Master Thesis

Process improvement to shorten the lead-time for the ACD division in the distribution center of L’Oréal located in Alphen aan den Rijn

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Delft University of Technology
ALPHEN AAN DEN RIJN

This document is confidential

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Preface

This report is the result of my master thesis project in order to complete the master Transport, Infrastructure and Logistics at Delft University of Technology. The aim of the project was to shorten the lead-time of the ACD division by improving the process in the distribution center for the Benelux of L’Oreal located in Alphen aan den Rijn.

I could not have completed this thesis with the help of the following people. First of all, I would like to thank Carlijn van den Berg and Wouter Lukas for the opportunity to do my thesis project at the distribution center. Their time, feedback and input helped me a lot to understand the business and challenged me to deliver a valuable outcome. I would also like to thank all the other colleagues of the ACD division as well as the other colleagues of L’Oréal.

Furthermore, I would to thank dr. R.R. Negenborn, dr. J.M. Vleugel and dr. W.W.A. Beelaerts van Blokand for the supervision and the support during the meetings and the presentations.

I could say that have learned a lot during my internship and that I liked the challenge to be between the business-side of L’Oréal and the scientific side of the TU Delft.

Thanks a lot and enjoy reading.

Alphen aan den Rijn, March 2017
Joris Jacquemijns
Abstract

To be successful in the cosmetics market, it is necessary to keep the right balance between costs, flexibility and customer satisfaction.

L’Oréal is the biggest player in the cosmetics market. In the distribution center (DC) in Alphen aan den Rijn two of the four divisions are distributed to customers in the Benelux:

- PPD: Professional Product Division - lead-time 1 workday
- ACD: Active Cosmetics Division - normal orders have a lead-time of 3 workdays; presales should be handled before the end of the month

The goal of the research project is to shorten the lead-time of the ACD division by developing a framework that improves the performance of the DC. The scope of the research is on the outbound of the DC and areas connected to the DC. In the current state, three problems can be seen in the DC: the first problem is that the DC is dealing with one capacity for two divisions. The second problem is the complex resource planning due to having a pool of fixed and temporary employees. The third problem is that there is no overall picture of the flows and the lead-times in the DC.

The following research question should be answered to solve these problems:

How to improve the process in the distribution center of L’Oréal in order to shorten the lead-time?

In order to answer this question a framework was developed based on the DMAIC cycle (Define, Measure, Analyze, Improve and Control). Furthermore, supply chain methodologies, process improvement methodologies and solution evaluation methodologies are used to form the framework. Next, the following three criteria were defined based on the needs of the DC of L’Oréal:

1. Cost: the implementation and operational costs of an improvement.
2. **Usability**: how usable is the improvement; how structural is the improvement, are human resources required to keep the improvement, is a lot of training required, is the effect of the improvement gradual or immediate.

3. **Feasibility**: is it IT feasible, is the improvement internal (at L’Oreal) or external, is it an all or nothing improvement or an extension on the current state.

A process analysis was made for the different departments. Customer care and sales are responsible for the orders. Sales uses Sales Force + (program), which updates 3 times a day to SAP. Customer care places the orders directly into SAP. The next step in the process is the process of the ACD portfolio manager. This function has an overview of all the orders in the system. The function is also responsible for forecasting the workload and pushing the orders to the DC. The next step is the physical distribution in the DC. Supervisors make the planning for the capacity and team-leaders manage the execution. The DC handles deliveries in waves, which are similar kind of deliveries. Deliveries are picked, packed, sealed and shipped to the customer.

The following constraints can be found in the current system.

- The wave structure makes it impossible to ship a part of a wave.
- SF+ updates only 3 times a day.
- The SAP in the headquarters updates only once a day to the SAP in the DC.
- Only 5.5% of the PPD customers are 48 hours customers. Those customers are served within 1 workday in most of the cases.
- The prioritization and control of the workload are difficult.
- Only 50.6% of ready-to-ship deliveries are shipped the same day.

An improvement should at least fulfill one of the following requirements: create flow, reduce waiting time or provide insights. By reducing waiting times and creating flow improvements are develop for the constraints. The following improvements were developed:

- **Real-time connection between systems improvement**: this improvement will push the orders more often through the systems. The connection between SF+ and SAP will be real-time. The connection between SAP in the headquarters and SAP in the warehouse will update three times a day instead of one time a day. The results of this improvement are more flow in the system and better insights in the demand.
The dynamic wave and resource planning improvement: this improvement will help the supervisors and team-leaders with the planning of the employees on a specific wave. Currently, prioritising of work is difficult and with this tool a better overview on the left workload is created. With the known capacity - based on the # of employees - team-leaders can plan which waves will be picked; The tool also shows the progress on a wave and presents the team-leaders the amount of employees needed to work on a wave in order to finish before the lead-time deadline. Furthermore, the improvement assigns the tours digitally. The tool creates more flow and extra insights for the management in the DC.

The transport network improvement: this improvement will change the transport network. Currently, deliveries will first go to a main transport hub of the transporter and later to regional transport hubs. The improvement will transport the deliveries immediately to the regional hubs. The improvement will reduce waiting time and create flow.

The wave structure and characteristics improvement: this improvement will attract more PPD 48 hours customers. In this manner extra flexibility is created. Furthermore, it makes it possible to ship a part of a wave. This results in the shipping of full trucks and an emptier floor at outbound. The improvement reduces waiting time for some deliveries and creates flow.

Integral improvement: this improvement connects forecasting with planning and capacity. Enough orders are collected until a full truckload (or truckloads) of workload is reached. Based on this a number of employees is planned to finish all the work. All deliveries are picked and shipped on the same day as they arrive in the DC. The improvement will reduces waiting time for a big part of the deliveries and create flow.

In order to find the best measure of improvement a Multi Criteria Analysis (MCA) was conducted. The three criteria cost, usability and feasibility are weighted by the 2 team-leaders, the 2 supervisors and the warehouse manager. Also equal weights for the criteria are used. The improvements are scored via ranking, scoring from 1 to 5 and scoring from 1 to 3. In total this results in 18 different outcomes for the MCA. The dynamic wave and resource planning improvement is the best in 14 of the 18 outcomes and is therefore the best improvement.

The best improvement can be implemented as follows: in SAP or in an extraction for SAP to Excel, an improved wave monitor should be created...
which can update automatically. Based on the wave creation date and the wave type the latest shipping date can be calculated. The monitor will be sorted on the latest shipping date. The following information can be found on the monitor: total pick, left picks, wave progress, time left to finish a wave on time and the number of employees needed to finish on time.

A simulation was conducted to find out how much the dynamic wave and resource planning improvement will reduce the lead-time. First the current wave finishing time is calculated. The calculation can be done by taking the difference between the wave creation date and time and the latest dock date and time. Next, the monitor is presented to the team-leaders who had to plan where they would use which part of the capacity. In total three simulation were conducted. November 2015 with almost no presales, and March and June 2016 with a significant part of presales. The results of lead-time shortening are presented in the table below.

<table>
<thead>
<tr>
<th>Month</th>
<th>Actual lead-time</th>
<th>Simulated lead-time</th>
<th>Reduction [%]</th>
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<tr>
<td>November 2015</td>
<td>1.52</td>
<td>1.44</td>
<td>-5.6</td>
</tr>
<tr>
<td>March 2016</td>
<td>2.53</td>
<td>1.35</td>
<td>-46.7</td>
</tr>
<tr>
<td>June 2016</td>
<td>2.57</td>
<td>1.64</td>
<td>-36.3</td>
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Table 1: Results of lead-time simulation

Next, the research question is answered:

How to improve the process in the distribution center of L’Oréal in order to shorten the lead-time?

The process in the DC can be improved with different measures. The best measure is the dynamic wave and resource planning improvement. This improvement provides a tool to prioritise the waves and plans the resources in a better way. The improvement results in a reduction in lead-time of 5 till 47% bringing the average lead-time down from 2.2 to 1.5 days. In addition, the real-time connection between the systems pushes the orders more often through the system and could further help to reduce the lead-time even more.
Recommendation: it is recommended for L’Oréal to implement the dynamic wave and resource planning improvement, which is the best scoring improvement. This improvement tackles the rootcause of the problem, which is not finishing waves according to priority. The wave structure and characteristics improvement provides a solution to ship a part of wave. This helps reducing the lead-time but is solving the problem caused by the rootcause instead of the rootcause itself. It is however recommended to attract more 48 hours customers. The real-time connection between the systems improvement is also recommended in order to get the orders pushed through the system more often.

Further research: in order to get more insight and visibility in the process further research is needed on the following five areas:

- **Process improvements**: in the current detail-picking process employees need to start their tour by putting stickers on specific boxes. This takes about a quarter of the time of a tour. Further research should be done to find out if automation of this part is feasible.

- **Truck planning**: in the current state one person is responsible for the planning of the trucks. No information is tracked about the truck planning and therefore it is not possible to know how well the truck planning is done. It is recommended to track the truck planning so analysis could be conducted. Further research is needed to find the best way of truck planning.

- **KPIs**: there are no KPIs used for the lead-time. In order to track the performance of the DC and to see if an improvement will work it is important to track the lead-time.

- **Total lead-time**: the focus for this research was shortening of the lead-time in the DC. However, for the customers the total lead-time is important. Further research is necessary to shorten the lead-time from ordering until delivery.

- **Optimal wave size**: the optimal wave size is unclear. Large wave sizes offer efficiency in picking tours and short wave sizes reduce waiting times. Research is necessary to find the optimal wave size.
## List of abbreviations

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<td>PPD</td>
<td>Professional Product Division</td>
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<td>ACD</td>
<td>Active Cosmetics Division</td>
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<tr>
<td>CPD</td>
<td>Consumer Products Division</td>
</tr>
<tr>
<td>DC</td>
<td>Distribution Center</td>
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<td>DMAIC</td>
<td>Define, Measure, Analyze, Improve, Control</td>
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<tr>
<td>DF</td>
<td>Demand Forecasting</td>
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<td>DP</td>
<td>Demand Planning</td>
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<tr>
<td>DM</td>
<td>Demand Management</td>
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<tr>
<td>MSE</td>
<td>Mean Squared Error</td>
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<td>MCA</td>
<td>Multi Criteria Analysis</td>
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<td>Human Resources</td>
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Part I

Define
Figure 1: Detail picking area with the typical U-shapes for optimized picking
Chapter 1
Introduction

This document presents the project of L’Oréal Alphen aan den Rijn for the Graduation of the Master Transport, Infrastructure and Logistics at Delft University of Technology. This chapter starts with the context analysis in section 1.1. Next, L’Oréal - the world largest cosmetics company - is introduced in section 1.2. In section 1.3 the problem definition, objectives and research question are discussed. Finally, the report structure is given in section 1.4.

1.1 Context analysis

In the past 10 years the worldwide cosmetics market has grown with an average rate of about 4% per year. The total market is worth about 203 billion euros and is expanding constantly driven by demographic trends in the new markets, new needs linked to urbanisation, and new consumer desires fuelled by social networks [L’Oréal, 2016a]. It is expected that the cosmetics market will grow even more due to the growth in e-commerce and growth
in online beauty sales. The world cosmetics market can be divided in six different segments (see figure 1.2).

![Figure 1.2: Breakdown of cosmetics market 2015 [Statista, 2016a]](image)

In figure 1.3 the revenue of the 7 biggest market players in the cosmetics market is shown.

![Figure 1.3: Revenue top 7 beauty brands in 2015 [Statista, 2016b]](image)
1.2  L’Oréal: the world largest cosmetics company

L’Oréal is the world largest cosmetics company. [L’Oréal, 2016b]. L’Oréal’s headquarters are located in Hoofddorp for the Netherlands and in Brussel for Belgium. In total L’Oréal has over 50 brands and 4 different divisions in Europe. The following divisions can be distinguished:

- CPD: Consumer Products Division. This division sells products to the mass market. It is therefore distributed via mass retailing channels: hypermarkets, supermarkets, drugstores and traditional stores.

- Luxe Division: This division operates in the skin care, make-up and perfume business. It has different mayor brands in it’s portfolio, like Lancome, Giorgio Armani and Biotherm. The products are sold in department stores, cosmetics stores and boutiques.

- PPD: Professional Products Division. This division has a range of products for hair salons. The products are used to color, shape and style hair. This division also has shampoos and hair conditioners [L’Oréal, 2016c]. The products are mainly sold in hair-salons.

- ACD: Active Cosmetics Division. This division has a range of different skincare products mainly sold to health-care wholesalers, pharmacies, drugstores and medi-spas. [L’Oréal, 2016d]

For this research only the PPD and ACD divisions are considered. In Alphen aan den Rijn a distribution center (DC) for these divisions is located which serves customers in the Benelux. The focus for this research is on the ACD division in the DC.

1.2.1  The total system of the PPD and ACD divisions in the Benelux

In figure 1.4 the total manufacturing, ordering and distributing system is visualised for the ACD and PPD divisions. In the center of the figure the DC in Alphen can be found. Alphen aan den Rijn is supply with ACD and PPD products from the manufacturers mainly located in Spain, Belgium and from some other places in Europe. Customers make orders via Customer Care or via sales representatives who visit their stores. Sales representatives use Mercure (PPD) and Sales Force + (ACD) to place the orders. Eventually, orders are pushed into SAP and from that moment visible for all the departments of
L’Oréal. When orders are pushed to the DC they can be picked, packed and shipped via external shippers to the customers. The customers are business and therefore the network is a B2B network and not a B2C network.

Figure 1.4: Position of the distribution center in the system

1.2.2 The distribution center in Alphen aan den Rijn

In the DC in Alphen aan den Rijn a distinction between three different kinds of order picking is made:

- Pallet picking: One or multiple pallets with the same product is picked for big deliveries

- Standard picking: These are picks of full boxes of the same products. Multiple full boxes of products are combined on a pallet to be shipped to a customer. These orders can also be combined with detail picking boxes.

- Loose picking: These are picks of one or several of the same kind of products. The picks are done in the detail picking area and are combined on pallets.
Furthermore, a distinction between the types of products can be made as follows:

- Normal. These products can be in the shelves with no extra safety measures.

- (Semi-)liquid products. For the liquid products a box is put underneath the rack to keep the damage small in case of leaking products.

- Aerosols In high volumes they are stored in a separate bunker. In smaller volumes they are stored in special racks that are separated from the other racks by using shutters. The different types of aerosols are:
  - Type 1: Foams
  - Type 2: Sprays
  - Type 3: Deodorants

- Dangerous goods: stored in a special fire proof locker

1.3 Problem definition, objectives and research question

This section will first give the problem definition. Later, the objectives are presented and at last the research question is given and explained.

1.3.1 Problem definition

Nowadays it is possible to order products today and get them delivered the next day. In this way companies provide service to their customers. This is how it works in the B2C market. L’Oréal’s DC operates in the B2B market delivering products to wholesalers and retailers. Currently, the time-span - lead-time - from ordering until delivering is between 2 and 8 workdays. In order to keep the customers satisfied and attract new customers L’Oréal wants to shorten the lead-time to 5 workdays. The mayor problem in the DC is that it is unknown how much work - workload or demand - will arrive in the next day. On basis of a forecast the number of needed employees - capacity - is planned and team-leaders distribute the employees on a specific area at a specific time to ship the deliveries on time.

Shortening the lead-time might also result in the following two benefits:
1. Receiving orders more often

2. Receiving a more evenly distributed workload: in this way planning is easier.

This research focuses on shortening the lead-time for ACD products. But first, what is lead time:

\[
\text{Amount of time that is needed for the completion of an operation or process [Dictionary, 2016]}
\]

In this research the lead-time starts when the order is made into a delivery in SAP - and is therefore pick-able - and ends when the delivery is loaded in the truck of the transporter.

Summarized, the following problems can be seen:

- Two different divisions with different lead-times sharing their capacity:
  - PPD: a lead-time of 1 workday
  - ACD: a lead-time of maximum 3 workdays
  - Note: ACD has also presales; those presales should leave the DC the same month as they arrive in the DC

- Complex resource planning due to working with a pool of temporary people

- No clear view on the demand for the next day(s)

- No overall picture about: flows sizes, waiting times, truck planning

- No clear monitoring of lead-time for the physical distribution in the DC

### 1.3.2 Objectives

The aim is to develop a plan to improve the forecast and planning and the process itself to shorten the lead-time of the ACD division in the DC in Alphen aan den Rijn. To satisfy both L’Oréal as well as the TU Delft, the following objectives are stated:

- Understanding the process steps and the decisions that are made in the process from ordering to shipping
• Provide a more detailed view of the current lead-times for the PPD and ACD flows.
  – Indicate the waves and flows in the distribution center
  – Understand the current planning methods
• Visualise the current demand
• Design measurements to improve the process in the distribution center to shorten the lead-time
• Make an implementation plan of how to implement the best measure of improvement and simulate the expected lead-time improvement

1.3.3 Research question

The project focuses on the following research question based on the research objectives:

_How to improve the process in the distribution center of L’Oréal in order to shorten the lead-time?_

The following sub questions can be asked in order to answer this research question.

<table>
<thead>
<tr>
<th>Sub-questions</th>
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<tbody>
<tr>
<td>1</td>
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<td>10</td>
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<tr>
<td>11</td>
</tr>
</tbody>
</table>

Table 1.1: Sub-questions
1.3.4 Scope

During the project the following boundaries will be used. A visualisation of the scope and the DC in the scope is given in figure 1.5.

