Decreasing the down time in the factory due to delivery delays after moving to a new dedicated distribution center

Bachelor Graduation Thesis - Industrial Engineering and Management

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Preface

Dear reader,

In front of you lies my bachelor thesis assignment “Decreasing the down time in the factory due to delivery delays after moving to a new dedicated distribution center”, for the completion of the bachelor’s degree Industrial Engineering and Management at the University of Twente. The research is performed at the company Mead Johnson, located in Nijmegen.

Mead Johnson provided me this opportunity and valuable experience for which I am grateful. Especially the possibility of working on-site during times of COVID gave me the unique chance of seeing how the processes go and to keep better in touch with all employees that were involved in the process. I want to thank all employees, both from Mead Johnson and Nabuurs, who have helped with me during this research. A special thanks goes to my company supervisor Francesc Ferreres. I was able to learn a lot with the help of his guidance in which he shared his experiences. Last, I would like to thank Eduardo Lalla-Ruiz, my supervisor from the university, for the guidance and feedback which steered me in the right direction.

I sincerely hope that you will enjoy reading this thesis.

Kind Regards,

Sander Phijffer

Enschede, June 2022

Management summary

Mead Johnson is a nutrition company that produces Infant Formula and Child Nutrition, feeding up to 1 million babies worldwide. The research is conducted at their site in Nijmegen, where the factory and offices are located. At this site, there is only not enough space to store all materials. Therefore, the distribution centers called Frigolanda and Cornelissen are used.

The main problem is that there is too much down time in the factory due to a lack of material at the moment of production. This is often because the materials are delivered not On Time In Full from the distribution centers to the factory. Because of this, it was decided to move from the two distribution centers to only one dedicated distribution center at Nabuurs. Therefore, as part of the solution approach, the following knowledge problem is formed:

How can the late deliveries to the factory be decreased by onboarding all materials successfully to the new dedicated distribution center at Nabuurs?

This knowledge problem is solved on the basis of five research questions. These are answered with the help of the seven steps of the Managerial Problem-Solving Method of Heerkens & Van Winden, 2016. In order to validate whether the research is successful, three Key Performance Indicators are determined which together fully cover the performance of the operations. For all KPIs, targets are set in advance and after all, the performances before and after will be compared and it is checked whether the targets have been achieved.

As a first step to understand the problem better, a problem analysis has been made. This is first done by investigating the current supply chain to make clear where the problems occur, which is almost at the beginning of the supply chain between the raw material suppliers and the factory. This is the place where the inbounds from the distribution centers to the factory take place. Secondly, the definition of a successful onboarding plan is made by going deeper into its restrictions. There restrictions are the time restriction issue of a two-month transfer window, not having clear which materials are needed for production in these two months to keep it cost-efficient and some resource restriction issues like the availability of trucks, the truck capacity, and the loading/unloading capacity. Thirdly, an overview of the planning and logistics department of Mead Johnson is made including external employees that are relevant in the process. Also, the agreements between Mead Johnson and Nabuurs from the Service Level Agreement are clarified. What particularly strikes here is the fact that there is little specific information about delivery delays and possible sanctions. Nevertheless, the preference was on first focussing on making the whole process run better rather than immediately imposing sanctions. Also, a Swimlane Value Stream Map is made of the whole delivery process in which it is indicated where the problems occur. The five main problems are no steady flow in the delivery of loads, the communication about deviations between Nabuurs & Mead Johnson, not having an escalation model, the updating of the statuses of the Transfer Orders and its problems, and the reporting and analysing of the delays. Last, the consequences of the delivery delays are explained. The worst-case scenario is that the production lines must be stopped due to a lack of material. In this case, Overall Equipment Effectiveness loss occurs. The percentage of this OEE loss due to a lack of materials before implementing the solutions was 5,8% and the goal was to reduce this to 3%.

The second step is to review the literature about this problem. First, the Lean Principle and its link with the Toyota Production System and the renewed Toyota Way 2001 Model is investigated. The main goal, based on the lean principle, is to eliminate waste, which is the non-value-added activity from the viewpoint of the customer. According to Slack, in modern supply chain management these wastes are not only in the flow of products and materials, but also very much concerned on managing the information flows. This supports to the idea that the information flows must get optimally streamlined to reduce these wastes. All problems are based on the principles of the Toyota Production System, which is actually a culture where every employee is allowed to report problems to continuously improve the processes. After this, the 'Seven Deadly Wastes of Logistics' based on the seven primary sources of waste from the Toyota Production System were reviewed and compared to the situation at Mead Johnson. The wastes that were most relevant to the situation of Mead Johnson were Inventory, Space and Errors. Inventory in case of unnecessary inventory in the pre-staging area when deviations to deliveries occur. Space when the truck capacity cannot be used optimally due to bulging powder pallets. And last Errors as all deviations to deliveries causes rework, unnecessary adjustments and/or returns. Currently, this rework is not done in the most time-efficient way. This will be solved by the renewed Escalation Model.

Based on the problem analysis and the findings in the literature, the five solutions has been generated. First, the most cost-efficient onboarding plan which is made by using Pivot Tables and the right Excel functions. In this way it is found which materials must be moved and which not. Second, a legend for the statuses of the Transfer Orders in which the deviations are categorized into the following four categories: green for On Time In Full, yellow for Incomplete/Incorrect/Damage, red for After Requirement Date and white for not delivered but before Requirement Date. Thirdly, a renewed day schedule, using timeslots to create more steady flow in the deliveries by anticipating on the number of Transfer Orders per day and divide them evenly on a day. Fourthly a dashboard of the delivery delays by making lists and tables of the delays per category and making graphs out of this. Next to the categories of delivery delays, also the causes has been analyzed. This is done by composing eight different reason codes to keep it uncluttered. Last, the escalation model to solve possible deviations as time efficient as possible. Shorty, in this Escalation Model, a streamline of tasks is made that needs to be executed by different teams within 4 hours.

After this, in the implementation phase, it becomes clear that all targets of the KPIs have been met. KPI 1, the total extra costs of transferring materials to Nabuurs before going to the factory is positively influenced by the consequences of the onboarding plan which led to an outcome €34644, with which the target of lower than €36000 has been more than achieved. KPI 2, the percentage of deliveries from the distribution center to the factory that are On Time In Full has gone to 98,74% within a half year which is an increase of 2,12% and so the target of 98% is achieved. The most occurring reason code 'No time left (end of the day)' has enormously decreased from 9 to 0 between the first and last month, which is mainly due to the renewed Day Schedule. Also, the target of the last KPI, the percentage of OEE loss due to a lack of materials, has been achieved by a decrease from 5,8% to 3%. After all the solutions are successfully reviewed with some small remarks. This is done with the help of a review form filled in by the employees that have the most to do with the solutions.

Table of Contents

List of Figures and Equations

This gives an overview of all Figures and Equations in this research.

Figures

Equations

List of abbreviations

These are all abbreviations used in this research in alphabetical order.

Abbreviation	Meaning
CI	Continuous Improvement
CMR	Convention on the Contract for the International Carriage of Goods by Road
DB	Dry Blending
DC	Distribution Center
EDI	Electronic Data Interchange
EOQ	Economic Order Quantity
EU	European Union
HU	Handling Unit
KPI	Key Performance Indicator
LP	Liquid Processing
MJN	Mead Johnson
MRP	Material Requirement Planning
MPSM	Managerial Problem-Solving Method
OEE	Overall Equipment Effectiveness
OP	Outbound Processing
OTIF	On Time In Full
PSA	Pre Staging Area
SAP	System Analysis Program Development
SLA	Service Level Agreement
SLED	Shelf Life Expiration Date
SU	Storage Unit
TO	Transfer Order
TPS	Toyota Production System
WM	Warehouse Management
WMS	Warehouse Management System

1. Introduction

This chapter introduces the research based on three sections. The first section gives a summary of the company and the place of research within the organization. Secondly, Section 1.2 identifies the problem by describing the action problem, determine the norm and reality and defining the core problem statement by making a problem cluster. The last section gives the problem-solving approach. Here, the knowledge problem and research questions are stated, the research methodology is explained, the scope and limitations are set and last all deliverables are listed.

1.1. Organization

1.1.1 About Reckitt

Reckitt is an international company committed to creating a cleaner and healthier world through the production of hygiene, health, and nutrition products. Reckitt is a growing community with 47,642 employees worldwide on February 24, 2021. Reckitt was founded in 1819 by Thomas and Isaac Reckitt. Reckitt is now a multinational company with headquarters located in Slough in the United Kingdom. Reckitt's CEO is Laxman Narasimhan. Reckitt is the umbrella company of many major brands such as Dettol, Finish, Durex, Nurofen etc. Reckitt has strategic ambitions to protect, heal and nurture in the relentless pursuit of a cleaner, healthier world. This means working responsibly and sustainably while innovating products that improve lives and impact reduce the environment. The Reckitt brands work at the frontline to ensure that the latest health and hygiene information is as widely available as possible and that products can be found online and in-store 24/7, from the largest city to the smallest village.

1.1.2 About Mead Johnson

Reckitt is divided into three global business units (BU), these are: hygiene, health, and nutrition. The nutrition BU includes the company Mead Johnson B.V, located in Nijmegen. This is a company that produces 60 million Kilograms of Infant Formula and Child Nutrition per year feeding up to 1 million babies worldwide. The nutrition brand Enfamil, which is produced in Nijmegen supplies Europe and Asia, including the key Chinese market. Mead Johnson B.V. employs approximately 800 people.

1.1.3 Place of research within the organization

Within Mead Johnson B.V. there are several departments that together strive to nourish babies worldwide in a healthy way. This research will be conducted within the Planning & Logistics department.

1.2 Problem identification

1.2.1 Description of the action problem

The old situation at Mead Johnson was that they had over 25000 pallets of materials and products at 4 suppliers and 8 locations. This gave Mead Johnson the main problem of high logistical complexity which has a lot of disadvantages. One of the most impactful disadvantages was that Mead Johnson had too much downtime in the factory due to delivery delays from the multiple storage locations. In the last year, Mead Johnson has already decreased the number of distribution centers to two.

In the new situation, Mead Johnson will use only one dedicated distribution center at Nabuurs in Cuijck. Here, 'dedicated' means that Mead Johnson will be the only user of the distribution center and Nabuurs will overtake many logistics tasks of Mead Johnson. This will optimize their transport flows, reducing the CO2 footprint and transport costs. Also, Mead Johnson will be more able to standardize processes, which reduces unnecessary waste of time, energy and costs. Therefore, all materials need to be transferred in the most cost-effective manner to this new distribution center, so without making unnecessary transport costs. This 'onboarding' of materials needs to be done while the factory is running in a 24/7 operation and as little as possible downtime or interruption of operations is allowed during or after the move. Onboarding is a term used at the company to describe the movement of the materials from the two distribution centers to Nabuurs. The first step to do this in the most cost-efficient is way by making clear which materials can be transferred when and which not. After onboarding the materials, the process of delivering the materials from Nabuurs to the factory must be mapped out to look where most problems occur. In this way, solutions can be generated in the further phase. In this way, the deliveries from the new distribution center should be on-time more often than in the old situation at the two distribution centers to prevent unnecessary downtime in the factory.

In summary, the action problem at Mead Johnson is that the down time in the factory due to delivery delays is too high. This action problem leads to the core problem statement in Section 1.2.4 by linking all subproblems in the problem cluster in Section 1.2.3.

1.2.2 Norm and reality

According to the book *Solving managerial problems systematically* (Heerkens & van Winden, 2017), an action problem is "anything or any situation that is not how you want it to be". When this is the case, there is a difference between reality and the norm.

The reality at Mead Johnson is that there are over 25000 pallets at 2 different locations, including the huge problem of too many delivery delays from these distribution centers to the factory causing downtime. In order to consolidate to the new dedicated distribution center at Nabuurs in Cuijck, Mead Johnson needs the definition and execution of a successful onboarding plan. This means that there should be a clear and successful plan for transferring the materials from the old distribution centers to Nabuurs. The reality at this moment is that

there is no onboarding plan at all. Also, there is no overview of the causes of the delivery delays and so on no plan how to decrease them once all materials are onboarded to Nabuurs.

According to the problem owner, the norm should be that in about a half year time Mead Johnson Nijmegen is fully onboarded in a successful way to the new distribution center and after implementing solutions, this should lead to a decrease in delivery delays to the factory. In this way, the downtime of the production lines in the factory due to this cause should decrease.

1.2.3 Problem cluster

To have a clear overview of all problems and their connection to the action- and core problem, a problem cluster is made which can be seen in Figure 1. On the left side of the cluster, the action problem is summarized. The action problem is the problem that the client, in this case Mead Johnson, gives. This action problem is then divided into the difficulty of not making unnecessary costs by transferring the materials to the new distribution center and not having an overview of the causes of the delivery delays from the distribution centers to the factory. After this, there are four main reasons why this is a problem. It can be concluded that there is not a cost-efficient onboarding plan which has to be executed afterwards. Also, it is possible like in the old situation at Frigolanda and Cornelissen that the production lines in the factory must stop due to too delivery delays. This will possibly lead to Overall Equipment Effectiveness loss. All these mentioned problems have not been further specified as this requires better investigation in the upcoming phases of the research. All problems together then lead to the core problem statement.

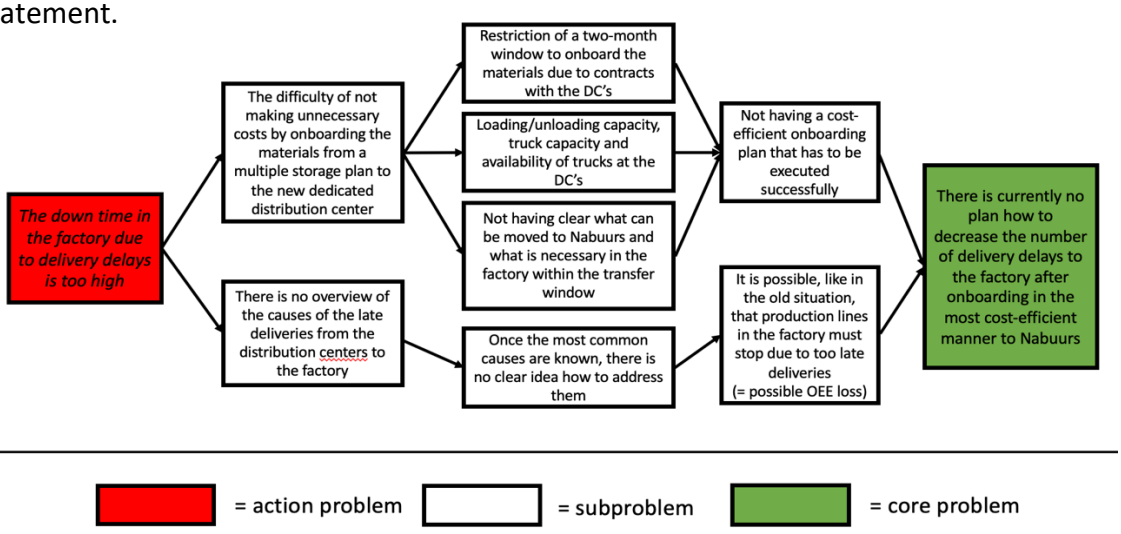


Figure 1: Problem cluster of the action problem

1.2.4 Core problem statement

As can be seen in the problem cluster, the following problem statement has been made to define the core problem:

There is currently no plan how to decrease the number of delivery delays to the factory after onboarding in the most cost-efficient manner to Nabuurs.

1.3 Problem solving approach

1.3.1 Knowledge problem & research questions

During the research, the action problem will be tackled by means of several research questions. The knowledge problem, which is reflected by the main question is:

How can the delivery delays to the factory be decreased after onboarding all materials cost-efficiently to the new dedicated distribution center at Nabuurs?

To answer this knowledge problem, five research questions have been made including some sub-questions. These are the following:

Research Question 1 – **What is the current situation at Mead Johnson before consolidating from multiple distribution centers to one dedicated distribution center at Nabuurs?**

- What does Mead Johnson's supply chain currently look like and how can the supply chain become leaner?
- What should be considered when making a successful onboarding plan?
- How are the delivery delays currently addressed and what are the main causes of late deliveries?

Research Question 2 – **What is the best way to make the performance of the operations measurable?**

- Which key performance indicators (KPIs) are most suitable to measure the performance of the transferring operations?
- What are the targets for these KPIs?

Research Question 3 – **What can be found in the literature about decreasing delivery delays which can be implemented in the solution approach?**

- In which ways will the lean principle and its implementation at other companies support the solution approach?
- Which main logistics wastes, which are supported by literature, occur at Mead Johnson?

Research Question 4 – **What is the best solution approach for Mead Johnson to minimize the downtime in the factory due to delivery delays?**

- How can all materials successfully be onboarded at Nabuurs without making unnecessary transfer costs?
- How can the number of hours in the week that the production lines in the factory are stopped due to delivering too late from the distribution center be decreased?

Research Question 5 – **Has the desired norm, the decrease of delivery delays to the factory by moving successfully to the new distribution center, been met?**

- Are the targets of the Key Performance Indicators met?
- How does Mead Johnson reflect on the solution approach?

1.3.2 Scope and limitations

Before conducting the research, it is important to have the scope clear including possible limitations.

My task for making a successful onboarding plan is to determine which materials should be transferred and which not. However, I do not have to arrange the trucks including the loading and unloading times at the distribution centers. This work is fully in hands of the three 3PL's: Frigolanda, Cornelissen and Nabuurs. I can give a rough advice of which materials should be transferred when, but I am not responsible for the time planning of the transfers.

Then the scope for the delivery delays. The Overall Equipment Effectiveness is one of the most important KPIs in the factory at Mead Johnson. However, my own KPI is only a small part of this KPI. I will only be responsible for the percentage of the OEE that is caused by the too late deliveries from the Nabuurs distribution center. Within the factory there are a great number of possible causes of production lines that must be stopped, but this is not in the scope of this research.

Now the scope is clear, the most important research limitations should be summed up. These are the following:

- The research is conducted at one company. This company has his own unique situation which is not fully comparable with the situation at other companies. In order to get a full understanding of the problems, more research should be conducted at other companies as well.
- Another limitation of this research is the time available. This will be about three months, which is not much to solve the logistics problems. It could be so that the problems would be solved even better if more time was available. This would improve the research.
- The third limitation is the difficulty of the data analyses. In all three analyses there are many variables that has to be investigated. To make the right link between all these variables clear is difficult since it could be a combination of variables which causes something.
- The fourth limitation is the qualitative data gathering methods. Although a systematic literature research is done in this project plan in order to find the right sources, it is impossible to scan all literature on a subject and so you will not be completely sure whether the used sources were the best sources. The same holds for the interviews. The answers of the interviewee depend on many factors and you will never know whether the given answer is the right sincere answer.

1.3.3 Deliverables

The first deliverable will a Microsoft Visio file whereby the whole process of addressing the inbound deliveries from the distribution centers to Mead Johnson will be explained with the use of a value stream mapping. The type of value stream mapping that will be used is called a swimlane diagram.

The second deliverable will be a Microsoft Excel file including all information about the onboarding plan. This file includes the stock list and demand lists from SAP including pivots of them and a dashboard, which makes it clear what can be moved. This leads to a total list what is moved from the distribution centers to Nabuurs including important information. In the end, a calculation can be made of the saved transport costs as a result of the transfer plan. Hereby, a comparison will be made with the beforehand cost expectations and the actual outcome.

The third deliverable will be an analysis of the delivery delays to the factory from the distribution centers. This includes a model where the too late deliveries can be categorized into more general causes. In this way, there can be seen what the new trends of causes at Nabuurs are, that need to be addressed. After this analyse is made, the most effective way to attack the most common causes will be investigated. In the end, there will be a comparison between the first and last month, where there will be results as a proof of less delivery delays.

The fourth deliverable will be a PowerPoint file where an escalation model will be sketched for when there occurs a delay in the delivering of materials. Once this is the case, the problem has to be solved as soon as possible and this model will help to understand how best to do this.

The whole project will be written out in a report in Word, mainly to describe all steps of the research described in Sections 1.3.1 ‘Knowledge problem & research questions’ and 1.3.2. ‘Research methodology’. Also, all recommendations that came out of the analyses in Microsoft Excel will be described in the report.

2. Problem Analysis

In this chapter, the problem is analysed with the help of four sections. In Section 2.1, the problem is seen from the bigger picture by zooming out by making an analysis of their current supply chain. In Section 2.2, the definition of a successful onboarding plan will be made. The three main problems from the problem cluster in Figure 1 are explained more in detail and an estimation of the total extra costs that the onboarding will bring will be made.

In Section 2.3, there is an analysis about the delivery delays which is divided into four sub sections. Section 2.3.1 gives an overview of the planning & logistics department of Mead Johnson and external people who are responsible in the process. In Section 2.3.2, the Service Level Agreement between Mead Johnson and Nabuurs is investigated. Section 2.3.3 gives a Value Stream Map of the delivery process from Nabuurs to Mead Johnson so it becomes clear were the main problems are and in Section 2.3.4 the consequences of the delivery delays are listed. Last, in Section 2.4, the three Key Performance Indicators are explained to make the performance of the operations measurable.

In this chapter, answers are given on Research Questions 1 and 2. The three sub-questions of Research Question 1 are answered in Sections 2.1, 2.2 and 2.3 in respective order. Last, in Section 2.4, Research Question 2 is answered.

2.1 Current and desired Supply Chain

To improve the logistics performance at Mead Johnson, the most important problems within the scope of the research must be defined. This will first be done by taking a look at the bigger picture and making an analysis of their supply chain, so the entire process from raw materials to finished goods at the end consumers. Since there was no clear overview of the entire current supply chain, Mead Johnson instructed to start with this. Once the bigger picture is better in view, it is easier to understand what it is all about. After many conversations with employees, both internally and externally, and observations of the transport flows and the production process the following supply chain is drawn in this Figure 3.

