouping area, closest open location storage is used so that the trolleys are as closest to the conveyor or wall as possible.

To summarize, the collection/storage strategies per moment in the receiving processes are:

- Current location
    - Arrival of the trolleys
        - Current location
            - Closest open location storage, when there is no space in the receiving points, this strategy is first used in the buffer of Hamifleurs at the production street, otherwise at the receiving points.
        - New location
            - Closest open location storage
    - After executing step 1 and before executing step 2
        - Current location
            - Closest open location storage
        - New location
            - Family grouping
    - While executing step 2
        - Dedicated storage, family grouping and closest open location storage

4.2.2 Agreements

The agreements that are used with the suppliers within the conceptual model are mentioned both for the current and new location of the receiving processes.

Current location receiving processes

When the receiving processes are executed at the production street of Hamifleurs, there are some new agreements that have to be made with the suppliers to obtain the best performance at the receiving processes. With help of the agreements with the suppliers, the number of trolleys at the production street can be limited. With this limited number of trolley at the product street, the safety of the employees at the production street can be maintained. A maximum amount of trolleys at the production street is set on 230 trolleys to maintain the safety. This maximum amount of trolleys at the production street can be accomplished by creating a buffer at one of the suppliers where all the suppliers bring their trolleys. Having this buffer at a place of the suppliers could include extra costs for the buffer space. When there are 16 trolleys in this buffer and there is space at the production street, the supplier that is made responsible for the buffer will bring these trolleys to Hamifleurs. Another reason to bring the trolleys to Hamifleurs is when the maximum amount of 45 minutes has passed for the trolley that arrived first at the buffer and there is place at the production street. The trolleys that are at that moment in the buffer will also be moved to the production street of Hamifleurs. The last agreement that is used is about the moment that the last trolley has arrived of that day. When the last

trolleys have arrived of that day, the last trolley and the other trolleys at the buffer of the suppliers will also be moved to Hamifleurs.

New location receiving processes

When the receiving processes will be executed at another place, for example at Flora Holland Naaldwijk, agreements need to be made with the suppliers. Within the conceptual model, the suppliers have to deliver the trolleys directly at the new location. Using the new location for the receiving processes, new costs have to be made for renting another space for the receiving processes. When using this new location, the travel distance that have to be executed from that location to Hamifleurs, will probably be executed by employees of Hamifleurs. This saves time for the employees of the suppliers, so probably new agreements for these savings have to be made.

To summarize, the agreements per location with the suppliers are:

- Current location
    - Create a buffer for the trolleys at a place of the suppliers and let the suppliers move the trolleys to this new location, this could include extra costs for the buffer space.
    - When there are 16 trolleys at this buffer, move the trolleys to Hamifleurs if there is space at the production street.
    - When the maximum amount of 45 minutes is passed, move the trolleys that are in the buffer to Hamifleurs, if there is space at the production street.
    - When the last trolley has arrived, move the trolleys that are in the buffer to Hamifleurs, if there is space at the production street.
- New location
    - The trolleys of the suppliers directly have to be brought to the new location.

4.2.3 Assumptions

For the current situation and the earlier defined interventions, it is not possible to maintain the exact same situation in the simulation model as the one that is actually happening. Therefore several assumptions have to be made. The assumptions made contain only small differences with reality, for example considering time.

The incoming amount of trolleys is the same as the outgoing amount of trolleys at each step

The first assumption is that the incoming amount of trolleys is the same as the outgoing amount of trolleys at each step. The trolleys arrive at the production street with different amount of products and in different ways. When sorting the trolleys in the right state before they can go further to process step 2, batches of the trolley are put on other trolleys to get the trolley ready. Here more trolleys could go to process step 2 than the amount of trolleys that arrived in process step 1. This also works the other way around, when a trolley arrives with a low utilization, batches of other trolleys that have a high utilization are put on that trolley. How often these cases occur is not measured, so the assumption is made that the same amount of trolleys is coming in and going out at a process step.

The trolleys fit in the conditioned/refrigerated areas

Another assumption is that the trolleys fit in the designated conditioned/refrigerated areas. In the current situation it almost never occurs that trolleys do not fit in their designated area. During the experiments, we assume that the trolleys will always fit at their designated area.

When performing step 1 of receiving point J2-84 at the production street, step 2 includes the same statistics as the statistics of Group 1 of step 2 of the receiving processes

In the current situation, both of the process steps of the receiving point J2-84 are not executed at the production street. We assume that when the first process step of the receiving point J2-84 is executed at the production street, this includes the same statistics as the statistics of Group 1 of step 2 of the receiving processes (Section 3.4.2).

The extra time used for the processing time of step 2 takes into account the changed location of the receiving points and/or the time when the incoming trolleys do not go to their dedicated receiving point

Another assumption is that the extra time used for the processing time of step 2 includes the changed location of the receiving points and/or the time when the incoming trolleys do not go to their dedicated receiving point. Normally, the amount of trolleys that is ready for processing step 2 will be distributed to their area. However, when the receiving locations of the trolleys change and trolleys of different product groups will be collected together, this could result in a less amount of trolleys that has to go to the same area. Within the extra time used for process step 2, the assumption is that the time needed to put the trolleys from the receiving point to their storage area stays the same.

The trolleys can only be transported with their own product group, when the location of the receiving processes is at Flora Holland Naaldwijk

When the location of the receiving processes is changed to a place at Flora Holland Naaldwijk, the time to distribute the trolleys from that area to Hamifleurs is eight minutes per batch. A batch is allowed to be distributed to Hamifleurs, when the amount of the batch is between six and sixteen trolleys. The batches are sorted per product group and we assume that the trolleys are only transported with their own product group, even when there is just one trolley that needs transport, because the last trolley has arrived or when the maximum amount of 30 minutes is reached. The maximum amount of 30 minutes is defined by the logistics manager.

Each weekday has the same start time of the employees for each week and every employee starts and ends at the same time

Normally the start time of the employees differ per weekday and week, while taken into account the workload of that day. But here we assume that each weekday has the same start time of the employees for each week. We assume also that every employee starts and ends at the same time.

To summarize, the assumptions are:

- The incoming amount of trolleys at each step is the same as the outgoing amount of trolleys.
- The trolleys fit in the conditioned/refrigerated areas
- When performing step 1 of receiving point J2-84 at the production street, step 2 includes the same statistics as the statistics of Group 1 of step 2 of the receiving processes

- The extra time used for the processing time of step 2 includes the changed location of the receiving points and/or the time when the incoming trolleys do not go to their dedicated receiving point
- The trolleys can only be transported with their own product group, when the location of the receiving processes is at Flora Holland Naaldwijk
- Each weekday has the same start time of the employees for each week and every employee starts and ends at the same time

4.2.4 Input data

Several data are needed as input for the model. Data that is used as input is defined and described in this section.

Arrival of trolleys from the suppliers

For the arrival of trolleys from the suppliers, we use historical data directly. An empirical distribution over the inter arrival times is hard to set up, because of the several correlations that could occur at the arrival of the trolleys. For example, the arrival of an amount of trolleys depends on the time and day of the year. The amount of trolleys that arrive per supply delivery is different and the arrival process does not only exist of all separate arrivals. At one time only one trolley arrives, while at the other time twenty trolleys arrive at once. For each supplier some arrival data is known.

For each supplier a date is randomly selected from the dates from which the arrival data is known of that supplier. The weekday of the randomly selected date has to be the same as the weekday that is needed. When a date is found for each supplier that corresponds with the needed weekday, the arrival data of these dates are used as the input data for the arrival of trolleys from the suppliers. The data periods from which historical data is used can be different per supplier. For De Winter Logistics, data is used from January to September, for Flora Holland Naaldwijk, the data used is from January to mid-October and for Connect the data used is from September to mid-October. For example, when a Monday is modelled, for each supplier a Monday is randomly chosen out of the data. The combinations of these Monday, represents the Monday that is used in the model.

Processing time

For the processing time, the data in Table 5 and Table 6 is used for the right receiving point in the process step. When changing the locations of the collection areas, the processing time of step 2 will be increased by 10 seconds. By combining some, but not all, locations with each other and some not, a combination of these processing times is used for the processing time of step 2. When the employees are able to work at more than one receiving point, the processing time of step 1 is increased by 30 seconds when they switch receiving point. When the receiving processes will be held at another location, like Flora Holland Naaldwijk, the extra time of step 2 is eight minutes per batch which is four minutes to travel from the receiving processes to their storage and four minutes to go back from the storage to the receiving processes.

Supply throughput

To create a safe environment at the production street, a maximum amount of 180 trolleys can be stored on the downside and 50 on the upside. The throughput of the supply will be managed during the experiments of the current location. This is not used for the current situation, because in the current situation the safe environment that considers the amount of trolleys at the production street is not taken into consideration in reality. When changing the location of the receiving processes to a new location, there is no maximum amount of trolleys that has to be taken into consideration.

Amount of receiving points

The amount of receiving points is also an input in the model. For the current location applies that each receiving point has a maximum amount of employees that can execute step 1 and 2 of the receiving processes. This maximum amount of employees is two for both of the processing steps. In the current situation the arrival of the trolleys is dedicated per product and clock group at the receiving points, while during the experiments choices can be made to let all kind of products on trolleys arrive per receiving point. When a new location is used for the receiving processes, there is no maximum amount of trolleys per process step per receiving point.

Amount of employees and their tasks

The amount of employees working at the receiving processes is also input data. Even as the processes that the employees can execute. Employees can execute processes at only one receiving point and one process step, but they can also execute processes at multiple receiving points and at both processing steps.

Work planning of the employees

To dedicate the work hours of the employees, the start time is needed for the employees. In the current situation all the employees have breaks at the same time. These times are currently used. During the experiments, there are experiments that are executed with separate breaks for the employees. We choose to let the other breaks go directly after the original break. Depending on the break group of the employees, the employees will be available or not during certain times. The end time of an employee is when all the trolleys are received and processed. Depending on the experiment, the employee could get dedicated to a certain receiving point, step and/or break group. The number of employees is also an input for the work planning of the employees. At each receiving point the optimal results that can be obtained using the current location, is a maximum of two employees that can execute step 1 of the receiving processes and also two employees for step 2 for the current location. The start and break times for each weekday and group is stated in Table 16. Where group 1 contains the break times, that are currently used and group 2 contains the break times when separate breaks are taken into consideration. The difference between the amounts of employees per break group is a maximum of one employee, when using separate break groups.

Table 16: Work planning

Weekday	Start Time	Break 1 of Group 1	Break 1 of Group 2	Break 2 of Group 1	Break 2 of Group 2	Break 3 of Group 1	Break 3 of Group 2	Break 4 of Group 1	Break 4 of Group 2
Monday	06:00	08:00-08:30	08:30-09:00	10:00-10:15	10:15-10:30	12:00-12:30	12:30-13:00	15:30-15:45	15:45-16:00
Tuesday	07:00	09:00-09:30	09:30-10:00	12:00-12:30	12:30-13:00	15:30-15:45	15:45-16:00		
Wednesday	07:00	09:00-09:30	09:30-10:00	12:00-12:30	12:30-13:00	15:30-15:45	15:45-16:00		
Thursday	08:00	10:00-10:15	10:15-10:30	12:00-12:30	12:30-13:00	15:30-15:45	15:45-16:00		
Friday	06:00	08:00-08:30	08:30-09:00	10:00-10:15	10:15-10:30	12:00-12:30	12:30-13:00	15:30-15:45	15:45-16:00

Cost per employee per hour

The cost per employee per hour is 20 euros. Within the breaks (Table 16), there is a part of the break that Hamifleurs pays to the employee each day. For each break and weekday this is different. When the employee starts at six, the second and the last break is paid by Hamifleurs. When an employee starts at seven, half of the first break is paid by Hamifleurs and the last break is totally paid by Hamifleurs. At the last start time, when employees start at eight, Hamifleurs pays for the first and last break.

Summarized, the input data is:

- Arrival of trolleys from the suppliers
- Processing time
- Supply throughput
- Amount of receiving points
- Amount of employees and their tasks
- Work planning of the employees
- Cost per employee per hour

4.2.5 Output data

The output data consists of the performance indicators that are appropriate to compare and base conclusions on. Some explanations of the output data are given, followed by a summary of the output data.

When the trolleys have a lower lead time at the production street, there will be a less amount of trolleys at the production street. With a lower amount of trolleys at the production street, the trolleys can directly be transferred to the production street, while maintaining a safe environment for the employees.

The effect of the flexibility of the employees to switch receiving point and the difference in the amount of receiving points can be measured through the utilization of the employees. Even as the waiting time and lead time of the trolleys, when there is more flexibility at the employees or when there will be a different amount of receiving points. Within the utilization we made a distinction between the

effective utilization and the utilization that also includes the extra times that are used. The extra time is the time that is needed when the location of receiving processes is changed and/or the employees can execute process step 1 at several receiving points. With help of the difference between these two utilizations, the utilization that is not effective can be seen.

There are also some problems in the scope that cannot be measured as output data in the conceptual model. Namely that it is hard to visually distinguish difference between types of flowers per receiving point and that it is hard to put the right stickers at the right batch for this reason. Knowledge retrieved from the employees at the receiving points is, that when several receiving points will be combined, it could get easier to see the difference between types of flowers and to put the right sticker at the right batch.

Summarized, the output data is:

- Average waiting time of the trolleys before they start with their next step in the process
- Average lead time of the trolleys to go through the whole receiving processes
- Average time needed to finish after the last arrival of that day
- Average utilization of the employees per weekday, one including the extra time and one excluding the extra time.
- Average difference between the effective utilization (without the extra time) and the utilization that includes the extra time
- Average labor costs per weekday

4.2.6 Flowcharts

The flowcharts used to set up the model are shown in this section. The process flowchart is presented in Figure 16. This flowchart describes the processes of one trolley. First the trolley is moved to the buffer of step 1, followed by executing step 1. When step 1 is finished, the trolley is moved further to the buffer of step 2, where step 2 will be executed and will be moved to the storage.

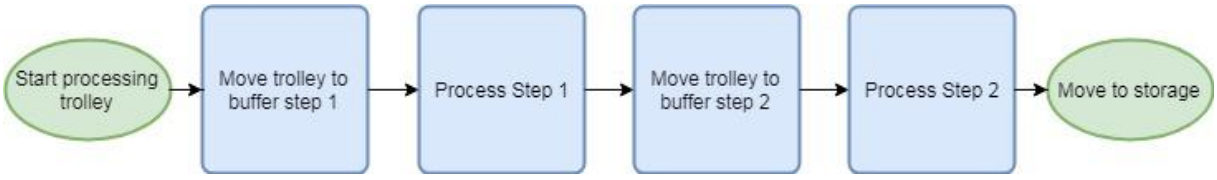

Figure 16: Process flowchart

A scheme of the logic flowcharts is given in Figure 17. Before the run starts, the supply data have to be selected. When time is running, trolleys arrive at their arrival time. This event triggers the following event namely ‘Start work’. This event is also triggered at the end of a break. Within the event ‘Start work’ the event ‘Employee available’ is triggered. Within the event ‘Start work’, the time that the trolley is finished in that process step is determined. With help of this finish time, the event ‘Employee finish process step trolley’ is called in advance. After the event ‘Employee finish process step trolley’, the event ‘Start work’ is triggered again, because an employee will get available when work is finished. When all the trolleys of a day went through the process, the event ‘End day’ is triggered.

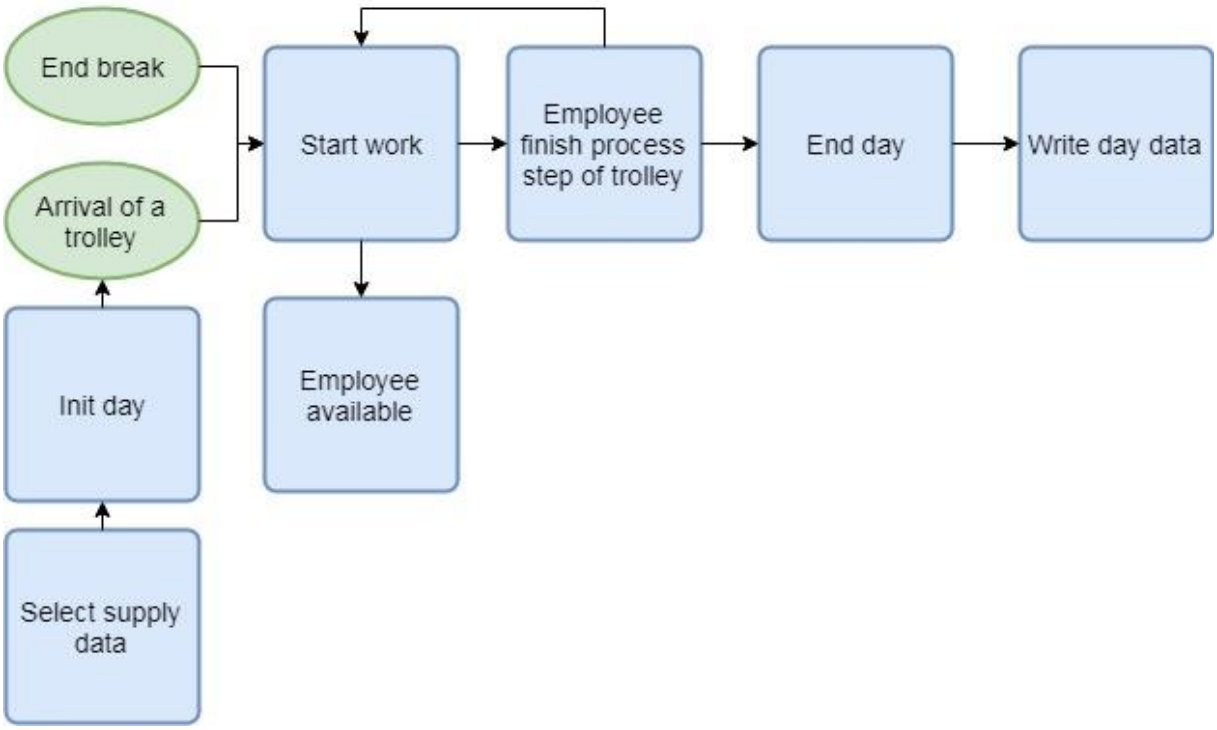

Figure 17: Scheme of logic flowcharts

When an arrow goes to right, the answer is no, when the arrow goes down, the answer is yes in the logic flowcharts of Figure 17. The supply data have to be selected first for the amount of runs. When the supply data is selected we come to the first event, namely 'Init day'. The flowchart of 'Init day' is presented in Figure 18. At the beginning of each day, there have to be checked whether the current week is equal to the amount of weeks that has to run. Depending on the decision the event 'End' or the 'Set start time, latest arrival time and select right employees table' is selected. Within this event 'End' the time stops and the simulation is finished.

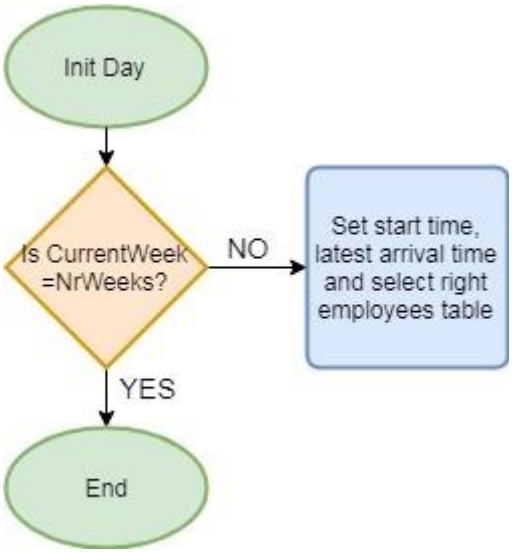

Figure 18: Init Day

The sources were trolleys are created, are called at the times stated in the delivery tables, which contain all the arrival times. When a trolley arrives within the current situation and in the new location

of the receiving processes, the attributes have to be set right and the buffer will be moved to step 1 where the event 'Start work' (Figure 21) is triggered. The flowchart of the event 'Arrival of a trolley' within the current situation and the new location is presented in Figure 19.

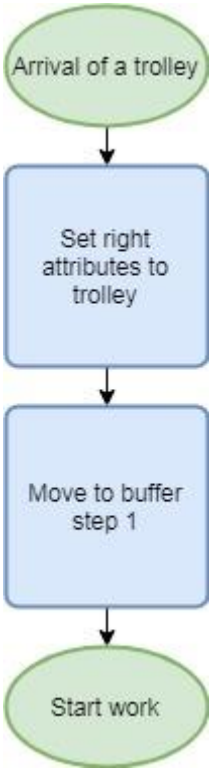

Figure 19: Arrival of a trolley (current situation and new location)

The flowchart of the event 'Arrival of a trolley', when the current location is used, is shown in Figure 20. Within this flowchart, extra buffers are used to maintain the safety of the employees. Because of the use of buffer, there is a difference with the flowchart of Figure 19, which is used for the current situation and the new location. When a trolley arrives, the attributes of that trolley are set right followed by the transport of the trolley to the buffer of the supplier. When a trolley is moved to the buffer of the supplier, or when the maximum time of a trolley in the buffer of the supplier is reached, it is whether there is space at the production street. The amount of trolleys at the production street cannot exceed the amount of 230 trolleys. If so, and there is space, it is checked whether there are 16 trolleys waiting at the supplier buffer, or if there is a trolley waiting for longer than the maximum time or whether the last trolley is arrived. To move a batch of 16 trolleys is optimal, but when the maximum time is exceeded or when the last trolley has arrived, an exception is made and the trolleys have to be moved to the production street. If one of those decisions is true, the trolley is moved to the buffer of Hamifleurs. At this buffer it is checked whether there is space for the trolley(s) at the receiving point buffer. If so, the trolley is moved to step 1 and the event 'Start work' is triggered. The time for moving the trolleys from and to the buffer of step 1 and 2, is included in the extra time of processing step 2. When the event 'End' occurs the time continues running, without changing anything.

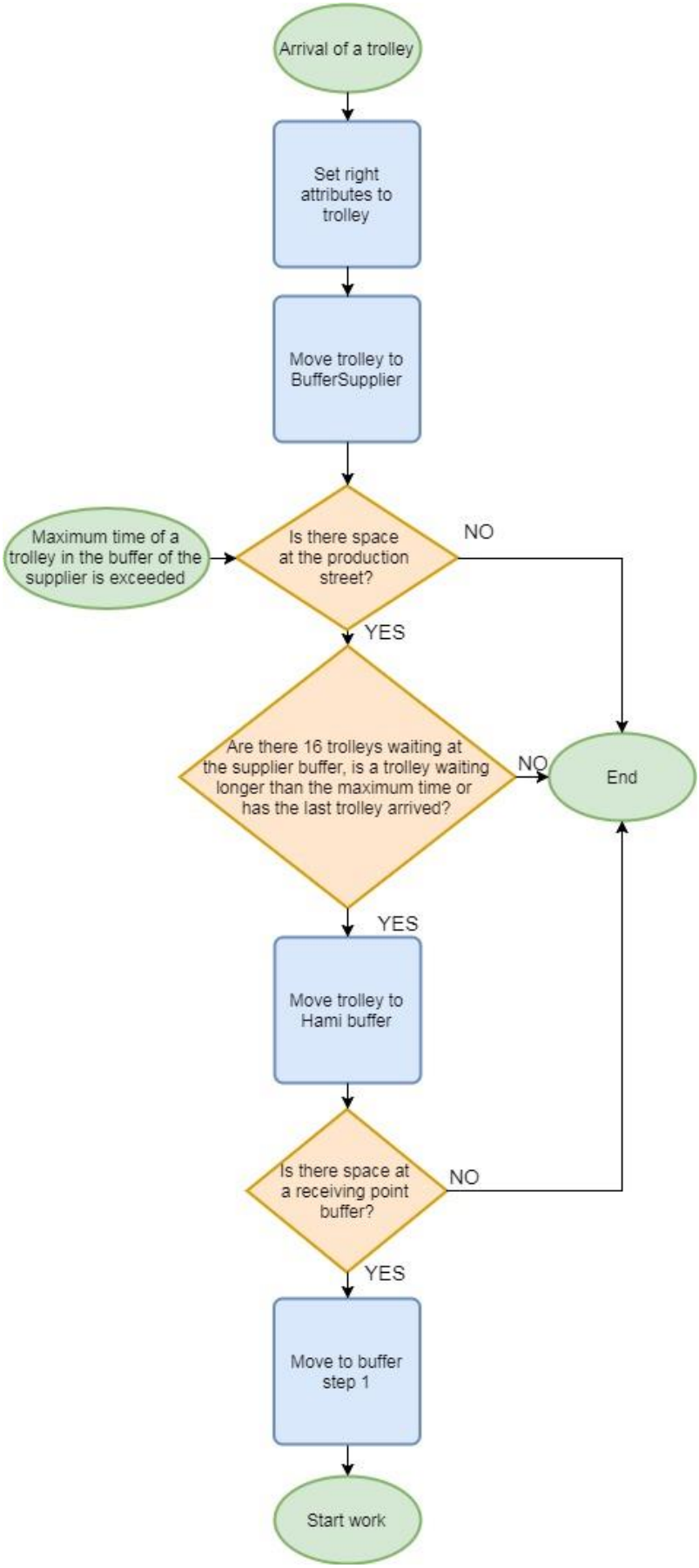

Figure 20: Arrival of a trolley (current location)

The event ‘Start work’ is triggered at the arrival of a trolley at buffer step 1, at the end of a break and when an employee finishes a process step of a trolley. The corresponding flowchart is presented in Figure 21. Within the event ‘Start work’ for each receiving point and process step it is checked whether the buffer is not empty and trolleys are waiting. When there is a trolley in the buffer, it is checked whether there is place in the receiving point and process step. When this is also true, the event ‘Employee available’ (Figure 22) is triggered. When there is an employee available, this employee is set unavailable and the time finished of the employee is noted and the process step is executed by that trolley and employee. When the event ‘End’ occurs the time continues running, without changing anything.