- The focus will be on the process of handling deliveries in the DC: The process of sales and customer car are not considered.
- The focus is on improving the lead-time for the ACD division
- The focus will be on measurements of improvement in the DC or a process strongly linked with the DC
- The technical aspects of order-picking are out of scope
- The pallet picks are out of scope

1.4 Report structure

The research approach for the project is the DMAIC cycle: Define, Measure, Analyze, Improve and Control. The cycle is presented in figure 1.6.

Define

In the define phase the problem is defined. Furthermore, the research topic and it’s boundaries and the research approach are given. Next, the literature review and the case study at L’Oréal Alphen aan den Rijn are given.
Measure
In the measure phase the process analysis is conducted. Furthermore, current methods for forecasting and planning of demand are explained.

Analyze
In the analyze phase the current process is analyzed in detail. Most important analyses are the lead-time analysis, dock-time analyses and observations. The constraints in the current system are identified.

Improve
In the improve phase measures of improvement are designed to tackle the constraints in the current state. The different measures of improvement are assessed via a multi criteria analysis and the best improvement is found.

Control
First an implementation plan is given for the best measures of improvement. Next, a simulation is conducted to test how much the lead-time improvement of the best measure of improvement is.

Finally, in a separate part the main and sub research questions are answered. Next, the literature framework is evaluated. At last, recommendations and areas for further research are presented.
Chapter 2

Literature review and methodology framework

This chapter answers the first research question:

1. What research framework can be designed based on literature to evaluate solutions to improve the process in the DC?

The research structure is based on different methodologies. First of all definitions about cosmetics logistics and demand management are given in the supply chain methodologies in section 2.1. Later process improvement methodologies are presented in section 2.2. Solution evaluation methodologies are given in section 2.3. Finally, the research structure is presented in section 2.4. In Appendix A "Lessons learned from case studies" are summarized. The structure of this chapter can be found in figure 2.1.

Figure 2.1: Structure of methodology chapter
2.1 Supply chain methodologies

The aim of the methodology in this section is to understand the supply chain and the cosmetics logistics. Before literature is discussed it is necessary to know the definition of supply chain: "A supply chain is a system of organizations, people, activities, information and resources involved in moving a product or service from supplier to customer. Supply chain activities involve the transformation of natural resources, raw materials, and components into a finished product that is delivered to the end customer [Kozlenkova et al., 2015]."

In order to manage logistical activity it is necessary to understand and involve other departments of a company. Knowledge about the marketing, finance, purchasing and production should be involved [Chen, 2004].

The following definitions are discussed in this section: cosmetics logistics and demand departments in the supply chain.

2.1.1 Cosmetics Logistics

In the article of Justine Brown [Brown, 2016] the cosmetics logistics explained.

The cosmetics and skincare industry which is dealing with a constant battle between demand and supply. Beauty and skincare companies promote the latest trend often via big promotion and marketing campaigns. Once the demand is generated those companies must have the products available on the shelves. Handling the products to the point of sale requires a punctual and reliable transportation, storage and distribution. A warehouse in the cosmetics and skincare industry has to deal with extra measures compared to a ‘normal’ warehouse. Cosmetics products have a limited shelf-life and health conditions and hygiene are of importance. Also products (like deodorants) can be ‘dangerous’ so special measures should be taken.

Furthermore, cosmetics industry has four different retail streams:

<table>
<thead>
<tr>
<th>Retail stream</th>
<th>Market</th>
</tr>
</thead>
<tbody>
<tr>
<td>Consumer products</td>
<td>Mass retailers and chain drugstores</td>
</tr>
<tr>
<td>Beauty supplies</td>
<td>Salons and professional product groups</td>
</tr>
<tr>
<td>Luxury brands</td>
<td>Department stores and boutiques</td>
</tr>
<tr>
<td>Dermatological products</td>
<td>Pharmacies and dermatologists</td>
</tr>
</tbody>
</table>

Table 2.1: Retail streams cosmetics market
The four target markets need different ways of promotion and promotion materials and order in different order sizes what makes it complex.

At last, there can be said that the beauty business is market-driven. Marketing is setting out the way demand is generated and marketing should work together with the logistics department to make sure that the generated demand can be handled.

2.1.2 Definitions about demand in the supply chain

According to MIT a distinction can be made between the following activities [Lapide, 2016]:

1. Demand planning - DP: what to do to shape and create demand
2. Demand forecasting - DF: what will the demand be for a given demand plan
3. Demand management - DM: how do you act on demand when it comes in. Or matching supply and demand over time - in real time and during planning

In order to optimize DM supply chain visibility and decision support information are key.

2.2 Process improvement methodologies

The aim of the methodology in this section is to create a way of thinking to develop measures of improvement.

In 1991 there was already said that improving business processes is key to increased profits and market share [Harrington, 1991]. More recent, there was said that business process improvement is fundamental to business development, quality improvement and the management of change [Bendell, 2005]. The idea of the process improvement activity to have greater process understanding ownership and some redesign by performing simple process mapping and analysis. Apart from that, businesses are also motivated for business process improvement due to the world wide used ISO standardization.

Different methodologies for process improvement are known. This section discusses the following: lean, six sigma, lean six sigma, scenario-based design, benefits of lead-time shortening, balancing demand and supply and improving demand planning.
2.2.1 Lean

John Krafcik used the word ‘Lean’ to describe the new production techniques introduced by Taiichi Ohno at Toyota after World War II [Bendell, 2005]. The developers - Womack and Jones - of the ”Lean Thinking” identify five key principles of the Lean Organisation:

- Lean focuses on the following principles [Lean.org, 2016a]:
  1. Elimination of waste
  2. Identification of the Value Stream
  3. Create flow
  4. Establish pull
  5. Continuous pursuit of perfection

To conclude a definition of lean is given: “The idea of lean is to maximize customer value while minimizing waste or in other words creating more value for customers with fewer resources” [Lean.org, 2016b].

Furthermore, the points below explain the lean principles a bit more [Flinchbaugh, 2016]:

**Work in parallel**: if work is completed parallel instead of series, there is not less work, but the work is completed faster. For instance, do some paperwork when a PC is starting up.

**Eliminate loops**: Working faster often fails. In this case work has to be re-done and cost time and therefore money. Therefore, try to work clean instead of fast.

**Eliminate handoffs**: Make sure that the number of handoffs are minimal. The reason for this is that a handoffs results in transferring of a product. Furthermore, the next resource is not immediately ready to begin, which results in a waiting queue.

**Eliminate steps altogether**: An extra step in a process results in two extra handoffs. Therefore, it is preferred to eliminate as many steps as possible.

**Compress the work**: Try to shorten the process by working smarter instead of faster.

**Increase capacity**: A solution for this is adding more resources. Furthermore, extra resources reduce the queue

In order to use the lean methodology tools are necessary. The following lean tools are relevant for this research.
Ishikawa diagram

In order to find the root causes for a problem an Ishikawa, also called fishbone diagram, can be used (see figure 2.2). A Ishikawa diagram captures the root causes of a problem [Brook, 2014].

Figure 2.2: Ishikawa diagram or fishbone diagram [Wikipedia, 2016]

Observations

During a project many observations will be done. Those observations should be mapped to get a full insights of the current process and know in which direction further research is needed.

2.2.2 Six Sigma

Six Sigma was a methodology used for the first time in the mid-1980s when a Japanese firm took over a Motorola factory that manufactured Quasar television sets in the United States [Pyzdek, 2003]. The principle of the Six Sigma methodology focused on accomplishing a high level of quality. Six Sigma became public knowledge after Motorola won the Malcolm National Quality Award. Six Sigma is not dealing with the traditional way people think about quality. Six Sigma is helping companies by improving customer value and efficiency. Quality in Six Sigma can be found in two ways: Firstly, potential quality, which stands for the maximum value added per unit of input. Secondly, actual quality, which stands for the current value added per unit of input. The difference between those two qualities is called waste. The Six Sigma methodology helps by reducing this waste by producing the
products and services better, faster and cheaper. More generally there can be said that Six Sigma focuses on eliminating the variations in the process to increase the quality.

Finally, the following definition for Six Sigma is given:
"Six Sigma is a disciplined, data-driven approach and methodology for eliminating defects in any process" [Isixsigma, 2016]

To accomplish this objective the sub-methodology of DMAIC is used: Define, Measure, Analyse, Improve, Control.

2.2.3 Lean Six Sigma

Lean Six Sigma is a methodology that is combining Lean and Six Sigma [George, 2002]. Lean’s cultural aspects of improving combined with the data driven investigations of Six Sigma results in a sustainable approach to organisational change and process improvement [Pepper and Spedding, 2010].

2.2.4 Scenario-based design

A framework for scenario-based design is given by Rosson and Carrol [Rosson, 2002]. In figure 2.3 the framework is given. First it is important to develop a rich understanding of current activities and work practises. This understanding should be used as a basis for activity transformation. In the analysis problems and claims and their consequences - both positive and negative - for the scenario actors should be enumerated. The different problem scenarios are transformed into activity scenarios. Each set of scenarios should be complemented by claims that analyze the positive and negative consequences of their designs. After the scenarios are defined they can be tested. After testing the evaluation should be done to classify the use-fullness of each scenario.

2.2.5 Benefits of lead-time shortening

In the article The Value of Short Inventory Lead Time [Ordoro, 2016] there is said that reducing inventory lead-time increases profits. The reason for this is that customer satisfaction is key in success. With a market full of competitors, customers can easily find other businesses that satisfy their needs for quality, delivery and costs. Trends have indicated that quality and delivery often surpass costs in terms of customer value. Furthermore, a long lead-time means an overabundance of inventories, expedition costs, excessive overtime pay and inefficient use of resources. Two solutions for lead-time shortening are suggested. The first solution is better practice scheduling and
production control. Key element for this solution is improving the forecast. The second solution is re-engineer manufacturing operations: try to see were improvements in the process can be made. For this solution either the process time should shortened or the waiting times, number of handling etcetera should be decreased.

### 2.2.6 Balancing demand and supply

A big gain in improving the lead-time is to balance demand and supply. The following four points are suggested by Robert Tousignant [Canada, 2016]:

1. Improved planning and coordination: The first complexity is the different ways of seeing demand at each department. For instance, sales is calculating demand in value, while a distribution center is calculation in the number and size of the orders.

2. Outsourcing "flex" capacity: In order to deal with the demand peaks it is necessary to have some extra "flex" capacity. Contract manufacturers do have pools to deal with these peaks at different companies.
3. Segmenting the customer base: In order to provide the right service to the right customer it is necessary to categorize the customers. This could result in providing more important customers more service. For instance, if there are not enough products available to deliver, deliver the last stock to the most important customer.

4. Maintain safety stock for raw materials and work in progress: Try to prepare your orders before the peak if possible. For instance, prepare shipping boxes with some standard products are create areas where fastmovers can be picked easily.

2.2.7 Improving demand planning

According to Dave Blanchard [Blanchard, 2016] there are five tips to better demand planning and forecasting.

1. One size does not fit all:
   Forecasting needs and challenges vary widely. This is not only the case between companies, their size and industry but also within the company. Before the demand planning process is tackled, manufacturers should clearly define their forecast. For instance, is this stock of financially driven, are they working with short or long-term financial projections and how is their demand.

2. Understand the drivers of uncertainty.
   There are numerous factors that can impact the forecast. If those factors are in advance a forecast will be more accurate. Manufacturers should know how consistent their demand is, what level of supply chain visibility they have and how reliable their modes of transport are.

3. Keep it simple
   The forecasting method and tools can be kept simple. Most important is the have the right and clear data when forecasting. A right solution for forecasting depends on the company and could be a stand-alone tool or an enterprise-wide solution.

4. Prepare for change
   Make sure that the right ingredients are available when the company is planning for changing the demand planning process. More detailed this means, make sure that the right skill sets are available, put the right training programs in place, engage sales and operations and define methods for measuring performance.
5. Expect the unexpected
Forecast will never be exactly as planned. Therefore, a backup plan is crucial. The following points can help: make sure there is enough flexibility for supplies, look at transportation services with shorter lead-times, ensure that you work with flexible business models and plan ahead for every scenario.

2.2.8 Exponential forecasting
There are different kind of forecasting methods. The following methods are interesting [Hyndman, 2013]:

- Single exponentially smoothing method. This method is used if there is no trend or seasonal pattern. Based on historical data an smoothing parameter $\alpha$ can be determined. The best fitting value of $\alpha$ can be found by minimizing the MSE

- Double exponentially forecasting. This method - also called Holt’s linear trend method - is used if there is a trend in the data. It has two parameter: $\alpha$ for level and $\beta$ for trend. Based on a minimum MSE the best fitting parameters can be found [Taylor, 2003]

- Triple exponential forecasting. This method adds an extra parameter $\gamma$ to the double exponential method. This parameter deals with the seasonality. Parameters can be found via the same method [Taylor, 2010]

2.3 Solution evaluation methodologies
After the measures of improvement are developed and the pros and cons are known the measures should be assessed. When multiple measures are compared a Multi Criteria Analysis (MCA) is done. This methodology part discusses the different components and possible approaches of a MCA.

2.3.1 Determine criteria
In order to evaluate the different measures of improvement criteria should be defined. Criteria should be: measurable, independent of each other and defined such that it is known for everybody what is meant with it.

Korpela gives and approach to evaluate warehouse network and designs [Korpela, 1999]. First, a preliminary analysis should be conducted. Next,
Table 2.2: Overview of definitions and process improvement methodologies

<table>
<thead>
<tr>
<th>Methodology</th>
<th>Key elements</th>
<th>Aim</th>
<th>Usefulness</th>
<th>DMAIC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cosmetics Logistics</td>
<td>Cosmetics Market</td>
<td>Understand the market and influencers</td>
<td>++</td>
<td>D</td>
</tr>
<tr>
<td>Definitions about demand in the supply chain</td>
<td>Demand in supply chain</td>
<td>Get to know demand definitions</td>
<td>++</td>
<td>D</td>
</tr>
<tr>
<td>Lean</td>
<td>Flow, Pull, Identify Value</td>
<td>Maximize customer value while minimizing waste</td>
<td>++</td>
<td>DMAIC</td>
</tr>
<tr>
<td>Six Sigma</td>
<td>Measurement based</td>
<td>Data-driven approach for eliminating defects</td>
<td>++</td>
<td>DMAIC</td>
</tr>
<tr>
<td>Scenario-based design</td>
<td>Framework</td>
<td>Developing scenarios</td>
<td>0</td>
<td>-</td>
</tr>
<tr>
<td>Lean Six Sigma</td>
<td>Combining Lean and Six Sigma</td>
<td>Understand the benefit of the combination</td>
<td>++</td>
<td>DMAIC</td>
</tr>
<tr>
<td>Benefits of lead-time shortening</td>
<td>Forecast improvement, customer value</td>
<td>Shorten lead-time</td>
<td>+</td>
<td>D</td>
</tr>
<tr>
<td>Balancing demand and supply</td>
<td>Flex capacity, improved planning</td>
<td>Dealing with demand</td>
<td>+</td>
<td>I</td>
</tr>
<tr>
<td>Improving demand planning</td>
<td>Planning, forecast</td>
<td>Improve demand and forecast</td>
<td>++</td>
<td>I</td>
</tr>
<tr>
<td>Exponential forecasting</td>
<td>Forecasting, parameters</td>
<td>Methods to forecast</td>
<td>-</td>
<td>I</td>
</tr>
</tbody>
</table>

The final evaluation problem should be defined. The next step is an analysis that helps to set up the criteria to analyse the warehouse operators. Korpela uses an AHP (see later on 2.3.1). Below in figure 2.4 the goal-tree of with the criteria used to evaluate a warehouse network can be found.

As shown in figure 2.4 reliability, flexibility and customer’s logistics costs are of importance. Furthermore, it useful to define sub-criteria to define the
Jamani has written an article about warehousing KPIs [Jamani, 2014]. First of all, KPIs are needed because an organization is setting goals. To achieve this goals current performance indicators should be measured and with KPIs there is a possibility to track the progress towards a goal. The most important KPIs for warehouses are as follows: costs, utilization (of space, labour, equipment, etc.) and fulfilment (percentage of orders on time, accuracy of order fullfilment etc.).

**Analytical Hierarchy Process (AHP)**

Analytical Hierarchy Process is a subjective method in decision making and is used in a wide variety of decisions. [Roszkowska, 2013] AHP provides a comprehensive and rational framework for structuring a decision problem. The framework should have an overall goal. This goal can easily comprehended in easier to define sub-problems which can later be converted into criteria. The criteria are compared pairwise and values from 1 till 9 can be applied [Majumder, 2015]. A value 1 means that the two criteria are of equal importance, whereas a 9 means that one criterion is of absolute importance compared to the other. The inverse is used of a criteria is of less importance. A score matrix is formed and the score per criteria is calculated by summing the scores. The weight is found by taking the score of a criteria and divide that by the total score.

The weight of the criteria can also be addressed via different methods:

**Equal weight method**
The equal weight method is the simplest method of ranking. All the criteria
are weighted equally. This method is used if no or little information is known about the different criteria.

**Weighted relationship diagram**

The weighted relationship diagram deals with the in a similar way as the AHP. It also pairwise compares two criteria but uses the value 1 (if of more importance) and 0 (if of less importance). The weights are now calculated via the same way as the AHP method.

**Weighting determined by different angles**

This method will look from different angles to determine the weights of the criteria. Different kind of ‘glasses’ are used, for instance a practical ‘glass’ or a more financial ‘glass’.

