# VISUALIZING OCEAN CARRIER PERFORMANCE

## A FRAMEWORK FOR EVALUATING LOGISTIC PARTNERS

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# Visualizing Ocean Carrier Performance: A framework for evaluating logistic partners

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# Preface

This bachelor thesis is written in fulfilment of the bachelor Industrial Engineering and Management at the University of Twente. The writing of this thesis has been an exciting and challenging journey for the last six months. This research was conducted on behalf of CAPE Groep for a Logistic Service Provider. During this assignment, I investigated how the performance of ocean carriers can be visualized and ranked, to improve the selection of carriers.

I want to thank CAPE Groep for giving me the opportunity to conduct my research. I want to show my gratitude to Maik Wesselink in particular, for providing guidance and information during this assignment. Furthermore, I would like to thank the Logistic Service Provider for the opportunity to conduct research in their company and improve their processes.

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I wish you a pleasant read.

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# Management Summary


**Introduction**

The maritime sector has a bad reputation regarding the performance of vessels. The Logistic Service Provider (LSP) in this research is struggling to contract the best performing carrier on each route. At this moment a carrier is contracted based on price alone, as no up-to-date performance is available for the different carriers. The research will provide a solution for the visualization and comparison of current carrier performance.

This research is conducted at CAPE Groep, commissioned by an LSP who handles the outbound logistics of Company X. Customers of Company X have expressed their concerns regarding the information sharing of orders and performance of carriers. Furthermore, employees of the LSP are experiencing a high workload, as a lot of time is lost in solving problems for delayed shipments. Both these issues occur as there is no up-to-date performance data available. Furthermore, there is only a limited amount of data available in the Logistic Management System of the LSP.

Firstly, the aim of this research is to visualize and automate the calculation of carrier performances, which must be done frequently. Secondly, research will be conducted into the collection of extra data, as some destinations only have a limited amount of orders each quarter, or do not have performances available for every carrier.

In this study, the main research question is answered:
"Which KPIs are valuable in evaluating an ocean carrier's performance, and how can these KPIs be visualized to give a Logistic Service Provider insight into carrier performance?"

**Approach**

To solve the problem and develop the solution, the systematic approach of the Design Science Research Methodology was followed. Literature research together with interviews determined the design and functionalities of the prototype. For the development of the dashboards, literature research was conducted into the following subjects:

- KPIs for evaluating ocean carrier performance
- Managing the data required for KPI calculations
- Ranking the performance of carriers, based on multiple criteria
- Designing a functional and attractive dashboard.

**Prototype design**

As a result of the literature research and conversations with the LSP, a prototype was created. Three different dashboards have been created in the Mendix application of the LSP, based on solution objectives. Each of these dashboards can be filtered on different criteria such as Port of Delivery, Shipping Lane, Carrier, Sales Area and Time period.

- General dashboard: Overview of the average performance of different carriers. This dashboard allows for carrier comparisons on specific Shipping Lanes or Areas.
- Carrier dashboard: Overview of the performance of different carriers on different routes. This dashboard allows for comparing the performance of a carrier on different routes.
- Problem Routes dashboard: Overview of the ten worst performing shipping lanes are shown based on the selected ranking.

**Conclusions and recommendations**

This research improves the availability of carrier performance, by automating the calculation of performance KPIs. The designed dashboards solve the core problem as performances of carriers are updated each day. The restrictions in the dashboard allow the LSP to compare different carriers on the different shipping lanes in a period.

Despite the realization of the goals, the prototype can be improved. Therefore, several recommendations are given to improve the prototype: Preparing the prototype for production, Collection of additional data, addition of extra functionalities, customer dashboards, and options for further research are discussed.

**From use case to general framework**

The solution developed in this research was specifically made for the mentioned LSP. Similar companies are likely to use different systems and data. Therefore, a general framework was developed that addresses the different steps to be taken in order to visualize and rank carriers based on performance. This framework includes the selection of KPIs, collection and management of data, design of dashboards, and ranking methods of carriers, that allow similar companies to evaluate and compare the performance of carriers.

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# Reader’s guide

This report contains the research conducted for the bachelor’s thesis Industrial Engineering and Management. The research titled “Visualizing Ocean Carrier Performance: A framework for evaluating logistic partners” is structured into eight chapters, which are introduced below.

**Chapter 1 | Introduction** covers a general introduction into the research. The context of the problem is discussed as well as the companies involved in this project. The problem is then introduced and investigated to find the core problem. The relevance of solving the problem is addressed, after which the methodology and research questions for solving the problem are discussed.

**Chapter 2 | Current and preferred situation** addresses two current processes occurring at the LSP. afterwards, the ideal situation for the LSP is explained and the goals for this research are determined. To measure the improved situation, several variables and indicators were determined.

**Chapter 3 | Theoretical Framework** explains the theory that is used for the development of the prototype and framework. A systematic literature review was done into KPIs that asses the performance of carriers, as well as research into data management, Multi-Criteria Decision Analysis, and dashboards.

**Chapter 4 | New Situation** clarifies the KPIs that were chosen from the literature and will be implemented in the prototype. Furthermore, research was done into the collection of extra data on ocean carriers, as there is only a limited amount of performance data available on certain destinations.

**Chapter 5 | Design and Development** shows steps taken in the creation of the prototype. Firstly, the requirements were determined, after which Mock-ups were created. Then, the approach of developing the prototype is discussed, as well as its architecture. The development is addressed afterwards, as well as the management of the data. And finally, KPI calculations and the ranking of carriers is shortly described.

**Chapter 6 | Prototype Demonstration** visualizes the developed dashboards. The page for changing the KPI weights is showed as well, as it was specifically developed for this prototype. And lastly, the carrier overview page is shown, as it is used for the updating of KPIs.

**Chapter 7 | Conclusion** answers the question whether the developed dashboards solved the core problem and improved the current situation. In this chapter, the limitations of this research and also recommendations for further research are discussed.

**Chapter 8 | Framework for evaluating logistic partners** structures an approach for visualizing carrier performance in the form of a ranking. The approach for the specific use-case that was explained in the previous chapters is generalized to be applicable for similar Logistic Service Providers or Small and Medium Enterprises.

## List of abbreviations

| | |
|---|---|
| ATA | Actual Time of Arrival |
| ATD | Actual Time of Departure |
| BPMN | Business Process Model and Notation |
| B/L | Bill of Lading |
| DSRM | Design Science Research Methodology |
| ETA | Expected Time of Arrival |
| ETD | Expected Time of Departure |
| KPI | Key Performance Indicator |
| LMS | Logistic management system (Mendix application) |
| LSP | Logistic Service Provider |
| MPSM | Managerial Problem-Solving Method |
| MVP | Minimal Viable Product |
| POD | Port of Delivery |
| POL | Port of Loading |
| SME | Small and Medium Enterprises |
| STA | Scheduled Time of Arrival |
| STD | Scheduled Time of Departure |

## Definitions

| | |
|---|---|
| Known carriers | Carriers that were contracted in a certain quarter. The performances of these carriers can be calculated through the saved shipment information of the orders. |
| Unknown carriers | Carriers that were not contracted in a certain quarter. No performance information is available in the system of the LSP. Therefore, information on their performance must be collected from other sources. |
| Cold store | A Building which is artificially cooled so that food can be preserved in it. |
| Reefer container | A shipping container, also called refrigerated container, used in intermodal freight transport, that can effectively control the temperature between -65 °C and 40 °C. |
| Problem cluster | A tool that helps a researcher find the relations between the problems. It brings order to the context and identifies the core problem(s) (Heerkens, van Winden & Tjooitink, 2017). |
| Problem owner | A person, a group, or an organization, that feels that a certain problem exists (Heerkens et al., 2017). |
| Action Problem | The discrepancy between the norm and reality as perceived by the owner of the problem (Heerkens et al., 2017). |
| Knowledge problem | A knowledge problem is a description of the research population, the variables and, if necessary, the relations that need to be investigated (Heerkens et al., 2017). |

| | |
|---|---|
| Core Problem | The problem(s) that is/are chosen to be solved. This problem cannot be caused by other problems. Not all causes of the problems are worth solving. For example, problems like the weather cannot be solved, or other solutions cost more than they return (Heerkens et al., 2017). |
| KPI | A Key Performance Indicator is a measurable value that shows the performance of a business objective. |
| DSRM | A methodology for conducting Design Science Research in Information Systems. The object created in this methodology is an artefact and the two major activities are designing and investigating this artefact. The artefact is designed to interact with the problem context and improve it (Wieringa, 2014). |
| MPSM | A simple framework and method to solve managerial problems. It can be applied to various problems by following the seven phases. The Managerial Problem Solving Method takes into account that most problems are not an isolated issue and expresses these problems in variables (Heerkens et al., 2017). |
| Mock-up | In software engineering, a mock-up is used to create a user interface that shows the end user what the software and functions will look like. It is not required to build the software or functionality. By using mock-ups, feedback can be collected in the early stages of development, which saves both time and money. |
| Balanced Scorecard | A business framework for tracking and managing an organizations strategy. the BSC distinguishes 4 different perspectives: Learning and growth, Business processes, Customer perspective and financial data (Kaplan & Norton, 1996). |
| BPMN | The Business Process Model and Notation (BPMN) provides a flowchart visualization, which is made up of graphical elements. The goal of the BPMN is providing a notation that is understandable and intuitive to business users (White, n.d.) |

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# 1 Introduction

In this chapter, companies that are involved in the project are introduced in section 1.2 after the general problem context is addressed in section 1.1. Additionally, a description of the occurring problems can be found in part 1.3. The core problems will be identified by means of a problem cluster in section 1.4 and 1.5, after which in part 1.6 the relevance is described. Section 1.7 states the research questions and problem approach. Finally, the scope and structure of the report are discussed in section 1.8 and 1.9 respectively.

## 1.1 Context

The world seaborne transportation was estimated at a total of 10.7 billion tons in 2017, which make it the largest transport method in terms of weight (Asariotis et al., 2018). 17.1% of this maritime transport was transported overseas in large 20- or 40-foot containers. Over the years, customers have been more demanding regarding the on-time arrival of their shipments. Customers are requesting more performance and information about delivery times and transport visibility. However, the maritime sector has a bad reputation with respect to the timeliness of vessels. In 2018 the average schedule reliability only measured 62.3% (CargoSmart, 2019). Logistic Service Providers have difficulty in selecting the best performing carriers, in order to improve the performances of containers shipped by them, as little information about carrier performance is available.

## 1.2 The involved companies

Multiple companies were involved in the creation of this report. Therefore, each company will be introduced together with their role in this research.

### CAPE Groep

CAPE Groep, where is referred to as 'CAPE' further in this report, is an IT consultancy company which delivers services like software development, connectivity, business intelligence and integrations to businesses. These services are mainly created with the model-driven development platforms Mendix and eMagiz. Whereas Mendix is the foundation of dynamic and customized applications, eMagiz provides integrations between the different IT systems used by a company and the Mendix applications.

### Logistic Service Provider

A Logistic Service Provider, from here on referred to as LSP, takes care of the partial or total logistics services of a company as a third party. LSPs are specialized in transport and can serve multiple clients at the same time ("Logistic Service Provider," 2013). In this situation, the LSP[1] is a customer of CAPE and takes care of all the outbound logistics of a company that produces frozen food: Company X. The LSP does not own any trucks or vessels, but places orders for the shipments at the different carriers. CAPE has developed an application where all the orders of the LSP are processed and stored: the Logistic Management System (LMS).

### Company X

Company X is a producer of frozen potato products, which are transported all over the world. The frozen potato products are shipped in 20- of 40-foot reefer containers, which can effectively control the temperature between -60 °C and 40 °C ("Refrigerated containers," n.d.). Company X used to have its own

[1] Due to confidentiality the actual names of the LSP and Company X are left out of this report

logistics department, but growth resulted in outsourcing the logistical processes. The LSP was founded to take care of the logistics of company X.

### Dinalog project

This research is part of the "Autonomous Logistics Miners for Small-medium Businesses" project of TKI-Dinalog. The mission of TKI-Dinalog is to boost innovation in the logistics of the Netherlands to maintain en strengthen the logistics sector. The aim of this project is to increase the competitiveness of Small and Medium Enterprises (SMEs) by using smart data mining agents, which process data with minimal intervention of humans ("Autonomous Logistics," 2018). Large quantities of data will be analyzed to help SMEs react quickly on disruptive circumstances and delays in the supply chain. Furthermore, it will help SMEs respond to the changes in trends and demand and provide insight into performance indicators and efficiency.

### INTTRA / CargoSmart

INTTRA is an ocean trade platform, where shipments can be planned, booked and tracked from one easy-to-use software system. To date, it is the largest shipping network in the world with more than 60 connected carriers, including 9 of the top 10 shipping companies based on Twenty-foot Equivalent units (TEU) According to "Top 10 International Container Shipping Companies" (2016).

CargoSmart is also a platform that, among other offered solutions, provides shippers with the option to submit booking requests online to improve the speed of the bookings. Over 40 carriers are connected to this platform including some of the world leading ocean carriers (CargoSmart, 2019). The LSP in this research mainly uses this platform for the carriers that are not connected to the INTTRA platform like Orient Overseas Container Line (OOCL).

## 1.3 Introduction to the problem

The Logistics service provider takes care of all outbound logistics of Company X. The deep-frozen food Company X produces, is shipped all over the world. Every week, on average 165 containers of potato products are transported from the factory to a cold store and from the cold store to the port of destination. The customers take care of road transport between the destination port and their businesses themselves.