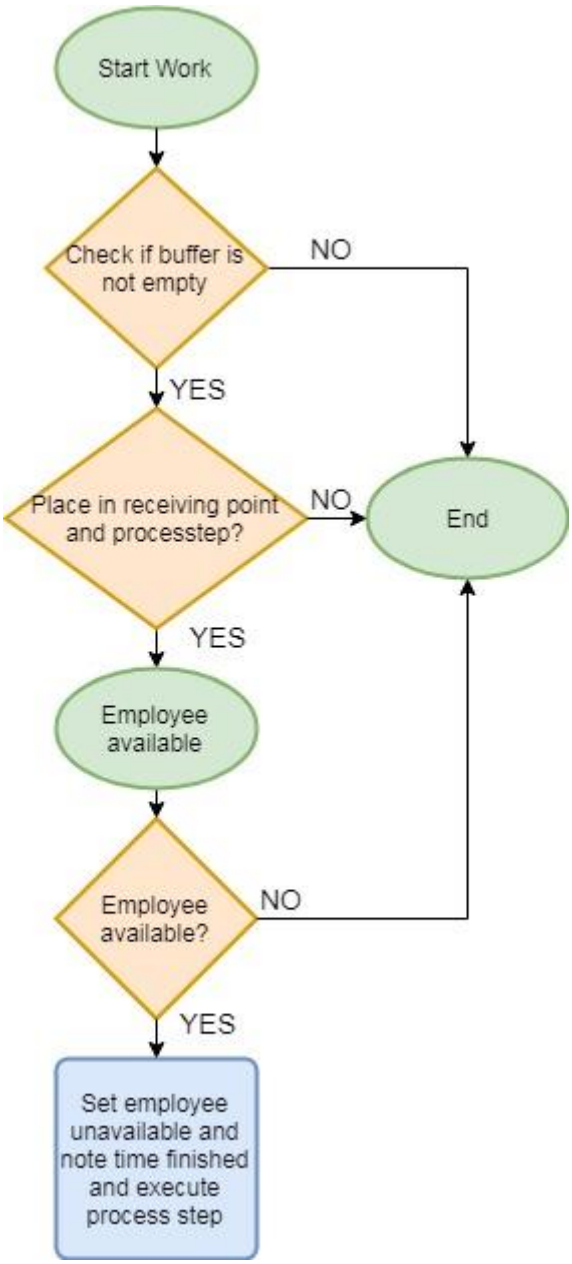

Figure 21: Start work

The event ‘Employee available’ is presented in Figure 22 and is triggered by the event ‘Start work’ (Figure 21) when a trolley is waiting for a receiving point and process step, while there is space at that receiving point and process step. Within this event there is checked whether an employee is available for the needed processing station.

In the employee table the number of employee is stated together with some attributes like process step and process station. One employee can contain multiple rows. Therefore, it is checked whether there is a row in the employee table with the same employee number. If so, it is checked whether one of those rows has a job. If so, the employee is not available because the employee is already on a job. When the rows of the employee do not have a job, the last location is set the same for the other row of the same employee.

Thereafter the specifics breaks are set to true if the current time is within the time range of the correspond break, and to false otherwise. When there is no row that has the same employee number and the employee does not have a job, specifics breaks are also set to true or false. If the employee has a job, the employee characteristics are set to not available, which means that the employee is not available.

When the specific breaks are set to true or false according to the time, the question is asked whether the employee is available. If this is not the case, the employee is not available, but if so, it is checked whether the employee is able to work at that specific processing point. If this is not the case, it is checked whether the employee already has a last location, and if this last location is equal to the required processing station. If this is not the case, it is checked whether there is another employee available, where the last location is equal to the required processing station. If so, this employee is available and will execute a trolley on that processing station. If this is not the case it is checked whether there is space at the last location processing station of the earlier defined employee. If so, it is checked whether there are trolleys waiting at the buffer of the last location processing station. If so, there is checked whether the processing step of the employee is step 1 and if the last location of that employee is equal with the required processing station. If so, some extra time is added, because the employee has to walk to another processing station and this employee will execute a trolley on that processing station. Otherwise there is no space or trolleys and is the employee not available to execute a process step.

The result of this flowchart is used in the event ‘Start work’ (Figure 21). If an employee is available, the employee can execute the process step, otherwise the employee cannot, because the employee is not available or there is no space or trolley at the processing station.

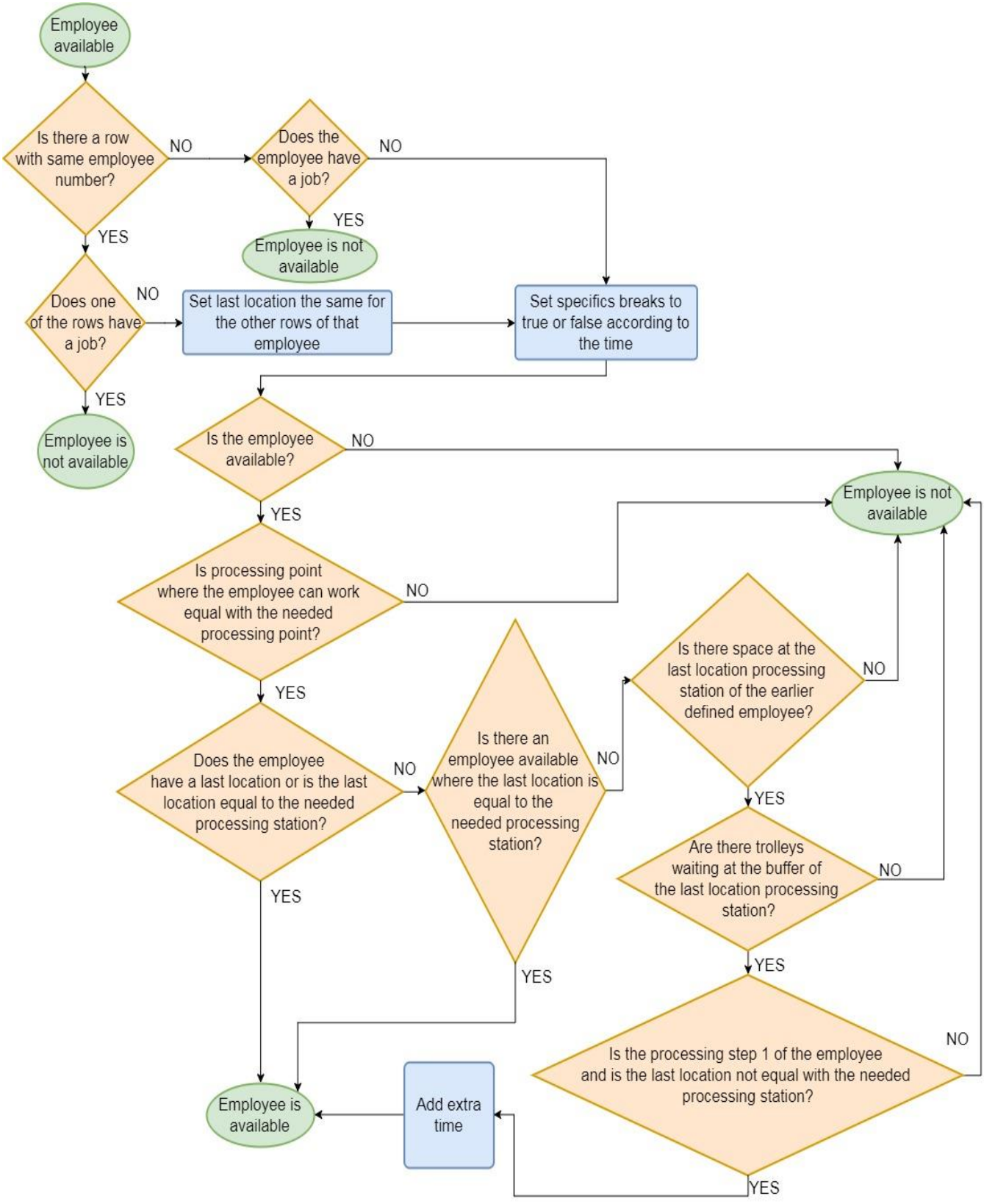

Figure 22: Employee is available

The flowchart of the event 'Employee finish process step of trolley' is presented in Figure 23. This flowchart is triggered when the time is exceeded from the event 'Start work' (Figure 21). Here the trolley is moved to the destination and the employee that executed the trolley is set available. When

the last trolley is already delivered and the buffer- and process stations are empty, the event 'End day' is triggered. Within 'End day' the total break time for each group is calculated. Followed by 'Write data' that writes the gathered data into tables. Otherwise the event 'Start work' is triggered (Figure 21).

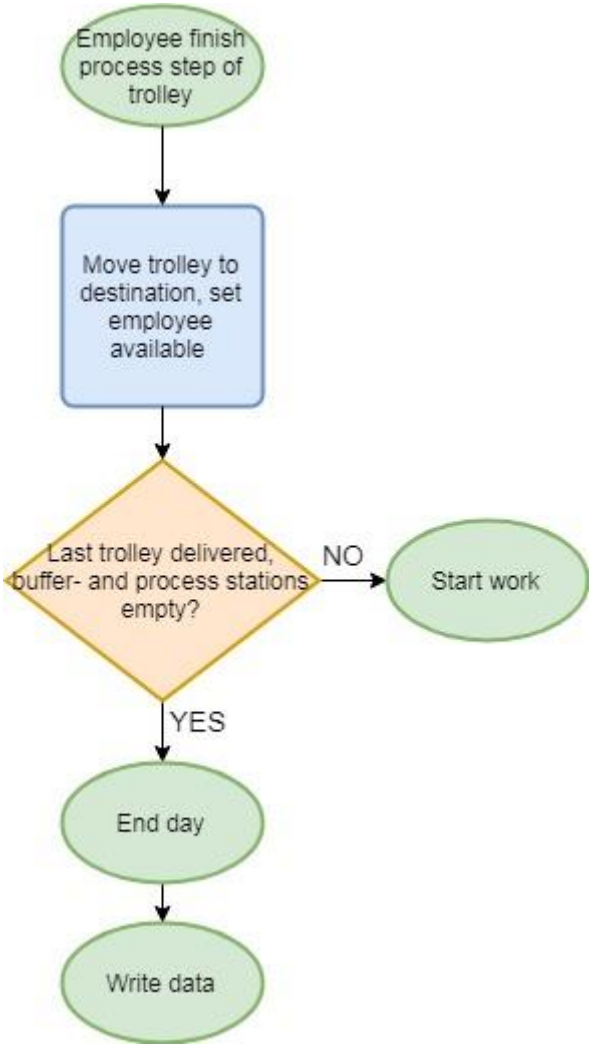

Figure 23: Employee finish process step of trolley

4.2.7 Type of simulation

The receiving process of this research can be modelled using a terminating simulation and for this reason no warm up length is needed during the experimentation. The reason that this is a terminating simulation is because every day the system starts and ends with an empty system. The day is only finished when all the trolleys went through the processing steps and are stored in the defined areas. Each weekday needs a different amount of hours of employees to process the trolleys through the receiving processes as is shown in Table 9. For this reason, experiments are executed for each weekday separately. So, the run length for the experimentation is a day, for each weekday.

4.2.8 Determining the number of replications

To determine the number of replications, the confidence interval half width of the average lead time have to be smaller than the relative error for each weekday. The lead time used to calculate the average lead time is the amount of processing and waiting time excluding the extra time that is used. The extra time includes for example the travel and walking time from a receiving point to another. The

reason that we choose to look at the confidence interval of the average lead time per trolley, is that this includes both the processing and waiting time. When the confidence interval is smaller than the relative error, the number of replications that is therefore used is considered to be satisfactory. One replication contains a day and the confidence interval is calculated for each day. Within the number of replications that are determined out of the confidence intervals, the maximum number of replications needed to get a good confidence interval for a day is used as the number of replications for this model. This is executed for each weekday. The number of replications needed for the Monday, Tuesday, Wednesday, Thursday and Friday, are 35, 87, 21, 81 and 136 respectively. These numbers of replications are also used for these weekdays. In Appendix G, more insight is given into the calculation of the relative error and the confidence interval. The alpha in the confidence interval is 5% and the relative error γ is 10%.

4.3 Implemented model

'What does the implemented model look like?'

Figure 24 represents the main frame of the simulation model. A description of the simulation model is given below. Not all the methods are described, but they are explained with the help of flowcharts in Section 4.2.6.

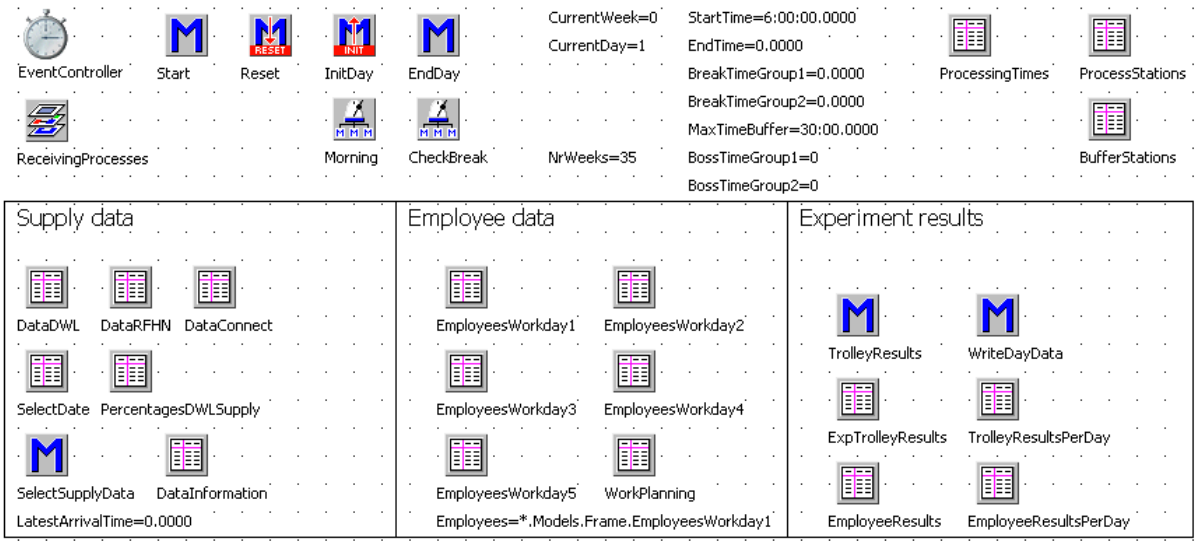

Figure 24: Main frame of the simulation model

To start the simulation model, the 'Start' method has to be run. This 'Start' method calls the 'Reset' method, followed by the method 'SelectSupplyData' where after the EventController will start. The 'Reset' method deletes the produced tables and sets all configurations back to the basis. The 'SelectSupplyData' method, selects the data for the weeks that are needed to run the model with enough accuracy. The data is selected from the tables 'DataDWL', 'DataRFHN' and 'DataConnect' which contains historical data of the arrival processes of the corresponding suppliers. The table 'SelectDate' ensures that only dates can be selected with a specific weekday. The tables 'ArrivalRFHN', 'ArrivalDWL' and 'ArrivalConnect' in Figure 25, that presents the frame 'ReceivingProcesses' and will be explained more later, will be filled with the selected data.

When the ‘StartTime’ is equal to the time of the EventController, the generator ‘Morning’ is called. When the generator ‘Morning’ is activated, the method ‘InitDay’ will start. The generator ‘CheckBreak’ calls the method ‘StartWork’ at the ReceivingProcesses frame every quarter to check if there is work and if there is an employee available. The variable ‘CurrentWeek’ presents the current week, whereas that the variable ‘CurrentDay’ represents the current day. In the variable ‘NrWeeks’ the amount of weeks (runs) that have to be performed can be defined. The variables ‘StartTime’, ‘EndTime’, ‘BreakTimeGroup1’, ‘BreakTimeGroup2’ represent the start time of the day, the end time of the day, the amount of time that group 1 has had a break and the amount of time that group 2 has had a break respectively. The variables ‘BossTimeGroup1’ and ‘BossTimeGroup2’ represent the time that Hamifleurs will pay for break of the employee.

The variable ‘MaxTimeBuffer’ is not used in the current situation but is used in the experiments. When using the current location, this variable presents the maximum time that the trolleys can be waiting in the buffer of the supplier to complete a batch that can be moved to the production street of Hamifleurs. When this maximum time is reached, the trolleys that are in the buffer of the supplier will be moved to the production street of Hamifleurs, even if the batch is incomplete. Within the new location, this variable presents the time that trolleys can wait to form a batch at step 2 of the receiving processes to be moved to their refrigerated/conditioned area.

The table ‘ProcessingTimes’ presents the mean time and the standard deviation of the time that is needed for a trolley at each processing step, receiving point and supplier. The table ‘ProcessStations’ represents in the first column the processing stations that execute step 1 and the second column the processing stations that execute step 2 of the receiving processes. The table ‘BufferStations’ represents the buffer stations, processing stations and the destination of the processing stations.

To finish the description of the supply data, the tables of the ‘PercentagesDWLSupply’ and ‘DataInformation’ still have to be explained, as well as the variable ‘LatestArrivalTime’. The table ‘PercentagesDWLSupply’ shows the percentages of trolleys that have to go to a specific receiving point on a specific day. The table ‘DataInformation’ contains the dates that are chosen for each week and day. The latest arrival time of these dates is also noted in this table. This brings us to the variable ‘LatestArrivalTime’, which is the latest arrival time for the current day and week.

The box ‘Employee data’ contains the employee data through several tables and a variable. The tables ‘EmployeesWorkday1’, ‘EmployeesWorkday2’, ‘EmployeesWorkday3’, ‘EmployeesWorkday4’ and ‘EmployeesWorkday5’ contain the configurations and variable data of the employees for that weekday. The employees that execute the process steps at the receiving processes are passive objects. Reason for this is that the employees can now work easily at several receiving points and process steps. The specifications of the employee are stated in one of above named tables. Each row in this table contains an employee number with the corresponding configurations; receiving point, processing step and break group. During the simulation the variable data for each row is checked whether the employee is available, what the current location and trolley of the employee is, what the time is that the employee is finished, the total processing time, amount of trolleys finished of that employee, the last location of that employee and the amount of extra time that is needed to execute the processes. The table ‘WorkPlanning’ represents the start time of the day and the start, end and break time for each group and weekday. The variable ‘Employees’ shows which table of the employees is used for the current day.

The box ‘Experiment results’ contains two methods ‘TrolleyResults’ and ‘WriteDayData’. These methods are both used to store data gained from the simulation model in the tables ‘ExpTrolleyResults’, ‘EmployeeResults’, ‘TrolleyResultsPerDay’ and ‘EmployeeResultsPerDay’. The method ‘ExpTrolleyResults’ is called when there is an entrance of a trolley on the storage at the receiving processes frame and writes the data of the trolley in the table.

The ‘ReceivingProcesses’ frame (Figure 25) also needs some explanation.

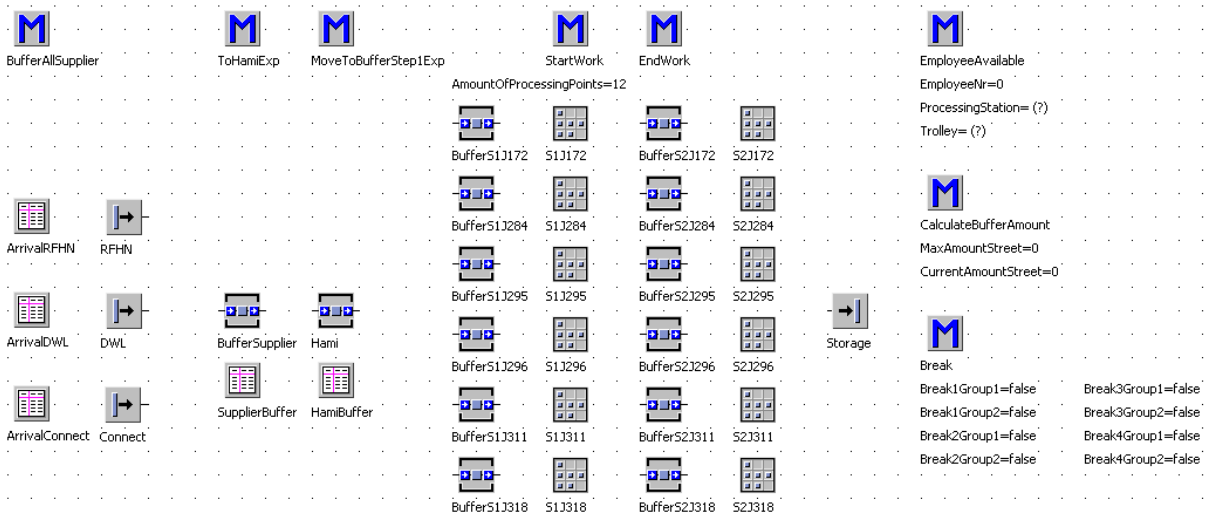

Figure 25: Receiving processes frame of the simulation model

The method ‘BufferAllSupplier’ sets the right attributes to the created trolleys (MU’s). The trolleys are created through the sources ‘RFHN’, ‘DWL’ and ‘Connect’, which are controlled by the delivery tables ‘ArrivalRFHN’, ‘ArrivalDWL’ and ‘ArrivalConnect’ respectively. In the current situation the trolleys are directly moved to the right buffer with the methods ‘ToHami’ and ‘MoveToBufferStep1’. During the experiments, the buffers ‘BufferSupplier’ and ‘Hami’ are also used, because with the experiments some extra code is added to the methods ‘ToHami’ and ‘MoveToBufferStep1’. The trolleys that are in these buffers are noted in the tables ‘SupplierBuffer’ and ‘HamiBuffer’ respectively. The variable ‘AmountOfProcessingPoints’ represents the amount of processing stations in the receiving processes. The methods ‘StartWork’ and ‘EndWork’ are responsible to start and end the work. The method ‘EmployeeAvailable’ checks whether an employee is available and if so, the number of that employee is presented in the variable ‘EmployeeNr’. The variables ‘ProcessingStation’ and ‘Trolley’ are the processing point and trolley that are saved on the frame to be used through several methods. The method ‘CalculateBufferAmount’, calculates the amount of trolleys in the buffer. The variable ‘MaxAmountStreet’ presents the maximum amount of trolleys at the production street during the simulation, which is calculated in the method ‘CalculateBufferAmount’. The variable ‘CurrentAmountStreet’ represents the current amount of trolleys on the street during the simulation. The method ‘Break’, compares the time of the event controller, with the time of the breaks presented in the earlier mentioned work planning and sets the variables to true or false, depending if there is a break for a specific group.

4.4 Verification and validation

'Does the simulation model accurately represents the conceptual model and reality?'

To know whether the simulation model represents the conceptual model and reality, the model is verified and validated. With the help of verification, it is checked whether the simulation model represents the conceptual model. The model is verified to ensure the accuracy, correctness and truth of the gained information, while validation checks whether the simulation model represents reality well enough.

4.4.1 Verification

During coding the simulation model is tested on correctness with help of debugging, following MU's (Moving Units) through the model and checking tables that presents the gained results. Step by step a verification is executed when a new (part of a) method was build. For example, it is checked whether the incoming amount of trolleys per receiving point is equal to the outgoing amount of trolleys.

4.4.2 Validation

To validate the simulation model, first the configurations of the model are clearly defined, followed by an explanation of the difference in the amount of employees between the current situation (reality) and the simulation model. According to this difference, new labor costs, utilizations and waiting times of the employees are implied. Thereafter, we did a t-test on significance differences between the reality (Section 3.5) and the simulation model.

Configurations

The current situation contains six receiving points. According to the operational manager, the optimal occupation for the receiving processes is eight employees for the Thursdays and 11 employees for the other days. All the employees have the same break group. Some employees execute both processing steps of their receiving point, other employees execute their processing step at more receiving points, while some employees only execute processes at one receiving point and one processing step. The configurations of the current situation that are used in the simulation model are mentioned in Appendix H. This appendix also presents the results of the current situation that are obtained using the simulation model.

Difference in the amount of employees

There is a difference in the amount of employees in the reality and in the simulation model as is showed in Table 17. The amount of employees used in the simulation model is the optimal occupation for the receiving processes, which is desirable but not always achievable. The amount of employees in the reality is the average amount of employees that is gathered through the historical data. The end time for both the current situation and the simulation model is nearly the same. When changing the amount of employees a little bit, the end time for both situations would stay nearly the same because in both cases employees must wait for the last trolley. The amount of employees has an impact on the labor costs and utilization and waiting times of the employees, but also on the lead times of the trolleys. An honest comparison between the simulation model and the current situation can be made while taking into account the difference amount of employees in the simulation model and the current situation (reality). Therefore, some corrections are made on the results regarding to the labor costs, utilization and waiting times of the employees. For example, the amount of employees is not equal when the

amount of employees in the simulation model is eleven employees and the current situation contains 11.1 employees. Therefore, the labor costs of the simulation model, for example on Monday € 2,105.02 are divided by eleven and multiplied with 11.1, which results in labor costs of € 2,124.16.

