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Improving the container planning (process),
by means of a planning tool

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Management Summary

With the aim to make the container planning (process) more efficient, this report describes a solution to digitalise and optimise the process and planning. The solution is a planning tool, for which a minimal viable product version has been developed.

Motivation of research

The logistics service provider (LSP) in this study, is a customer of CAPE Groep. The LSP delivers total outbound logistic solutions for cooled and frozen products. The global forwarding department of the LSP is responsible for the planning of the deep-sea containers. This department is experiencing an increased workload due to the rapid growth in the transport of overseas products.

The goal of this study is to come up with a solution that will improve both the workload of the global forwarding department and the accuracy of the container planning. To reach this goal, the following main research question is answered during the study:

“How to improve the container planning (process), by means of data processing and visualisation of this data in a planning tool?”

Methodology

To answer the main research question, the current situation of the planning process has been mapped out. By mapping out the current situation, it was possible to make a better analysis of the problems that occur during the planning process. Together with the planners of the LSP and the analysis of the current situation, a preferred situation was drawn up. To see if the solution would work in the preferred situation, a prototype has been made. This prototype functions as a validation for the solution.

Conclusion & Evaluation

The proposed planning tool is of great added value for both the efficiency and improvement of the planning process. The time to process one container is reduced by more than 60% and the steps taken by the planner are reduced by 50%. The moments that an error may occur during the processing of data, is reduced by more than 80%.

Because of the planning tool, the calculation of the time windows is also more accurate. The calculation of a time window is 38% more precise. In addition, the planning tool has shown that the manual steps in the cold store planning process can be fully automated.

Recommendations

The developed prototype is a Minimal Valuable Product, which needs to be developed further. The algorithm does the calculation which the planner did and is able to calculate a more precise time window, by using additional data. The algorithm can be expanded so that the time window will be even more accurate.

Preface

This report is the result of the bachelor thesis which I have conducted to complete my bachelor Industrial Engineering and Management at the University of Twente. In this research, I studied the container planning (process) of an LSP and investigated how the planning, as well as the process, could be improved by means of a planning tool.

I am very grateful to CAPE Groep for their cooperation and the opportunity to develop myself. In particular, I want to show my gratitude to Maik Wesselink for his time and guidance during the study. Who was always available for questions or brainstorm sessions about the possibilities within the study. I would also like to thank all employees of CAPE Groep, for answering my questions and thinking along with me during this study. Furthermore, I want to thank the LSP for the opportunity to carry out this study and test the prototype in their process.

Finally, I would like to thank my supervisors from the University of Twente, Maria Iacob and Lucas Meertens for their guidance during my bachelor thesis. Their feedback provided valuable additions to the research.

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Enschede, August 2018

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List of abbreviations

<i>Abbreviation</i>	<i>Full name</i>
ALI	Artificial Logistics Intelligence
API	Application Programming Interface
BCO	Booking confirmation
BPD	Business Process Diagram
BPMN	Business Process Modelling Notation
DSRM	Design Science Research Methodology
IoT	Internet of Things
LIOT	Logistics Internet of Things
LMS	Logistic Management System (Mendix application)
LSP	Logistics Service Provider
MPSM	Managerial Problem-Solving Method
MVP	Minimal Viable Product
NVWA	Netherlands Food and Consumer Product Safety Authority
REST	Representational State Transfer
SOAP	Simple Object Access Protocol
STA	Scheduled Time of Arrival
STD	Scheduled Time of Departure
VAL-info	Value Added Logistics information
VGM	Verified Gross Mass

1. Introduction

This first chapter introduces the research that is carried out at CAPE Groep and an LSP. First, all parties involved are mentioned shortly. Then, the problem is discussed in the problem identification. Furthermore, the research questions are set out per phase of the chosen research methodology. Finally, the scope of the research and the structure of this report are described.

1.1. Companies involved

The following companies are involved in the research of this report. Therefore, each company is discussed shortly. Finally, the research is discussed, on which this study is based.

1.1.1. CAPE Groep

CAPE Groep is a fast-growing consultancy company in Enschede. Based on the customers' business strategy and objects, CAPE Groep develops a business case and a roadmap together with their customers. CAPE Groep delivers services in the areas software development, connectivity, integrations, business intelligence, reports and cloud computing. With long-term relationships, CAPE Groep tries to create synergy between people, methodology, and technology to be agile and innovative in the long term.

The IT-solutions provided by CAPE Groep are made with two model-driven programming software. Mendix is used to create tailor-made applications for the client. eMagiz is used to connect the Mendix application with the existing infrastructure of the customer.

1.1.2. Logistics service provider (LSP)

The logistics service provider (LSP), in this report, is a customer of CAPE Groep. The LSP delivers total outbound logistic solutions for cooled and frozen food. For the past eight years, the LSP delivered solutions for one company (company X). In the near future, the LSP wants to take on other customers as well.

1.1.3. Company X

Company X is a frozen food producer and has customers worldwide. Company X has always had their own logistics department, however, the company kept growing and the logistics needed to be outsourced. Resulting in the founding of the LSP, which is established by company X.

1.1.4. Cold Store

Two cold stores are used in this report. One is located on the Maasvlakte (Netherlands) and the other in Lommel (Belgium). Products from company X are transported to the cold store, where they are stored until needed for a shipment. When products are needed, they are loaded into a container at the cold store.

1.1.5. INTTRA

INTTRA is an ocean trade platform where members plan, book and track their shipments. Members are shippers, carriers, and logistics service providers. The LSP in this report uses INTTRA to communicate with the carriers.

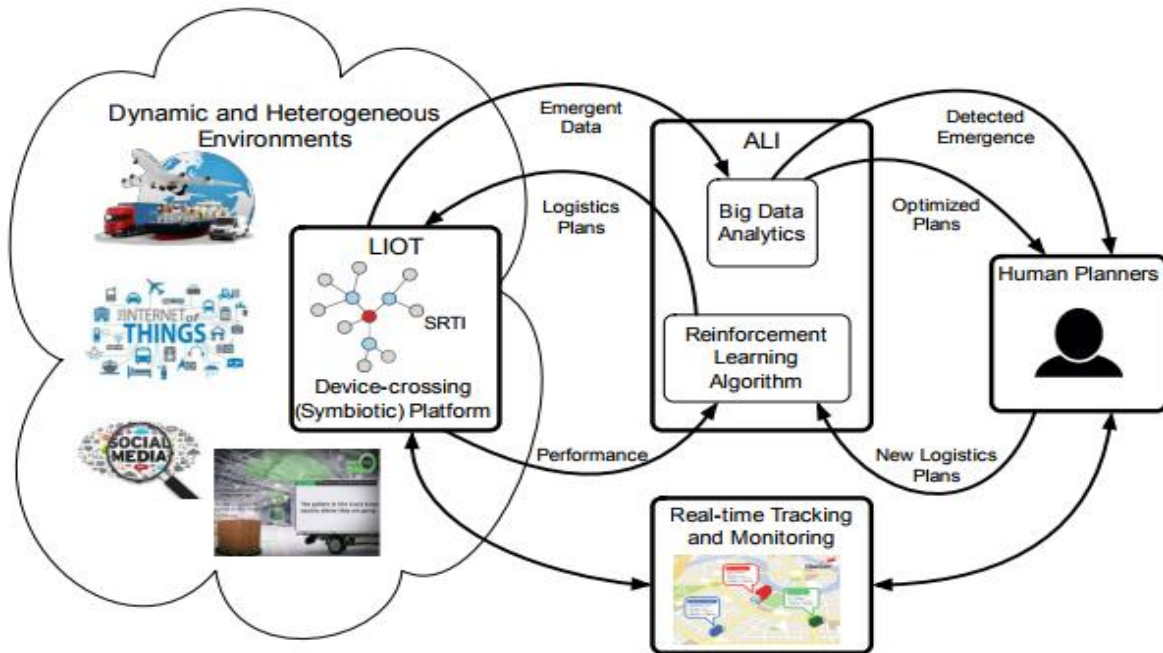


Figure 1: The Datarel project

1.1.6. Datarel project

CAPE Groep and the LSP collaborate with other companies on the Datarel project. The Datarel project aims at discovering the emergence from daily logistic supply chain through enhancing extant IoT platform and novel big data solutions, to improve the resilience and efficiency of real-time quality control and planning (Figure 1). This report focuses on the right side of this figure. A more optimal planning is made, through the use of data analytics and an algorithm, to help the human planner.

1.2. Problem identification

As mentioned before, the LSP manages the outbound transport for company X. Figure 2 shows the outbound logistic chain. The LSP is responsible for the area within the dotted rectangle. Via trucks, the products are transported locally. With deep-sea ships, the products are transported worldwide. The focus in this report is the container transport via deep-sea ships.

The potato products from company X are transported by truck to the cold store on the Maasvlakte and to the cold store in Lommel. In the cold store, the products are stored until they are needed in a

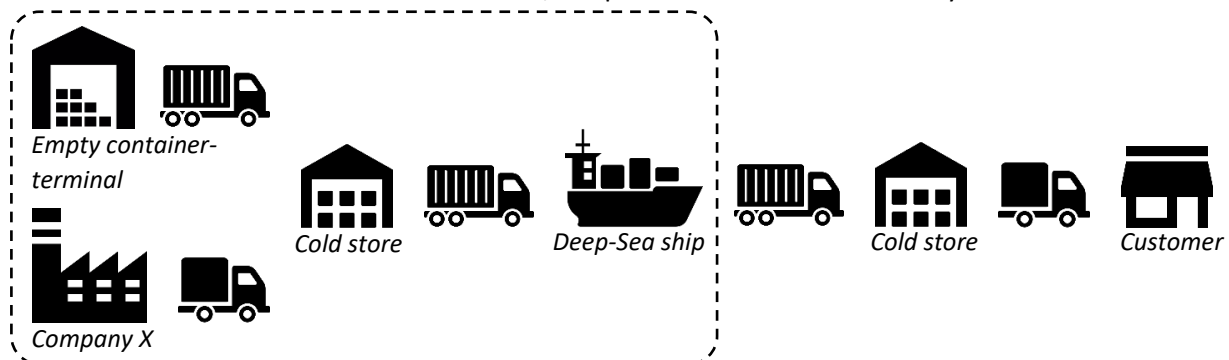


Figure 2: Outbound logistics chain.

shipment. Time of stay of these products ranges from 2 days to a couple of months. The products are shipped from the port of Rotterdam and the port of Antwerp to the rest of the world.

When a shipment is planned, an empty container needs to be picked up from the empty container terminal. Here the container is loaded on a chassis, which is from then on occupied and cannot be used for other containers. The chassis is available again when the container is delivered to the ship. This occupation time can be up to 2 days.

When the empty container arrives at the cold store, the products are loaded into the container. Loading a container with products stored on pallets will take around half an hour. When additional services are required, it can take up to three hours to load a container. The container needs to be loaded 24 hours before the vessel will arrive at the port of Rotterdam. Also, a container needs to be loaded before the VGM closing time. The verified gross mass (VGM) needs to be sent to the carrier. The weight of the container determines the place of the container on the deep-sea ship. If necessary, the cold store can hold a container for 1 to 2 days maximum.

The global forwarding department of the LSP is responsible for the planning of the containers. This department is experiencing an increased workload due to the rapid growth in the transport of overseas products from company X. The predicted number of containers that need to be planned in 2018 was 7500, but the latest expectations are around 9000 containers. A team of five people is responsible for the planning of these containers. In the last years, the total time for planning one container has already improved from 70 minutes to 50 minutes. This improvement is supported by the methodology and Mendix solutions of CAPE Groep. The increasing number of containers from company X and the plans of the LSP to take more customers drives the ambition to keep improving the planning process.

During an introduction meeting at the LSP, the Datarel project was discussed more in detail and multiple points of improvement within the LSP were also discussed. One part was the improvement of the collection, storage and use of data within the planning process, to improve the planning (process).

1.2.1. Problem cluster

To get an overview of the process and the accompanying problems, it is useful to make a problem cluster (Heerkens & van Winden, 2012). Figure 3 shows how the problems in the planning process are related to each other. The arrows show the consequences of a problem.

The global forwarding department has two action problems. The first one is a high workload in the department, the second one is a container planning which is not optimal. The high workload has three causes. The first one is that the number of containers that need to be planned is increasing. This on itself is not that bad, but as a result, the workload increases. Second is solving problems. Because of uncertainty at third parties (e.g. no delivery of empty containers and the delay of deep-sea ships), the planners need to solve problems instead of their normal work. This also increases the workload.

Last is that the planning process takes a lot of time. This because containers need to be re-planned and because data processing is not optimal. The latter is due to many data sources used, manual data collecting and processing of data, and the fact that there is not a central overview of all data available. Another result of the inefficient data process is that not all data available is used to plan containers, and

1.2.3. Focus of assignment

The planning process consists of several sub-processes that could benefit from automatic data processing, but the focus of this report is the part where a loading time for a container is determined. From the interview and observation studies appeared that in the short-term, the global forwarding department benefits most from a solution in this part of the process. Also, a solution in this part of the process will improve both the container planning and the workload. When a solution for this part of the planning process is made, the LSP can implement it in other parts of the planning process as well.

1.2.4. Variables and indicators

The core problem needs to be made measurable with variables. If a problem is measurable, the effect of the solution on the problem can be examined. The 'reality value' reflects on the current situation and the 'norm value' is the desired value (Heerkens & van Winden, 2012). The reality value of the problem is: "manual data processing". The norm value of the problem is: "automatic data processing". These variables are not very clear and hard to measure. To make these variables measurable, indicators are added to the variables.

The first indicator is "time needed to plan a loading time for one container". This indicator shows how much time will be saved, with the implementation of the planning tool. The second indicator is "number of steps needed to plan a loading time for one container". A reduction in the number of steps taken by the planner indicates a more efficient planning process. The third indicator is "data transfer error moments". In the current planning process, there are a lot of manual data transfer moments. In these moments, data transfer errors could occur. Due to automation of the process, there are fewer manual data transfer moments. This results in a decrease of the data transfer error moments. The last indicator is "average length of time window". To calculate the time window, an algorithm is made. A more precise calculation of the time window decreases the length of the time window.