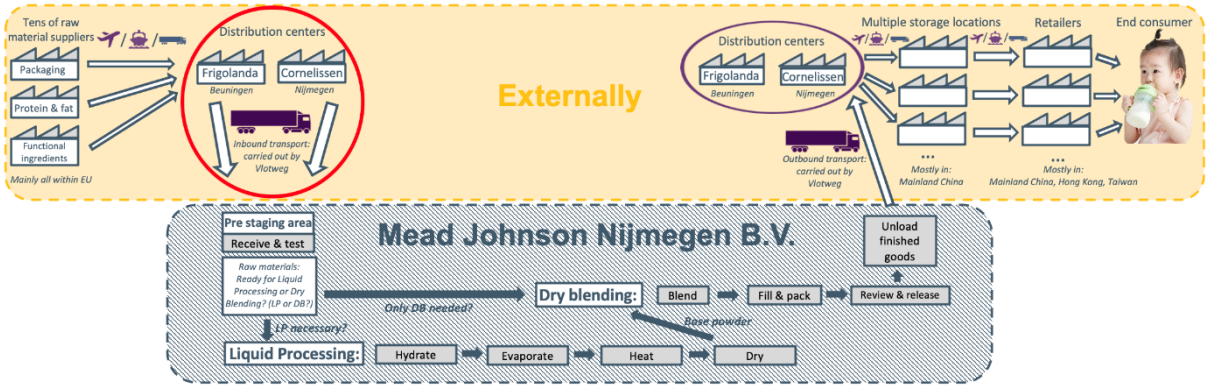


Figure 3: The current supply chain of Mead Johnson

The supply chain of Mead Johnson is divided into two different parts: above the flow between all external partners of Mead Johnson and underneath the process internally of producing the

products. The whole supply chain starts with tens of raw material suppliers, which are mainly all located in Europe. There are three different kinds of suppliers: packaging-, protein & fat- and functional ingredients suppliers. These raw materials are then all transported to the distribution centers of Frigolanda and Cornelissen, located in Nijmegen and Beuningen. This is done because in this way all materials are located very closely (within 15 minutes) to the factory of Mead Johnson. From here on, the materials that are necessary for production are transported to the factory, called inbound transport, which is carried out by the transport company Vlotweg. Most of the problems regarding the delays in deliveries towards the factory occur here as the targets for the inbound transport are not met. More explanation about this will be given in Section 2.3.4. Shortly. the flows of both materials and information are not lean in this part of the supply chain. Deeper explanation about what this actually means is given in Chapter 3.

Once the materials arrive at Mead Johnson, they are stored in the small warehouse attached to the factory. This warehouse cannot be used for the storage of all materials so that the previous step of distribution centers can be skipped, as there is way too much space for this. This warehouse is called the pre-staging area, where all materials are received, stored, and tested immediately before it will be used in production. The testing of materials also frequently takes place externally, as many requirements must be met, both from Europe and from China. In the pre-staging area, a distinction is made between materials that require liquid processing or those that can be added later in the process and only need the dry blending. Furthermore, we are not going to pay too much attention to the production process since this is out of the scope of this research.

Once the products are all filled, packed, reviewed and released, they are labelled as 'finished goods'. This means that the products are ready for outbound transport, again carried out by Vlotweg, back towards the distribution centers of Frigolanda and Cornelissen. From here on, the products are all transported to different storage locations, mostly in Mainland China, since most customers of the nutrition products of Mead Johnson are located here. The products then go to thousands of retailers all over China, Hong Kong and Taiwan, where the products will be bought by the end consumers.

The desired goal of Mead Johnson as mentioned in Section 1.2.2 is to decrease the number of late deliveries to the factory which will lead to less downtime in the factory. The Senior Planning & Logistics Manager said that there are "almost 10 years plans for moving to a dedicated distribution center, especially after seeing multiple comparable companies growing due to moving to a dedicated DC." The Senior Planning & Logistics Manager agrees with the idea of making the flows of both materials and information in the supply chain leaner by moving to Nabuurs, which will be supported by the literature in Chapter 3. Mead Johnson is solely responsible and only influences their own part of the supply chain from the DCs to the factory and back. Therefore, the focus of this research will be on this part of the supply chain.

In Figure 3, a red circle is drawn at the part where most problems occur regarding the delivery delays. Figure 9 thereafter shows how the desired supply chain looks like without this red circled part by moving to Nabuurs. The possibility of expanding the small warehouse next to the factory was also investigated, but it turned out that there was far too little space for this. After this, Nabuurs is ultimately chosen as the best possible external DC. The fact that this DC

will become ‘dedicated’ only for Mead Johnson is an additional reason that the flows will become more structured, since Mead Johnson could “expect a higher overall logistics performance by Nabuurs in comparison with the old situation” according to The Senior Planning & Logistics Manager. In the following figure, the desired future supply chain of Mead Johnson, based on the indications of the Senior Manager of the department, with only the dedicated distribution center of Nabuurs is drawn.

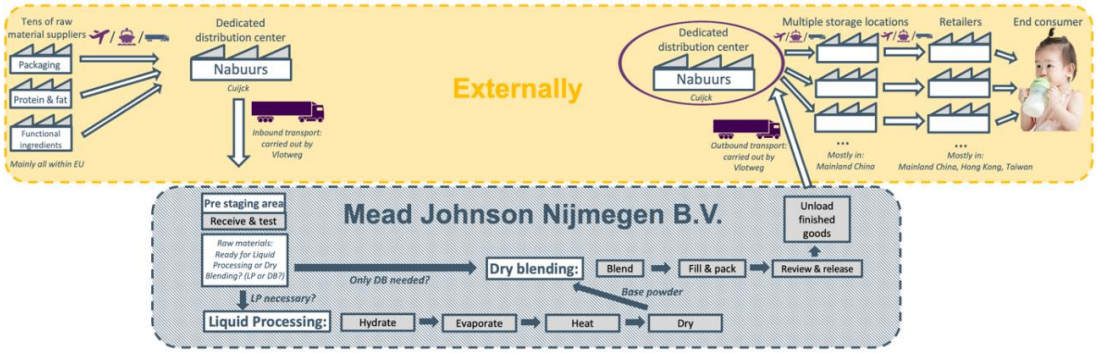


Figure 4: The desired future supply chain of Mead Johnson

2.2 Restrictions onboarding plan

In this section the definition of a successful onboarding plan is made by making an overview of what needs to be considered in the process of onboarding the materials to the new dedicated DC of Nabuurs. Out of the problem cluster in Figure 1 from Section 1.2.3, the three main problems are already shortly mentioned. These problems are explained more in detail in the following paragraphs.

The first problem is a time restriction issue. The contracts with the three different distribution centers states when Mead Johnson may use the services and spaces of the DCs. The new distribution center at Nabuurs is ready for use from the 1st of June, whereby the contracts with Cornelissen and Frigolanda both end on the 1st of August. This means that for the onboarding of all materials from Frigolanda and Cornelissen to Nabuurs, there is the restriction of a two-month transfer window. It has been agreed with both DCs that there are possibilities to move in August if calamities occur. Nevertheless, this two-month transfer window will be used as a goal and starting point for making estimates in the following paragraph.

The second problem is not having clear which materials must be onboarded to Nabuurs and which not. The most important factor here is to know which materials will be necessary for the factory for production within the transfer window. It would be useless to first transport materials to Nabuurs, where it eventually turns out that it is needed for production in the transfer window. The onboarding of materials must be done in the most cost-efficient manner, so without making unnecessary transport costs. This means that all materials must be onboarded to Nabuurs, except the materials that are needed in the two-month onboarding window. These materials are the stocks, the available materials, minus the demand, the materials needed in the factory. To have this clear, an overview must be made of the actual stocks and demands which are located at the two DCs Frigolanda and Cornelissen. These data

can be obtained out of the enterprise resource planning program SAP. This data will then be converted from SAP to Microsoft Excel.

The third problem is that there are some other resource restrictions. There are no unlimited trucks available, the trucks have a limited capacity and there is no unlimited time for the loading and unloading of the trucks. Firstly, the number of trucks available. These trucks are from the transport company Vlotweg, which also operate the usual transport from the distribution centers to the factory of Mead Johnson. For them, this onboarding of materials to Nabuurs comes as extra work on top. Therefore, an indication of the number of trucks in total be made. Secondly, the truck capacity, the number of pallets that can be transported by one truck. This number is 26 pallets per truck. One important sidenote to make here is that there are a lot of bulging powder bags, which are wider than the pallets they stand on. In this way there are less pallets that can be moved per truck. Therefore, an estimation is made based on previous experiences from the usual transport to the factory that on average 24 pallets will be moved per truck. Last, the loading and unloading capacity must be discussed with the shipper receivers of the three distribution centers. For them, just like for the transport company Vlotweg, the onboarding comes as extra work next to the daily loading- and unloading tasks they already have.

To make an estimation of the total extra costs due to the onboarding, the following Equation 1 is made. This equation is further explained in the next paragraph, as are the estimates made.

$$Total\ extra\ costs\ of\ onboarding\ materials\ to\ Nabuurs = \frac{(X - Y)}{Z} * C$$

Where:
Total costs of onboarding materials to Nabuurs in euros
X = Total stocks at Cornelissen & Frigolanda in number of pallets
Y = Total demand in factory in June & July in number of pallets
Z = Average truck capacity in number of pallets per truck
C = Transport costs per truck in euros

Equation 1: Total extra costs of onboarding materials to Nabuurs

In the week before onboarding, a last check of the stocks at the distribution centers had been made, just as the demand list for the upcoming two months. These stock lists minus the demand lists gave an indication of the number of pallets that must be onboarded. The estimates that came from this were around 5000 pallets for Frigolanda and around 2500 pallets for Cornelissen, which gives a total of around 7500 pallets. This number must be divided by the average truck capacity, which is 24 pallets. The costs that Vlotweg invoices to Mead Johnson per trip from Frigolanda or Cornelissen to Nabuurs is €114,75. This gives a first estimate of the total extra costs of onboarding of €35860. These costs will also be used as a goal for the first KPI in Section 2.4.

Another estimation that will be made is the average number of trucks per day that will be needed. This is the number of trucks needed divided by the number of days available for the onboarding of materials. There will be no rides in the weekends so only the weekdays in June and July must be added up, which gives a total of 44 available days. (5000/24)/44 and (2500/24)/44 gives an average of 4,7 trucks from Frigolanda and an average of 2,4 trucks from Cornelissen.

$$Estimate\ of\ Equation\ 1 = \frac{7500}{24} * 114{,}75 \approx €35860$$

Where:
Estimate of Equation 1 in euros
(X-Y) = 7500 = Total stocks at Cornelissen & Frigolanda – total demand in factory in June & July in number of pallets
Z = 24 = Average truck capacity in number of pallets per truck
C = 114,75 = Transport costs per truck in euros

Equation 2: Estimate of total extra costs of onboarding materials to Nabuurs

Shortly, after this analysis of the three main problems that the onboarding brings, the plan is to move as cost-efficient as possible which is measured by the first KPI from Section 2.4 including the goal determined above. This is done based on the stock and demand lists from the SAP program, which are converted to Microsoft Excel. Whereby the explanation of executing this is made in the later stages of the research in Chapter 4.

2.3 Delivery delays

2.3.1 Planning & Logistics department

Once all materials are successfully onboarded to the new DC at Nabuurs, the way of addressing deliveries from Nabuurs to the factory must become clear and the main causes of the delivery delays must be investigated.

Firstly, in Figure 5 an overview is made of the planning and logistics department to have clear who is responsible for arranging that the deliveries are delivered on time. In purple there are the employees of Mead Johnson in this department. In yellow, all external employees, of Nabuurs and Vlotweg, who will be of importance in this process are mentioned. The green arrows indicate the main flow of data interchange and communication within this process.

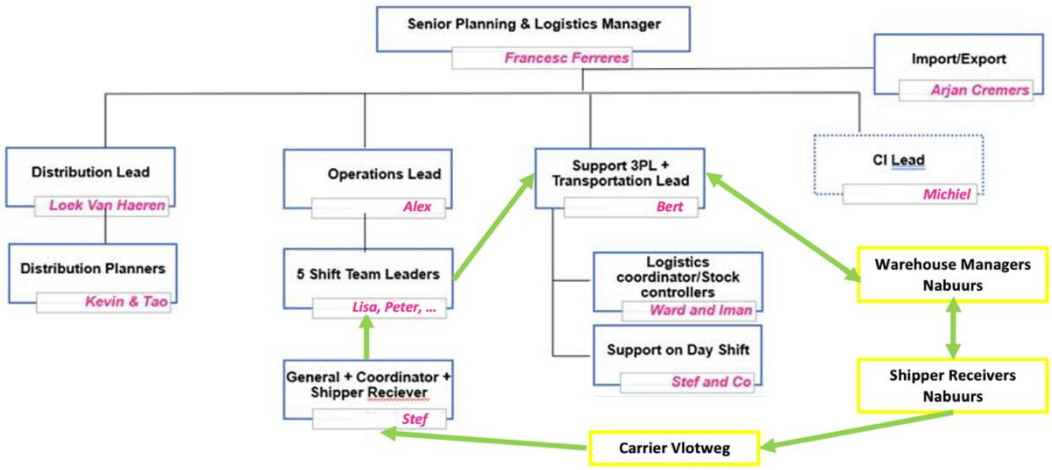


Figure 5: Overview of the planning and logistics department of Mead Johnson including external employees that are relevant in the process

On top of the figure, there is the Senior Manager of the department who will especially keep a helicopter view over all processes going on in the department. On the left side, there are the Distribution Lead and Distribution Planners, who are mainly responsible for the distribution from the distribution centers to the multiple storage locaters and retailers in China, Hong Kong and Taiwan, as can be seen in Figure 3. The Operations Lead is responsible for all the work internally in the factory, so actually the purple area from Figure 3. Within the scope of this research, it is of importance that the five shift team leaders, who are responsible for the shipper receivers, stay in contact with the Support 3PL about the status of the inbound and outbound materials. Once there is a lack of materials, the Warehouse Managers at Nabuurs will be contacted by him what went wrong and in which way the problem can be solved. Most of the times, this must be checked together with their Shipper Receivers who load the trucks of Vlotweg. The Support 3PL gets help from the Logistics coordinators/Stock controllers who determine which materials must be inbounded from Nabuurs and control the stocks internally. Right next to Support 3PL you have the CI Lead who support all employees with continuously improving the processes in the department. Often, employees carry out their work every day in the same way causing that they have little time left to see how this can be done better. In addition, they also do not know how to approach the improvement of the processes in the right way and the CI Lead helps to tackle this together step by step. This step-by-step approach is comparable to how it is addressed in this research. Last, you have on the upper right the Import/Export Lead who is mainly responsible for ordering the right number of raw materials at the suppliers which is determined by the demand.

2.3.2 Service Level Agreement

Next to the overview of the responsible people in the process in the previous section, it is important to clarify the agreements between Mead Johnson and Nabuurs. All agreements are laid down in the Service Level Agreement (SLA) of almost 100 pages. Nevertheless, not all these pages are of importance in this research. Therefore, only the topics that align with this research has been filtered. After analyzing the contract, discussions were held together with Senior Planning & Logistics Manager and the Warehouse Managers of Nabuurs about things that were still not completely clear. This also showed that several points that seemed important in advance did not apply at all to the situation in this research. Unfortunately, not all details can be shared as the SLA must be kept secret between the two companies. Despite this, the following points that are of importance has been reviewed:

- Section 15 of the SLA ‘Force Majeure’ is a list of extreme situations when Nabuurs is no longer liable for any damage or late deliveries. From this it became clear that Force Majeure can only be invoked in very extreme cases beyond the control of people (e.g., extreme weather conditions). It is extremely important that this regulation does not apply to human errors.
- Section 23 of the SLA ‘Electronic Data Interchange (EDI)’ there is an explanation about the method to interchange the data between Mead Johnson and Nabuurs. Since the two companies use different warehouse management systems, EDI is needed to interchange the data between these two systems. The role of EDI in the process is explained in the Value Stream Map in Section 2.3.3.

- In Section 33 of the SLA 'The Charges' it became clear that Vlotweg will still keep in charge of the transport between Nabuurs and Mead Johnson. Nabuurs has also offered the option to take over the transport. In conversation with the Senior Planning & Logistics Manager, it became clear that this option was not taken because Nabuurs asked much more money for the transport than Vlotweg. The reason for this was because Nabuurs had to make investments in about 20 trucks since they could not efficiently transport the pallets that Mead Johnson used with their current trucks. Since Mead Johnson was quite satisfied with the work that Vlotweg has carried out in recent years, it has been decided to still make use of the services of Vlotweg. Furthermore, in this section, the storage-, handling-, and processing costs that Nabuurs charges are set out. However, these are not relevant in this research. For the transport costs, Vlotweg must be approached.
- Section 39 of the SLA 'Monthly Reporting' sets out several KPIs that must be tracked monthly to measure performance. The only one that is important in this research is the KPI 'percentage of deliveries from Nabuurs to Mead Johnson that are on time in full'. This KPI returns later in the study as the second KPI in Section 2.4.

What was particularly striking after analysing the contract is that there is little specific information about delivery delays and possible sanctions. Section 39 does state that several KPIs are tracked monthly, including a KPI specifically about delivery delays. However, after asking Nabuurs for this data, it became clear that these KPIs are not kept up very well. For example, the reasons for delivery delays are not kept up to date and the data are often incorrect when you dig a little deeper. However, there are no sanctions for not properly maintaining the KPIs and/or structurally underperforming on the basis of these KPIs. When this observation was made to Senior Planning & Logistics Manager, it was proved right. Nevertheless, the feedback on this was that the focus should first go to making the whole process run better rather than immediately imposing sanctions. This feedback had two main reasons. The first reason was that the contract is fixed and therefore adjusting things is difficult to carry out. In addition, the moment you start demanding sanctions for failure to achieve KPIs by Nabuurs, Nabuurs will probably also demand stricter agreements that could end in the disadvantage of Mead Johnson. However, it became clear that tracking the KPIs regarding delivery delays, including its causes, in the form of a dashboard is seen as an important first step in the solutions. Especially since this will start to increase awareness of the problem among everyone and better analyses can be made of the causes.

2.3.3 Value Stream Mapping

In this section, a Value Stream Map is made of the whole delivery process. A value stream map is a "process flow chart that shows each step in the production of a good or material and is a very significant component of any Lean initiative, providing a framework that highlights waste and the negative effect it has on overall process performance and flow" (King, 2015). In short, value stream mapping is an excellent way to get an overview of a large process to subsequently analyze and eliminate the waste according to the lean principle as explained later in Section 3. The total understanding of the process that is drawn out in the value stream map has come by holding many conversations with employees and watching daily how things are going.

In this value stream mapping different types of flowchart shapes have been used to keep it as clear as possible. Before going through the value stream mapping, it is useful to first explain the types of flowchart shapes that has been used as can be seen in Figure 6.

Figure 6: Overview of all different types of flowchart shapes that has been used in the value stream mapping

In the value stream map, there are multiple swimlanes to keep the total picture uncluttered. The swimlanes show who is responsible for the tasks in that block. I have clustered the employees that are of importance from Figure 6 and on the left side of every swimlane, the responsible job functions or groups are mentioned. The type of value stream mapping that is used here is therefore called a swimlane diagram. On the top left and right, the start and end symbol are used, which shows the starting and ending point of the whole process. The box 'process/task' can represent a single step or a sub-process within the large process. These tasks must be executed by the employees from the swimlane. When this box is red, improvements must be taken place later in the solution generating and implementation phases, so in Chapters 4 and 5. More explanation about these red boxes will be given below when the value stream mapping is explained. At the diamond symbol, a decision must be made whether it is a yes or no is. The outcome of these decisions brings you to different tasks in the process. The last symbol shows the type of data that is shared to other employees. Now it is time to go through the value stream mapping, the different types of data will also be explained.

In Figure 7, Swimlane Value Stream Mapping of the delivery process from Nabuurs to Mead Johnson is drawn. Firstly, we start with explaining the different swimlanes. Every swimlane represents a team of multiple employees to keep the Value Stream Mapping as uncluttered as possible. Within these teams, it is clear who is responsible for which task. Just like earlier in the drawn supply chain (Figure 3) and overview of the organization (Figure 5), a clear distinction is made between which processes/tasks go on internally, at Mead Johnson, and which externally, so at Nabuurs and Vlotweg. The two blue swimlanes above are for Mead Johnson. The first one, called Material Requirement Planning, will be executed by 'Support 3PL+Transportation Lead', the 'Logistics coordinator/Stock controllers' and the 'Support on Day Shift' as can be found Figure 5. The second one, called 'Inbound Processing', will be executed by the 'Shipper Receivers' and the five 'Shift Team Leaders', also in Figure 5. The swimlane in the middle is executed by the carriers from Vlotweg. And last, the two swimlanes underneath are for Nabuurs including a distinction between Warehouse Management and Outbound Processing. Warehouse Management is done by the 'Warehouse Managers Nabuurs' and Outbound Processing by the 'Shipper Receivers Nabuurs', both in Figure 5. The Value Stream Map is explained per box in the underneath paragraphs. These four boxes are outlined black and has a number bottom right. These boxes are made in order to keep the explanation of the Value Stream Map more uncluttered.