Table 17: Amount of employees used per weekday

	Monday	Tuesday	Wednesday	Thursday	Friday
Employees simulation model	11	11	11	8	11
Employees current situation	11.1	10.7	10.2	7.6	9.6

Labor costs

When the difference in the amount of employees is included in the labor costs, new labor costs arise. These new labor costs are shown in Table 18 in the column 'Labor costs simulation model after correction'. The differences between the labor costs of the simulation model after correction and the current situation is presented in the last column of Table 18. The amount of employees and labor costs of the current situation are retrieved from Section 3.5.4.

Table 18: Simulation model current situation: Costs

Weekday	Labor costs simulation model	Labor costs simulation model after correction	Labor costs current situation	Difference between labor costs simulation model after correction and current situation
Monday	€ 2,105.02	€ 2,124.16	€ 1,943.51	€ 181
Tuesday	€ 1,434.83	€ 1,395.69	€ 1,452.88	€ 57
Wednesday	€ 1,439.89	€ 1,335.17	€ 1,173.78	€ 161
Thursday	€ 840.68	€ 798.65	€ 640.15	€ 159
Friday	€ 1,843.50	€ 1,608.87	€ 1,365.97	€ 243
Total	**€ 7,663.92**	**€ 7,262.54**	**€ 6,576.29**	**€ 686**

It is possible that this difference is gained through the processing times that are not exactly the same as in reality. Within the gained data of the current situation for each employee 2 hours per day is used at the distribution center, this is already removed from the data that is presented in the current situation. But within these hours, the assumption is made that the employees did not change their working status officially from the receiving department to the distribution one. That the employees do not change their working status officially is most common and so not taken into account. But when an employee does change their working status officially, the labor costs are deleted extra from the current situation.

Utilizations of the employees

To compare the utilizations of the current situation and the simulation model with each other, the break time that is paid by Hamifleurs have to be reduced with the amount of time that the employees had a break and so did not work. The amount of hours resulting from this is stated as 'Boss time' in

Table 19. Using the results of the simulation model, we can take the average of the time that was paid by Hamifleurs for each weekday and multiply this with the amount of employees in the current situation (Table 17).

When using a higher amount of employees in the simulation model, the utilization should be lower than when a less amount of employees is used. To make an honest comparison between these utilizations, the amounts of employees have to be equal. Therefore the implied utilization of the simulation model is calculated, assuming the same workload, but with the amount of employees that is used in the current situation as stated in (Table 17).

Table 19 shows the results of these calculations. This table shows that the utilizations in the current situation are always higher, except for the Tuesday. This means that the labor costs of the simulation model should always be higher, except for the Tuesdays and the Tuesday should be higher for the current situation than for the simulation model. As presented in Table 18 this is true. The amounts of hours needed and used from Table 19 are retrieved from Section 3.4.3. For the Monday the difference in the utilization is the smallest, the difference in amount of employees in the simulation model or current situation is also the smallest. The Thursday is a special day in the flower business and therefore the difference in the utilization is not unexpected. According to the logistics manager is the difference in utilization and labor costs on the Friday is remarkable. The difference in the amount of employees used in the simulation model and the current situation is also big. Calculating the utilization of the simulation model after correcting the amount of employees is surely different then when the same amount of employees was used in the simulation model. This could explain the difference in the utilization on the Friday a bit.

Table 19: Comparing utilizations current situation and simulation model

	Monday	Tuesday	Wednesday	Thursday	Friday
Amount of hours needed	36:38:38	21:39:32	19:25:53	13:08:19	26:04:49
Amount of hours used	97:10:32	72:38:38	58:41:20	32:00:27	68:17:55
Boss time	05:18:44	02:55:16	02:40:17	03:48:00	03:34:56
Amount of hours used after correction	91:51:48	69:43:22	56:01:03	28:12:27	64:42:59
Utilization current situation	**39.89%**	**31.06%**	**34.69%**	**46.58%**	**40.30%**
Utilization simulation model after correction	**38.17%**	**33.43%**	**30.33%**	**38.02%**	**33.21%**
Difference between utilizations	**1.72%**	**2.37%**	**4.36%**	**8.56%**	**7.09%**

Waiting times of the employees

The average waiting times per employee are calculated and presented in Table 20. The same as with the utilizations, an honest comparison between the waiting times of the current situation and the simulation can only be made with an equal amount of employees. Therefore, the implied waiting times is calculated, assuming the same workload, but with the amount of employees that is used in the current situation as stated in (Table 17).

Table 20: Comparing waiting times current situation and simulation model

	Monday	Tuesday	Wednesday	Thursday	Friday
Waiting time current situation	05:26:50	04:46:18	03:52:04	02:28:14	04:24:33
Waiting time simulation model	05:35:38	04:14:36	03:59:38	03:08:03	05:41:45
Waiting time simulation model after correction	05:38:41	04:05:20	03:42:13	02:58:39	04:58:15
Difference between waiting times	**00:11:51**	**00:40:58**	**00:09:51**	**00:30:25**	**00:33:42**

Test on significance

A t-test is executed, where the labor costs, utilizations and waiting times of the employees are used as means for each weekday in Table 18, Table 19 and Table 20. With an alpha of 5%, there is no significant difference between the labor costs, utilizations and waiting times of the employees of the simulation model and the labor costs, utilizations and waiting times of the employees of the current situation (Appendix H). The comparisons between the experiments and the current situation are executed with the data that is retrieved from the simulation model. Some more detailed results of the simulation model, including times et cetera can be found in Appendix H.

4.5 Conclusion

The main question of this chapter is how the receiving processes can be modelled. With the help of the collection/storage strategies, agreements and input and output data that is needed for the interventions, a simulation model is made while using some assumptions. This simulation model uses the collection/storage strategies, agreements, input data and interventions to create the output data. The interventions are:

- Changing the amount and/or location of the receiving points combined with the amount of employees per receiving point and process step
- Allowing employees to execute both of the process steps and at multiple receiving points
- Use separate breaks for employees
- Limiting the number of trolleys at the production street

The collection/storage strategies used in the new situations are presented in Table 21.

Table 21: Summary of the collection/storage strategies

	Current location	New location
Arrival of the trolleys	Closest open location storage	Closest open location storage
Between step 1 and 2	Closest open location storage	Family grouping
While executing step 2	Dedicated storage, family grouping and closest open location storage	Dedicated storage, family grouping and closest open location storage
Employees	Progressive assembly zoning	Progressive assembly zoning

The agreements that are needed within the model in both locations with the suppliers are about the buffer and receiving location. The agreements while using the new situations are:

- Current location

    - Create a buffer for the trolleys at a place of the suppliers and let the suppliers move the trolleys to this new location, this could include extra costs for the buffer space.
    - When there are 16 trolleys at this buffer, move the trolleys to Hamifleurs if there is space at the production street.
    - When the maximum amount of 45 minutes is passed, move the trolleys that are in the buffer to Hamifleurs, if there is space at the production street.
    - When the last trolley has arrived, move the trolleys that are in the buffer to Hamifleurs, if there is space at the production street.
- New location
    - The trolleys of the suppliers directly have to be brought to the new location.

The input data is:

- Arrival of trolleys from the suppliers
- Processing time
- Supply throughput
- Amount of receiving points
- Amount of employees and their tasks
- Work planning of the employees
- Cost per employee per hour

The output data is:

- Average waiting time of the trolleys before they start with their next step in the process
- Average lead time of the trolleys to go through the whole receiving processes
- Average time needed to finish after the last arrival of that day
- Average utilization of the employees per weekday, one including the extra time and one excluding the extra time.
- Average difference between the effective utilization (without the extra time) and the utilization that includes the extra time
- Average labor costs per weekday

The assumptions that are used to generate the simulation model are:

- The incoming amount of trolleys is the same as the outgoing amount of trolleys at each step
- The trolleys fit in the conditioned/refrigerated areas.
- When performing step 1 of receiving point J2-84 at the production street, step 2 includes the same statistics as the statistics of Group 1 of step 2 of the receiving processes.
- The extra time used for the processing time of step 2 takes into account the changed location of the receiving points and/or the time when the incoming trolleys do not go to their dedicated receiving point.
- The trolleys can only be transported with their own product group, when the location of the receiving processes is at Flora Holland Naaldwijk.
- Each weekday has the same start time of the employees for each week
- Every employee starts and ends at the same time.

An important simplification is that the resistance of the employees is not taken into account, which could occur when changing the work situation. Several flowcharts are made to give a good overview of the simulation model and their events. The type of simulation is terminating with a run length of one weekday. So, each weekday needs its own number of replications and experiments. Verification of the model is executed to ensure the accuracy, correctness and truth of the gained information. And with the validation the conclusion is that the data gained in the current situation (chapter 3) is not exactly the same as the data retrieved from the simulation model. Reasons for this could be that some of the employees sometimes change their working status officially and that the amount of employees in the simulation model and in the current situation is not exactly the same. After performing a t-test on the labor costs, utilizations and waiting times of the employees, we can say that there is no significantly difference when using an alpha of 5% between the data of the simulation model and the data of the current situation (Appendix H). Because there is no significant difference, the data of the experiments is compared with the data of the simulation model.

5 Experimental results

'What are the effects of the interventions in the receiving processes?'

To know what the effects of the interventions are in the receiving points, the experiments and the results of the experiments have to be mentioned for the current and the new location of the receiving processes. Thereafter, a sensitivity analysis is executed for the supply data, by adding and reducing the supply, and the results followed by this analysis are compared with their original results.

5.1 Experiments and results receiving processes

According to the interventions that are made in section 4.1, experiments originate. The interventions indicate the changes in variables and the experiments use several values and decisions for these variables and combine the interventions. Firstly, the design of experiments is mentioned for the current and new location (Section 4.2.1), followed by the results of these experiments per location and weekday.

Within the design of experiments, we made a distinction between the experiments that are executed for each weekday and per weekday. The work planning in Table 16 is the same for each experiment and first there is no difference in break groups between the employees. As mentioned at the input data (section 4.2.4), the maximum amount of employees at the receiving points for the current location is two employees per processing step.

The experiments are evaluated in a simulation model (Section 1.6). The results of these experiments are sorted by the amount of employees, followed by average lead time and average time finished after last arrival. The results that occur when these tables are sorted for each weekday on amount of employees and lead time and time finished after last arrival are presented per weekday. For each amount of employees the best result, i.e. smallest lead time, is chosen and the other results are deleted. When a less amount of employees costs more than a higher amount of employees, this result is also deleted from the best results. These results are discussed with the logistics manager, where from an amount of employees is chosen wherefore more experiments have to be executed for that weekday. The extra experiments on the best results per weekday and location includes using separate break groups for the employees. The best lead times per weekday and location could have large difference, which is because the amount of hours work per weekday is fluctuating (Section 3.4.3) and the end time per day is also very different.

During the experiments with separate breaks for the employees, differences could occur in labor costs. These differences are due to breaks where employees finish their work in the break time, but do not get paid. It is cheaper when employees has the early break and finish their work during the beginning of the break. Compared to a situation with an employee that has the latest break and get paid for their work but finish their work for the break. In the real situation, sometimes breaks are skipped, so little labor costs differences do not apply here.

For both the current and new location the originated experiments and results from the proposed interventions are mentioned.

5.1.1 Experiments and results current location receiving processes

'Which experiments originate from the proposed interventions and what are these results, when using the current location of the receiving processes?'

For the current location (Section 4.2.1), first 15 experiments are executed for each weekday. The experiments executed for each day are described and defined in Table 22. The more detailed configurations of these experiments that are executed for each weekday can be found in Appendix I. For each weekday the results of the experiments and the best results are shown in Appendix K, according to the design of experiments described in Section 5.1, followed by an experiment with separate break groups by the best result chosen by the logistics manager.

Table 22: Summary of the experiments executed for each weekday using current location receiving processes

Experiments	Amount of receiving points	Amount of employees	Employee(s) proceeding step 1 at multiple receiving points	Employee(s) proceeding step 2 at multiple receiving points	Employee(s) proceeding both steps
Experiment I	6	9	No	Yes	No
Experiment II	3 (J3-18 dedicated)	9	No	No	Yes
Experiment III	3	9	No	No	No
Experiment IV	3	8	No	Yes	No
Experiment V	3	7	No	No	Yes
Experiment VI	2	8	No	No	No
Experiment VII	2	8	No	Yes	No
Experiment VIII	2	7	No	Yes	No
Experiment IX	2	7	No	Yes	No
Experiment X	2	6	No	No	No
Experiment XI	2	6	No	No	Yes
Experiment XII	2	6	No	Yes	No
Experiment XIII	2	5	Yes	No	No
Experiment XIV	2	5	No	Yes	No
Experiment XV	1	4	No	No	No

The results of the experiments are presented together with the sorted best results for each weekday in Appendix K. From the best results tables in Appendix K, the logistics manager chooses the best solution for each weekday, which results in the best results that are shown in Table 23.

For the Monday, two experiments are chosen, the best experiment chosen by the logistics manager contains three receiving points. That is why we decided to add another experiment also to the best results, because this experiment contains two receiving points and the difference in results is not that big. On both these experiments, experiments are executed with separate break groups for the employees. For the other weekdays applies that only one experiment is chosen by the logistics manager to do the extra experiments on with separate break groups for the employees.

Table 23: Best results current location

Weekday	Amount of employees (amount of receiving points)	Separate break or not	Average lead time	Average time finished after last arrival	Labor costs
Monday	8 (3)	No separate breaks	00:34:13	00:19:36	€ 1,440.85
		Separate breaks	00:32:13	00:18:28	€ 1,439.52
	8 (2)	No separate breaks	00:35:31	00:17:20	€ 1,434.80
		Separate breaks	00:32:29	00:16:20	€ 1,433.83
Tuesday	6 (2)	No separate breaks	00:27:03	00:20:23	€ 797.03
		Separate breaks	00:26:26	00:20:38	€ 797.50
Wednesday	5 (2)	No separate breaks	00:34:39	00:26:28	€ 681.41
		Separate breaks	00:32:48	00:24:21	€ 678.34
Thursday	4 (1)	No separate breaks	00:49:41	00:20:44	€ 411.81
		Separate breaks	00:48:08	00:21:06	€ 413.28
Friday	5 (2)	No separate breaks	00:48:13	00:28:57	€ 850.24
		Separate breaks	00:46:27	00:28:13	€ 849.96

A more detailed overview of the configuration per weekday for the current location of the receiving processes is presented in Appendix L. In all weekdays it is better for the lead time and time finished after last arrival to have separate breaks for the employees. The divisions of the employees per break group are also stated in Appendix L for each weekday.

The average waiting time of an employee and the labor costs reduces with 42% and 46% respectively compared with the current situation when using the current location and no separate breaks. The average utilization of the employees increases with a factor of 1.99 compared to the current situation. These results are presented for each weekday in Appendix K.

5.1.2 Experiments and results new location receiving processes

'Which experiments originate from the proposed interventions and what are these results, when using a new location for the receiving processes?'

For the new location (Section 4.2.1), first 17 experiments are executed for each weekday. The experiments executed for each day are described and defined in Table 22. The more detailed configurations of these experiments that are executed for each weekday can be found in Appendix J. The differences between these experiments are the amount of employees that execute step 1 and step 2 of the receiving processes. For each weekday the best results are shown according to the design of experiments described in Section 5.1, followed by an experiment with separate break groups by the best result chosen by the logistics manager.

Table 24: Summary of the experiments executed for each weekday using new location receiving processes

Experiments	Amount of employees	Amount of employees for step 1	Amount of employees for step 2
Experiment XVI	11	6	5
Experiment XVII	11	5	6

Experiment XVIII	10	5	5
Experiment XIX	10	4	6
Experiment XX	10	6	4
Experiment XXI	9	5	4
Experiment XXII	9	4	5
Experiment XXIII	8	4	4
Experiment XXIV	8	3	5
Experiment XXV	8	5	3
Experiment XXVI	7	4	3
Experiment XXVII	7	3	4
Experiment XXVIII	6	3	3
Experiment XXIX	6	2	4
Experiment XXX	6	4	2
Experiment XXXI	5	2	3
Experiment XXXII	5	3	2

The results of the experiments are presented together with the sorted best results for each weekday in Appendix M. From the best results tables in Appendix M, the logistics manager chooses the best solution for each weekday, which results in the best results that are shown in Table 25.

Table 25: Best results new location

Weekday	Amount of employees	Separate break or not	Average lead time	Average time finished after last arrival	Labor costs
Monday	9	No separate breaks	00:38:02	00:20:09	€ 1,634.58
		Separate breaks	00:33:56	00:17:47	€ 1,629.80
Tuesday	7	No separate breaks	00:35:23	00:25:50	€ 951.89
		Separate breaks	00:32:36	00:23:29	€ 948.26
Wednesday	6	No separate breaks	00:36:34	00:22:35	€ 817.92
		Separate breaks	00:37:25	00:25:37	€ 815.98
Thursday	7	No separate breaks	00:34:46	00:18:56	€ 724.91
		Separate breaks	00:32:03	00:17:08	€ 722.47
Friday	7	No separate breaks	00:32:00	00:23:19	€ 1,186.51
		Separate breaks	00:28:33	00:20:35	€ 1,180.57

A more detailed overview of the configuration per weekday for the new location of the receiving processes is presented in Appendix N. In all weekdays it is better for the lead time and time finished after last arrival to have separate breaks for the employees. The divisions of the employees per break group are also stated in Appendix N for each weekday.

The average waiting time of an employee and the labor costs reduces with 48% and 31% respectively compared with the current situation when using the new location and no separate breaks. The average utilization of the employees increases with a factor of 2.10 compared to the current situation. These results are presented for each weekday in Appendix M.

5.1.3 Comparisons current situation, current location and new location

To compare the new location with the current location of the receiving processes, the results from the current situation are also presented in Figure 26, Figure 27 and Figure 28. The data of the experiments is compared with the data of the current situation that is retrieved from the simulation model. This data is used instead of the reality data, because as mentioned in Section 4.4.2 there is no significantly difference between the reality data and the data retrieved through the simulation model. As we can see in Figure 26 does the current situation mostly have the shortest average lead time and time finished after last arrival, this also results in the highest cost as shown in Figure 28.

Figure 26 shows that the average lead time when using the new location of the receiving processes is most steady. The same applies at Figure 27 that represents the average time finished after last arrival. This is mostly a consequence of the decisions that are made by the logistics manager. The logistics manager chooses the best results on the amount of employees and lead times per weekday. The best lead time is different for each weekday, which results, especially for the results of the current location in a fluctuating lead time for the week.

The times of the new location are not always smaller than the times when using the current location or the current situation. The processing time of step 2 is per definition four and three minutes and fifty seconds longer than when using the current situation and location respectively. Another difference in the lead time is that with the new location, the trolleys have to wait to form a batch of minimal six trolleys. While at the current location the trolleys are directly moved to the storage when an employee is available. Trolleys could spend thirty minutes in the buffer of step 2. In reality the chance is high that when there are for example three batches from five trolleys at the buffers, these batches will be combined and be travelled earlier to the storage which results in a shorter lead time. In the other way at the current location, the trolleys have to wait at the buffer of the supplier when they did not form a batch of sixteen trolleys for example. But the average time at the buffer of the supplier is five minutes.

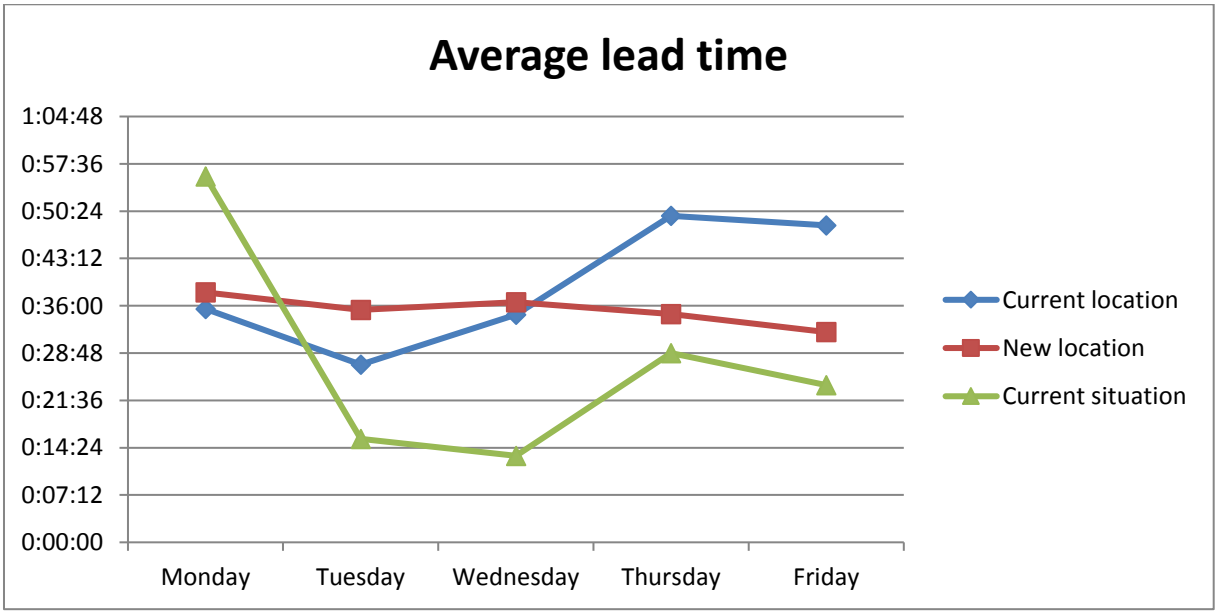

Figure 26: Average lead time comparisons

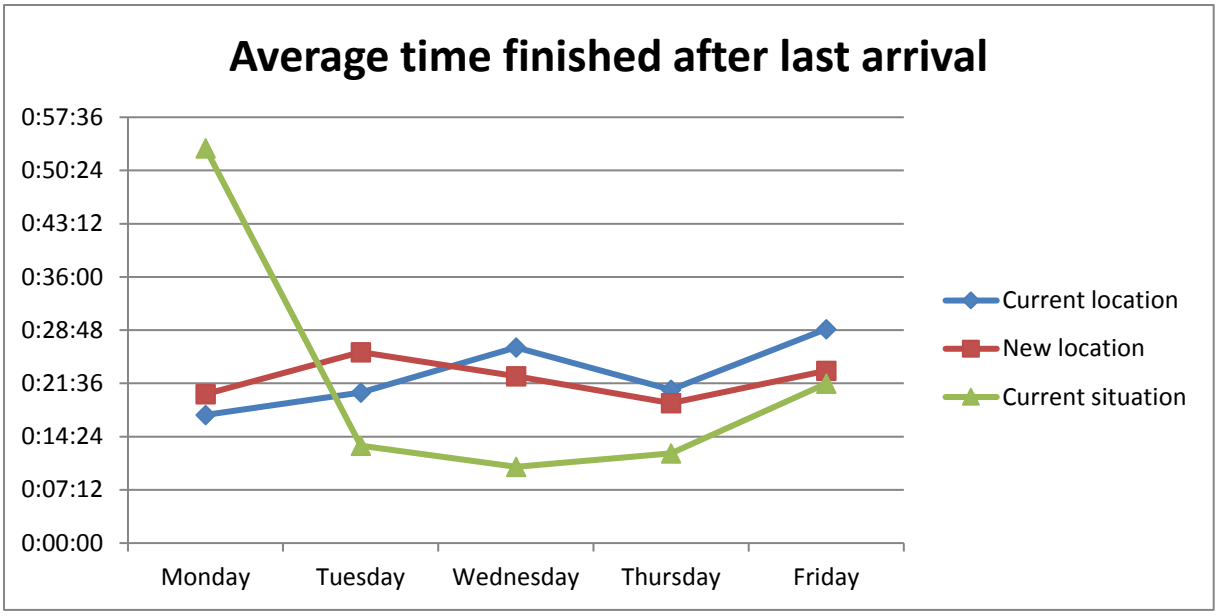

Figure 27: Average time finished after last arrival comparisons

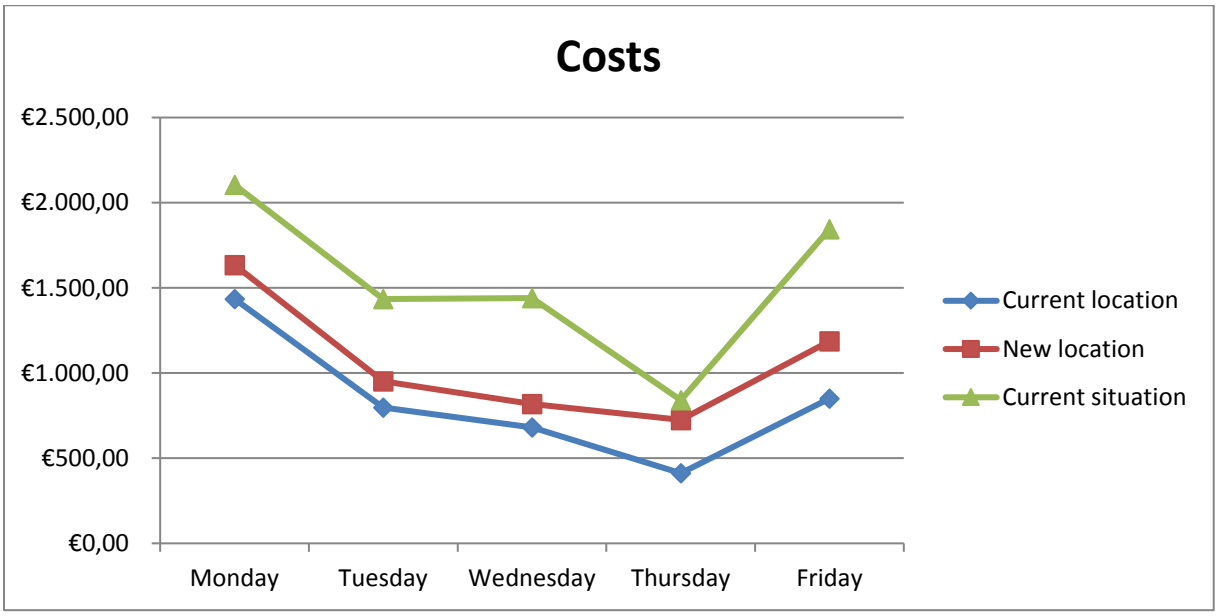

Figure 28: Labor costs comparisons

The difference in labor costs between the results is mainly because the amount of employees is different (Table 26). The amount of employees for process step 1 in the current location and new location, is every weekday the same except for the Monday and Thursday. We assume that the employee of the Tuesday that executes both process steps is approximately one employee extra for step 1 at their receiving point. The only difference for step 1 at the current and new location is the amount of receiving points, which is respectively two and one.