### 2.3.2 Forecasting evaluation

The forecast accuracy can be evaluated by determining the Mean Squared Error (MSE). First the forecast error should be calculated as follows: actual demand - fore-casted demand. The second step is to quadrate this error. This should be calculated for each historical datapoint. By taking the mean of all these errors the MSE is calculated. The Solver function in Excel can calculate parameters (which all have a value between 0 and 1) by minimizing the MSE [Hyndman, 2013].

### 2.4 Methodology framework

First, a framework used in an earlier case study in Mexico is presented. Next, the used framework for this research based on Case Study in Mexico and the DMAIC cycle is explained.

#### 2.4.1 Framework used to improve order lead-time

According to Villareal and Salido [Villarreal, 2011] the general scheme of figure 2.5 can be used to improve the performance of a distribution system. The following 4 stages are needed:

1. Consider Marketing Strategy: the rest of the supply chain is depending on this strategy. Main aspects to identify are those concerning with the product mix and expected market growth. Market characteristics are also useful because that will determine the chain structure, the distribution scheme and the inventory deployment strategy.
2. Analysis of Current System: Purpose is to setup the basis and reference for the development of the improvement strategy. Further to describe the structure of the chain, the inventory deployment scheme, and its transportation and sourcing strategies. Also the identifying of waste with lean tools.

3. Improvement Strategy Definition: This stage is meant to develop alternatives for improvement. The alternatives should include projects oriented to obtain better levels of the competitive factors of interests.

4. Strategy implementation: The fourth stage is concerned with the implementation of the selected strategy. A detailed program with responsible and specific points of control should be laid out.

2.4.2 Define, measure, analyse, improve, control (DMAIC)

The research will focus on a improvement in the process of the total lead-time for the ACD division. L’Oreál has as goal to shorten the lead-time. According to Mast and Lokkerbol (2012) [de Mast, 2012] the DMAIC approach can be used for problem solving and improvement approach. Furthermore, the Lean Six Sigma tools can be used for the different stages of the DMAIC approach.
For this research the following DMAIC cycle will be used [Sokovic, 2010]:

- **Define:** identifying and selecting the right project;
  - Making general process flowchart (see 1.4)
  - Defining problems, objectives and goals
  - Setting boundaries for the project

- **Measure:** scoping parameters and their performance;
  - Detailed process flowchart
  - Get to know what data and timestamps are available
  - Understand the current forecasting, planning and the process itself

- **Analyse:** Identifying the key causes and process determinants;
  - Interview employers to understand the process steps and the reasoning of decisions in the process
  - Analyzing current lead-times
  - Analyzing current workload
  - Analyzing current performance
  - Ishikawa or Fishbone diagram: A diagram to find the root-causes of the problems

- **Improve:** Changing the process and optimizing performance;
  - Develop measures of improvement that tackle the analyzed constraints
  - Conduct a multi criteria analysis to find the best measure of improvement

- **Control:** Sustain the benefits of the improvements:
  - Write an implementation plan to implement the best measure of improvement
  - Conduct a simulation to quantify the lead-time reduction
Figure 2.6: Methodology framework
2.5 Summary of literature review and methodology

This chapter has answered the first sub-research question:

1. What research framework can be designed based on literature to evaluate solutions to improve the process in the DC?

The framework is based on supply chain definitions, process improvement methodologies and solution evaluation methodologies. The framework has the following steps:

- Defining the problems, boundaries and criteria to evaluate improvements
- Current planning and forecasting state and the process itself
- Detailed analysis of the current state and process
- Developing measures of improvement to tackle the current constraints
- Evaluation of measures of improvements via MCA
- Implementation plan for the best solution
- Simulation to quantify the lead-time improvement

Table 2.3: Summary of literature review and methodology
Chapter 3

Defining criteria to evaluate measures of improvement

This chapter answers the following sub-research question:

2. What criteria can be used to evaluate the current state and the measurements of improvement?

First, the strategies in the cosmetics market are defined in section 3.1. Later, the literature to evaluate measures of improvement are defined in section 3.2. At the end a summary is given of this chapter. The structure of this chapter is visualised in figure 3.1.

![Figure 3.1: Structure of criteria to evaluate solutions chapter](image)

3.1 Strategies in the cosmetics market

First it is important to know how the strategy in the cosmetics market works (see 2.4.1. L’Oréal and other players in the cosmetics market have to compete on three different aspects:}

28
• Cost: all costs involved in order to deliver a product or service at the end at the customer

• Customer satisfaction: the positive emotional state reached by a customer after purchasing a product or service [Carson, 2015]

• Flexibility: the capability of an organization to respond to major changes

These aspects can be put into a triangle. Ideally, cost would be low, customer satisfaction high and flexibility high. Cost are important for L’Oréal in order to be a profitable company. Customer satisfaction can be high by providing on time delivery, giving customer insights about their order and making sure that the right products arrive with the right quality on the right time. Flexibility is of importance in order to deal with high peaks in demand. It is not possible to achieve those three aspects, so trade-offs are necessary.

![Figure 3.2: How to be a successful business in the future](image)

3.2 Criteria to evaluate measurements of improvement

The research focuses on improving the process in the DC to shorten the lead-time. To evaluate the different measures of improvement criteria need to be defined.

The ambition of L’Oréal is to have ”Beauty for all, beauty for each individual” [L’Oreal, 2017]. In order to achieve this ambition L’Oréal can set the
following goal: "How to be a success-full player in the cosmetics market". With this goal in mind and the criteria found in the literature (see section 2.3.1) a discussion with the management in Alphen was started. Criteria to evaluate the improvements are: cost, usability and feasibility. For all the criteria sub-criteria are defined.

In cooperation with the management of the distribution center the following criteria are defined:

I Cost:
This criterion is can be split into the different sub-criteria:
- Implementation costs: the cost needed to implement the improvement, for instance resources needed to develop the improvement.
- Operational costs: the increase or decrease in operational costs after implementation.

Preference for L’Oréal: Lower cost are preferred to higher costs; operational cost are more important compared to implementation costs.

II Usability:
For the usability criterion four different sub-criteria are defined:
- Manual or automatic: does the improvement work automatically or does it regular needs updates.
- Amount of human resources needed use the improvement.
- Required training: the amount of training needed to work with the improvement.
- Gradual effect or immediate effect of improvement: will the improvement immediately result in benefits or will it gradually result in benefits.

Preference for L’Oréal: an automatic improvement is preferred to an improvement that needs updates; the amount of HR needed to use the improvement should be minimum; the required training is preferred to be low; the effect of the improvement is preferred to increase gradually than to see immediately a result. Reason for this is that employees need to be involved in the development and understanding of the improvement.

III Feasibility:
For the feasibility criterion four different sub-criteria are defined:
- IT feasibility: is it possible to develop the improvement IT-wise and
how much develop time will this take.
- Internal of external area of improvement: should the improvement conducted at LOréal or at a third party.
- All or nothing improvement or extension on current state: will the improvement change the current state drastically or will it be an extension on the current state.

**Preference for L’Oréal:** The needed IT should be minimum as well as the development time; An internal improvement at LOréal is preferred compared to an external improvement; An extension on the current state is preferred compared to an all or nothing improvement.

The overview of the goal tree with the criteria and sub-criteria can be found in figure 3.3.

![Goal tree for the DC with criteria to evaluate measures of improvement](image)
3.3 Summary of case study

This chapter has answered the second sub-research question:

2. *What criteria can be used to evaluate the current state and the measures of improvement?*

First the cosmetics market was discussed. The ambition, the goal of L’Oréal and discussions with the management in Alphen were used to define criteria and sub-criteria to evaluate the different improvements. The following criteria are defined:
- Cost: the amount of implementation and operational costs
- Usability: is the improvement automatic or does it need updates; how much time is needed to use the improvement; how much training is needed and who needs the training; is the effect if the improvement gradual or immediate
- Feasibility: IT feasibility; internal or external area of improvement; all or nothing improvement or extension on the current state.

Table 3.1: Summary of criteria
Part II

Measure
Figure 3.4: Bulk locations where pallets of the same products are stored
Chapter 4

Measuring of the current state

This chapter answers the following sub-research question:

3. How is the current demand forecasted and planned?

First, the methods used to measure the current state are discussed in 4.1. The order types are discussed in section 4.2. The process analysis done with a process flowchart is presented in section 4.3. A data collection plan can be found in 4.4. The current forecasting and planning methods are given in sections 4.5 and 4.6. The chapter is concluded with a summary in section 4.7.

Figure 4.1: Structure of measure phase chapter
4.1 Methods used to measure the current state

This section discusses the methods used to measure the current state.

4.1.1 Process flowchart

In order to get a detailed insight of the processes a process flowchart is used. A process flowchart is a simple step by step process of activities carried out in the process. [pro, 2017]. Furthermore, a process flowchart helps to understand how a process works and a process flowchart forms the basis of process improvement.

4.1.2 Data collection plan to calculate lead-time

A data collection plan should help investigate where in the system timestamps are and perhaps where extra timestamps are necessary. The current timestamps can be added to the process flowchart. With the timestamps and a clear plan how to extract data out of the SAP system lead-times can be calculated.

4.2 Order types

In the total process different distinctions can be made regarding the orders:

- Country: Orders will go to Belgium or to the Netherlands. The reason for this is that different transporters are used.

- PPD and ACD: the different divisions in the DC.

- Internal or external: internal orders are done by L’Oréal. They are for instance used by the sales representatives to show to the customers

- Normal or presales: normal orders are orders with a leadtime of 1 (PPD) or 3 (ACD) workdays; Presales are the same kind of orders that are sold in special periods. There are multiple presales per year and presales are only done for the ACD division. An example of presales is selling sunburn products in spring.

In figure 4.2 the distribution between the ACD and the PPD divisions is shown. For both the standard as well as the detailpicks 63% of the workload is created by the PPD division. For the PPD division the following distinction for the delivery types can be made: normal deliveries and 48 hours deliveries.
For the ACD division the following distinction for the delivery types can be made: normal deliveries, prio deliveries, presales deliveries and internal deliveries. The distributions for standard and detail of the different delivery types are presented in the figures 4.3 and 4.4.
4.3 Process analysis

The total process is visualised in figure 4.5. Detailed processes will be explained in this section.

![Figure 4.5: Total lead-time](image)

4.3.1 Sales and customer care *Brussel, Hoofddorp, at customer* - Order entry & adjusting

In figure 4.6 the detailed process of customer care is presented. Orders can enter the SAP system via three different ways.

1. Direct via Customer Care; Customer Care will put the orders to SAP. Bigger customers send their orders via an EDI file, which is also checked by Customer Care.

2. Via Sales Force + (SF+); This is a software tool for ACD representatives;
Via Mercure; This is a software tool for PPD representatives;

Note: orders are pushed in SAP via Mercure and SF+ via the following schedule (see table 4.1). When the orders are in SAP, they are visible for the Portfolio Manager. Note: Sales representatives are pushing their turnover at the end of the month and might be in the position to provide customers with promotions or discounts which results in more workload.

Figure 4.6: Detailed process of sales and customer care

<table>
<thead>
<tr>
<th>Day</th>
<th>13:00</th>
<th>17:00</th>
<th>23:00</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mo</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Tu</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
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<td>We</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Th</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Fr</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Sa</td>
<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Su</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 4.1: Sales Force + update to SAP
4.3.2 ACD portfolio manager *Hoofddorp* - Product availability & delivery creation

In figure 4.7 the process of the ACD portfolio manager is visualised. The ACD portfolio manager does have an overview of all the incoming orders. A distinction is made between the following type of orders:

- **Presales orders**: these orders can have a longer lead-time and do have a big size. This work is most of the times spread over several days.

- **Orders of which not all products are on stock**: these orders will not be put into delivery right away. Most of the times this stock is being transported to the DC. These type of orders orders are made into deliveries when the products will arrive at the DC. Another option is to deliver the products that are in stock and send a backorder later when the missing products are in stock.

- **Automated orders**: the products for these orders are in stock in the DC and will be pushed at the end each day to the DC.

The decisions that are made by the ACD portfolio are:

- **Try to send the presales to the DC on the right moment to make sure that the deliveries can be handled and the presales arrive on time at the customer**

- **Make sure that the current trade-off is made between having no backorders but more lead-time and having backorders**

- **Make phasing based on information of sales departments**

The DC in Alphen uses a wave structure for efficient picking. A wave is a batch of orders with similar characteristics. Waves are created by the SAP autojob or manually. There are different kind of waves for PPD (see figure 4.8) and for ACD (see figure 4.9). Furthermore, PPD has a problem wave in which unpacked orders are fixed. This wave arrives at the DC around 11am. The unpacked orders for ACD are not put in a problem wave, but are added to the other deliveries for the next day.
Figure 4.7: Detailed process of the ACD portfolio manager

Figure 4.8: Autojobs process for PPD waves
Table 4.2: PPD wave types based on data from October 2015 - September 2016

<table>
<thead>
<tr>
<th>Wave Types</th>
<th>Belgium</th>
<th>Netherlands</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>37.3%</td>
<td>20.5%</td>
</tr>
<tr>
<td>Presales</td>
<td>24.9%</td>
<td>13.2%</td>
</tr>
<tr>
<td>Prio</td>
<td>1.0%</td>
<td>1.3%</td>
</tr>
<tr>
<td>Internal</td>
<td>1.0%</td>
<td>0.8%</td>
</tr>
<tr>
<td>Totals</td>
<td>100%</td>
<td></td>
</tr>
</tbody>
</table>

Table 4.3: ACD wave types based on data from October 2015 - September 2016

<table>
<thead>
<tr>
<th>Wave Types</th>
<th>Belgium</th>
<th>Netherlands</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>49.7%</td>
<td>13.8%</td>
</tr>
<tr>
<td>Big</td>
<td>5.1%</td>
<td>0.0%</td>
</tr>
<tr>
<td>Internal</td>
<td>2.2%</td>
<td></td>
</tr>
<tr>
<td>48 hours</td>
<td>14.6%</td>
<td></td>
</tr>
<tr>
<td>Problem</td>
<td>13.6%</td>
<td></td>
</tr>
<tr>
<td>Prework</td>
<td>1.1%</td>
<td></td>
</tr>
<tr>
<td>Totals</td>
<td>100.0%</td>
<td></td>
</tr>
</tbody>
</table>
When wave are created orders can be packed or unpacked. If orders are packed a delivery can be made. If orders are unpacked orders cannot be picked. Orders are unpacked if:

- There is no location with the product in f.i. the detail-picking area. The product is in this case available in the DC at a bulk location. A location in the detail-picking area needs to be assigned which results in an internal transfer order.

- The order quantity is not equal to the delivery quantity. For instance, products are packed by set of 3, so 3, 6, 9 etc. products, but the order quantity is 4. Customer care has to solve this problem; The delivery will be canceled and a new order should be made.

### 4.3.3 The distribution center *Alphen aan den Rijn* - Order preparation & truck loading

In figure 4.10 the detailed process of the physical distribution at the DC is given. The ACD team-leader will print the waves based on DC leaving time. The ACD-teamleader is responsible for putting the employees on the right picking wave or picking area at the right time in order to finish picking on time. Furthermore, the team-leader will fix the unpacked deliveries and is contact for all the employees on the workfloor.

**Figure 4.10: Detailed process of the ACD teamleader**

In figure 4.11 an overview of the distribution center in Alphen aan den Rijn is presented. About 2/3 of the surface is filled with 5-level racks. All
lower levels (A-levels) are used for standard picking and the other levels are used for bulk storage. There is also a special bunker in the top of the figure in which aerosols are stored. In the left bottom corner inbound and returns is located. Outbound is located right of inbound and has 5 docks for loading trucks. Management is located at the bottom right. Detail picking is located next to the management.

Figure 4.11: Layout of the distribution center in Alphen aan den Rijn

As said before there are three kinds of picking in the DC. However, as said before, pallet picking is not considered for this research. First the standard picking explained, later the detail-picking.
Standard picking

The standard picking is picking of full boxes one product. A picker has to perform the following handlings to pick a delivery:

- Get the paperwork and stickers for the tour. Scan the tour.
- Step on the order picking truck and get pallet.
- Put all the boxes of the deliveries on the order picking truck and check the right product by scanning and weighing. Label each box.
- Bring the pallet with products to outbound and seal the pallet.

Detail picking

The detail-picking takes place in the detail picking area designed with U-shapes.

The picking exists out of the following steps:

- The picker gets a picking tour at the start-stop station; A tour exist of one up to six boxes.
- Stickers are printed by the picker and will be put on the specific chosen box for a delivery. Also a sticker which explains if there are dangerous goods in the box or a sticker that says that the invoice is in the box are added if necessary.
- Boxes will be put on the shopper. The shopper can be seen in 4.12 and has three weighing scales and two barcode readers.
- The tour starts at the start-stop station and the picking starts in the U-shape. The picker always walks in one direction in the U-shape. First three boxes will be filled with products, then full boxes can be changed for the other three on the shopper.
- The location of the product is shown on the screen of the shopper. When a product is picked it should be scanned to make sure the right product is picked.
- The right product is chosen and a display shows how much products should put in which box.
• After picking the products the picker has to press the OK button. If the weight is correct and therefore the number of products, the new location is shown. If the weight is incorrect it is shown if there is too much or too little weight.

• During a tour consisting of 4 until 6 deliveries the picker has to change the finished picking boxes on the weighing scale with the boxes not on the weighing scale.

• After finishing the tour the picker has to fill the remaining space of the box with plastic air-packs before putting it on the conveyor belt.