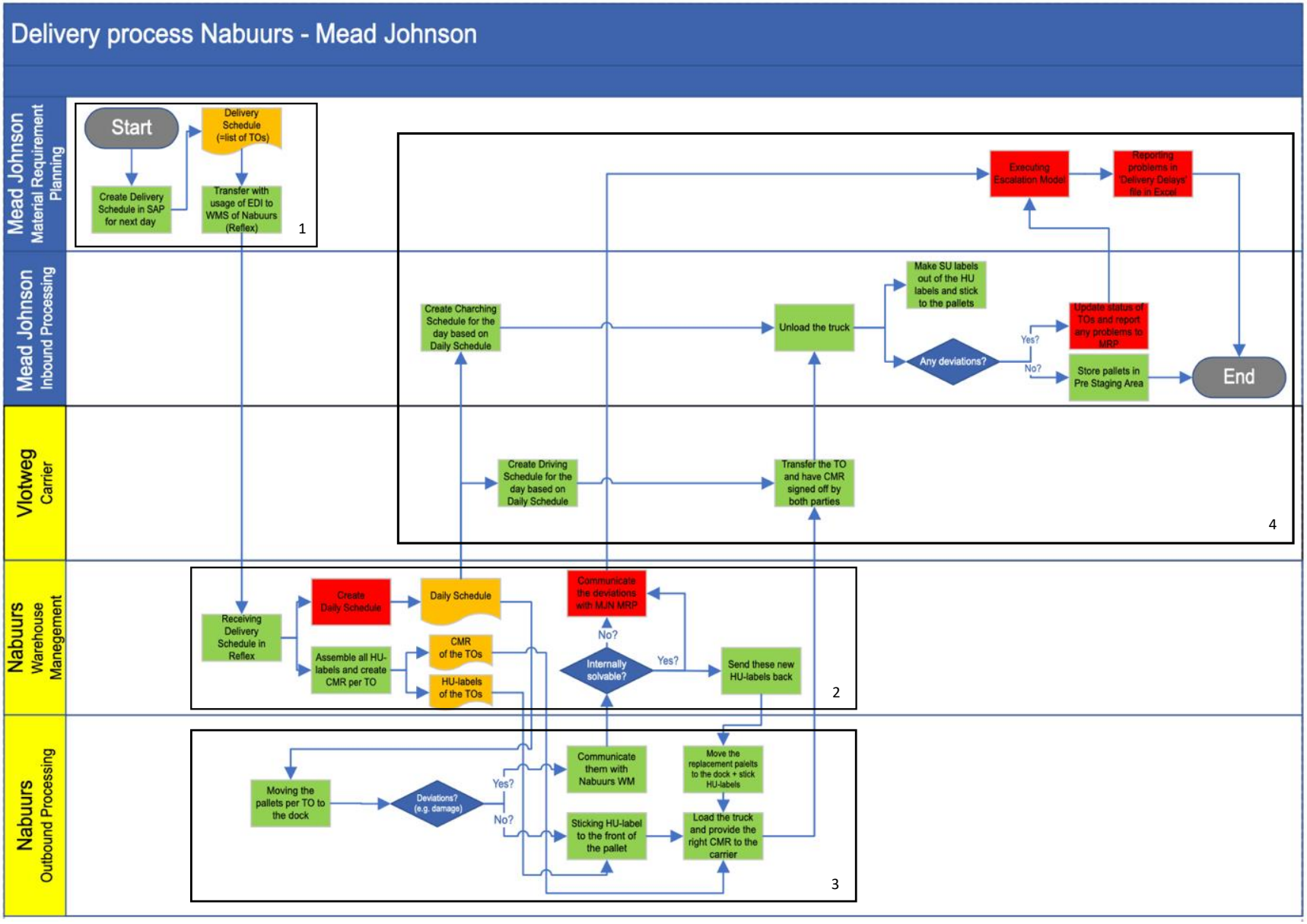


Figure 7: Swimlane Value Stream Mapping of the delivery process from Nabuurs to Mead Johns

Box 1

Let us start on the top left corner, where the Material Requirement Planning team starts with creating a Delivery Schedule in which all TOs that must be moved the next day are listed. This is done in the enterprise resource planning software program SAP where the demand determines the materials that must be transferred towards the factory for production. At first sight, the thought was that the Economic Order Quantity, "the company's optimal order quantity for minimizing its total costs related to ordering, receiving, and holding inventory" (Fernando, 2022), was not optimally determined. Nevertheless, this idea was not right according to Senior Planning & Logistics Manager: "The EOQ is maybe the most important theory used in optimizing our procurement efficiency and this is perfectly calculated daily in the program SAP. The problem down time in the factory due to delivery delays is not because the wrong materials are asked from Nabuurs, but because of issues later in the process."

Box 2

Therefore, in order to find these issues, we analyse the Value Stream Map more in detail. The Delivery Schedules must be sent to the Nabuurs Warehouse Managers. Since Nabuurs uses another Warehouse Management System (WMS) called Reflex, the Delivery Schedules are sent with the usage of Electronic Data Interchange (EDI). Once Nabuurs has received the Delivery Schedule, the following three tasks must be fulfilled. First, a Daily Schedule must be created for the next day. This means that out of the Delivery Schedule a plan is made which TO will be delivered at which time. This Daily Schedule must then be sent to three different parties: Mead Johnson Inbound Processing, Vlotweg Carrier and Nabuurs Outbound Processing. Second, all HU-labels per TO are assembled and send to Nabuurs Outbound Processing. HU-labels stands for Handling Unit labels. Handling units are groups of materials packed together, in this case packed per pallet. HU-labels are used to know where the materials are located and by scanning the barcode, this location is updated. In this way errors are minimalized, and it provides better traceability. The HU-labels can be used from distribution centers to end users so in the whole supply chain. Thirdly, a CMR must be created for every TO and send to Nabuurs Outbound Processing. A CMR, which stands for 'Convention on the Contract for the International Carriage of Goods by Road', is required for international road transport under auspices of the United Nations. Although the transport from Nabuurs to Mead Johnson is domestic, a CMR is still used for every TO, because it is a good tool to officially establish the transport. A CMR includes all important information about that transport, from date and place to description about the transported goods like weight, packaging method and information about dangerous goods.

Box 3

Then the tasks for the Nabuurs Outbound Processing team. First, they prepare the outbound of the TOs by moving the right pallets from the warehouse to the dock. Here a check must be carried out whether there are deviations in these pallets, for example damage or that the incorrect pallet has been moved to the dock. When there are no deviations at all, the HU-labels will be sticked in front of the pallets so they can be scanned in a fast way by Mead Johnson. In case there are deviations, these must be communicated with Nabuurs Warehouse Management. They will check whether the deviations are internally solvable by sending another Handling Unit including the same materials, or not. If this is the case, the HU-labels of these Handling Units will be sent back to the Outbound Processing team who will move the replacement pallets to the dock and stick the HU-labels on the pallets. Also, the damages

must be communicated with the Mead Johnson Material Requirement Planning team. If it is not internally solvable, the situation must be communicated as soon as possible to the Material Requirement Planning team of Mead Johnson. Once the whole TO is collected correctly and truck of Vlotweg is arrived, the pallets must be loaded in the truck and the right CMR is provided to the carrier of Vlotweg including a signature of the truck loader of Nabuurs. The carrier of Vlotweg will then transport the TO to Mead Johnson.

Box 4

Just like Nabuurs create a Daily Schedule for the deliveries, Mead Johnson and Vlotweg also create a Charging- and Driving Schedule respectively, which indicates who performs the tasks for which TO. Once the carrier of Vlotweg has arrived at Mead Johnson, the truck must be unloaded, the CMR must be signed, and the HU-labels must be scanned. Out of these HU-labels, SU-labels are made and sticked to the pallets too. SU stands for Storage Unit. The idea is the same as a Handling Unit, but the difference in existence is that a Storage Unit exists in the warehouse only, while a Handling Unit (HU) exists in the whole Supply Chain. The usefulness of a SU-label is that the location of a pallet can be indicated more precisely within the warehouse, for example within the Pre Staging Area, than a HU-label can do. Just like Nabuurs did a check whether there are deviations, the Inbound Processing team of Mead Johnson does the same. Is the TO complete, are all Handling Units correct and are there no damages? Then all pallets can be stored in the Pre Staging Area waiting to be used in production. In case there are problems, these must be reported to the Material Requirement Planning team. They must execute the Escalation Model, so the problem is solved as soon as possible, and the problems must be reported in the Microsoft Excel file called 'Delivery Delays', so all deviations can be analyzed.
This Value Stream Map shows how the process should actually go, but there are many moments in this process that are not running optimally at the moment. These moments are coloured red for clarity. To further explain this, we go through each red task how they are currently being implemented and in which respects improvements should be made.

Five red tasks

First, the Daily Schedule which should be created by the Warehouse Management team of Nabuurs. Out of a discussion with Bert Bruijsten, Warehouse Support Lead at Mead Johnson, it became clear that there is no steady flow in the delivery of loads. "In the morning there is often nothing to unload, while the staff is there for it. Then later in the day several loads arrive in quick succession. Ultimately, during the evening shift, it is sometimes concluded that 1 or 2 loads can no longer be delivered due to a lack of time. This is a huge waste of time and money!". At the moment, mutual calls are made between Nabuurs, Mead Johnson and Vlotweg when a freight is going to be delivered, but there is no strict schedule yet. A new Daily Schedule with time slots spread out as much as possible throughout the day and as early as possible in the morning will ensure more steady flow in the operation. The available time slots on a day will depend on the number of freights to be transported on that day. This idea is supported by the Lean Principle and so the operation becomes less ad hoc, which will be discussed in Section 3.

Another red task what the Warehouse Management team of Nabuurs is responsible for is to communicate the deviations with the Mead Johnson Material Requirement Planning team. These deviations are currently communicated in daily calls in the morning between the two

teams. Next to that, there is a lot of mail contact throughout the day. What stands out when attending these calls and reading these mails is that the conversations are not structured and thus there are some deviations to deliveries that simply slip through and are forgotten to be explained. It is also noticeable that the communication is particularly practical about which loads or pallets are late, incomplete or incorrect, but not with the reasons for this. There is absolutely no overview of the reasons why the target is not being achieved at the moment. Internally at Mead Johnson, the meetings are way more structured and efficient due to applying theory about communication in business. The difference between these meetings and the meetings between Mead Johnson and Nabuurs are big. Also, the communication through mail must become more efficient by sharing a Microsoft Excel file where all deviations will be collected.

In total, there are five red tasks in the Value Stream Map. The first one is for the Inbound Processing team and is comparable to above paragraph. This one is about updating the status of the TOs and reporting any problems to the Material Requirement Planning team. At the moment, this is all done by mail contact. However, the feedback from the MRP team is that the TOs are signed worthless. To avoid this, communication needs to be easier, faster and less hassle. For example, only photos of any damage should be communicated by e-mail and not the status of each TO or pallet. Communication about the latter matters could also take place better in Microsoft Excel, just like explained in the paragraph above.

The two last tasks are for the Material Requirement Planning team. The first one is the executing of the Escalation Model. The Escalation Model should be used in case of delivery delays so the problems can be solved as soon as possible. Currently the Escalation Model is just a list of telephone numbers at Nabuurs that need to be called. This is not how it should look like. Solving such problems is not ‘just a call’, it is a stream of tasks that needs to be executed with high speed. The Escalation Model will become a clear overview of this stream of tasks to prevent panic in the future. Then the last task, the reporting of the problems in the Microsoft Excel file ‘Delivery Delays’. Due to the fact that all deviations are not well communicated by both Nabuurs and Mead Johnson as explained earlier, this file does also not looks how it should look like. It is just one list of all deviations in a sheet, but the different kind of problems are not sorted, and no reason codes are added to the deviations. Another important addition would be to make a dashboard out of these data including all important graphs, so analyses can be made way easier.

2.3.4 Consequences of delivery delays

The delivery delays from the distribution centers to the factory have in some cases huge negative consequences. There are three different scenarios when materials are delivered later than the requirements date. In most cases, the delays bring no extra costs when the materials since they are not in short-term necessary for production. In this case, the materials are delivered as soon as possible with the other regular deliveries. To make this happen as often as possible, the requirement date is set as early as possible before it is really needed in production. However, this is not always the case since production schedules are set late depending on product demand.

A second scenario, which can be seen as a middle ground between the first and last scenario, is that the materials are still delivered as soon as possible by means of an 'urgent delivery' by the transport partner Vlotweg. Vlotweg asks 50% extra over the original transport costs, so Mead Johnson of course prefers to avoid this. But when there is no other way, it is always better than the last scenario, where production lines in the factory come to a standstill.

This can be seen as the worst-case scenario, since it mostly brings huge costs when production lines must stand still. In this way, the demand cannot be met. Unfortunately, according to the Senior Planning & Logistics Manager no data can be shared about the exact costs that the standstill in the factory entails. However, it is known that this quickly amounts to thousands of euros. Much more than the extra costs for urgent deliveries.

For this scenario, the term Overall Equipment Effectiveness (OEE) is important. Overall Equipment Effectiveness is "a hierarchy of metrics that focus on how effectively a manufacturing operation is utilized" (Stamatis, 2010). In this way it identifies and tracks loss and windows of opportunity. When the OEE is not 100%, we speak of OEE loss. There are a huge number of possible causes for OEE loss, so it is important to filter the OEE loss caused by delivery delays. In order the analyze the OEE including all its causes, Mead Johnson uses the production monitoring software of Patch. Within this program, there are very clear overviews of the OEE of Mead Johnson, per production lines, dates, and reasons. To keep this analysis clear, we will analyze the total OEE losses in the factory, so not per production line, but with the focus on the date periods and reasons.

We will analyze the OEE of Mead Johnson over four periods. The first period that we will analyze now is the period before moving to the new dedicated distribution center of Nabuurs, so the period with both Frigolanda and Cornelissen as DC's. The second period will be during the two-month onboarding window where all materials are moved from Frigolanda and Cornelissen to Nabuurs. The third period will be the first months at Nabuurs and the fourth period will be the last period of this research where the solutions are hopefully implemented. The last three periods will be analyzed later in this research since this is not possible at this moment. So first, we start with the period from March to May 2021, where Mead Johnson used two different DCs at Frigolanda and Cornelissen. The overview from this period can be seen in the following Figure 8:

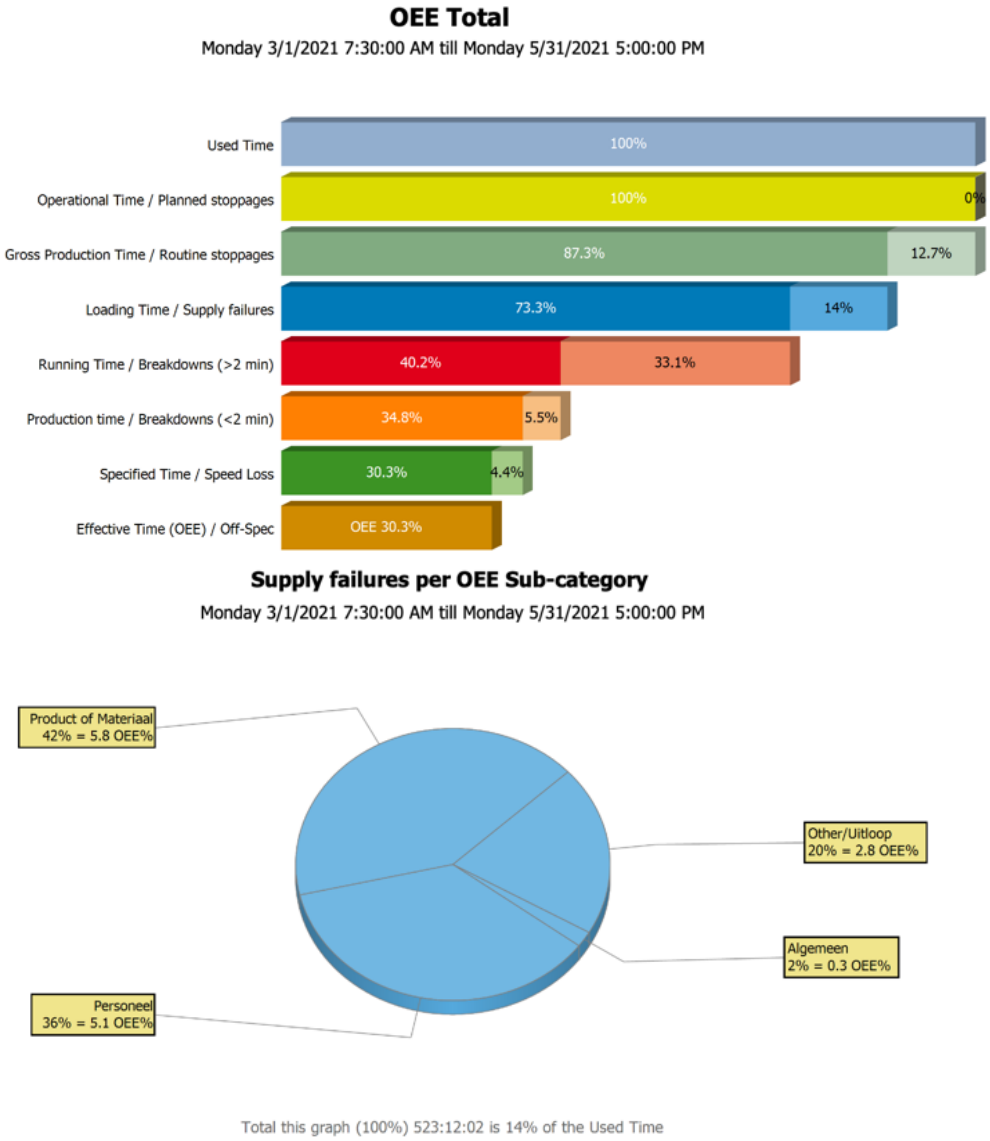


Figure 8: OEE loss due to supply failures from March to May 2021

The OEE loss is firstly divided into four more general categories, whereby the more specific causes can be seen when clicking on one of these general categories. The four more general categories can be seen in the overview on the left in Figure 8. The first category is 'routine stoppages', where all calculated stoppages are included. One example of these routine stoppages is when production lines are about to make other products due to differences in demand. In this case, the production lines must be prepared for a change in input raw materials. Another example is all planned cleaning of the production lines. However, this category is not important in this research.

The percentage of OEE loss due to delivery delays can be found in the second category 'supply failures'. 14% of all OEE losses from March to May were due to supply failures. Nevertheless, not all 'supply failures' are delivery delays. On the right graph in Figure 8, it becomes clear that there are three big categories of 'supply failures'. The first one called 'personeel' are staff shortages internally at the production lines due to waiting for technical support, staff breaks or understaffing. The second one called 'other/uitloop' is a collection of reasons like unplanned extra cleaning, taking too long to start up the production lines and all maintenance

to the devices in the production lines. The really small piece called 'algemeen' actually belongs to this category, but was put into the system incorrectly by the team leaders.

The third one is where the focus will be on in this research. This category 'product of materials' means all OEE loss due to a lack of the right materials at the moment of production. This could be that there is the wrong, no, or not enough material. An important side note here is that this does not necessarily have to be due to a delay in delivery from the distribution centers, but that it can also be due to internal failure, even if the materials were already present in the warehouse in the factory on time. In the last three months of using the distribution centers of Frigolanda and Cornelissen, the percentage of OEE loss due to a lack of materials was 5,8%. It was concluded by the Senior Planning & Logistics Manager of Mead Johnson that this percentage could not be tolerated as it is one of the few categories where much profit could be made.

The fourth category 'breakdowns' is divided into two parts: the breakdowns that cause more than two minutes down time and the breakdowns that cause less than two minutes down time. By breakdowns is meant all kind of malfunctions and failures of the machines in the production lines making them fall out completely. The fifth and last category 'speedloss' are all minor defects to the machines whereby the production lines keep running, but not at maximum speed. These two categories are also out of the scope of this research. When all loss is added up, only 30,3% Overall Equipment Effectiveness in the period March till May stays.

As mentioned earlier, the other three periods will be analyzed later in this research with hopefully better results regarding OEE loss due to lack of materials. This percentage will also be included as a KPI in the following Section 2.4 'Measurement of the Key Performance Indicators'.

2.4 Measurement of the Key Performance Indicators

To make the whole performance measurable in a quantitative way, Key Performance Indicators must be made. According to Slack (2016), a KPI is "the most important indicator for judging whether an operation is good, bad or indifferent". In this research, there are three KPIs in order to measure the performance of all key operations. All these KPIs are aligned with the Problem Analysis above, which is explained per KPI underneath.

KPI 1: total extra costs of transferring materials to Nabuurs before going to the factory
The planning & logistics department usually works with costs per pallet/weight. The KPI for the transferring of materials will be the total extra costs of transferring materials to Nabuurs before going to the factory in Euros. These costs should be as low as possible since it will be wasted money when materials are transported first to Nabuurs and then to the factory in the two-month window of transferring. Materials that will not be necessary for the factory in this window should go to Nabuurs, the others not. This will mainly depend on the stock and demand of the materials.

The goal related to this first KPI is to keep these total extra costs under €36000. This goal is based on the estimation made in Section 2.2.

KPI 2: percentage of deliveries from the distribution center to the factory that are On Time In Full

The second KPI will be there in order that the production lines in the factory must stop less. One of the reasons for a discontinued production line is the number of materials that are delivered too late from the distribution center to the factory. However, not all late deliveries directly lead to a discontinued production line. To tackle all late deliveries, the second KPI will be the percentage of deliveries from the distribution center to the factory that are on time in full. This means that a truck is delivered on or before the requirements date and in full, so no damages, incorrect pallets, or incomplete trucks.

The goal for this second KPI is to have the percentage of deliveries that are On Time In Full at 98%. This target is based on the current percentage of about 96%, as explained in Section 2.3.4.