Every quarter, carriers are contracted for the different destinations the reefer containers must be shipped to. The LSP sends a list to all carriers with the expected number of containers that need shipping. The carriers decide on which route they want to compete for a contract with other carriers. If they want to do a bid on a certain route, they send back their price proposal. Additionally, the carriers include extra conditions like the number of days a container can stay free of charge in the destination port.

At this moment, the decision for a carrier on each route is primarily based on price, as the other conditions included in the proposal are not very important to the LSP. No up-to-date information on carrier performance is easily accessible by employees of the LSP, which limits them to selecting carriers only based on price.

When looking back on past performances, there is a significant difference between the promised and attained performances of carriers on several routes. In the last quarter, the preferred and contracted carrier was changed for 1/3$^{rd}$ of the destinations, based on both their poor performances and changed prices. Furthermore, research done by an external party with the customers of Company X showed that the sharing of performance information is not at the desired level of the customers.

## 1.4 Problem statement

To get a clear overview of the problem and show the relations between the problems, a problem cluster was created. The problem cluster starts with a situation that is not how we want it to be, in this case the high workload at the LSP and the customers that are not satisfied with the sharing of shipment information. The discrepancy between this reality and the norm we want to have is called the action problem (Heerkens et al., 2017).

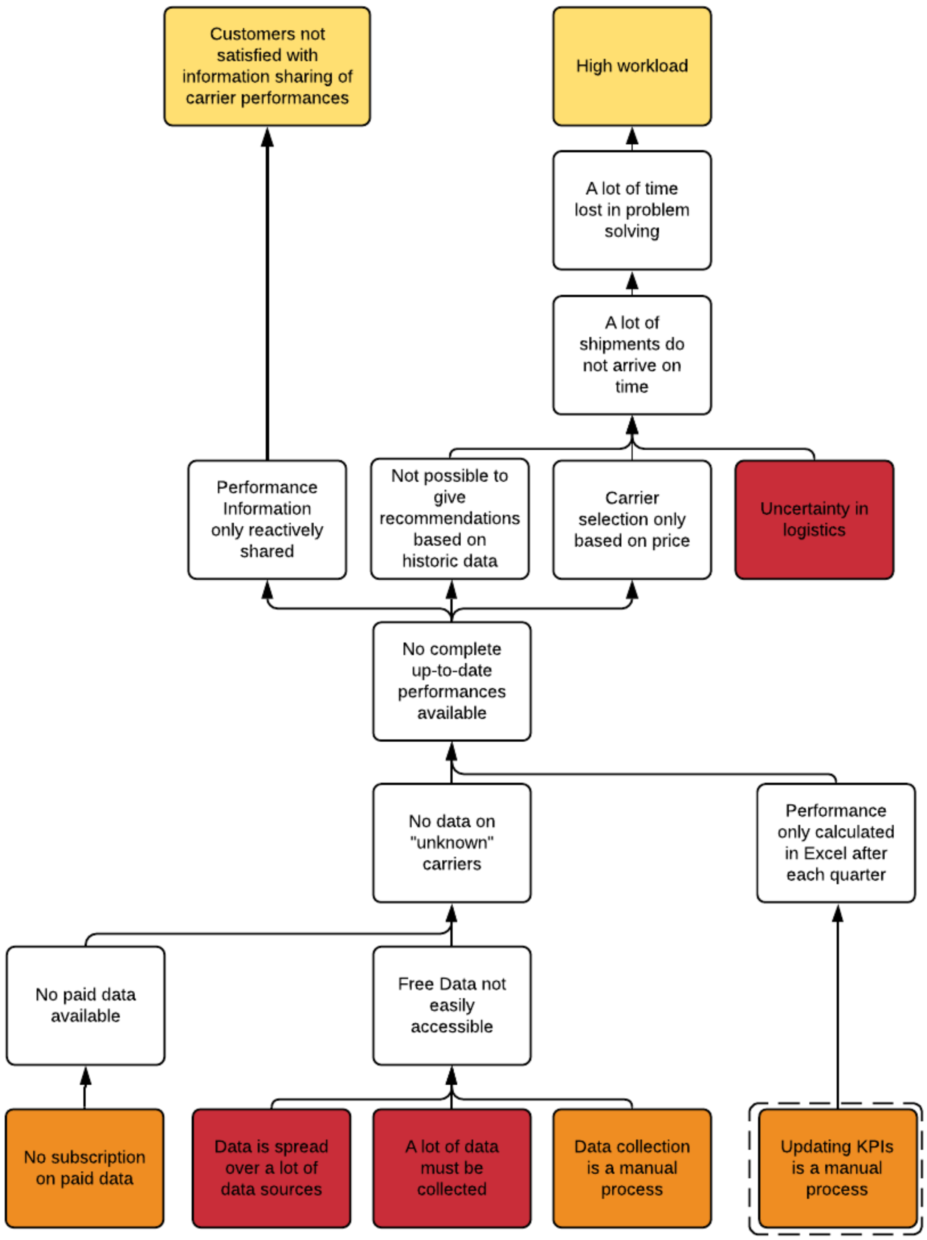



*Figure 1: Problem cluster*

| | |
|---|---|
| Yellow | Action problem |
| Red | Problem that cannot be influenced |
| Orange | Core problem that is addressed in this research |

*Table 1: Legend problem cluster*

The problem cluster starts at the top with the two action problems high workload and unsatisfied customers. Planners of the LSP lose a lot of time in handling the problems that occur during the shipping of orders, which increases their workload. When looking back on the performances of carriers in the last quarters, a lot of shipments did not arrive at the time initially promised by the carrier. For every shipment that did not arrive on time, the LSP must track the shipment, contact the carrier and inform customers with the new information on their shipments.

One of the main reasons that a shipment does not arrive on time, is that the preferred carrier is only selected based on the price that is offered before each quarter. When an employee books an order, he looks which carrier is contracted on that route and checks their scheduled sailings towards that destination. Only If no sailing is available within the timeframe, then another carrier is selected for the shipment. The current process of booking a shipment, together with the carrier contracting process were visualized using the BPMN to clarify the processes and find possibilities for the data visualization. Both these processes are addressed in Chapter 2: Current situation.

Secondly, it is not possible to give recommendations to planners based on historical data when booking a shipment. For example, a carrier is always around 7 days late when sailing from Rotterdam to Shanghai. A customer needs to have extra stock to take care of this uncertainty. When it is known that a carrier is around 7 days late, the LSP books a sailing one week earlier and the shipment is now at the right time in Shanghai which reduces the amount of stock the customer should have because the arrival date is more accurately determined.

And the last reason why shipments are often late is the uncertainty in logistics. This uncertainty is caused by unexpected breakdowns, weather, customs delays and many more. Unfortunately, most of these problems are not solvable by an LSP or only have a minor impact on the process which makes them not attractive to solve.

As mentioned before as the other action problem, the customers of company X are not content with the current sharing of information. The information on carrier delays is only shared reactively after the shipment is delayed, and performance information on specific destinations is not available to share with customers. Company X has given high priority to sharing relevant and up-to-date shipping information with customers. The data that is used for the sharing must come from the LSP, who takes care of the outbound logistics.

At this moment, customers cannot be informed with actual and complete performance data. There are multiple reasons why the performance data is not available or up-to-date: The Performances of shipments are not calculated frequently and they are not easily accessible for employees of the LSP. Furthermore, there is no performance data on carriers that did not ship containers for the LSP in a certain quarter. Therefore, it is not always possible to compare different carriers based on their performance for specific destinations.

**No KPIs calculated**

That the performances in the form of KPIs are not calculated frequently, is because there is no place available for KPIs in the LMS. Only after each quarter, the general performance is manually calculated in an Excel dashboard. This dashboard does not allow for comparing the performance of carriers on specific Shipping Lanes, Areas or Destinations and is only based on the data of the last quarter. Updating these KPIs takes numerous steps and a significant amount of time, which is the main reason why the performances are only calculated quarterly. A detailed explanation of the current process of updating KPIs can be found in Chapter 2: Current situation.

**No data on unknown carriers**

The problem of finding the performance of an "unknown" carrier, a carrier that was not contracted in a quarter, is more complicated. There are two reasons why no data is available on these carriers. Firstly, because the free data is difficult to collect. The data required to get KPIs like on-time performance or booking response time is spread across many websites and sources, while the KPIs must still be calculated from this data. Collecting this data manually is time-consuming and vulnerable to mistakes, as a lot of data needs to be collected to produce a reliable performance.

Secondly, other data of "unknown" carriers is not accessible because the LSP does not have access to paid performance data, which is easier to collect. Several websites offer a subscription where it is possible to see performance data of carriers on route and vessel levels.

## 1.5 The core problem

The problems, which cannot have another cause, chosen to be solved in research can be identified as core problems (Heerkens et al., 2017). There are six candidate core problems visualized in the problem cluster:

- Uncertainty in logistics
- No subscription on paid data
- Data is spread over a lot of sources
- A lot of data must be collected
- Data collection is a manual process
- Updating KPIs is a manual process

When assessing the problem cluster, three candidate core problems can be recognized. Three other problems are not solvable, as uncertainty in logistics like the weather cannot be solved. Furthermore, it is not desired to change the number of data sources and the amount of data that has to be collected. Reducing one of these two will either limit the amount of KPIs or will make the KPIs less reliable with fewer data points.

Heerkens advices to keep the number of core problems to a minimum, as it could lead to half-solved problems (Heerkens et al., 2017). This is especially relevant when considering the limited amount of time that is available for this bachelor thesis, namely ten weeks. Therefore, the core problem that is solved in this research is:

*"The updating of carrier Key Performance Indicators is a manual and time-consuming process"*

In this study, a solution will be developed that solves the core problem. This dissolves the problem of not having up-to-date performance information based on historical data of contracted carriers. This solution allows for carrier negotiation and selection based on performance. The performance data can furthermore be used for the booking of shipments and sharing of performance information.

The other two candidate core problems will be addressed as well, but are not be solved in this research. Having performance information of "unknown" carriers allows the LSP to compare more carriers on the same route and improve the performance of contracted carriers by selecting the best one. Additional research will be conducted into possible sources for this extra data, but this data will not be collected due to the time restriction of this research. In the future, this extra data can be merged with the already available data in the LMS, to improve the amount of carrier data available for each destination.

## 1.6 Relevance of the problem

The LSP wants more insight into the performances of ocean carriers. By solving this problem, the LSP can save money and time by selecting better carriers. Time is saved because fewer problems occur during transport and the money is saved in avoiding delays and fines. Furthermore, the customers are content, as more orders arrive on time and performance information of their orders is actively shared. These advantages make it attractive and cost-saving for the LSP to solve the lack of performance information in the information sharing, order booking, and carrier selection processes. Therefore, the problem that is solved in this research is highly relevant to the LSP.

Additionally, the research is relevant for the University of Twente and TKI Dinalog, as research is done into ocean carrier performance and the visualization of these performances. This visualization of KPIs aims to help the LSP, or similar SMEs, in selecting the best performing carriers based on automatically calculated KPIs, to improve their competitiveness. In Chapter 8, a general framework for the visualization and evaluation of carrier performance is described, which was based on the case study performed for the LSP.

## 1.7 Methodology & Research Questions

The main goal of this research is to allow the LSP to make a well-reasoned decision in selecting the right carrier to improve the on-time performance and customer satisfaction. Therefore, the main research question is:

*Which KPIs are valuable in evaluating an ocean carrier's performance, and how can these KPIs be visualized to give a Logistic Service Provider insight into carrier performance?*

The main research question is split into several sub-research questions which will help to answer the main research question. The derived sub-questions and the chapters where they are addressed are described below.

In order to systematically solve the occurring problem, the steps of the Design Science Research Methodology (DSRM) will be followed (Peffers, Tuunanen, Rothenberger & Chatterjee, 2007). This approach was chosen over the Managerial Problem-Solving Method (MPSM) (Heerkens et al., 2017) because one of the deliverables is a prototype. The DSRM is focused on research which delivers a prototype and validating this prototype afterwards. Despite the use of the DSRM, the steps and elements of the MPSM will be kept in mind during this research.

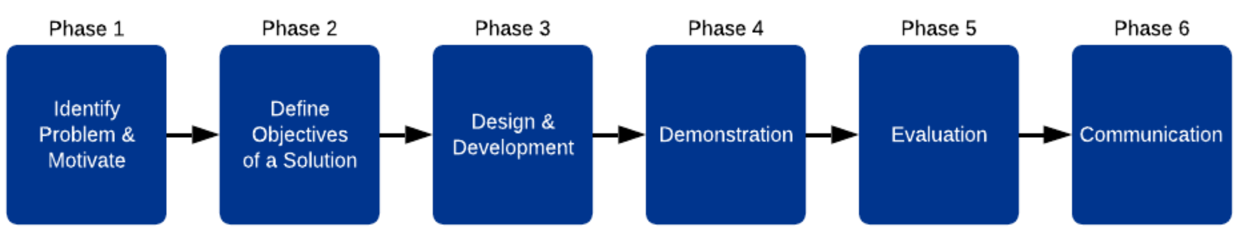



*Figure 2: Design Science Research Methodology (Peffers et al., 2008)*

**Phase 1 Identify problem**

In the first phase of the DSRM, the research problem is defined. Relevant problems and its relations are visualized by means of a problem cluster. Furthermore, the current processes are visualized by means of a BPMN model to gain more background understanding. To successfully visualize the current situation, the following sub-research questions were formulated:

1. What is the current situation?
    - 1.1. What does the current carrier contracting process look like?
    - 1.2. What does the current shipment planning process look like?
    - 1.3. What does the current KPI calculation process look like?