The reality values are known, but the norm values are not. The values of the norm are based on the desired and achievable values, according to the planning department. The opinion of the planners is used because for me it is hard to give an achievable norm to these indicators. The values of the indicators are shown in Table 1.

	<i>Reality</i>	<i>Norm</i>
<i>Time needed to plan a loading time for one container (mm:ss)</i>	1:00	0:30
<i>Number of steps needed to plan a loading time for one container</i>	8	2
<i>Data transfer error moments</i>	6	0
<i>Average length of time window (hours)</i>	48	24

Table 1: Value of the reality and norm indicators

1.2.5. Relevance of the solution

As mentioned earlier, the focus of this report is the process where a loading time for a container is determined. A solution improves the job efficiency of the planner. Less time is needed for planning the container, and as a result, the planner can focus more on solving the problems that occur through uncertainty.

Solving the problem in this part of the process opens opportunities to other processes in the planning process as well. For this part, research is done, and a solution is found. The knowledge acquired during the study can be used to implement the solution in other parts of the planning process.

The knowledge acquired opens, for example, an opportunity to track and trace containers. In combination with automated data collection, an up-to-date overview of all container positions can be made. With this overview, it would be possible to track and trace containers. At this moment, the LSP has not an overview of where all containers are and if they are delayed. As a result, the customer does not know if the container is on time.

Also, the part of the planning process where a sailing is booked may benefit from this study. With an automated data collection method and an automatic data process, a tool could search for a sailing at the carrier and an algorithm could choose a sailing based on variables set by the global forwarding department.

1.3. Methodology & Research questions

The goal of this study is to come up with a solution that will improve both the container planning and the workload of the global forwarding department. The solution is in the form of a planning tool. This planning tool helps the planner to determine a loading time for a container, by calculating the time window. To come up with a solution, the following main research question is answered in this report:

“How to improve the container planning (process), by means of data processing and visualisation of this data in a planning tool?”

The Design Science Research Methodology (DSRM) is used during this study. The DSRM is developed for producing design science research in information systems and focusses on solving a problem by doing an investigation and making a prototype to solve the problem and validate the solution. The DSRM has six phases as shown in Figure 4 (Peffer, Tuunanen, Rothenberger, & Chatterjee, 2007).

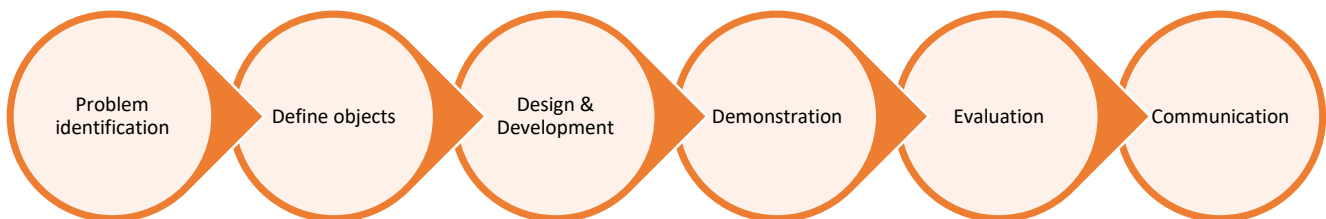


Figure 4: Phases of the DSRM

The managerial problem-solving method (Heerkens & van Winden, 2012) was kept in mind during the study. But this is not the main methodology used.

Phase 1: Problem identification

The first phase of the DSRM is the problem identification. In this phase, the specific research problem is defined, and the value of a solution is justified. Also, the current situation is researched. Interview and observations studies are conducted to study the current planning process. The data collected during these studies is used to draw up a BPMN model and textual analysis of the current situation. These

results are validated by a planner of the global forwarding department. The following research questions are researched in this phase:

1. *What does the current planning process look like?*
 - 1.1. *What data and data sources used in the planning process?*
 - 1.2. *What data and strategy are used to plan a loading time for a container?*
 - 1.3. *What problems occur during the planning process?*

Phase 2: Define objects

In this phase of the DSRM objectives for the potential solutions are studied. This phase discusses what will be achieved with the solution, describes what the impact of the solution is and what is needed to come to the solution.

Phase 3: Design and Development

This is a phase with a lot of activities. In this phase, potential solutions are examined and the solution objectives from the LSP for the solution are formulated, through interviews with the planners. Based on the solution objectives, a prototype is built to validate the solution. The solution design of the prototype is made in sprint 0. The prototype is developed in two sprints of two weeks each. An important part of the planning tool is the algorithm that calculates the time window. A literature review is done to know what kind of algorithm is used by the planning tool. The following research questions are answered in phase 3, in order to design and make a prototype:

2. *What algorithm could be used to calculate a time window?*
3. *What will be the solution design of the planning tool?*
 - 3.1. *How does the preferred planning process look like?*
 - 3.2. *What requirements does the LSP have for the planning tool?*

Phase 4: Demonstration

In phase 4, the prototype is implemented and tested by a planner of the LSP. It is important to find out if the prototype works and if it contributes to solving the problem. Before the prototype is implemented, the planner is explained how the prototype works.

Phase 5: Evaluation

In the evaluation phase is validated if the prototype has improved the container planning and the workload. The indicator norms set in advance are compared with the test results. Based on this evaluation, further research is described.

4. *Does the proposed solution meet the goals and requirements?*

Phase 6: Communication

The last phase is about communicating the problem, its importance, the solution and the outcomes to the public. This is done through this report.

1.4. Scope of the assignment

A prototype has to be demonstrated extensively in order to validate the results of the prototype. After the demonstration, a prototype can be evaluated and improved. To let the planner work with the prototype properly, he needs to be trained on how to use the prototype. Because of the limited time and the availability of the planner, the demonstration and evaluation of this prototype are done in one week.

The information about the data that the cold store uses to plan a loading time of a container (section 4.2.), comes from the planner at the LSP. To make a fully optimal planning, it is important to validate at the cold store what data they use to plan a loading time. But at this moment it is not possible to validate the information at the cold store.

1.5. Structure of the report

<i>DSRM phase</i>	<i>Section</i>	<i>Research questions</i>
Problem identification & Define objects	1. Introduction	<p><i>1. What does the current planning process look like?</i></p> <p><i>1.1. What data and data sources used in the planning process?</i></p> <p><i>1.2. What data and strategy are used to plan a loading time for a container?</i></p> <p><i>1.3. What problems occur during the planning process?</i></p>
	2. Current process	
Design and Development	3. Theoretical framework	<i>2. What algorithm could be used to calculate a time window?</i>
	4. Preferred planning process	<p><i>3. What will be the solution design of the planning tool?</i></p> <p><i>3.1. How does the preferred planning process look like?</i></p> <p><i>3.2. What requirements does the LSP have for the planning tool?</i></p>
	5. Design and development	
Demonstration	6. Demonstration	
Evaluation	7. Evaluation	<i>4. Does the proposed solution meet the goals and requirements?</i>
	8. Conclusion	

Table 2: Structure overview of the report

2. Current planning process

In this section, the current situation of the planning process at the LSP is mapped out and analysed. The current situation is based on interview and observation studies, conducted at the LSP. It is important to map out the current planning process, to draw up requirements for a solution and to compare the new situation with the current situation.

In 2.1 the responsibilities of the global forwarding department at the LSP are discussed. The planning process is divided into two parts, which are discussed in 2.2 and 2.3. The first part is about the booking of a sailing. The second part is about the planning for the cold store, which is the focus of the study. In 2.5 an answer to research question 1 is given.

2.1. Global forwarding department

The LSP has a global forwarding department that is responsible for the planning of containers on deep-sea ships. The team consists of five people, each responsible for a specific task within the planning process:

- Shipment planner, responsible for booking a sailing for a container.
- Cold store planner, responsible for planning a loading time for the container at the cold store.
- One person is responsible for the documentation.
- There is one person responsible for the carrier selection.
- Coordinator, responsible for the global forwarding department.

In Appendix A, there is a BPMN model of the planning process. The planning process is divided into three parts: shipment planning process (green area), cold store planning process (red area) and the last task is to notify the truck carrier to pick up the container. Both processes are discussed in more detail, to clarify the BPMN model.

2.2. Subprocess 1: Shipment planning

When an order is sent from company X to the LSP, it appears in the Mendix application, Logistic Management System (LMS), of the LSP and in Mitoz. Mitoz is a program only used for the paperwork to the invoicing company. The incoming order is printed, and a paper dossier is made.

Then a sailing is booked. A sailing is based on the following data:

- Scheduled Time of Arrival (STA) at the port of arrival.
- Value Added Logistics information (VAL-info), preferred date of departure.
- The preferred carrier to the destination.
- Port of departure.

When a sailing date is determined, the planner will first look in their database. In this database are all the previous sailings saved, but this database is not up-to-date. So, when a ship has a delay, it is not updated in the database. If there is a ship leaving on the same date as the container, the planner can choose the sailing in the database. The planner still has to check, if the ship will be on time. If there is no ship leaving on the same date as the container, the planner will search on the site of the preferred carrier if there is a sailing available on the planned date of sailing. When a sailing is found, it is inserted into the database. The details of the sailing are sent to the carrier via INTTRA. The carrier will send the LSP a booking confirmation if the container can be shipped with the chosen sailing.

This confirmation is verified with the data of the LSP. If the data does not correspond, a mail with the correct info is send to the carrier and the carrier will send a new booking confirmation. If the data does correspond, a time window needs to be planned. All data collected during the shipment planning part of the planning process is stored in the LMS.

2.3. Subprocess 2: Cold store planning

In this part of the process, a time window for loading a container is determined. This is not the actual planning, but a proposal to the cold store. The LSP uses the following data to determine a time window for a container:

- VGM closing time: (Verified Gross Mass) Time when the weight of the container needs to be reported to the carrier. This is important for where a container is loaded onto the ship.
- VAL info: A customer can have a preferred or binding loading date for the container.

At the end of each day, an email is drawn up. This email contains all the containers, plus time windows that were planned that day. This email is sent to the cold store, which plans time slots for the containers. These time slots are forwarded to the LSP. The cold store has also data which they use to plan a container in a certain time slot:

- SGS inspection: The inspection of containers is done between 06:00 and 15:00, also it is desirable if containers that need inspection are filled after each other.
- VAL-info: If customers have additional requirements it can take more time to load a container. There are three slots A, B, and C, with respectively loading times of 1 hour, 1,5 hour and 3 hours.
- The number of order lines: If a shipment has multiple order lines, it will take longer to fill the container.

When a final loading date and time is set, it is processed in the LMS and a booking confirmation (BCO) is sent to company X and the invoicing company. A day before the container is loaded, a reminder to a truck transporter is send. Figure 5 shows a detailed overview of the cold store planning process.

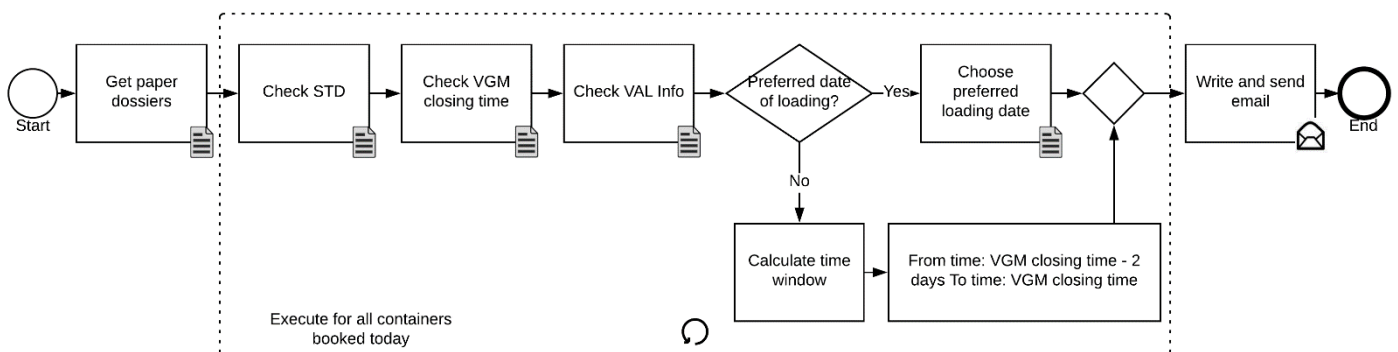


Figure 5: Current cold store planning process

2.4. Analysis of the current process

By mapping the current process, it is possible to make a better analysis of the problems that do occur during the planning process. In the problem identification phase, it became clear that the two action problems 'high workload' and 'planning not optimal', had a number of different causes. The following causes were given:

- Data collection is a manual process.
- Data processing is a manual process
- No central overview of all data available.
- Many data sources used.

These causes were based on interviews. Now that the current situation has been clearly mapped, it can be checked whether these causes are still correct, and the details of these causes can be discussed.

During the interview and observation study, it appeared that the global forwarding department of the LSP already has a good view of how the process works, and what problems do occur during the process. There are many ideas and thoughts on how to solve these problems, but not the knowledge to actually solve them. Also, there are many ideas for further improvements.

During the study, it was noticed that almost all data is searched and processed manually. The search for a sailing at the carrier is done manually, most of the data needs to be inserted manually, the planning for the cold store is made manually and the validation of data is also done manually. Data found in the processes is saved in the LMS of the global forwarding department, but processing and inserting the data manually takes a lot of time and it is sensitive for typing errors.

An example of a problem is the email which is written at the end of the day. This email contains all the containers, with their time windows. All this data is stored online, but still, the container numbers and the time windows are typed in manually. This is not efficient and there is a big risk of typing errors.

Multiple data sources are used during the whole planning process. The first sub-process is to book a sailing at the carrier. For every container, the planner needs to visit the site of the preferred carrier at the destination of the container. Then the planner has to search for a sailing near the scheduled time of departure (STD). When there is no sailing available, the planner will search at another carrier for a sailing. So sometimes the planner has to search on different carrier sites to plan one container. Another data source is INTTRA, a platform where carriers and shippers share their sailing schedules. Marine Traffic is used to track ships and their departure times. And finally, there are third parties like container depots, harbours, cold stores and transport companies which share data with the LSP.

Another point that was noticed during the study, is the use of paper dossiers. Every shipment has its own paper dossier. Paper dossiers are used to check the status of the shipment and as a data source for general information about the shipment. All data is stored online in the LMS, but there is not a central overview of the necessary data per step in the process. Therefore, they print an overview with basic information and they put it in the dossier. These paper dossiers can get lost in the office, and the data in these dossiers is not up-to-date unless it is printed after each data change.