KPI 3: percentage of OEE loss in the factory due to a lack of materials at the moment of production

The third KPI will be based on the most negative consequence of delivery delays, namely OEE loss. As explained in Section 2.3.4, the percentage of OEE loss in the factory due to a lack of materials at the moment of production can be obtained out of the program Patch. This KPI will be measured over the four different periods in the research as explained earlier in that Section. One very important sidenote is that not all lack of materials is due to delivery delays. It is also possible that something goes wrong internally at Mead Johnson, although the materials where on time in the pre staging area. Unfortunately, it is not possible to obtain this percentage out of Patch. Despite this sidenote, it is still a very important KPI in this research because the vast majority of this percentage is due to delivery delays, and it is a direct indicator about the extreme consequences that it can bring.

The goal for this third KPI is to have the percentage of OEE loss due to a lack of materials below 3%. This target is based on the current percentage of 5,8%, as explained in Section 2.3.4.

For all KPIs there will be enough quantitative data from the company to make the measurements. Quantitative data can be characterized as countable and numerical data. These quantitative data will mainly come from the Graphical User Interference of the enterprise resource planning software program SAP which Mead Johnson uses, data from the program Patch about the reason codes of the down times and possibly data from Microsoft Excel sheets of colleagues. Within the program SAP, it is possible to make an overview of the actual stocks and demands which are located at the two DCs Frigolanda and Cornelissen. Next to this, analyses will be made of the data in the program Microsoft Excel.

The qualitative data that will be used will come from interviews mostly inside, but also outside of the company and literature will be reviewed in the following Chapter 3. The interviews will most of the times be an open conversation with some prepared questions to get all the information that is needed. In these interviews the goal is to know how they currently work out their decisions and where the problems are lying in order to come to solutions.

2.5 Conclusion on this chapter

In this chapter, answers are provided on the Research Questions 1 & 2. First, the current supply chain is analyzed to give an answer on the first sub question of the Research Question 1. Most problems regarding the delivery delays occur at the inbound transport part of the supply chain, from the distribution centers of Frigolanda and Cornelissen to Mead Johnson. The targets for the inbound transport are not met, as explained in Section 2.3.4. Here, the three different scenarios when materials are delivered later than the requirements date are analysed. The worst-case scenario is that the production lines must be stopped due to a lack of material. In this case, Overall Equipment Effectiveness loss occurs. In the last three months of using the distribution centers of Frigolanda and Cornelissen, the percentage of this OEE loss due to a lack of materials was 5,8%. This percentage could not be tolerated as it is one of the few categories where much profit could be made. Shortly, the flows of both materials and information in this part of the supply chain must become leaner by moving to a new dedicated distribution center.

The second sub question of Research Question 1 is what should be considered when making a successful onboarding plan. Therefore, the three main problems from the problem cluster in Figure 1 are considered. First, there is a time restriction issue of a two-month transfer window due to the contract between Mead Johnson and the DCs. The second problem is that it is not clear which materials are needed for production in these two months as these are the materials that must not be onboarded to Nabuurs to make it as cost-efficient as possible. Thirdly, there are some resource restriction issues, namely the availability of trucks, the truck capacity, and the loading/unloading capacity. Based on these three problems, estimations on the total extra costs of onboarding materials to Nabuurs and the average number of trucks per day that will be needed, are made.

To have clear how the delivery delays are currently addressed and what the main causes of late deliveries are, multiple analyses are made. First, an overview is made of the planning and logistics department and all external employees, of Nabuurs and Vlotweg, who will be of importance in this process, is made to have clear who is responsible for what. This overview is thereafter aligned with the Swimlane Value Stream Map in Figure 7. In this map, each step of the whole delivery process is shown including the five ‘red tasks’ where currently most of the problems occur. Also, the Service Level Agreement between Mead Johnson and Nabuurs is investigated. What particularly strikes here is the fact that there is little specific information about delivery delays and possible sanctions. Nevertheless, the feedback on this was that the focus should first go to making the whole process run better rather than immediately imposing sanctions. However, it became clear that tracking the KPIs regarding delivery delays, including its causes, in the form of a dashboard is seen as an important first step, especially to increase the awareness of the problem and to make better analyses of the causes. The other possible solutions in Chapter 4 are based on the red tasks in the Value Stream Map.

In Section 2.4, Research Question 2 is answered. Based on the Problem Analysis, three KPIs are made including their targets. These are the total extra costs of transferring materials to Nabuurs before going to the factory, the percentage of deliveries from the distribution center to the factory that are On Time In Full, and the percentage of OEE loss in the factory due to a lack of materials at the moment of production.

3. Literature review

In this chapter, the literature which supports the solution generating in the next chapter will be reviewed. Also, an answer is given on Research Question 3 including its two sub-questions which will respectively be answered by Sections 3.1 and 3.2. As the main goal is to make the delivery process leaner, the first investigation will be on what is meant with lean and its implementation at other companies. The Lean Principle is based on the Toyota Production System (TPS) and it is the most used system for making processes leaner. Therefore, Section 3.1 it is investigated in which way the TPS and its renewed Toyota Way 2001 Model can be implemented in the solution generating phase. To make the process leaner, all possible wastes must be sought. Since it concerns logistical wasted, Section 3.2 reviews the 'Seven Deadly Wastes of Logistics' based on the seven primary sources of waste from the Toyota Production System. These wastes are compared to the situation at Mead Johnson. In the last section, the conclusion, a final answer is given on Research Question 3.

3.1 Lean Principle and Toyota Production System

In order to achieve the main goal of decreasing delivery delays, the red circled part of the supply chain in Figure 3 should become way leaner. Lean is a "team-based form of continuous improvement that focuses on identifying and eliminating waste. Where waste is non-value-added activity from the viewpoint of the customer" (Myerson, 2016). Having multiple distribution centers, causing more delivery delays, can be seen as waste. There are namely more activities going on due to not having the DCs centralized and all these 'extra' activities are not value-added for the customer. The flow of both the materials and products as the flow of information in a supply chain must be as streamlined as possible following the Lean principle. This is also something that Slack (2016) supports: "Although the most obvious failure in supply chain management occurs when the downstream flow of products and services fails to meet customer requirements, the root cause may be a failure in the upstream flow of information. Modern supply chain management is as much concerned with managing information flows as it is with managing the flow of products and services." By going from multiple DCs to only one dedicated DC at Nabuurs, the flows of materials, products and information can become way more structured.

The lean principle is based on the Toyota Production System (TPS). This production system from the automobile manufacturer Toyota has been successful in delivering better cars than its competitors and is today seen as the standard for world class manufacturing. TPSs approach is based on "doing it right the first time by applying continuous problem solving by every employee to make the system even stronger." (Sutherland, 2007) This culture that developed at Toyota that every employee was allowed to report problems and make improvements instead of focusing on other resources besides the people, ensures that people become more motivated. Also, the root causes are found earlier than by 'jumping to conclusions'. This way of reporting and continuous improvement will be one of the important starting points in generating solutions in the next chapter.

To make this idea of the TPS and based on its two pillars: 'continuous improvement' and 'respect for people' more visual, Toyota revealed their 'Toyota Way House' in 2001. These

two pillars are built on three and two foundational blocks respectively as shown in Figure 9b. The blocks for the pillar 'Continuous Improvement' are the following:

- Challenge. This means that the company has to "form a long-term vision, meeting challenges with courage and creativity to realise dreams." (Coetzee, 2016)
- Kaizen. This means that the company has to "improve business operations continuously, always striving for innovation and evolution. " (Coetzee, 2016)
- Genchi genbutsu (which is Japanese for 'Go and see for yourself'). This means that the company has to "believe in going to the source to find the facts and to make correct decisions, building consensus, and achieving goals at the best speed." (Coetzee, 2016)

The blocks for the pillar 'Respect for people' are the following two:

- Respect. This means that all employees have to "respect each other, make every effort to understand each other, take responsibility, and build mutual trust." (Coetzee, 2016)
- Team work. This means that the company has to "stimulate personal and professional growth, share the opportunities of development, and maximise individual and team performance." (Coetzee, 2016)"

In Figure 9a, the original TPS house is shown. Although they look quite similar, there is a main difference between the old TPS house and the new Toyota Way house. This is confirmed by Coetzee: "In the TPS house, the core pillars are just-in-time and jidoka, which are both technical concepts. In contrast, the pillars of the Toyota Way model focus on people: CI and respect for each other." The main pillars where the solutions are based on in Chapter 4 are the two pillars of the Toyota Way. The reason for this is that most problems occur due to human error and underperformance of the employees. To keep them motivated in continuously improving the whole process, they must get more power in the process, so they get their deserved respect and the problem is solved based on teamwork instead of individuals just performing their own tasks.

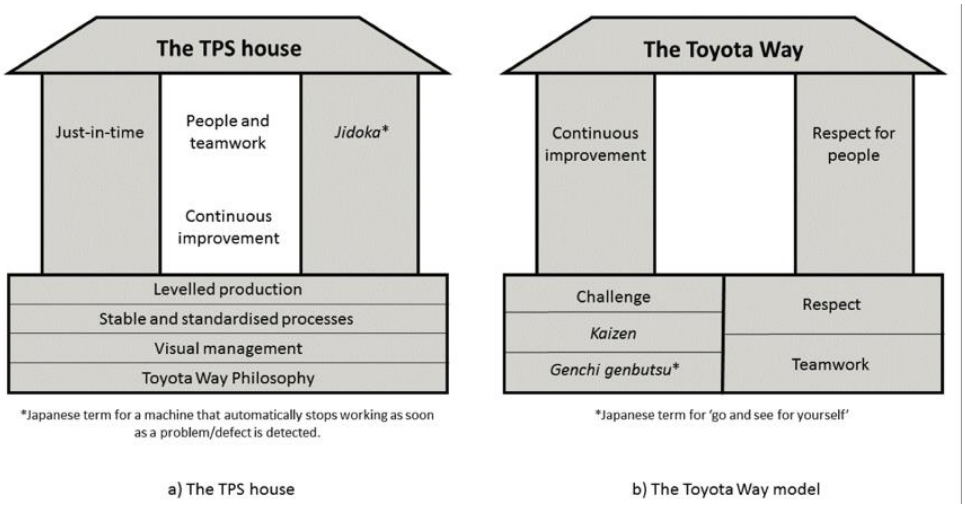


Figure 9: Illustrating the difference between the TPS house and the Toyota Way 2001 model in terms of their foundations and pillars (Coetzee, 2016)

Despite the focus is on the pillars of the Toyota Way, the two pillars of the TPS house also come back in the solutions. The first pillar, just-in-time basically means "to produce the

necessary units in the necessary quantities at the necessary time." (Monden, 2012) To achieve this, the OEE must be as high as possible and that is exactly what is improved by the solutions. To produce the necessary units in the necessary quantities, the right materials in the right quantities must be delivered at the right moment towards Mead Johnson. Otherwise, it is not produced in the 'necessary time' and OEE is lost. The second pillar, Jidoka (Japanese for Autonomation), "may be loosely interpreted as autonomous defects control. It supports JIT by never allowing defective units from a preceding process to flow into and disrupt a subsequent process." (Monden, 2012) This is achieved in this research by an improved escalation model, which needs to be executed once deviations in the delivery process occur. The flow of tasks that would be executed if no deviations occurred are disrupted and the escalation model is set in motion. Explanation about this escalation model is provided in Chapter 4.

3.2 Seven Deadly Wastes of Logistics

Taiichi Ohno, founder of the Toyota Production System, identified the "The Seven Deadly Wastes", which are the seven primary sources of waste. These are the following:

1. Overproduction
2. Delay/Waiting
3. Transportation/Conveyance
4. Motion
5. Inventory
6. Over-processing
7. Defects/Correction

Almost all of these sources also apply in this research when it comes to delivery delays. Actually, these seven sources are based on production. However, these can also be applied to logistics waste. Therefore, these seven have been converted to the "Seven Deadly Wastes of Logistics", made by Sutherland and Bennett (2007). This conversion, including an explanation of what kind of waste is involved in logistics and whether it is relevant to the situation at Mead Johnson, is listed below:

1. **Overproduction**: Delivering products before they are needed is overproduction. More serious for the entire supply chain is demand information overproduction—what Toyota calls "created demand." Created demand is caused by requesting a quantity greater than needed for end use or requesting it earlier than needed.

- Relevant to the situation at Mead Johnson in this research? The created demand problem is not that big with Mead Johnson. This is because the determination of the demand is well determined in the ERP system SAP using the Economic Order Quantity method.

2. **Delay/Waiting**: Any delay between the end of one activity and the start of the next activity. Examples include the time between the arrival of a truck for a pick-up and the loading of the trailer, and the delay between receiving the customer's order information and beginning to work on fulfilling the order.

- Relevant to the situation at Mead Johnson in this research? The loading- and unloading capacity at Nabuurs and Mead Johnson is more than enough as when a truck arrives, there are always enough shipper receivers available to do the work. It could be that this work is not done fully time efficient, but this is not a big deal as we are talking about delays in deliveries of days instead of seconds/minutes. However, no delay/waiting when something is delivered to late is crucial and therefore an escalation model is a part of the solutions in Chapter 4.

3. **Transportation/Conveyance**: Unnecessary transport that results in added cost. Examples include out-of-route stops, excessive backhaul, and locating fast-moving inventory to the back of the warehouse causing unnecessary material handling distances to be incurred.

- Relevant to the situation at Mead Johnson in this research? The layout of the warehouses has been optimized based on what is needed at what times and therefore falls outside the scope of the research, just like the transport itself, which is determined by Vlotweg. The most optimal route is determined on the basis of the route description from Google Maps that is the least error-prone and the refueling of the trucks is done outside working hours. However, when transporting more than needed in the onboarding fase, it is definetly waste.

4. **Motion**: Unnecessary movement of people, such as walking, reaching, and stretching. Examples include extra travel or reaching due to poor storage arrangement or poor ergonomic design of packaging work areas.

- Relevant to the situation at Mead Johnson in this research? On the basis of the SU and HD labels, the location of the pallets can be optimally found to prevent unnecessary motion of employees. The shipper receivers are then informed at which dock the carriers of Vlotweg will arrive, so unnecessary motion is also limited as much as possible here.

5. **Inventory**: Any logistics activity that results in more inventories being positioned than needed or in a location other than where needed. Examples include early deliveries, receipt of order for a quantity greater than needed, and inventory in the wrong DC.

- Relevant to the situation at Mead Johnson in this research? In case the wrong pallets are delivered, or the quantities delivered are too big, there is unnecessary inventory in the pre-staging area van Mead Johnson. Since there is not much space in this area, unnecessary inventory at Mead Johnson must be prevented and all materials that are not directly needed can better be stored at Nabuurs.

6. **Space**: Use of space that is less than optimal. Examples include less than full/optimal trailer loads, cartons that are not filled to capacity, inefficient use of warehouse space, and even loads in excess of capacity.

- Relevant to the situation at Mead Johnson in this research? The truck capacity is used as optimally as possible by always loading it as full as possible. However, this is not

always possible due to pallets bulging out, for example, which in turn can cause delays. The pallets are also stacked as fully as possible by the raw material suppliers, the leftmost in the supply chain in Figure 3.

7. **Errors**: Any activity that causes rework, unnecessary adjustments or returns. Examples include billing errors, inventory discrepancies and adjustments, and damaged/defective/wrong/mislabeled product.

- Relevant to the situation at Mead Johnson in this research? Many damages take place during transport. As a result, the right materials are not in stock and solutions have to be found on the basis of returns and adjustments. Many incorrect pallets are also delivered. These categories of delivery delays will also need to be separated.

3.3 Conclusion on this chapter

The main goal, based on the lean principle, is to eliminate waste, which is the non-value-added activity from the viewpoint of the customer. According to Slack, in modern supply chain management these wastes are not only in the flow of products and materials, but also very much concerned on managing the information flows. This supports to the idea that the information flows must get optimally streamlined to reduce these wastes. The lean principle is based on the Toyota Production System, which is actually a culture where every employee is allowed to report problems to continuously improve the processes. In this way the employees also become extra motivated. Therefore, the renewed Toyota Way 2001 model, is focused on these two pillars: 'continuous improvement' and 'respect for people' using five foundational blocks. Compared to the old TPS house, the Toyota Way 2001 model is more focused on the people instead of technical concepts and therefore the solutions will be based on this model. Especially since most problems at the moment occur due to human error and underperformance of the employees. The two pillars of the TPS house, 'just-in-time' and 'Jidoka', also come back in the solutions. The first pillar is to "produce the necessary units in the necessary quantities at the necessary time." (Monden, 2012) to keep the OEE as high as possible. This is done by delivering the right materials in the right quantities at the right moment towards Mead Johnson, where all solutions are based on. The second pillar "may be loosely interpreted as autonomous defects control" (Monden, 2012), which is achieved by an improved escalation model.

Next to this, there is analysed which of the "Seven Deadly Wastes of Logistics", made by Sutherland and Bennett (2007) are relevant to the situation at Mead Johnson. These wastes are based on the "The Seven Deadly Wastes" from Taiichi Ohno, founder of the Toyota Production System. The first four wastes are already solved well, which is explained per waste in the previous section. Examples are making use of the Economic Order Quantity method, outsourcing the transportation to Vlotweg and using SU and HD labels for motion optimalisation. The wastes that were most relevant to the situation of Mead Johnson are 5. 'Inventory', 6. 'Space' and 7. 'Errors'. First 5. 'Inventory', in case of unnecessary inventory in the pre-staging area when deviations to deliveries occur. Secondly 6. 'Space', when the truck capacity cannot be used optimally due to bulging powder pallets. And thirdly 7. 'Errors', as all deviations to deliveries causes rework, unnecessary adjustments and/or returns. Currently,

this rework is not done in the most time-efficient way. This will be solved by the renewed Escalation Model.

4. Solution generating & decision making

In this chapter, Phases 4 & 5 of the MPSM will be executed. Solutions are generated and decisions will be made based on the findings in Sections 2 & 3. In this way, an answer on Research Question 4 will be given including its two sub-questions. In Section 4.1 the solution of how to get to this desired supply chain is given on the basis of the onboarding plan. Section 4.2 includes all solutions for decreasing the delivery delays after onboarding to Nabuurs. Every solution has its own sub-section: Section 4.2.1 for the Legend for statuses of the Transfer Orders, Section 4.2.2 for the renewed Day Schedule, Section 4.2.3 for the Dashboard and finally Section 4.2.4 for the Escalation Model. At the end, an answer is given on Research Question 4 in Section 4.3, the conclusion.

4.1 Onboarding plan

In Section 3.2, the literature about the Seven Deadly Wastes of Logistics is investigated. In case that not the right materials are transported many of these seven wastes are the case. Namely unnecessary transportation and motions and inefficient use of the inventory and space available. These are respectively numbers 3, 4, 5 and 6. The plan is built to prevent these wastes and is based on only filtering the materials that are not needed during the onboarding window at the Mead Johnson factory, as explained in section 2.2. This is done by making use of multiple functions and techniques in Excel. These will be explained in the following paragraphs.

Only the above mentioned materials should be moved to Nabuurs to onboard as cost-efficient as possible. This is the total stock in the distribution centers minus the demand during the onboarding window in the factory. In this way, KPI 1 will be kept as low as possible. From the Enterprise Resource Planning program SAP, the stock lists of the two distribution centers Frigolanda and Cornelissen and the demand list of the Mead Johnson factory can be retrieved and exported as a spreadsheet to Microsoft Excel. These two lists form the basis of the onboarding plan. It is important when retrieving the demand list that the demand until the end of the onboarding window must be collected. The retrieval and execution of these lists must be done daily as they are constantly changing. In the Excel file, the stock and demand lists are from Thursday 19 August to give more clarity how it is determined which materials are transferred when. August is of course after the agreed onboarding window according to the contracts but explanation about this will follow in Chapter 5.

We start with the fifth sheet called 'Stock'. This is the combined stock list of both distribution centers as explained above. The materials in the stock list have several properties that are all stored in SAP as can be seen in Figure 10. We will briefly go through these to make it clear which data is important, and which is not.

	A	B	C	D	E	F	G	H	I	J
1	Material	Material Description	Batch	Distribution Center	Total stock	Storage Unit	Last movement	SLED	Pallet size	Amount of pallets in stock
2	1225870	LACTOSE 100 MESH 1000KG BIG BAG LP EU	FR20679	Frigolanda	1.000	00060897186	15/07/2021	30/03/2022	1000	1

Figure 10: Properties from the stock list

- First, the material number and its description. The material number is a 7-digit number to identify the different materials. In addition, there is also a description, but it is often too long to look up or work with quickly and efficiently. In total, Mead Johnson uses no fewer than 320 different materials, which means that identification using material numbers is necessary.
- In addition, the batch number. The materials are transported by the suppliers in batches. These batches all have numbers where the first two letters indicate to which distribution center it goes to keep it clear. FR for Frigolanda and CR for Cornelissen. This is also indicated in the fourth column of the sheet.
- Then of course the total stock per pallet. This number indicates the total amount of material that is on the pallet. Usually this is the maximum of the pallet size from Column I, but this is not always the case. The pallet size is obtained from the 'Material' sheet using a VLOOKUP function and indicates how much of a material fit on a pallet. The number of pallets in stock can then be calculated by dividing column E by column I in column J. Adding this for both distributions centers shows that there were 465 pallets in stock at Frigolanda on the 19th of August and 0 pallets at Cornelissen in stock.
- Using the Storage Unit, it is possible to identify exactly where the pallet is located in the supply chain. Last Movement indicates when the pallet was last moved. Usually this is the date that the pallet has gone from the supplier to the distribution center. Then the Shelf Life Expiration Date (SLED) which indicates the maximum date that a material can be stored. However, these dates are all in 2022 so not of importance in this research.