**Phase 2 Define the objectives of a solution**

In phase 2 the desired situation is described. The objectives of the research and the objectives of the LSP are formulated. Additionally, literature research will be done into KPIs and data analysis, MCDA and dashboards to gain the knowledge to implement the solution successfully. The research questions in this second phase are:

2. Which existing KPIs can express the performance of ocean carriers?
    - 2.1. Which of these KPIs can be calculated with available or easily collectable data?
    - 2.2. How to gather and manage the required KPI data?
3. Which MCDA tool can be used to rank carriers based on their performance?
4. How to develop a dashboard for the selected KPIs?
5. Where could additional carrier performance data be gathered from?

**Phase 3 Design & Development**

In the 3rd phase, the prototype is developed. Before the development, the solution design of the prototype is drawn up in consultation with the LSP and CAPE. Based on the solution objectives, the prototype is developed in several sprints.

6. What will be the solution design of the prototype?
    - 6.1. Which KPIs does the LSP want to use in the carrier comparison?
        - 6.1.1. Which data is required for those KPIs?
    - 6.2. What are the requirements for the prototype?

**Phase 4 Demonstration**

After the prototype is developed, it will be presented to the stakeholders. After the demonstration, it will be tested on its functionalities and efficiency in phase 4 of the DSRM.

**Phase 5 Evaluation**

In phase 5 the prototype and its functions are evaluated. Does the solution, which is implemented in the prototype, indeed reduce the number of delayed shipments? The calculated indicators are compared with the base values to calculate the improvements.

**Phase 6 Communication**

The final phase of the DSRM is about communicating the research and its solution to other researchers and relevant audiences. Based on the results in the evaluation phase, the limitations and further research possibilities of this study are described. Additionally, a general framework was developed, which addresses the steps to be taken to visualize the performance of logistic carriers. This proposed framework is addressed in Chapter 8.

## 1.8 Scope

Because the time of conducting this research is limited to ten weeks, not all the findings and solutions can be implemented. Therefore, it was chosen to only advice on the collection of extra data for carrier performance. Selecting such a source and collecting, implementing and calculating performances with this data, would take more time than the scheduled ten weeks. Hence, the focus will only be on visualizing the performances, and not on improving processes related to these performances, although certain processes can be improved through automation.

## 1.9 Structure of the report

| Chapter | DSRM phase | Research Questions |
|---|---|---|
| **1 Introduction** | Identify the problem and motivate | Introduction and problem identification |
| **2 Current + preferred situation** | | 1. What is the current situation?<br>1.1 What does the current carrier contracting process look like?<br>1.2 What does the current shipment planning process look like?<br>1.3 What does the current KPI calculation process look like? |
| | Define the objectives of a solution | Description of the ideal situation and goals of this research |
| **3 Theoretical Framework** | | 2. Which KPIs exist that can express the performance of ocean carriers?<br>2.1 Which of these KPIs can be calculated with available or easily collectable data?<br>2.2 How to gather and manage the required KPI data? |
| | | 3. Which MCDA tool can be used to rank carriers based on their performance? |
| | | 4. How to develop a dashboard for the selected KPIs? |
| **4 New situation** | | 5. Where could additional carrier performance data be gathered from? |
| | Design and Development | 6. What will be the solution design of the prototype?<br>6.1 Which KPIs does the LSP want to use in the carrier comparison?<br>6.1.1 Which data is required for those KPIs? |
| **5 Design and Development** | | 6.2 What are the requirements for the prototype? |
| **6 Demonstration** | Demonstration | - |
| **7 Evaluation** | Evaluation | Conclusions of this research, does the prototype fulfil the requirements? |
| | Communication | The limitations, recommendations, and possible further research options are discussed. |
| **8 Framework for evaluating logistic partners** | | Description of the general framework deduced from the previously developed solution for the case study. |

*Table 2: Structure of the report*

# 2 Current and preferred situation

In this chapter, research question 1: “What is the current situation?” and its sub-questions are answered. The current situation of carrier contracting together with the updating of KPIs, and the shipment planning process are explained and modelled in the BPMN in sections 2.1.1 and 2.1.2 respectively. Preceding research, which was done by Rasing in 2018, is addressed shortly, as the designed solution can make use of the performance visualized in this research. Consecutively, the ideal situation for the LSP is addressed and goals for this research are determined.

## 2.1 Current processes

### 2.1.1 Carrier contracting process

Before each quarter, carriers are contracted to ensure the best price for the shipments that are booked in each quarter. The LSP sends out a list with the forecasted number of containers to be shipped on each lane to every carrier. The carriers decide on which Shipping Lanes they want to return a price proposal. When the proposals of every carrier are received, a carrier is chosen for every Shipping Lane by an employee of the LSP. Carriers are contracted based on their proposed price and general feeling on performance by the planner of the LSP. The price is at this moment the only factor that can be objectively used for carrier comparison.

When looking back on past quarters, a lot of shipments did not arrive according to schedule. This conclusion was made based on quarterly dashboards and the significant length of time employees are busy with delayed shipments. The up-to-date carrier performance is unknown since these dashboards are not made frequently and are only used for reporting purposes. The detailed current carrier contracting process can be found in Appendix B.

**Research by Rasing**

Research was done into the carrier contracting process of the LSP by Rasing (2018). This study produced a prototype version within the LMS, where the carrier contracting process was optimized. However, this prototype is still in the development phase and is not used until fully completed and tested. In this research, the number of steps to be taken to choose a preferred carrier was reduced. Also, the time it takes, and the possibilities of mistakes were reduced as the process was automatized. Furthermore, Rasing made it possible to use performance KPIs in the carrier selection process.

To demonstrate the possible use of KPIs in the carrier contracting process, Rasing developed the possibility to upload performance KPIs into the LMS. In total, 4 KPIs that were available in the Excel dashboard, were calculated based on data from Q1 2018 and uploaded into the LMS.

The LSP plans on implementing the newly designed process by Rasing. However, it is already known that the KPIs will not be used as demonstrated in the prototype. This calculation only consists of data in a single quarter and takes too much time to calculate. Calculating these KPIs and using them in carrier selection was not the aim of Rasing’s Research. Therefore, getting insight into actual carrier performance through calculating KPIs takes a lot of time, involves a lot of manual steps, and requires the use of the Excel dashboard made by the LSP.

**Updating KPIs**

In order to update the KPIs, shipment data must be exported out of the LMS into the Excel dashboard. As shipping data of an order is not always complete, the data must be checked for mistakes and empty values manually. For example, when the actual time of arrival is missing, the KPI on-time performance cannot be calculated. Each quarter, more than 2100 orders are created and shipped. It takes a lot of time to perform all these checks manually. When each order must be checked on mistakes before a KPI calculation can be performed, a lot of time is lost.

If the order is checked, the KPI calculation can be made in the dashboard. When all the KPIs are calculated, the different KPIs could be exported back into the LMS. When exported back into the LMS, the employee of the LSP can view the KPIs and use them in the carrier contracting and order planning processes.

### 2.1.2 Shipment planning process

Orders from Company X are sent to the LMS of the LSP. When an order is received, the planner of the LSP will look for a suitable sailing. Basic information, such as the port of delivery and preferred arrival time, is already filled in by Company X. Usually, the planner will look for a sailing with the contracted carrier that fits within the timeframe. Only if booking the contracted carrier is not possible, then a sailing is booked at another carrier. When a sailing is selected, details of the sailing are sent to the carrier via a booking platform. The carrier will send back a booking confirmation when the booking is accepted. The shipment planning process is modelled in Appendix A. Further steps taken in the shipment planning process, such as cold store planning, are not relevant in this research and are thus left out of this report.

## 2.2 Ideal situation

The LSP wants to have a selection of relevant KPIs available in the LMS for all ocean carriers. With these KPIs, ocean carriers can be evaluated on their performance for different destinations and against other carriers. The aim of the LSP is to contract carriers based on their complete performances and not only on price, which is currently the only criterion.

These selected KPIs must be updated regularly to ensure that the KPIs are valid and up-to-date. These calculated KPIs can be used in several situations. One of the objectives is choosing the best performing carrier on each route. Therefore, data from carriers where the LSP does not work with at this moment should be available in the LMS as well. Only when all the possible carriers can be evaluated based on their performance, a well-reasoned carrier selection can be made.

The LSP aspires to use the performance KPIs in various other situations when the performance data becomes available. Performance information will be shared with customers to provide insight into performance of different carriers. In contract negotiations, carriers can be asked to explain why the promised performance was not achieved.

Furthermore, having a large selection of data available in the LMS provides opportunities for the LSP to improve the forecasts of Transit Times and ETAs with data analysis and machine learning. A first step would be giving planners advice in booking shipments. Advising a planner to book a shipment a week earlier when a carrier is always seven days late is an example of such an advice. Providing insight into carrier performance can be seen as the first step towards shipment recommendations or even the automatic selection of carriers, which is one of the goals of the LSP in the future.

## 2.3 Goals

Not all the identified possible core problems can be solved in this bachelor thesis. Therefore, two core problems were selected: KPIs will be defined and automatically calculated in the LMS, and research will be conducted into the data collection of KPIs for unknown carriers. The KPIs will be researched and selected with the focus on carrier selection. The literature research into these KPIs can be found in Chapter 3: Theoretical Framework.

The first goal is to make the process of updating KPIs automatic, instead of the now manual process and use of Excel. These automatic updates in the LMS will make sure that the KPIs are up-to-date and can be easily used in multiple processes. No more manual steps are needed to retrieve performance information, which is time-consuming and vulnerable to mistakes.

All the available and freshly calculated KPIs should be available in the Logistic Management System of the LSP. A prototype will be created, where the automatic updates of the KPIs are implemented. The KPIs will be visualized in a dashboard, where they can be filtered based on several restrictions. The functionalities and appearance of the prototype were determined after consultation with the LSP and CAPE and can be found in Chapter 5: Design and Development.

When the KPIs are available in the LMS, they can be used in multiple processes of the LSP. These processes include, but are not limited to, Carrier selection, shipment planning, and information sharing with customers. For valid and reliable KPI calculations, research will be done into data management, which can be found in Chapter 3.2: Data management.

Besides the historically available shipment data, the LSP wants data on carriers where they did not ship with in a quarter. This data will not be part of the prototype, but possible options where this data can be collected from will be given. In total, the four most relevant options will be investigated in Chapter 4, where both the advantages and disadvantages of each option are discussed.

## 2.4 Measurability

The core problems must be measurable to evaluate if the developed solution is an improvement on the current situation (Heerkens et al., 2017). Having carrier performance available in the LMS is a large improvement on the current situation where performance is only available in the quarterly dashboards. The presence of performance data does not show whether current processes are improved. For this reason, improvements will be measured in several other ways.

First, the number of criteria on which an employee selects a carrier is improved. At this moment, it is not known how many KPIs will be in the prototype and therefore the number of assessment criteria is also unknown. However, every criterion that is added to the LMS is an improvement on the current situation, as there are no KPIs available in the LMS.

The time it takes to get and calculate the performance of a carrier will be reduced. Instead of at least five hours of data gathering, processing and analyzing, the performance KPIs will be automatically calculated. This process can take some time but is done automatically without the involvement of humans.

Additionally, the time between two calculations of performance KPIs will be reduced from one quarter to preferably a single day. And lastly, the amount of data available for KPI calculations will be increased. The quarterly calculated dashboards only contain data of shipments in the last three months. Some destinations do not have any or only a small amount of orders in a quarter. Using older data can improve the reliability of a carriers' performance for such a destination.

Although improvements are evident, they are hard to measure in time reduction as the solution does not directly replace any process. Due to the time limit of this research, the improvements cannot be measured in costs saved. These costs savings could be determined after using the dashboards for carrier contracting. However, the results are only evident after a quarter. Another way to measure improvements is the use of a maturity model to determine the level of Business analytics. Arbela has created a simple and accurate overview of all the levels of Business intelligence, based on the first maturity model developed by Wayne Erickson.

In order to assess if the prototype increases the level of business analytics, we must first distinguish the differences between the stages.

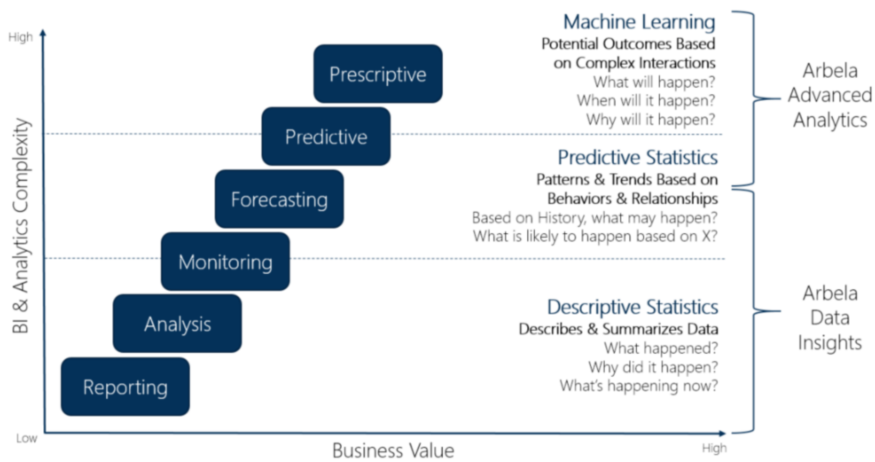


Figure 3: Arbela Maturity Model (Arbela, 2017)

Reporting is the organizing of data in informal summaries to monitor how different areas or shipping lanes are performing. The next step in the maturity model is analysis. In the analysis phase, data is explored to find reasons why certain events happened, to better understand and improve business performance. Monitoring is the next step, which is keeping track of current performance. Forecasting is estimating future events based on past and present data, and thus requires the previous steps of reporting and monitoring.