![Shopper for detail-picking](image.png)

Figure 4.12: Shopper for detail-picking

**Outbound**

Outbound will make an estimation of the number of needed trucks to be able to ship the deliveries. At outbound the conveyor belt will end and all the deliveries are assigned and distributed automatically to one of the eight exits lanes. From the exits boxes are put on the pallets. Full pallets are sealed and placed at the outbound docks. During the day trucks arrive. First, trucks for Belgium are loaded, later trucks for the Netherlands.

**4.3.4 Shipping and delivery**

In the DC the deliveries are loaded. A distinction is made for the orders for the Netherlands and for Belgium. The first truck for Belgium will leave around 14:00 because it has to drive to a transportation hub in Brussel. It depends on the workload how many trucks will leave the DC, but on average 4 trucks leave the DC each day. The truck for the Netherlands will leave
latest at 18.30. This truck will go to the transportation hub in Zoetermeer. The deliveries that leave the truck on one day will be delivered before 5 pm the next day at the customer. The transportation distribution hubs process the orders during the night. If the current system is used it is not interesting to ship the deliveries earlier to the client, because the orders will be delivered the next day.

4.4 Data collection plan

To measure the current state it is needed to know what timestamps are available in the system. The process flowchart helped to understand which steps need to be taken to finish an order. With this information the needed timestamps can be determined.

L’Oréal has SAP as internal ERP system. Orders are entered into SAP directly, via SF+ or via Mercure. The following timestamps can be extracted from the SAP system (see figure 4.13):

- *Order creation date*: Time that the order is visible in SAP. If the order is made via customer care this is the time that the customer has made the order.
- *Delivery creation date*: The time that the order is visible for the ACD portfolio manager.
- *Wave creation date*: The time that the delivery is ready to be picked.
- *Dock date*: The time that the delivery is at the outbound dock on a sealed pallet and ready to be transported.
- *Billing date*: The time that the delivery is in the truck and leaves the DC.
4.5 Current forecasting

Forecasting is in the current state done by the ACD portfolio manager. The forecast is always in amount of sales. With the information of marketing and sales a forecast is made. Forecast are adjusted every day. Reason for this is that the ACD portfolio manager has an overview of the orders that can be put send to the DC. Furthermore, the ACD portfolio manager is responsible for pushing the orders to the DC.
4.6 Current planning

In the current state the planning is based on the forecast. There is a forecast on the following levels:

- Netherlands PPD
- Belgium PPD
- Netherlands ACD
- Belgium ACD

With the sales numbers the amount of detail-picks and standard picks can be estimated. Every day the forecasting department changes the forecast of the day before by the revealed amount of sales. A planning of the capacity for the next day is based on the amount of picks in the system and is made every day at 2pm. The amount of picks includes the picks that were already in the system and the new picks that will arrive the next day.

The number of employees is planned based on the performance of the last few days. For PPD enough people are planned to make sure that there are no picks left on the end of the day. For ACD some margin is held to make sure that in case the forecast is too high no employees have to be sent home. ACD is planning on a lead-time of 3 workdays. Reasons for this are that in theory peaks can handled better if three days of picking are available instead of only 2 days.

The teamleaders of ACD and PPD are responsible for the placing of the employees on the different departments and picking areas. They have to make sure that waves are picked in the right order. If PPD needs more capacity it is taken away from ACD.
4.7 Summary of measuring of current state

This chapter has answered the following sub-research question:

3. How is the current demand fore-casted and planned?

The current demand is fore-casted by the ACD portfolio and is based on the input of sales and marketing. A forecast is always made in amount of sales in euros. The planning is done by the supervisors of ACD and PPD. First, they translate the amount of sales into the amount of standard and detail picks. PPD plans enough capacity so that all deliveries can be handled. To reduce costs ACD is planning on a lead-time of 3 workdays. Team-leaders plan where they are going to use the capacity - and therefore the employees - at what time. If PPD needs more capacity it is taken away from ACD. If ACD is not being able to reach a lead-time of 3 days overtime is used to make sure that the lead-time goals will be achieved.

Table 4.4: Summary of measuring of current state
Part III
Analyze
Figure 4.14: Standard picking shelves from which standard picking is done
Chapter 5

Current state analysis

This chapter discusses the analyses of the current state.

This chapter answers the following sub-research questions:

4. What is the capacity of the distribution center
5. What is the current lead-time of the PPD and ACD divisions?
6. What are major influencers of the lead-time?

This chapter analysis the current state. First the lead-time analysis is presented in section 5.2. Next, the capacity analysis is conducted in section 5.1. In section 5.3 the demand or workload analysis is given. In section 5.4 the performance analysis of the standard and detail-picking can be found. The customer analysis can be found in section 5.5. The dock-time analysis about how long the ready to ship pallets on average stand at outbound can be found in 5.7. At last, a summary of this chapter is given and the sub-research questions of this chapter are answered.
5.1 Capacity analysis of distribution center

To understand the process and its resources in more detail an analysis of the number of employees on the workfloor is made.

In the table below an overview of the minimum and maximum number of employees and its capacity to operate the DC is given.

In the table 5.1 the maximum capacity is given. The following notes can be made:

- The capacity is based on 100 standard picks and 268 detail picks per hour per resource. These numbers are the average performances based on data between October 2015 and September 2016 (see section 5.4).

Via SAP an extraction is made of the amount of work that is done on every day of the year. In this extraction the maximum number of handled units on a day were found. More detailed information about the handled units can be found in Appendix B.

- Standard picks: The maximum was 8266 picks. Theoretically, this is 1000 per hour, so 7250 (10 * 7.25 * 100) per working day. Based on working with 10 standard pickers and 10.75 hours of effective work out of the 12 hours, the theoretical capacity is 10750 picks. For a normal workday the theoretical capacity is 7250 standard picks.
Note: All hours exceeding the 8 hours should be paid 150% for both the fixed as well as the temporary staff.

5.2 Lead-time analysis

For the period of October 2015 until September 2016 the lead-time for the different divisions is calculated. A distinction is made between the different waves and therefore the different order types. There is no difference made for
deliveries with standard or detail picks. The reason for this is that deliveries could have only standard picks only detail-picks or both standard and detail-picks. With the information gathered during the measure phase, it was known what data should be extracted from SAP to conduct a lead-time analysis (see section 4.4.

5.2.1 ACD lead-time analysis

The following order types and waves can be seen.

- **Prio**: orders that have to leave the warehouse in 24 hours
- **Presales**: a lot of the same kind of orders. There is no specific lead-time for these orders. However, the orders should leave the DC the same month as they arrive.
- **Normal orders**: these orders should leave the DC within three workdays.

The lead-time for and the percentages of the different wavetypes can be found in tables 5.2, 5.3, 5.4 and 5.5. More detailed information can be found in Appendix C.
<table>
<thead>
<tr>
<th>Lead-time</th>
<th># of deliveries</th>
<th>% cum (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>19</td>
<td>2</td>
<td>7.8%</td>
</tr>
<tr>
<td>23</td>
<td>7</td>
<td>8.1%</td>
</tr>
<tr>
<td>32</td>
<td>0</td>
<td>5.1%</td>
</tr>
<tr>
<td>46</td>
<td>0</td>
<td>0.5%</td>
</tr>
<tr>
<td>50</td>
<td>0</td>
<td>0.0%</td>
</tr>
<tr>
<td>55</td>
<td>0</td>
<td>0.2%</td>
</tr>
</tbody>
</table>

Table 5.3: Lead-time prio ACD deliveries

<table>
<thead>
<tr>
<th>Lead-time</th>
<th># of deliveries</th>
<th>% cum (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>1</td>
<td>5.8%</td>
</tr>
<tr>
<td>21</td>
<td>4</td>
<td>7.5%</td>
</tr>
<tr>
<td>34</td>
<td>1</td>
<td>1.7%</td>
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<tr>
<td>46</td>
<td>0</td>
<td>5.8%</td>
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<tr>
<td>52</td>
<td>6</td>
<td>14.0%</td>
</tr>
<tr>
<td>53</td>
<td>6</td>
<td>11.9%</td>
</tr>
</tbody>
</table>

Table 5.4: Lead-time presales ACD deliveries

<table>
<thead>
<tr>
<th>Lead-time</th>
<th># of deliveries</th>
<th>% cum (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>13</td>
<td>8</td>
<td>33.3%</td>
</tr>
<tr>
<td>23</td>
<td>4</td>
<td>8.2%</td>
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<td>31</td>
<td>1</td>
<td>1.0%</td>
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<tr>
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<td>6</td>
<td>12.6%</td>
</tr>
<tr>
<td>52</td>
<td>2</td>
<td>2.5%</td>
</tr>
<tr>
<td>58</td>
<td>0</td>
<td>0.9%</td>
</tr>
</tbody>
</table>

Table 5.5: Lead-time internal ACD deliveries

Note: for the project the main interest is on the ACD normal work. The current lead-time deadline is 3 workdays. With the distribution as calculated in table 5.2 and the assumption that >5 is a lead-time of 5 days the average lead-time is 2.35 workdays.
PPD lead-time

The lead-time for and the percentages of the different PPD wavetypes can be found in 5.7. More detailed information can be found in Appendix C.

5.3 Demand analysis

Via SAP extractions be made from the work that is done, what is also analyzed in 5.1. However, it is more relevant to know what work should be done. This is called the workload or demand for the DC. A distinction is made on two levels:

1. Standard and detail-picking
2. PPD, ACD normal or ACD presales
Confidential
Graphs for the demand for ACD presales, ACD normal, and PPD can be found in figures 5.2 and 5.3.

There can be said that ACD and PPD have a kind of constant workload during the year. However, in the month of July a summer dip can be found. Furthermore, ACD has presales namely in February but also a lot in March, September, and October. In Appendix D the demand per month is presented.

5.4 Performance analysis

The productivity of all the employees is measured at all time. In order to get a good overview chosen is to extract the performance of all the employees per month in the period of October 2015 until September 2016 (see Table 5.8).

<table>
<thead>
<tr>
<th>Year</th>
<th>Month</th>
<th>Performance detail</th>
<th>Performance standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>2015</td>
<td>October</td>
<td>286</td>
<td>97</td>
</tr>
<tr>
<td></td>
<td>November</td>
<td>291</td>
<td>94</td>
</tr>
<tr>
<td></td>
<td>December</td>
<td>266</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>January</td>
<td>257</td>
<td>88</td>
</tr>
<tr>
<td></td>
<td>February</td>
<td>293</td>
<td>107</td>
</tr>
<tr>
<td></td>
<td>March</td>
<td>298</td>
<td>113</td>
</tr>
<tr>
<td></td>
<td>April</td>
<td>257</td>
<td>104</td>
</tr>
<tr>
<td>2016</td>
<td>May</td>
<td>280</td>
<td>99</td>
</tr>
<tr>
<td></td>
<td>June</td>
<td>264</td>
<td>98</td>
</tr>
<tr>
<td></td>
<td>July</td>
<td>259</td>
<td>98</td>
</tr>
<tr>
<td></td>
<td>August</td>
<td>219</td>
<td>106</td>
</tr>
<tr>
<td></td>
<td>September</td>
<td>249</td>
<td>102</td>
</tr>
</tbody>
</table>

Average performance: 268, standard performance: 100

Table 5.8: Performance detail and standard picking October 2015 until September 2016

In line with the performance analysis, an analysis is conducted about the workhours. This analysis compares the actual workhours needed to handle the workload with the theoretical (needed) workhours. The analysis can be found in Appendix E. The most important conclusion of this analysis was that productivity increases when extra deliveries are in the system. There are two main causes for this increase. At first, with more orders better tours can be created. Secondly, people feel more pressure to perform if the workload is high.
5.5 Customer analysis

Eventually a lead-time improvement has benefits for the customer. However, which customers do need what kind of lead-time. For this analysis a distinction is made between the customers for the PPD and the ACD division.

5.5.1 Customers of the ACD division

The following customer types for ACD can be distinguished:

- Pharmacies
- Chains of pharmacies
- Skin therapy saloons

Furthermore, the wholesalers place their orders at Monday and Wednesday. In a contract L’Oréal has made the appointment that these orders will be delivered within 5 workdays. The delivery within the 5 workdays is not tracked and it is not known for these customers when their orders will arrive. The wish for the wholesalers is that an delivery can be tracked and the 5 workday deadline is met.

There are also customers who have their orders shipped with priority. For the DC this means that they should be shipped in 1 workday. A customer will become a prio customer when the customers asks for this and has enough turnover. With this strategy a balance is found to meet the wishes of the customer and the flexibility of L’Oréal’s DC.

5.5.2 Customers of the PPD division

A distinction is made between the type of customers:

- Hair-salons
- Chains of hair-salons

The customers of this division have a lead-time of 1 workday. It is not possible to bring this back to multiple days due to the fact that customers are used to the fast handling. There is also a small group with 48 hours customers. However, as also shown in the lead-time analysis, almost all deliveries are handled within a workday.
5.6  Analysis with the lean tools

Two lean tools are used: observations and the Ishikawa diagram.

5.6.1  Observations

During the time in the DC, customer care and the portfolio department the following is observed:

- When employees work more than 8 hours their mood and performance will decrease
- Orders are only updated once a day into SAP from SF+ and Mercure
- Different systems are used for ordering, handling orders and tracking the performance of employees
- There are no KPI’s for On Time Delivery. On Time Delivery means in this case that deliveries for PPD are finished in 1 day and deliveries for ACD are finished in 3 days
- The performance of the replenishers and the return employees is not tracked
- The shoppers and trucks are sometimes not available due to mechanical issues
- A planning model in Excel is used to plan the number of employees needed for the next. However, it will not give any information about the number of left picks and deliveries and when they need to leave the DC
- A delivery can only be shipped of all other deliveries in the same wave are also ready to be shipped
- Team-leaders are responsible for the control and the order in which waves are picked
- Waves are printed and not digitally assigned to shoppers or trucks.

5.6.2  Ishikawa diagram

In order to see what the influencers of the lead-time are an Ishikawa is formed. The result can be found in figure 5.4.
5.7 Docktime analysis

The docktime analysis gives insight about the amount of time deliveries spend in the dock at outbound. In SAP an extra timestamp is available. This timestamp is called the *dock time*. That is the time that a sealed pallet ready to be shipped is at the outbound docks. As said before, a wave can only be shipped of all the deliveries of a wave a picked. In table 5.9 an overview of how much time the normal ACD deliveries spend at the outbound dock.

Confidential
5.8 Conclusions of analysis and summary

The following constraints can be found in the current system:

- The wave structure makes it impossible to ship a part of a wave
- The flexibility that the PPD 48 hours wave creates is not used
- SF+ updates only 3 times a day; the connection between SAP at the headquarters and SAP in the DC is only updated once a day
- The capacity is not always used to finish the work based on priority
- Planning of the capacity for the next day is based on the left workload and the expected workload; the age of the workload is not taken into account
- Only 50.6% of the ready to ship deliveries are shipped on the same day

A measures of improvement should result in one of the following points:

1. Creates flow
2. Reduces waiting time
3. Creates insights
This chapter has answered the following sub-research questions:

4. What is the capacity of the distribution center
   The capacity theoretical capacity for standard picking is 7250 picks during a normal
day and 10750 during a day with the maximum number of over-hours. For detail
picking these numbers are 46632 for a normal day and for 69144 day with the
maximum number over-hours. It is important to know that over-hours should be
paid 150% and the number of over-hours are limited. At last, there can be said that
the most important aspect is where to put the capacity when. This is one of the
most important influencers on the lead-time.

5. What are the current lead-time of the PPD and ACD divisions?
   Lead-times can be calculated per division and per wave:
   - PPD normal: 94.3% is finished in 1 workday.
   - PPD 48 hours: 98.3% in 1 workday, 99.5% in two workdays. This wave creates
     the only flexibility of capacity for PPD
   - ACD normal: 13.8% is finished in 1 workday, 57.0% in two workdays and 95.4% in
     3 workdays. Two causes for having a significant amount of deliveries with 2 and day
     3 workdays are found. The first cause is not always working according to priority.
The second cause is the fact that the wave structure that makes it impossible to
ship a part of a wave. This results in having sealed pallets waiting for shipping until
the last deliveries in that specific wave are ready for shipping.
   - ACD prio: 78.7% is finished in 1 workday.
   - ACD presales: 80.9% is finished within 5 workdays

6. What are mayor influencers of the lead-time?
   Mayor influences for the lead-time are as follows:
   - Fluctuations in demand: the forecast is not always accurate and at the end of the
     month sales the workload increases
   - The PPD workload: the PPD workload should be finished in one day; if PPD
     needs capacity it is taken away from PPD
   - The used systems: the systems update 1 to 3 times a day, which results in extra
     waiting time
   - Warehouse capacity constraints: the capacity of the DC is limited in # of employ-
     ees, opening hours and order types

Table 5.10: Summary of current state analysis
Part IV

Improve
Figure 5.5: Standard picking area for picking of full boxes
Chapter 6

Measurements of improvement

This chapter answers the following sub-research question:

7. What are possible measures to improve the process?

First, the way how the measures of improvement are developed is discussed in section 6.1. Next, in section 6.2 the measures of improvement for the process are given. Later, a total measure of improvement is given in section 6.3. Finally, a summary and the answering of the sub-research question is given in section 6.4. Furthermore, exponential forecasting methods are used to analyse and improve the current forecast of demand (see Appendix F). However, these forecasts are not more accurate than the current forecast and are also out of scope for this research. Also an extension on the current planning is developed. However, this extension is a small improvement. The extension can be found in Appendix G.