Secondly, the sixth sheet called ‘Demand’. This is the total demand for the factory needed in the onboarding window. Also here we will briefly go through the properties of the demands as can be seen in Figure 11.

	A	B	C	D	E
1	Requirements Date	Material	Material Description	Total demand	Base Unit of Measure
2	04/08/2021	2039496	INSTANT WHOLE MILK PWD CODEX HC 575KG BB	7.272,285	KG

Figure 11: Properties from the demand list

- The first one is the Requirements Date, which is the date that the material is needed in the factory. All Requirements Dates are in the onboarding window. Beyond that, it doesn't matter exactly when the requirements date falls in this window as we focus on the transports to Nabuurs in this part of the research.
- Second the Material Number and Description. This is the same as explained in the above paragraph.
- Thirdly, the total demand per material. This is the total number of demand needed in the factory during the onboarding window in the base unit of measure indicated in the next Column E. This Base Unit of Measure is in grams or kilograms and depends on the weight of the materials.

As there are many different pallets per material and batch number on the stock list and the demand list shows the demand per Requirements Date, there is still no clear overview of the stocks and demands per material. Therefore, there will be make usage of Pivot Tables. A pivot

table is a type of table that can dynamically summarize, arrange, group, and edit data lists in spreadsheets such as Microsoft Excel. In the sheet 'Stock Pivot Table', this is done for the stocks using two rows for the Material Number and Description and next to that the Sum of the total stock per material. In the sheet 'Demand Pivot Table', this is done for the demand using the same idea. Important here is to refresh the Pivot Tables daily as this is not done automatically.

A	B	C	D	E	F	G	H	I	J	K
Material	Material Description	Stock	Demand	Stock - Demand	Transport towards	Pallet size	Pallets	Truckload	Distribution Center	Total trucks to be moved to Nabuurs
1265529	POLYDEXTROSE NON-GMO/IP LIQUID 930KG IBC	36.270	12.877	23.393	Nabuurs	930	25,15	1,05	Frigolanda	25,00

Figure 12: First two rows of sheet 'Materials to Nabuurs'

Figure 12 are the first two rows of the first sheet called 'Materials to Nabuurs'. Here, the first two columns from the Stock Pivot Table are copied and pasted. Then in Columns C and D the stock and demand per material are searched using a VLOOKUP function in a IFERROR function. The lookup value is @A:A, which means the value in the cell with the same row number in column A. This is the material number which is then looked up in respectively the table arrays A to C in the Stock Pivot Table and the Demand Pivot Table. The value that needs to be the outcome of the function is in Columns C of the Pivot Tables, so the third column. The IFERROR function is used so that if the lookup value is not in the Pivot Table that the outcome of the function becomes 0, so no stock or demand. In Column E there is the stock minus the demands. Column F is an IF function to have clear if it needs to be moved to Nabuurs or not. If the value in E is more than 0, it must be moved. If this is not the case, it must be transported to Mead Johnson. In Column G there is a VLOOKUP function for the pallet size out of the sheet called 'Material'. In Column H, the outcome of Column E divided by the pallet size in Column G indicates the number of pallets. This value divided by the average truck capacity, which is about 24 as explained in Section 2.2, then gives the truckload in Column I. Column J is used to look up whether the materials are stored at which distribution center so this can be filtered easily. The total trucks that still needs to be moved to Nabuurs is in Cell K2 with an SUMIF function of Column I, only if Column F is "Nabuurs".

This file is sent every morning to the warehouse managers of both distribution centers. They will look in the first sheet discussed above which materials can be moved and in the second sheet called 'Pivot for movements' which batch numbers there are in stock. The truckload in 'Materials to Nabuurs' sheet are sorted descending, so there can be seen which materials has the most pallets that must be moved. Further, the warehouse managers of the distribution centers decide for themselves which pallets they want to be moved as it is not important for Mead Johnson, but it is for the distribution centers as they want some spaces in the warehouse empty sooner than others. All trucks are filled as full as possible by the warehouse managers. In the 'Onboarding plan' sheets of both distribution centers, there is an overview when the trucks are moved including their contents. A review on this will be done in the next Section.

4.2 Solutions to reduce delivery delays

To make sure that all the red tasks from the Value Stream Map are tackled, there are four solutions helping together to achieve the targets set in Chapter 2. Some of the solutions are connected to each other in some way as will be explained in the sections, but not all do. Simultaneously they will help with achieving the main goal: decreasing delivery delays.

4.2.1 Legend for status Transfer Order

As indicated in the Value Stream Map in Section 2.3.3, the communicating of the status of the TOs and reporting of the problems to the Material Requirement Planning team must be improved. This communication should take place in Microsoft Excel instead of all mail contact. The only mail contact needed next to the communication via Microsoft Excel will be photos of the damages. This new working method will detect possible deviations in deliveries more efficiently and actions can be taken in good time. Also, it will make shift transfers smoother and easier.

The best way of making this communication uncluttered and insightful is working with a legend where the different kind of statuses get a colour in the delivery schedules. In Figure 13, there is the first legend made. Every status has a colour and on the right these statuses are explained including the possible action(s) that needs to be taken.

Colour in delivery schedule	Description status	Explanation status & possible action(s)
01/01/2022	TO is delivered complete and on time without further deviations and placed in the rack(s). (=On Time In Full)	The truck this TO was in was unloaded without any deviation. The pallets were scanned according to the procedure and placed in the racks, so that this TO is no longer open in SAP.
01/01/2022	TO is delivered complete and on time without further deviations and still needs to be placed in the racks	The truck this TO was in was unloaded without any deviation. The pallets were scanned according to the procedure. They only must be placed in the racks.
01/01/2022	TO is delivered with damage pallet(s).	The truck in which this TO was located has been unloaded and one or more damage pallet(s) have been found in the trailer that fall under this TO. Photos of these pallets were taken in the trailer and sent to Mead Johnson MRP and Nabuurs Warehouse Management. From here, it is investigated what the reason code of the damage is, and a solution is sought following the Escalation Model as soon as possible.
01/01/2022	TO is delivered incomplete	The truck in which this TO was located has been unloaded and one or more pallets were missing. From here, it is investigated what the reason code of the incompleteness is, and a solution is sought following the Escalation Model as soon as possible.
01/01/2022	TO is delivered incorrect.	The truck in which this TO was located has been unloaded and one or more incorrect pallet(s) have been found in the trailer that fall under this TO. From here, it is investigated what the reason code of the delivery of the wrong pallets is and a solution is sought following the Escalation Model as soon as possible.
01/02/2022	TO not delivered on the predetermined requirement date (minimum +1 day).	The truck in which this TO was located, has arrived at Mead Johnson at least one day later (+1) than the predetermined requirement date. From here, it is investigated what the reason code of the delivery delay is, and a solution is sought following the Escalation Model as soon as possible.
	TO is still open on the pre-determined day of the requirement date.	The truck containing this TO is still expected on the predetermined requirement date itself. When the trailer has arrived at MJN, one of the above colours is given based on the current situation.

Figure 13: First legend for statuses TOs made

The feedback on this first made legend was that it was not smart to give every status another colour as it would become too unclear. The goal is to make it as less effort as possible according to the lean principle for the shipper receivers and team shift leaders. Otherwise, it will possibly not happen always on the most accurate way. Out of this feedback, the idea came to stick to three colours and group the statuses as can be seen in Figure 13.

Colour in delivery schedule	Description status	Explanation status & possible action(s)
01/01/2022	TO is delivered complete and on time without further deviations and placed in the rack(s). (=On Time In Full)	The truck this TO was in was unloaded without any deviation. The pallets were scanned according to the procedure and placed in the racks, so that this TO is no longer open in SAP.
01/01/2022	One of the following statuses: 1. TO is delivered with damage pallet(s) 2. TO is delivered incomplete 3. TO is delivered with incorrect pallet(s)	The truck in which this TO was located has been unloaded and one or more pallet(s) are damaged, missing, or incorrect. If pallets are damaged, photos of these pallets are taken and sent to Mead Johnson MRP and Nabuurs Warehouse Management. For the damaged, incomplete, and incorrect pallets, it is investigated what the reason code is, and a solution is sought following the Escalation Model as soon as possible.
01/01/2022	TO not delivered on the predetermined requirement date (minimum +1 day).	The truck in which this TO was located, has arrived at Mead Johnson at least one day later (+1) than the predetermined requirement date. From here, it is investigated what the reason code of the delivery delay is, and a solution is sought following the Escalation Model as soon as possible.
	TO is still open on the pre-determined day of the requirement date.	The truck containing this TO is still expected on the predetermined requirement date itself. When the trailer has arrived at MJN, one of the above colours is given based on the current situation.

Figure 14: Improved legend for statuses TOs

Shortly, the green status is only for all On Time In Full TOs that are placed in the racks. The yellow status is when the TO is not in full due to one of the following three causes: damage, incomplete, or incorrect. Red is when the TO is not delivered on the predetermined requirement date and white is when the TO is still open.

Next to these colours, an extra dropdown menu will be placed next to the yellow TOs which of the three causes is the case. Also, for all yellow and red TOs a dropdown menu will be placed what the reason code is that the TO is not delivered OTIF. Further explanation about the dropdown menus is in Section 4.2.3.

Furthermore, in this setup it is very important that the team shift leaders always keep the delivery schedule up to date and that everything physically and administratively agree. In order to achieve this, it is crucial that they are kept informed of every unloading process by their shipper receivers.

4.2.2 Day Schedule

Another solution to decrease the delivery delays is to create more steady flow in the deliveries. To achieve this, the Day Schedule created by the warehouse managers of Nabuurs must be anticipate on the number of Transfer Orders per day and divide them evenly on a day. In this way, it is prevented that there are too many TOs open on the end of the day and they cannot be delivered due to a lack of time. The usual calls between Mead Johnson, Nabuurs and the carriers of Vlotweg must change to calls that are only incidental when incidents occur and replaced by a strict Day Schedule shared by all three parties in Microsoft Excel.

The goal in this Day Schedule is to spread the deliveries as much as possible throughout the day. The carriers of Vlotweg are available from 08:00 till 18:00. These 10 hours must be used optimally. The average number of Transfer Orders per day is 25 with a maximum of 50. In case there are 50 Transfer Orders, on average 5 must be transferred per hour. Timeslots of

12 minutes would be unclear and therefore there is chosen for 6 timeslots per hour, so every 10 minutes. Not all timeslots will always be used of course as it depends on the number of TOs on that day. To determine this time interval, a function in Microsoft Excel is used called FLOOR. This function rounds a number down to a given multiple. This multiple is in this situation the time interval between the timeslots, so 10 minutes. There is chosen for this function because when the time interval is rounded up, there could arise a lack of time for some TOs at the end of the day. Therefore, the preference is to save time instead of running out of time.

The number that must be rounded down to the multiple of 10 is the number of available hours per day, which is 10, divided to the number of TO, which is Cell A2, multiplied by 60, the number of minutes in an hour. This gives the function in Cell B2: =FLOOR((10/A2)*60;10). In the example in Figure 15, the number of TOs is 22. (10/22)*60 gives a time interval of about 27. Nevertheless, this is rounded down to 20 by the FLOOR function. The TO numbers could then be filled in per 20 minutes next to the timeslots. There is chosen for this solution, because the use should be as simple as possible for all employees to keep it error-prone.

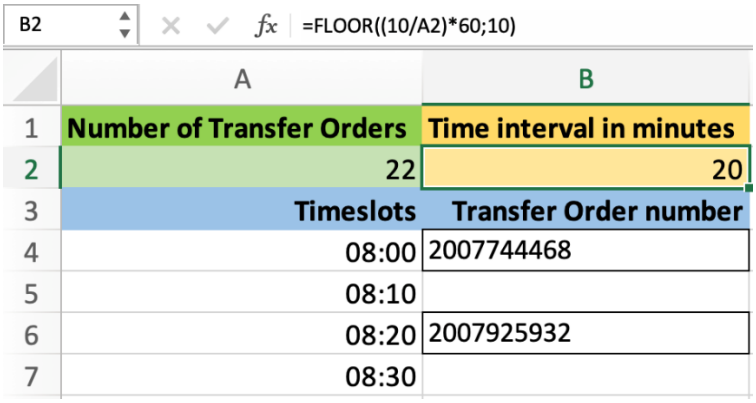


Figure 15: Basis of Day Schedule using timeslots

4.2.3 Dashboard Delivery Delays

Perhaps the most important solution to the delivery delays is better reporting of the problems. As explained in Section 2.3.3, this is currently done with a long list of complaints and deviations, but this list is often incorrect, often no reasons are given and no analyses are made. The different statuses from the legend created in Section 4.2.1 is the most important starting point for better reporting of the delivery delays. In the following paragraphs the deliverable called 'Dashboard Delivery Delays' from Microsoft Excel will be explained.

From October, all red and yellow TOs from the delivery schedules will be collected separately from each other in the fifth and sixth sheets called 'After Requirement Date' and 'Incomplete Incorrect Damage' respectively. The following information about the TOs can be found in these sheets:

- Delivery Date, which is the date that the TO is delivered to Mead Johnson.
- TO number, which is the number belonging to the Transfer Order.
- Distribution Center, which is always Nabuurs since the move.

- Material- number and description, which is from the pallets that are not delivered OTIF in that TO.
- Number of pallets in the Transfer Order and next to that the TO quantity, which is the amount of materials in that TO.
- Job order and production line is where the missing materials would be used in production. This is important to know for the employees working in the factory.
- Requirement Date, which is the date that the TO was supposed to be delivered.
- Last, the reason code. This is the reason that there are deviations to the TO. All reasons are grouped and later these reason codes will be explained.

Next to these data, there are some data specific for whether the status is red or yellow which need to be filled in by the team shift leaders of Mead Johnson. These are for the red TOs the number of days that the TO is delivered too late, so the delivery date minus the requirement date. For the yellow TOs it is whether the missing materials are incomplete, incorrect, or damaged. Incomplete means that they are missing in the truck and so that the number of pallets is not correct. Incorrect means that the wrong pallets are delivered and damaged means that (some of) the materials on the pallets cannot be used due to damage. Also, the number of pallets in that TO that are delivered wrong are added in Column L. Both columns are easy to filter due to the dropdown menus.

These two sheets form the basis for the following sheets. First, sheet 'Data per day' in Figure 18. From October to February, this sheet records the number of TOs for each day and removes the deviations from the previous two sheets. One table is for the After Requirement Date, one for the Incomplete/Incorrect/Damage and the leftmost sheet then merges the two.

First the table for the After Requirement Date. These are extracted from the sheet using a SUMIF function. The criteria herein is that the date must be equal to the Requirement Date of the overdue TO. Then it lists Column M, where there is a 1 everywhere because a row equals a late delivery. Then the 'On Time' is the number of TOs minus the number of After Req. date. The percentage is the number of After Req. Date divided by the number of TOs.

The same idea happens with the following table for the Incomplete/Incorrect/Damage. However, this uses a SUMIFS function since both the date and the category must match. For example, the incomplete, incorrect and damage are counted separately and then added up in Column U to determine the total number of yellow TOs. The percentages are then determined again in the last columns.

In the leftmost table, these two tables are merged by adding them together and this is then the number that is Not On Time In Full. The percentage of OTIF is the number of OTIF divided by the number of TOs. This is KPI 2 and the target for this is 98% which is added in the column after.

The same idea but per week and month is done in the sheets 'Data per week' and 'Data per month', respectively Figures 19 and 20. The data for this is again taken from the 'Data per day' sheet using multiple SUMIF functions. In the 'Data per month' sheet, a ratio table has also been added as the last table. This ratio is how much of the total Not On Time In Full, After

Req. Date, Incomplete, Incorrect or Damage is. Out of all these tables, graphs are made in the sheet called 'Dashboard' and these are analyzed in the Section 5.1.2.

Next to the categories of delivery delays explained above, there are also the causes that need to be analyzed. To keep this as uncluttered as possible, there are some reason codes formed based on analyzing the earlier used mail contact for communicating deviations and by attending all morning calls between Mead Johnson and Nabuurs. Using these reason codes, the warehouse managers of Nabuurs can communicate the reasons of the deviations with Mead Johnson way more easily. For the four categories of delivery delays there are the following eight reason codes formed:

- After Requirement Date
    - Forgotten on Day Schedule
        - The first reason code is that a TO is forgotten to put into the Day Schedule. From the Delivery Schedule received from Mead Johnson, all TOs must be filled into the Day Schedule for the next day. The main solution to prevent this is by double checking whether they are all included on the list. This is not always done by the warehouse managers of Nabuurs.
    - Delivery Schedule too late (after 14:00)
        - The second reason code is that the Delivery Schedule is received too late from Mead Johnson. If the Delivery Schedule is sent after 14:00, it could be that Nabuurs is too late with making the Day Schedule so time is lost the next morning that was needed to be used for transferring TOs. The solution for this mainly lies at Mead Johnson by sending them always on time.
    - No time left (end of the day)
        - The third reason code for this category is that there is no time left at the end of the day for sending the last TO(s) to Mead Johnson. This is already explained in Section 2.3.3. The solution for creating more steady flow in the deliveries is explained in Section 4.2.2

	A	B	C	D	E	F	G	H	I	J	K	L
1	Delivery Date	TO number	Distribution Center	Material number	Material description	#Pallets	TO QTY	Job order	Production line	Req. Date	Days too late	Reason code
2	02/10/2021	2007744468	NABUURS	2030374	PMX ENFAKID A+ MAJOR MINERAL 20KG BAG	23	2660	JOB T	DB	01/10/2021	1	No time left, end of the day

Figure 16: Data from 'After Requirement Date' sheet

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	Delivery Date	TO number	Distribution Center	Material number	Material description	#Pallets	TO QTY	Job order	Production line	Req. Date	Incomplete/Incorrect/Damage	# Pallets wrong	Reason code
2	02/10/2021	2007744516	NABUURS	2059662	PMX VIT ENFAMIL A+ S1 20KG SG/BR	24	68	JOB S	DB	02/10/2021	Damage	1	Caused by pallet truck

Figure 17: Data from 'Incomplete Incorrect Damage' sheet

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y
1																									
2																									
3	Month	Week	Deliveries to the factory: On Time In Full (green-red-yellow)							After Requirement Date (red)						Incomplete/Incorrect/Damage (yellow)									
4			Datum	TO's	On Time In Full	Not On Time In Full	Percentage OTIF	Target		Datum	TO's	On Time	After Req. Date	Percentage		Datum	TO's	Incomplete	Incorrect	Damage	Total Yellow	Percentage incomplete	Percentage incorrect	Percentage Damage	Percentage total
5	10	39	01/Oct	15	14	1	93,33%	98,00%		01/Oct	15	14	1	6,67%		01/Oct	15	0	0	0	0	0,00%	0,00%	0,00%	0,00%
6	10	39	02/Oct	18	17	1	94,44%	98,00%		02/Oct	18	18	0	0,00%		02/Oct	18	0	0	1	1	0,00%	0,00%	5,56%	5,56%
7	10	39	03/Oct	29	29	0	100,00%	98,00%		03/Oct	29	29	0	0,00%		03/Oct	29	0	0	0	0	0,00%	0,00%	0,00%	0,00%
8	10	40	04/Oct	16	15	1	93,75%	98,00%		04/Oct	16	15	1	6,25%		04/Oct	16	0	0	0	0	0,00%	0,00%	0,00%	0,00%
9	10	40	05/Oct	17	16	1	94,12%	98,00%		05/Oct	17	17	0	0,00%		05/Oct	17	0	0	1	1	0,00%	0,00%	5,88%	5,88%
10	10	40	06/Oct	14	13	1	92,86%	98,00%		06/Oct	14	13	1	7,14%		06/Oct	14	0	0	0	0	0,00%	0,00%	0,00%	0,00%
11	10	40	07/Oct	16	14	2	87,50%	98,00%		07/Oct	16	15	1	6,25%		07/Oct	16	0	1	0	1	0,00%	0,00%	6,25%	6,25%
12	10	40	08/Oct	18	18	0	100,00%	98,00%		08/Oct	18	18	0	0,00%		08/Oct	18	0	0	0	0	0,00%	0,00%	0,00%	0,00%
13	10	40	09/Oct	19	18	1	94,74%	98,00%		09/Oct	19	19	0	0,00%		09/Oct	19	0	0	1	1	0,00%	0,00%	5,26%	5,26%
14	10	40	10/Oct	16	16	0	100,00%	98,00%		10/Oct	16	16	0	0,00%		10/Oct	16	0	0	0	0	0,00%	0,00%	0,00%	0,00%