Predictive statistics uses data mining and probability to estimate more specific outcomes. For example, forecasting estimates the number of customers for the next quarter, whereas predictive modelling could more specifically identify customers who are likely to buy the product. Prescriptive analysis goes even further and suggests decisions that will reduce the risk or maximize the return of each decision.

The current Excel dashboards are best classified as reporting analytics. Every quarter, a dashboard is calculated where the general performance of carriers is visualized. In the ideal scenario, the LSP would like to use machine learning to automatically and accurately predict ETAs and other relevant information, which is the 6$^{th}$ level of the Arbela maturity model.

| | Quarterly dashboard | Preferred |
|---|---|---|
| **Number of KPIs available** | 4 | Depends on result literature research |
| **Time between the updating of performance** | Quarter | Day |
| **Time to update KPIs** | 5 hours | No human involvement |
| **Data availability** | Last quarter | All Time |
| **Maturity model level** | 1 | 6 (Not possible within this research) |

*Table 3: Evaluating the improvements in the prototype*

# Chapter 3: Theoretical Framework

In this chapter, research questions 2, 3, and 4 will be answered in sections 3.1 and 3.2, 3.3 and 3.4 respectively. The findings and answers will be used to create a prototype in the LMS, where KPIs are visualized and analyzed to provide useful information for the LSP. This prototype will be further explained in chapter 5: Design and development.

## 3.1 KPIs for evaluating ocean carriers

A LSP is evaluated primarily based on their price and shipment performance. Therefore, an LSP wants to contract the carrier that has the best balance between price and performance. KPI measure a strategic objective against a set goal (Turban et al., 2010), which provide a means to compare the performance of different carriers. Selecting and comparing suitable KPIs for assessing carriers, will help the LSP to contract the best carrier on each route. Therefore, the research question 'Which existing KPIs can express the performance of ocean carriers?' is answered in this section through a systematic literature review. The steps taken in the search and the in- and exclusion criteria can be found in Appendix D: Systematic literature review.

### 3.1.1 Filtering KPIs

There is a large number of KPIs available in the literature that can express the performance of transport companies. However, not all these KPIs are useful for an LSP to assess the performance of an ocean carrier. For example, the LSP is not interested in the capacity utilization of a vessel and overtime hours of employees.

Besides these KPIs, there is also a number of KPIs where no data is available for, as carriers want to keep them classified. Examples of such KPIs are profit margins and cost levels. In most of the conducted studies, all these KPIs are mixed together as they are focused on evaluating carriers. Only the relevant KPIs for LSPs were selected and gathered from the different sources. A list of all KPIs can be found in Appendix F: Complete list of distinct KPIs for carrier performance.

### 3.1.2 Structuring KPIs

There are many KPIs available to evaluate carriers or logistics and as not all KPIs are relevant for an LSP, it is of great value to structure the KPIs into an understandable overview. Krauth et. al (2005) developed a framework in the area of third-party logistics with different points of view on a company's performance. The KPIs are grouped into four perspectives: Internal Management, Internal Employee, External Customer and External Society. The perspectives were created because of the different points of view stakeholders have on different KPIs. For example, management wants the shipping price to be as high as possible to maximize profit, in contrast to the customer, who wants the lowest price to reduce costs.

In the case of the LSP, the customers point-of-view is most important. The LSP can be seen as a customer of the carrier and want to improve the performance for their own customers. Also, the management and society perspectives are looked at, as some of these KPIs are relevant for the LSP. An example of these perspectives is the level of sustainability from the social viewpoint. In contrast, no useful KPI for carrier evaluation was found in the employee's perspective. Thus, the employee's perspective is left out of the created table.

### 3.1.3 Selecting KPIs

The selection of KPIs that is used for carrier evaluation can slightly differ for each LSP. All the relevant KPIs, which could be useful for an LSP in assessing a carrier's performance, can be found in Appendix E. In this

Appendix, the KPIs are structured according to their perspective and source. A list of distinct KPIs is documented in Appendix F, where the availability of the data and the possibility to collect additional data is included as well.

When contracting a carrier, the LSP wants a selection of the most relevant KPIs calculated, to evaluate the overall performance. The LSP is limited by the data that is available in their application or data that is collectable from other sources. A handful of KPIs was removed, as no data was available. In consultation with the LSP, six KPIs were selected and will be used in the prototype dashboard, which can be found in Chapter 4: New situation.

## 3.2 Data management

After the KPIs have been selected data must be gathered and managed in order to be able to calculate the chosen KPIs. Chaudhuri et al. (2011) describe the process of integrating, cleansing and standardizing data as rather challenging. Efficient use of valid and reliable data is essential for Business intelligence. The data will be updated regularly and need to be quickly aggregated when restrictions on destinations and time periods are set in the dashboard.

### 3.2.1 Data gathering

The data used in the calculation of the selected KPIs are already structured and available in the LMS. In the future, it is likely that additional data will be collected from various sources, as the LSP wants to have data on carriers that were not contracted. This data is not directly available in the LMS and must be collected from another website. In contrary to the LMS, the data quality of these external sources can vary. The different sources can use their own representations, codes and formats, which needs to be changed to fit the data in the LMS. Possible sources where carrier performance data can be gathered from are listed in Chapter 4: New situation. When the source for the additional data is selected, it must be checked on the previously mentioned possible problems and integrated with the data in the LMS.

### 3.2.2 Data structure

The LSP saves data of all orders in the LMS where it is structured into a Mendix domain Model. In Figure 4, a simplified domain model is shown. This domain model is, like most modern-day business applications, a structured data representation of a set of entities which are related to one another (Loshin, 2013). The data is stored in a database where every entity is a separate table. The entity Customer consists of several attributes as the customer has a Name and an Address. All the entities are linked together through relationships, or in Mendix called associations.

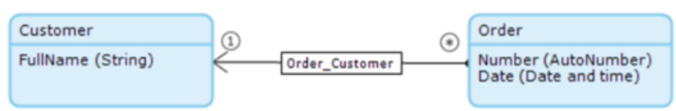


*Figure 4: Example Mendix domain model*

### 3.2.3 Data quality

When data is used from external sources, errors could occur through inconsistent representations for the same value and missing values. In the LMS the data is well structured through the domain model. However, it is still possible for data to be incorrect or missing. Therefore, the data must be checked before it can be used in KPI calculations or data analysis processes. It must be kept in mind that the quality of the data might be sufficient for one situation but not for the other (Olson, 2003). More specifically, When the ATA of a shipment is missing, the Bill of Lading performance could still be calculated, but the on-time performance of the shipments cannot.

### 3.2.4 Data cleaning

In order to ensure the quality of data used for the performance calculations, data cleaning activities must be performed. Data cleaning is the process of removing or modifying data in the database that is incorrect, incomplete, improperly formatted, or duplicated (Rouse, 2010). Using the 6 data quality dimensions, developed by DAMA (2013), the quality of the data can be checked and endorsed.

The quality requirements for each company vary but can be categorized into the following categories: Completeness, Uniqueness, Timeliness, Validity, Accuracy and Consistency (DAMA, 2013). The Completeness dimension checks how many empty fields (or null values) are present in an attribute. When calculating with empty or null values the results can differ from reality or produce errors as empty values cannot be calculated with. The uniqueness check verifies whether all things are only recorded once in the database. An example is the difference between Maersk, Maersk Line and A. P. Moller-Maersk, as they are still the same shipping company. The timeliness dimension assesses the time taken between an occurrence of the situation and the event being stored in the system (Batini & Scannapieco, 2006). The data is more likely to be incorrect, the longer it takes to save it in the system.


*Figure 5: Data quality Dimensions (DAMA, 2016)*

The data is valid if it is consistent with the predetermined format, type and range. With the accuracy check, the data is checked whether it describes the real objects or events (Batini & Scannapieco, 2006). An example is whether there are any spelling mistakes, wrong data formats or not current data values. And lastly, the consistency dimension checks whether two or more representations are the same in different data sets, so that they can be easily linked with each other.

When conducting cleansing activities, every critical data item that is used should be checked with the selected data quality dimensions and their determined values or ranges. The dimensions and restrictions used for the prototype can be found in Chapter 5: Development of the Prototype.

After determining and checking the data on the 6 quality dimensions, the decision must be made of what to do with the data that did not pass the determined requirements. There are three main approaches to take care of this data: Listwise deletion, Pairwise deletion and predictive replacement (Cooper & Schindler, 2013). In listwise deletion cases with missing a variable are deleted, whereas pairwise deletion uses all the cases with no missing data to create an estimation and use it as a replacement for the missing value. Predictive replacement uses a prediction form observed values on another variable as a replacement.

Deleting the data that is not complete or valid can only be safely done if the missing data occurs at random. When data is missing systematically and still deleted, the calculated KPIs could be biased.

As the used data is already structured according to the domain model, several potential problems are already addressed in Mendix. Each variable has a type property which for example prevents an integer to contain letters. Additionally, each attribute in the domain model can have validation rules, which declare the range, uniqueness or expression of the attribute. At this moment, not all variables that are used in the performance calculations, have all the required validation rules to ensure the data quality. The validation rules, which are created for the used attributes, are listed in Appendix J: Data used

### 3.2.5 Data filtering

Data filtering is the process of refining data sets to the needs of the user, such that repetitive, irrelevant or sensitive data are excluded. The reduced size of the data used will also improve the processing time of the queries. In the instance of the LSP, every order is only present once in the LMS. Therefore, data filtering is not required in the processes of the LSP. Some orders do not contain the required data that is necessary for the calculation of any KPIs. Those orders will not be deleted but are excluded from the KPI calculations.

## 3.3 Multi-Criteria Decision Analysis

In multiple criteria decision analysis (MCDA) multiple alternatives are evaluated based on a number of criteria that are in interference (Kumar et al., 2017). For example, most of the time the lowest price does not go together with the best performance. The LSP wants to make a well-balanced decision for carriers on each route, and therefore an MCDA method will be selected to rank the ocean carriers based on the selected KPIs. One of the requirements that was set for the prototype by the LSP, was that priorities of the different KPIs are likely to change in the future. As the dashboard will be frequently used in the future, the LSP wants to be able to change the importance of each KPI when desired. This requirement already limits the amount of MCDA methods, as pairwise comparisons are difficult to implement into the LMS of the LSP.

The initial selection of MCDA methods was determined using the website mcda.it, which filters MCDA methods based on decision weights, comparison scales, uncertainty and decision problematics. These criteria were the result of a study, which collected a large number of MCDA methods and categorized them in a decision tree (Watróbski et al., 2018). This research is especially helpful in narrowing down suitable MCDA methods, as there is a large number of MCDA methods, which appear to be identical at a first glance.

From the results, two possible methods that are applicable in this use case are discussed. Besides these methods, the WSM method is discussed as well. In Chapter 5: Design and Development, a method is chosen and implemented in the prototype design.

### 3.3.1 Weighted Sum Method (WSM)

The weighted sum model (WSM) is the simplest and best-known MCDA method for evaluating several options on a number of criteria (Figueira, Greco & Ehrgott, 2005). For every criterion, a weight is determined to distinguish their importance relative to each other. Then the score of an option is multiplied by the weight and added up. It is important to note that when using the WSM method, all the scores must be expressed in the same unit and preferably the same scale.

### 3.3.2 VIKOR method

The VIKOR method looks for the closest option to an ideal situation and was developed by Serafim Opricovic. The method produces a compromise ranking list based on given weights for each criterion. First, the best and worst value are determined for every single criterion. then, values are computed, weighed and normalized, in order to be able to rank the different alternatives. The result is a sorted list, which is based on the maximum utility and lowest regret. The maximum utility concept can be explained as the greatest outcome for the least amount of money (Chatterjee & Chakraborty, 2016).

### 3.3.3 TOPSIS method

The Technique for Order Preference by Similarity to an Ideal Solution, which is shortened as TOPSIS, was developed by Ching-Lai Hwang and Yoon in 1981. Whereas the VIKOR method uses an aggregating function to represent to closeness to the ideal situation, the TOPSIS method's solution is an outcome with the shortest Euclidian distance from the best situation and the farthest from the worst situation (Lai, Liu & Hwang, 1994). The performances are first normalized and multiplied by the weight of the specific criteria. Then, the best and worst criteria are determined for each criterion. The Euclidean distance, basically a straight line between points, is then determined between the alternative and the best and worst alternative. Then the final performance score is calculated by dividing the distance to the worst performance, by the sum of the distance to the best and worst performance. The alternatives are ranked based on the performances scores.

## 3.4 Dashboards

When developed correctly, dashboards can give users a powerful means to present information. However, poor implementations account for a large number of dashboards to be ineffective and inefficient (Few, 2006). Poor choice of graphs, dimensions, design and colours all have a negative impact on the effectiveness of the dashboard. Cahyadi and Prananto (2015) concluded after a literature review, that a dashboard could be broken down into 6 components. In order to develop a good dashboard, these components must be well-understood. The prototype created in this research will be build based on these 6 components.

*Data* is the first component addressed by Cahyadi and Prananto and consists of the three design elements data warehouse, database systems and data quality. What information is required to show the selected performance indicators? Furthermore, it is key to understand where that data is coming from and where it is stored. Moreover, how good is the quality of the data? Is the data incomplete or are the values false? The data component and its issues were previously discussed in section 3.2 Data management. The steps taken in the data management process of the prototype can be found in chapter 5.

The *Technologies* component addresses the platform the dashboard is built upon, system architecture, software and information systems used. Which software is going to be used and how is the data linked to the dashboard?

Knowing the dashboard *User* is a key component of developing a dashboard. Who will view the dashboards in day to day operations? What is the user supposed to see, and what are his preferences when using the dashboard? Does the user have a lot of background knowledge, or does the dashboard require extra explanation?.