Table 26: Amount of employees per situation, location and process step

Weekday	Current situation (step 1, step 2, both steps)	Current location (step 1, step 2, both steps)	New location (step 1, step 2)	Difference amount employees step 1 in current and new location
Monday	11 (5, 4, 2)	8 (4, 4, 0)	9 (5, 4)	1
Tuesday	11 (5, 4, 2)	6 (2, 2, 2)	7 (3, 4)	0
Wednesday	11 (5, 4, 2)	5 (3, 2, 0)	6 (3, 3)	0
Thursday	8 (3, 3, 2)	4 (2, 2, 0)	7 (3, 4)	1
Friday	11 (5, 4, 2)	5 (3, 2, 0)	7 (3, 4)	0

The amount of processing time is for both locations exactly the same, so the utilizations of the employees for processing step 1 should be the same depending on the average time finished after last arrival. To compare these utilizations with each other, the utilizations are presented per step and presented in Table 27. The utilization for the current situation should be lower for all weekdays for both the current and new location. Because the amount of employees that execute step 1 is for all cases higher. As Table 27 shows it is true that the utilization is lower for the current situation than for the current and new location for the employees that execute step 1.

Table 27: Utilization per step per utilization and location for each weekday

	Current situation			Current location			New location	
Weekday	Step 1	Step 2	Both	Step 1	Step 2	Both	Step 1	Step 2
Monday	39.32%	29.68%	54.18%	60.81%	60.46%		54.27%	84.62%
Tuesday	32.88%	29.95%	36.79%	60.47%	69.71%	73.13%	66.15%	79.12%
Wednesday	28.13%	24.89%	34.56%	57.67%	72.84%		57.14%	83.19%
Thursday	46.55%	28.14%	18.36%	74.32%	66.42%		52.63%	69.39%
Friday	27.01%	24.05%	43.75%	60.61%	77.79%		60.83%	75.38%

The utilization of the new location should be higher than the utilization of the current location for process step 1. The trolleys that are waiting at the new location are directly available for all the employees of process step 1, while at the current location there is a chance that a trolley is waiting at another receiving point than where an employee is available, except for the Thursday. In this case an employee could do nothing while there is a trolley waiting that needs to be processed. The work time of the employees is dependent on when the last trolley is finished (Figure 27). The utilization is also dependent on this, but the amounts of break also have to be taken into consideration. The utilization of the employees for step 1 is always higher for the new location (Table 27), except for the Wednesday. The utilizations of the Monday and Thursday are higher for the current location, but this is related to a higher amount of employees working at process step 1 at the new location.

When the utilizations of the current location are divided with their amount of employees for that process step and multiplied with the amount of employees for step 1 for the new location, the utilization of the new location is higher. This results in a utilization of 48.65% and 49.55% respectively for the Monday and Thursday when the amount of employees in process step 1 change. The utilization of the employees of step 1 for the Wednesday is just a little bit lower for the new location than for the current location. This could be because the average time finished after last arrival is lower for the new

location. This could be on a breakeven point so that the current location includes a break, while the new location finishes just before the break. For the other days, where the average time finished after last arrival is higher for the new location than for the current location, the difference in utilization of the employees for step 1 is higher for the Monday and Tuesday than for the Wednesday. Therefore this cannot be related to the break difference.

The average utilization per situation and location for all employees is presented in Table 28. Even though the amount of employees is higher for the new location for all days, the utilization of these days is also higher for the weekdays, except for the Thursday. The average time finished after last arrival is almost the same for the current and new location for this day, while the average lead time of the current location is a lot higher than for the new location. The same amount of work is executed in almost the same time and the difference in lead time is dedicated to the amount of employees and is visible in the utilizations. The average waiting times of the employees are 04:21:38, 02:35:33 and 02:14:46 respectively for the current situation, current location and new location.

Table 28: Average utilization per situation and location

Weekday	Current situation	Current location	New location
Monday	38.52%	60.63%	67.76%
Tuesday	32.52%	63.10%	73.56%
Wednesday	28.12%	63.74%	70.16%
Thursday	36.12%	75.58%	62.21%
Friday	28.98%	67.48%	69.14%

The average utilizations of the Monday are presented in Table 29 for each situation and location. The utilizations of the current and new location are more equal than the utilizations of the current situation. Comparing the values within the same step with each other, the workload per employee is more even and also higher when using one of the new situations (current and new location) of the receiving processes. For example the workload for different employees that both execute step 1 of the receiving processes, at the same day, differ from as low as 19.86% to as high as 54.40%.

Table 29: Utilizations of the employee at a Monday (italic employees step 2, underlined employees both steps, normal employees step 1)

Employee	Current situation	Current location	New location
1	19.86%	69.32%	56.56%
2	*16.09%*	68.80%	54.89%
3	22.27%	*56.52%*	53.86%
4	54.20%	*48.62%*	53.41%
5	*33.86%*	68.60%	52.60%
6	54.40%	67.96%	*90.01%*
7	*41.89%*	*56.40%*	*86.04%*
8	34.83%	*48.87%*	*82.57%*
9	33.32%		*79.87%*
10	*26.88%*		
11	86.09%		
Mean	**38.52%**	**60.63%**	**67.76%**

The average waiting times per day of the employees are presented in Table 30 for each situation and location. In both the current and new location, the employees have to wait less than in the current situation. For all days the waiting time when using the new location is less, except for the Thursday. This is because the Thursday has in both current and new location one receiving point and more employees are needed at the new location. Employees have to wait when using the new location before executing step 2, so that the trolleys form a batch. Using the current situation, the trolleys can be directly moved and so employees have to wait less.

Table 30: Average waiting times per employee

Situation	Monday	Tuesday	Wednesday	Thursday	Friday
Current situation	05:38:41	04:05:20	03:42:13	02:58:39	04:58:15
Current location	03:25:32	02:24:35	02:28:12	01:15:37	02:40:00
New location	02:49:17	01:45:39	02:01:32	01:54:08	02:31:27

Appendix O presents the percentage lead times, relative to not using separate break groups, compared to the current situation. Especially for the current location there are large differences in lead times, only the lead time of the Monday improves, but this is related to a less amount of employees. The best configurations based on the lead times and amount of employees were chosen by the logistics manager.

When using the best configurations with separate breaks, the percentage differences between the average lead times with and without separate breaks are stated in Appendix O for each weekday. Except for the Wednesday when using the new location, the average lead times will reduce when using separate breaks, this could be related to the fact that trolleys arrive mostly during the breaks of group 2.

Table 31 presents the percentage and factorial differences of the new situations compared with the current situation. The percentage differences of the labor costs, waiting time of the employees, the lead times of the trolleys and the percentage of improving with separate breaks and the factorial improvement of the utilization of the employees are presented. Appendix O presents the differences in percentages and factors for each weekday.

Table 31: Percentage and factorial differences for the new situations compared with the current situation

	Current location	New location
Labor costs	-46%	-31%
Utilization employees	1.99	2.10
Waiting time employees	-42%	-48%
Lead times trolleys	43%	52%
Lead times trolleys improvement with separate breaks	-7%	-10%

Using the results of this research, a cost saving on labor costs can be achieved. The results of the current situation of the simulation model are compared with the current and new location. The percentages of this cost saving are presented in Table 31, while the best lead times to minimize the amount of employees needed per new situation (without separate breaks) are maintained according to the logistics manager. These costs only include the labor costs and do not include the costs of the

photo boxes, rent of the location and spared costs when using the new location. The average lead times for both locations are also presented in Table 31, together with the average time finished after last arrival. The total labor costs per week of the current and new location are € 4,175.29 and € 5,315.81 respectively. In the current situation the average utilization was 35.57% per employee, the average utilizations per employee in the current and new location are 65.07% and 68.48% respectively. The lead times will even get less, when using separate break groups (Table 31).

Table 32: Labor cost savings percentages according to the current situation and utilization, lead time and time finished for both locations

	Current location				New location			
Weekday	Labor cost saving	Average utilization	Average lead time	Average time finished after last arrival	Labor cost saving	Average utilization	Average lead time	Average time finished after last arrival
Monday	32%	60.63%	00:35:31	00:17:20	22%	67.76%	00:38:02	00:20:09
Tuesday	44%	63.10%	00:27:03	00:20:23	34%	73.56%	00:35:23	00:25:50
Wednesday	53%	63.74%	00:34:39	00:24:21	43%	70.16%	00:36:34	00:22:35
Thursday	51%	75.58%	00:49:41	00:20:44	14%	62.21%	00:34:46	00:18:56
Friday	54%	67.48%	00:48:13	00:28:57	36%	69.14%	00:32:00	00:23:19

5.1.4 Conclusion

We conclude that for process step 1 it is better to use the new location, but the difference between the current location with two receiving points and the new location with only one receiving point is minimal for process step 1.

The labor costs can be reduced with 46% using the current location and 31% using the new location. The average utilization increases with a factor of 1.99 and 2.10 for the current and new location respectively. The waiting times of the employees will reduce for the current and new location with 42% and 47% respectively. The lead times of the trolleys will increase on average with 43% and 52%. Using separate break groups, these lead times will improve with 7% and 10% for the current and new location respectively.

Therefore, the current or new location is a better fit depending on the costs differences, like photo boxes, rent of location and transportation costs.

5.2 Sensitivity analysis

'What is the impact of adding and reducing the supply when executing a sensitivity analysis?'

A sensitivity analysis is executed by adding and reducing the supply with 5%, 10% and 15%. These trolleys are randomly added and deleted from the supply. The ratio of trolleys between suppliers and product groups will stay the same when the trolleys are added. When deleting the trolleys, the ratio of trolleys between suppliers and products groups can change. We decided to delete the trolley directly when this is needed according to the randomness and do not use retroactive effect to keep the same ratio of trolleys between suppliers and product groups.

The sensitivity analysis is only executed for the configurations that had the best results in the experiments. Within these best configurations that are determined in Section 0 and 5.1.2, the sensitivity analysis is only executed without using the separate breaks. In all cases the time results of the experiments with separate breaks are better than without. So, when the time results of the sensitivity analysis are accepted without using separate breaks, the time results are definitely accepted when using separate breaks. A distinction is made between the locations of the receiving processes, namely the current location and the new location.

The average amounts of trolleys that occur when removing and adding the supply are presented in Table 33. Within the brackets, first the maximum amount of trolleys at the buffer of Flora Holland Naaldwijk is presented while using the current location followed by the maximum amount of trolleys at the receiving processes of Flora Holland Naaldwijk while using the new location. For each weekday a figure shows what happens with the average waiting and lead times and with the average time finished after last arrival.

Table 33: Average amount of trolleys (maximum amount of trolleys at the buffer and receiving processes of Flora Holland Naaldwijk for the current and new location) when adding and reducing the supply

	Monday	Tuesday	Wednesday	Thursday	Friday
Reducing with 15%	823 (53, 286)	491 (16, 235)	427 (16, 148)	324 (16, 187)	577 (83, 263)
Reducing with 10%	871 (64, 312)	520 (16, 261)	452 (16, 154)	342 (16, 197)	611 (134, 260)
Reducing with 5%	918 (88, 314)	549 (31, 283)	476 (16, 167)	361 (16, 209)	645 (164, 295)
Current	966 (109, 358)	578 (53, 327)	499 (16, 181)	379 (16, 234)	679 (206, 337)
Adding 5%	1013 (130, 396)	607 (94, 366)	523 (16, 202)	398 (34, 251)	714 (248, 350)
Adding 10%	1061 (154, 406)	636 (135, 400)	547 (16, 230)	416 (50, 260)	748 (294, 396)
Adding 15%	1108 (184, 460)	665 (171, 448)	572 (16, 248)	435 (70, 268)	782 (347, 451)

Firstly, the results of the sensitivity analysis when using the current location are given, followed by the results of the sensitivity analysis when using the new location.

5.2.1 Current location receiving processes

For each weekday the results of the average times are shown in a graph when a sensitivity analysis is executed for the best configurations when the current location of the receiving processes is used. These graphs are presented in Appendix P. For the Monday we choose to do the sensitivity analysis on the configurations with two receiving points and not with three for the same reason that is mentioned before with the separate breaks. The results of the experiments with three receiving points were better than the results of the experiments with two receiving points. So, when the time results of the sensitivity analysis are accepted when using two receiving points, the time results are definitely accepted when using three receiving points.

By taking the average of the times of each weekday, Figure 29 presents the results of the sensitivity analysis. The average of the waiting and lead time is calculated, by summing the multiplied average times with the amount of trolleys for each weekday (Table 33) dividing with the total amount of trolleys per week. For the average time finished after last arrival the average is calculated for all weekdays. Within this graph it is mainly about the trend of the line. As we can see in this figure, the average waiting and lead time increases when supply is added and the average time finished after last arrival

stays nearly the same. Therefore, we can conclude that when these lead times are accepted for the receiving processes the labor costs will stay nearly the same.

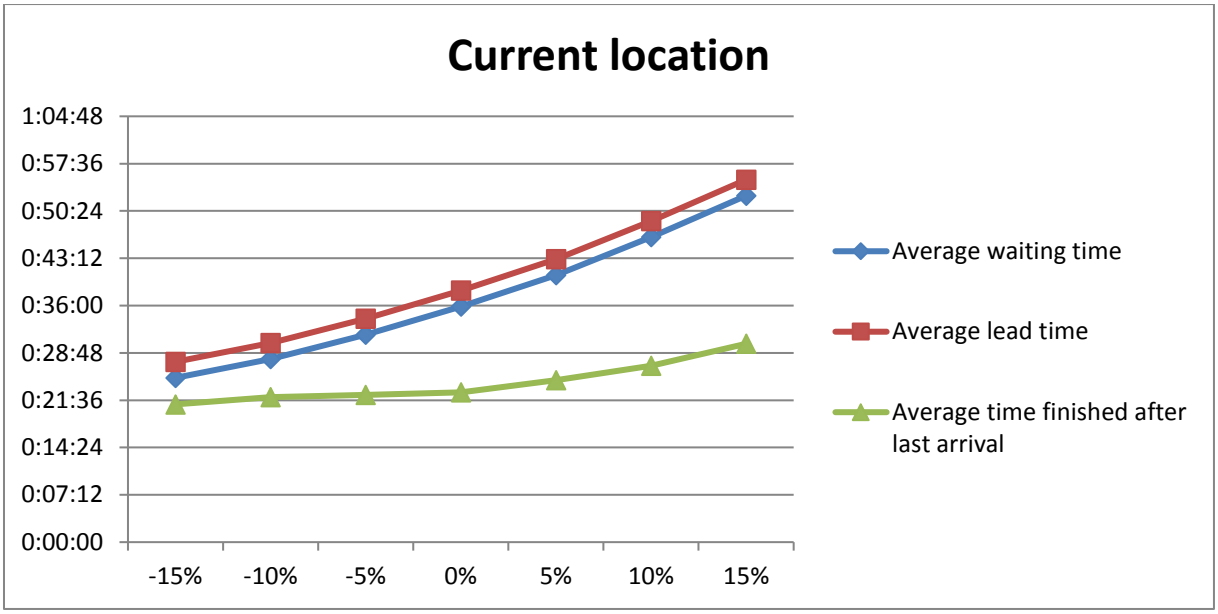

Figure 29: Results sensitivity analysis while using current location

The average difference between the times, while using the current location, when the supply is reduced and added with 15% is 00:27:43 minutes for the average lead time and 00:09:13 minutes for the average time finished after last arrival. For example, when supply is added with 15% the average lead time is 00:27:43 minutes longer than when the supply is reduced with 15%. The differences per weekday are presented in Appendix P even as the minimum and maximum of the average lead time and the average time finished after last trolley.

The buffer at the supplier while using the current location should be able to store two hundred trolleys when supply stays the same and three hundred trolleys when supply will be added with 10% (Table 33).

5.2.2 New location receiving processes

For each weekday the results of the average times are shown in a graph when a sensitivity analysis is executed for the best configurations when the new location of the receiving processes is used. These graphs are presented in Appendix Q.

By taking the average of the times of each weekday, Figure 30 presents the results of the sensitivity analysis. The average of the waiting and lead time is calculated, by summing the multiplied average times with the amount of trolleys for each weekday (Table 33) dividing with the total amount of trolleys per week. For the average time finished after last arrival the average is calculated for all weekdays. Within this graph it is mainly about the trend of the line. As we can see in this figure is that the average waiting and lead time increases when supply is added, while the average time finished after last arrival stays nearly the same. Therefore, we can conclude that when these lead times are accepted for the receiving processes the labor costs will stay nearly the same.

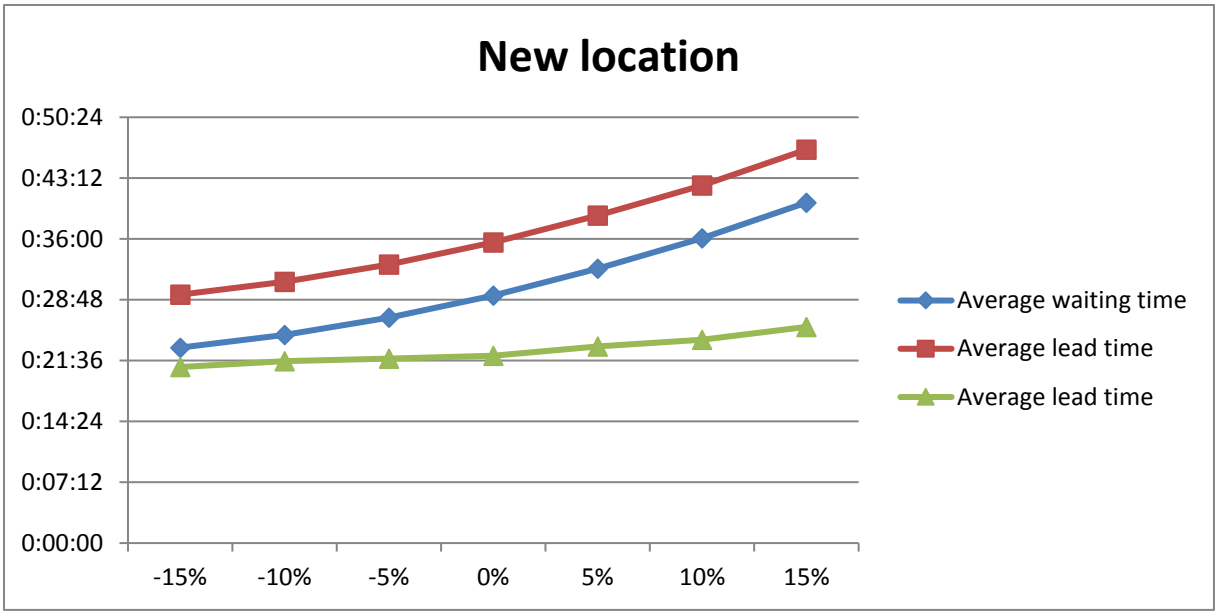

Figure 30: Results sensitivity analysis while using new location

The average difference between the times, while using the new location, when the supply is reduced and added with 15% is 00:17:10 minutes for the average lead time and 00:04:45 minutes for the average time finished after last arrival. For example, when supply is added with 15% the average lead time is 00:17:10 minutes longer than when the supply is reduced with 15%. The differences per weekday are presented in Appendix Q even as the minimum and maximum of the average lead time and the average time finished after last trolley.

The new location should be able to store three hundred and fifty trolleys to be able to manage the current supply and four hundred trolleys when there is an increase of 10% at the supply (Table 33).

5.2.3 Comparison current and new location receiving processes

For each weekday the percentage differences of the several average times are shown in Appendix R, when comparing the new location with the current location.

The comparison of the new location (Figure 30) with the current location (Figure 29) is presented in Figure 31. Within this graph it is mainly about the trend of the line. The percentage differences of the waiting and lead times show a linear correlation in the advantage of the new location compared with the current location when adding supply from -15% until 15%. For example, when the supply is added with 5%, the average lead time of the new location is 10% smaller than the average lead time of the current location. The percentage difference of the average time finished after last arrival is a little bit more fluctuating when the supply is reduced, but when supply is added, the advantage is in the new location. For example, when adding the supply with 15% the average time finished after last arrival is 15% smaller while using the new location compared with the current location.

As we can see in Appendix Q, the percentage differences of the waiting and lead times stays nearly the same for the Tuesday between the current and new location. The percentage difference of the average time finished after last arrival is better while using the new location on the Thursday and Friday and for the Tuesday the current location will always provide better results. For the other weekdays it depends on the amount of supply that is added or removed.

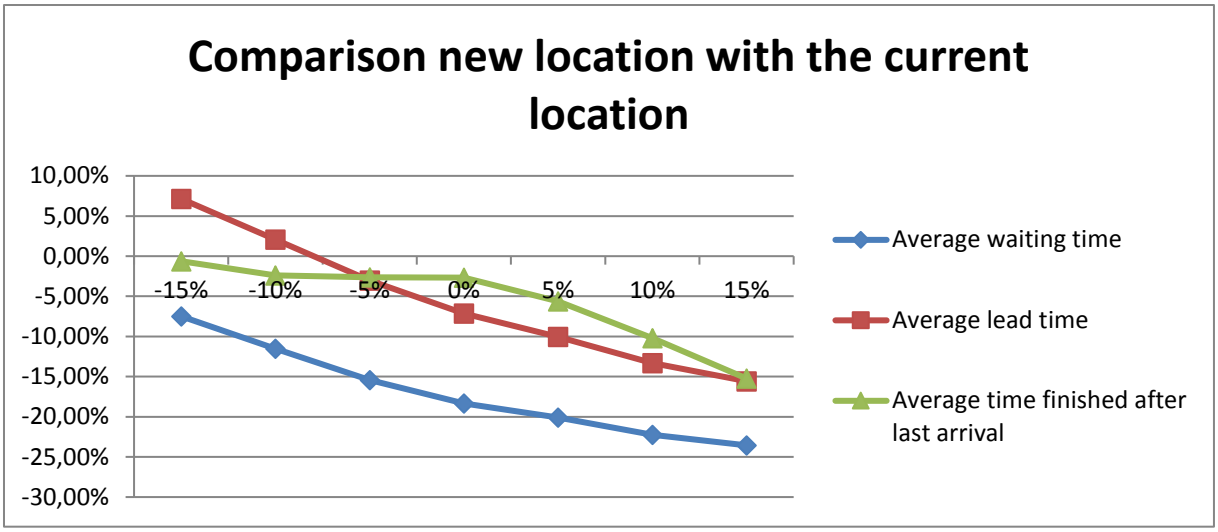

Figure 31: Comparing the new location with the current location according to the sensitivity results

5.2.4 Conclusion

The impact of adding and reducing supply is different per location that is used. The differences between the times are smaller for the new location, when the supply is reduced and added with 15%. We also conclude that when supply is added, there is a negative correlation in the advantage of the new location for the average times between the percentage differences of the new location compared with the current location. For the times, the new location is getting better in comparison with the current situation when supply is added.

The buffer at Flora Holland while using the current location should be able to store two hundred trolleys when supply stays the same. The new location should be able to store three hundred and fifty trolleys to be able to manage the current supply (Table 33).

5.3 Conclusion

The effects of the interventions in the receiving processes are answered while using two different locations of the receiving processes, the current and new location of the receiving processes.

Through the current and new location, the labor costs and utilization of the employees will improve and the waiting times of the employees will reduce. The lead times of the trolleys will increase, except for the Monday. Using separate break groups, the lead times will improve compared to the lead time when no separate breaks are used, except for the Wednesday when using the new location.