Figure 18: Tables in 'Data per day' sheet

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W
1		Deliveries to the factory: On Time In Full (green-red-yellow)						After Requirement Date (red)						Incomplete/Incorrect/Damage (yellow)									
2	Week	TO's	On Time In Full	Not On Time In Full	Percentage OTIF	Target		Week	TO's	On Time	After Req. Date	Percentage		Week	TO's	Incomplete	Incorrect	Damage	Total Yellow	Percentage incomplete	Percentage incorrect	Percentage Damage	Percentage total
3	39	62	60	2	96,77%	98,00%		39	62	61	1	1,61%		39	62	0	0	1	1	0,00%	0,00%	1,61%	1,61%
4	40	116	110	6	94,83%	98,00%		40	116	113	3	2,59%		40	116	0	1	2	3	0,00%	0,86%	1,72%	2,59%
5	41	119	116	3	97,48%	98,00%		41	119	117	2	1,68%		41	119	1	0	0	1	0,84%	0,00%	0,00%	0,84%
6	42	170	164	6	96,47%	98,00%		42	170	166	4	2,35%		42	170	0	0	2	2	0,00%	0,00%	1,18%	1,18%
7	43	184	179	5	97,28%	98,00%		43	184	182	2	1,09%		43	184	2	1	0	3	1,09%	0,54%	0,00%	1,63%
8	44	191	185	6	96,86%	98,00%		44	191	188	3	1,57%		44	191	1	0	2	3	0,52%	0,00%	1,05%	1,57%
9	45	230	223	7	96,96%	98,00%		45	230	226	4	1,74%		45	230	2	1	0	3	0,87%	0,43%	0,00%	1,30%
10	46	218	214	4	98,17%	98,00%		46	218	216	2	0,92%		46	218	0	1	1	2	0,00%	0,46%	0,46%	0,92%
11	47	149	144	5	96,64%	98,00%		47	149	146	3	2,01%		47	149	0	1	1	2	0,00%	0,67%	0,67%	1,34%
12	48	248	241	7	97,18%	98,00%		48	248	245	3	1,21%		48	248	1	2	1	4	0,40%	0,81%	0,40%	1,61%
13	49	242	236	6	97,52%	98,00%		49	242	239	3	1,24%		49	242	0	2	1	3	0,00%	0,83%	0,41%	1,24%
14	50	217	213	4	98,16%	98,00%		50	217	215	2	0,92%		50	217	0	1	1	2	0,00%	0,46%	0,46%	0,92%
15	51	172	167	5	97,09%	98,00%		51	172	170	2	1,16%		51	172	0	2	1	3	0,00%	1,16%	0,58%	1,74%
16	52	110	107	3	97,27%	98,00%		52	110	108	2	1,82%		52	110	0	0	1	1	0,00%	0,00%	0,91%	0,91%
17	1	261	256	5	98,08%	98,00%		1	261	259	2	0,77%		1	261	2	0	1	3	0,77%	0,00%	0,38%	1,15%
18	2	218	215	3	98,62%	98,00%		2	218	216	2	0,92%		2	218	0	1	0	1	0,00%	0,46%	0,00%	0,46%
19	3	121	117	4	96,69%	98,00%		3	121	119	2	1,65%		3	121	0	1	1	2	0,00%	0,83%	0,83%	1,65%
20	4	163	159	4	97,55%	98,00%		4	163	161	2	1,23%		4	163	1	0	1	2	0,61%	0,00%	0,61%	1,23%
21	5	219	216	3	98,63%	98,00%		5	219	217	2	0,91%		5	219	0	1	0	1	0,00%	0,46%	0,00%	0,46%
22	6	235	232	3	98,72%	98,00%		6	235	234	1	0,43%		6	235	0	1	1	2	0,00%	0,43%	0,43%	0,85%
23	7	242	240	2	99,17%	98,00%		7	242	241	1	0,41%		7	242	0	0	1	1	0,00%	0,00%	0,41%	0,41%
24	8	178	175	3	98,31%	98,00%		8	178	177	1	0,56%		8	178	1	1	0	2	0,56%	0,56%	0,00%	1,12%
25	9	24	24	0	100,00%	98,00%		9	24	24	0	0,00%		9	24	0	0	0	0	0,00%	0,00%	0,00%	0,00%

Figure 19: Tables in 'Data per week' sheet

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD	AE	AF	AG	AH
1	Deliveries to the factory: On time In full								After Requirement Date (red)							Incomplete/Incorrect/Damage (yellow)													Ratio After Req. Date/Incomplete/Incorrect/Damage							
2	Month	Month Nr.	TO's	On Time In Full	Not On Time In Full	Percentage OTIF	Target		Month	Month Nr.	TO's	On Time	After Req. Date	Percentage		Month	Month Nr.	TO's	Incomplete	Incorrect	Damage	Total Yellow	Percentage incomplete	Percentage incorrect	Percentage Damage	Percentage total		Month	After Req. Date	Incomplete	Incorrect	Damage	Total	Not On Time In Full	
3	Oct.21	10	651	629	22	96,62%	98,00%		Oct.21	10	651	639	12	1,84%		Oct.21	10	651	3	2	5	10	0,46%	0,31%	0,77%	1,54%		Oct.21	12	3	2	5	22		
4	Nov.21	11	848	824	24	97,17%	98,00%		Nov.21	11	848	835	13	1,53%		Nov.21	11	848	3	4	4	11	0,35%	0,47%	0,47%	1,30%		Nov.21	13	3	4	4	24		
5	Dec.21	12	929	906	23	97,52%	98,00%		Dec.21	12	929	918	11	1,18%		Dec.21	12	929	1	6	5	12	0,11%	0,65%	0,54%	1,29%		Dec.21	11	1	6	5	23		
6	Jan.22	1	791	775	16	97,98%	98,00%		Jan.22	1	791	783	8	1,01%		Jan.22	1	791	3	2	3	8	0,38%	0,25%	0,38%	1,01%		Jan.22	8	3	2	3	16		
7	Feb.22	2	870	859	11	98,74%	98,00%		Feb.22	2	870	865	5	0,57%		Feb.22	2	870	1	3	2	6	0,11%	0,34%	0,23%	0,69%		Feb.22	5	1	3	2	11		
8																Total			11	17	19	47						Total	49	11	17	19	96		

Figure 20: Tables in 'Data per month' sheet

- Incomplete
    - Not included at CMR
        - The only reason code for incomplete TOs is that a Handling Unit is not included to the CMR made by Nabuurs. For every TO, a CMR including all Handling Units must be made and sometimes a TO is forgotten due to human failure. The solution is the same for 'Forgotten on Day Schedule': always double checking whether all TOs are on the CMR list.
- Incorrect
    - Labelling mistake
        - As explained in Section 2.3.3, the Nabuurs Outbound Processing team is responsible for sticking the Handling Unit-labels to the front of the pallets. Sometimes this goes wrong when the wrong label is sticked to the pallet. In this case, the incorrect Handling Unit is sent in the truck. Just like the above reason code, it is the only cause of its category and the solution is simply double checking.
- Damage
    - Fell over during activities
        - Some Handling Units fell over during activities. Most are stored high in the racks and the forklift drivers can make faults by putting them in or out of these recks.
    - Forklift driver failure
        - It is also possible that not the whole Handling Unit falls over, but that the forklift is placed above the pallet instead of in the pallet. In this case, materials can be damaged. The solutions for these two reason codes is by having highly trained forklift drivers, either by hiring the right ones or by offering extra training courses.
    - Hole in big bag for unknown reason
        - The last reason code is that there is a hole in a big bag for unknown reason. The only possible solution for this is by using higher quality big bags. This is considered by Mead Johnson. However, the conclusion was that the higher prices for all these big bags did not weigh up to the number of damaged pallets that it gives at this moment.

In the sheet called 'Reason codes', there are two tables made from the reason code data from the 'After Requirement Date' and 'Incomplete / Incorrect / Damage' sheets, using COUNTIF(S) functions. The outcome these data is analyzed in Section 5.1.2 using the graphs from the 'Dashboard' sheets.

4.2.4 Escalation Model

In case problems occur in the production, Mead Johnson uses an Escalation Model so the problems are solved within a certain time frame and as little OEE as possible is lost. There is however no Escalation Model in case of delivery delays. The following stream of tasks in Figure 21 must be executed in high speed and the goal is to solve every problem within four hours. Therefore, a timeline has been made to make clear how much time is given for which task. Underneath the timeline there is the explanation of the way of communicating per task.

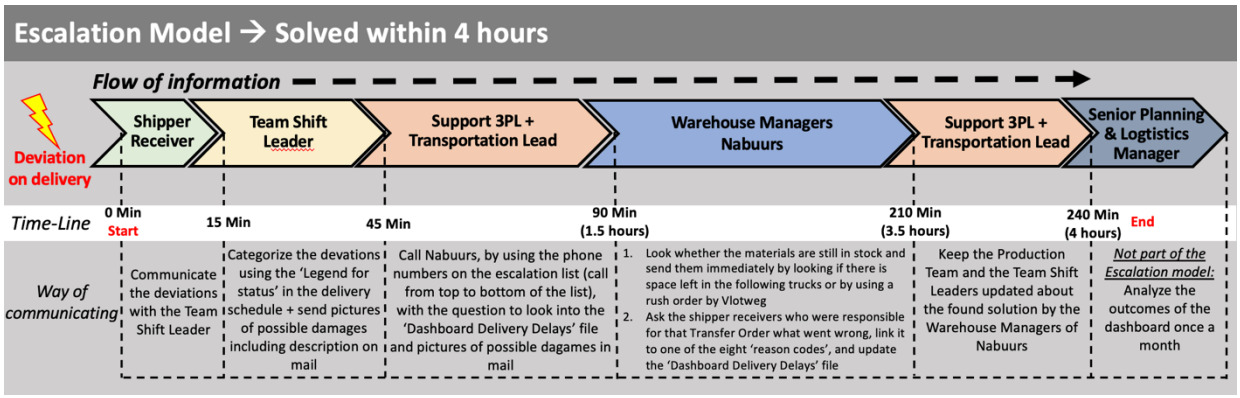


Figure 21: Escalation model when deviations on deliveries occur

The spark on the top left indicates a deviation has been detected by Mead Johnson's shipper receivers. They communicate these with their Team Shift Leaders who categorize the deviations using the 'Legend for status' in the delivery schedule and send pictures of possible damages including a description of what is wrong on the mail to Support 3PL + Transportation Lead. They immediately call Nabuurs by using the right phone numbers on the escalation list with the question to look into the 'Dashboard Delivery Delays' file and possible mail contact that is linked to the deviation in case of damage. Availabilities are listed next to the phone numbers and calls must be made from top to bottom until someone is reached.

This all is done within 1.5 hours after it is time for the Warehouse Managers of Nabuurs to take action. They have two main tasks, and they must start with the first one: solving the problem. This is done by looking whether the materials where the deviations occurred are still in stock and these must be sent immediately. There are two possibilities for sending the missing materials. First is by looking whether some space is left in the following trucks that are leaving. This is only possible in case of a yellow category deviation with not too much missing Handling Units. The second is by using a rush order offered by Vlotweg. In this case, 1,5x the transport costs of ordinary transport are charged, so it is never preferred but always better than taking the risk of making OEE loss. The next task after the solution is found is to ask the shipper receivers who were responsible for that Transfer Order what went wrong. This must be linked to one of the eight 'reason codes' and the 'Dashboard Delivery Delays' file must be updated. Finally, Support 3PL + Transportation Lead keeps the Production Team and the Team Shift Leaders updated about the found solution by the Warehouse Managers of Nabuurs.

The reporting for updating the dashboard is used for analysing the outcomes together with the Senior Planning & Logistics Manager of Mead Johnson. This is not part of the Escalation Model anymore as it is done once a month (sometimes more often in case of highly fluctuating outcomes). But it is added to have clear why the reporting is so important, and all employees are aware that their findings are analysed in a later time. This Escalation Model is therefore based on the Toyota Way principles for Section 3.1 as continuous improvement and respect for people are ultimately combined in the model.

4.3 Conclusion on this chapter

In order to move to Nabuurs, an onboarding plan is needed to do this as cost-efficient as possible to keep the first KPI low. Only the materials that are not needed during the onboarding window at the Mead Johnson factory should be moved to Nabuurs, which are the total stock in the two distribution centers minus the demand during the onboarding window in the factory. Therefore, these stock and demand lists are daily retrieved and executed from the ERP program SAP to Excel. Out of these lists, only the important properties are filtered for usage in the rest of the plan. By then using Pivot Tables and the right Excel functions, it is found which materials must be moved and which not. Also, there is an overview added when the trucks are moved including its contents.

In Section 4.2.1, the communicating of the statuses of the TOs and reporting of the problems to the Material Requirement Planning team has been improved using a Legend to categorize the deviations. This is done in Excel instead of all mail contact in the old situation. In the end this gave four categories: green for On Time In Full, yellow for Incomplete/Incorrect/Damage, red for After Requirement Date and white for not delivered but before Requirement Date. Secondly, there is a new Day Schedule using timeslots to create more steady flow in the deliveries by anticipating on the number of Transfer Orders per day and divide them evenly on a day. This Day Schedule is based on creating more lean and less ad hoc as explained in the literature.

Subsequently, the different statuses from the legend created in Section 4.2.1 is the most important starting point for better reporting and analysing the delivery delays using a dashboard. Separately, two lists of the red and yellow delivery delays are made including all required information and from this tables are made per day, week, and month. These tables are used for the graphs in the dashboard. Next to the categories of delivery delays, also the causes need to be analyzed. This is done by composing eight different reason codes to keep it uncluttered. In the Dashboard, there are also two graphs included about the reason codes and one for the ratio between the categories. Last, in Section 4.2.4 an Escalation Model is made so possible deviations to deliveries are solved as time efficient as possible. Shorty, this Escalation Model is a streamline of tasks that needs to be executed by different teams within 4 hours.

All these solutions together led to an answer on Research Question 4: What is the best solution approach for Mead Johnson to minimalize the downtime in the factory due to delivery delays? The solutions are further reviewed in the next Chapter 5 Implementation.

5. Implementation

In this chapter, Phase 6 of the MPSM will be executed. The solutions from the previous chapter are implemented. This is done by reviewing whether the targets of the Key Performance Indicators are met in Section 5.1. This section has three sub-sections for every KPI. After this, the review form for the employees is explained and the outcomes are analysed in respectively Sections 5.2.1 and 5.2.2. At the end, an answer is given on Research Question 5 in Section 5.4, the conclusion.

5.1 Outcomes of Key Performance Indicators

5.1.1 KPI 1: Total extra costs of onboarding materials to Nabuurs

Key Performance Indicator 1, the total extra costs of transferring materials to Nabuurs before going to the factory, is analysed by comparing the outcomes of Equation 1. This equation indicates how this KPI is determined. From Frigolanda and Cornelissen, a total of respectively 4987 and 2440 pallets has been transferred to Nabuurs. This is less than the estimation made in Equation 2, where respectively 5000 and 2500 pallets were estimated out of the stocks and demands onboarding. This is due to fluctuating stock and demand numbers and by determining daily which materials must be moved. Adding up the total pallets transferred gives 4987+2440=7427 pallets. Respectively 201 and 101 truck has gone from Frigolanda and Cornelissen, which is in total 302 trucks. Dividing the number of pallets by the total of trucks gives an average truck capacity of 24,6. This number is higher than the estimated average truck capacity from Equation 2, which is positive for the outcome of KPI 1. The estimation of 24 pallets on average per truck was based on having bulging pallets and turned out well. Another estimation was the average number of trucks per day that will be needed. In total, 49 days was needed to move the materials from Frigolanda. The total number of truck divided by this gives an average of 201/49=4,1 trucks per day. For Cornelissen, 27 days were needed to move the materials. The total number of truck divided by 27 days gives an average of 101/27=3,7 trucks per day. For Frigolanda, this number has turned out lower due to having more days available for onboarding, which is returned on later in this section. For Cornelissen, the number has turned out higher due to onboarding in a faster tempo as there were enough trucks available per day. The transport costs per truck is a constant of €114,75. Using all these numbers gives the outcome of KPI 1 in Equation 3.

$$Outcome\ of\ KPI\ 1 = \frac{7427}{24{,}6} * 114{,}75 \approx €34644$$

Where:
Outcome of KPI 1 in euros
(X-Y) = 4987+2440 = 7427 = Total stocks at Cornelissen & Frigolanda – total demand in factory in June & July in number of pallets
Z = 24,6 = Average truck capacity in number of pallets per truck
C = 114,75 = Transport costs per truck in euros

Equation 3: Estimate of total extra costs of onboarding materials to Nabuurs

The target of keeping this KPI below €36000 has been met and it is even €1216 lower than the estimation made in Equation 2. Because of this, it can be concluded that the onboarding plan is successfully executed. Nevertheless, there is also onboarded after the agreed onboarding window at Frigolanda, namely in August. The reason for this was Frigolanda had some busy days where they had no time to do the loading work as it came as extra work for them. These days are filled red in the Excel file called Material Transition Plan. Therefore, Frigolanda offered the option of onboarding in August. There were no extra costs involved for this as Frigolanda was the cause of the problem. Therefore, it had no impact on the outcome of KPI 1. However, the onboarding at Frigolanda could have been done more time-efficient of no problems occurred. Despite this, the onboarding at Cornelissen has been done very time efficient as there was half a month left in the onboarding window.

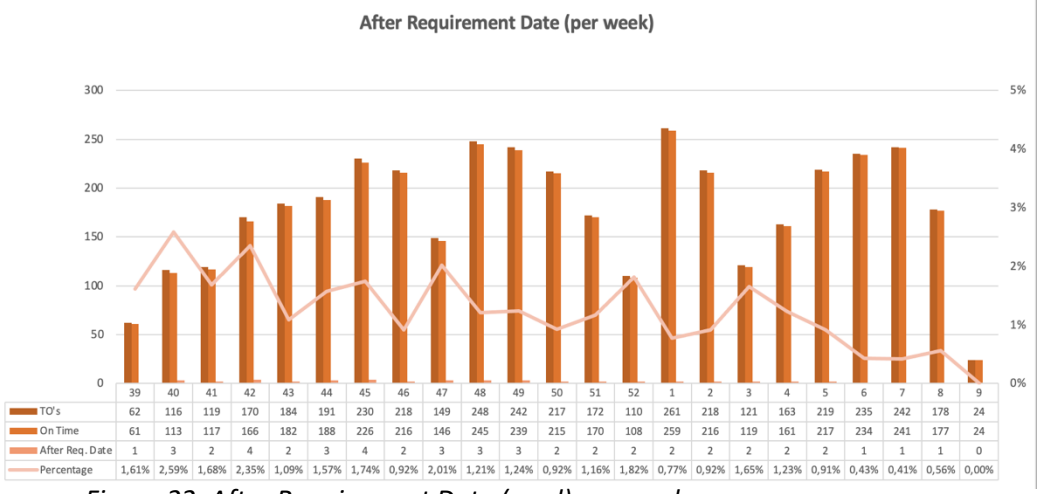
5.1.2 KPI 2: Percentage of deliveries On Time In Full

The second Key Performance Indicator is the percentage of deliveries from the distribution center to the factory that are On Time In Full. This means that a truck is delivered on or before the requirements date and in full, so no damages, incorrect pallets, or incomplete trucks. To analyse the outcome of this KPI, the dashboard from the Excel file 'Dashboard Delivery Delays' is used.

First, the analysis of the red and yellow categories made in Section 4.2.1 is done separate. Also, the ratio between the four categories of deliveries Not On Time In Full is analysed, just like the reason codes of the deviations. After all, there is the analysis of the percentage of deliveries On Time In Full, where all deviations come together, and where an final answer on the outcome of this KPI is given.

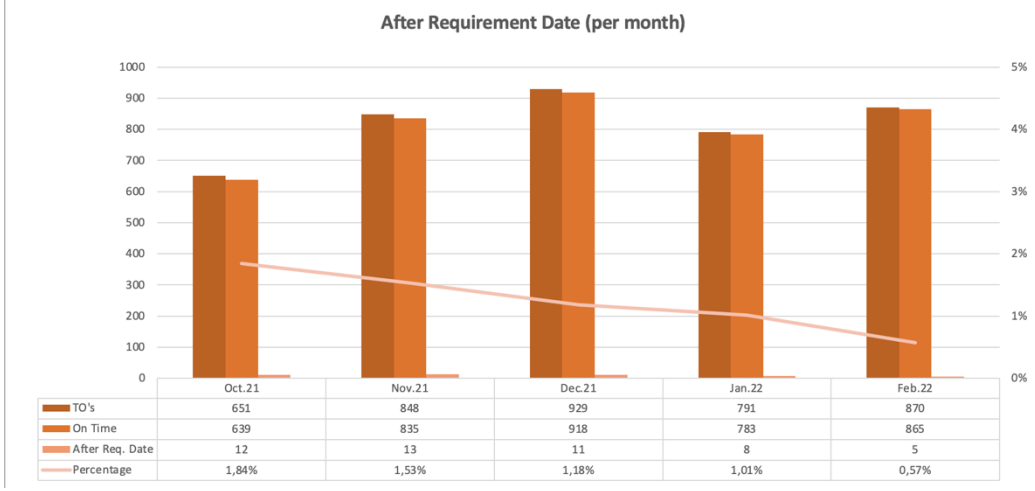
In the dashboard, the graphs show the results per week and per month. The percentages are the best indicators of the performances over a longer period. These percentages of the red and yellow categories over the total Transfer Orders have gone down in the five-month period. This can be seen in Figures 22, 23, 24 and 25. Especially when looking at both overviews per month (the graphs on the right), there are descending percentages lines. For the After Requirement Dates category there is a difference of 1,27% (=1,84-0,57) between the October and February, respectively the first and last month. In the first month, no solutions were applied and in the last month the whole solution generating phase was finished. The same applies to the yellow category, with a difference of 0,85% (=1,54-0,69) between October and February.

Taking these two categories together, the outcomes of KPI 2 are shown in Figures 26 and 27. The target of this KPI was to have the percentage of deliveries that are On Time In Full at 98%. This target is met as the percentage in the last month is 98,74%, which is an increase of 2,12% compared to October.