What does an *Organization* want to achieve with their dashboard? What are the requirements of the dashboard and which types of employees will use the dashboard? Few (2006) has defined 3 types of dashboards that support the different business activities: Operational, Strategic and Analytical. An operational dashboard is used multiple times per day, and updated very frequently, as they monitor progress towards a goal. A strategic dashboard is used less often. It is mostly a reporting tool to monitor the status of KPIs. It is not required to update the data as often as operational dashboards. Lastly, the analytical dashboards are mainly developed for and by data analysts. The goal is to analyze large volumes of data to investigate trends, predict outcomes, and discover insights

Specifying the *Features* that will be added to the dashboard is another component of dashboard design. What are the different options for specifying the graphs or tables? Are drill-downs implemented to perform further analysis and if so, what options will be available?

*Graphs and Metrics* are about the user interface and metrics selections. Which types of graphs will present the selected performance indicators in a clear way? How can the graphs be organized in a structured way? Additionally, how can the selected graph immediately show the performance?

One important element of dashboards is not part of these 6 components. Therefore, another component is added to this research: *Aesthetics.* Aesthetics do certainly play an important part in the effectiveness of dashboards. One of the important characteristics of aesthetics is choosing the right colour scheme. The selected colours should be in alignment with the message that the graph is showing (Bhatt, Aggarwal & Sharma, 2017). Typography, choosing the right font and font sizes, and the layout is are key elements of the dashboard's aesthetics. Selecting the best display medium should be based on the nature of the information and message, and the preferences of the users. For example, should filter options be present in a left bar or a top bar? Another example if additional text is required to explain a graph, or do the users know where the graph is about.

# 4. New situation

Before a specific solution is designed for the identified problems, it is important to gather the requirements of the LSP for the solution. What functions should be implemented, and which KPIs should be available in the solution. In consultation with the LSP, the performance KPIs were determined based on the literature research and a list of requirements for the prototype was made. The selected KPIs, which are the answer to research question 6.1: ‘Which KPI does the LSP want to use in the Logistic Management System”, are discussed below in part 4.1. whereas the requirements set for the prototype can be found in chapter 5.1: Prototype requirements. Additionally, research was conducted into the collection of additional data, which can be found in chapter 4.2. This research answers research question 5: “Where can additional carrier performance data be gathered from?”.

## 4.1 KPI Selection

The systematic literature review produced a large number of KPIs that could be used to evaluate carrier performance. In consultation with the LSP, a selection of 6 KPIs was made which will be implemented in the prototype. This selection was based on KPIs that were most important for the LSP, like on-time performance. Furthermore, some KPIs could not be calculated as data is unavailable, or the effect of the KPIs was of minimal impact on the processes of the LSP. For example, the number of complaints about damage to shipments was at most 3 claims per carrier per year. The limited number of claims made the KPI irrelevant for carrier comparison. Similarly, a seventh KPI, the number of booking rejections was selected at first, but did not occur often enough to have any impact on the processes of the LSP. The list of data, which is required for calculating the KPIs, and provides the answer to research question 6.1.1, can be found in Appendix J: Required data.

| KPI | Calculation |
|---|---|
| On-Time performance | Actual time of arrival – scheduled time of arrival is <7 or >-4 |
| Average number of days late | Days between scheduled and actual time of arrival |
| Transit Reliability | Days between the scheduled and actual transit time <7 |
| Booking Response time | Time booking is sent until arrival of confirmation |
| B/L performance | Actual departure time until Final B/L sent |
| BICEPS Ranking | A-F as given by the biceps network |

*Table 4: Prototype KPI selection*

### 4.1.1 On-Time performance

No general consensus exists in logistics for shipments to be considered ‘on-time’ or ‘late’. Even in the ocean shipping industry, different companies use their own definitions for orders to be ‘on-time’. The LSP defines orders as ‘late’ when they arrive 7 or more days after their scheduled time of arrival. Furthermore, an order should not arrive more than 4 days before the scheduled time of arrival. Orders that do arrive more than 4 days before the STA are also considered to be ‘late’ although they are technically early. As shipments are rarely early, they are added to the list of ‘late’ shipments for simplification.

### 4.1.2 Average delay

The average delay KPI aggregates the delays of all orders. The LSP has defined 3 different stages of delay for their shipments. If shipments arrive less than 4 days late, they are considered to be ‘on-time’ and no action is taken. If orders arrive between 4 and 7 days after ETA, they are still marked ‘on-time’, but an automatic update is sent to the customers to inform them of the delay. Only if an order arrives 7 or more days late, an order is marked ‘late’ and an employee of the LSP undertakes action. The respective carrier is asked for a delay statement about the reason for the delay. The customer is informed afterwards with the reason for the delay by an employee of the LSP.

When an order arrives more than 4 days early, the shipment is marked as ‘late’, but no action is undertaken by the LSP. As reporting is only done reactively based on events, the LSP cannot inform customers of shipments arriving early as this information is only available when the shipment has arrived.

### 4.1.3 Transit Time reliability

Transit-time is understood as the time it takes to ship an object, in this case a reefer container, from the port of departure to the port of delivery. The performance of this transit time is measured in the difference between the scheduled transit time in advance and the actual achieved transit time. When the scheduled and actual transit time differ 7 or more days, both positively as well as negatively, the transit-time reliability is regarded ‘late’. The total transit-time reliability is the percentage of orders that were ‘on-time’.

### 4.1.4 Booking response time

The booking response time of a shipment is the time passed between sending a booking request to INTTRA or CargoSmart and receiving a booking confirmation from the carrier through one of these platforms. As some smaller carriers are not connected to these networks, there is no possibility of measuring their Booking Response Time and thus their booking response time will be left out of the dashboard.

### 4.1.5 Bill of Lading performance

A Bill of lading (B/L) is a legal document provided by the carrier, which contains the details of the goods transported by the carrier like type, quantity and port of delivery (“Bill of Lading,” 2019). The LSP wants the B/L in their possession within 3 days after the departure of the container. When the B/L arrives within 2 days, it is considered “good”. Between 2 and 3 days, it is marked “risky” and if it takes longer than 3 days, the Bill of lading is regarded “late”.

### 4.1.6 BICEPS ranking

The environmental impact of businesses is rapidly growing in importance. Customers demand greener production, reduction of waste and less pollution in supply chains. Ocean transportation and large container ships have a bad reputation regarding the emissions of greenhouse gases, water and sound pollution, and oil spill (Sheppard, 2019). The LSP therefore highly values the use of more eco-friendly carriers in ocean and land transportation. Unfortunately, the real impact of the different carriers on the environment is hard to measure.

The BICEPS network, the Boosting Initiatives for Collaborative Emission-reduction with the Power of Shippers, is a group of shippers who joined forces to improve the transition of the shipping sector towards more sustainability (BICEPS, 2019). The goals are to reduce the emissions of $CO_2$, Sulphur and black carbon, better treatment of waste on board, and a reduction of the impact of ballast water on biodiversity. Shippers are awarded a score ranging from A to F, depending on their level of sustainability.

The score of carriers is based on their performance on 5 factors: publication of sustainability information, emission scores, improvement projects, collaborations of the carrier with the outside world and the long-time sustainability goals of the carrier. The ranking system is relative, which make that only a limited number of carriers can be awarded A or B. The results of a BICEPS ranking are not directly quantifiable. However, they give a good indication of the activities regarding the sustainability of a carrier. The awarded letters are therefore translated into numerical values for usage in the carrier ranking.

Despite the growing number of connected carriers, still not all carriers are evaluated by the BICEPS Network. Customers will value a high BICEPS rating over carriers with poor or unknown ratings and it will therefore give the connected carriers an advantage.

### 4.1.7 Booking rejections

At first, a seventh KPI was selected from literature to be part of the prototype: The number of booking rejections. The LSP was interested if there was a difference in rejections percentages for specific routes or carriers. However, after the initial calculation of the KPI, the number of booking rejections was not significant enough to influence the carrier comparisons.

In most cases, when an order cannot be booked on a specific date, the carrier would return a proposal for another sailing. This proposal is not seen as a booking rejection by the LSP and therefore it was chosen to remove the booking rejections KPI from the final KPI selection. The KPI is still included in this report, as it was deemed important by the LSP. Other LSPs or SMEs might encounter more booking rejections and would like to include this KPI in their evaluation process.

## 4.2 Data gathering unknown carriers

The aim of the LSP is to possess performance data of all carriers that sail towards the locations of Company X it's customers. As the LSP only contracts one carrier per destination each quarter, data only is gathered for this carrier. As some destinations only have a total of 3 orders per quarter, a limited amount of data is available for such destinations. In order to obtain reliable performance information, more sailing data must be gathered and analyzed. There are 3 types of websites who offer a significant amount of data, which can be used for calculating the selected KPIs.

### 4.2.1 INTTRA

INTTRA was founded in 2001 to create a standard electronic booking system for the ocean freight industry (INTTRA, 2018). Nowadays, more than 60 carriers are connected to INTTRA, and for this reason is the LSP booking shipments through the INTTRA platform. INTTRA has developed pre-built dashboards that provide insights to improve shipment planning. For all the connected carriers, performance data is available and can be specified on carrier, shipping-lane and time-period. The most common KPIs in logistics are available in their dashboard, including the reliability of shipments, transit times and booking response times.

At first, the INTTRA website was considered to be the best option by the LSP, as it was the source with the highest number of KPIs present. However, after some research, it turned out that the trading platform only shared the information that was linked to the orders of the LSP. Most of this information is already collected in the LMS, which was specifically developed for the LSP. The data collected from these dashboards would therefore be identical to the already gathered data.

Another drawback is that only carriers that are connected to the platform can be evaluated on performance, which does not include the often-used carrier OOCL. The INTTRA alternative will not return new usable data for the LSP. However, other SMEs who do not have a similar data collection system in place might see the benefit in easy accessibility to a large amount of performance data.

### 4.2.2 Big Schedules

Big schedules is a relatively new company which was founded in 2015. It was launched by Cargosmart, a booking platform similar to INTTRA, which is also used by the LSP to book shipments at certain carriers. The platform of Big Schedules actively searches newly added and changed schedules as well as vessel locations. Big Schedules claims to cover 30 major carriers and 5000 vessel services, which would cover 90% of the container capacity (Big Schedules, 2018). A drawback is that only the on-time reliability and transit-time reliability are calculated. Big schedules does provide the functionality of route recommendations based on the performance data. The route recommendation suggests alternative routes to nearby ports, which have a better record of on-time performance and transit-time reliability.

*Figure 6: Sample dashboard (Big Schedules, 2019)*

This means that not all the desired KPIs can be retrieved from this platform. On the other hand, the costs of acquiring the data are relatively low: 600$ per year for the analytics package. This analytics package includes the following features:

- Carrier performance analytics and the possibility to download them
- Route recommendations
- Vessel tracking and arrival alerts
- Schedule comparison

The choice for this platform depends on the importance of several factors. With the assumption that all relevant carriers and routes are present, it depends on the selection of KPIs determined by the LSP. If these KPIs are important to the LSP or similarly to other SMEs, they can prove to be a valuable addition.

### 4.2.3 MarineTraffic

In contrary to Big Schedules, MarineTraffic offers an almost limitless amount of data about carriers, shipments and vessels. The live vessel tracking option is free, but for more specific data like historic vessel locations, a subscription is required. Unfortunately, MarineTraffic does not offer direct performance data on different carriers like INTTRA and Big schedules do. Each vessel must be separately tracked, and the performance of vessels must be combined to find the total performance of a carrier on a certain route.

Collecting the performance data requires the LSP to set up a database to store all the information. The data must be managed and processed before it can be used in performance evaluations. The price of this solution depends heavily on the type and amount of data gathered. It is not unlikely, that the costs of gathering and analyzing this data are higher than the collection of performances from INTTRA or Big schedules.

However, data is available for every ship that is currently sailing the ocean. Data can be specifically selected based on the KPIs that the LSP chose, which would allow for the most detailed and accurate performance information. At this moment, the detail of the information available on MarineTraffic is not needed for calculating the selected KPIs.

However, when keeping the long-term objectives of the LSP in mind, more data will certainly be collected in the future. For example, to improve the ETA of a shipment, research can be done into ocean currents and weather, which is available on MarineTraffic. The live vessel tracking site is therefore a considerable option for data collection.

### 4.2.4 Carrier websites

The previously mentioned websites all require a subscription in order to obtain the relevant performance data. Another option is to collect information for free from different carrier websites. Most carriers offer free schedules and actual arrival times on their websites. Unfortunately, the actual arrival time overwrites the estimated time of arrival, which makes it impossible to calculated historic performance. In order to calculate performance, information must be collected at multiple points in time. Before departure, the schedule and its STD and STA must be retrieved. Then, after departure and arrival, the ATD and ATA can be retrieved. An example of a carrier website is hapaglloyd.com, where scheduled and finished sailings can be checked as is visible in Figure 7.