Furthermore, it emerged that not all data available is used during the process. Take for example the focus of this study, the planning for the cold store. At this moment, some basic data about the container is used to determine a time window. When using all data available, a more specific time window can be

calculated. Setting up a real-time connection with the planning of the cold store is made, opens an opportunity to calculate an exact time slot.

The analysis of the current situation shows that the causes mentioned in the problem identification are still correct. By mapping out the situation, a better picture of these causes has emerged, and it has become clear what problems need to be solved to improve the planning (process). From the studies conducted in this section, it emerged that the LSP does not only want to reduce the workload at the global forwarding department, but they also want to improve the container planning. From this analysis, a preferred planning process is drawn up and used to develop a solution.

2.5. Conclusion

In chapter 2 the current planning process is described in detail. First, the shipment planning process is discussed, then the cold store planning process is discussed. The latter is the focus of this report. In section 2.4 the current process and problems are analysed. This chapter answers the first research question:

1. What does the current planning process look like?

The planning process is divided into two subprocesses. In the first subprocess, a sailing is booked for the shipment (section 2.2). When the sailing is confirmed by the carrier, the second subprocess starts (section 2.3). In this subprocess, the container is scheduled at the cold store for loading. The planner determines a time window, in which the container will be loaded. A BPMN model of the current process can be found in Appendix A. The process described in this chapter is validated by a planner of the LSP.

1.1. What data and data sources used in the planning process?

Below in Table 3 is an overview of the data used to book a sailing for a container. When this data is collected, it is stored in the LMS of the LSP.

<i>Data</i>	<i>Data source</i>
Scheduled Time of Arrival (STA)	Order from the customer
Scheduled Time of Departure (STD)	Site from the carrier
VAL-info	Order from the customer
Carrier selection	List of preferred carriers per destination

Table 3: Data and data sources used in the planning process

1.2. What data and strategy are used to plan a loading time for a container?

Below in Table 4 is an overview of the data used to plan a loading time for a container, also the data which the cold store uses is showed in this table. The planning strategy is a simple formula with the data from the table as variables. With this data, a time window is calculated, which is sent to the cold store as a proposal planning.

<i>LSP</i>		<i>Cold store</i>	
<i>Data</i>	<i>Data source</i>	<i>Data</i>	<i>Data source</i>
VGM closing time	Order	SGS inspection	Order
VAL-info	Order	VAL-info	Order
		Number of orderliness	Order

Table 4: Data and data sources used for planning loading time

1.3. What problems occur during the planning process?

Section 2.4 discusses the four following problems that do occur during the planning process:

- Processing the data manually takes a lot of time and it is sensitive to errors.
- The use of many data sources takes also a lot of time.
- There is not a clear overview of the required data.
- Not all data which is available is used to plan containers at the cold store.

3. Theoretical framework

Theory necessary to complete this study is discussed in this chapter. First, some theory about the planning algorithm is discussed. Then two methods for visualising business processes are explained. Both methods are used in this report.

3.1. Algorithm theory

An algorithm is used to calculate a time window for a shipment. The algorithm works with data from the shipment ('loading from', 'VGM due date' and 'VAL codes') and from the depots (opening times). The values of this data are checked and based on the values a decision is made. A common method used in these kinds of algorithms is forward chaining.

Forward chaining in a simple form is an interactive program that performs a loop of substitution. It follows a rule-based model until it finds a rule in which the conditions match the facts or situation. Based on the value of the input variable, the algorithm makes a decision and act. The action can be a value change for a variable, a process that starts or a new decision that has to be made. A decision is called an exclusive split in Mendix, Figure 6 shows an example of an exclusive split. The forward chaining algorithm has three basic steps (Tout & Evans, 1992):

1. Match and find – The left-hand side of the equation is compared to the right-hand side of the equation.
2. Select – Based on the value of the condition, an action is selected.
3. Act – The selected action is executed.

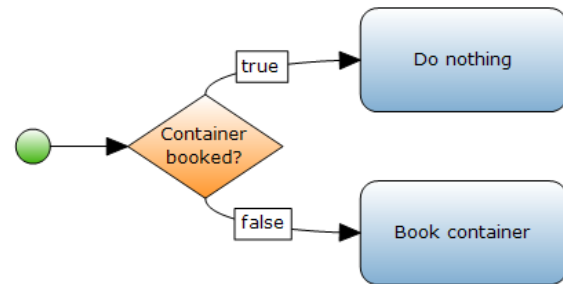


Figure 6: Exclusive split example

Rule-based models work with a structure of 'if/then' statements. The 'if' is the rule, which compares the right and left-hand side. 'Then' describes the action that is taken after the comparison (Sajid & Hussain, 2018). A rule can have one or multiple operators. The planning tool is made with Mendix, so the standard operators of Mendix are used in the algorithm (Mendix, 2018b).

<i>Operator</i>	<i>Description</i>
=	Equal to
!=	Not equal to
<	Less than
<=	Less than or equal to
>	Greater than
>=	Greater than or equal to
Or	Or
And	And

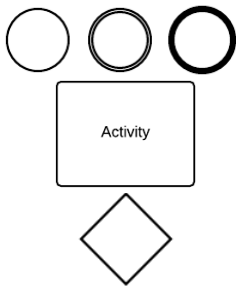
Table 5: Operators in Mendix (Mendix, 2018b)

3.2. BPMN

In this report, Business Process Modelling Notation (BPMN) is used to visualise the process flows at the LSP. Mendix also uses BPMN to create microflows. BPMN is a standard notation to visualise business processes. The notation is readable and understandable for all business users. Based on a flowcharting technique, the Business Process Diagram (BPD) is drawn up. Four principal elements in BPMN are Flow Objects, Connecting Objects, Swimlanes, and Artifacts. These will be explained in the next sections (White, 2004).

3.2.1. Flow Objects

There are three core elements in a BPD, these are called Flow Objects:



Event – An Event is something that triggers an Activity or is a result. From left to right there is a Start, Intermediate and End Event.

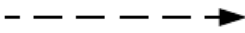
Activity – An Activity is a generic term for work that is done by the company or employee.

Gateway – A Gateway is used when there is a decision, or when flows join.

3.2.2. Connecting Objects



Sequence Flow – Sub sequential activities are connected through a Sequence Flow.



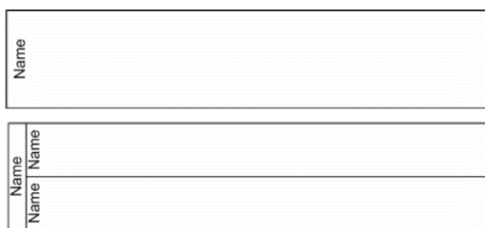
Message Flow – Messages between two separate Process Participants are connected through a Message Flow.



Association – A connection between Flow Objects and Artifacts are showed through an Association line.

3.2.3. Swimlanes

Swimlanes are used to visual category different activities in order to illustrate different responsibilities or functional capabilities.



Pool – A Pool represents a Participant in a process. This can be the main activity or a company.

Lane – A Lane is a sub-partition within the Pool and is used to organise and categorise activities.

3.2.4. Artifacts

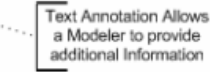
Artifacts make it possible to add more details to the process.



Data Object – Data Objects show how data is required or produced by an Activity. Data Objects are connected through an Association to an Activity.



Group – A Group is used for documentation or analysis but does not affect the Sequence Flow.



Annotation – Extra information or an explanation can be added to the business process model through an Annotation.

3.3. ArchiMate

The current application architecture of the LSP is adjusted because the planning tool is implemented in the current application. This Enterprise Architecture is modelled with ArchiMate. ArchiMate shows the structure of an Enterprise Architecture through elements and relationships between the architecture (The Open Group, 2017).

ArchiMate uses a framework to classify elements. In this framework, there are three different layers, the Business layer, Application layer, and Technology layer. Within this framework, there are all kinds of elements that shape the process (The Open Group, 2017).

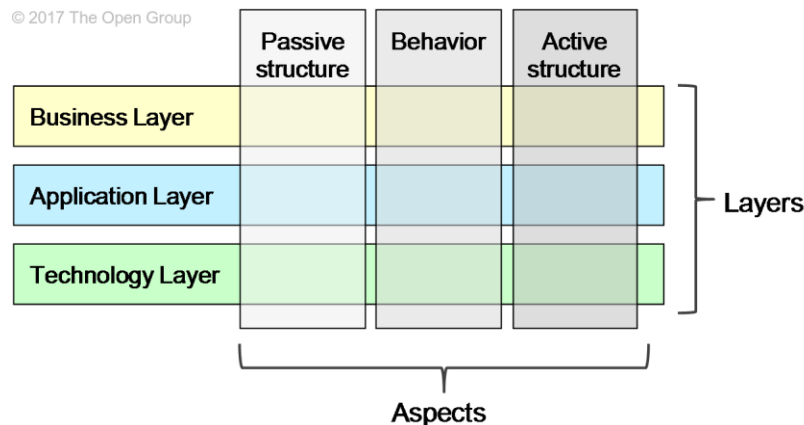


Figure 7: ArchiMate framework (The Open Group, 2017)

The business layer is used to model the business architecture of an enterprise. It provides an overview of the structure and interaction between business strategy, organisation, functions, business processes and information needs. The actions in this layer are performed by business actors.

The application layer supports the business layer with application services, realised by the application elements. This layer provides an overview of the structure and interaction between applications.

The technology layer shows how the technological architecture of an enterprise, supports the applications of an enterprise. The technology layer shows services, such as databases (The Open Group, 2017).

3.4. Conclusion

This chapter discusses the theory used in this study. First, the theory behind the algorithm is explained. Then BPMN is discussed, this method is used to visualise the business processes of the LSP. Finally, ArchiMate mentioned shortly. ArchiMate is used to visualise the Enterprise Architecture. This chapter gives an answer to research question 2:

2. What algorithm could be used to calculate a time window?

The forward chaining algorithm is used by the planning tool to calculate a time window. Forward chaining follows a rule-based model. This means that the algorithm consists of rules. In these rules, the left and right-hand side of an equation are compared. The forward chaining algorithm has three steps. First, the rule looks at the equation. Secondly, the algorithm selects an action, based on the value of the rule. Finally, the action is executed. The algorithm will repeat these steps until a goal is reached. In the calculation of the time window, several rules will be used to determine a time window.

4. Preferred planning process

Before designing the prototype, it is important to know what the preferred planning process for the LSP is. This section discusses the preferred planning process, based on the analysis of the current planning process from chapter 2. The information provided by the LSP is also taken into account, and the current application and architecture are used where possible.

Based on the analysis done in section 2.4, a possible situation is examined. In this situation, we look at a way to digitalise the container planning process. By doing so, data can be processed automatically, which results in time reduction and fewer errors during the processing of data. Also, a planning algorithm is designed. This algorithm uses data from the LMS to calculate a time window for a container.

4.1. Proposed planning process

A logistics management system (LMS) is used to digitalise the container planning process. The LSP has their own LMS, which is built in a Mendix application. This application is currently used as a support system. Orders and data can be viewed, and some small actions are digitalised. But most of the work is done manually, and as mentioned the data still needs to be entered manually.

The goal in long-term is to automate the whole planning process so that the global forwarding department only has to deal with the ad hoc decisions that have to be made. The short-term goal, the focus of this report, is to digitalise part of the container planning process.

A planner uses a paper dossier as a data source when determining a time window for a container. In the new situation, the planner makes use of a planning tool, which is implemented within the current application of the LSP. This planning tool has an algorithm that calculates a time window for the planner. To trigger this algorithm, the planner inserts a 'loading from' time.

At the end of each day, a mail with all the containers and their time windows is send to the cold store. This email is written manually, which costs a lot of time and is very sensitive for typing errors. In the new situation, a PDF is automatically generated. When a planner wants to send an email with the containers and their time windows, he pushes a button, which generates a PDF file. This functionality saves the planner time and because the PDF is generated automatically, there are no typing errors.

The new process is shown in a BPMN model in Figure 8. The figure shows that the planner does not have to leave the Mendix application anymore. In contrast to the old process, which is shown in Figure 5, where the planner had to work with paper, manually determine the time window and insert it in an email. A BPMN model of the whole preferred process can be found in Appendix B.

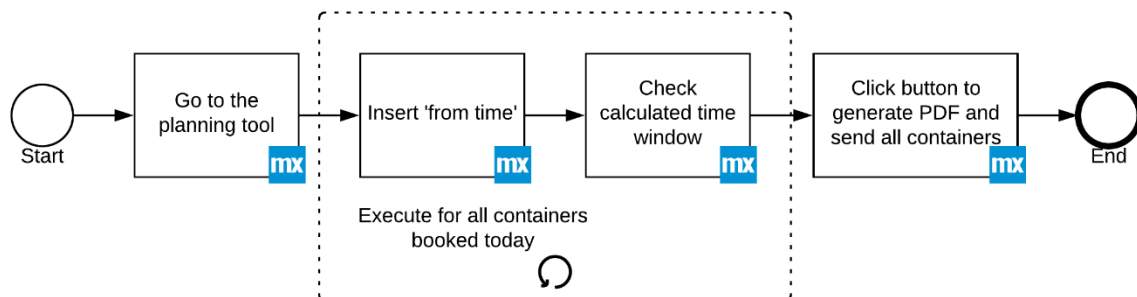


Figure 8: New cold store planning process

4.2. Algorithm for planning a loading time.

In the new container planning process, the planner makes use of the Mendix application. This opens opportunities for determining the time window. In the old situation, a broad time window was determined by the planner, with a paper dossier that shows some basic information. In the new situation, an algorithm calculates a time window. This algorithm is able to calculate a more precise time window than the planner, because of two reasons. First, the algorithm has direct access to the database, and therefore access to a lot more data than a paper dossier. Second, the algorithm can make more extensive and faster calculations than a human planner.

The long-term goal for the algorithm is to pick a specific time slot at the cold store, based on the data from the shipment. To accomplish this, a real-time link with the cold store is needed, but this is not yet possible. With this study, the first steps to the long-term goal are taken. The goal of this study is to calculate a more specific time window, than the one that the planner determines.