When reducing or adding the supply, Table 34 presents the minimum and maximum of the average lead time and the average time finished after last trolley and the maximum amount of trolleys on location. This maximum amount of trolleys on location is when the supply is added with 15%. As we can see, starts the new location with higher times, but ends with lesser times. Appendix P and Q presents these results for each weekday.

Table 34: Average results of the minimum and maximum time and the amount of trolleys at buffer or location supplier

Location	Min average lead time	Max average lead time	Min average time finished after last trolley	Max average time finished after last trolley	Max amount of trolleys at buffer or location of supplier
Current location	00:25:00	00:52:43	00:20:58	00:30:11	347
New location	00:29:24	00:46:34	00:20:50	00:25:35	460

Concluding on the labor costs, the current location is a better fit. Depending on the other costs differences between the current and new location, the best solution will be chosen. The costs differences between the current and new location consists of several variables. These costs are the costs of photo boxes, rent of location, costs on transportation when the suppliers will do the transport or Hamifleurs, costs to train the employees for multiple product groups and the labor costs. However, in this research only the labor costs are included in the scope. Probably the extra costs for the current location are lower than for the new location, but further research should be executed to examine the exact impacts.

6 Conclusions and recommendations

In this chapter the conclusions and recommendations of this research are given.

6.1 Conclusions

The main question of this research was:

'How to create a more efficient flow at the receiving points of Hamifleurs, which takes the corresponding logistical costs into account while maintaining the quality control of the flowers?'

This question is answered through four sub questions.

What does the literature say about the receiving processes?

According to the literature it is possible that several changes like responsibility of the employees, training, equal workflow (Boeve, 2016), less waiting for new arrivals (Fontijn, 2016) and the right collection/storage strategies in the logistical organization of the receiving processes (de Graaff, 2016) can lead to improvements and to a more efficient flow at the receiving points, such that the lead and waiting times are minimized and the utilization of the employees are maximized.

What is the current situation at the receiving processes?

At the moment each supplier delivers their trolleys for Hamifleurs separately and each delivery can contain a different amount of trolleys. There are three different supply flows with no agreements on the amount of trolleys and time per delivery, which results in an unequal supply.

The average supply for a week is 3065 trolleys, divided over each weekday with 925, 567, 512, 369 and 692 trolleys from Monday to Friday respectively. The current collection/storage strategies at the receiving points are a combination of family grouping and dedicated storage, which means that products are sorted on their group and have to be put on their own conditioned/refrigerated area.

The average weekly labor costs for the receiving processes are €6576. In the current situation the utilization of an employee is 35.57%, whereby the average waiting time of an employee is 4:18:35 hours per day. In a theoretical situation when the utilization of the employees can be 100% and no mistakes occur and the waiting times can be fully reduced, a cost saving of €4237 could take place per week on the labor costs.

How can the receiving processes be modelled?

With the help of the input data that is needed for the interventions, a simulation model is made while using some assumptions. An important simplification is that the resistance of the employees at the receiving processes is not taken into account while modeling the receiving processes. The interventions are:

- Changing the amount and/or location of the receiving points combined with the amount of employees per receiving point and step.
- Allowing employees to execute both of the process steps and at multiple receiving points.
- Use separate breaks for employees.
- Limiting the number of trolleys at the production street.

The collection/storage strategies that are used within the model are defined in Table 35. An explanation is given in Section 2.3. The biggest difference within this table is the difference at the arrival of the trolleys. Because of this change in the arrival, employees have to be trained to check quality for all product groups.

Table 35: Summary of the collection/storage strategies

	Current situation	Current location	New location
Arrival of the trolleys	Dedicated storage and family grouping	Closest open location storage	Closest open location storage
Between step 1 and 2	Closest open location storage	Closest open location storage	Family grouping
While executing step 2	Dedicated storage, family grouping and closest open location storage	Dedicated storage, family grouping and closest open location storage	Dedicated storage, family grouping and closest open location storage
Employees	Progressive assembly zoning	Progressive assembly zoning	Progressive assembly zoning

The agreements that are needed within the model in both locations with the suppliers are about the buffer and receiving location. The agreements while using the current location are:

- Create a buffer for the trolleys at a place of the suppliers and let the suppliers move the trolleys to this new location, this could include extra costs for the buffer space.
- When there are 16 trolleys at this buffer, move the trolleys to Hamifleurs if there is space at the production street.
- When the maximum amount of 45 minutes is passed, move the trolleys that are in the buffer to Hamifleurs, if there is space at the production street.
- When the last trolley has arrived, move the trolleys that are in the buffer to Hamifleurs, if there is space at the production street.

The agreements while using the new location are:

- The trolleys of the suppliers directly have to be brought to the new location.

This simulation model uses the input data and the mentioned interventions to create the output data. Within the simulation model the interventions are created and changed. The safety of the employees is maintained through limiting the amount of trolleys at the production street to 230 trolleys. While validating the results of the simulation model with the reality, no significant difference is found between the labor costs, utilizations and waiting times of the employees. Therefore, we compare the data of the experiments that originate from the interventions with the data of the simulation model.

What are the effects of the proposed interventions at the receiving processes?

The effects of the proposed interventions result in two different situations, the current location of the receiving processes or new location. Depending on the costs differences between the current and new location, the current or new location is a better fit. The costs differences between the current and new location consist of several variables. Namely:

- The costs of the photo boxes.
- The rent of the location(s).
- The costs on transportation when the suppliers will do the transport or Hamifleurs.
- The costs to train the employees for all product groups.
- Labor costs.

Of these costs elements, only the labor costs are within the scope of this research.

Comparing the current and new location with the current situation, the percentage and factorial differences presented in Table 36. As we can see in Table 36, the utilization of the employees improves and the waiting time of the employees and the labor costs reduces. Depending on the lead times and amount of employees, that are chosen for both new situations by the logistics manager, the lead times will change comparing with the current situation with the percentages also mentioned in Table 36. This table shows the difference in lead times compared with the current situation and compared whether the use of separate break groups for the employees or not. Only for the Monday, the lead times will decrease in both new situations as we can see in Appendix O. For the other days the lead times will increase in the new situations. With separate breaks the lead times will decrease for all weekdays compared to the lead time of the new situations without separate breaks (Table 36), except for the Wednesday when using the new location (Appendix O). This could be related to the fact that trolleys arrive mostly during the breaks of group 2 on the Wednesday. The labor costs will reduce from €6,576 to €3,551 when the current location is used and from €6,576 to €4,537 when the new location is used.

Table 36: Percentage and factorial differences for the new situations compared with the current situation

	Current location	New location
Labor costs	-46%	-31%
Utilization employees	1.99	2.10
Waiting time employees	-42%	-48%
Lead times trolleys	43%	52%
With separate breaks (lead times)	-7%	-10%

After answering the sub questions above this bring us to the main question:

'How to create a more efficient flow at the receiving points of Hamifleurs, which takes the corresponding logistical costs into account while maintaining the quality control of the flowers?'

The supply of the receiving processes of Hamifleurs deals a lot with fluctuation in the amount of trolleys per time and product group. Currently the flows of the three suppliers are divided into six flows. At each of these flows employees are waiting until trolleys arrive from their flow/product group. This leads to a fluctuated supply per receiving point and a fluctuated workload of the employees.

To create an equal workload at the receiving points, each employee should be able to execute their own process step at each trolley, instead of only from their own product group. When for example 10 trolleys roses arrive and 20 trolleys lilies, e.g., with the same processing time per trolley, both employees can execute the process step at 15 trolleys. To accomplish this, less receiving points should be in use but the employees should be trained for all the product groups to maintain the quality control of the flowers. When using the current location, there is a maximum amount of employees that can

work per receiving point and process step, which results in two receiving points for each weekday, except for the Thursday, where only one receiving point is needed. When the new location is used for the receiving processes, all the trolleys arrive at the same receiving point, where after a buffer is used for the distinction between the refrigerated/conditioned storage areas of the trolleys.

A more efficient flow can be created at the receiving points of Hamifleurs that takes the corresponding logistical costs into account while maintaining the quality control of the flowers, by changing the amount and/or location of the receiving points, amount of employees and their tasks and creating separate break groups for the employees. The amounts of employees per location and processing step to gain the best results that are chosen by the logistics manager are presented in Table 37. The corresponding results are presented in Table 36. The more detailed configurations are stated in Appendix L and Appendix N respectively for the current and new location. The new location is manned by more employees, especially in step 2 because the travel time is enlarged with eight minutes regarding to the current situation and around six or seven minutes with the current location. The travel time is enlarged, because the new location of the receiving processes is further than the current location and within the current location, the trolleys needs transport from the buffer to the receiving points which costs time. The logistics manager chooses the best lead time and employees for both locations differently. Depending on the costs differences between the current location and the new location, the best solution can be chosen. These costs will depend on the photo boxes, rent of the location, transportation costs and labor costs. However, in this research only the labor costs are included in the scope.

Table 37: Amount of employees per situation and/or location

Weekday	Current situation (step 1, step 2, both steps)	Current location (step 1, step 2, both steps)	New location (step 1, step 2)
Monday	11 (5, 4, 2)	8 (4, 4, 0)	9 (5, 4)
Tuesday	11 (5, 4, 2)	6 (2, 2, 2)	7 (3, 4)
Wednesday	11 (5, 4, 2)	5 (3, 2, 0)	6 (3, 3)
Thursday	8 (3, 3, 2)	4 (2, 2, 0)	7 (3, 4)
Friday	11 (5, 4, 2)	5 (3, 2, 0)	7 (3, 4)

Using the current location, extra costs could be included for the space that is needed for the buffer at the supplier. Using the new location, new costs have to be included for renting another space for the receiving processes. When using this new location, the extra distance that have to be traveled from that location to Hamifleurs, will probably be taken care of by employees of Hamifleurs. This will save time for the employees of the suppliers, so probably new agreements for these savings can be made.

Concluding, a more efficient flow can be created when one of the new situations will be used. The key performance indicators that would be reached by using the new situations are stated in Table 36. The utilization of the employees improves and the labor costs decreases. The downside is the increased lead times in both new situations, but the new lead times are chosen by the logistics manager and therefore accepted. When only taking the labor costs into consideration, the current location is a better fit with a decrease in costs of 46% compared to the current situation. Depending on the other costs next to the labor costs, the current or new location is a better fit. Probably the extra costs when using the new location are higher than when using the current location, but to ensure this further

research should be executed to the extra costs. Using separate break groups, the lead times will even get less in both situations.

6.2 Recommendations

First the six recommendations of this research are mentioned here, followed with some recommended further research.

Recommendation 1

The first recommendation is to change the amount and/or location of the receiving points, amount of employees, the tasks of the employees and separate break groups according to Appendix L and Appendix N. Together with this recommendation, employees have to be trained to retrieve knowledge for all products, to maintain the quality control of the flowers. Through this recommendation labor costs can be reduced with 46% when using the current location and 31% when using the new location.

Recommendation 2

The second recommendation is to make better and new agreements with the suppliers. The agreements that have to be made accordingly to the current or new location are mostly about the delivery location of the trolleys.

Two other agreements are regarding the space that is needed when using the current or new location. We recommend making a flexible arrangement with the supplier for buffer or location space. The differences in the maximum amount of trolleys per weekday and supply are significant (Table 33) and therefore we would recommend a flexible buffer or location space at the supplier for the current and new location respectively.

The other agreement is regarding the information on the trolley, this information should be totally clear on the barcode or product note. It should not be possible that a trolley arrives with no information on it. The research to this problem is not included in the scope, but when solving this problem, this could save space and time at the receiving processes. The agreements needed depend on the chosen location. Per location the needed agreements are mentioned.

Current location

- Create a buffer for the trolleys at one of the suppliers and let the suppliers move the trolleys to this new location; this could include extra costs for the buffer space.
- When there are 16 trolleys at this buffer, move the trolleys to Hamifleurs if there is space at the production street.
- When the maximum amount of 45 minutes is passed, move the trolleys that are in the buffer to Hamifleurs, if there is space at the production street.
- When the last trolley has arrived, move the trolleys that are in the buffer to Hamifleurs, if there is space at the production street.

Using the current location, extra costs could be included for the space that is needed for the buffer at the supplier.

New location

- The trolleys of the suppliers have to be brought to the new location.

Using the new location, new costs have to be made for renting another space for the receiving processes. When using this new location, the travel distance that have to be executed from that location to Hamifleurs, will probably be executed by employees of Hamifleurs. This saves time for the employees of the suppliers, so probably new agreements for these savings have to be made.

Recommendation 3

The third recommendation is to only put information that is necessary on the batch sticker. This information contains the product specifications like name, color, length, the name of the grower, the amount of collies and sort cask, the amount of flowers per colli and batch number. When only useful information is shown on the batch sticker, it is easier to put the batch sticker on the right batch.

Recommendation 4

The fourth recommendation is to communicate the ETA at the receiving processes automatically when the product is bought. For each supplier there is an agreement how much time they have before the products has to arrive at Hamifleurs. When this maximum time is added when the product is bought, the employees at the receiving processes would know if a product did not arrive while it should have. This information is already available but has to be communicated to the employees of the receiving processes. This observation can be communicated to the buyer, so that the action can be taken directly and we will not miss the products when they are already needed. To know more precisely the ETA, the system of Hamifleurs has to be connected with the systems of the suppliers.

Recommendation 5

The fifth recommendation contains the storage area. While executing step 2, the products are currently stored at their dedicated storage and further sorted through family grouping and closest open location storage. For this research the processes after the receiving processes were out of scope, but we recommend to not using the dedicated storage and family grouping, while executing step 2. The temperatures of the conditioned areas are the same, even as the refrigerated areas. When combining the products in the storage areas, it would get easier for the distributer to see the differences between the batches. It also is easier to locate the trolleys during step 2, because no distinction has to be made between the trolleys and the areas. Further research should be executed to the pros and cons of this recommendation.

Recommendation 6

The last recommendation partly includes the sixth recommendation. The last recommendation is to change the collection/storage strategies depending on the chosen new situation. The strategy of the arrival of the trolley and the strategy between step 1 and 2 could change. Depending on the further research executed to the storage strategies, the strategy used while executing step 2 will change too.

Further research

Further research should be executed to the extra costs, the photo boxes, the resistance of the employees in case of changes and the storage areas. A more detailed description is given per research subject.

Extra costs

Further research should be executed to the extra costs next to the labor costs of the current and new location. These extra costs consist of:

- The costs of the photo boxes.
- The (flexible) rent of the location.
- The costs on transportation when the suppliers will do the transport or Hamifleurs.
- The costs to train the employees for multiple product groups.

Photo boxes

A more defined research should be executed to the photo boxes too. At the moment each receiving point contains its own photo box and photo camera and everyone could make pictures of the products. The settings of the cameras are not always the same, the photo boxes do not always contain the same amount of light and not each employee is able to take good photos. The best results contain mostly two receiving points for the current location and one for the new location. Research should be executed to know which photo boxes have to be gained while using the current and new location, so that the quality of the photo can be assured.

Resistance of the employees

Further research should also be executed to the resistance of the employees. In the problem description, it is discussed that the flexibility of the employees is one of the problems. When implementing some of the interventions mentioned in this research, flexibility of the employees is needed. Research should be executed whether the employees are willing to be flexible for some changes, for example:

- Employees have to work together at the same receiving point and process step.
- Within the new location, employees could have their break at Flora Holland.
- Employees will have separate breaks while working at the receiving processes.

Storage areas

More research should be executed to the pros and cons of dedicating the storage areas after executing the receiving processes. There used to be reasons that it was not clear where products were located, but at the moment each batch does get a location which can be found in the computer. Another reason is that the dedicated receiving points are close to the right dedicated and conditioned areas. When combining the receiving points and product groups in one of the new situations this is no longer the case. Another reason is that by combing the same product groups with each other, buyers do not have a clear overview of their bought products. Some cons are that when an order includes several products combined with each other, a job sticker is needed to combine these products from several batches. At the moment job stickers cannot be made, when batches are located in several storage areas. When this is possible, it could cost more time to combine these products from several batches and storage

areas with each other than when the products are collected in the same storage area. Another con is that the employees are specialized at the moment in a specific product group, but this could be improved by trainings. The lengths of the flowers are also different, so the trolleys cannot be efficiently combined when space is needed and products on trolleys are put together.

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8 Appendices

Appendix A: Supply of Flora Holland Naaldwijk (Confidential)

Appendix B: Supply of Connect (Confidential)

Appendix C: Supply of De Winter Logistics (Confidential)

Appendix D: Total supply (Confidential)

Appendix E: Processing times step 1 of the receiving processes (Confidential)

Appendix F: Processing times step 2 of the receiving processes (Confidential)

Appendix G: Number of replications

Appendix H: Validation and several results simulation model

Appendix I: Experiments current location

Appendix J: Experiments new location

Appendix K: Results experiments current location

Appendix L: Best configurations for the current location

Appendix M: Results experiments new location

Appendix N: Best configurations for the current location

Appendix O: Comparing the current situation with the new situations

Appendix P: Sensitivity results current location

Appendix Q: Sensitivity results new location

Appendix R: Comparing the sensitivity results of the new location with the current location

Appendix G: Number of replications

To find the number of replications for which the half width of the confidence interval is smaller than the relative error. The following formula can be used to find the relative error (gamma') with a gamma of 0,10:

$$y' = \frac{y}{y+1} = 0.090909091$$

The number of replications can be found based on the calculation of the confidence interval, using the following formula:

$$n^* = \min\left\{(i \geq n: \frac{(t_{i-1,1-\frac{\alpha}{2}}\sqrt{\frac{S_n^2}{i}})}{(|\overline{X_n}|)} < \left(\frac{\gamma}{\gamma+1}\right)\right\}$$

Appendix H: Validation and several results simulation model

Configurations used in the current situation for the employees on the Monday, Tuesday, Wednesday and Friday

Employee	Receiving Point	Step	Break Group
1	J1-72	1	1
2	J1-72	2	1
3	J2-84	Both	1
4	J2-95	1	1
5	J2-95	2	1
6	J2-96	1	1
7	J2-96	2	1
8	J3-11	1	1
9	J3-11	1	1
10	J3-11	2	1
11	J3-18	Both	1

Configurations used in the current situation for the employees on the Thursday

Employee	Receiving Point	Step	Break Group
1	J1-72	1	1
2	J1-72	2	1
3	J2-84	Both	1
4	J2-95 and J2-96	1	1
5	J2-95 and J2-96	2	1
6	J3-11	1	1
7	J3-11	2	1
8	J3-18	Both	1

Labor costs

t-test: Two-sample Assuming Equal Means		
	Variable 1	Variable 2
Mean	2420,846667	2192,096667
Variance	5810097,092	4791476,071
Observations	6	6
Pearson-correlation	0,99890436	
Estimation of difference between means	0	
Degrees of freedom	5	
t-test	2,27594403	
P(T<=t) one-tail	0,03595098	
T Critical one-tail	2,015048373	
P(T<=t) two-tail	0,071901959	
T Critical two-tail	2,776445105	

Utilization of the employees

t-test: Two-sample Assuming Equal Means		
	Variable 1	Variable 2
Mean	0,384263462	0,345994231
Variance	0,00281018	0,000920038
Observations	6	6
Pearson-correlation	0,685879102	
Estimation of difference between means	0	
Degrees of freedom	5	
t-test	2,40082125	
P(T<=t) one-tail	0,030779132	
T Critical one-tail	2,015048373	
P(T<=t) two-tail	0,061558263	
T Critical two-tail	2,570581836	

Waiting times of the employees

t-test: Two-sample Assuming Equal Means		
	Variable 1	Variable 2
Mean	0,175533944	0,178791595
Variance	0,001749546	0,001531498
Observations	6	6
Pearson-correlation	0,888685321	
Estimation of difference between means	0	
Degrees of freedom	5	
t-test	-0,413903319	
P(T<=t) one-tail	0,348050316	
T Critical one-tail	2,015048373	
P(T<=t) two-tail	0,696100633	
T Critical two-tail	2,570581836	

Simulation model, current situation: Utilization (including extra times)

Employee	Monday	Tuesday	Wednesday	Thursday	Friday
1	19,86%	27,60%	22,21%	25,40%	18,13%
2	16,09%	22,28%	18,15%	20,49%	14,63%
3	22,27%	26,98%	20,49%	18,36%	22,36%
4	54,20%	50,85%	40,24%	68,11%	47,39%
5	33,86%	34,57%	26,91%	49,55%	30,82%
6	54,40%	45,74%	40,04%	22,48%	36,10%
7	41,89%	39,77%	33,80%	14,38%	31,18%
8	34,83%	21,16%	20,11%	70,19%	17,72%
9	33,32%	19,03%	18,05%		15,73%
10	26,88%	23,19%	20,70%		19,55%

11	86,09%	46,59%	48,63%		65,13%
Mean	**38,52%**	**32,52%**	**28,12%**	**36,12%**	**28,98%**

Simulation model, current situation: Utilization 2 (excluding extra times)

Employee	Monday	Tuesday	Wednesday	Thursday	Friday
1	19,86%	27,60%	22,21%	25,40%	18,13%
2	16,09%	22,28%	18,15%	20,49%	14,63%
3	22,27%	26,98%	20,49%	18,36%	22,36%
4	54,20%	50,85%	40,24%	66,51%	47,39%
5	33,86%	34,57%	26,91%	49,55%	30,82%
6	54,40%	45,74%	40,04%	22,48%	36,10%
7	41,89%	39,77%	33,80%	14,38%	31,18%
8	34,83%	21,16%	20,11%	70,19%	17,72%
9	33,32%	19,03%	18,05%		15,73%
10	26,88%	23,19%	20,70%		19,55%
11	86,09%	46,59%	48,63%		65,13%
Mean	**38,52%**	**32,52%**	**28,12%**	**35,92%**	**28,98%**

Simulation model, current situation: Difference in utilization per employee and weekday

Employee	Monday	Tuesday	Wednesday	Thursday	Friday
1	0,00%	0,00%	0,00%	0,00%	0,00%
2	0,00%	0,00%	0,00%	0,00%	0,00%
3	0,00%	0,00%	0,00%	0,00%	0,00%
4	0,00%	0,00%	0,00%	1,59%	0,00%
5	0,00%	0,00%	0,00%	0,00%	0,00%
6	0,00%	0,00%	0,00%	0,00%	0,00%
7	0,00%	0,00%	0,00%	0,00%	0,00%
8	0,00%	0,00%	0,00%	0,00%	0,00%
9	0,00%	0,00%	0,00%		0,00%
10	0,00%	0,00%	0,00%		0,00%
11	0,00%	0,00%	0,00%		0,00%
Mean	**0,00%**	**0,00%**	**0,00%**	**0,20%**	**0,00%**

Average waiting and lead time of the trolleys and the average time finished after last arrival

	Waiting time for step 1	Waiting time for step 2	Waiting time	Lead time	Average time finished after last arrival
Monday	00:26:29	00:26:50	00:53:19	00:55:41	00:53:23
Tuesday	00:09:51	00:03:38	00:13:29	00:15:46	00:13:11
Wednesday	00:07:44	00:03:11	00:10:55	00:13:10	00:10:19
Thursday	00:17:40	00:09:01	00:26:41	00:28:49	00:12:08
Friday	00:10:40	00:11:02	00:21:42	00:23:56	00:21:35

Appendix I: Experiments current location

For the experiments on the current location, experiments are executed for the amount of six, three, two one receiving point(s). The amount of employees is between the four and nine employees per receiving point.

Six receiving points (A is 50 trolleys, F is 20 trolleys, the rest is 40 trolleys)

For the amount of six receiving points, one experiment is executed with nine employees.

- **Nine employees**

Experiment I

Employee	Receiving Point	Step	Break Group
1	A	1	1
2	B	1	1
3	C	1	1
4	D	1	1
5	E	1	1
6	F	1	1
7	A and B	2	1
8	C and D	2	1
9	E and F	2	1

Three receiving points (A is 50 trolleys, rest is 40 trolleys)

For the amount of three receiving points, experiments are executed with nine, eight and seven employees.

- **Nine employees**

One experiment has a dedicated receiving point, namely J3-18 and in the other experiment there are no dedicated receiving points.

Experiment II

Employee	Receiving Point	Step	Break Group
1	A	1	1
2	A	1	1
3	A	2	1
4	A	2	1
5	B	1	1
6	B	1	1
7	B	2	1
8	B	2	1
9	J3-18	Both	1

Experiment III

Employee	Receiving Point	Step	Break Group
1	A	1	1
2	A	1	1
3	B	1	1
4	B	1	1
5	C	1	1
6	C	1	1
7	A	2	1
8	B	2	1
9	C	2	1

- **Eight employees**

Experiment IV

Employee	Receiving Point	Step	Break Group
1	A	1	1
2	A	1	1
3	B	1	1
4	B	1	1
5	C	1	1
6	All	2	1
7	All	2	1
8	All	2	1

- **Seven employees**

Experiment V

Employee	Receiving Point	Step	Break Group
1	A	1	1
2	A	1	1
3	B	1	1
4	B	1	1
5	C	Both	1
6	A	2	1
7	B	2	1

Two receiving points (A is 50 trolleys and B is 40 trolleys)

For the amount of two receiving points, experiments are executed with eight, seven, six and five employees.