The biggest drawback of this approach is that a lot of data must be collected from a large number of sources. Data on every ship must be separately collected, which results in data for thousands of vessels in total. This requires an investment in and design of the collection and storage of the data, similar to what is needed for MarineTraffic. However, when the collection method is operational, it can be personalized to fit the LSPs needs and the data is freely available.

| Port of Loading | Transshipments | Vessels / Services | Port of Discharge | Transit Time (days) |
|---|---|---|---|---|
| ROTTERDAM \| NL 2019-01-03 | 0 | NYK EAGLE / 013E / FE3 | SINGAPORE \| SG 2019-02-08 | 36 |
| ROTTERDAM \| NL 2019-01-11 | 0 | NYK IBIS / 014E / FE3 | SINGAPORE \| SG 2019-02-11 | 31 |
| ROTTERDAM \| NL 2019-01-18 | 0 | YM WIND / 008E / FE3 | SINGAPORE \| SG 2019-02-17 | 30 |
| ROTTERDAM \| NL 2019-01-03 | 0 | ONE CONTINUITY / 042E / FE1 | SINGAPORE \| SG 2019-01-30 | 27 |
| ROTTERDAM \| NL 2019-01-10 | 0 | NYK VENUS / 059E / FE1 | SINGAPORE \| SG 2019-02-06 | 27 |
| ROTTERDAM \| NL 2019-01-06 | 0 | SEASPAN HUDSON / 010E / FE5 | SINGAPORE \| SG 2019-02-10 | 35 |
| ROTTERDAM \| NL 2019-01-16 | 0 | NYK SWAN / 007E / FE5 | SINGAPORE \| SG 2019-02-19 | 34 |

*Figure 7: Example historic performance (Hapag-Lloyd, 2019)*

### 4.2.5 Conclusion

All these advantages and disadvantages of the different sources make it a difficult choice. Neither option is better than the others in every single aspect. The choice for a single or even using multiple sources depends on the current and future needs of the LSP. How much data does the LSP want to have on each carrier and for which destinations? How is the data going to be used, and will it justify the costs involved in collecting and facilitating this data? The LSP must carefully weigh all the advantages and disadvantages to decide which platform offers the most value for money and can help to improve the processes of the LSP while keeping the strategic goals for the future in mind.

# 5. Design and development

In the second chapter, the preferred process of the LSP was described. By developing a prototype, the functions of the solution can be tested and improved if necessary. The prototype is developed based on solution objectives in multiple sprints, which are part of the Scrum methodology. These solution objectives answer research question 6.2: 'What are the requirements for the prototype?'. The solution objectives and sprints can be found in part 5.1 and 5.3 respectively. Consecutively, the prototype architecture and development of the prototype is discussed.

## 5.1 Prototype requirements

A Minimal Viable Product (MVP) will be developed based on the mockups and solution objectives. This MVP shows the basic functions of the end product, as the time for the development is limited. Based on the performance of the prototype and the feedback gotten from its users, the prototype can be developed into the production version. Using MVP allows for a large amount of feedback on the product with the least amount of time spend and saves both time and money. A list of requirements was drawn up, to ensure that every functionality requested by the LSP was included:

- The dashboard prototype must be integrated into the current Logistic Management System (LMS), which is a Mendix application, to be easily accessible for employees of the LSP.
- The data used for the selected KPIs must be filtered on a specific set of criteria to make sure the data are reliable and valid.
- Both performances of active and closed orders should be calculated.
- The selected KPIs from literature should be implemented in the prototype.
- The KPI performances must be updated/calculated on a set time each day.
- The prototype must have a dashboard where a clear overview of the performance KPIs of each ocean carrier can be seen.
- The dashboard must be filterable based on time period, Port of destination, Shipping lane, Area and Carrier.
- The dashboard must have the following tabs:
  - General overview of performance to compare carriers on area, shipping lane and time period
  - Specific carrier overview, to see carrier specific performance on different lanes filterable on area and period.
  - Overview problem routes: an overview of the routes per carrier that have the worst performance in the set time period.
- Shipping lanes should be addable and changeable on the master data sea page
- The weights for ranking the carriers should be changeable by employees of the LSP. Preferably on the master data sea page.
- The restrictions for performances to show up on the poor performing shipping lanes tab should be adjustable.

## 5.2 Mock-ups

The LSP had a clear picture in mind regarding the functionalities of the dashboards, which was addressed above. However, with regards to styling and the appearance of the dashboard they did not have specific requirements. To prevent miscommunication and a difference of opinion, three mockups were created to show the appearance and functionalities of each dashboard tab in the prototype. The basic function of switching between tabs was implemented in the Mock-ups to give the LSP employees the feel of a real dashboard. The reactions of the LSP were positive, and the prototype was developed based on these created Mock-ups. The most substantial alteration was relocating the graphs and counters from the top to the left-hand side. The relocation allowed for more rows of the table to be visible, without having to scroll. The three Mock-up dashboard tabs can be found in Appendix G: Mock-ups.

## 5.3 Scrum

Scrum is an agile framework and methodology which contributes to faster market times, greater flexibility and higher customer satisfaction (Goncalves, 2018). Cape uses this methodology in their projects and even trains people in using the Scrum methodology in their own academy. A more detailed explanation of Scrum and its user roles and workflow can be found in Appendix H. Three sprints were created with several user stories that were based on the prototype requirements. The user stories for every sprint can be found in Appendix I.

Normally, the scrum team consists of 3 to 9 team members who have their own role: Product Owner, Scrum master or developer. As this project was not executed with a standard scrum team, the roles were slightly different. At the start, the user stories were defined by the researcher based on the prototype requirements which were made together with the LSP and a consultant at Cape Groep. After the stories were checked, the development of the prototype was done by the researcher himself. After each sprint, the developed functionalities were checked and improvements were added to the backlog. After the first 2 sprints, the prototype was shown to the LSP, which provided feedback on the aesthetics and functionalities of the prototype. The feedback was then added to the 3rd sprint to further improve the prototype.

## 5.4 Architecture

The prototype does not change any of the current processes performed by the employees of the LSP. However, because of the addition of dashboards in the LMS, several automatic functionalities were added to this application as well. The Architecture of the application was expanded, with the new KPI calculations and dashboard visualizations.

ArchiMate is an open source modelling language for enterprise architecture developed by the Open Group (2017). It is an independent standard for enterprise architecture that supports the description, analysis and visualization of architecture within business domains. The latest version, ArchiMate 3, was released in June 2016.

The ArchiMate Core Framework visualizes the main concepts and elements of the ArchiMate language. It consists of 3 main layers: Business, Application and Technology layer (ArchiMate® 3.0.1 Specification, 2017). The business layer provides products and services to customers which are executed within the company business actors and roles. The application layer provides the business layer with application

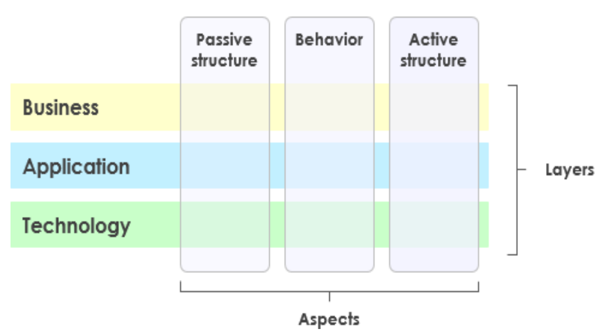


*Figure 8: ArchiMate Core Framework*

services. The required services such as processing, storage and communication are provided by the technology layer to the Application layer.

The Enterprise Architecture related to the prototype can be found in the figure below. The processes related to the updating of KPIs and the aggregation of data opening dashboards are modelled in this figure. The application layer visualizes the actions that are performed by the prototype.

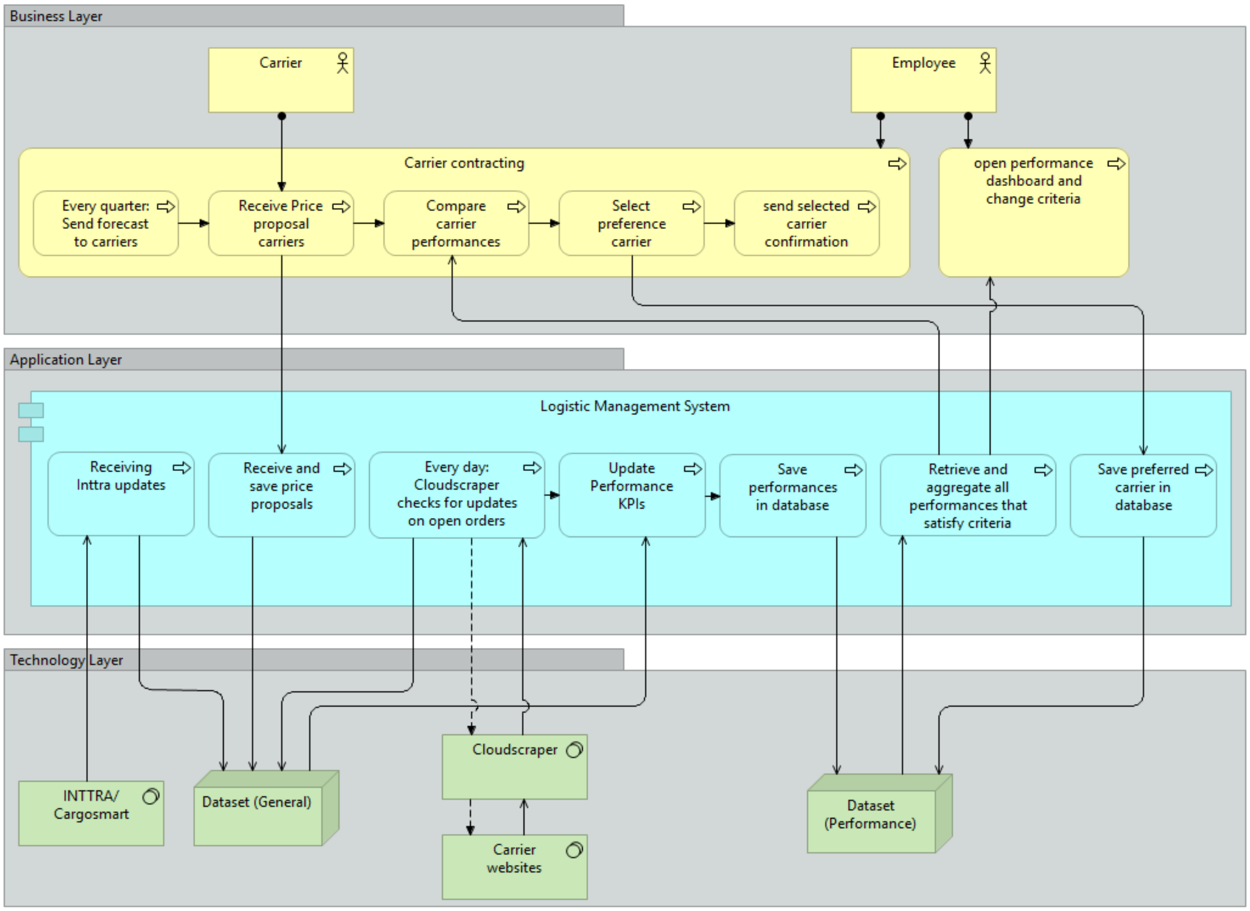



*Figure 9: ArchiMate Model*

The ArchiMate model was made the represent the ideal scenario. At this moment, no price information of carriers is saved in the LMS, although it is visualized in the ArchiMate model. The preferred carriers are also not saved in the LMS. Both of these processes will be implemented in the near future. The biggest change implemented with the prototype is the addition of the performance dataset. The aim of the LSP is to use the price information and preferred carriers together with the performances in the carrier contracting process.

## 5.5 Development of the prototype

### 5.5.1 Mendix

CAPE has developed an application in Mendix where all the orders of Company X are processed by employees of the LSP. The goal is to implement the solution into the current application of the LSP. Therefore, the prototype will be developed in Mendix. Mendix is a low-code visual software platform, for building web and mobile applications (Mendix, 2018). The aim of a low-code development platform is to improve the speed of application development through graphical user interfaces and configurations, which reduce the amount of hand-coding. Furthermore, people who do not possess programming skills can still contribute to application development.

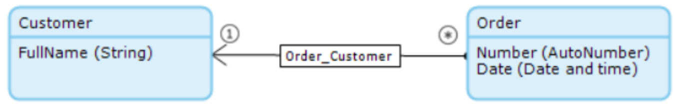


*Figure 10: A Simplified domain model*

In Mendix, the data is structured in the Mendix Domain Model, often referred to as a Data model. A Data model is an abstract way to organize elements of data and show how they relate to each other. The example Mendix domain model consists of entities (*Customer and Order*) and relationships (*Order_Customer*), which determine the structure of the data. the Entities themselves consist of attributes (*FullName*) which are visualized in the figure. In this case, a customer with a name can have multiple orders, whereas an order can only have a single customer, which is depicted in the one to many relationship *Order_Customer (Song & Froehlich, 1994)*.

Microflows are used to express the logic of an application. Through drag and drop, various actions can be implemented such as creating and changing objects, showing pages or making choices. In the creation of the prototype, several microflows were made to calculate the performances and visualize the KPIs in the dashboards. In the figure below, an example microflow can be seen, where the Average delay of separate performances is aggregated into a total average delay, which is used in the dashboard.

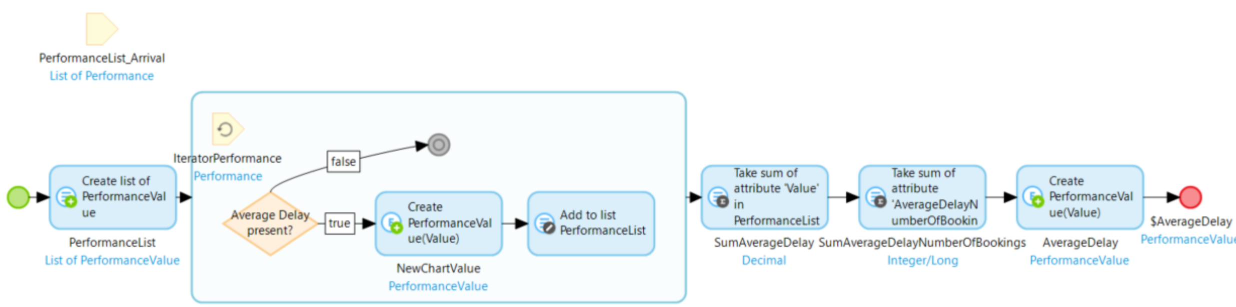


*Figure 11: Example Microflow*

Although the purpose of this research is to visualize shipping performance, Mendix is not the most sophisticated visualization tool. Basic graphs can be created in Mendix but more complex visualizations like performances projected on a map are difficult. However, as most of the processes of the LSP are in Mendix and to reduce the time of accessing the performance data, it was decided that the dashboard would be made within the Mendix application of the LSP. Furthermore, the Mendix visualization options are more than adequate for the purpose of the developed dashboard.