The algorithm uses the basic data, which is also used by the planner. Besides this data, it will also include the locations of the empty pick up depots and the full return depots for the containers. These depots have different opening and closing times. These times limit the pickup and return moments of a container. The algorithm built in this study functions as a basis for further research. The algorithm can be extended so that more data is taken into account in the calculation of a time window. In chapter 5, the algorithm will be discussed in more detail.

4.3. Conclusion

Together with the planners of the LSP and the analysis of the current situation, a preferred situation is drawn up. This preferred situation is used to make the Solution Design (Chapter 5). Chapter 4 gives an answer to the following research question:

3.1. How does the preferred planning process look like?

In the preferred situation, part of the work done by the planner is taken over by the planning tool. When a booking confirmation is sent by the carrier, the shipment is ready to be scheduled at the cold store. The planner will insert a 'loading from' time. This action triggers an algorithm that calculates a time window for the shipment. After the time window is calculated, the planner confirms the time window and sends it to the cold store.

5. Design and development

After drawing up the preferred planning process of the LSP, this section discusses how this process can become reality. With a prototype, a first step is taken towards the preferred situation. First, a list of solution objectives is drawn up. These requirements are used to make the user stories, from which the prototype is built. With this prototype, it is tested how much time is saved and if the planning is more accurate.

5.1. Solution objectives

The prototype is a planning tool which improves both the planning process and the container planning. Because there is a limited time available for developing the prototype, the prototype only has to meet minimum requirements. The prototype is a minimal viable product, also called an MVP version of the application. In consultation with the LSP, the following solution objectives are drawn up:

- The planning tool will be integrated into the current Logistic Management System (LMS) of the LSP. This means that the LMS is developed in Mendix. Also, part of the tool is built into existing pages and microflows.
- The planning tool must show a clear overview of where shipments are in the planning process.
- The prototype will calculate a time window for containers that are filled in the cold store at the Maasvlakte.
- To calculate a time window, the planners of the global forwarding department will fill in a 'loading from'. This 'loading from' functions as a minimum time for the time window. The 'to time' (maximum time) of the time window is the VGM closing time.
- To calculate a more accurate time window, the algorithm will also take into account the locations of the container depots.
- One VAL code will be used in the prototype. This VAL code is 1040: Third party check at the cold store. This code indicates that there is an SGS inspection and that the container needs to be inspected. Because this is done in a standard time window, it overrules the time window based on the location.

Based on these solution objectives, user stories are formulated. The user stories are shown per sprint in Appendix C.

5.2. Architecture of the planning tool

To realise the preferred situation, the architecture is adjusted. The LSP currently uses the LMS as a support tool and the planner makes manual actions. In the new situation, most of these actions are done automatically by the planning tool. Because of these changes, the architecture is adjusted. Figure 9 shows the architecture of the planning tool.

Currently, when a booking confirmation (BCO) is sent via INTTRA to the LSP, a time window is determined by the planner. In the new situation, a shipment is added to the planning tool when it has a BCO and the shipment will get a status 'to plan'. When a planner inserts a 'loading from' to the shipment, the algorithm of the planning tool calculates a time window for the container. This time window is checked by the planner before it is added to the send list. Sending the containers with their time windows to the cold store is the last action taken by the planner. The planning tool generates a PDF file with all the containers.

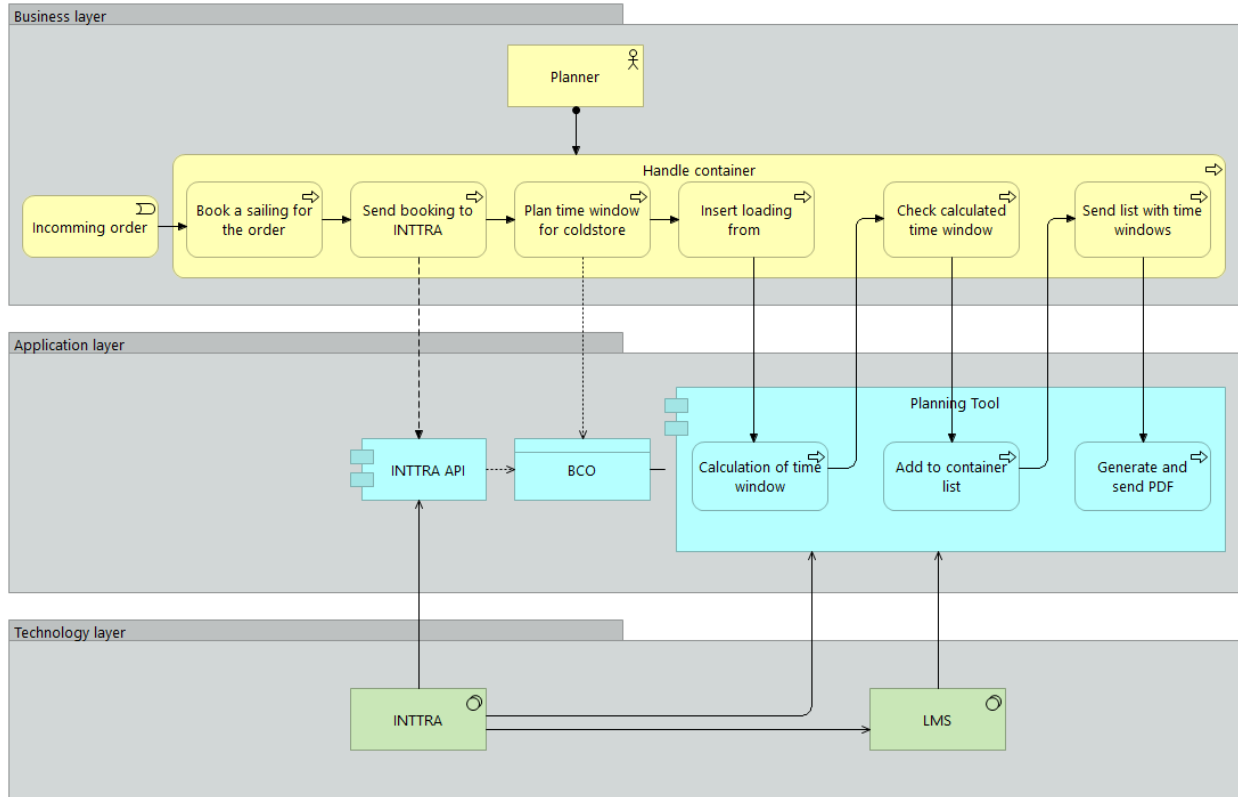


Figure 9: Architecture of the planning tool

5.3. Development of the prototype

CAPE Groep uses Scrum as a fixed method for the development of applications. This method is explained in the first section. The second section discusses the software platform that is used to build the prototype.

5.3.1. Scrum

Scrum helps in the development of projects, where not all events are known beforehand, by providing an agile framework (Schwaber & Sutherland, 2017). The framework gives an overview of what is happening in the project, and how far the project is. Figure 10 shows the process of Scrum.

Three roles can be described in Scrum; the product owner, the scrum master and the development team. The product owner has an idea to solve a problem for himself and/or for his stakeholders, but he has not the knowledge to solve the problem himself. The product owner makes a list of requirements and tasks for the solution, these are called user stories. From these user stories, a product backlog is made. This product backlog is a guide during the development of the software.

The development team develops the software, based on the backlog. This development is done in sprints, which takes on average about two to four weeks. At the end of each sprint, a working product is delivered to the product owner. This way, there is always a working product.

Each sprint starts with a sprint planning meeting. In this meeting, the aims for the sprint are defined in a sprint backlog. This sprint backlog is based on the most important tasks from product backlog. At the end of each sprint, there is a sprint review. This meeting is to demonstrate the new product. From this demonstration, new user stories can be added to the product backlog.

The Scrum master is not a traditional team leader or project manager but facilitates the sprints. The Scrum master is not responsible to manage the development team. He is responsible to coach the development team during the sprints, stimulate them to be self-motivated and help together with the product owner to maintain the product backlog.

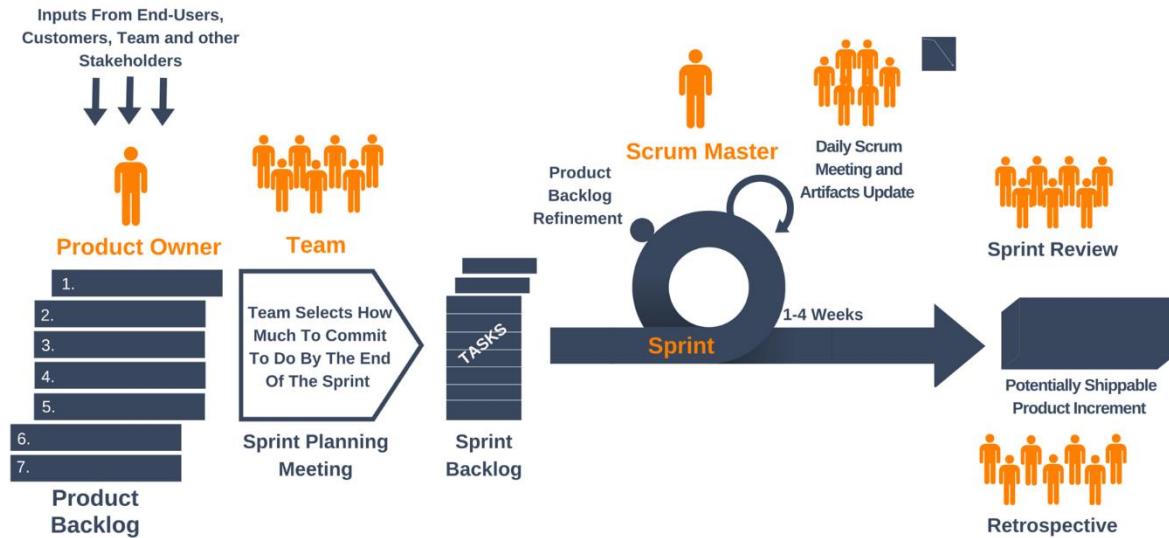


Figure 10: Scrum process overview

5.3.1.1. Implementation of Scrum

During the development of the prototype, there was not a whole scrum team. In this study, I was the only developer. The role of the product owner is fulfilled by a planner from the LSP, together we draw up the user stories for the prototype. These user stories are checked by my supervisor from CAPE Groep. During the development phase, I work independently on the user stories. At the end of the sprints, there is a sprint review together with my supervisor. After this sprint review, I give a demonstration to the product owner. Based on these demonstrations, new user stories are added to the product backlog. The user stories and product backlog can be viewed in Appendix C.

5.3.2. Mendix

Mendix is a low-code, visual and model-driven software development platform, to build mobile and website applications. Mendix provides tools to build, test and deploy these applications (Mendix, 2018a). CAPE Groep uses Mendix to develop applications for their customers, but also for applications for internal use.

5.4. Conclusion

This chapter discusses how the prototype is developed and what the functionalities of the prototype are. This chapter also gives an answer to research question 3 and 3.2, question 3.1 is answered in chapter 4.

3. What will be the solution design of the planning tool?

3.2. What requirements does the LSP have for the planning tool?

The solution objectives (Section 5.1) are used to make the User Stories which can be found in Appendix C. To implement the planning tool, the current architecture is adjusted. This new architecture is discussed in section 5.2.

Because of the short development time, the prototype only meets the minimum requirements. Therefore, the prototype is a minimal viable product (MVP) version of the final planning tool.

In consultation with a planner of the LSP, a list of solution objectives for the prototype is drawn up (section 5.1). The planning tool improves both the planning process and the container planning. The planning tool improves the planning process because part of the manual work done by the planner is taken over by the planning tool. The container planning is more accurate because more data is used to calculate a time window.

6. Demonstration

This chapter demonstrates the planning tool. The functionalities of the tool are discussed, by going through the planning tool, as the planner of the LSP does. Screenshots are added, to provide a better view of the planning tool.

6.1. Shipment overview

The first screen that a planner uses when he is going to plan a shipment is the active shipment overview, see Figure 11. When company X sends a new booking to the LSP, it appears on this screen. From this screen, a planner goes to a shipment and will book a sailing for this shipment. As mentioned in section 2.2, the LSP will get a booking confirmation from INTRA when the booking is confirmed by the carrier.

When a shipment gets a booking confirmation, it will get a status 'To Plan'. This status is part of an enumeration which is added to the shipment entity. This enumeration has the following statuses to indicate how far the shipment is in the cold store planning process: 'To Plan', 'Time Calculated', 'Time Confirmed', 'Time Send', 'ColdstoreFinalTime'.

Shipment	Status	Coldstore	Port of loading	Port of delivery	Carrier	Booking reference	Loading from	Loading date coldstore	CLS	STD	STA	VGM closing
CK18000	Order	Maasvlakte Coldst...	Maasvlakte Rotter...	Dubai	HAPAG LLOYD	CK18000B	28-08-2018 14:00	31-08-2018 00:00	01-09-2018 18:00			31-08-2018
CK18001	Order	Maasvlakte Coldst...	Maasvlakte Rotter...	Buenos Aires	HAPAG LLOYD	CK18001B	27-10-2018 00:00	29-10-2018 00:00	30-10-2018 00:00			29-10-2018
CK18002	Order	Maasvlakte Coldst...	Maasvlakte Rotter...	Dubai	MAERSK	CK18002B	23-10-2018 00:00	25-10-2018 00:00	26-10-2018 00:00			25-10-2018
CK18003	Order	Maasvlakte Coldst...	Maasvlakte Rotter...	Buenos Aires	MAERSK	CK18003B	18-10-2018 00:00	19-10-2018 00:00	20-10-2018 00:00			19-10-2018
CK18004	Order	Maasvlakte Coldst...	Maasvlakte Rotter...	Dubai	HAPAG LLOYD	CK18004B	24-10-2018 00:00	25-10-2018 00:00	26-10-2018 00:00			25-10-2018
CK18005	Order	Maasvlakte Coldst...	Maasvlakte Rotter...	Dubai	HAPAG LLOYD	CK18005B	23-10-2018 00:00	25-10-2018 00:00	26-10-2018 00:00			25-10-2018
CK18006	Order	Maasvlakte Coldst...	Maasvlakte Rotter...	Dubai	HAPAG LLOYD	CK18006B	24-10-2018 00:00	25-10-2018 00:00	26-10-2018 00:00			25-10-2018
CK18007	Order	Maasvlakte Coldst...	Maasvlakte Rotter...	Buenos Aires	HAPAG LLOYD	CK18007B	27-10-2018 00:00	29-10-2018 00:00	30-10-2018 00:00			29-10-2018
CK18008	Order	Maasvlakte Coldst...	Maasvlakte Rotter...	Buenos Aires	HAPAG LLOYD	CK18008B	28-10-2018 00:00	29-10-2018 00:00	30-10-2018 00:00			29-10-2018

Figure 11: Active shipments overview

6.2. Shipments to plan

When a shipment gets the status 'To Plan', it appears in the planning tool for the first time. The shipment is added to the first tab 'Shipments to plan' (Figure 12). All the shipments shown on this tab, are ready to be scheduled at the cold store.