- **Eight employees**

Experiment VI

Employee	Receiving Point	Step	Break Group
1	A	1	1
2	A	1	1
3	A	2	1
4	A	2	1
5	B	1	1
6	B	1	1
7	B	2	1
8	B	2	1

Experiment VII

Employee	Receiving Point	Step	Break Group
1	A	1	1
2	A	1	1
3	B	1	1
4	B	1	1
5	Both	2	1
6	Both	2	1
7	Both	2	1
8	Both	2	1

- **Seven employees**

Experiment VIII

Employee	Receiving Point	Step	Break Group
1	A	1	1
2	A	1	1
3	B	1	1
4	B	1	1
5	Both	2	1
6	Both	2	1
7	Both	2	1

Experiment IX

Employee	Receiving Point	Step	Break Group
1	A	1	1
2	A	1	1
3	B	1	1
4	B	1	1
5	A	2	1
6	B	2	1
7	Both	2	1

- **Six employees**

Experiment X

Employee	Receiving Point	Step	Break Group
1	A	1	1
2	A	1	1
3	A	2	1
4	B	1	1
5	B	1	1
6	B	2	1

Experiment XI

Employee	Receiving Point	Step	Break Group
1	A	1	1
2	A	2	1
3	A	Both	1
4	B	1	1
5	B	2	1
6	B	Both	1

Experiment XII

Employee	Receiving Point	Step	Break Group
1	A	1	1
2	A	1	1
3	B	1	1
4	B	1	1
5	Both	2	1
6	Both	2	1

- **Five employees**

Experiment XIII

Employee	Receiving Point	Step	Break Group
1	A	1	1
2	A	2	1
3	B	1	1
4	B	2	1
5	Both	1	1

Experiment XIV

Employee	Receiving Point	Step	Break Group
1	A	1	1
2	A	1	1
3	B	1	1
4	Both	2	1
5	Both	2	1

One receiving point (A is 50 trolleys)

One experiment is executed with one receiving point. This experiment is executed with four employees.

- **Four employees**

Experiment XV

Employee	Receiving Point	Step	Break Group
1	A	1	1
2	A	1	1
3	A	2	1
4	A	2	1

Appendix J: Experiments new location

The experiments executed for the new location with one receiving point, do not have the maximum amount of two employees working per processing point and there is no supplier or Hamifleurs buffer. The trolleys go directly to the buffer of processing step 1. The trolleys only start with step 2 of the receiving processes when there are 6 or more trolleys waiting of their product group or when a trolley is waiting longer than 30 minutes in their buffer. The extra time for process step 2 is eight minutes per batch. The amounts of employees in these experiments are eleven, ten, nine, eight, seven, six and five.

- **Eleven employees**

Experiment XVI

Employee	Receiving Point	Step	Break Group
1	A	1	1
2	A	1	1
3	A	1	1
4	A	1	1
5	A	1	1
6	A	1	1
7	A	2	1
8	A	2	1
9	A	2	1
10	A	2	1
11	A	2	1

Experiment XVII

Employee	Receiving Point	Step	Break Group
1	A	1	1
2	A	1	1
3	A	1	1
4	A	1	1
5	A	1	1
6	A	2	1
7	A	2	1
8	A	2	1
9	A	2	1
10	A	2	1
11	A	2	1

- **Ten employees**

Experiment XVIII

Employee	Receiving Point	Step	Break Group
1	A	1	1
2	A	1	1
3	A	1	1
4	A	1	1
5	A	1	1
6	A	2	1
7	A	2	1
8	A	2	1
9	A	2	1
10	A	2	1

Experiment XIX

Employee	Receiving Point	Step	Break Group
1	A	1	1
2	A	1	1
3	A	1	1
4	A	1	1
5	A	2	1
6	A	2	1
7	A	2	1
8	A	2	1
9	A	2	1
10	A	2	1

Experiment XX

Employee	Receiving Point	Step	Break Group
1	A	1	1
2	A	1	1
3	A	1	1
4	A	1	1
5	A	1	1
6	A	1	1
7	A	2	1
8	A	2	1
9	A	2	1
10	A	2	1

- **Nine employees**

Experiment XXI

Employee	Receiving Point	Step	Break Group
1	A	1	1
2	A	1	1
3	A	1	1
4	A	1	1
5	A	1	1
6	A	2	1
7	A	2	1
8	A	2	1
9	A	2	1

Experiment XXII

Employee	Receiving Point	Step	Break Group
1	A	1	1
2	A	1	1
3	A	1	1
4	A	1	1
5	A	2	1
6	A	2	1
7	A	2	1
8	A	2	1
9	A	2	1

- **Eight employees**

Experiment XXIII

Employee	Receiving Point	Step	Break Group
1	A	1	1
2	A	1	1
3	A	1	1
4	A	1	1
5	A	2	1
6	A	2	1
7	A	2	1
8	A	2	1

Experiment XXIV

Employee	Receiving Point	Step	Break Group
1	A	1	1
2	A	1	1
3	A	1	1
4	A	2	1
5	A	2	1
6	A	2	1
7	A	2	1
8	A	2	1

Experiment XXV

Employee	Receiving Point	Step	Break Group
1	A	1	1
2	A	1	1
3	A	1	1
4	A	1	1
5	A	1	1
6	A	2	1
7	A	2	1
8	A	2	1

- **Seven employees**

Experiment XXVI

Employee	Receiving Point	Step	Break Group
1	A	1	1
2	A	1	1
3	A	1	1
4	A	1	1
5	A	2	1
6	A	2	1
7	A	2	1

Experiment XXVII

Employee	Receiving Point	Step	Break Group
1	A	1	1
2	A	1	1
3	A	1	1
4	A	2	1
5	A	2	1
6	A	2	1
7	A	2	1

- **Six employees**

Experiment XXVIII

Employee	Receiving Point	Step	Break Group
1	A	1	1
2	A	1	1
3	A	1	1
4	A	2	1
5	A	2	1
6	A	2	1

Experiment XXIX

Employee	Receiving Point	Step	Break Group
1	A	1	1
2	A	1	1
3	A	2	1
4	A	2	1
5	A	2	1
6	A	2	1

Experiment XXX

Employee	Receiving Point	Step	Break Group
1	A	1	1
2	A	1	1
3	A	1	1
4	A	1	1
5	A	2	1
6	A	2	1

- **Five employees**

Experiment XXXI

Employee	Receiving Point	Step	Break Group
1	A	1	1
2	A	1	1
3	A	2	1
4	A	2	1
5	A	2	1

Experiment XXXII

Employee	Receiving Point	Step	Break Group
1	A	1	1
2	A	1	1
3	A	1	1
4	A	2	1
5	A	2	1

Appendix K: Results experiments current location

For each weekday a table with results of the experiments on the current location are shown, followed by another table with the best results of these experiments. The best results chosen, contains an extra experiment that involves separate break groups for the employees.

Monday

Results Monday using current location receiving processes excluding separate break groups

	Average waiting time	Average lead time	Average time finished after last arrival	Utilization (including extra time)	Utilization2 (excluding extra time)	Difference in utilization	Labor costs
Experiment I	00:28:18	00:30:51	00:19:58	53.67%	50.17%	3.50%	€ 1,622.04
Experiment II	00:48:31	00:51:00	01:00:43	48.79%	46.54%	2.25%	€ 1,744.31
Experiment III	00:27:56	00:30:29	00:19:42	53.64%	50.15%	3.50%	€ 1,621.25
Experiment IV	00:31:40	00:34:13	00:19:36	60.42%	56.48%	3.94%	€ 1,440.85
Experiment V	01:08:40	01:11:12	00:33:44	67.07%	62.69%	4.37%	€ 1,293.73
Experiment VI	00:32:59	00:35:31	00:17:20	60.63%	56.68%	3.95%	€ 1,434.80
Experiment VII	00:36:30	00:39:03	00:18:10	60.49%	56.55%	3.95%	€ 1,437.03
Experiment VIII	00:47:08	00:49:40	00:20:34	68.90%	64.40%	4.49%	€ 1,263.01
Experiment IX	00:46:00	00:48:32	00:20:04	68.98%	64.48%	4.50%	€ 1,261.82
Experiment X	01:54:50	01:57:22	01:23:09	71.62%	66.95%	4.67%	€ 1,207.72
Experiment XI	01:00:28	01:03:00	00:22:05	80.18%	74.95%	5.23%	€ 1,085.60
Experiment XII	01:53:26	01:55:58	01:19:03	72.14%	67.44%	4.70%	€ 1,199.52
Experiment XIII	02:33:20	02:35:54	01:51:19	82.99%	76.59%	6.40%	€ 1,053.38
Experiment XIV	02:21:38	02:24:10	01:36:02	84.02%	78.54%	5.47%	€ 1,027.92
Experiment XV	03:57:41	04:00:13	03:28:42	88.18%	82.43%	5.75%	€ 972.55

Best results Monday using current location receiving processes excluding separate break groups

Experiments		Lead Time	Time finished after last arrival	Amount employees (amount receiving points)
Experiment XV		04:00:13	03:28:42	4 (2)
Experiment XIV		02:24:10	01:36:02	5 (2)
Experiment XI		01:03:00	00:22:05	6 (2)
Experiment IX		00:48:32	00:20:04	7 (2)

Experiment VI	**No separate breaks**	**00:35:31**	**00:17:20**	**8 (2)**
	Separate breaks	**00:32:29**	**00:16:20**	**8 (2)**
Experiment IV	**No separate breaks**	**00:34:13**	**00:19:36**	**8 (3)**
	Separate breaks	**00:32:13**	**0:18:28**	**8 (3)**
Experiment I		00:30:51	00:19:58	9 (6)

Tuesday

Results Tuesday using current location receiving processes excluding separate break groups

	Average waiting time	Average lead time	Average time finished after last arrival	Utilization (including extra time)	Utilization2 (excluding extra time)	Difference in utilization	Labor costs
Experiment I	00:17:50	00:20:17	00:19:04	42.27%	39.40%	2.87%	€ 1,191.58
Experiment II	00:16:13	00:18:37	00:20:30	41.59%	39.27%	2.32%	€ 1,195.90
Experiment III	00:17:40	00:20:06	00:18:38	60.32%	56.23%	4.09%	€ 1,190.26
Experiment IV	00:17:50	00:20:16	00:18:34	47.65%	44.41%	3.23%	€ 1,057.83
Experiment V	00:30:11	00:32:37	00:30:04	52.48%	48.92%	3.56%	€ 952.44
Experiment VI	00:15:25	00:17:52	00:16:12	48.07%	44.81%	3.26%	€ 1,051.53
Experiment VII	00:15:40	00:18:06	00:16:36	47.98%	44.72%	3.25%	€ 1,052.62
Experiment VIII	00:18:37	00:21:03	00:18:38	54.43%	50.74%	3.69%	€ 925.78
Experiment IX	00:18:44	00:21:11	00:18:56	54.38%	50.69%	3.69%	€ 926.46
Experiment X	00:44:27	00:46:53	00:36:44	60.09%	56.01%	4.07%	€ 829.70
Experiment XI	00:24:37	00:27:03	00:20:23	63.10%	58.82%	4.28%	€ 797.03
Experiment XII	00:44:05	00:46:32	00:35:30	60.32%	56.23%	4.09%	€ 827.25
Experiment XIII	00:50:41	00:53:09	00:39:43	72.13%	66.65%	5.48%	€ 696.39
Experiment XIV	00:45:45	00:48:11	00:36:42	72.14%	67.25%	4.89%	€ 691.38
Experiment XV	01:11:25	01:13:51	00:57:19	85.29%	79.51%	5.78%	€ 580.58

Best results Tuesday using current location receiving processes excluding separate break groups

Experiments		Lead Time	Time finished after last arrival	Amount employees (amount receiving points)
Experiment XV		01:13:51	00:57:19	4 (2)
Experiment XIV		00:48:11	00:36:42	5 (2)
Experiment XI	**No separate breaks**	**00:27:03**	**00:20:23**	**6 (2)**
	Separate breaks	**00:26:26**	**00:20:38**	**6 (2)**
Experiment VIII		00:21:03	00:18:38	7 (2)
Experiment VI		00:17:52	00:16:12	8 (2)

Wednesday

Results Wednesday using current location receiving processes excluding separate break groups

	Average waiting time	Average lead time	Average time finished after last arrival	Utilization (including extra time)	Utilization2 (excluding extra time)	Difference in utilization	Labor costs
Experiment I	00:14:57	00:17:22	00:18:23	36.38%	33.89%	2.48%	€ 1,202.26
Experiment II	00:14:47	00:17:10	00:20:55	35.59%	33.68%	1.91%	€ 1,209.88
Experiment III	00:14:50	00:17:16	00:20:15	36.20%	33.73%	2.47%	€ 1,207.85
Experiment IV	00:15:08	00:17:34	00:19:45	40.79%	38.00%	2.78%	€ 1,072.31
Experiment V	00:23:25	00:25:51	00:22:40	46.04%	42.90%	3.14%	€ 945.09
Experiment VI	00:13:45	00:16:10	00:20:12	40.76%	37.98%	2.78%	€ 1,073.54
Experiment VII	00:13:46	00:16:11	00:20:12	40.76%	37.98%	2.78%	€ 1,073.54
Experiment VIII	00:15:52	00:18:17	00:19:06	46.68%	43.50%	3.19%	€ 936.77
Experiment IX	00:15:57	00:18:22	00:19:13	46.66%	43.48%	3.18%	€ 937.03
Experiment X	00:30:27	00:32:53	00:25:26	53.13%	49.51%	3.63%	€ 815.61
Experiment XI	00:19:38	00:22:03	00:19:43	54.34%	50.63%	3.71%	€ 804.19
Experiment XII	00:30:05	00:32:30	00:24:36	53.31%	49.67%	3.64%	€ 813.94
Experiment XIII	00:36:39	00:39:05	00:27:23	64.04%	59.17%	4.87%	€ 682.93
Experiment XIV	00:32:14	00:34:39	00:26:28	63.74%	59.39%	4.35%	€ 681.41
Experiment XV	00:52:52	00:55:17	00:35:08	77.28%	72.00%	5.28%	€ 556.68

Best results Wednesday using current location receiving processes excluding separate break groups

Experiments		Lead Time	Time finished after last arrival	Amount employees (amount receiving points)
Experiment XV		00:55:17	00:35:08	4 (2)
Experiment XIV	**No separate breaks**	**00:34:39**	**00:26:28**	**5 (2)**
	Separate breaks	**00:32:48**	**00:24:21**	**5 (2)**
Experiment XI		00:22:03	00:19:43	6 (2)
Experiment VIII		00:18:17	00:19:06	7 (2)
Experiment VI		00:16:10	00:20:12	8 (2)

Thursday

Results Thursday using current location receiving processes excluding separate break groups

	Average waiting time	Average lead time	Average time finished after last arrival	Utilization (including extra time)	Utilization2 (excluding extra time)	Difference in utilization	Labor costs
Experiment I	00:17:48	00:20:05	00:14:22	34.47%	31.97%	2.50%	€ 909.69
Experiment II	00:22:17	00:24:31	00:17:38	33.22%	31.56%	1.66%	€ 917.26
Experiment III	00:17:47	00:20:04	00:13:54	34.54%	32.03%	2.51%	€ 908.29
Experiment IV	00:17:53	00:20:10	00:14:23	38.77%	35.95%	2.81%	€ 808.64
Experiment V	00:27:34	00:29:51	00:17:51	43.76%	40.59%	3.18%	€ 713.94
Experiment VI	00:16:02	00:18:19	00:13:50	38.87%	36.05%	2.82%	€ 807.20
Experiment VII	00:16:33	00:18:50	00:13:51	38.87%	36.05%	2.82%	€ 807.20
Experiment VIII	00:18:54	00:21:11	00:14:09	44.35%	41.13%	3.22%	€ 707.00
Experiment IX	00:18:35	00:20:52	00:14:14	44.33%	41.12%	3.22%	€ 707.23
Experiment X	00:34:50	00:37:07	00:17:21	51.15%	47.43%	3.71%	€ 610.93
Experiment XI	00:23:41	00:25:58	00:14:51	51.66%	47.91%	3.75%	€ 606.68
Experiment XII	00:34:34	00:36:51	00:16:58	51.22%	47.50%	3.72%	€ 610.16
Experiment XIII	00:39:20	00:41:39	00:18:15	61.65%	56.69%	4.96%	€ 510.61
Experiment XIV	00:35:16	00:37:33	00:17:57	61.20%	56.76%	4.44%	€ 510.12
Experiment XV	00:47:24	00:49:41	00:20:44	75.58%	70.10%	5.49%	€ 411.81

Best results Thursday using current location receiving processes excluding separate break groups

Experiments		Lead Time	Time finished after last arrival	Amount employees (amount receiving points)
Experiment XV	**No separate breaks**	**00:49:41**	**00:20:44**	**4 (2)**
	Separate breaks	**00:48:08**	**00:21:06**	**4 (2)**
Experiment XIV		00:37:33	00:17:57	5 (2)
Experiment XI		00:25:58	00:14:51	6 (2)
Experiment IX		00:20:52	00:14:14	7 (2)
Experiment VI		00:18:19	00:13:50	8 (2)

Friday

Results Friday using current location receiving processes excluding separate break groups

	Average waiting time	Average lead time	Average time finished after last arrival	Utilization (including extra time)	Utilization2 (excluding extra time)	Difference in utilization	Labor costs
Experiment I	00:17:28	00:19:52	00:18:35	38.43%	35.77%	2.66%	€ 1,499.30
Experiment II	00:23:05	00:25:26	00:30:09	36.69%	34.85%	1.84%	€ 1,534.03
Experiment III	00:17:12	00:19:35	00:18:17	38.45%	35.79%	2.66%	€ 1,498.40
Experiment IV	00:17:19	00:19:43	00:18:26	43.24%	40.25%	2.99%	€ 1,332.34
Experiment V	00:30:14	00:32:37	00:26:51	48.51%	45.15%	3.35%	€ 1,185.44
Experiment VI	00:14:10	00:16:34	00:16:58	43.41%	40.41%	3.00%	€ 1,328.44
Experiment VII	00:14:24	00:16:48	00:17:00	43.40%	40.40%	3.00%	€ 1,328.51
Experiment VIII	00:17:49	00:20:12	00:18:32	49.41%	45.99%	3.41%	€ 1,166.04
Experiment IX	00:17:55	00:20:18	00:18:36	49.40%	45.99%	3.41%	€ 1,166.19
Experiment X	00:45:28	00:47:52	00:29:42	56.12%	52.25%	3.88%	€ 1,021.79
Experiment XI	00:23:33	00:25:57	00:19:17	57.54%	53.56%	3.98%	€ 1,000.96
Experiment XII	00:45:13	00:47:37	00:28:28	56.29%	52.40%	3.89%	€ 1,019.33
Experiment XIII	00:48:11	00:50:37	00:31:30	67.77%	62.45%	5.32%	€ 854.49
Experiment XIV	00:45:49	00:48:13	00:28:57	67.48%	62.82%	4.66%	€ 850.24
Experiment XV	01:05:43	01:08:07	00:41:13	82.12%	76.45%	5.68%	€ 696.54

Best results Friday using current location receiving processes excluding separate break groups

Table 38: Best results Friday using current location receiving processes excluding break groups

Experiments		Lead Time	Time finished after last arrival	Amount employees
Experiment XV		01:08:07	00:41:13	4 (2)
Experiment XIV	**No separate breaks**	**00:48:13**	**00:28:57**	**5 (2)**
	Separate breaks	**00:46:27**	**00:28:13**	**5 (2)**
Experiment XI		00:25:57	00:19:17	6 (2)
Experiment VIII		00:20:12	00:18:32	7 (2)
Experiment VI		00:16:34	00:16:58	8 (2)

Extra results current location

Results best configurations of the current location regarding the labor costs, the waiting time and the utilization of the employees compared with the current situation.

	Labor costs	Waiting time employee	Utilization employees
Monday	-32%	-39%	57%
Tuesday	-44%	-41%	94%
Wednesday	-53%	-33%	127%
Thursday	-51%	-58%	109%
Friday	-54%	-46%	133%

Appendix L: Best configurations for the current location

Weekday	Step	Receiving point	Amount of employees	Amount of employees in break group 1	Amount of employees in break group 2
Monday (three receiving points)	1	A	2	1	1
	1	B	2	2	0
	1	C	1	0	1
	2	A, B, C	3	1	2
Monday (two receiving points)	1	A	2	1	1
	1	B	2	1	1
	2	A	2	1	1
	2	B	2	1	1
Tuesday	1	A	1	1	0
	2	A	1	1	0
	Both	A	1	0	1
	1	B	1	0	1
	2	B	1	0	1
	Both	B	1	1	0
Wednesday	1	A	2	1	1
	1	B	1	0	1
	2	Both	2	1	1
Thursday	1	A	2	1	1
	2	A	2	1	1
Friday	1	A	2	1	1
	1	B	1	0	1
	2	Both	2	1	1

Appendix M: Results experiments new location

For each weekday a table with results of the experiments on the new location are shown, followed by another table with the best results of these experiments. The best results chosen, contains an extra experiment that involves separate break groups for the employees.

Monday

Results Monday using new location receiving processes excluding separate break groups

	Average waiting time	Average lead time	Average time finished after last arrival	Utilization (including extra time)	Utilization2 (excluding extra time)	Difference in utilization	Labor costs
Experiment XVI	00:20:09	00:26:32	00:16:24	59.15%	41.01%	18.14%	€ 1,984.10
Experiment XVII	00:22:13	00:28:36	00:15:37	61.57%	41.08%	20.49%	€ 1,981.22
Experiment XVIII	00:24:20	00:30:44	00:17:10	64.92%	45.04%	19.88%	€ 1,806.25
Experiment XIX	00:37:45	00:44:08	00:16:32	67.97%	45.10%	22.88%	€ 1,804.16
Experiment XX	00:26:34	00:32:57	00:19:46	60.94%	44.78%	16.16%	€ 1,814.93
Experiment XXI	00:31:39	00:38:02	00:20:09	67.76%	49.76%	17.99%	€ 1,634.58
Experiment XXII	00:39:32	00:45:55	00:18:02	72.02%	49.95%	22.07%	€ 1,628.24
Experiment XXIII	00:46:07	00:52:31	00:20:39	75.95%	55.99%	19.97%	€ 1,454.31
Experiment XXIV	01:37:20	01:43:43	00:33:03	82.24%	54.65%	27.59%	€ 1,487.37
Experiment XXV	00:59:23	01:05:47	00:34:38	69.41%	54.55%	14.86%	€ 1,491.61
Experiment XXVI	01:16:41	01:23:04	00:40:52	78.88%	61.61%	17.27%	€ 1,319.70
Experiment XXVII	01:40:23	01:46:46	00:38:22	87.18%	62.01%	25.17%	€ 1,313.84
Experiment XXVIII	01:57:52	02:04:16	00:59:39	89.94%	69.39%	20.55%	€ 1,168.73
Experiment XXIX	04:05:47	04:12:10	03:45:04	84.01%	53.39%	30.62%	€ 1,499.57
Experiment XXX	02:52:15	02:58:38	03:15:58	68.74%	55.70%	13.04%	€ 1,441.36
Experiment XXXI	04:09:03	04:15:26	03:55:02	91.84%	63.18%	28.66%	€ 1,266.25
Experiment XXXII	03:24:03	03:30:26	03:47:36	80.05%	63.90%	16.15%	€ 1,253.87

Best results Monday using new location receiving processes excluding separate break groups

Experiments		Lead Time	Time finished after last arrival	Amount employees (step 1, step 2)	Max amount street
Experiment XXVIII		02:04:16	00:59:39	6 (3, 3)	626
Experiment XXVI		01:23:04	00:40:52	7 (4, 3)	528
Experiment XXIII		00:52:31	00:20:39	8 (4, 4)	379
Experiment XXI	**No separate breaks**	**00:38:02**	**00:20:09**	**9 (5, 4)**	**358**
	Separate breaks	**00:33:56**	**00:17:47**	**9 (5, 4)**	**337**
Experiment XVIII		00:30:44	00:17:10	10 (5, 5)	340
Experiment XVI		00:26:32	00:16:24	11 (6, 5)	347

Tuesday

Results Tuesday using new location receiving processes excluding separate break groups

	Average waiting time	Average lead time	Average time finished after last arrival	Utilization (including extra time)	Utilization2 (excluding extra time)	Difference in utilization	Labor costs
Experiment XVI	00:15:13	00:21:31	00:16:20	49.35%	32.06%	17.29%	€ 1,461.04
Experiment XVII	00:15:29	00:21:47	00:15:18	51.19%	32.14%	19.04%	€ 1,457.23
Experiment XVIII	00:16:33	00:22:51	00:16:53	54.32%	35.19%	19.13%	€ 1,330.01
Experiment XIX	00:18:10	00:24:28	00:16:30	56.67%	35.20%	21.47%	€ 1,328.75
Experiment XX	00:18:09	00:24:26	00:21:03	51.11%	34.75%	16.35%	€ 1,343.93
Experiment XXI	00:19:18	00:25:36	00:21:38	56.75%	38.54%	18.21%	€ 1,211.26
Experiment XXII	00:19:05	00:25:22	00:18:20	60.56%	38.89%	21.67%	€ 1,201.35
Experiment XXIII	00:21:29	00:27:46	00:22:23	64.05%	43.24%	20.80%	€ 1,078.70
Experiment XXIV	00:27:00	00:33:18	00:22:25	68.79%	43.13%	25.66%	€ 1,078.78
Experiment XXV	00:29:46	00:36:04	00:30:51	57.94%	42.20%	15.74%	€ 1,101.26
Experiment XXVI	00:32:06	00:38:23	00:31:28	66.14%	48.13%	18.01%	€ 965.05
Experiment XXVII	00:29:06	00:35:23	00:25:50	73.56%	48.86%	24.70%	€ 951.89
Experiment XXVIII	00:37:32	00:43:50	00:33:27	77.16%	55.87%	21.29%	€ 831.16