![Figure 6.1: Structure of measurements of improvement chapter](image)
6.1 How to develop measures of improvement

The measurements of improvement are developed by creating solutions for the constraints that were found in chapter 5. The measures of improvement are created using the following lean principles: reducing waste (in this case the waste waiting) and creating flow. Furthermore, the data driven approach of the six sigma methodology is used to identify areas of improvement.

6.2 Measures of improvement for the process itself

This section discusses the following measures of improvement for the process itself:

1. Real-time connection between different systems improvement
2. Dynamic wave and resource planning improvement
3. Transport network improvement
4. Wave structure and characteristics improvement

6.2.1 Real-time connection between different systems

Currently different systems are used for ordering, managing orders, managing deliveries and managing performances. Mercure and SF+ update only three times a day (see section 4.1), which results in having workload three peaks in the order pattern. Furthermore, the SAP system in Brussel and Hoofddorp only push the orders to the DC once a day. A visualization of the current systems and it’s waiting times is presented in figure 6.2.

**Improvement:** The real-time connection improves the current process by reducing the waiting times between the different steps (see principle in section 2.2.3. The orders are pushed through the systems instead of pull. If real time ordering is used, the orders arrive earlier in Hoofddorp and therefore deliveries arrive earlier in Alpen aan den Rijn. A visualization of the improved system is given in figure 6.3. SF+ will push the orders faster to SAP and SAP as order will push the orders to SAP as delivery if enough orders are collected to create optimal picking tours.

In order the achieve this improvement the external company behind SF+ should be involved to change the update time of SF+. The SAP systems
Figure 6.2: Current situation of systems

Figure 6.3: Realtime update of systems

in Hoofddorp and Brussel are different compared to the system in Alphen. Alphen uses a warehouse SAP system instead of an ordering SAP system. L’Oréal’s SAP team has to work on this. Furthermore, ACD portfolio manager, the supervisors and the team-leaders have to learn to work with more order and delivery updates during the day. The measure is implemented and will change the current way of working immediately. Enough orders should be collected to create optimal waves. Therefore, further research should be done to find out what the optimal update time will be between the SAP system in Hoofddorp and Brussel and the SAP system in the DC.
Pros
- More flow
- Less waiting time
- Creates insights of amount of orders more often

Cons
- Change of current systems SAP, SF+
- Further research necessary to find to optimal update time to the SAP DC system
- Training required for ACD portfolio manager, supervisors and team-leaders

Table 6.1: Pros and cons of real-time connection between different systems

6.2.2 Dynamic wave and resource planning improvement

Currently, the supervisor and the team-leaders have a monitor with all the left waves. It is difficult to see which waves should be finished first, because only the left number of picks and the wave creation date and time are known. Another constraint is that team-leaders have to print the tours to be able to start a picking tour. The printing of a wave costs about minutes and the papers have to be sorted per picking department.

**Improvement:** To prioritize work and give the team-leaders more visibility on the waves the improved wave monitor is developed. With the known wave type the amount of time before a wave should be finished is known. If this number is added to the wave creation date it is known how much time is left before a wave should be finished. The improved monitor sorts the waves based on "time left to finish wave". It is also known how far the progress of a wave is, how many standard and detail-picks are left and how many employees should be working on a wave to reach the lead-time deadline. As extra improvement it is necessary to assign the tours digitally to the employees. In this manner even more visibility is created about how far the waves are picked and who is picking on which wave.

The following pros and cons can be listed:

6.2.3 Transport network improvement

In the current state the shipper is picking up the deliveries during the day. The deliveries are handled at night and the next day the deliveries are delivered at the customer. Result of this working method is that the waste waiting time is created. In order to create more flow (see Lean principle in
Pros
- Less waiting time and more flow because of prioritising
- More insights and control about waves

Cons
- Update in the SAP system needed to identify the workload in the system
- Training required for the supervisors and team-leaders

Table 6.2: Pros and cons of dynamic wave and resource planning improvement

section 2.2.1) it is recommended to remove this waste.

**Improvement:** The transport network improvement removes one step in the transportation network. Currently, there is a distinction between deliveries that are handled in Belgium and deliveries that are handled in the Netherlands. In Belgium the deliveries are distributed from the central point near Brussel. In the Netherlands the deliveries are distributed from Zoetermeer. In these head transport hubs deliveries are scanned and will be transported to the smaller regional DCs (40 in total).

The measure of improvement would focus on distributing smaller shipments directly to the regional DCs. Deliveries are already scanned by L’Oréal in the DC. In total 40 smaller trucks will arrive on average each day. The picking should be done more strict per region. The benefit is that the deliveries will arrive in the evening in the regional transportation DCs, what makes it possible to deliver the products to the customer in the morning.

Furthermore, the current shippers do not provide any information about when the deliveries are delivered at the customer. When deliveries are shipped to the regional DCs smaller trucks should be used. Supervisors, team-leaders and picking employees should work more per region, which requires extensive training. The current transporter should be able to ship with smaller trucks or a new transporter should be found. A visualisation of the suggested improvement for the Netherlands and Belgium can be found in figure 6.4.
The following pros and cons can be listed:
Table 6.3: Pros and cons of transportation network improvement

<table>
<thead>
<tr>
<th>Pros</th>
<th>Cons</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Extra step at main shipment DC will be removed</td>
<td>- Deliveries should be selected per region</td>
</tr>
<tr>
<td></td>
<td>- Demand per truck is smaller</td>
</tr>
<tr>
<td>- Earlier delivery of products</td>
<td>- Extra transportation costs due to smaller trucks</td>
</tr>
</tbody>
</table>

6.2.4 Wave structure and characteristics improvement

This improvement focuses on creating more flow in the process in the DC by shipping the deliveries when they are ready to ship. (see section 2.2.1).

Current wave structure: The current system makes it impossible to ship a part of the deliveries of a wave. In this way, sometimes deliveries that are ready to be shipped cannot be shipped because one or multiple deliveries are not picked yet. This results in the current state of adding one (or more) day (s) to the lead-time. Furthermore, the wave structure dated and needs an update. For instance, the 48 hours wave of PPD, which is good for 5.5% of the PPD orders, (see Appendix C) is finished for more that 94% in 1 day. The 48 hours provides the only flexibility of PPD so this should be used. Another constraint in the current system is in the fact that if ACD deliveries are unpacked, the deliveries will be fixed in the afternoon and become 'pickable' (packed) deliveries the next day. By applying this method the maximum lead-time for the orders becomes 3 + 1 workdays instead of 3 workdays.

Improvement: The improvement wave structure find solutions for all the constrains above. The first improvement is in the wave characteristics. The following wave types are suggested:

More customers should be attracted for the PPD 48 hours waves and the flexibility / capacity that this 48 hours wave creates should be used to finish waves that almost reach their lead-time deadline. Secondly, the waves should be named with the latest shipment date. So for instance a wave name could be ACD Normal Belgium 03022017, which means that the latest shipping date is the third of February 2017. It should also be possible to add the unpacked deliveries the next day to a wave so that the lead-time of 3 workdays could be maintained. Thirdly, the improvement makes it possible to ship a part of a wave. This will create flow in the process. Furthermore, more overview on the workfloor is created by this improvement and trucks can be loaded with extra pallets until a truck is completely full.
Table 6.4: Suggested wave types

<table>
<thead>
<tr>
<th>PPD</th>
<th>ACD</th>
</tr>
</thead>
<tbody>
<tr>
<td>- PPD Normal BE</td>
<td>- ACD Normal BE</td>
</tr>
<tr>
<td>- PPD Normal NL</td>
<td>- ACD Normal NL</td>
</tr>
<tr>
<td>- PPD 48 hours (more customers) BE</td>
<td>- ACD Presales BE</td>
</tr>
<tr>
<td>- PPD 48 hours (more customers) NL</td>
<td>- ACD Presales NL</td>
</tr>
<tr>
<td>- PPD Prio BE</td>
<td>- ACD Prio BE</td>
</tr>
<tr>
<td>- PPD Prio NL</td>
<td>- ACD Prio NL</td>
</tr>
<tr>
<td>- PPD Internal NL</td>
<td>- ACD Internal NL</td>
</tr>
</tbody>
</table>

In order to implement this benefit, customer care should invest some time in updating the wave types of all the customers. Furthermore, they should attract extra customers for the 48 hours wave. Next to that, the SAP team should make it possible to ship a part of a wave and be able to add unpacked orders that are packed now to an existing wave. The process itself in the DC will not change expect for outbound. Outbound should make the decision on a daily basis to split up some waves in order to ship the deliveries earlier to the customers.

The following pros and cons can be listed:

<table>
<thead>
<tr>
<th>Pros</th>
<th>Cons</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Reduces waiting time</td>
<td>- Wave structure and customers should be updated</td>
</tr>
<tr>
<td>- Creates flow</td>
<td>- Multiple deliveries for the same customer should be shipped together</td>
</tr>
<tr>
<td>- Gives better overview on the workfloor</td>
<td></td>
</tr>
</tbody>
</table>

Table 6.5: Pros and cons of wave structure and characteristics improvement
6.3 Total measure of improvement

The integral measure of improvement combines the forecasting with the planning and capacity.

6.3.1 Integral solution

The bottleneck in the system is the fact that waves cannot be split in multiple pieces and the fact that you do not want to ship a half-full truck. Furthermore, waves are not always picked based on priority.

**Improvement:** The integral solution tackles the constraints via the following steps:

- Enough orders are collected until a truckload of workload is reached
- This work will be collected in a big wave, in which, if needed smaller sub-waves can be created
- On this wave a the needed number of employees and machinery is placed which is estimated on historical data (performances, chance of illness)
- Deliveries will be picked and leave the DC on the same day.

The first step is limiting the amount of work till full truckloads of work. This is done as follows: For each order the amount and type of boxes is known. With the number of possible boxes on a pallet and the number of pallet places in a truck the number of needed trucks is known. The number of trucks is therefore fixed. Furthermore, this solution will create an empty floor at outbound at the end of the day. In order to achieve this enough employees need to be planned. If employees work as expected they finish right on time. If they work faster they finish early and if they work slower they have to make some overtime.

A downside of this solution is that for some orders extra waiting time is created at the headquarters due to not pushing some orders to the DC. Those orders will be handled the next day.

A benefit of this solution is that orders that arrive in the DC in the morning will be at the customer before 5 pm the next day. Therefore, it is possible to inform the customer about the date of the expected delivery. For the supervisors and the team-leaders training is required to put the employees on the right picking area at the right time in order to use the capacity optimally. Furthermore, they should try to prioritise the work per truck to make sure that the workload at outbound is as constant as possible. To achieve this
solutions the SAP team needs to define and input rules that limit the workload to full truckloads. Furthermore, an extra system is needed that knows on which box will go on which pallet and in which truck.

The visualisation of the improved process is shown in figure 6.6.
For each delivery it is known in which box-type it will go, on which pallet it is placed, in which truck it has to go and who is going to pick the it.

![Figure 6.6: Integral solution which reduces waiting time and creates flow](image)

The following pros and cons can be listed:

<table>
<thead>
<tr>
<th>Pros</th>
<th>Cons</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Creates flow</td>
<td>- Deliveries in multiple boxes should be put in the same truck</td>
</tr>
<tr>
<td>- Creates possibilities to give customer extra insights</td>
<td>- Strong fluctuations in number of employees possible</td>
</tr>
<tr>
<td>- Reduces lead-time for most of the deliveries</td>
<td>- Creates for some orders extra waiting time in the headquarters</td>
</tr>
</tbody>
</table>

Table 6.6: Pros and cons of integral solution improvement
6.4 Summary of measurements of improvement

This chapter has answered the following sub-research question:

7. What are possible measures to improve the process?

The improvements are created based on the lean principles of creating flow and reducing waiting time. Furthermore, the data driven approach of the six sigma is used to identify areas of improvement. Two kind of measurements of improvement are created:

1. Process improvements
   - Real-time connection between different systems improvement: this improvement will push the orders more often through the system.
   - Dynamic wave and resource planning improvement: this improvement helps the supervisor and team-leaders to prioritise and control the workload.
   - Transport network improvement: this improvement ships the deliveries direct to the regional transport hubs.
   - Wave structure and characteristics improvement: this improvement makes it possible to ship a part of a wave. Furthermore, more customers become 48 hour customers to increase flexibility in capacity.

2. Total solution
   - Integral solution: Connects forecasting with planning and capacity; the workload is fixed to full-truck loads of work and all deliveries are handled the same day as they arrive in the DC.

Table 6.7: Summary of measures for improvement
Chapter 7

Evaluation of measures of improvements

This chapter answers the following sub-research questions:

8. How can the measures of improvement be evaluated?
9. What is the best measure of improvement?

This chapter evaluates the different measures of improvement. First, the methods to evaluate the measures of improvement are discussed in section 7.1. In section 7.2 the process measures of improvement and integral solution are evaluated. Finally, a summary of this chapter is given in section 7.3. Furthermore, a simulation of 2 days lead-time versus 3 days lead-time is conducted. The simulation and the evaluation of the simulation can be found in Appendix H.
7.1 Methods to evaluate the measures of improvement

Multi Criteria Analysis process measures of improvement and integral measure of improvement: A Multi-Criteria Analysis (MCA) is a decision-making tool for complex problems. The reason to use this is that reaching a general consensus in a multidisciplinary team can be very difficult. A MCA gives weight to different criteria and scores the different alternatives. In order to add a weight to the different criteria different views on a possible measure of improvement are used.

7.2 Evaluation of process improvements and integral measure of improvement

The is section discusses the evaluation of the process improvements and the total integral solution. First, the different criteria are explained. Secondly, the weights for the criteria are given and at thirdly the scoring of solutions is given. Finally, the total scores are calculated and the best solution is found.

7.2.1 Criteria and weighing of criteria

The criteria are defined with the knowledge from the literature review and brainstorm-sessions with the management of the DC (see section 3.2). In order to weigh the criteria the warehouse manager, team-leaders and supervisors were given the definitions of the criteria. They had to distribute 100% over the different criteria [for Communities and London, 2009]. This resulted in the following weights put to the criteria (see table 7.1. Furthermore, the case of having no preference is used to evaluate the different measures of improvement.

7.2.2 Scoring of alternatives

In order to score the different alternatives three different scoring scales are used. The higher the score, the better.

- Scoring with ranking method, 5 for the best 1 of the ’worst’ alternative [for Communities and London, 2009]
- Scoring on a scale from 1 to 5
### Table 7.1: Weights defined by different functions in the DC and equal weighted criteria

<table>
<thead>
<tr>
<th>Function</th>
<th>I</th>
<th>II</th>
<th>III</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teamleader 1</td>
<td>0.1</td>
<td>0.6</td>
<td>0.3</td>
</tr>
<tr>
<td>Teamleader 2</td>
<td>0.25</td>
<td>0.5</td>
<td>0.25</td>
</tr>
<tr>
<td>Supervisor 1</td>
<td>0.3</td>
<td>0.5</td>
<td>0.2</td>
</tr>
<tr>
<td>Supervisor 2</td>
<td>0.6</td>
<td>0.2</td>
<td>0.2</td>
</tr>
<tr>
<td>Warehouse manager</td>
<td>0.6</td>
<td>0.25</td>
<td>0.15</td>
</tr>
<tr>
<td>Equal weighted</td>
<td>0.33</td>
<td>0.33</td>
<td>0.33</td>
</tr>
</tbody>
</table>

- Scoring on a scale from 1 to 3

The criteria are scored with the help of the management of the DC. Furthermore, a employee who has done many SAP improvement projects has indicated how much time the SAP team needs, how much the implementation will cost, how the IT feasibility is and what the development time is. In total 5 different weighing methods were defined by the employees in Alphen and one method with equal weights is used. With three different scoring methods, this results in 18 MCA outcomes.

### 7.2.3 Scoring of measures of improvement via a multi criteria analysis

The measures of improvement can be numbers as follows:

1. Real-time connection between systems
2. Dynamic wave and resource planning
3. Transport network improvement
4. Wave structure and characteristics
5. Integral solution

**Scoring of "Real-time connection between different systems" - measure of improvement 1**

1. Cost:
Implementation cost: SF+ should be involved to change the update time. It is an external company and the change will cost 10k. Furthermore, changes in SAP should be made. The SAP system in the headquarters should push orders more often to the DC. This will cost the internal SAP team 1 workday.

Operational cost: There is no change in operational costs.

II Usability:

(a) Automatic or manual: The improvement is done once and will work automatically.

(b) Amount of HR needed: There is no time needed to use the improvement.

(c) Required training: The ACD portfolio manager, supervisors and team-leaders should be trained to get the insights that orders/waves arrive more often.

(d) Gradual or immediate effect: The effect of the improvement is immediate. Employees on the workfloor will not notice a significant change in their work. However, the process above this will change immediately due to the extra updates of the systems.

III Feasibility:

(a) IT feasibility: SF+ en SAP have to be changed and 1 month of development is needed.

(b) Internal or external area of improvement: The improvement is internal (SAP team) and external (SF+).

(c) All or nothing or extension: The improvement is an all or nothing improvement. It will change the current process. However, it is possible to go back to the current state, but to go back to the current state an extra investment in SF+ and SAP is needed.

Scoring of ”Dynamic wave and resource planning” - measure of improvement 2

I Cost:

(a) Implementation cost: The SAP team should or make an extraction to Excel or make a new transaction in SAP. Furthermore, they need to find out how tours can be assigned to the pickers digitally. The development will cost 5 workdays.
(b) Operational cost: The monitor helps to prioritize work. Trade-offs between extra hours and using lead-time can be made much easier. Therefore, a reduction in operational cost is expected. However, it is difficult to give an indication of these costs.