Shipment	Status	Coldstore	Port of loading	From time	VGM Closing	STD	Empty Container Depot	Full Return Depot
CX18001	Order	Maasvlakte Coldstore	Maasvlakte Rotterdam		29-10-2018 00:00		Alconet BV	APH Terminals Rotterdam
CX18002	Order	Maasvlakte Coldstore	Maasvlakte Rotterdam		25-10-2018 00:00		Alconet BV	APH Terminals Rotterdam
CX18003	Order	Maasvlakte Coldstore	Maasvlakte Rotterdam		19-10-2018 00:00		APH Terminals Rotterdam	Alconet BV

Figure 12: Shipments to plan

6.3. Shipment new edit page

From the previous window, the planner can open a shipment (Figure 13). In this window, all the information about a shipment can be viewed and edited. The 'cold store planning' status of the shipment is shown at 1. This status indicates where the shipment is in the 'cold store planning' process.

When the planner fills in the 'loading from' text box (2.), the algorithm that calculates the time window is triggered. This 'loading from' is a date and time attribute, which is used by the algorithm as a start time to calculate a time window. On average this is one or two days before the VGM due date.

Field 3. shows the empty pick up and full return depots. The opening times of these depots are used by the algorithm, to calculate a more accurate time window for the container. When no depot is selected, a standard time window will be calculated. When a depot is selected later, the time window will be calculated again.

Figure 13: Shipment edit page

6.4. Calculation of time window

The algorithm calculates a time window for each container. This algorithm is triggered when one of the attributes used by the algorithm is inserted or changed. The following attributes are used during the calculation:

- Loading from
- VGM due date
- Empty pick up depot (opening times)
- Full return depot (opening times)
- VAL codes (Code 1040)

All this data is validated before the algorithm starts with the calculation of the time window. The data is stored in the database and used by the algorithm, so their values need to be correct.

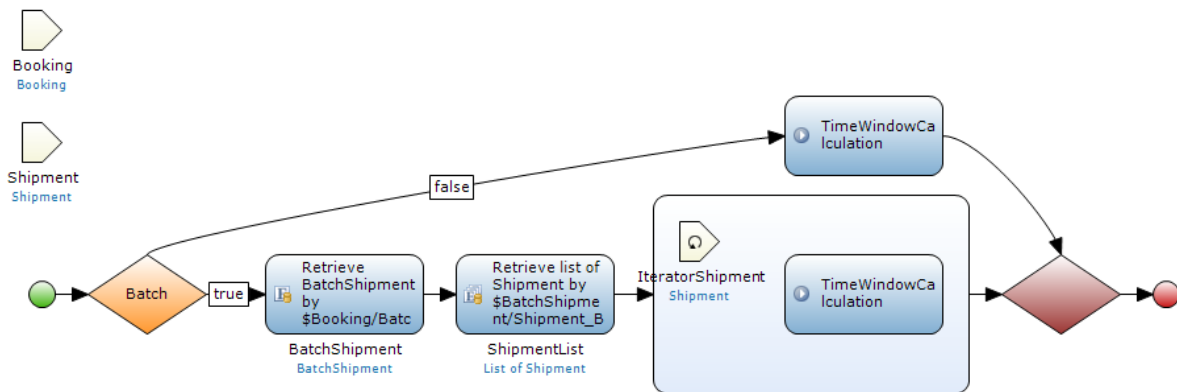


Figure 14: Microflow TimeWindowOnChange

The first microflow that is triggered, when an attribute is changed, is the 'TimeWindowOnChange' microflow (Figure 14). This microflow checks whether the selected container is part of a batch. When this is false the microflow 'TimeWindowCalculation' is triggered. This microflow calculates a time window for the container. When the shipment is part of a batch, a list with all containers is retrieved. Then a loop starts. When all the containers in this batch have a time window, the loop stops.

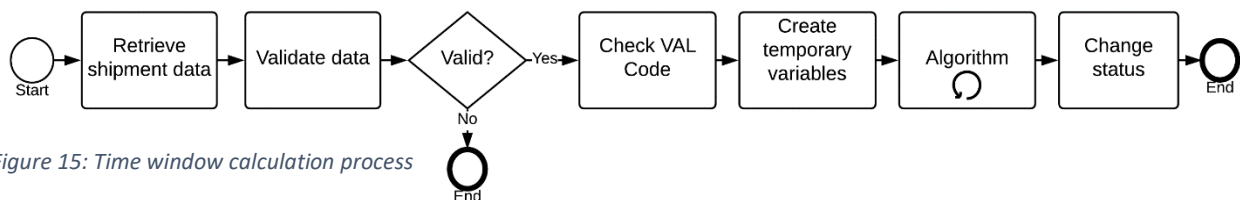


Figure 15: Time window calculation process

When the 'TimeWindowCalculation' microflow in Figure 14 is triggered, the process in Figure 15 starts. First, all the data of the shipment is retrieved. It could happen that not all the information of the shipment is saved correctly. So, the second step validates the data. When data is not valid, the process stops, and the planner gets a notification. When all data is valid, it is checked if the shipment has VAL code 1040. If a shipment has this VAL code, the algorithm will plan the container in a standard time window. Before the algorithm starts, some temporary variables are created. These variables are used by the algorithm microflow. The time window is then calculated by the algorithm. It often happens that the 'loading from' and 'VGM Due Date' are on different days. So, the algorithm loops, until the 'VGM Due Date' is reached. Finally, the shipment gets a status change to 'Time Calculated'.

This section discusses shortly the calculation of the time window. Appendix D contains a more detailed explanation of how the time window is calculated.

6.5. Confirmation of time window

After the calculation of the time window(s), a pop-up window is shown (Figure 16). In this window, the planner can add, edit, delete and confirm time windows. By confirming the time windows, the status is changed to 'Time Confirmed', and the time windows of the shipment are ready to be sent to the cold store. The planner can also close the page. In this case, the status is not changed, and the time window(s) can be confirmed later.

When the planner wants to confirm the time window(s) of the shipment, a validation microflow will start. This microflow validates if a depot is selected. When there is no depot selected, a warning message will pop up, but the time window(s) will be confirmed. When there is a depot selected the time window(s) will be confirmed.

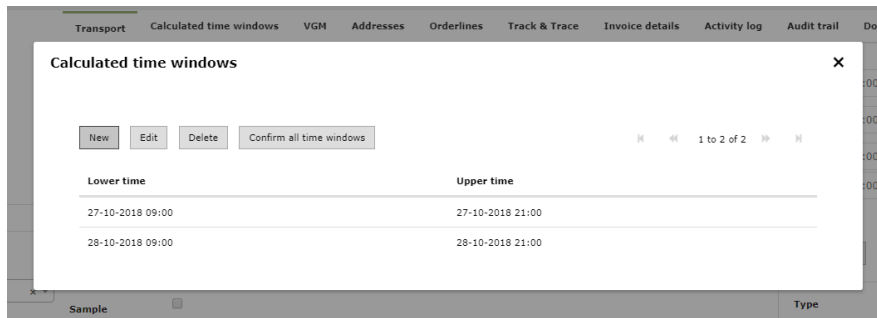


Figure 16: Calculated time windows pop up

6.6. Sending shipments to cold store

When the time windows of a shipment are confirmed, they appear on the 'loading time confirmed' tab (Figure 17). Once or twice a day, these shipments are sent to the cold store.

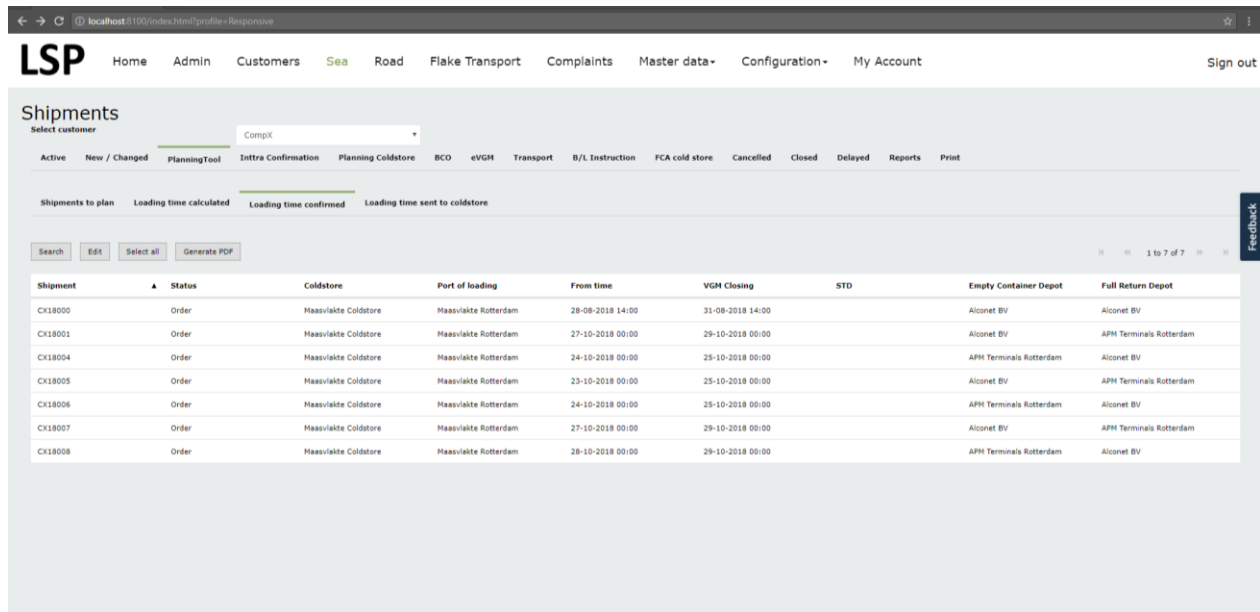


Figure 17: Loading time confirmed tab

When the planner pushes the 'Generate PDF' button a PDF file is generated (Figure 18) for the selected shipments. The file shows per container the shipment number, time window(s) and VAL code(s). The planner sends this file to the cold store, they plan the container in a specific time slot. The shipment gets a status 'Time Send' when the PDF is created.

Container loading times

LSP

Shipmentnumber	Lower time	Upper time	VAL Code	Description
NL322071	27-10-2018 09:00	27-10-2018 21:00	1002	Push Pull
	28-10-2018 09:00	28-10-2018 21:00	1010	Max 2 lot codes
NL322072	27-10-2018 00:00	27-10-2018 23:59	1002	Push Pull
	28-10-2018 00:00	28-10-2018 23:59	1010	Max 2 lot codes
NL322073	27-10-2018 00:00	27-10-2018 23:59	1002	Push Pull
	28-10-2018 00:00	28-10-2018 23:59	1010	Max 2 lot codes
NL322074	27-10-2018 00:00	27-10-2018 23:59	1002	Push Pull
	28-10-2018 00:00	28-10-2018 23:59	1010	Max 2 lot codes

Figure 18: PDF File

6.7. Delete shipments from the last tab

Each shipment on the 'Loading time sent to cold store' tab (Figure 19), needs to be scheduled at the cold store. The cold store sends a final loading time to the LSP, which the planner adds to the shipment on the ShipmentEdit page (Figure 13). When the 'Loading cold store' is filled in with the final loading time, the shipment gets a final 'cold store planning' status and leaves the planning tool.

Shipment	Status	Coldstore	Port of loading	From time	VGH Closing	STD	Empty Container Depot	Full Return Depot
CK18001	Order	Haasvlakte Coldstore	Haasvlakte Rotterdam	27-10-2018 00:00	29-10-2018 00:00		Alconet BV	APH Terminals Rotterdam
CK18004	Order	Haasvlakte Coldstore	Haasvlakte Rotterdam	24-10-2018 00:00	25-10-2018 00:00		APH Terminals Rotterdam	Alconet BV
CK18005	Order	Haasvlakte Coldstore	Haasvlakte Rotterdam	23-10-2018 00:00	25-10-2018 00:00		Alconet BV	APH Terminals Rotterdam
CK18006	Order	Haasvlakte Coldstore	Haasvlakte Rotterdam	24-10-2018 00:00	25-10-2018 00:00		APH Terminals Rotterdam	Alconet BV
CK18007	Order	Haasvlakte Coldstore	Haasvlakte Rotterdam	27-10-2018 00:00	29-10-2018 00:00		Alconet BV	APH Terminals Rotterdam
CK18008	Order	Haasvlakte Coldstore	Haasvlakte Rotterdam	28-10-2018 00:00	29-10-2018 00:00		APH Terminals Rotterdam	Alconet BV

Figure 19: Loading time sent to cold store tab

6.8. User testing

After the development, the prototype is tested by a planner of the LSP. This demonstration has two goals. The first goal is to validate if the prototype contributes to solving the problem at hand. The second goal is to receive feedback and improve the prototype.

Testing the prototype shows that the planning tool is easy to use. It is not tested if a shipment gets automatically a 'To Plan' status when a booking confirmation is sent. This because the prototype is tested in a testing environment, with test data. The rest of the prototype and its functionalities are successfully tested in the test environment.

After each demonstration the planner gave feedback. The feedback that could be added to the next sprint was included into the next sprint. There was also feedback about new functionalities. These are added to the product backlog because it takes too much time to implement these in this study.