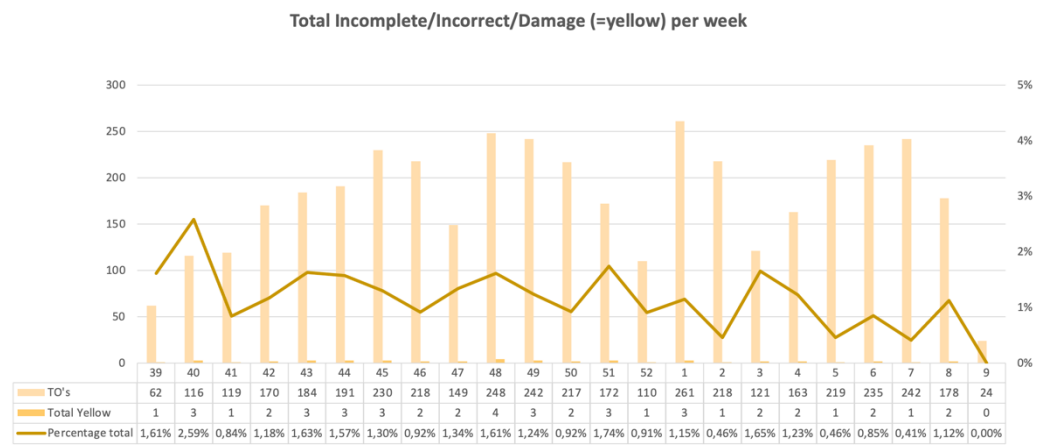
	39	40	41	42	43	44	45	46	47	48	49	50	51	52	1	2	3	4	5	6	7	8	9
TO's	62	116	119	170	184	191	230	218	149	248	242	217	172	110	261	218	121	163	219	235	242	178	24
On Time	61	113	117	166	182	188	226	216	146	245	239	215	170	108	259	216	119	161	217	234	241	177	24
After Req. Date	1	3	2	4	2	3	4	2	3	3	3	2	2	2	2	2	2	2	2	1	1	1	0
Percentage	1,61%	2,59%	1,68%	2,35%	1,09%	1,57%	1,74%	0,92%	2,01%	1,21%	1,24%	0,92%	1,16%	1,82%	0,77%	0,92%	1,65%	1,23%	0,91%	0,43%	0,41%	0,56%	0,00%

Figure 22: After Requirement Date (=red) per week



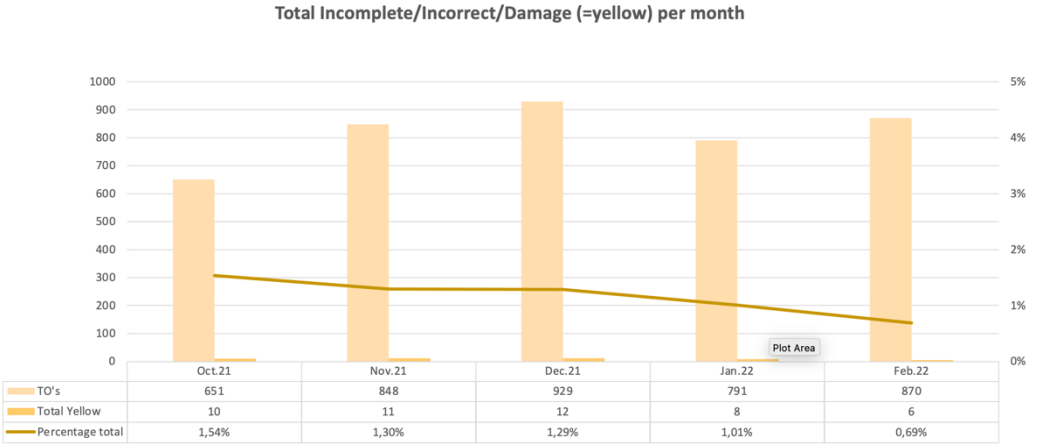
	Oct.21	Nov.21	Dec.21	Jan.22	Feb.22
TO's	651	848	929	791	870
On Time	639	835	918	783	865
After Req. Date	12	13	11	8	5
Percentage	1,84%	1,53%	1,18%	1,01%	0,57%

Figure 23: After Requirement Date (=red) per month



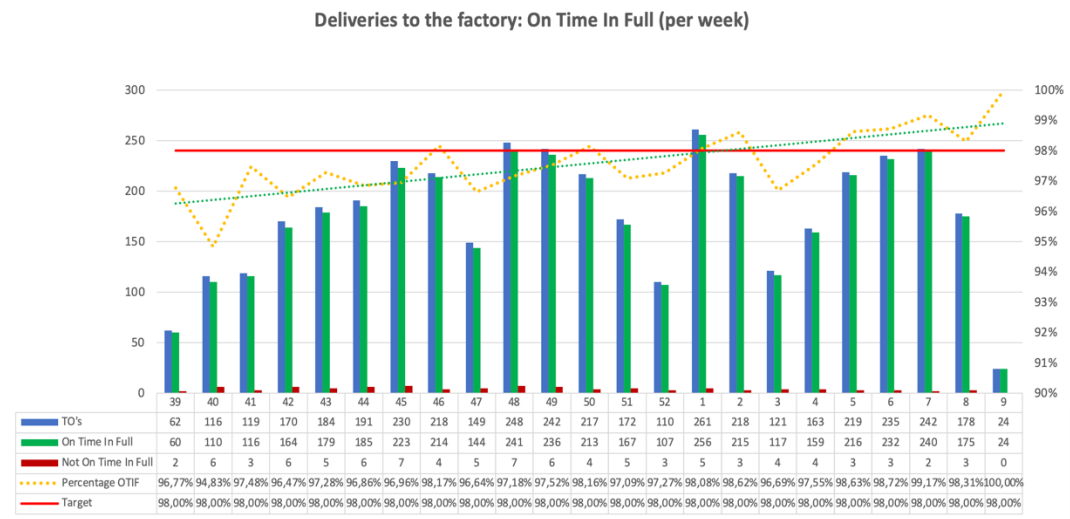
	39	40	41	42	43	44	45	46	47	48	49	50	51	52	1	2	3	4	5	6	7	8	9
TO's	62	116	119	170	184	191	230	218	149	248	242	217	172	110	261	218	121	163	219	235	242	178	24
Total Yellow	1	3	1	2	3	3	3	2	2	4	3	2	3	1	3	1	2	2	1	2	1	2	0
Percentage total	1,61%	2,59%	0,84%	1,18%	1,63%	1,57%	1,30%	0,92%	1,34%	1,61%	1,24%	0,92%	1,74%	0,91%	1,15%	0,46%	1,65%	1,23%	0,46%	0,85%	0,41%	1,12%	0,00%

Figure 24: Total Incomplete/Incorrect/Damage (=yellow) per week



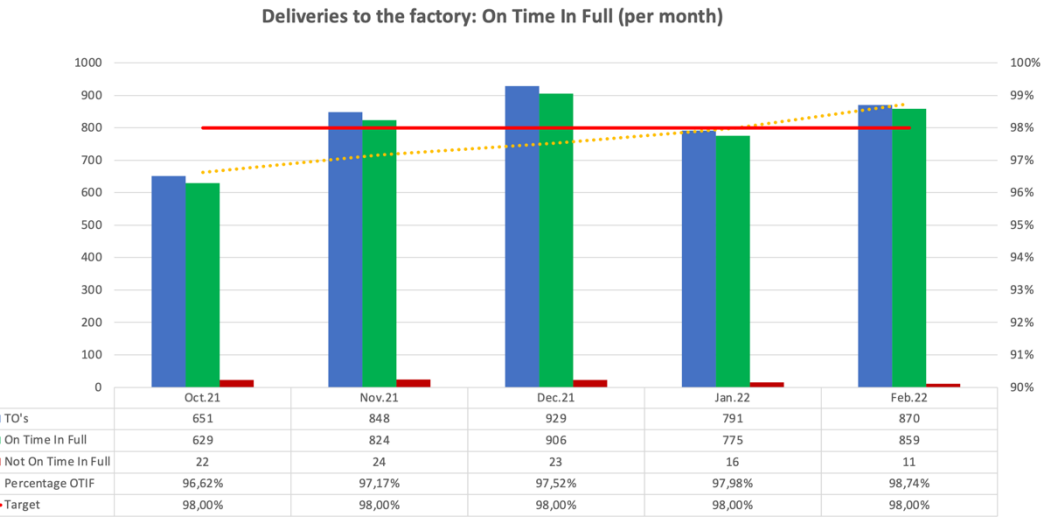
	Oct.21	Nov.21	Dec.21	Jan.22	Feb.22
TO's	651	848	929	791	870
Total Yellow	10	11	12	8	6
Percentage total	1,54%	1,30%	1,29%	1,01%	0,69%

Figure 25: Total Incomplete/Incorrect/Damage (=yellow) per month



	39	40	41	42	43	44	45	46	47	48	49	50	51	52	1	2	3	4	5	6	7	8	9
TO's	62	116	119	170	184	191	230	218	149	248	242	217	172	110	261	218	121	163	219	235	242	178	24
On Time In Full	60	110	116	164	179	185	223	214	144	241	236	213	167	107	256	215	117	159	216	232	240	175	24
Not On Time In Full	2	6	3	6	5	6	7	4	5	7	6	4	5	3	5	3	4	4	3	3	2	3	0
Percentage OTIF	96,77%	94,83%	97,48%	96,47%	97,28%	96,86%	96,96%	98,17%	96,64%	97,18%	97,52%	98,16%	97,09%	97,27%	98,08%	98,62%	96,69%	97,55%	98,63%	98,72%	99,17%	98,31%	100,00%
Target	98,00%	98,00%	98,00%	98,00%	98,00%	98,00%	98,00%	98,00%	98,00%	98,00%	98,00%	98,00%	98,00%	98,00%	98,00%	98,00%	98,00%	98,00%	98,00%	98,00%	98,00%	98,00%	98,00%

Figure 26: Deliveries to the factory that are On Time In Full (per week)



	Oct.21	Nov.21	Dec.21	Jan.22	Feb.22
TO's	651	848	929	791	870
On Time In Full	629	824	906	775	859
Not On Time In Full	22	24	23	16	11
Percentage OTIF	96,62%	97,17%	97,52%	97,98%	98,74%
Target	98,00%	98,00%	98,00%	98,00%	98,00%

Figure 27: Deliveries to the factory that are On Time In Full (per month)

Another graph from the dashboard shows the ratio between After Requirement Date, Incomplete, Incorrect or Damage per month and at last in total (Figure 28). At the most right, it shows that 49 of the in total 96 of TOs where deviations occurred were after the requirement date. Especially since the After Requirement Date means that all pallets of that TO are too late and it is more than the half of the TOs with deviations, the focus must be to decrease these. The same holds for the damaged and incorrect pallets as these are the most occurring from the yellow category. Therefore, the focus for the future must be on the reason codes of these categories. This is also part of the recommendations in Chapter 6.

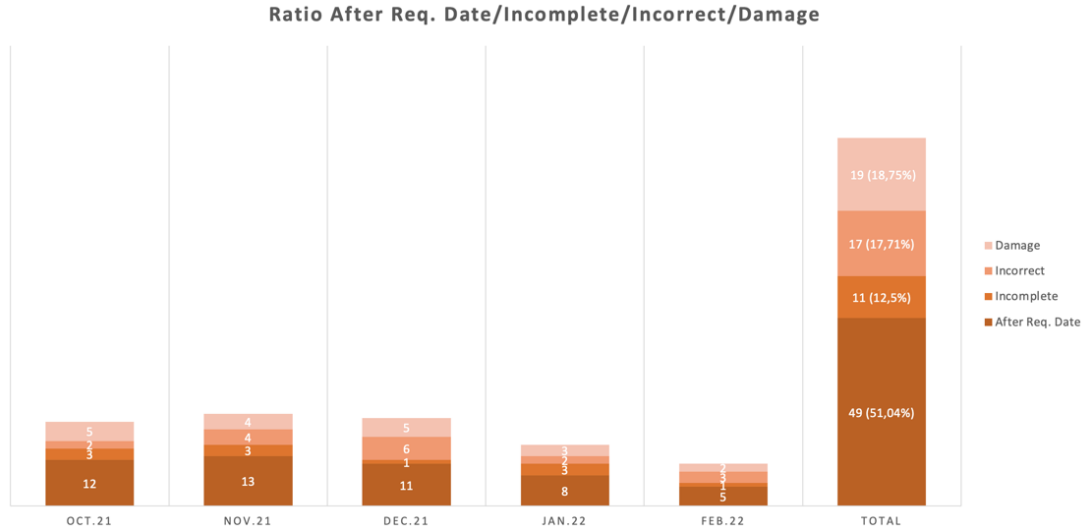


Figure 28: Ratio After Req. Date / Incomplete / Incorrect / Damage per month and in total

The categories 'Incorrect' and 'Incomplete' both only have only one reason code, so therefore only the outcome of the reason codes of 'After Req. Date' and 'Damage' are analyzed in the dashboard. First, the reason codes of 'After Req. Date' in Figure 29. The main observation that must be made here is that the reason code 'No time left (end of the day)' is the most occurring in total. However, there is a decreasing line since the solution of the new Day Schedule is implemented in January. This has led to zero 'No time left (end of the day)' delays in January. Since the After Requirement Date is the category with the most delayed TOs, the new Day Schedule has worked out as an important solution for decreasing the delivery delays.

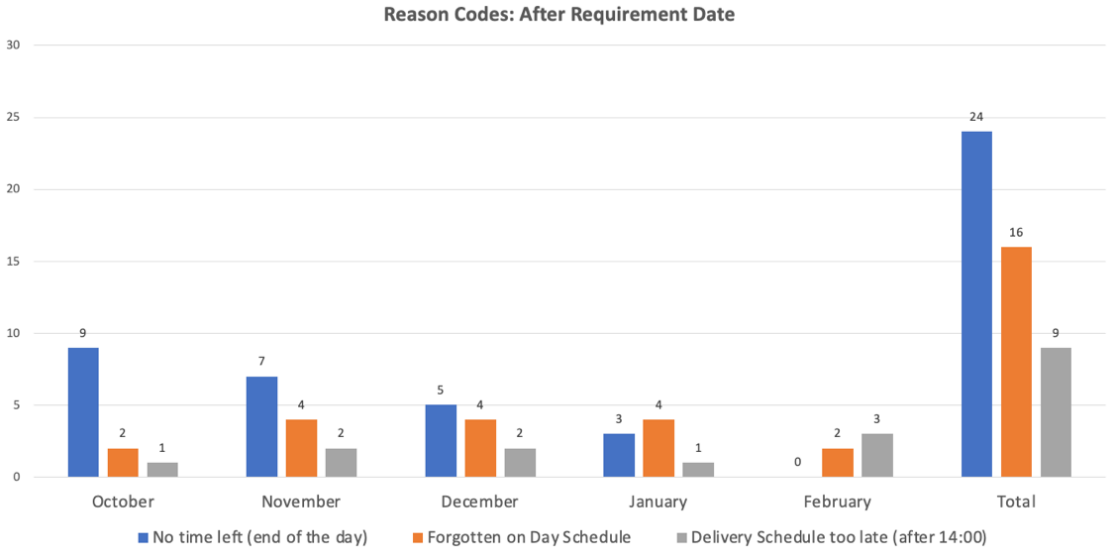


Figure 29: Overview of Reason Codes of After Requirement Date delays

Last, the reason codes for the yellow category, which is a pie in pie chart. On the left there are the three reason codes for the sub-categories of the yellow category and the green part, which are all damaged TOs, is after this divided into the right pie as it is the only sub-category from 'yellow' with multiple reason codes. The most occurring here is the 'hole in big bag for unknown reason', but as explained in Section 4.2.1, there will be no change in the short future as there is decided to not invest in higher quality big bags. The 'labelling mistake' and 'not included at CMR' are also both common reason codes with in total 59% and must be prevented by double checking in all cases. The last two reason codes, which are least common: 'Fell over during activities' and 'Forklift driver failure', could always be prevented in the future by offering training courses to the forklift drivers or hiring better ones. However, this is not an issue at the moment as these two are the least common reason codes.

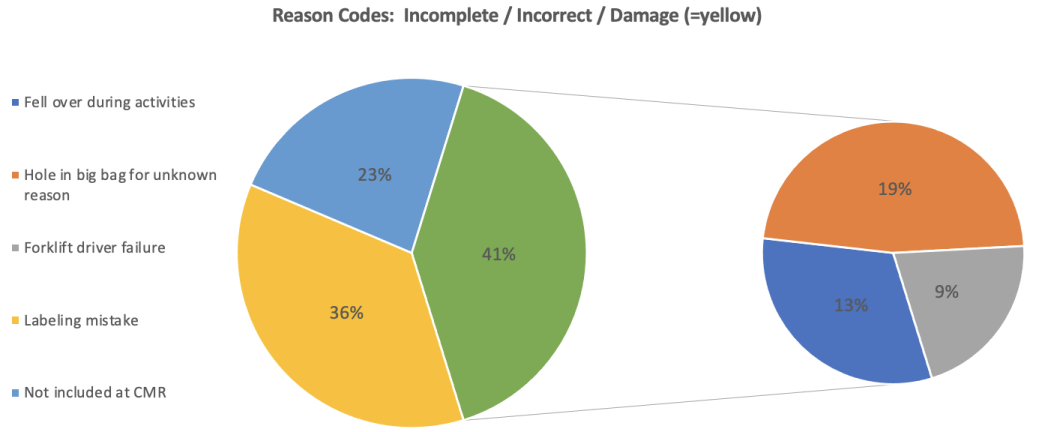


Figure 30: Overview of Reason Codes of Incomplete / Incorrect / Damage (=yellow)

5.1.3 KPI 3: Percentage of OEE loss due to a lack of material

In Section 2.3.4, the percentage of the OEE loss in the factory that was due to a lack of materials at the moment of production was analyzed over the first period: before moving to the new dedicated distribution center of Nabuurs. This percentage was at that moment 5,8% and therefore the target was set to have this percentage below 3% within half a year. The different categories of OEE loss have already been explained in Section 2.3.4, so the focus is on the OEE loss due to a 'lack of material' out of the 'supply failures' category. In total, four periods are compared as explained earlier. The complete analysis, in the same way as done in Section 2.3.4, is in Figure 31.

The second period, from June to August, is the onboarding window where all materials were moved from Frigolanda and Cornelissen to Nabuurs. In this period, the percentage was 3,8% which is still above the target. The third period, from September to November, which were the first months at Nabuurs, before further solutions were implemented the percentage was already at the target of 3% for the first time.

The last period is from December to February were almost all solutions were implemented. Here the percentage was again 3%. Unfortunately, the KPI was not below the target which was the goal. But it is very positive that the percentage is at the target over a quite long period. Also, the OEE loss from the third period was quite higher than it was in the fourth period so there can be concluded that the OEE loss due to a lack of material has decreased

after implementing the solutions from the previous chapter. Still, an important side note to make here is that a lack of material does not necessarily have to be due to a delay in delivery from the distribution centers, but that it can also be due to internal failure, even if the materials were already present in the pre staging area of the factory on time. Despite this sidenote, it is still a very important KPI in this research because the vast majority of this percentage is due to delivery delays, and it is a direct indicator about the extreme consequences that it can bring.

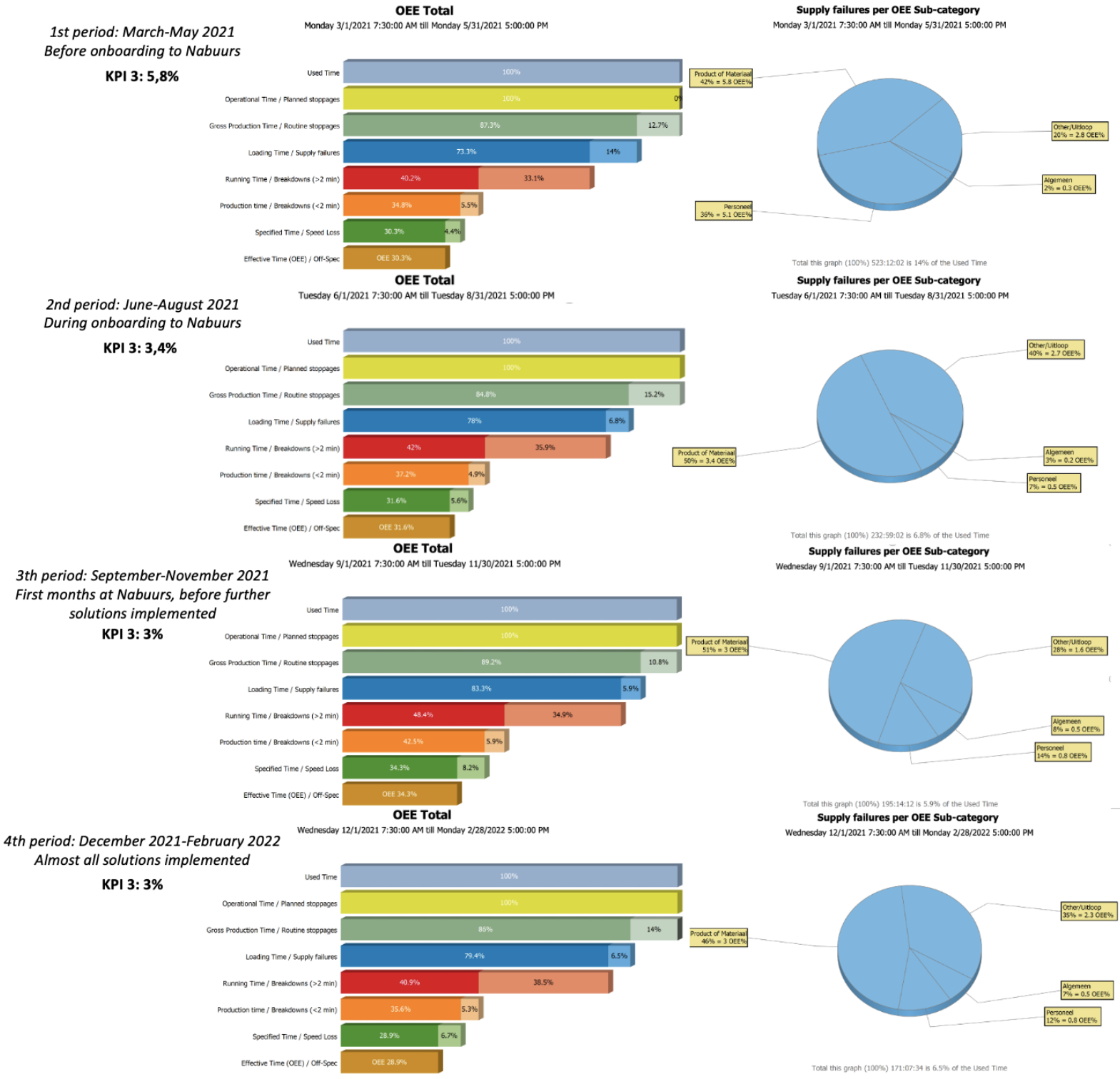


Figure 31: Analysis of KPI 3: OEE loss due to lack of materials over four periods

5.2 Review form for employees

Next to evaluating the outcomes of the KPIs, another approach of evaluating the solutions is by reflecting together with the employees that must work with them with the help of a review form. In Section 5.2.1, the review form is explained and in Section 5.2.2, the results of the form are thereafter analyzed.