Experiment XXIX	01:19:12	01:25:30	01:04:43	83.55%	51.51%	32.04%	€ 893.69
Experiment XXX	01:24:03	01:30:21	01:24:33	62.69%	49.44%	13.24%	€ 933.36
Experiment XXXI	01:22:27	01:28:44	01:11:01	91.42%	61.00%	30.42%	€ 755.23
Experiment XXXII	01:29:13	01:35:30	01:28:14	74.78%	58.88%	15.90%	€ 783.92

Best results Tuesday using new location receiving processes excluding separate break groups

Table 39: Best results Tuesday using new location receiving processes excluding break groups

Experiments		Lead Time	Time finished after last arrival	Amount employees (step 1, step 2)	Max amount street
Experiment XXXI		01:28:44	01:11:01	5 (2, 3)	519
Experiment XXVIII		00:43:50	00:33:27	6 (3, 3)	379
Experiment XXVII	**No separate breaks**	**00:35:23**	**00:25:50**	**7 (3, 4)**	**327**
	Separate breaks	**00:32:36**	**00:23:29**	**7 (3, 4)**	**311**
Experiment XXIII		00:27:46	00:22:23	8 (4, 4)	263
Experiment XXII		00:25:22	00:18:20	9 (4, 5)	247
Experiment XVIII		00:22:51	00:16:53	10 (5, 5)	241
Experiment XVI		00:21:31	00:16:20	11 (6, 5)	237

Wednesday

Results Wednesday using new location receiving processes excluding separate break groups

	Average waiting time	Average lead time	Average time finished after last arrival	Utilization (including extra time)	Utilization2 (excluding extra time)	Difference in utilization	Labor costs
Experiment XVI	00:14:23	00:20:40	00:15:49	43.40%	27.31%	16.09%	€ 1,474.73
Experiment XVII	00:14:51	00:21:07	00:15:01	44.78%	27.37%	17.41%	€ 1,471.76
Experiment XVIII	00:15:14	00:21:30	00:15:56	47.90%	30.04%	17.86%	€ 1,341.01
Experiment XIX	00:16:44	00:22:59	00:15:08	49.65%	30.11%	19.54%	€ 1,338.35
Experiment XX	00:16:20	00:22:37	00:18:10	45.56%	29.82%	15.74%	€ 1,348.49
Experiment XXI	00:17:22	00:23:39	00:18:40	50.59%	33.08%	17.51%	€ 1,215.10

Experiment XXII	00:17:23	00:23:39	00:16:26	53.47%	33.31%	20.16%	€ 1,208.42
Experiment XXIII	00:19:18	00:25:34	00:18:36	56.82%	37.24%	19.58%	€ 1,079.95
Experiment XXIV	00:23:04	00:29:20	00:17:37	60.72%	37.33%	23.39%	€ 1,077.30
Experiment XXV	00:23:26	00:29:43	00:21:06	52.72%	36.94%	15.78%	€ 1,086.59
Experiment XXVI	00:25:43	00:32:00	00:21:35	60.05%	42.14%	17.91%	€ 951.89
Experiment XXVII	00:24:16	00:30:33	00:19:26	65.74%	42.45%	23.29%	€ 946.86
Experiment XXVIII	00:30:18	00:36:34	00:22:35	70.16%	49.02%	21.14%	€ 817.92
Experiment XXIX	01:00:27	01:06:43	00:34:42	76.88%	47.04%	29.83%	€ 842.15
Experiment XXX	00:59:26	01:05:43	00:43:17	59.64%	45.94%	13.70%	€ 859.32
Experiment XXXI	01:03:41	01:09:57	00:37:50	84.72%	55.96%	28.76%	€ 707.01
Experiment XXXII	01:06:57	01:13:13	00:48:16	70.77%	54.52%	16.26%	€ 724.39

Best results Wednesday using new location receiving processes excluding separate break groups

Experiments		Lead Time	Time finished after last arrival	Amount employees (step 1, step 2)	Max amount street
Experiment XXXI		01:09:57	00:37:50	5 (2, 3)	263
Experiment XXVIII	**No separate breaks**	**00:36:34**	**00:22:35**	**6 (3, 3)**	**181**
	Separate breaks	**00:37:25**	**00:25:37**	**6 (3, 3)**	**178**
Experiment XXVII		00:30:33	00:19:26	7 (3, 4)	165
Experiment XXIII		00:25:34	00:18:36	8 (4, 4)	140
Experiment XXII		00:23:39	00:16:26	9 (4, 5)	135
Experiment XVIII		00:21:30	00:15:56	10 (5, 5)	136
Experiment XVI		00:20:40	00:15:49	11 (6, 5)	138

Thursday

Results Thursday using new location receiving processes excluding separate break groups

	Average waiting time	Average lead time	Average time finished after last arrival	Utilization (including extra time)	Utilization2 (excluding extra time)	Difference in utilization	Labor costs
Experiment XVI	00:16:32	00:22:40	00:15:08	41.09%	25.67%	15.42%	€ 1,125.23
Experiment XVII	00:17:01	00:23:09	00:14:04	46.70%	28.37%	18.33%	€ 1,121.32
Experiment XVIII	00:17:59	00:24:07	00:15:38	45.26%	28.14%	17.13%	€ 1,024.60
Experiment XIX	00:19:43	00:25:50	00:14:46	47.03%	28.23%	18.80%	€ 1,021.70
Experiment XX	00:19:06	00:25:14	00:17:03	43.25%	28.00%	15.25%	€ 1,029.35
Experiment XXI	00:20:28	00:26:36	00:17:47	47.90%	30.96%	16.94%	€ 928.58
Experiment XXII	00:20:34	00:26:42	00:16:00	50.57%	31.22%	19.35%	€ 923.24
Experiment XXIII	00:22:51	00:28:59	00:18:11	53.85%	34.77%	19.09%	€ 826.49
Experiment XXIV	00:26:54	00:33:02	00:17:25	57.57%	34.87%	22.70%	€ 824.44
Experiment XXV	00:27:50	00:33:58	00:20:33	50.01%	34.44%	15.57%	€ 832.80
Experiment XXVI	00:30:00	00:36:08	00:20:43	57.18%	39.33%	17.85%	€ 729.08
Experiment XXVII	00:28:37	00:34:46	00:18:56	62.21%	39.61%	22.60%	€ 724.91
Experiment XXVIII	00:34:48	00:40:56	00:21:17	66.84%	45.79%	21.05%	€ 626.08
Experiment XXIX	00:55:10	01:01:18	00:23:42	75.44%	45.27%	30.17%	€ 630.88
Experiment XXX	01:00:28	01:06:36	00:36:03	57.28%	43.33%	13.95%	€ 655.58
Experiment XXXI	00:58:15	01:04:23	00:27:21	82.29%	53.58%	28.71%	€ 531.82
Experiment XXXII	01:04:47	01:10:55	00:37:21	68.52%	51.74%	16.78%	€ 548.50

Best results Thursday using new location receiving processes excluding separate break groups

Experiments	Lead Time	Time finished after last arrival	Amount employees (step 1, step 2)	Max amount street
Experiment XXXI	01:04:23	00:27:21	5 (2, 3)	260

Experiment XXVIII		00:40:56	00:21:17	6 (3, 3)	234
Experiment XXVII	**No separate breaks**	**00:34:46**	**00:18:56**	**7 (3, 4)**	**234**
	Separate breaks	**00:32:03**	**00:17:08**	**7 (3, 4)**	**234**
Experiment XXIII		00:28:59	00:18:11	8 (4, 4)	219
Experiment XXI		00:26:36	00:17:47	9 (5, 4)	217
Experiment XVIII		00:24:07	00:15:38	10 (5, 5)	204
Experiment XVI		00:22:40	00:15:08	11 (6, 5)	204

Friday

Results Friday using new location receiving processes excluding separate break groups

	Average waiting time	Average lead time	Average time finished after last arrival	Utilization (including extra time)	Utilization2 (excluding extra time)	Difference in utilization	Labor costs
Experiment XVI	00:14:25	00:20:38	00:17:55	45.38%	28.99%	16.39%	€ 1,844.74
Experiment XVII	00:14:24	00:20:38	00:17:10	46.90%	29.04%	17.86%	€ 1,841.97
Experiment XVIII	00:15:16	00:21:30	00:18:24	50.03%	31.86%	18.17%	€ 1,678.61
Experiment XIX	00:16:26	00:22:39	00:17:42	52.01%	31.91%	20.10%	€ 1,676.28
Experiment XX	00:17:03	00:23:16	00:20:43	47.54%	31.69%	15.85%	€ 1,686.36
Experiment XXI	00:17:44	00:23:58	00:21:03	52.93%	35.19%	17.74%	€ 1,518.75
Experiment XXII	00:17:11	00:23:24	00:19:07	55.90%	35.34%	20.56%	€ 1,512.90
Experiment XXIII	00:19:28	00:25:42	00:21:42	59.69%	39.53%	20.16%	€ 1,351.72
Experiment XXIV	00:23:58	00:30:12	00:20:50	63.99%	39.61%	24.39%	€ 1,349.42
Experiment XXV	00:28:03	00:34:16	00:25:57	54.96%	39.18%	15.78%	€ 1,363.06
Experiment XXVI	00:29:17	00:35:31	00:26:24	62.88%	44.75%	18.13%	€ 1,193.70
Experiment XXVII	00:25:46	00:32:00	00:23:19	69.14%	45.03%	24.11%	€ 1,186.51
Experiment XXVIII	00:32:56	00:39:10	00:28:03	73.64%	52.04%	21.60%	€ 1,026.47
Experiment XXIX	01:06:31	01:12:44	00:44:35	81.93%	50.24%	31.69%	€ 1,059.54
Experiment XXX	01:19:41	01:25:54	01:14:32	61.37%	47.73%	13.64%	€ 1,119.44

Experiment XXXI	01:09:33	01:15:47	00:50:41	89.85%	59.63%	30.23%	€ 893.12
Experiment XXXII	01:21:08	01:27:22	01:15:02	73.53%	57.17%	16.35%	€ 933.70

Best results Friday using new location receiving processes excluding separate break groups

Experiments		Lead Time	Time finished after last arrival	Amount employees (step 1, step 2)	Max amount street
Experiment XXXI		01:15:47	00:50:41	5 (2, 3)	514
Experiment XXVIII		00:39:10	00:28:03	6 (3, 3)	376
Experiment XXVII	**No separate breaks**	**00:32:00**	**00:23:19**	**7 (3, 4)**	**337**
	Separate breaks	**00:28:33**	**00:20:35**	**7 (3, 4)**	**332**
Experiment XXIII		00:25:42	00:21:42	8 (4, 4)	287
Experiment XXII		00:23:24	00:19:07	9 (4, 5)	251
Experiment XVIII		00:21:30	00:18:24	10 (5, 5)	236
Experiment XVII		00:20:38	00:17:10	11 (5, 6)	224

Extra results new location

Results best configurations of the new location regarding the labor costs, the waiting time and the utilization of the employees compared with the current situation.

	Labor costs	Waiting time employee	Utilization employees
Monday	-22%	-50%	76%
Tuesday	-34%	-57%	126%
Wednesday	-43%	-45%	150%
Thursday	-14%	-36%	72%
Friday	-36%	-49%	139%

Appendix N: Best configurations for the current location

Weekday	Step	Amount of employees	Amount of employees in break group 1	Amount of employees in break group 2
Monday	1	5	2	3
	2	4	2	2
Tuesday	1	3	2	1
	2	4	2	2
Wednesday	1	3	1	2
	2	3	2	1
Thursday	1	3	1	2
	2	4	2	2
Friday	1	3	2	1
	2	4	2	2

Appendix O: Comparing the current situation with the new situations

Factorial difference utilization employees according to the current situation

Weekday	Current location	New location
Monday	1.57	1.76
Tuesday	1.94	2.26
Wednesday	2.27	2.50
Thursday	2.09	1.72
Friday	2.33	2.39

Percentage difference waiting times employees according to the current situation

Weekday	Current location	New location
Monday	-39%	-50%
Tuesday	-41%	-57%
Wednesday	-33%	-45%
Thursday	-58%	-36%
Friday	-46%	-49%

Percentage difference in lead time according to the current situation

Weekday	Current location	New location
Monday	-36%	-32%
Tuesday	72%	124%
Wednesday	63%	178%
Thursday	72%	21%
Friday	101%	34%

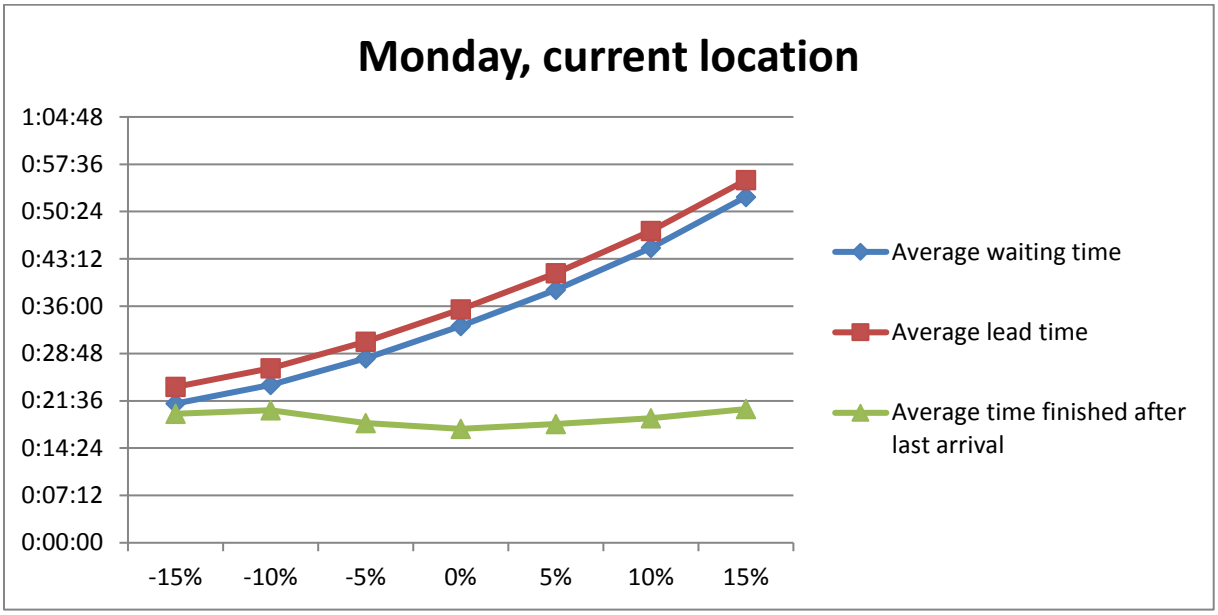
Average lead times percentages between using and not using the separate breaks

Weekday	Current location	New location
Monday	-9%	-11%
Tuesday	-2%	-8%
Wednesday	-5%	2%
Thursday	-3%	-8%
Friday	-4%	-11%

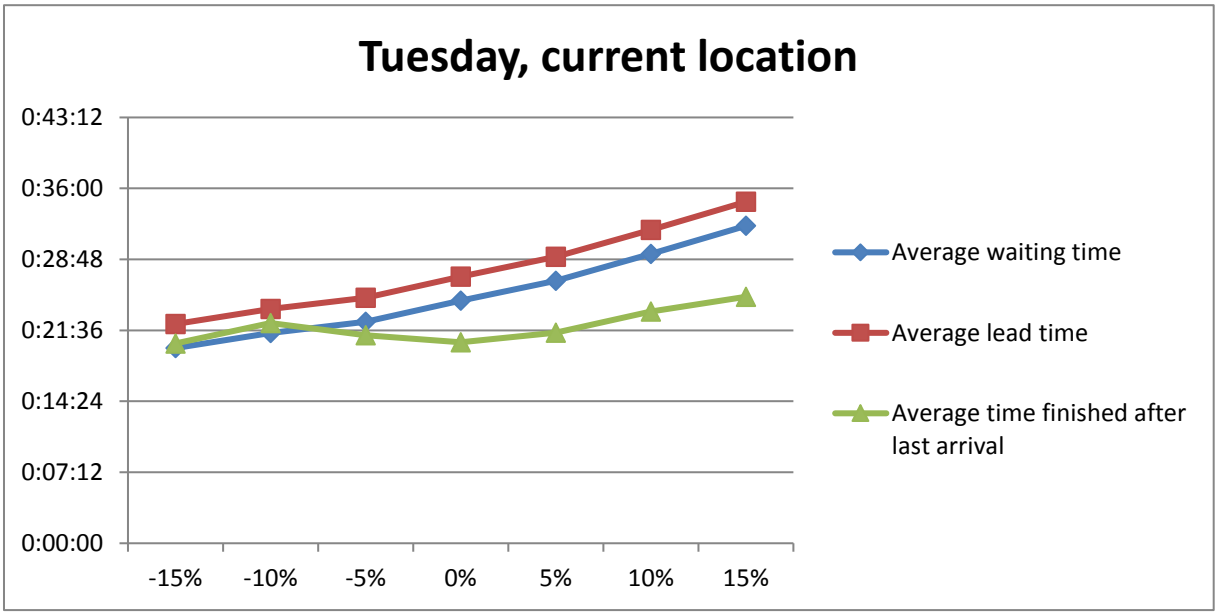
Appendix P: Sensitivity results current location

For each weekday a figure presents the average times in case of adding and reducing the supply when the current location is used.

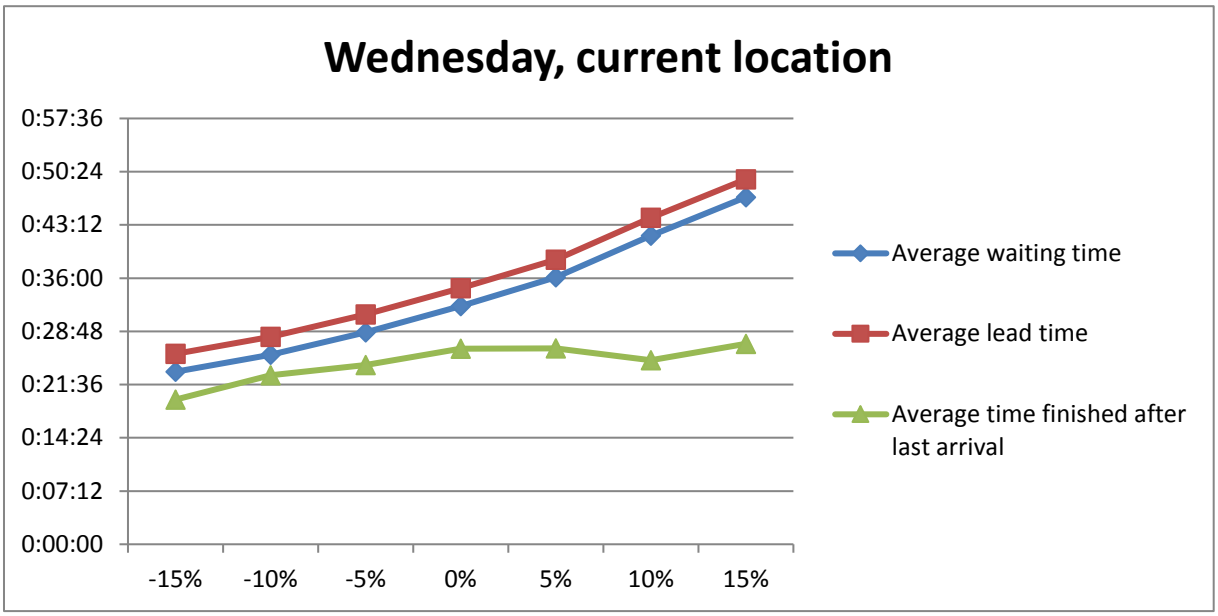
Monday



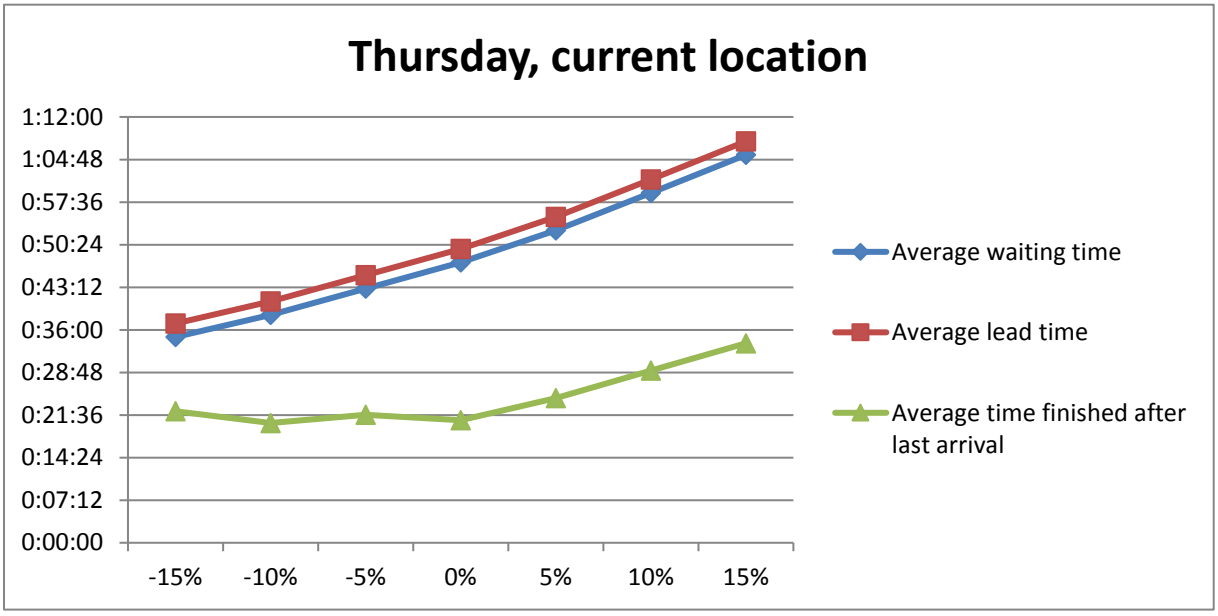
Tuesday



Wednesday



Thursday



Friday

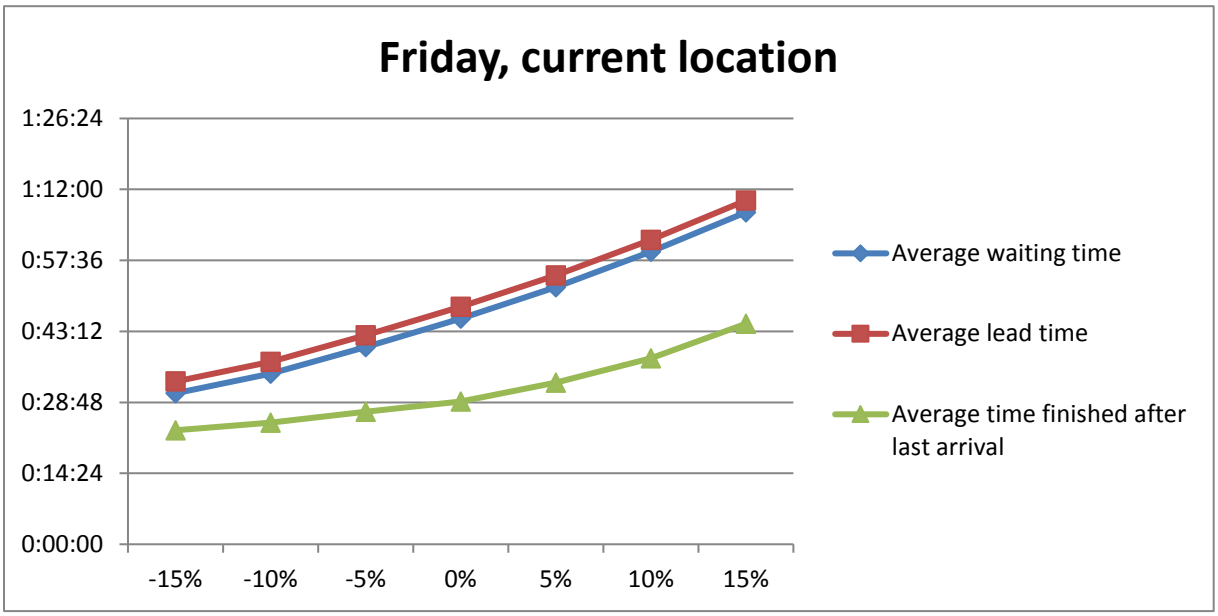


Table 40: Differences in time using current location when adding and reducing the supply with 15%

Differences in time using current location when adding and reducing the supply with 15%

Weekday	Difference average lead time	Difference average time finished after last trolley
Monday	00:31:28	00:03:01
Tuesday	00:12:24	00:04:44
Wednesday	00:23:37	00:07:33
Thursday	00:30:48	00:13:28
Friday	00:36:43	00:21:37