II Usability:

(a) Automatic or manual: The monitor will work automatically. Rules are defined for the different waves and SAP or Excel will be able to sort the different waves based on maximum lead-time.

(b) Amount of HR needed: There is no extra time needed to use the improvement. Team-leaders and supervisors only have a better overview of the left workload.

(c) Required training: Mainly team-leaders should be trained to use the screen. However, they are in the current state already trained to work without a decent monitor.

(d) Gradual or immediate effect: The effect of the improvement is gradual. Team-leaders and supervisors need the learn to work with the monitor and the capacity planning.

III Feasibility:

(a) IT feasibility: The development of the screen will take about 6 months. The difficulty is in the fact that the multiple small improvements will be made that are based on the input of the team-leaders and supervisors. Furthermore, developing the real-time connection of the wave monitor is complicated.

(b) Internal or external area of improvement: The area of improvement is internal (SAP team and supervisors and team-leaders).

(c) All or nothing or extension: The improvement is an extension on the current process.

Scoring of "Transport network improvement" - measure of improvement 3

I Cost:

(a) Implementation cost: The SAP team should make sure that deliveries are grouped per region. The improvement will cost the SAP team 1 workday.
Operational cost: Instead of the average 4 trucks a day, about 40 smaller trucks a day arrive at the DC. The cost of driving 1 truck is 300 euros. If nothing can combined with other customers of the shipper this results in an increase of 12000 euros a day. If in the best case 90% can be combined, this will result in an increase of 1200 euros a day.

II Usability:

(a) Automatic or manual: The improvement should be conducted once and works automatically.

(b) Amount of HR needed: On a daily basis the team-leaders should make sure that deliveries are picked per region. Furthermore, outbound should handle 40 trucks instead of 4 trucks. There are only 5 docks so a strict planning of the trucks is necessary. Making shipping documents and putting a tag on a truck should also be done 40 times instead of 4 times.

(c) Required training: The team-leaders, pickers and outbound employees need a lot of training to work and ship per region.

(d) Gradual or immediate effect: The effect of the improvement is immediate.

III Feasibility:

(a) IT feasibility: One month of development time is needed to implement the improvement.

(b) Internal or external area of improvement: The improvement is in the external area. The current transporter or a future transporter should be involved. Furthermore, picking should be done per region what is an internal area of improvement.

(c) All or nothing or extension: The improvement is an all or nothing improvement. It is difficult to go back to the current state because contracts with the transporters are fixed for a period of a couple months.

Scoring of "Wave structure and characteristics improvement" - measure of improvement 4

I Cost:
(a) Implementation cost: For the implementation, the SAP team needs 0.5 workdays to be able to change the wave characteristics. Customer care needs 1.5 workdays to indicate which customers can be put in the 48 hours wave and to check whether all customers are in the correct wave.

(b) Operational cost: It is possible to ship more full truckloads. Currently, a truck is filled with on average 28 pallets while 33 is possible. An assumption can be made that 2 extra pallets be shipped in each trucks. On average 4 trucks are shipped every day. Per month 5 trucks less are needed, what results in a decrease of 1500 euros a month.

II Usability:

(a) Automatic or manual: The wishes of the customers change constantly. Therefore, regularly time in needed to update the wave type of the customers.

(b) Amount of HR needed: Regularly customer care needs to update the wave type for customers. Outbound should make decisions which pallets can be shipped extra on a daily basis.

(c) Required training: The customer care team should be informed how to change the wave type for customers. Furthermore, outbound employees should be trained on what to ship when extra places are available in a truck.

(d) Gradual or immediate effect: The effect of the improvement is gradual. The better the customers are categorized, the better the system will work. The same effect can be expected for the learning process of the outbound employees.

III Feasibility:

(a) IT feasibility: Partial shipping of a wave is not possible due to the fact that shipping documents are created when waves are created. Updating the wave types for the customers will take 2 months of developing.

(b) Internal or external area of improvement: The area of improvement is internal.

(c) All or nothing or extension: It is an extension on the current process.
Scoring of ”Integral solution: Connects forecasting with planning and capacity” - measure of improvement 5

I Cost:

(a) Implementation cost: The SAP team should define rules that make sure that the workload is limited to full-truck loads. It will cost them 3 workdays.

(b) Operational cost: It is possible to ship full truckloads. Currently, a truck is filled with on average 28 pallets while 33 is possible. An assumption can be made that 5 extra pallets be shipped in each trucks. On average 4 trucks are shipped every day. Per month 12 trucks less are needed, what results in a decrease of 3600 euros a month.

II Usability:

(a) Automatic or manual: The improvement will work automatic for the system.

(b) Amount of HR needed: Team-leaders should put the capacity stricter on the right location on the right time because all the deliveries should leave the DC the same day. Furthermore, a bigger pool of temps is needed too handle higher peaks in demand.

(c) Required training: The ACD portfolio manager, the supervisors and the team-leaders should be trained to cooperate in a better way and put the capacity on the right moment on the right place.

(d) Gradual or immediate effect: The effect can be felt immediately.

III Feasibility:

(a) IT feasibility: The improvement needs 3 months of development.

(b) Internal or external area of improvement: The improvement is internal.

(c) All or nothing or extension: It is an all or nothing improvement. Falling back on the current state is only possible after the SAP team has turned their improvement back.

Scores of measures of improvement

In table scoring3methods the overview the measures of improvement can be found.
Measures of improvement

<table>
<thead>
<tr>
<th>Scoring method</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
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<tbody>
<tr>
<td>ranking</td>
<td>2</td>
<td>3</td>
<td>1</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>score 1 - 5</td>
<td>2</td>
<td>4</td>
<td>1</td>
<td>4</td>
<td>5</td>
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<tr>
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<td>1</td>
<td>3</td>
<td>2</td>
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<tr>
<td>score 1 - 5</td>
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<td>2</td>
<td>1</td>
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<td>4</td>
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<tr>
<td>score 1 - 5</td>
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<td>4</td>
<td>2</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>score 1 - 3</td>
<td>1</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>

Table 7.2: Scoring of different measures of improvement

In the tables below to MCA scores of the different scoring methods and different weighing methods can be found. The outcome of the MCA is as follows:

- Measure 2: Dynamic wave and resource planning (14 / 18 best)
- Measure 4: Wave structure and characteristics (2 / 18 best) - more often second
- Measure 5: Integral solution (2 / 18 best)
- Measure 1: Real-time connection between systems
- Measure 3: Transport improvement

<table>
<thead>
<tr>
<th>Function</th>
<th>Measures of improvement</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
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<tr>
<td>Team-leader 1</td>
<td>2.9</td>
</tr>
<tr>
<td>Team-leader 2</td>
<td>2.8</td>
</tr>
<tr>
<td>Supervisor 1</td>
<td>2.8</td>
</tr>
<tr>
<td>Supervisor 2</td>
<td>2.2</td>
</tr>
<tr>
<td>Warehouse manager</td>
<td>2.4</td>
</tr>
<tr>
<td>Equal weights</td>
<td>2.3</td>
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</table>

Table 7.3: Scores with ranking method
<table>
<thead>
<tr>
<th>Function</th>
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<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
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<tr>
<td>Team-leader 1</td>
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<td>4.6</td>
<td>1.3</td>
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<td>2.0</td>
</tr>
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<td>Team-leader 2</td>
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<td>4.5</td>
<td>1.3</td>
<td>2.8</td>
<td>2.5</td>
</tr>
<tr>
<td>Supervisor 1</td>
<td>2.8</td>
<td>4.5</td>
<td>1.2</td>
<td>2.8</td>
<td>2.6</td>
</tr>
<tr>
<td>Supervisor 2</td>
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<td>4.2</td>
<td>1.2</td>
<td>3.4</td>
<td>3.8</td>
</tr>
<tr>
<td>Warehouse manager</td>
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<td>4.3</td>
<td>1.2</td>
<td>3.4</td>
<td>3.7</td>
</tr>
<tr>
<td>Equal weights</td>
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<td>4.3</td>
<td>1.3</td>
<td>3.0</td>
<td>3.0</td>
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Table 7.4: Scores with scoring 1 - 5 method

<table>
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<th>Function</th>
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<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Team-leader 1</td>
<td>2.2</td>
<td>2.9</td>
<td>1.0</td>
<td>2.1</td>
<td>1.5</td>
</tr>
<tr>
<td>Team-leader 2</td>
<td>2.0</td>
<td>2.8</td>
<td>1.0</td>
<td>2.3</td>
<td>1.8</td>
</tr>
<tr>
<td>Supervisor 1</td>
<td>2.0</td>
<td>2.7</td>
<td>1.0</td>
<td>2.3</td>
<td>1.8</td>
</tr>
<tr>
<td>Supervisor 2</td>
<td>1.4</td>
<td>2.4</td>
<td>1.0</td>
<td>2.6</td>
<td>2.4</td>
</tr>
<tr>
<td>Warehouse manager</td>
<td>1.5</td>
<td>2.4</td>
<td>1.0</td>
<td>2.6</td>
<td>2.4</td>
</tr>
<tr>
<td>Equal weights</td>
<td>1.7</td>
<td>2.7</td>
<td>1.0</td>
<td>2.3</td>
<td>2.0</td>
</tr>
</tbody>
</table>

Table 7.5: Scores with scoring 1 - 3 method
7.3 Summary of evaluation of measures of improvement

This chapter has answered the following sub-research questions:

8. How can the measures of improvement be evaluated?
The measures of improvements are evaluated via an multi criteria analysis. The criteria were already earlier defined and are as follows: costs, usability and feasibility. The weights of the criteria were defined by the 2 team-leaders, the 2 supervisors and the warehouse manager. Also equal weights for the criteria are used. Eventually, the measures of improvement are scored via three different scales: ranking (best scores a 5, worst score a 1), scoring from 1 to 5 (best) and scoring from 1 to 3 (best). In total this results in 18 different MCA scores.

9. What is the best measure of improvement?
The best improvement is the dynamic wave and resource planning improvement (14/18 times best) followed by the wave structure and characteristics improvement (2/18 times best) and the integral solution (2/18 times best).

Table 7.6: Summary of evaluation of measures of improvement
Part V

Control
Figure 7.2: Standard picking area where pallet trucks with scales are used to make tours
Chapter 8

Implementation and simulation of best improvement

This chapter gives advice about how to implement the dynamic wave and resource planning improvement. First, the implementation plan of the improvement is given in section 8.1. Later, the simulation to quantify the lead-time reduction is presented in section 8.2. At last, the sub-research questions are answered in section 8.3. This chapter answers the following sub-research questions:

10. How can the best solution be implemented?
11. What lead-time improvement creates the best improvement?

Figure 8.1: Structure of implementation and simulation of best improvement

8.1 Implementation of planning improvement

The implementation of the dynamic wave and resource planning improvement will not cause any nuisance in the system or on the workfloor. The
tool will provide a way in which waves and therefore deliveries can be handled best. The tool is interesting for the supervisors and the team-leaders. The following steps should be taken to implement the planning improvement:

1. The waves and the number of standard and detail-picks should be extracted from SAP; Also the wave creation date is needed. With this information there can be calculated what the expected DC leaving date and time is. The SAP team of L’Oréal needs in total 3 workdays to develop this.

2. The monitor should be able to update at any time.

3. Give an information session about what information is on the screen and how the information can be used.

4. Input of supervisors and team-leaders is needed to make sure that only relevant information is on the monitor.

5. Start a trial to see how well the screens are working. The working of the screens can be tested by calculating the wave finishing time (see next section).

6. A second part of the improvement is the digital assigning of the tours to the shoppers. For this the SAP team needs 6 months of development (to test) and 2 days of work.

An example of the monitor of the dynamic wave and resource planning can be found in figure 8.2. In the screen the waves are visualised and sorted based on "time left to finish wave". Based on the wave creation time and the wave type it is known when the wave should be finished and leave the DC. For Belgium deliveries the latest time of picking is 3 PM. For deliveries to the Netherlands this time is 5 PM. Furthermore, there is shown how much standard and detail-picks should be handled. Also there is given how many employees on standard and detail-picking are needed on a wave to be able to reach the lead-time deadlines. The wave progress is also shown as a percentage. Summarized, there can be said that the team-leaders will have a better overview of the workload and can assign the employees in a better way.
8.2 Simulation to quantify lead-time improvement

In order to quantify the lead-time improvement a simulation is conducted. The wave creation date and the max dock date are extracted for deliveries in the months November in 2015 and March and June in 2016. With those dates the average process time of the finishing of a wave is calculated. These months are chosen for the following reasons. November is a month with almost no presales. March has a lot of presales and June quite some presales.

8.2.1 Current wave finishing time

First, the current wave finishing is calculated. This is the time that all the deliveries in a wave can be picked until all the deliveries are ready for shipping. To calculate the wave finishing time the following timestamps are used (see also in figure 8.3):

- Wave creation date and time: the time that a wave is in the DC and the deliveries of a wave can be picked.
- Dock date and time: the date that a delivery is at the outbound dock sealed on a pallet. Note: a wave has multiple deliveries. Therefore, the needed date is dock date of the latest delivery in the wave.

<table>
<thead>
<tr>
<th>Wave</th>
<th>Wave Creation Date &amp; Time</th>
<th>Time left to finish wave</th>
<th># of needed employees</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Day</td>
<td>Time</td>
</tr>
<tr>
<td>PPD Normal BE</td>
<td>7-02-17 6:42</td>
<td>0</td>
<td>2:42</td>
</tr>
<tr>
<td>PPD Normal BE</td>
<td>7-02-17 7:12</td>
<td>0</td>
<td>2:42</td>
</tr>
<tr>
<td>ACD Proc NL</td>
<td>7-02-17 8:04</td>
<td>0</td>
<td>4:42</td>
</tr>
<tr>
<td>ACD Proc NL</td>
<td>7-02-17 10:12</td>
<td>0</td>
<td>4:42</td>
</tr>
<tr>
<td>PPD 48 hours BE</td>
<td>6-02-17 9:05</td>
<td>1</td>
<td>2:42</td>
</tr>
<tr>
<td>PPD 48 hours NL</td>
<td>5-02-17 6:42</td>
<td>1</td>
<td>4:42</td>
</tr>
<tr>
<td>ACD Normal BE</td>
<td>7-02-17 5:11</td>
<td>2</td>
<td>2:42</td>
</tr>
<tr>
<td>ACD Normal NL</td>
<td>7-02-17 8:31</td>
<td>2</td>
<td>4:42</td>
</tr>
<tr>
<td>ACD Parcels</td>
<td>2-02-17 15:41</td>
<td>9</td>
<td>4:42</td>
</tr>
</tbody>
</table>
8.2.2 The simulation

In figure 8.4 a print-screen is presented of the simulation. Shown is the wave monitor on the first of June in 2016. In the orange frame the date and the capacity on that date is given. In the list below all the waves for that date are sorted based on shipping date. The shipping date is calculated by adding the lead-time deadlines for the specific waves. Furthermore, deliveries for Belgium have to be picked earlier due to shipping at 3 PM. Waves for the Netherlands have to be picked before 5 PM. The waves are sorted based on earliest shipping date. With the given capacity the team-leaders could fill in on which waves the capacity was used. The left capacity for a day can be found in the green frame. The wave progress in the blue frame shows how far the wave is finished. If a wave is finished, an estimation of the wave finishing time in the red frame was made based on the capacity for that day. For the presales chosen is to have an maximum lead-time of 7 days (5 workdays). Prio and internal deliveries have a lead-time of 1 workday and normal deliveries a lead-time of 3 workdays.
The simulation was conducted for three full months. With the simulated wave finishing date and time and the wave creation date and time the simulated wave finishing time was calculated. The results of the simulation can be found in the next subsection.

8.2.3 Results of the simulations

Below, the result of the simulation can be found. The following conclusions can be drawn from the simulation.

- The presales offers the opportunity to deal with peaks in demand due to the fact that presales have a lead-time of 7 days. The more presales, the higher the change of having a lead-time improvement on the ACD normal wave.

- November only has 6 presales deliveries. The average lead-time improved by 5.6% to 1.44 days. Not a significant improvement is gained.

- In March 47% of the deliveries were presales. This resulted in a lead-time reduction by 46.7% and an average lead-time of 1.35 days.

- In June, the amount of presales was moderate. The lead-time improved by 36.3% to 1.64 days.
Summarized, there can be said that the improvement can bring the average lead-time back to 1.5 days. Furthermore, the more presales workload there is, the better the lead-time improvement is.