5.2.1 Explanation of the review form

Earlier on the solutions were shortly explained in a presentation so the employees are able to implement them in the best way. Now they have worked with these solutions for almost two months it is time to reflect on them together. This is done by using a review form, which is a survey, where all solutions are separately reviewed. The employees have the choice to use the survey in English or Dutch. The employees that have filled in the review form are the ones that have the most to do with the solutions as explained in Chapters 2 and 4. These are the following ten:

- The five Team Shift Leaders of the Shipper Receivers at Mead Johnson
- Two employees of the Material Requirement Planning team of Mead Johnson
- The two most present Warehouse Managers of Nabuurs
- And last, the Senior Planning & Logistics Manager of Mead Johnson

The following solutions are reviewed separately. The legend for the statuses of the TOs are taken together with the Dashboard as they are used simultaneously. Next to this, the onboarding plan to Nabuurs is not included since it was only used during the onboarding period and not by the employees mentioned above. The statements of the review form are the same for every solution so the results can be optimally compared.

- Day Schedule using timeslots
- Dashboard & Legend for statuses TOs
- Escalation Model

The statements are most of all closed and can be rated on a scale of 1 to 5, where strongly disagree and 5 is the strongly agree. There is always the possibility the make additional comments or recommendations on the closed statements in the ‘Additional comments on closed statements’ part and it is asked to do so in case of giving a low rate to a statement.

5.2.2 Analysis of results from the review form

In Figure 32 the outcomes of the review form are displayed and by taking the averages per team. The average scores of the Day Schedule, Dashboard & Legend and Escalation Model are respectively 4,4, 4,5 and 4,4. This means that the Dashboard & Legend solution is rated the highest. Of course, the employees have given many compliments, but in order to search for possible improvements to the solutions, mainly the remarks and recommendations are analysed. The first one is of the Team Shift Leaders about the Day Schedule. The warehouse managers of Nabuurs were the most enthusiastic about this solution, but the Team Shift Leaders of Mead Johnson gave slightly less higher marks including the remark that the

expected arrival time and arrival dock could be included as the implementation was now too much focused on outbound for Nabuurs and not inbound for Mead Johnson. This is however easily solvable by adding two rows and let them fill in by the Inbound Planners.

Statements per solution / ***Different teams of employees***	**Team Shift Leaders of the Shipper Receivers at Mead Johnson**	**Material Requirement Planning team of Mead Johnson**	**Warehouse Managers of Nabuurs**	**Senior Planning & Logistics Manager of Mead Johnson**
Day Schedule using timeslots	*Average score of 4,4*			
I have enough previous knowledge to make use of the Day Schedule.	4,8	5	4,5	5
The Day Schedule is complete and contains no superfluous information.	3,4	4,5	4,5	4
The Day Schedule is useful and will help me in my daily work.	4,2	4	5	4
The Day Schedule is user-friendly and well understandable.	3,8	4,5	5	5
The Day Schedule has contributed a lot to the better KPI results.	4,5	4,5	4,5	5
Additional comments on statements	Team Shift Leaders: Include expected arrival time and arrival dock next to the TOs.			
Dashboard & Legend for statuses TOs	*Average score of 4,5*			
I have enough previous knowledge to make use of the Dashboard & Legend.	4,4	4	5	5
The Dashboard & Legend is complete and contains no superfluous information.	4	3,5	4	4
The Dashboard & Legend is useful and will help me in my daily work.	4,6	5	4	5
The Dashboard & Legend is user-friendly and well understandable.	4,8	5	4,5	5
The Dashboard & Legend has contributed a lot to the better KPI results.	4,2	4,5	4	5
Additional comments on statements	MRP team of Mead Johnson: Some superfluous information in the sheets (production line, job order), but not in Dashboard.			
Escalation Model	*Average score of 4,4*			
I have enough previous knowledge to make use of the Escalation Model.	4,8	4,5	4	5
The Escalation Model is complete and contains no superfluous information.	4,2	4,5	4,5	4
The Escalation Model is useful and will help me in my daily work.	4,2	4,5	5	4
The Escalation Model is user-friendly and well understandable.	4,4	4,5	3,5	5
The Escalation Model has contributed a lot to the better KPI results.	4,2	5	4	5
Additional comments on statements	Warehouse Managers of Nabuurs: The available time frame of 2 hours is sometimes too short, and the task description could be more extensive.			

Figure 32: Outcomes of the review form for employees

The main remark on the Dashboard & Legend was from the Material Requirement Planning team of Mead Johnson that there is still some superfluous information in the sheets like 'production line' and 'job order'. However, there is no superfluous information in the Dashboard where it is all about. According to the Senior Planning & Logistics Manager, a great addition would be to add a graph of the place of OEE loss within the factory to the Dashboard. The main compliments that were given was that the Legend was very user-friendly for the Team Shift Leaders and therefore uncluttered and that the Dashboard was very understandable and useful in the daily work of the MRP team and to make for the monthly analyses by the Senior Planning & Logistics Manager. The results on the escalation model were too very optimistic. The main comment here was from the Warehouse Managers of Nabuurs that the given available time frame of 2 hours was sometimes too short for them, and the task description could be more extensive. With that last remark they meant that a second scenario if the materials are not in stock could be included. The compliments were that mostly the problems were way earlier solved than in the time without a clear estimation model and everybody was unstructured looking for the right solutions. Also, the escalation model was found to be very well-arranged with exactly the right information.

5.3 Conclusion on this chapter

The total extra costs of transferring materials to Nabuurs before going to the factory, which is KPI 1, is positively influenced by the following consequences of the onboarding plan: less pallets are transferred than the estimation of 7500 and the average truck capacity was higher than estimated. This has led to an outcome of KPI 1 of €34644, with which the target of lower than €36000 has been more than achieved. And because of this, it can be concluded that the onboarding plan is successfully executed. One remark to make is that the onboarding from Frigolanda could have been done more time efficient as August is also used, but it had no influence on the outcome of KPI 1 since this delay was due to Frigolanda themselves. KPI 2, the percentage of deliveries from the distribution center to the factory that are On Time In Full, is reviewed making use of the Dashboard. Within half a year, this percentage has gone to 98,74% in the last month. This is an increase of 2,12% compared to the first month and so the target is achieved. The category 'After Req. Date' is the most occurring and because of this the focus is on improving its reason codes in the future. Its most occurring reason code 'No time left (end of the day)' has enormously decreased from 9 to 0 between the first and last month. This is mainly due to the renewed Day Schedule. Also, the target of the last KPI, the percentage of OEE loss due to a lack of materials, has been achieved by a decrease from 5,8% to 3% between the first and last period after all solutions have been implemented.

Last, a review form is made so the employees can reflect on the solution approach. In this review form, statements per solution are rated per team. Also, additional comments or recommendations are given on the closed statements. Especially if in case of giving a low rate to a statement. The average scores of the solutions were 4,4, 4,5 and 4,4 which are high. Every solution has one main remark that was given. The first is that the expected arrival time and arrival dock next to the TOs could be included in the Day Schedule for the Team Shift Leaders. The second from the MRP team of Mead Johnson is that there is some superfluous information in the sheets of the Dashboard file like production line and job order. And the last from the Warehouse Managers of Nabuurs is that the available time frame of 2 hours is sometimes too short and that their task description could be more extensive.

6. Conclusions

In this chapter, the main question is whether the knowledge problem **"**How can the late deliveries to the factory be decreased by onboarding all materials successfully to the new dedicated distribution center at Nabuurs?" has been answered. To answer this, many different aspects have been reviewed, like the norm made in the problem identification phase, the outcomes of the Key Performance Indicators, the whole process of coming to these outcomes, the opinions of the stakeholders and looking whether the solutions are future-proof. In this way the whole research optimally evaluated. After this, the research is discussed by looking at its limitations and other remarks. Last, a list of recommendations for both Mead Johnson as Nabuurs is made based on the research.

6.1 Evaluation

According to the problem owner, the norm that was determined before this research was that in about a half year time Mead Johnson Nijmegen should be fully onboarded in a successful way to the new distribution center and this should lead to a decrease in late deliveries to the factory. In this way, the downtime of the production lines in the factory due to this cause should decrease. It can be concluded that this norm has been achieved, especially since all targets of the three Key Performance Indicators have been met. The total extra costs of transferring materials to Nabuurs before going to the factory have turned out €1216 lower than the estimation of €36000 that has been set as target. The percentage of deliveries that are delivered On Time in Full has increased with 2,12% to 98,74% between the first and the last month after implementing all solutions. This is higher than the target of 98%. Also, the percentage of Overall Effectiveness Loss due to a lack of material is currently at the target of 3% over the last months after implementing the solutions. This percentage was 5,8% before onboarding to Nabuurs.

The whole process of coming to this outcome has been successful by getting through all steps of the MPSM. Not a single step was skipped and this way the problem is solved systematically. Each step helped enormously for the other because there was really no way to start the next step until the previous step was completed. The step that helped the most to generate solutions was the Value Stream Map from the Problem Analysis. A lot of work has gone into this by talking a lot with all employees involved and looking at the process on a daily basis. This made it easier to know what to focus on, namely the five red tasks. The literature also brought many new insights that supported the solutions generating phase.

Next to this, the implementations are experienced as guaranteed by the operators and other stakeholders. This can be concluded out of the results of the review form in Chapter 5. Nevertheless, there was also some feedback on the solutions, which has been reviewed in the previous chapter. The remarks are all additions to the current solutions rather than replacing them, which is positive. It can also be concluded from this that the solutions will continue to be used, whatever the employees themselves indicated. The solutions are also expected to be future-proof, since all tasks are done much more efficiently this way through the solutions, mostly in Excel, than compared to the old situations where there was far too much emailing and calling and everyone lost the overview. The assessment that the solutions are future-

proof is also made by the Senior Planning & Logistics Manager. At the end, all solutions contributed in their own way to the final outcome and so covered the problem as much as possible.

6.2 Discussion

Although the research is reviewed positively by the stakeholders and the outcomes of the KPIs are good, there are still some remarks that must be made. The first remark is that since the takeover of Nabuurs, the volumes in products per month and thus the number of materials sent to the factory have grown enormously. The fact that the volumes are going up means that Nabuurs' service will also have to go up. This may also have contributed to the increase in human error that often appeared in the reason codes. However, this is difficult to prove because the implementation of solutions and the increase in volumes happened simultaneously and it is therefore difficult to establish a link since you are dealing with two variables. That is why we have kept the increases in volumes outside the scope of this research.

Another point of discussion is that the research is only conducted once at one company in a limited time frame. To have real proof that the solutions work, the same research should be conducted multiple times and in other circumstances so at other companies and the results should be reviewed over a longer period. Something that is also difficult in the reviewing part of the research is that all solutions are implemented simultaneously. In this way, it cannot be proved how much a solution has contributed to the end result. It could be possible that mainly one solution has led to the good KPI results, but this cannot be analysed. The only way the solutions could be compared is by analysing the outcomes of the reform form, which is done in Section 5.2.2.

The last point of discussion is the relevance of the reason codes. Over the last months, these were the reason codes that were most occurring in case of deviations. However, this could change over time and therefore the dashboard must continue to be analysed in the future. In case changes occur, the reason codes could always be changed into others.

6.3 Recommendations

With the results of this research, Mead Johnson and Nabuurs have a starting point for decreasing the delivery delays. Based on the outcomes, there are some recommendations to be made to both companies, which are the following:

- Above all, one will have to continue to use the solutions from Section 4 and continue to analyse the KPIs and results from the dashboard on a monthly basis to see if the results remain good and to look where improvements must be made. This way you also keep the awareness among all staff of how important the problem is.
- As advice to Nabuurs: keep reducing the most common reason codes as much as possible. The 'no time left' has already been solved well and now the focus can be on, among other things, the reason codes 'forgotten on day schedule', 'labelling mistake', 'not included at CMR' and 'forklift drives failures'. These are all human errors. In case

the numbers get too high, one could think of additional training of the employees or the hiring of higher qualified personnel. A final piece of advice to Nabuurs is to have three TOs ready at the docks every morning so that they are not left behind later. In this way the reason code 'no time left' is further decreased.

- From now on, Mead Johnson must make the delivery schedules for the weekends on Thursday instead of Friday and send them on time every day. In this way, Nabuurs can determine the workload for the weekend (how many staff / how many hours) on time and with this they can make a better planning so that there is more delivered On Time In Full.
- Last, if the results decline and Nabuurs fails to do its job, it is always possible to look at tightening the Service Level Agreement with the help of sanctions as discussed in Section 2.3.2. Fortunately, this is not relevant now as the process is going well and the results are good. It was recommended not to immediately tighten the SLA as explained in the relevant section. Nevertheless, it can always be a last resort in the event of a lapse.

Bibliography

- Fernando, J. (n.d.). Learn What Stakeholders Are and the Roles That They Play. Retrieved 15 April 2021, from https://www.investopedia.com/terms/s/stakeholder.asp
- Mendelow, A. L. (1991) 'Environmental Scanning: The Impact of the Stakeholder Concept'. Proceedings From the Second International Conference on Information Systems 407-418. Cambridge, MA.
- Sugrue, C. (2011, May 13). Professional Responsibility. Retrieved 7 May 2021, from https://books.google.nl/books?hl=nl&lr=&id=2uDgAwAAQBAJ&oi=fnd&pg=PA11&dq=professional+responsibility+meaning&ots=493KMMMwHe&sig=iWc_KZCdlqGT9eVLYwDH1bv12ac&redir_esc=y#v=onepage&q=professional%20responsibility%20meaning&f=false
- Rehman, A. A., & Alharthi, K. (2016, October 1). An introduction to research paradigms. Retrieved from https://www.researchgate.net/publication/325022648_An_introduction_to_research_paradigms
- Monton, B. (2021, April 13). Constructive Empiricism (Stanford Encyclopedia of Philosophy). Retrieved from https://plato.stanford.edu/entries/constructive-empiricism/
- Weustink, T. (2018). Het reduceren van afsteltijd ten gevolge van ombouwen. Enschede: Universiteit Twente.
- Heerkens, H., & van Winden, A. (2017). *Solving Managerial Problems Systematically*. Noordhoff Uitgevers.
- Perkins, W. S. A. W. T. B. K. (2021, 28 oktober). What is supply chain management? Mastering logistics end to end. CIO. Retrieved on 29 October 2021, from https://www.cio.com/article/2439493/what-is-supply-chain-management-mastering-logistics-end-to-end.html
- Profile, B. P. H. V. (2021, 10 September). Definition, tools and advantages of Lean Management. Manutan. Retrieved on 29 October 2021, from https://www.manutan.com/blog/en/glossary/lean-management-definition-and-tools
- Slack, N., Brandon-Jones, A., & Johnston, R. (2016). *Operations Management* (Eight edition, Vol. 2016). Pearson.
- Myerson, P. (2017). *Lean Supply Chain and Logistics Management.* Van Haren Publishing.
- King, J. S., & King, J. S. (2015). *Value Stream Mapping for the Process Industries.* Taylor & Francis.
- Stamatis, D. H. (2010). *The OEE Primer: Understanding Overall Equipment Effectiveness, Reliability, and Maintainability.* Productivity Press.
- Fernando, J. (2022, 17 maart). *Economic Order Quantity (EOQ)*. Investopedia. Retrieved on 21 April 2022, from https://www.investopedia.com/terms/e/economicorderquantity.asp
- Coetzee, R., Van der Merwe, K., & Van Dyk, L. (2016). LEAN IMPLEMENTATION STRATEGIES: HOW ARE THE TOYOTA WAY PRINCIPLES ADDRESSED? South African Journal of Industrial Engineering, 27(3). https://doi.org/10.7166/27-3-1641
- Monden, Y. (2011). Toyota Production System. Taylor & Francis.
- Sutherland, J., & Bennett, B. (2007). The Seven Deadly Wastes of Logistics: Applying Toyota Production System Principles to Create Logistics Value. Lehigh University.

Appendices

Appendix 1: Research Methodology

The phases of the MPSM, the 'Managerial problem-solving method' of (Heerkens & Winden, 2017), will be used to structure the research (Figure 2). The emphasis of the research will be on the following four phases: 3. 'Problem analysis', 4. 'Generating solutions', 6. 'Implementation' and 7. 'Evaluation'. The five research questions mentioned above have been formulated for these four phases, including a few sub-questions in order to define some of the research questions more clearly.

Figure 2: The seven phases of the 'Managerial problem-solving method'

The first two phases of the MPSM do not contain any research questions since they are already part of this project plan. In phase 3, the problem analysis, the first research questions will be answered.

Phase 1: The problem identification

In the first phase of the MPSM, the action problem has been defined. This is done by investigating the reason of the problem and the norm & reality, linking all problems in a problem cluster, and defining the core problem statement.

1. Reason of the action problem
2. Norm & reality
3. Problem cluster
4. Core problem statement

The outcome of this first phase of the MPSM can be seen in the above Section 1.2. 'Problem Identification'.

Phase 2: The problem-solving approach

Before the problem is analysed more deeply and the solutions are generated, the solving approach of the problem should be defined in this second phase of the MPSM. This is done by carrying out the following steps, all in this Section 1.3 'Problem solving approach':

1. Knowledge problem & research questions
2. Research methodology
3. Type of research
4. Types of data used in the research
5. Theoretical support
6. Assessment of validity and reliability of measurement
7. Scope & Limitations
8. Deliverables

Phase 3: The problem analysis

It is important for the research to first define the problem features clearly. Therefore, before looking how to improve the logistics performance at Mead Johnson, the current situation should be analysed first. This will be done in the first research questions, which includes three sub-questions. In the first sub-question, there will be elaborated on the problem features at the situation of the current supply chain by having multiple distribution centers and of course sketching what it will look like in the future by having one dedicated distribution center at Nabuurs including its possibilities. For this, also some literature about supply chain management and lean management will be used to get a good picture of the current and new desired supply chain.

To move to Nabuurs there should be analysed what needs to be taken into account to make a successful onboarding plan. This will be done in the second sub-question of the first research question. Also, in the third sub-question an analyse must be made of how the delivery delays are currently addressed and what the main causes of these delivery delays are. This will help with generating solutions in the next phase, since the problem becomes clearer. The most important way of answering this research question will be by holding interviews with colleagues at Mead Johnson and people at Nabuurs. Also, the contract between Mead Johnson and Nabuurs will be analysed to have clear what the agreements and targets are.

Mead Johnson has not dealt earlier with these problems. This means that new measurable definitions must be defined, called Key Performance Indicators (KPIs). However, the exact way of measuring them is not clear. Therefore, this must be investigated in Research Question 2 before generating solutions and implementing them. It is already clear that the KPIs depend on many different variables. This means that the links between these variables and the KPIs also must be investigated. Important is that the measurements of the KPIs will be valid and reliable. In order to answer this research question, literature will be used to go into the KPIs.

Phase 4: Generating solutions

Once the current and future situation including the problems are defined and we know how to operationalize the KPIs, it is time to know how to optimize them. In this way, the problem can actually be solved. This means that in Research Question 3, the following two questions must be answered: how can all materials successfully be onboarded at Nabuurs without making unnecessary transfer costs? And how can the number of hours in the week that the production lines in the factory are stopped due to delivering too late from the distribution center be decreased? These questions will be answered with the help of Phase 3 of the MPSM where the problem is analysed. With the knowledge from Research Questions 1 & 2 and new interviews with people at the planning and logistics department of the company, possible solutions will be generated.

Phase 5: Making decisions

After the possible solutions are generated in the previous phase, decisions have to be taken in Phase 5. Together with my supervisor at the company, I will continuously think about which solution is the best for the action problem. This means that we will decide together which solution will be worked out in the implementation plan. The decision is based on our opinion on the chance of success and the feasibility of the solutions.

Phase 6: Implementation

In this phase, implementations from the previous research question are carried out and fully described step by step including explanation of the decisions. This does also mean that all deliverables mentioned in Section 1.3.4 'Deliverables' are part of this Research Question 4. At the moment it is not clear how the implementations will look because the possible solutions are not generated yet and so no solution is chosen. In this phase, the implementations will become fully clear by executing the chosen solutions.

Phase 7: Evaluation

The implementations must be guaranteed, and this must also be experienced as such by the operators and other stakeholders. The improvements should be checked using the previously defined concepts for standard and reality. And in the end, the colleagues should be completely satisfied with the results. In Research Question 5, which is part of the evaluation phase, the new reality will be compared with the desired norm from the problem identification phase. This will be done by reviewing the changed values of the Key Performance Indicators, the whole process of coming to this outcome and looking at whether the outcome is future-proof.