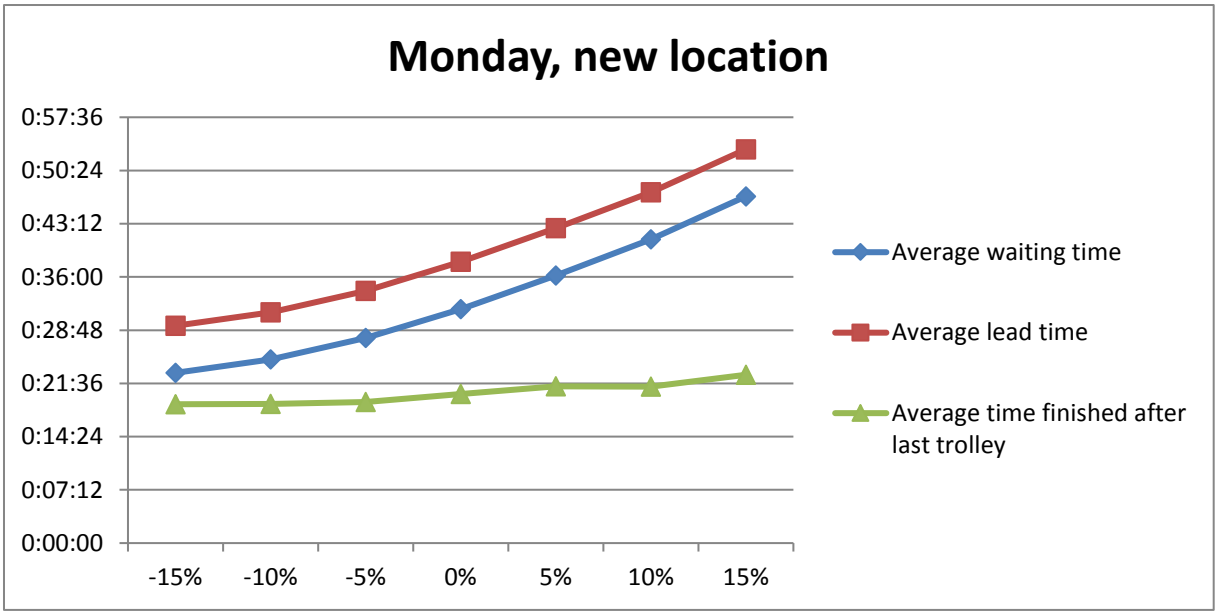
Minimum and maximum times sensitivity analysis for the current location

Weekday	Min average lead time	Max average lead time	Min average time finished after last trolley	Max average time finished after last trolley	Max amount of trolleys at buffer supplier
Monday	00:23:43	00:55:11	00:17:20	00:20:21	184
Tuesday	00:22:14	00:34:38	00:20:16	00:25:00	171
Wednesday	00:25:45	00:49:23	00:19:34	00:27:07	16
Thursday	00:37:04	01:07:52	00:20:15	00:33:44	70
Friday	00:33:02	01:09:45	00:23:08	00:44:44	347

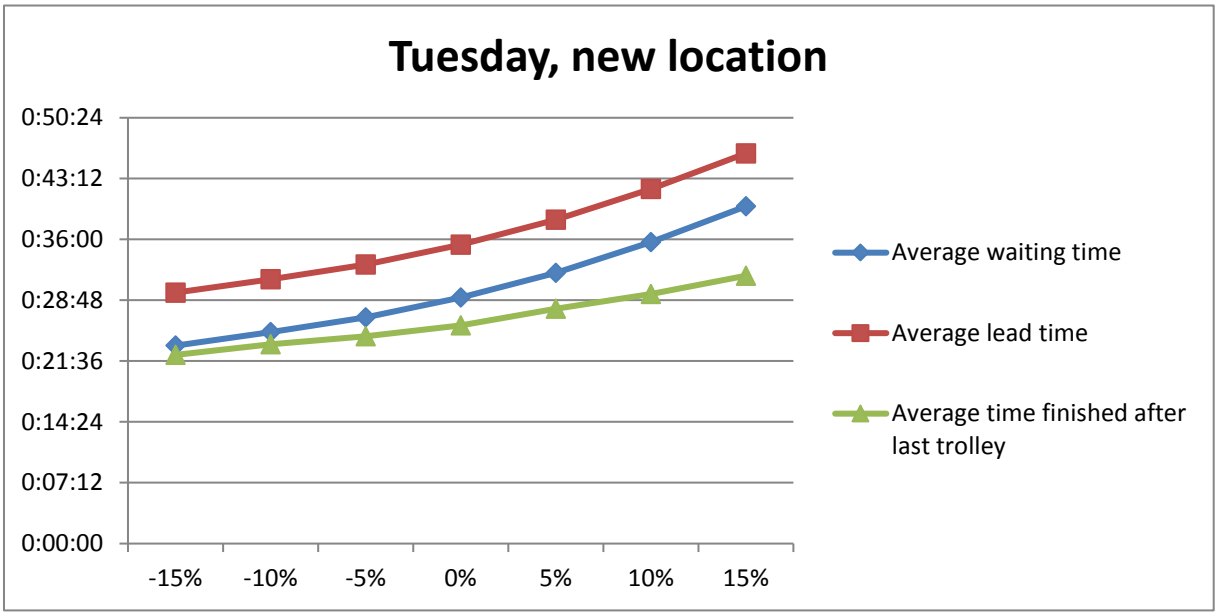
Appendix Q: Sensitivity results new location

For each weekday a figure presents the average times in case of adding and reducing the supply when the new location is used.

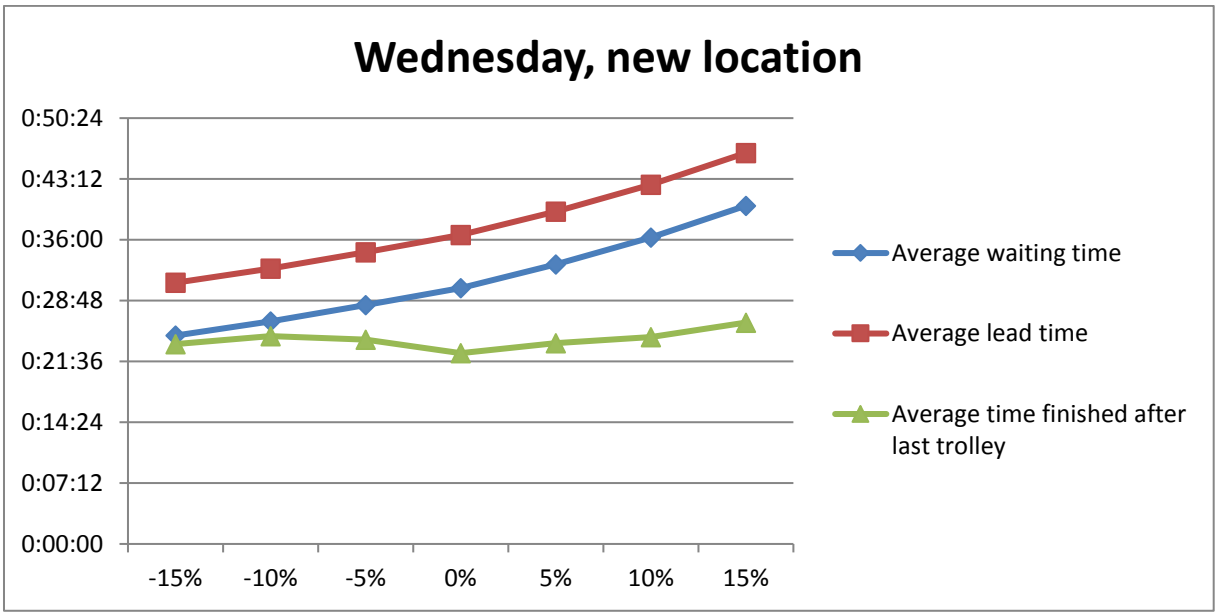
Monday



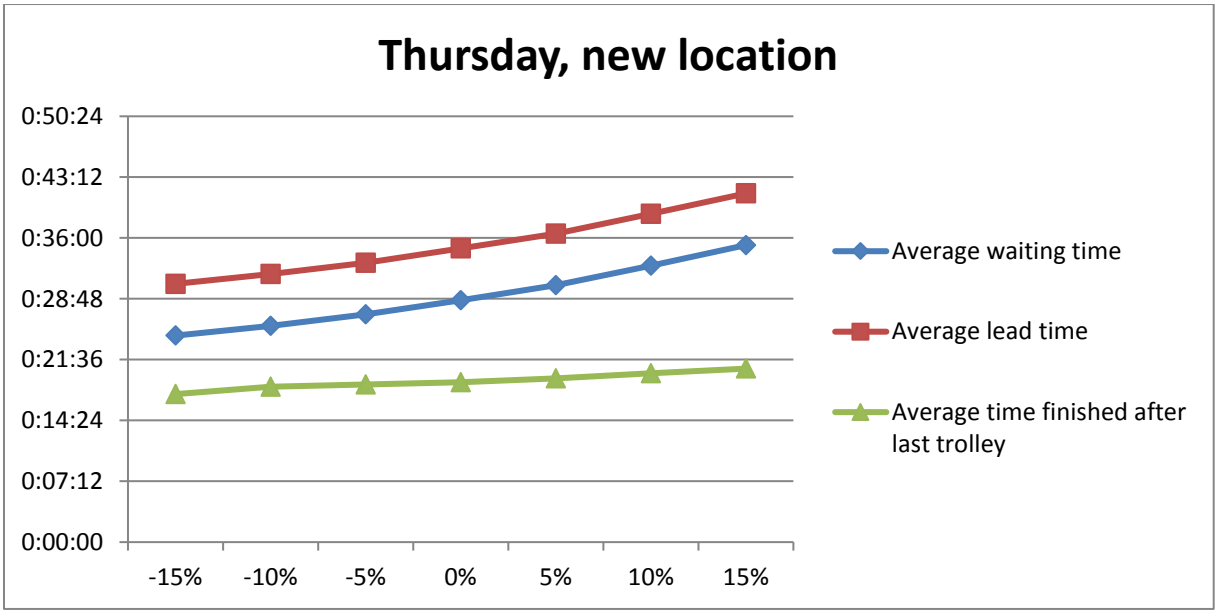
Tuesday



Wednesday



Thursday



Friday

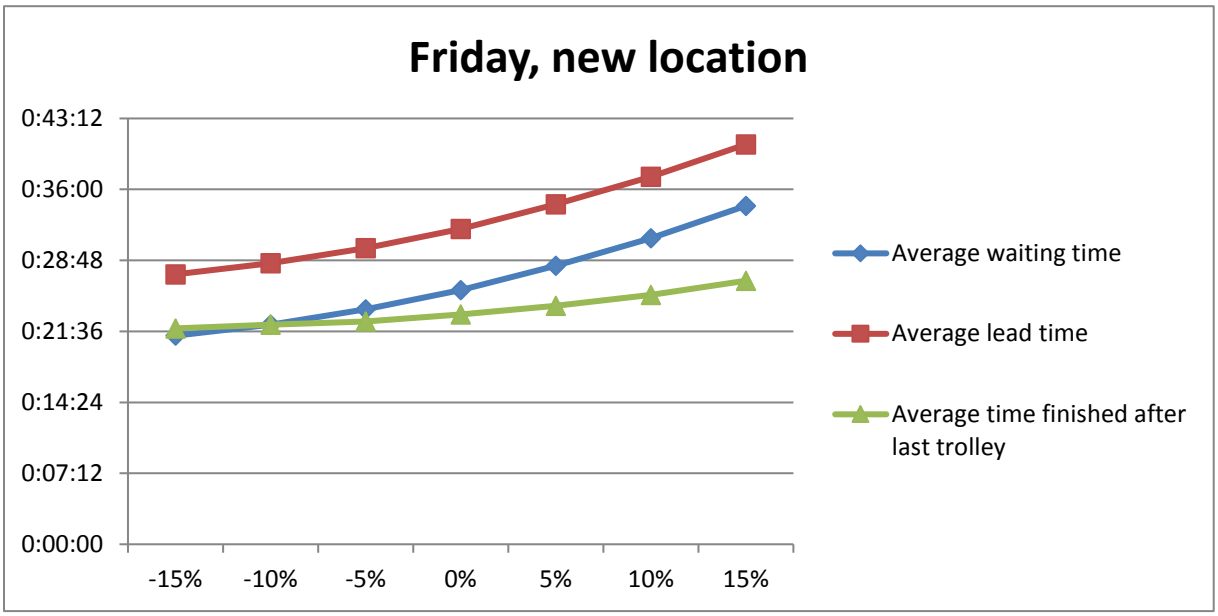


Table 41: Differences in time using new location when adding and reducing the supply with 15%

Differences in time using new location when adding and reducing the supply with 15%

Weekday	Difference average lead time	Difference average time finished after last trolley
Monday	00:23:52	00:03:59
Tuesday	00:16:29	00:09:22
Wednesday	00:15:22	00:03:37
Thursday	00:10:42	00:03:01
Friday	00:13:11	00:04:50

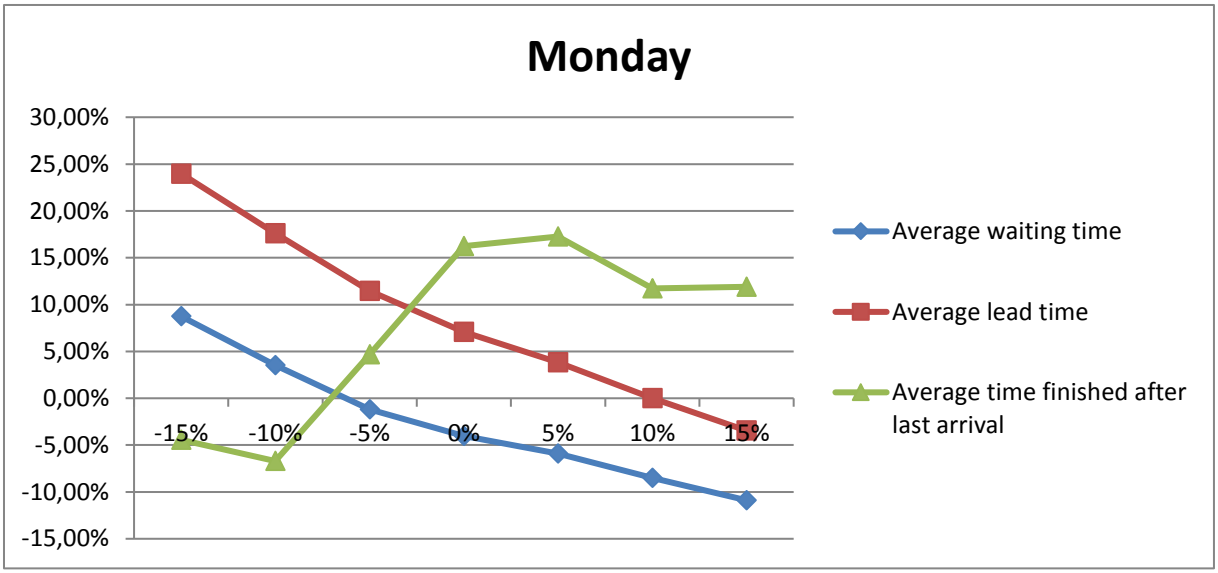
Minimum and maximum times sensitivity analysis and maximum amount of trolleys on location for the new location

Weekday	Min average lead time	Max average lead time	Min average time finished after last trolley	Max average time finished after last trolley	Max amount of trolleys on location
Monday	00:29:24	00:53:16	00:18:47	00:22:46	460
Tuesday	00:29:42	00:46:11	00:22:20	00:31:42	488
Wednesday	00:30:55	00:46:17	00:22:35	00:26:12	248
Thursday	00:30:34	00:41:16	00:17:31	00:20:32	268
Friday	00:27:23	00:40:34	00:21:54	00:26:44	451

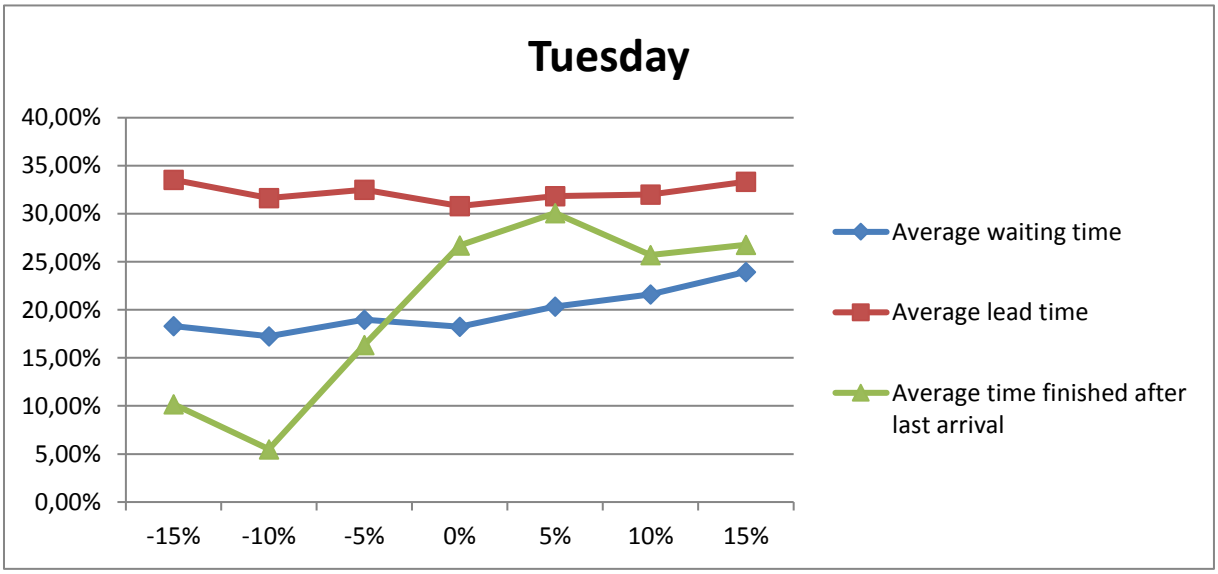
Appendix R: Comparing the sensitivity results of the new location with the current location

For each weekday a figure presents the percentage differences of the new location compared with the current location in case of adding and reducing the supply. In all the graphs, for example 10% means that the new location is 10% higher than the current location.

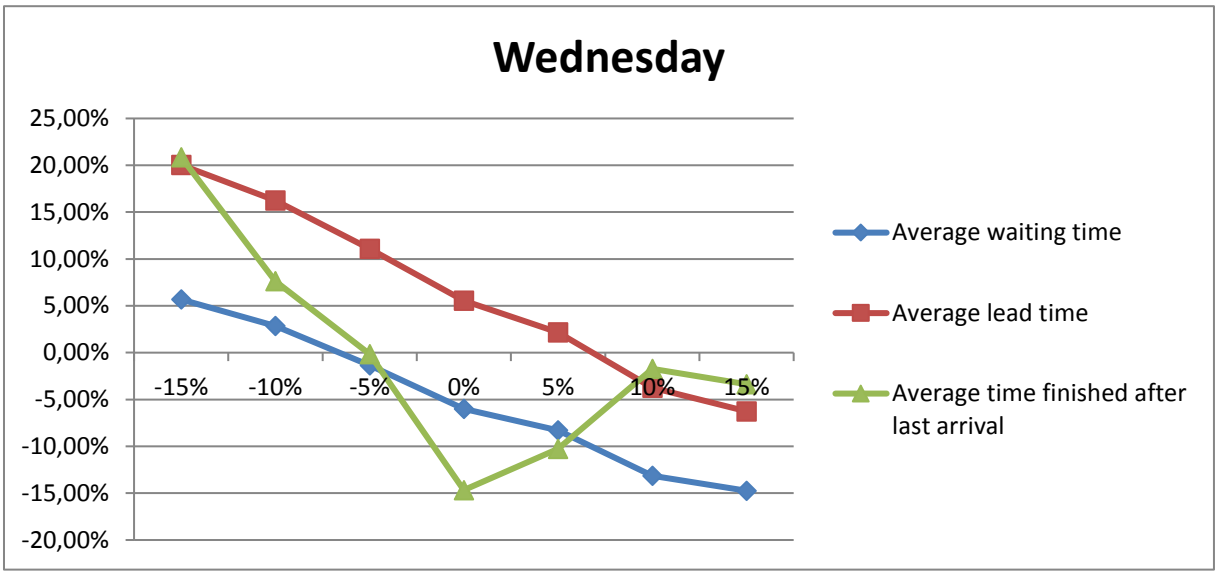
Monday



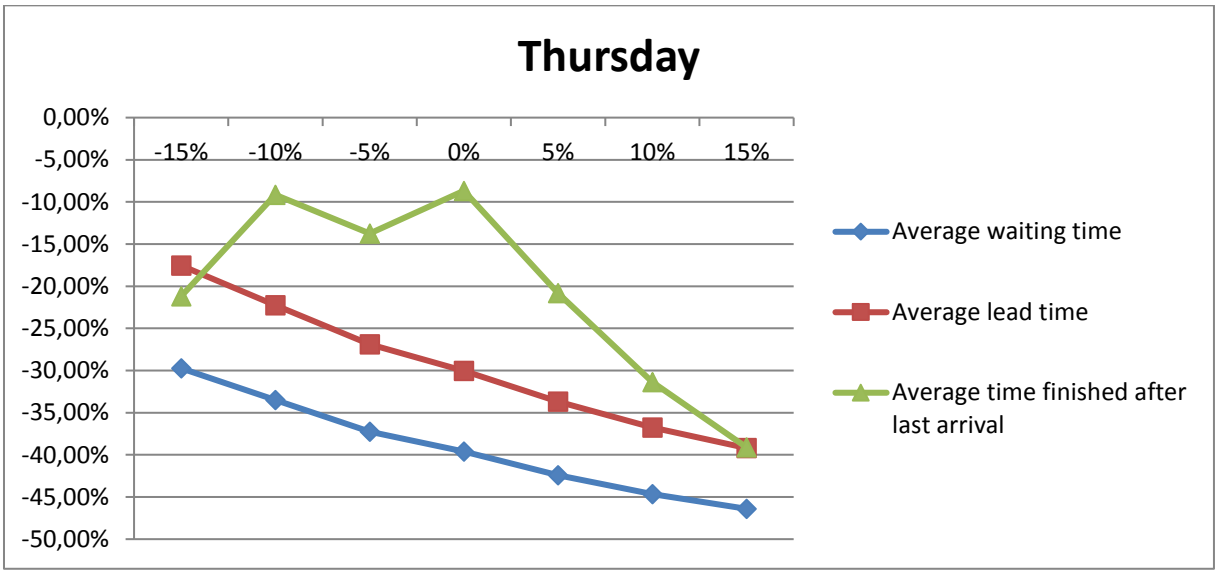
Tuesday



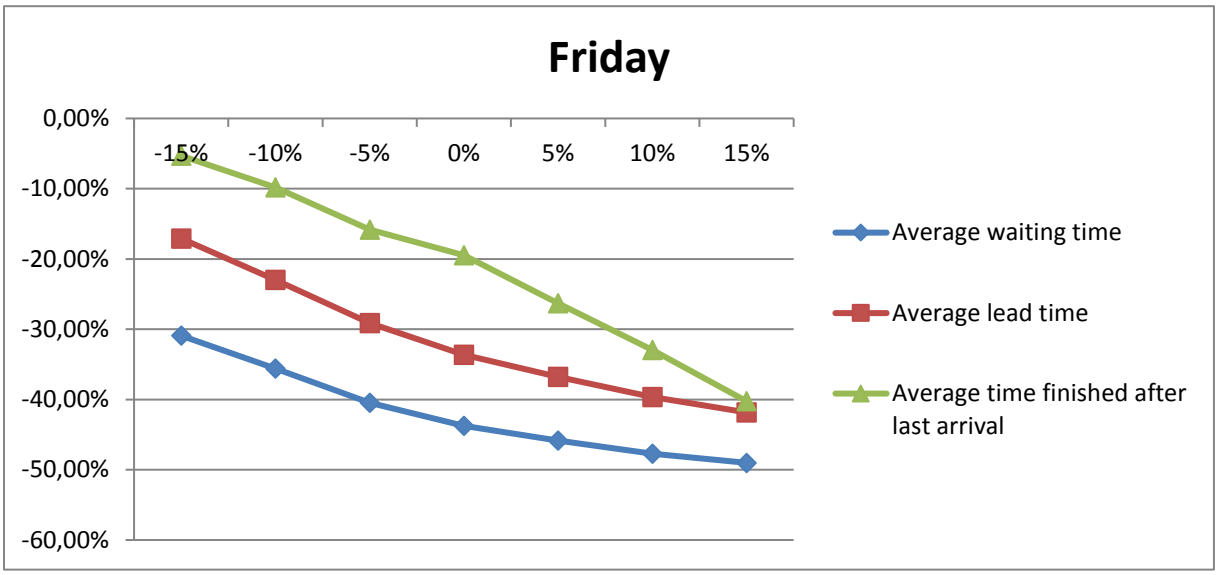
Wednesday



Thursday



Friday


Friday
0,00%
-10,00%
-20,00%
-30,00%
-40,00%
-50,00%
-60,00%
-15%
-10%
-5%
0%
5%
10%
15%
Average waiting time
Average lead time
Average time finished after last arrival