### 5.5.2 Dashboard design

As previously discussed in Chapter 3, it is important to determine the purpose of the dashboard before designing it. The business activity the dashboard will support is mostly operational, as employees use it in daily operations for carrier selection, order booking and information sharing. The performance dashboard is mostly used by the planners of the LSP and every now and then by a manager for route analysis. Analysis of trends and predictions will not be done in the Mendix dashboard, but in the previously mentioned quarterly dashboards. The features and data are addressed in Chapter 5.1: Prototype requirements and Chapter 5.6: Data management respectively.

The options for the design of the dashboard were limited, as it was created in the existing application of the LSP. The colours used for representing scores of KPIs in the dashboard had to match the colours already used in the LMS, such as the logo of the LSP. The basic flat colour scheme was used, as it shows the difference between good and poor performances clearly and matches the colours used in the LMS.

Similarly, the font used in the dashboard matches the font used in the rest of the LMS. As the main purpose of the dashboard is to show a large amount of data, a table was chosen as it can show multiple KPIs for several carriers simultaneously. A number of doughnut charts and counters were placed on the left side, which represents the average performance of the KPIs in the table.

### 5.5.3 Data used

Besides the required data for the KPIs additional data is gathered as well. The number of bookings is collected to get an impression of the reliability of the data and check whether the performance is a single occurrence or happens frequently. The area of a shipment is also saved in the performance, as it allows to specify the performance per area. The other filtering criteria: Shipping Lane, Carrier, Port of Delivery and Date are stored together with the performances for this same reason. A complete list of all the data used for the KPI calculations and filtering can be found in Appendix J: Data used.

## 5.6 Data management

Several attributes from different entities were selected to be used in the KPI calculations. Each of these attributes must be assessed on the restrictions that were determined for each attribute specifically. Mendix already supports multiple types of data integrity in various stages of the processes. For example, when generating a new entry in the database a check can be performed, or data can be validated with a microflow afterwards. For the data that is used in the calculation of selected KPIs, multiple methods are used to validate the data. In Appendix J, there is a list of specific filters that are used for each attribute, while the issues with this data are described in section 5.6.2.

### 5.6.1 Up-to-date data

One of the biggest problems for the LSP was the absence of up-to-date information of carrier performance. In the prototype, the KPIs are updated at a pre-determined time every day. As the shipping times are relatively long, and the number of orders in a year is relatively low, it is not required to update the KPIs more often.

A scheduled event was created which starts every day at the same time: 21:00:00. A microflow is called which retrieves all the performances with ATD or ATA in the last year and deletes all these performances. Afterwards, the microflow retrieves all orders with ATDs or ATAs in the last year. For these orders, the new performances are calculated and saved in the LMS.

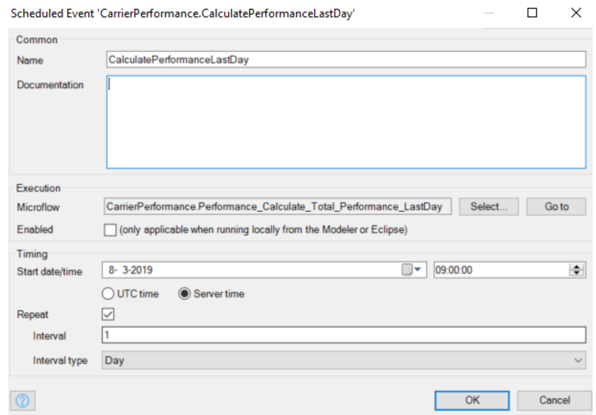


Figure 12: Scheduled event performance update

The problem is that different KPIs are gathered at different times. If an order is scheduled for tomorrow, the KPI booking response time is known, but the On-time performance is not. The LSP indicated that orders with data available for only one KPI should be calculated as well. Therefore, a single order collects data for different KPIs at various moments in time. This performance should be updated when data is collected for another KPI.

It is known that deleting the performances of last year and calculating them again is not optimal for the performance of the microflows. However, because of the limited time available and the purpose of the prototype is to show the basic functionalities. Moreover, it is the simplest way to calculate up-to-date performance. The time it takes to update the KPIs at night is less than 4 minutes, which meets the performance standards of the LSP.

## 5.6.2 Performance calculation

To update the performances, the last year is determined based on the current day first. The performances of shipments within this last year are retrieved and deleted in order to calculate them again. A list of carriers is retrieved, in order to distinguish the performance between the carriers. Then, for each carrier the list of shipments from last year are retrieved.

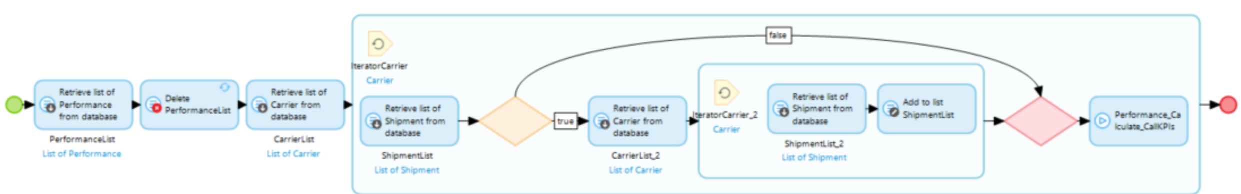


Figure 13: Microflow retrieve shipments

Consecutively, the next microflow is called which creates the new performances. This microflow checks for every shipment whether a performance exists which has the same ATD, ATA, Carrier, and Shipping Lane. If not, a new performance is created and every KPI is calculated for this shipment. If a performance does exist, the existing performance is retrieved, the shipment is added to this performance and the scores are averaged with the existing KPIs.

Besides the scheduled event, there is a button available in the LMS to calculate the all-time performance. The calculation is similar, except that all the historic orders are deleted and re-calculated instead of only the orders from last year.

### 5.6.3 Issues with data

Although the data is well structured through the domain model in Mendix, there are still occasional errors in the data that is used for KPI calculations. Therefore, some checks have been implemented in the LMS, that check the data before it is used in KPI calculations.

**Non-consistent Ports and Carriers**

When the LSP receives an order from Company X, information about the customer, destination and carrier is already provided. Unfortunately, Company X does not use a standard syntax for all the Carriers and Ports. Therefore, some Carriers or Ports are present in multiple forms in the LMS. For example, ocean carrier Hapag-Lloyd can be referred to as HAPAG LLOYD, Hapag Lloyd AG, Hapag Lloyd Line or similar. When calculating the performances, it ranks these names as different carriers while this is not the case. A microflow was developed by CAPE that can link these different names to the 'Master carrier': HAPAG-LLOYD.

Unfortunately, such a microflow does not exist for the Ports of Loading and Delivery. As there are only two POLs, Rotterdam or Antwerp, a simple check was implemented to save the POL in the right syntax. As there are over 200 possible port of deliveries, such a simple check is not possible. Due to the limited time available for this project, no check is performed on the POD. However, the prototype was not affected by this problem.

**Missing Data**

As the Mendix application is continuously evolving, new functions are added regularly. The collection of data that is needed for the different KPIs, started at different times over the last years. Furthermore, for some carriers, not all the KPIs can be collected. This missing data is depicted in the empty fields in the dashboard table.

In general, every destination has one contracted carrier per quarter. Despite the switch between carriers in different quarters, a reliable comparison is not possible. For example, seasonal occurrences and demand can influence the performance of carriers and can give false information when comparing different quarters.

For both reasons, research was conducted into additional data gathering. The extra data, which was addressed in chapter 4, makes it possible to compare multiple carriers on a single Shipping Lane.

**Extreme values**

When analyzing the data, a few shipments proved to have inaccurate data. For example, a departure date in 2018 was stored in the database as 0218, which had a large impact on the average delay. Furthermore, some Booking response times were negative, which is impossible as the carrier cannot confirm an order before it is booked. Several checks were implemented in the microflows, based on the limits the LSP has determined, that make sure the data is reliable. In Appendix K: KPI calculations, the limits of each KPI are addressed.

**Amount of data**

Although the LSP have processed over 18000 shipments in the last 3 years, it is still desirable to collect more data in the future. Some destinations like smaller islands, do only need a small number of containers with frozen products from company X each quarter. When only 3 reefer containers are sent to this destination in one quarter, it does not give a reliable indication of the carriers' performance on that shipping lane.

Although the performance can be aggregated over a longer period, more data is needed to provide the LSP with solid information for carrier selection. Therefore, advice on the collection of new data can be found in chapter 4: New situation.

## 5.8 Dashboard aggregations

For the visualizations of KPIs in the different dashboards, the previously calculated KPIs must be averaged to represent a single carrier or destination. When opening a dashboard, a microflow is called which averages the performances based on the restrictions and the type of dashboard. For example, the general dashboard does not distinguish the different shipping lanes in the table, but the Carrier dashboard does. Similarly, for every graph and counter a microflow is called, which aggregates the data in the table based on the values and the number of orders.

## 5.9 Ranking the Carriers

After calculating all the KPIs, the carriers must be ranked based on their performance. The LSP indicated that the weights of each criterion should be changeable as priorities could change in the future. For example, more and more emphasis is put into developing a sustainable supply chain and it is likely that its weight will increase even more in the future.

From the literature study, the Weighed Sum Method was selected to rank the carriers, as it serves the purpose of the dashboard well. Furthermore, it is relatively easy to implement into a dashboard and the weights can be easily adjusted by employees of the LSP. The weights given to the KPIs will then be automatically multiplied with their score on a KPI, and the total score on all criteria's will be the ranking in the dashboard.

The Score of a KPI can vary between 0 and 1 depending on the value of the KPI. For example, an On-time Performance of 100% will give value 1 and a value of 87% will give value .87. For the KPIs without a percentage, a maximum and minimum value were determined by the LSP. The best scoring Performance will receive score 1 and the worst will receive 0. The other values will receive their score linearly based on their KPI value. The maximum and minimum values for each KPI can be found in Appendix K: KPI calculation

# 6. Prototype demonstration

In this chapter, the look and functionalities of the prototype are addressed. The prototype was developed based on the prototype requirements and the created sprints in Chapter 5 and Appendix I respectively. The prototype will be explained by means of screenshots with descriptions for each dashboard.

## 6.1 General dashboard

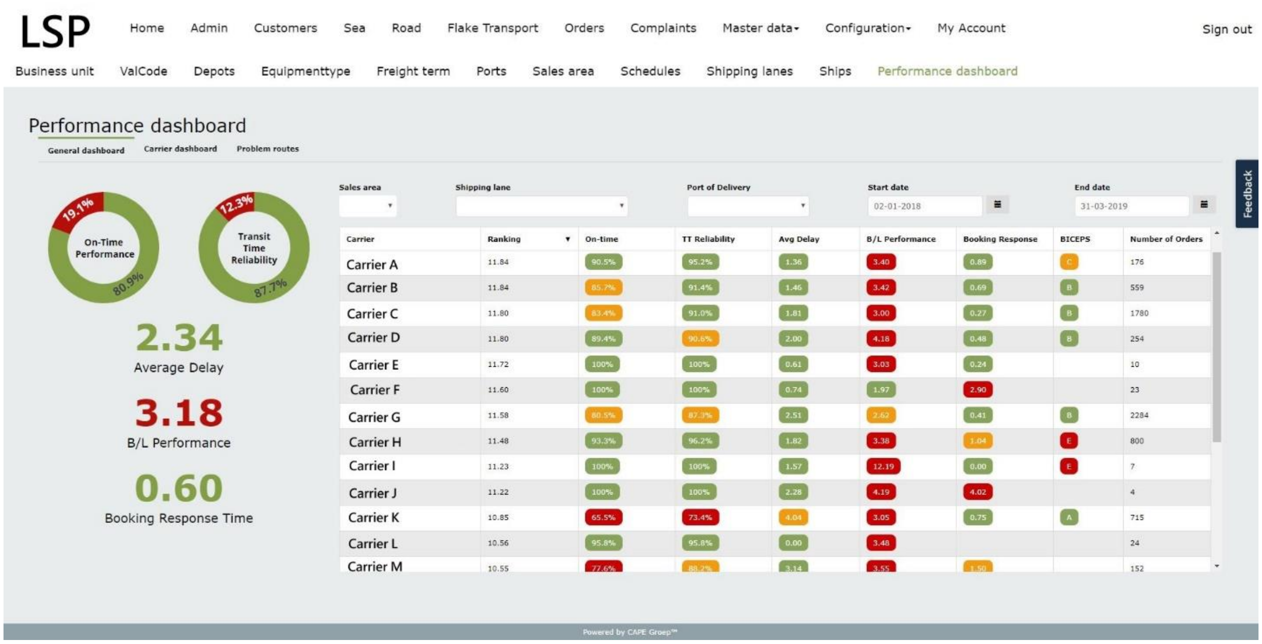



*Figure 14: General dashboard*

The performance dashboards are accessible via the Master data tab in the LMS. When opening the page, the General dashboard is shown. On the General dashboard tab, an average of the performance of all carriers can be found. The performance consists of the 6 selected KPIs from the literature, which can be found in chapter 5. The 2 doughnut charts and 3 counters represent the average of all performances that are shown in the table. The table shows the average performance of carriers who satisfy the search criteria. When opening the dashboard, the date range is automatically set to the last quarter, as it gives the most relevant information for the LSP. The performance can be specified further on Area, Shipping lane, port of delivery, and start/end date.