6.9. Conclusion

This chapter discusses the functionalities of the planning tool. The planning tool is described by going through the planning process, as the planner does. After the development, the prototype is tested by a planner of the LSP. These tests show that the prototype meets the solution objectives that were set in advance. During the testing, some feedback emerged to further develop the planning tool. Part of the feedback is included in the prototype directly. The rest is included in the backlog of the prototype because they are about new functionalities of the planning tool. These are discussed in the further research.

7. Evaluation

According to the Design Science Research Methodology, evaluation is important to observe and measure how well the prototype provides a solution to the problem. It is important to look at the goals set for the prototype and check to what extent these goals have been achieved (Peppers et al., 2007). So now the prototype is tested by a planner, we will look at the results of the tests.

The solution objectives for this prototype are converted into user stories (Appendix B). By checking whether all the user stories are finished, it becomes clear if all the solution objectives have been achieved. In consultation with the planner of the LSP, two user stories are not completed. These are 'As a planner I want that all other VAL codes are also included in the algorithm, so the time window will be more accurate' and 'As a planner I want to add time slots to the planning so that containers can be planned in at time slots instead of time windows'. Both are not included, because they take too much time to implement at this moment. Also, the user story about time slots is not relevant for the current prototype, it will be relevant if the algorithm is so precise, that it calculates actual time slots.

7.1. Variables and indicators

To see if the prototype contributes to solving the problem, the variables and indicators drawn up in section 1.2.4 are compared with the test results.

7.1.1. Duration of process

The first indicator is the duration of the cold store planning process and is measured per shipment. In the current situation, it takes 1 minute and 13 seconds to calculate a time window. When a shipment is part of a batch (multiple containers in one booking), the planner has to check each container and write for each container the time windows. When the algorithm calculates a time window for a container that is part of a batch, it also calculates the time windows of the other containers. When the planner uses the planning tool, it takes 25 seconds to calculate a time window for a container or a batch. This is a reduction of 66% per container. The time reduction of a batch is even more because the algorithm calculates a time window for all containers at once.

7.1.2. Number of steps in the process

In the current process (Figure 5), the planner needs to take eight steps to plan a shipment at the cold store. These steps are all manual steps. With the planning tool, the planner takes four steps (Figure 8). All these steps are taken in the application, three are pushing on a button and one is filling in a date and time. This is a reduction of 50% in the number of steps taken by the planner.

7.1.3. Data transfer errors

There are a lot of manual data processing steps in the current process. These are sensitive to reading and typing errors. In the current process, there are six moments where a data transfer error could occur (Table 6). With the planning tool, all data is processed automatically, and data is validated when it is inserted, so no data transfer errors should occur. The only moment where something could go wrong, is when a booking is sent to the LSP. There could be errors or faulty data in the original booking, provided by company X. The moments that a data transfer error could occur is reduced by 83%.

Current process	With planning tool
Incoming booking contains faulty data	Incoming booking contains faulty data
Read the VGM due date wrong	
Forget VAL info, or read VAL info wrong	
Making a calculation mistake	
Type error with container number in the email	
Type error with time window in email	

Table 6: Data transfer error moments

7.1.4. Length of time window

The average length of a time window is hard to measure because each time window is different. But in the current situation, a time window is on average 2 full days before the 'VGM due date'. This means that the time window has an average length of 48 hours.

With the planning tool, it is even harder to measure the average length of a time window is. The planning tool uses more data to determine the time window for each shipment. So, the time windows of shipments differ more in the new situation. To estimate the average length of the time window, three groups of time windows are made:

1. Shipments that are linked to a depot which is 24 hours open have a time window of 00:00 till 23:59. Assuming that the 'loading from' is still 2 days before the 'VGM due date', the length of the time window is 48 hours.
2. Shipments that are linked to a depot that is open from 09:00 till 21:00, have these times as time window. Spreading this over 2 days is a time window of 24 hours.
3. Shipments that have VAL code 1040, have a time window from 06:00 till 15:00. Spreading this over two days is a time window of 18 hours.

Assuming that all three groups are equally common, the average length of a time window in the new situation is $(48+24+18)/3$ is 30 hours. This is a reduction of 38%.

Table 7 shows the comparison of the indicators between the current situation and the new situation where the planning tool is used. For the indicators applies that the lowest value is the best. The last column shows the reduction of the values.

	Current process	With planning tool	Reduction
Time (per container) (mm:ss)	1:13	0:25	66%
Steps in the process	8	4	50%
Data transfer error moments	6	1	83%
Average length of time window (hours)	48	30	38%

Table 7: Comparison of the indicators

7.2. Conclusion

In this chapter, the results of the tests are compared to the data in the current situation. With these results, research question 4 can be answered.

4. Does the proposed solution meet the goals and requirements?

The goals and requirements of the planning tool were documented in the solution objectives for the prototype. These objectives were converted into user stories. All the user stories, except two, were completed. The two user stories that have not been completed were in consultation with the planner and were not completed because they did not add value for this prototype.

In the problem identification phase, indicators were drawn up. The values of these indicators are compared with the results of the test in section 7.1. All the indicators are improved. The time needed to plan a container at the cold store is reduced by 56% and the number of steps taken by the planner is reduced by 50%. The moments that an error could occur is reduced by 83% and the average length of a time window is reduced by 37,5%.

In summary, it can be concluded that the prototype has achieved the goals and that the prototype improves the current planning (process).

8. Conclusion

From the results of this research, it can be concluded that the cold store planning of the LSP can be automated via a planning tool, and that this results in both a more efficient process and a more accurate planning.

This last chapter explains how this conclusion is reached by summarising the answers to the research questions and answering the main research question. Furthermore, a number of recommendations will be made and points for further research will be discussed.

8.1. Research questions

The main research “How to improve the container planning (process), by means of data processing and visualisation of this data in a planning tool?” is answered using the research questions below.

1. What does the current planning process look like?

1.1. What data and data sources used in the planning process?

1.2. What data and strategy are used to plan a loading time for a container?

1.3. What problems occur during the planning process?

Chapter 2 discusses the current planning process at the LSP, through a BPMN model and an extensive description. The planning process is divided into two parts, the ‘shipment planning process’ and the ‘cold store planning process’. The latter is the focus of this report.

In the ‘cold store planning process’ the planner of the LSP determines a time window in which a container is loaded at the cold store. With a paper dossier that contains some basic data of the shipment, the planner calculates a time window. This time window is sent via email to the cold store.

During the analysis of the current process, some improvement opportunities did appear. There are three problems in the ‘cold store planning process’ that serve as the basis for the planning tool. The first problem is the manual processing of data. This takes a lot of time and it is sensitive to errors. Second, there many data sources used, which also takes a lot of time. Third, there is no clear overview of all data available, because of this a fourth problem arises. The time window per shipment is not very accurate, because not all data available is used.

2. What algorithm could be used to calculate a time window?

The algorithm used in the planning tool is the forward chaining algorithm. The algorithm follows a rule-based model. The rules compare the left and right-hand side of an equation and based on the outcome of the rule, an action is taken. The algorithm consists of several rules to determine a time window.

3. What will be the solution design of the planning tool?

3.1. How does the preferred planning process look like?

3.2. What requirements does the LSP have for the planning tool?

In the preferred planning process, part of the work done by a planner is taken over by a planning tool. After the booking confirmation is sent to the LSP, the planning tool can be used by the planner. The planner inserts a ‘loading from’ time, which triggers the algorithm that calculates a time window for the shipment. After the time window is calculated, the planner confirms the time window and sends it to the cold store.

To validate this process, a prototype is made. The prototype is a planning tool which improves both the planning process and the container planning. The manual actions of the planner are automated by the planning tool, and the algorithm calculates a time window. The prototype is a minimal viable product, because of the time. This means that the prototype does meet minimal requirements. In consultation with the LSP, the following solution objectives are drawn up:

- The planning tool will be integrated into the current Logistic Management System (LMS) of the LSP. This means that the LMS is developed in Mendix. Also, part of the tool is built into existing pages and microflows.
- The planning tool must show a clear overview of where shipments are in the planning process.
- The prototype will calculate a time window for containers that are filled in the cold store at the Maasvlakte.
- To calculate a time window, the planners of the global forwarding department will fill in a 'loading from'. This 'loading from' functions as a minimum time for the time window. The 'to time' (maximum time) of the time window is the VGM closing time.
- To calculate a more accurate time window, the algorithm will also take into account the locations of the container depots.
- One VAL code will be used in the prototype. This VAL code is 1040: Third party check at the cold store. This code indicates that there is an SGS inspection and that the container needs to be inspected. Because this is done in a standard time window, it overrules the time window based on the location.

These solution objectives are converted to user stories. The user stories are shown per sprint in Appendix C.

4. Does the proposed solution meet the goals and requirements?

The prototype is tested by a planner of the LSP. These tests show that the prototype is easy to use and that it meets the solution objectives that were set in advance. From the results of this test can be concluded that the prototype also contributes to solving the problems at hand. In the problem identification phase, indicators were drawn up. The values of these indicators are compared with the results of the test. As can be seen in Table 8, all the indicators improved by implementing the planning tool.

	<i>Current process</i>	<i>With planning tool</i>	<i>Reduction</i>
<i>Time (per container) (mm:ss)</i>	0:57	0:25	56%
<i>Steps in the process</i>	8	4	50%
<i>Moments an error can occur</i>	6	1	83%
<i>Average length of time window (hours)</i>	48	30	37,5%

Table 8: Comparison of the indicators

“How to improve the container planning (process), by means of data processing and visualisation of this data in a planning tool?”

Now that all research questions have been answered, an answer can be given to the main research question. It has become clear that the cold store planning process can be automated via a planning tool and that the time windows can be calculated by an algorithm. The result of this planning tool is a more efficient planning process and a more accurate planning. The two most essential components that ensure these improvements are:

- The automation of data processing in the planning process.
- An algorithm that calculates a time window.

8.2. Recommendations

Now that the preferred situation has been identified and the prototype has been tested, there are some short-term implementation recommendations for CAPE Groep and the LSP.

8.2.1. Minimal viable product

The prototype used in this report is an MVP version of the planning tool, which only meets the minimum requirements. When drawing up these requirements, it was important that the solution objectives of the prototype would result in a planning tool that could at least do the manual work of the planner. The functionalities of the planning tool can be extended, in order to improve the planning process and the container planning even more. Ideas for further research are discussed in section 8.3.

8.2.2. Activity log

All the actions made by the planner are stored in the activity log. By tracking all the changes made to a shipment, all steps can be traced back. The actions of the planning tool are not added to the activity log yet. Adding the actions of the planning tool to the activity log is one of the first functionalities that could be added. When problems do occur, or decisions have to be made, it is useful to trace back the decisions and calculations of the planning tool.

8.2.3. Human interaction

During the research, it became clear that the data of shipments change frequently, due to uncertainty at third parties. Because of the limited testing time, there was no time to run through all the possible scenarios. So for now, it is important that a human planner confirms the time windows of the shipment. Even when more scenarios are tested, and the planning tool knows what actions to take for each scenario, the human planner should be involved in the process. Not to plan a container, this can be done by the planning tool. But to solve the problems that need ad hoc solutions.

8.3. Further research

Besides the short-term recommendations, there emerged also points for further research during the study. The algorithm can be improved, so the time window becomes more precise. And the planning tool is integrated into the existing application, but not all actions of the current application are fully integrated yet. The following sections discuss the points for further research in more detail.

8.3.1. Travel time of trucks

The algorithm calculates with the opening times of the depots, but a truck has to drive from the depot to the cold store. To make the time window of a shipment more accurate, the algorithm needs to take the travel times into account. A function should be added that will look at the location of the selected depot(s) and the cold store. Based on these locations travel times can be calculated and extracted from the time window.

8.3.2. Time slots

The cold store works with time slots in which they load a container. The LSP has some standard time slots at the cold store, in which they can load their containers. When the algorithm calculates a more precise time window, it is possible that the planning tool recommends a couple of time slots, instead of time windows.

This functionality can be extended, if these time slots are saved in the application of the LSP. When a container is assigned to a time slot, this time slot becomes inactive. This way they recommended time slots are more accurate. Besides a more accurate planning, the LSP will also have a better overview of when containers are planned.

8.3.3. VAL codes

The recommendation of a time slot can be further improved by adding a functionality that determines in what type of time slot the container needs to be loaded.

The time slots at the cold store are divided into three types. Based on the VAL codes of a container, it will be loaded in a time slot type A, B or C. Time slot A is the shortest time slot and is for containers that have no or short VAL activities. Time slot B is for containers that have VAL activities, that will take a bit more time to execute. Time slot C is the longest time slot and is for containers that have complicated VAL activities.

The VAL codes determine in which time slot the container is loaded. By adding a functionality that connects the VAL codes to a time slot type, a better planning can be made.

8.3.4. Real-time connection with the cold store

In an optimal situation, the LSP has a real-time connection with the cold store. As a result, the LSP can view the cold store's planning and can directly schedule a container in a time slot. This will save time for both the LSP and cold store. In addition, the LSP is a lot more flexible when there are problems. Because the LSP can plan directly at the cold store, they can also easily change the time slot of a container.