Table 8.1: Simulation of monitor November 2015

<table>
<thead>
<tr>
<th>Wave types</th>
<th>#deliveries</th>
<th>Real wave finishing time</th>
<th>Simulated wave finishing time</th>
<th>Change [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>2906</td>
<td>1.52</td>
<td>1.44</td>
<td>-5.6</td>
</tr>
<tr>
<td>Internal</td>
<td>41</td>
<td>1.61</td>
<td>1.00</td>
<td>-37.9</td>
</tr>
<tr>
<td>Prio</td>
<td>80</td>
<td>1.03</td>
<td>0.99</td>
<td>-3.7</td>
</tr>
<tr>
<td>Presales</td>
<td>62</td>
<td>.33</td>
<td>1.17</td>
<td>-50.0</td>
</tr>
</tbody>
</table>

Table 8.2: Simulation of monitor March 2016

<table>
<thead>
<tr>
<th>Wave types</th>
<th>#deliveries</th>
<th>Real wave finishing time</th>
<th>Simulated wave finishing time</th>
<th>Change [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
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<td>2.53</td>
<td>1.35</td>
<td>-46.7</td>
</tr>
<tr>
<td>Internal</td>
<td>93</td>
<td>1.88</td>
<td>1.00</td>
<td>-46.9</td>
</tr>
<tr>
<td>Prio</td>
<td>187</td>
<td>1.18</td>
<td>1.08</td>
<td>-8.2</td>
</tr>
<tr>
<td>Presales</td>
<td>2694</td>
<td>3.96</td>
<td>4.01</td>
<td>+1.4</td>
</tr>
</tbody>
</table>

Table 8.3: Simulation of monitor June 2016

<table>
<thead>
<tr>
<th>Wave types</th>
<th>#deliveries</th>
<th>Real wave finishing time</th>
<th>Simulated wave finishing time</th>
<th>Change [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
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</tr>
<tr>
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<td>1.05</td>
<td>1.12</td>
<td>+6.3</td>
</tr>
<tr>
<td>Prio</td>
<td>10</td>
<td>1.00</td>
<td>1.00</td>
<td>0.0</td>
</tr>
<tr>
<td>Presales</td>
<td>133</td>
<td>1.08</td>
<td>3.14</td>
<td>+190.3</td>
</tr>
</tbody>
</table>
8.3 Summary of evaluation of measures of improvement

This chapter has answered the following sub-research question:

10. How can the best solution be implemented?
To implement the "dynamic wave and resource planning improvement" an extraction out of SAP should be made. This extraction should be able to update at any time. Furthermore, the improvement is a monitor with only the relevant information. It shows which waves are open and how much time is left before the deliveries should be shipped. The monitor also gives the needed number of employees to finish a wave on time and the wave progress as a percentage.

11. What lead-time improvement creates the best improvement?
The lead-time improvement is strongly dependent on the amount of presales in a month. If a month has more presales, there is more flexibility in capacity. In general, there can be said that the improvement offers the opportunity to have an average lead-time of 1.5 days. In March the biggest improvement was found. An improvement of 46.7% bringing the average lead-time to 1.35 days.

Table 8.4: Summary of implementation of improvement chapter
Part VI

Assessment of framework, conclusions and recommendations
Figure 8.5: Detail picking area with it’s typical U-shapes for optimized picking
Chapter 9
Conclusions and recommendations

This chapter concludes the whole research. First, the research questions are answered in 9.1. Next, the research framework is assessed in section 9.2. At last, the recommendations and further research will follow in section 9.3.

9.1 Answering of sub and main research questions

To answer the main research question ”How to improve forecasting and planning of the workload in the distribution center of L’Oréal in order to shorten the lead-time?” first the sub-research questions are answered.
1 What research framework can be designed based on literature to evaluate solutions to improve the process in the DC?

A framework is developed based on supply chain definitions, process improvement methodologies and solution evaluation methodologies. The framework itself is based on the DMAIC approach. First, the system, the problem and the criteria are defined (D). Later the current forecasting, planning and the process itself is measured (M). Next, the current state analysis is conducted (A). Measures of improvement are developed in the improve phase (I) and evaluated via a MCA. A implementation plan for the best measure of improvement is presented in the control phase (C). At last, a simulation is conducted to quantify the lead-time improvement.

2 What criteria can be used to assess the current state and the measurements of improvement?

The criteria are defined and developed based on the ambition and the goal of L’Oréal. Furthermore, discussions with the management in Alphen about the needs for the DC and how they see the future of the DC in Alphen resulted in the following criteria: cost, usability, and feasibility.

(a) **Cost**: the amount of implementation and operational costs
(b) **Usability**: how is the working of an improvement and is the improvement gradual or immediate
(c) **Feasibility**: is it feasible to implement the improvement

3 How is the current demand forecasted and planned?

The current demand is forecasted by the ACD portfolio and is based on the input of sales and marketing. A forecast is always made in amount of sales in euros and is translated by Alphen in a number of standard and detail picks. The planning is done by the supervisors of ACD and PPD. PPD plans the capacity based on finishing all the forecasted deliveries. ACD plans on finishing not all the deliveries within 3 days. If PPD needs more capacity it is taken away from ACD. If ACD is not being able to reach a lead-time of 3 days overtime is used to make sure that the lead-time goals will be achieved.
4 What is the capacity of the distribution center?

The theoretical capacity of the DC can be separated into the capacity for standard picking and detail picking and is based on historical performance data. Also a distinction can be made between normal hours and a full day of work with the maximum number of overhours. The maximum capacity of a normal workday is 7250 for standard and 46632 for detail. A day with overhours results in a maximum capacity of 10750 for standard and 69144 for detail. Furthermore, there can be said that using the capacity on the right place at the right time is one of the most important influencers on the lead-time.

5 What are the current lead-time of the PDD and ACD divisions?

With SAP extractions of deliveries are made for the period October 2015 until September 2016. The timestamps "Wave Creation Date" - the time at which the delivery is in the DC - and "Truck Loading Date" - the time that the truck has left the DC - are used to calculate the lead-time. Lead-times can be calculated per division and per wave:
- PPD normal: 94.3% is finished in 1 workday.
- PPD 48 hours: 98.3% in 1 workday, 99.5% in two workdays. This wave creates the only flexibility of capacity for PPD
- ACD normal: 13.8% is finished in 1 workday, 57.0% in two workdays and 95.4% in 3 workdays. Two causes for having a significant amount of deliveries with 2 and day 3 workdays are found. The first cause is not always working according to priority. The second cause is the fact that the wave structure that makes it impossible to ship a part of a wave. This results in having sealed pallets waiting for shipping until the last deliveries in that specific wave are ready for shipping.
- ACD prio: 78.7% is finished in 1 workday.
- ACD presales: 80.9% is finished within 5 workdays

6 What are the mayor influencers of the lead-time?

The lead-time of ACD is determined by four mayor influencers:
1. The fluctuations in demand: a forecast is made for each day, but the forecast is not that accurate. Also fluctuations during special sales (presales) and at the end of the month make it difficult to score well on lead-time.
2. **PPD workload**: the PPD workload has a lead-time of 1 workday compared to 3 workdays for ACD. If PPD needs more capacity this is taken away from ACD.

3. **The used systems**: The systems are only updated one up to three times a day. In this case peaks are created. Furthermore, wave sizes are assigned automatically.

4. **Warehouse capacity constraints**: there is a limit in scaling up the capacity. Also similar kind of deliveries can form a bottleneck because it is impossible to pick with the whole capacity at one location. At last, the warehouse has a limited amount of opening hours.

7 **What are possible measures to improve the process?**

The areas for improvement are identified with the data driven approach of six sigma. Furthermore, the measures of improvement focus on reducing the waste waiting and creating flow. Two kind of measurements of improvement are created:

1. **Process improvements**
   - Real-time connection between different systems improvement: this improvement will push the orders more often through the system.
   - Dynamic wave and resource planning improvement: this improvement helps the supervisor and team-leaders to prioritise and control the workload.
   - Transport network improvement: this improvement ships the deliveries direct to the regional transport hubs.
   - Wave structure and characteristics improvement: this improvement makes it possible to ship a part of a wave. Furthermore, more customers become 48 hour customers to increase flexibility in capacity

2. **Total solution**
   - Integral solution: Connects forecasting with planning and capacity.

8 **How can the measures of improvement be evaluated?**

The measures of improvements are evaluated via an multi criteria analysis. Three criteria are used: costs, usability and feasibility. For the weights of the criteria the 2 team-leaders, the 2 supervisors and the warehouse manager had to distribute 100% over the three criteria. Also equal weights for the criteria are used. Eventually, the measures of improvement are scored via three different scales: ranking (best scores a
5, worst score a 1), scoring from 1 to 5 (best) and scoring from 1 to 3 (best). In total this results in 18 different MCA scores.

9 What is the best measure of improvement?

The best improvement is the *dynamic wave and resource planning improvement* (14/18 times best) followed by the *wave structure and characteristics improvement* (2/18 times best) and the *integral solution* (2/18 times best). The *dynamic wave and resource planning improvement* was best improvement because it creates insights, is very usable due to the fact that a low amount of training is needed and the fact that it is an internal improvement.

10 How can the best solution be implemented?

To implement the "*dynamic wave and resource planning improvement*" an extraction out of SAP should be made. The input of the supervisors and the team-leaders is needed to develop a monitor that only shows relevant information. The monitor shows the time left to finish a wave, the left number of picks and the needed number of employees to finish the wave on time.

11 What lead-time improvement creates the best improvement?

The lead-time improvement is strongly dependent on the amount of presales in a month. If a month has more presales, there is more flexibility in capacity. An average lead-time of 1.5 workdays is possible with the improvement. In March, a month with 47% of presales deliveries, the biggest improvement was found. The improvement was 46.7% bringing the average lead-time to 1.35 days.

How to improve the process in the distribution center of L’Oréal in order to shorten the lead-time?

The process in the DC can be improved via different measures. The best measure is the dynamic wave and resource planning improvement. It helps to prioritise the waves and plan the resources. This improvement results in a reduction in lead-time from 5 till 47% bringing the average lead-time to 1.5 days. In addition, the real-time connection between the systems pushes the
orders more often through the system and could possible help to improve the lead-time even more.

9.2 Assessment of research framework

The research framework has proven it’s use. First of all, it is a framework based on a proven process improvement methodology, the DMAIC cycle. At the end, it is all about providing insights and result. The framework did provide a life line that could be followed to achieve this. Furthermore, the development of the framework was an iterative process. With going to a new phase of the framework new ideas and methodologies came together to extend the initial framework.

The framework itself is also applicable on other cases. However, it does differ per case which analysis should be conducted and which solution evaluation method is best.

9.3 Recommendations and further research

it is recommended for L’Oréal to implement the dynamic wave and resource planning improvement, which is the best scoring improvement. This improvement tackles the rootcause of the problem, which is not finishing waves according to priority. The wave structure and characteristics improvement provides a solution to ship a part of wave. This helps reducing the lead-time but is solving the problem caused by the rootcause instead of the rootcause itself. It is however recommended to attract more 48 hours customers. The real-time connection between the systems improvement is also recommended in order to get the orders pushed through the system more often.

The transport network improvement is not recommended, because the costs are high and it is complicated to work with waves for each region. The integral solution can result in a huge lead-time reduction, however there is a lot of risk involved in implementing this solution. For instance, not having enough employees to handle a high peak in demand.

Furthermore, the following recommendations can be made regarding further research:

- **Process improvements**: in the current detail-picking process employees need to start their tour by putting stickers on specific boxes. This takes about a quarter of the time of a tour. Further research should be done to find out if automation of this part is feasible.
• **Truck planning**: in the current state one person is responsible for the planning of the trucks. No information is tracked about the truck planning and therefore it is not possible to know how well the truck planning is done. It is recommended to track the truck planning so analysis could be conducted. Further research is needed to find the best way of truck planning.

• **KPIs**: there are no KPIs used for the lead-time. In order to track the performance of the DC and to see if an improvement will work it is important to track the lead-time.

• **Total lead-time**: the focus for this research was shortening of the lead-time in the DC. However, for the customers the total lead-time is important. Further research is necessary to shorten the lead-time from ordering until delivery.

• **Optimal wave size**: the optimal wave size is unclear. Large wave sizes offer efficiency in picking tours and short wave sizes reduce waiting times. Research is necessary to find the optimal wave size.
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Appendix
Appendix A

Lessons learned from case studies

A.1 Case studies:
This appendix is shows information learned from the case studies during the literature review.

A.1.1 Effect of extended hours of work
Harrington [Harrington, 2001] has found the following effects and solutions for that of shift work and extended hours of work.

- *Health effects*: Reduction in quality and quantity of sleep;
- *Safety effects*: Poorer performance; increased rate of accidents;
- *Solutions*: A shift should not be extended to 10 or 12 hours because the employees will be far more fatigue. More education about physical fitness, sleep and food will be beneficial for the productivity of the employee.

A.1.2 Temporary staff versus fixed staff
In an article of First [Firstbase, 2016] - Base the pros and cons of temporary employees are noted:

Pros
- They save time: reason for this is that the recruitment is already done. The employees that will come to your company are qualified will prob-
ably have to right mentality for the job. There is no time needed for interviewing and selecting staff.

- They save money: a temporary employee is not direct member of staff. Most of the time they are fixed by an agency so a hiring fee is paid and no further extras need to be paid. Expenses like sick pay, holiday, pensions contributions and a bonus are handled by the agency.

- They give you flexibility. If you need to expand your team to handle an increased workload, due to for instance promotions, temps give you extra capacity. On top of that a temporary employee can be hired when she/he is performing well.

**Cons**

- Motivation: The majority of temps are skilled, professional and motivated people. However, some employers find it difficult to integrate temps in their team. The reason for this is that they are never really your employees because they work for other companies as well.

- They could lack commitment to the company: Because they will not get the extra benefits of the fixed employees they are not willing to give the extra miles when needed. They will just do what is needed and nothing more.

- Investing time: temps have to be trained to learn what to do on the workfloor. Fixed employees or manager should put some time in the training. Furthermore, if the employees are trained the only know how the process works but probably will not work as fast as fixed employees in the first weeks.

**A.1.3 Successfullness of companies versus lead-time**

In the book Managing by Projects for Business Success [Parnaby et al., 2003] the following steps are given regarding success and lead-time.

**A.1.4 How to reduce inventory, while maintaining or improving service**

In the article of Chuck LaMacchia [Shelfplus, 2016] the following ways are given to reduce inventory, while maintaining or improving service.
Reduce replenishment lead times: in order to finish an order for a customer it is needed that the product is available. It is possible that a product is available in the supply chain, but not at the picking location. Having a high rate of replenishing makes sure that orders can be picked more often. Apart from that, orders that cannot be picked cause extra delay and attention and therefore cost more money.

Improve your forecasting: Making a right forecast is and will be difficult. In order to see a trend in the demand it is necessary to improve the following points first.

- Make sure that the relevant drivers of demand are put well in the data. For instance if marketing and sales adjust prices and have promotions the demand will differ. Do take this into account when forecasting the demand.

- Make sure the data is accurate. Make sure that if you forecast from shipments that the true customer order quantity and dates are correct based on unavailability of products and back-orders.

- Review the forecast method. If the inputs are right and the data is clean, basic forecasting methods will produce a good forecast.
If the resources are limited first focus on the right input and clean data before putting focusing on better forecasting methods.

- Reduce variability of demand and supply. First step is to reduce or eliminate the large end-of-period buys that are often a result of meeting the targets. This will result in less turnover at first, but however the profit margin will mostly increase. The reason for this, is the fact that the large end-of-period sales are discounted a lot. The difficulty of reducing this demand can be tackled when this is supported all the way in the organization.

<table>
<thead>
<tr>
<th>Case study</th>
<th>Key elements</th>
<th>Aim</th>
<th>Usefulness</th>
<th>DMAIC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temporary staff versus fixed staff</td>
<td>Benefits and cons of fixed and temporary staff</td>
<td>Why to use temporary staff</td>
<td>-</td>
<td>I</td>
</tr>
<tr>
<td>Successfullness of companies</td>
<td>Lead-times, forecast, chain alignment</td>
<td>How to be successful in logistics</td>
<td>0</td>
<td>I</td>
</tr>
<tr>
<td>versus lead-time</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Effect of extended hours of work</td>
<td>Health and safety issues</td>
<td>How to deal with extended hours of work</td>
<td>0</td>
<td>I</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>How to reduce inventory, while</td>
<td>Replenishment, forecasting, reducing variability</td>
<td>How to reduce inventory</td>
<td>+</td>
<td>A, I</td>
</tr>
<tr>
<td>maintaining or improving service</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Appendix B

Handled units

This appendix gives an overview of the handled units for all the working days in the DC. A distinction is made via the following ways:

- Division: H200 and B200 are PPD; H400 and B400 are ACD. Furthermore, H means Holland / The Netherlands - B means Belgium.

- Type of picks: pallet picks, standard picks and detail picks

- The number of total picks are shown in table B.1

<table>
<thead>
<tr>
<th>Month and Year</th>
<th>Number of Case Picks</th>
<th>Number of Loose Picks</th>
</tr>
</thead>
<tbody>
<tr>
<td>October 2015</td>
<td>77,685</td>
<td>564,872</td>
</tr>
<tr>
<td>November 2015</td>
<td>73,774</td>
<td>511,453</td>
</tr>
<tr>
<td>December 2015</td>
<td>69,506</td>
<td>481,936</td>
</tr>
<tr>
<td>January 2016</td>
<td>93,307</td>
<td>569,221</td>
</tr>
<tr>
<td>February 2016</td>
<td>108,149</td>
<td>724,558</td>
</tr>
<tr>
<td>March 2016</td>
<td>98,504</td>
<td>692,488</td>
</tr>
<tr>
<td>April 2016</td>
<td>78,827</td>
<td>549,793</td>
</tr>
<tr>
<td>May 2016</td>
<td>78,966</td>
<td>589,184</td>
</tr>
<tr>
<td>June 2016</td>
<td>98,361</td>
<td>664,602</td>
</tr>
<tr>
<td>July 2016</td>
<td>46,340</td>
<td>358,341</td>
</tr>
<tr>
<td>August 2016</td>
<td>72,061</td>
<td>501,361</td>
</tr>
<tr>
<td>September 2016</td>
<td>94,014</td>
<td>688,166</td>
</tr>
</tbody>
</table>

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<table>
<thead>
<tr>
<th>Type of picks</th>
<th>Maximum number of picks on a day</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pallet</td>
<td>84</td>
</tr>
<tr>
<td>Standard</td>
<td>8266</td>
</tr>
</tbody>
</table>

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Appendix C

Lead-time ACD and PPD

This appendix visualizes the lead-times of the ACD and PPD divisions in more detailed. Furthermore, some tables can be found with more detailed information about the lead-time.