9. References

- Heerkens, H., & van Winden, A. (2012). *Geen probleem: Een aanpak voor alle bedrijfskundige vragen en mysteries*. Nieuwegein: Van Winden Communicatie.
- Mendix. (2018a). Mendix. Retrieved July 10, 2018, from <https://www.mendix.com/>
- Mendix. (2018b). XPath Operators - Mendix 7 Reference Guide | Mendix Documentation. Retrieved July 25, 2018, from <https://docs.mendix.com/refguide/xpath-operators>
- Peffer, K., Tuunanen, T., Rothenberger, M. A., & Chatterjee, S. (2007). A Design Science Research Methodology for Information Systems Research. *Journal of Management Information Systems*, 24(3), 45–77. <https://doi.org/10.2753/MIS0742-1222240302>
- Sajid, A., & Hussain, K. (2018). Rule Based (Forward Chaining/Data Driven) Expert System for Node Level Congestion Handling in Opportunistic Network. *Mobile Networks and Applications*, 1–10. <https://doi.org/10.1007/s11036-018-1016-0>
- Schwaber, K., & Sutherland, J. (2017). The Scrum Guide. <https://doi.org/10.1053/j.jrn.2009.08.012>
- The Open Group. (2017). ArchiMate® 3.0.1 Specification. Retrieved July 24, 2018, from <http://pubs.opengroup.org/architecture/archimate3-doc/toc.html>
- Tout, K. R., & Evans, D. J. (1992). Parallel forward chaining technique with dynamic scheduling, for rule-based expert systems. *Parallel Computing*, 18(8), 913–930. [https://doi.org/10.1016/0167-8191\(92\)90037-8](https://doi.org/10.1016/0167-8191(92)90037-8)
- White, S. a. (2004). Introduction to BPMN. *BPTrends*, 1–11. <https://doi.org/10.3727/000000006783982421>

10. Appendix

Appendix A. BPMN model of the current planning process

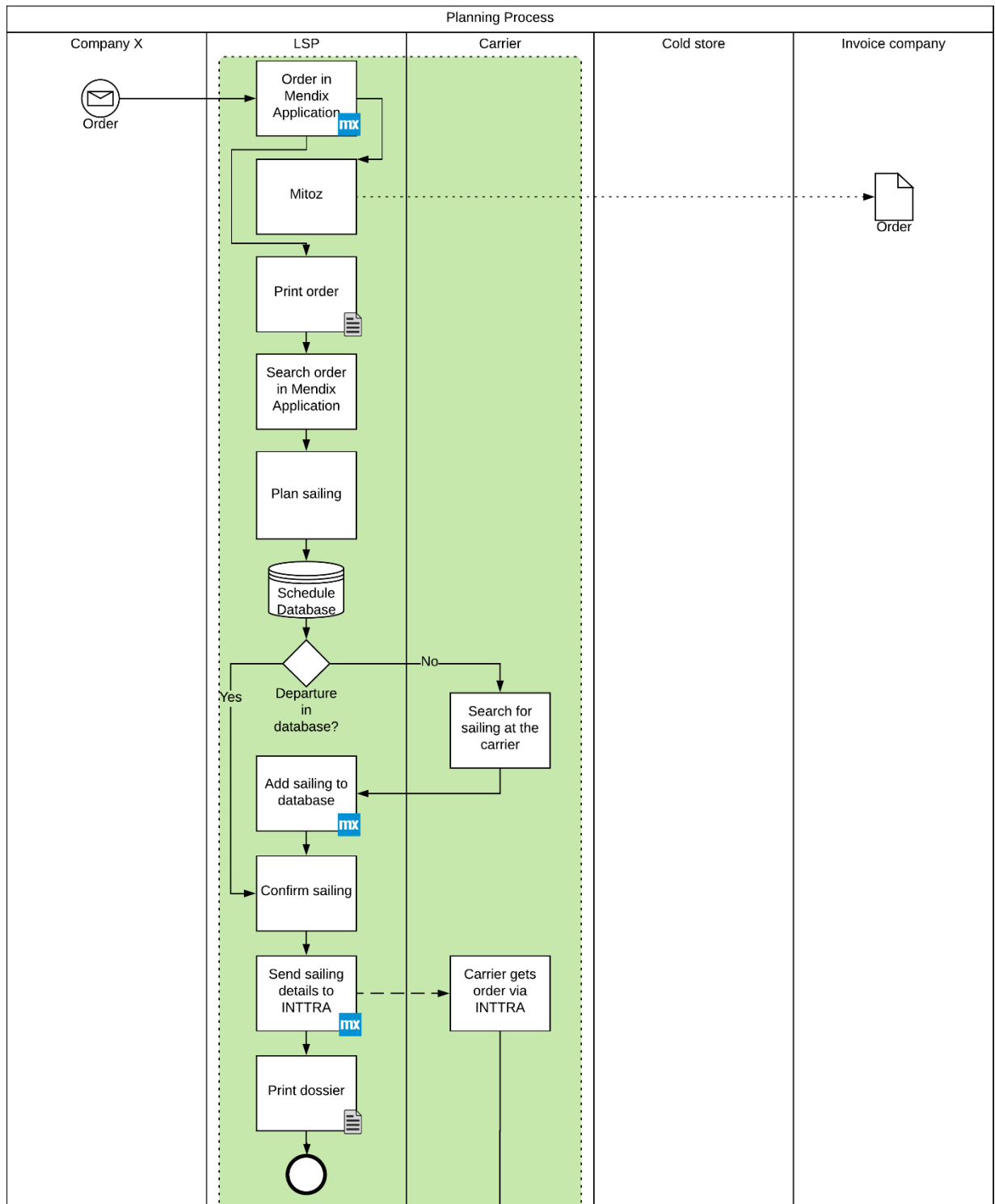


Figure 20: BPMN model of the current planning process (part I)

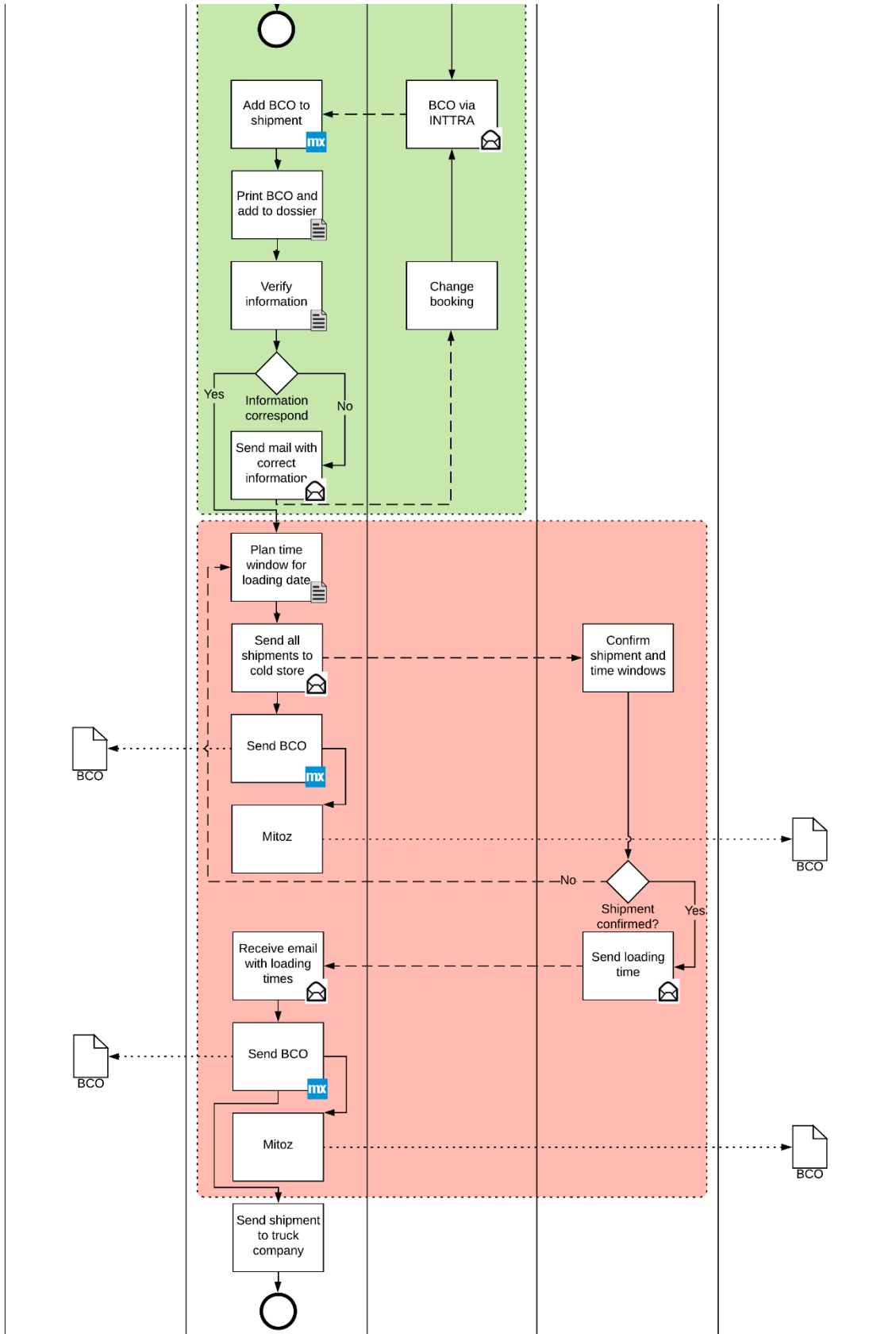


Figure 21: BPMN model of the current planning process (part II)

Appendix B. BPMN model of the preferred planning process

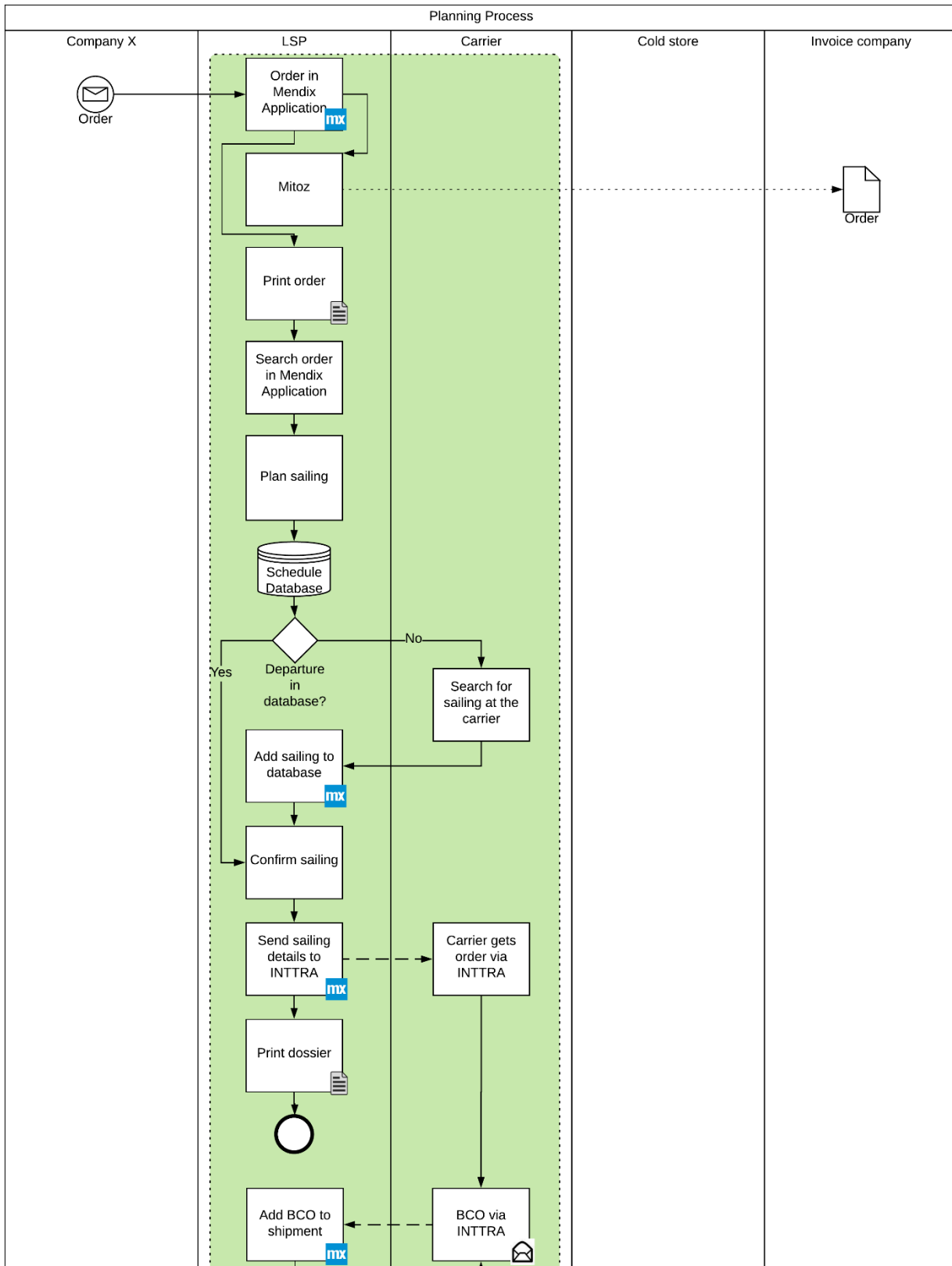


Figure 22: BPMN model of the preferred planning process (part I)

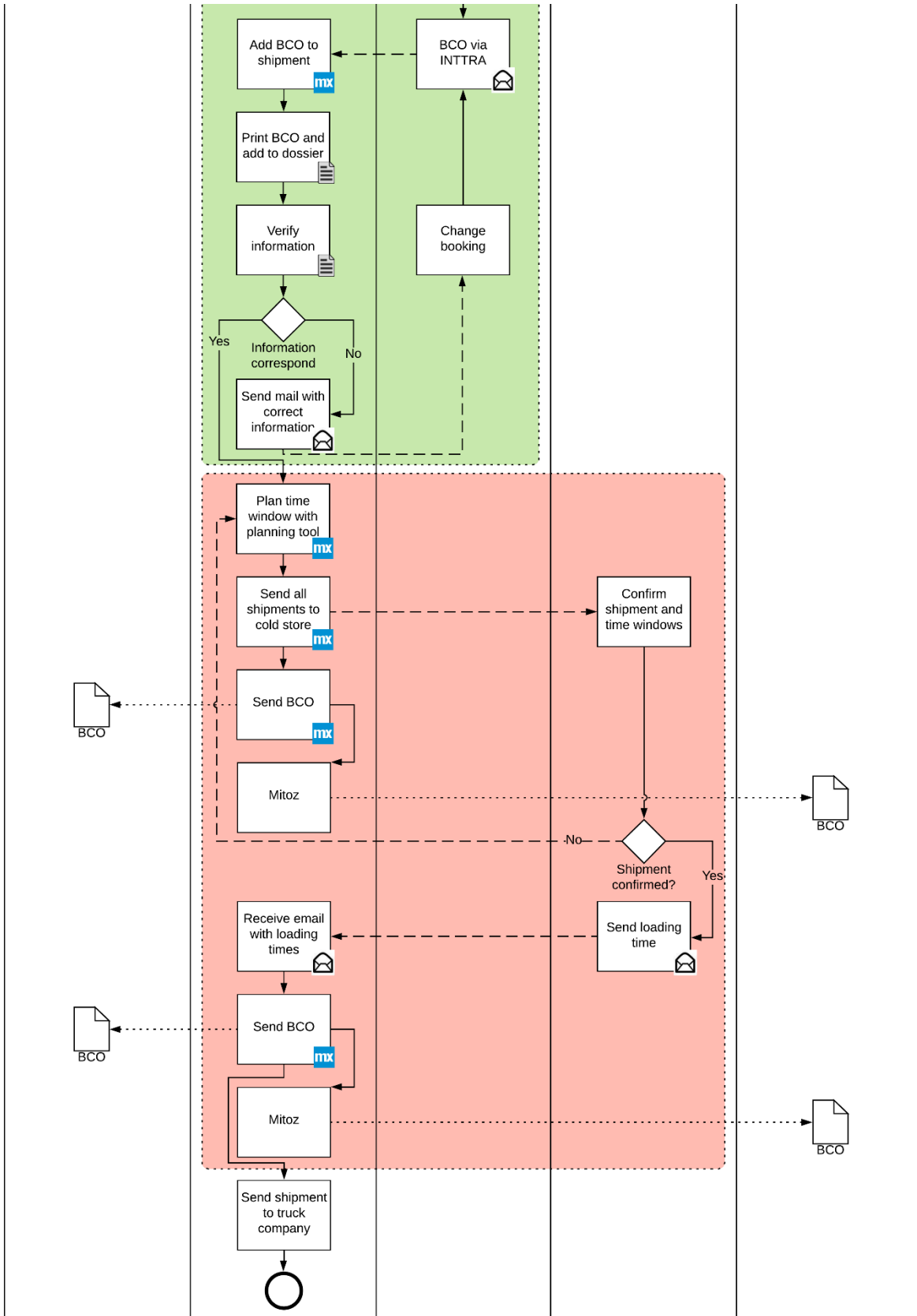


Figure 23: BPMN model of the preferred planning process (part II)

Appendix C. User Stories

Sprint 1

As a planner I want to have a central overview of all the containers that need to be planned at the cold store so that I have a clear overview of which containers need to be planned today.