C.1 Lead-time ACD

![ACD Prio lead-time](image)

Figure C.1: ACD Prio lead-time
Figure C.2: ACD Presales lead-time

Figure C.3: ACD Normal orders lead-time
### Table C.1: Lead-time of ACD orders - October 2015 until September 2016

<table>
<thead>
<tr>
<th></th>
<th>Normal</th>
<th>Presales</th>
<th>Prio</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>14.7%</td>
<td>5.8%</td>
<td>95.8%</td>
</tr>
<tr>
<td>2</td>
<td>42.7%</td>
<td>7.7%</td>
<td>13.5%</td>
</tr>
<tr>
<td>3</td>
<td>38.1%</td>
<td>21.7%</td>
<td>35.2%</td>
</tr>
<tr>
<td>4</td>
<td>3.3%</td>
<td>31.7%</td>
<td>66.9%</td>
</tr>
<tr>
<td>5</td>
<td>1.0%</td>
<td>14.0%</td>
<td>80.9%</td>
</tr>
<tr>
<td>6</td>
<td>0.1%</td>
<td>5.5%</td>
<td>86.4%</td>
</tr>
<tr>
<td>7</td>
<td>0.1%</td>
<td>0.5%</td>
<td>86.8%</td>
</tr>
<tr>
<td>8</td>
<td>0.0%</td>
<td>2.0%</td>
<td>88.8%</td>
</tr>
<tr>
<td>9</td>
<td>0.0%</td>
<td>5.1%</td>
<td>93.9%</td>
</tr>
<tr>
<td>10</td>
<td>0.0%</td>
<td>6.1%</td>
<td>100.0%</td>
</tr>
</tbody>
</table>

### Table C.2: Lead-time of PPD deliveries in Alphen

<table>
<thead>
<tr>
<th>Delivery Type</th>
<th>Percentage</th>
</tr>
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<tbody>
<tr>
<td>PPD 48 hours</td>
<td>5.5%</td>
</tr>
<tr>
<td>PPD normal</td>
<td>94.5%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Days</th>
<th>Number</th>
<th>Percentage</th>
<th>Cumulative Number</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>7809</td>
<td>98.3%</td>
<td>111042</td>
<td>82.2%</td>
</tr>
<tr>
<td>2</td>
<td>96</td>
<td>1.2%</td>
<td>21693</td>
<td>16.1%</td>
</tr>
<tr>
<td>3</td>
<td>26</td>
<td>0.3%</td>
<td>1202</td>
<td>0.9%</td>
</tr>
<tr>
<td>4</td>
<td>0</td>
<td>0.0%</td>
<td>320</td>
<td>0.0%</td>
</tr>
<tr>
<td>5</td>
<td>10</td>
<td>0.1%</td>
<td>944</td>
<td>0.7%</td>
</tr>
<tr>
<td>6</td>
<td>0</td>
<td>0.0%</td>
<td>944</td>
<td>0.7%</td>
</tr>
<tr>
<td>7</td>
<td>0</td>
<td>0.0%</td>
<td>944</td>
<td>0.7%</td>
</tr>
<tr>
<td>8</td>
<td>0</td>
<td>0.0%</td>
<td>944</td>
<td>0.7%</td>
</tr>
<tr>
<td>9</td>
<td>0</td>
<td>0.0%</td>
<td>944</td>
<td>0.7%</td>
</tr>
<tr>
<td>10</td>
<td>0</td>
<td>0.0%</td>
<td>944</td>
<td>0.7%</td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>0.0%</td>
<td>944</td>
<td>0.7%</td>
</tr>
</tbody>
</table>
Appendix D

Workload for PPD and ACD for standard and detail picking

This appendix is about the workload of the different departments.

In the DC there are PPD and ACD orders. A distinction is made between the workload of both divisions.

In figure D.1 a distribution of the number of detail picks is given. Figure D.2 gives the same overview for standard picks.
Figure D.2: Standard workload during the year 2016

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Appendix E

Workhours analysis in the distribution center

Based on the number of deliveries that were created and the number of picks the number of workhours needed to pick products can be calculated. The number of hours include the number of pallet pick hours, the number of standard pick hours and the number of detail pick hours. This sum of hours is compared with the actual number of hours that is worked that month. An overview per month for the year 2016 in which the actual workhours are projected against the needed workhours is shown in figure E.1.

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1 If more than average hours are needed to pick all the deliveries the productivity increases
• The first cause of this productivity increase is that employees work faster because they feel the pressure of finishing all the orders.

• The second cause is that if there are more deliveries better tours can be created, which results in more picks per hour.
Appendix F

Forecasting of demand

F.1 Measures of improvement for the forecasting constraints

Forecasting based on historical data
The current forecasting is based on the month target and the input of sales (see section 4.5). The measure of forecast improvement will use the historical data and the month target to forecast the demand in the DC. A key element of lead-time shortening is an accurate forecast (see section 2.2.5 [Ordoro, 2016]).

There are different kinds of forecasting methods. A popular method is the ‘single moving averages’ in which past observations are weighted equally. This method is not used because L’Oréal is working with month targets. Therefore, not only the the observation before is important but all the observations before are of importance.

Another one is exponential smoothing in which exponentially decreasing weights are assigned as the observations get older (see section 2.2.8).

In exponential smoothing different parameters needs to be determined to assign these to the observations.

First, a forecast is made based on the demand of a given month in the period October 2015 till September 2016. The parameter(s) for these exponential forecasts is / are determined by minimizing the mean squared error (MSE). The mean squared error is calculated as follows:

- Determine error: real demand - forecasted demand
- Determine error squared: error * error
• Calculate mean squared error: take the mean of all the error squared

With the "Solver function" in Excel the minimal MSE is determined. A minimum MSE means that all the errors between forecasted demand and the real demand are minimal. This means that the fit with the real demand is best. Therefore, the parameter(s) that is / are calculated are used to forecast the demand for a specific month. Later the new forecast demand can be compared with the realised demand. With these data the MSE can be determined and the best fitting method can be determined.

F.1.1 Single exponential smoothing

This forecasting method has one parameter. This parameter determines how much weight is assigned to the last observations.

F.1.2 Double exponential smoothing

This forecast method has two parameters. Compared to the single exponential smoothing this method is better at handling trends.

F.1.3 Triple exponential smoothing

This forecast method has three parameters. Compared to the double exponential smoothing this method is better in handling seasonal trends. In figure F.1 the different exponential forecasting methods are compared with the current forecasting (Rob) and the revealed demand.

Will be tested with the current planning based on fit compared with the revealed demand.

F.2 Evaluation of forecasting methods

F.2.1 Forecasting evaluation - Mean Squared Error

To evaluate the forecasting method the forecasting with the three different methods are compared to the actual demand. The error between the forecasting and the real demand is calculated for each datapoint. The mean of all these errors is called the mean squared error (MSE). The lower the MSE is, the better the forecast is [Hyndman, 2013].

The different forecasting methods are evaluated by the mean squared error (MSE). This measures the average of the squares of the errors which is the difference between the estimator and what is estimated.
Based on the data of a year earlier estimates are made for the current year. A distinction is made between standard and detail picking. A forecast is made for the following months.

- October 2016
- November 2016
- December 2016
- January 2017

In the table below the MSEs of the different forecasting techniques for the month November are presented. The double forecasting methods provides the smallest MSE. However, it differs per month how accurate the forecasting methods are. Most of the times the double and triple exponential forecasting methods is at least as good as the current forecasting. Unfortunately, it is difficult to draw one conclusion about the forecasting methods and how
much it can possible improve the lead-time. Therefore, it is not fulfilling the requirements of the solutions.

<table>
<thead>
<tr>
<th>Exponential smoothing method</th>
<th>MSE</th>
<th>( \alpha ) demand</th>
<th>( \beta ) seasonality</th>
<th>( \gamma ) trend</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single</td>
<td>9.77E+07</td>
<td>0.34</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Double</td>
<td>8.19E+07</td>
<td>0.06</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>Triple</td>
<td>9.16E+07</td>
<td>0.06</td>
<td>0.00</td>
<td>0.29</td>
</tr>
<tr>
<td>Current</td>
<td>8.06E+07</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table F.1: Comparison of MSEs October month

<table>
<thead>
<tr>
<th>Exponential smoothing method</th>
<th>MSE</th>
<th>( \alpha ) demand</th>
<th>( \beta ) seasonality</th>
<th>( \gamma ) trend</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single</td>
<td>9.07E+06</td>
<td>0.32</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Double</td>
<td>7.23E+06</td>
<td>0.09</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>Triple</td>
<td>8.25E+06</td>
<td>0.05</td>
<td>0.08</td>
<td>0.62</td>
</tr>
<tr>
<td>Current</td>
<td>1.15E+07</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table F.2: Comparison of MSEs November month

<table>
<thead>
<tr>
<th>Exponential smoothing method</th>
<th>MSE</th>
<th>( \alpha ) demand</th>
<th>( \beta ) seasonality</th>
<th>( \gamma ) trend</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single</td>
<td>2.55E+07</td>
<td>0.49</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Double</td>
<td>2.62E+07</td>
<td>0.29</td>
<td>0.00</td>
<td></td>
</tr>
<tr>
<td>Triple</td>
<td>9.40E+06</td>
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<td>0.10</td>
<td>0.76</td>
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<tr>
<td>Current</td>
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<td></td>
<td></td>
</tr>
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</table>

Table F.3: Comparison of MSEs December month

<table>
<thead>
<tr>
<th>Exponential smoothing method</th>
<th>MSE</th>
<th>( \alpha ) demand</th>
<th>( \beta ) seasonality</th>
<th>( \gamma ) trend</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single</td>
<td>1.16E+07</td>
<td>1.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Double</td>
<td>1.51E+07</td>
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<td></td>
</tr>
<tr>
<td>Triple</td>
<td>1.58E+06</td>
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<td>0.00</td>
<td>0.67</td>
</tr>
<tr>
<td>Current</td>
<td>1.18E+07</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table F.4: Comparison of MSEs January month
F.2.2 Conclusion

The forecasting of demand via the exponential forecasting methods is on average as good as the current forecasting. Due to a lot of human factors no clear trend can be found. The following human factors do cause nuisance in demand:

- Keeping orders in the headquarters to prevent having backorders
- Holidays that differ per year
- Teambuilding activities of employees in the DC
- Training of sales and supply chain employees

Furthermore, there can be said that the ACD portfolio manager is responsible for the forecasting and the pushing of the orders to the DC. Therefore, this person can change the forecast on a daily basis.
Appendix G

Planning tool

The current planning for the number of employees is focused on the left workload and the new expected workload. In order to optimize "demand management" it is necessary to have supply chain visibility and decision support information (see section 2.1.2 [Lapide, 2016]). The planning improvement focuses on getting visibility in the workload by making a distinction between the left workload and the new workload. Furthermore, it provides visibility by giving an overview of the current waves in the system and how much time is left to finish them.

Current workload: A visualization of an example of the workload for the next day is shown in figure G.1. It is not know from which days the ACD normal workload is and thus on which day the remaining workload should leave the DC at latest.

Improved view on the workload: A solution for this problem is a planning tool. This planning tool knows from which working day the workload in the system is and therefore when the deliveries should leave the DC. A visualisation is shown in figure G.2. To achieve the lead-time goal of 3 workdays, all the PPD deliveries and the ACD deliveries which are 3 workdays old should leave the DC. The extra capacity that can be created should be used to handle the 2 day and 1 day old deliveries and the ACD presales. With this information the truck planning can also be planned in a better way.
Figure G.1: Current planning tool
Figure G.2: Improved planning tool
Appendix H

Simulation of 2 days lead-time versus 3 days lead-time

During the research a simulation is done. This simulation compared a two days lead-time with a three days lead-time for the months January and June 2016. This section will assess the outcomes of the simulations. First, the criteria are determined. Later weights are applied on the criteria and finally the scores of two days lead-time with three days lead-time is compared.

H.1 Criteria

The criteria are based on the needs of have a successful operation. The following criteria are used:

I Costs: this criteria assesses how costs are made for picking. The costs can be split in two parts:

(a) Costs due to overhours: the total number of overhours is multiplied by 1.5.
(b) Costs due to normal hours: the total number of picking hours is multiplied by 1.

The total costs can be found by adding the numbers of the costs due to overhours by the cost due to normal hours. The higher, the worse.

II Fluctuation in number of employees: this criteria assesses how much the number of needed people fluctuates. This is done by calculating the average deviation in number of employees during the month.
III Overhours and sending people home: this criteria how often employees had to work extra (overhours) and how often people were send home. This is done by calculating how much overhours or sending home per employee was needed very day. In table H.1 an overview of the weights can be found. The worst what can happen is overtime (scores of 4 and 3). Sending people home is also not favourable, but less worse (scores over 2 and 1 are applied). Eventually a score can be calculated by multiplying the number of times a type of overhours or sending home has happened with the weight. The lower the score, the worse it is.

Table H.1: Weighing of hours overtime or sending home per employee

<table>
<thead>
<tr>
<th>Number of hours overtime or sending home per employee</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;1.5</td>
<td>2</td>
</tr>
<tr>
<td>-1.5 until -0.5</td>
<td>1</td>
</tr>
<tr>
<td>-0.5 until 0.5</td>
<td>0</td>
</tr>
<tr>
<td>0.5 until 1.5</td>
<td>3</td>
</tr>
<tr>
<td>&gt;1.5</td>
<td>4</td>
</tr>
</tbody>
</table>

H.2 Weight of the criteria

It is difficult to add weights to the different criteria and say something about how much impact a lead-time of 2 days will have compared to a lead-time of 3-days. Therefore all the criteria are determined apart from each other and can be assessed later when scores are calculated.

H.2.1 Scoring of 3 days lead-time versus 2 days lead-time

In the table below the average change of taking 2 days lead-time instead of 3 days lead-time is presented.

There can be said that if a lead-time of 2 days is used instead of a lead-time of 3 days all the criteria score worse. The cost will increase a little bit. More fluctuation in the number of needed employees is necessary and more often people are home or have to work overtime. However, with using a lead-time of 2 days the extra big peak that can occur due to inaccurate forecasting can be handled in a smoother way because only workload that is one day old is in the system and no workload of 3 days old is in the system.
Table H.2: Scoring of simulation 3 days lead-time versus two days of lead-time criteria I

<table>
<thead>
<tr>
<th></th>
<th>I(a)</th>
<th>I(b)</th>
<th>OVERHOURS</th>
<th>NORMAL HOURS</th>
<th>COSTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>January</td>
<td>June</td>
<td>January</td>
<td>June</td>
<td>January</td>
<td>June</td>
</tr>
<tr>
<td>Ruud</td>
<td>2d a</td>
<td>2g e</td>
<td>199</td>
<td>91</td>
<td>90</td>
</tr>
<tr>
<td></td>
<td>3d a</td>
<td>2</td>
<td>12</td>
<td>21</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-6.1%</td>
<td>15.9%</td>
<td>1.0%</td>
<td>0.0%</td>
</tr>
<tr>
<td>Carlijn</td>
<td>2d a</td>
<td>2</td>
<td>19</td>
<td>20</td>
<td>22</td>
</tr>
<tr>
<td></td>
<td>3d a</td>
<td>2</td>
<td>20</td>
<td>2</td>
<td>21</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-3.4%</td>
<td>5.5%</td>
<td>0.9%</td>
<td>0.3%</td>
</tr>
</tbody>
</table>

Table H.3: Scoring of simulation 3 days lead-time versus two days of lead-time criteria II & III

<table>
<thead>
<tr>
<th></th>
<th>II</th>
<th>III</th>
<th>FLUCTUATIONS</th>
<th>IN # OF</th>
<th>EMPLOYEES</th>
<th>OVERHOURS</th>
<th>&amp; SHORTER</th>
<th>WORKDAY</th>
</tr>
</thead>
<tbody>
<tr>
<td>January</td>
<td>June</td>
<td>January</td>
<td>June</td>
<td>Ruud</td>
<td>2d a</td>
<td>2.6</td>
<td>5</td>
<td>2.8</td>
</tr>
<tr>
<td></td>
<td>3d a</td>
<td>2.4</td>
<td>5</td>
<td>2.6</td>
<td>8</td>
<td>3</td>
<td>7</td>
<td>2</td>
</tr>
<tr>
<td>Carlijn</td>
<td>2d a</td>
<td>2.6</td>
<td>7</td>
<td>2.9</td>
<td>2</td>
<td>2</td>
<td>6</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>3d a</td>
<td>2.5</td>
<td>0</td>
<td>2.8</td>
<td>0</td>
<td>2</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6.8%</td>
<td>4.3%</td>
<td>-16.7%</td>
<td>32.0%</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table H.4: Scoring of 3 days lead-time versus 2 days of leadtime

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Change</th>
<th>Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fluctuations in # of employees</td>
<td>5.95%</td>
</tr>
<tr>
<td></td>
<td>Overhours and shorter workday</td>
<td>13.0%</td>
</tr>
<tr>
<td></td>
<td>Overall</td>
<td>139</td>
</tr>
</tbody>
</table>

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