- Add the first tab to the planning tool and insert data grid.
- Only show shipments that will have the status 'To Plan'.

As a planner I want to see only the shipments that will be loaded at the cold store on the Maasvlakte so that the planning tool only plans the containers at this cold store.

- Add an X-path constraint that checks where the container is filled, and only show the containers that are filled at the Maasvlakte.

As a developer I want to give shipments a planning status so that the shipments can be sorted over the different tabs in the planning tool.

- Where to store this attribute?
- Make Enumeration with four statuses:
 - To plan
 - Time calculated
 - Time confirmed
 - Time sent
- When the sailing of the container is confirmed, it will get a status that it needs to be planned at the cold store.
 - When INTTRA Booking is confirmed, change status. Do this in microflow of the incoming message.
 - When a booking is confirmed manually, call microflow that will change status.

As a planner I want to add a 'loading from' to an order so that the planning tool can calculate from there a time window.

- Add an attribute (String) to the domain model and add in the NewEdit page.
- Validate the data when inserted.

As a planner I want to see the time window on the shipment page so that all the information about the shipment is showed at the same place.

- Add a tab and a grid where the time windows can be viewed.
- Add X-path constraint, so that only the time windows of current shipment are shown.

As a planner I want to add opening and closing times to a depot so that the algorithm can calculate with these times.

- Add attributes (String) and fields for opening and closing time.
- Add an attribute (Boolean) and field for when a depot is 24 hours open.
- When Boolean is true, fill in opening and closing time automatically.
- Validate data when depot is saved.

As a planner I want that an optimal time window for loading the container is automatically calculated so that the planning is more accurate.

- When 'loading from' is inserted, the algorithm starts.
- Validate if all data that the algorithm will use is stored in LMS and if this data has valid values.
 - Loading from (bigger or equal than today and smaller then VGM closing)
 - VGM Due Date
 - Empty Pickup depot (and depot times)
 - Full delivery depot (and depot times)
- Delete loading from, when data is missing.

- The status will be changed after calculation.

As a planner I want that more time windows are made when 'from date' and 'VGM closing date' are on different days so that a time window is more precise.

- Create a loop so that the algorithm can calculate multiple time windows.

As a planner I want that when a container is part of a batch, that the algorithm calculates for each container in the batch a time window so that a whole batch is calculated at once.

- Check whether the container is part of a batch
- If the container is part of a batch, loop over all containers to calculate a time window.

As a planner I want to have a central overview of all the containers that are planned at the cold store so that I have a clear overview of which containers are planned today.

- Add a second tab to the planning tool and insert data grid.

As a planner I want to add VAL information so that these codes can be used in calculating the time window.

- Add entity with the following attributes:
 - Code (String)
 - Description (String)
 - Storage (Boolean)
 - Transport (Boolean)
 - Documents (Boolean)
 - Explanation (String)
 - Header, Line (Enumeration)
- Add a page where VAL information can be viewed, added and changed.
- Validate if all fields contain the right values.

As a planner I want that VAL code 1040 overrules all other criteria so that a container can be inspected.

- Check if the shipment has VAL code 1040.
- Change the algorithm, so that when a shipment has VAL code 1040, the container is planned in a specified time window.

As a planner I want to check the time window before it is added to the send list so that I can check if the algorithm does what we expect it to do.

- Add third tab and data grid, where shipments with a calculated time window are shown.
- Make a button on the tab page, that will change the status of the selected shipment.
- Make a button on the ShipmentNewEdit page, that will change the status of the shipment.

As a planner I want to send every day a document with all containers planned that day so that these emails are not written manually anymore.

- Add a button that generates a document, with all the containers that are planned that day.
- Make a layout for the document with the theme of the LSP.
- The following data need to be in the document:
 - Container number
 - Time window(s)
 - VAL code(s)
- The status will be changed when the document is generated.

As a planner I want to have a central overview of all the containers that are sent to the cold store so that I have a clear overview of which containers need to be scheduled at the cold store.

- Add a fourth tab to the planning tool and insert data grid.
- Only show shipments that are sent to the cold store.

As a planner I want that the algorithm calculates a new time window when a shipment is changed so that the time window is always accurate.

- Do this when the following data is changed:
 - VGM closing time
 - Loading from
 - Depot(s)

As a developer I want that pages, microflows, and entities are only accessible to persons that need to use them so that everyone sees what they must see.

- Check for all pages, microflows, and entities made which access rules must be added.

As a planner I want all pages up-to-date so that the data shown is up-to-date.

- Check what pages need to be refreshed automatically.

Table 9: User stories, sprint 1

Sprint 2

As a planner I want that a standard time window is calculated, even when there is no depot selected so that we can always send a BCO to company X.

- Change validation for depot
 - When no depot is selected, calculate standard time window (00:00 – 23:59).
- Give message that depot is not selected but can add later.

As a planner I want that the algorithm calculates a standard time window when a depot is deleted, so that there is a time window that can be sent to company X.

- When depot is deleted, a standard time window is calculated (00:00 – 23:59).

As a planner I want that the algorithm checks if a new time window needs to be calculated when a depot is added later in the process so that the time window is accurate for the chosen depots.

- When the depot is selected, new time window will be calculated by the algorithm.

As a planner I want to confirm multiple containers at once.

- Change the microflow behind the confirm button on the 'loading time calculated' page.

As a planner I want that a container can be confirmed without a depot so that the container can be planned at the cold store, and the depot can be added later.

- Change the microflows behind the different confirm buttons.
- Add warning messages, when the container is confirmed without a depot.

As a planner I want that a container is deleted from the 'loading time sent to cold store' tab when a final loading time is inserted so that the tab only shows shipments that yet need to be planned at the cold store.

- Add extra value to the cold store status Enumeration.
- Make an on change microflow for the 'loading date cold store' field.
- When this field contains a value of '00:00', it will not be deleted from the list. Because a value of '00:00' is given when the time is not known, but a BCO has to be sent. So, this is not a final loading time.

Table 10: User stories, sprint 2

Product Backlog

As a planner I want that all the actions from the planning tool are added to the activity log so that all actions can be traced back.

As a planner I want that the travel time to a depot is included in the algorithm.

As a planner I want that a VAL code comes with a booking, it is automatically added when not in the database.

As a planner I want that all other VAL codes are also included in the algorithm, so the time window will be more accurate.

As a planner I want that the time windows are automatically sent to the cold store.

As a planner I want to add time slots to the planning so that containers can be planned in at time slots instead of time windows.

As a planner I want that the cold store in Belgium is also included in the planning tool so that the planning tool can also be used for this cold store.

As a planner I want a direct link with the cold store planning so that we have an insight into their planning. This way, we can optimise our planning even further.

Table 11: Product Backlog

Appendix D. Algorithm

When the time window calculation in Figure 14 is triggered, the 'TimeWindowCalculation' microflow starts.

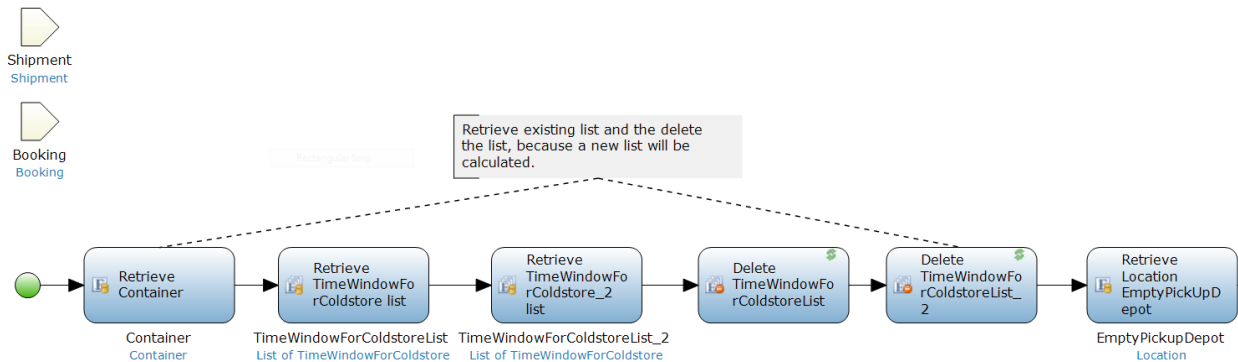


Figure 24: Microflow: TimeWindowCalculation (1)

When the 'TimeWindowCalculation' microflow (Figure 24) is triggered, it first retrieves the necessary entities (data). It often happens that data changes and a time window is calculated again. Therefore, there is also an action that deletes the current list with the time windows for this shipment.

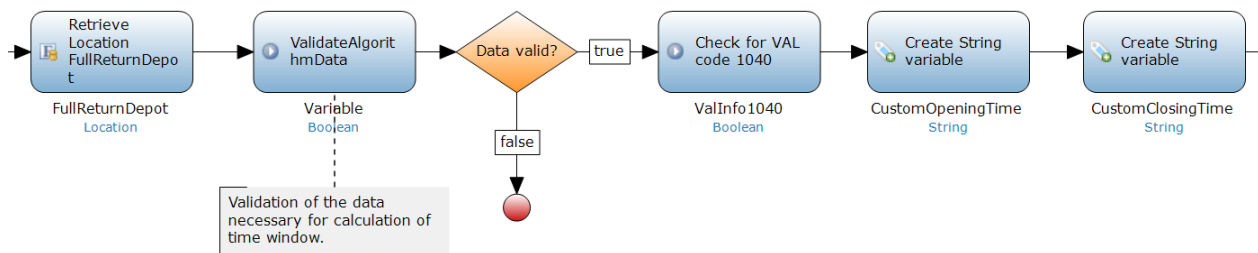


Figure 25: Microflow: TimeWindowCalculation (2)

As can be seen in Figure 25, all data is validated in the microflow 'ValidateAlgorithmData'. This microflow checks if all data is available and if the data has valid values. When data is not valid, the microflow returns a false Boolean, and the 'TimeWindowCalculation' microflow stops. If all data is valid it continues with the check for VAL code 1040. When a shipment has VAL code 1040 it needs to be inspected at the cold store and the microflow returns a Boolean with the value 'true'. The last two actions in this figure, are the creation of two temporary variables. The custom opening and closing time variables are used by the algorithm when there is no depot selected.

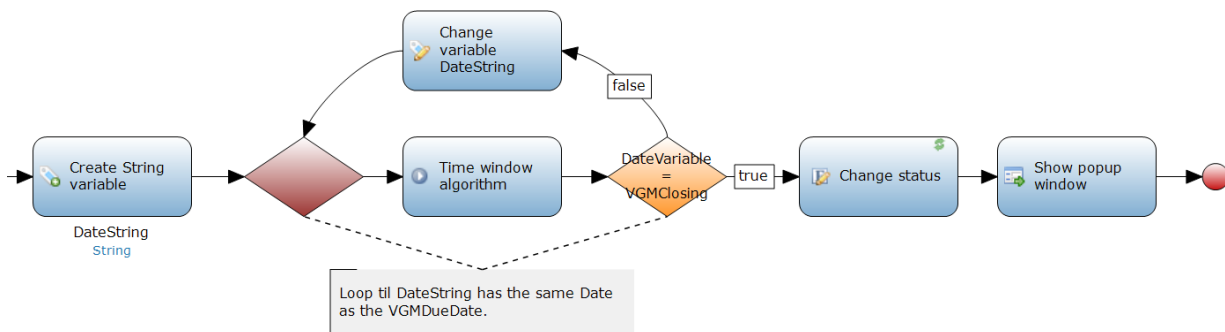


Figure 26: Microflow: TimeWindowCalculation (3)

It often happens that the 'loading from' date is not the same as the 'VGM due date'. This means that for each day, until the 'VGM due date' is reached, a time window needs to be calculated. To make this loop, a variable DateString is created (Figure 26). This variable has as start value the date of the 'loading from' and with each loop, one day is added to this variable until the date is the same as the 'VGM due date'. In the loop is the algorithm that calculates the time window. After the loop, the status of the shipment is changed to 'time calculated' and a pop-up window with the calculated time windows is shown.

The algorithm which is triggered in the loop calculates the time window. Based on the 'Loading from', 'VGM due date', empty pick up depot, full return depot and VAL code 1040 a time window is calculated. The upper and lower bound of the time window are determined by a forward chaining algorithm.