The ranking score of a carrier is based on the formula discussed in section 5.9: Ranking the carriers. On the far right, the number of orders where the performance is based on is shown. As the number of orders can be different for separate KPIs, the highest number was chosen.

## 6.2 Carrier dashboard

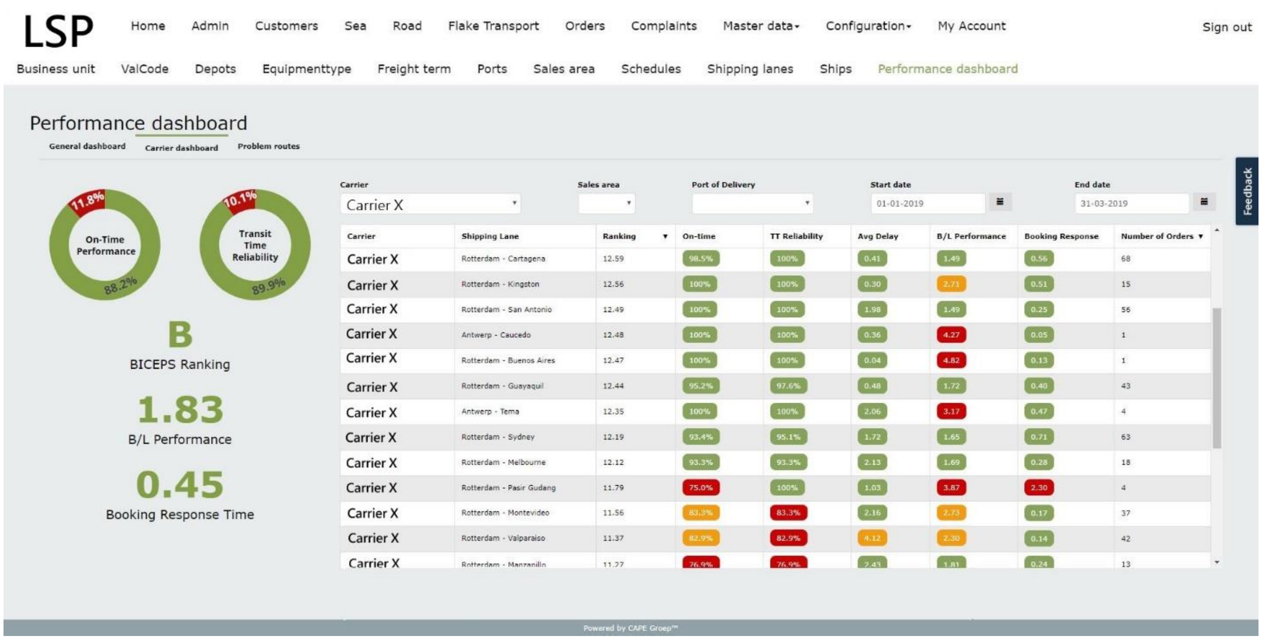



*Figure 15: Carrier dashboard*

As the general dashboard does not provide the option to compare shipping lanes with each other, a second dashboard was created. The carrier dashboard shows the average performance of the carriers on every shipping lane. Different Shipping lanes can be compared to each other with restrictions on carriers and other ports in the area. The counters and graphs do again represent the averages from the combined performances. This dashboard has a time period preset of the last quarter as well.

## 6.3 Poor performing shipping lanes

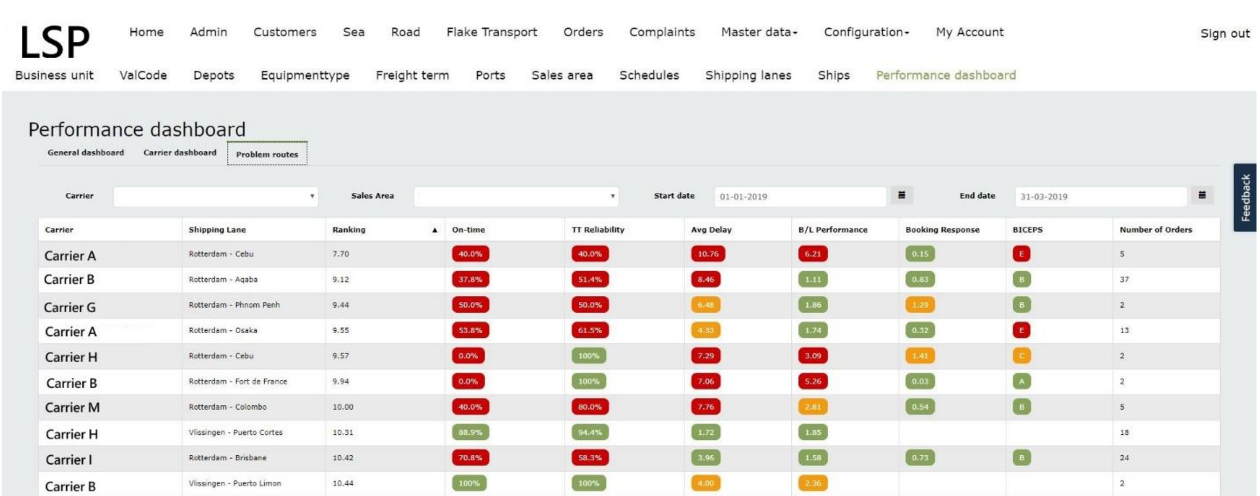



*Figure 16: Poor performing shipping lanes*

As the action problem of this research states, the problem is shipments not arriving on-time. The previously explained dashboards do not show the worst performing Shipping Lanes immediately. A dashboard page was created where the worst Shipping Lanes are directly shown. These Shipping Lanes score lowest based on the ranking of the KPIs. To improve overall performance, these Shipping Lanes will need to be improved first. Based on the available information in the dashboard, better performing carriers could be selected, sailing planning could be adjusted based on the available information, and customers can be informed of the performance on the different shipping lanes.

At this moment the 10 worst routes are shown in the problem routes dashboard. This could mean when a lot of restrictions are set in the dashboard, also the better performing shipping lanes are shown. The LSP must define specific criteria for the KPIs that will define a certain performance as ‘problematic’. For example, a maximum score on a KPI, but also restrictions of which KPIs must at least be present. Defining such criteria will prevent performances that score ‘OK’ or performances with only one KPI to show up in the dashboard.

## 6.4 KPI weight settings

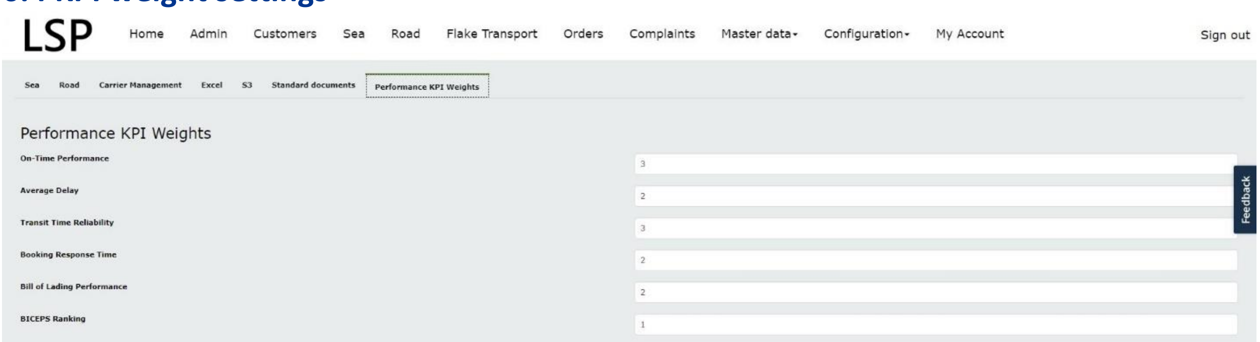
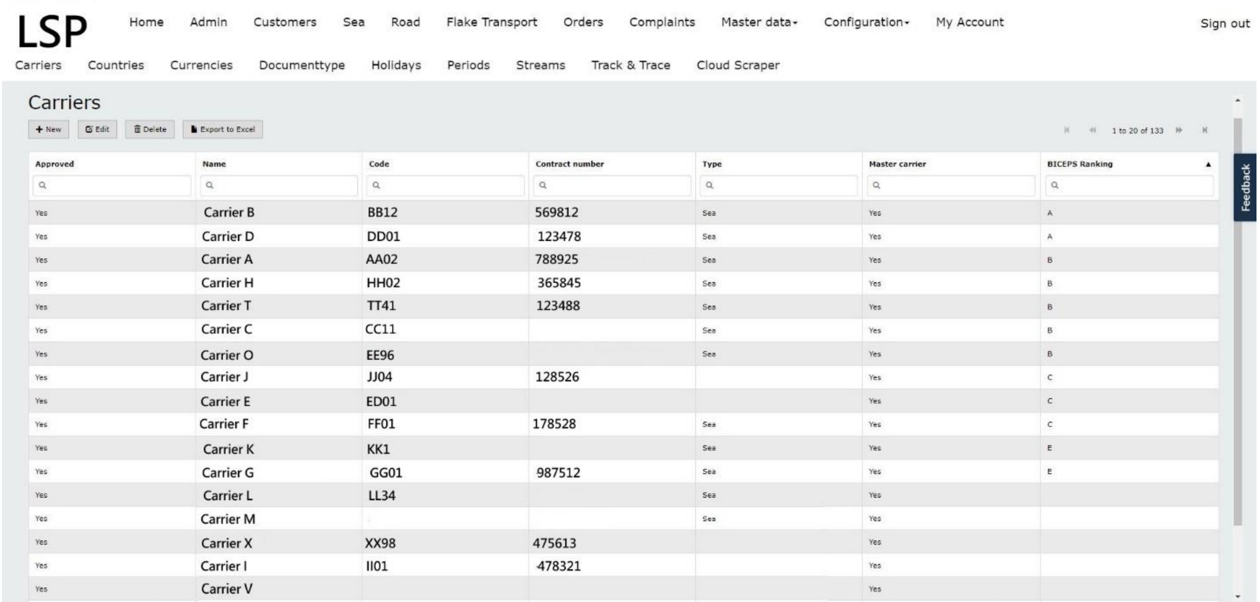



*Figure 17: KPI weight settings*

One of the requirements set by the LSP was the condition that the weights of the different KPIs should be changeable. This decision was made, as the importance of criteria like sustainability, could improve in the future. A page was generated, where different weights can be assigned to specific KPIs. Based on these weights, the carriers are ranked in the dashboards.

## 6.5 Biceps ranking




| Approved | Name | Code | Contract number | Type | Master carrier | BICEPS Ranking |
|---|---|---|---|---|---|---|
| Yes | Carrier B | BB12 | 569812 | Sea | Yes | A |
| Yes | Carrier D | DD01 | 123478 | Sea | Yes | A |
| Yes | Carrier A | AA02 | 788925 | Sea | Yes | B |
| Yes | Carrier H | HH02 | 365845 | Sea | Yes | B |
| Yes | Carrier T | TT41 | 123488 | Sea | Yes | B |
| Yes | Carrier C | CC11 | | Sea | Yes | B |
| Yes | Carrier O | EE96 | | Sea | Yes | B |
| Yes | Carrier J | JJ04 | 128526 | | Yes | C |
| Yes | Carrier E | ED01 | | | Yes | C |
| Yes | Carrier F | FF01 | 178528 | Sea | Yes | C |
| Yes | Carrier K | KK1 | | Sea | Yes | E |
| Yes | Carrier G | GG01 | 987512 | Sea | Yes | E |
| Yes | Carrier L | LL34 | | Sea | Yes | |
| Yes | Carrier M | | | Sea | Yes | |
| Yes | Carrier X | XX98 | 475613 | | Yes | |
| Yes | Carrier I | II01 | 478321 | | Yes | |
| Yes | Carrier V | | | | Yes | |

*Figure 18: BICEPS Ranking*

As discussed in chapter 4, carriers are ranked on sustainability based on the BICEPS ranking system. As the BICEPS network actively manages the rankings of carriers, they could change occasionally. Each carrier received the attribute ‘BICEPS Ranking’, which can be added, changed or deleted for every carrier on the carrier overview page.

## 6.8 User feedback

After the development of the first two sprints, the prototype was extensively tested by Global forwarding department of the LSP. The test results and feedback of the LSP were then added to Sprint 3. After sprint 3 the changed elements of the prototype were tested again, and it showed that the prototype meets all the requirements which were determined in chapter 5. As discussed in chapter 4, feedback received from the LSP revealed the need for extra data on the different routes, to improve the availability and reliability of the data.

# 7. Conclusion

The goal of this research was to find a solution to the core problem found in the problem cluster: 'There is no easy way to get access to the up-to-date performance information of ocean carriers.' To solve this core problem, the main research question was formulated: 'Which KPIs are valuable in evaluating an ocean carrier's performance, and how can these KPIs be visualized to give a Logistic Service Provider insight into carrier performance?' Furthermore, as the availability of data in the LMS is limited to the orders of the LSP, an additional research question was: 'Where could additional carrier performance data be gathered from.'

To solve the main research question, Literature research was done into KPIs that evaluate ocean carrier performance. In consultation with the LSP, 6 KPIs were selected where data was available for and were critical in the container planning and carrier selection processes of the LSP:

| KPI | Calculation |
|---|---|
| **On-Time performance** | Actual time of arrival – scheduled time of arrival is <7 or >-4 |
| **Average number of days late** | Days between scheduled and actual time of arrival |
| **Transit Reliability** | Days between the scheduled and actual transit time <7 |
| **Booking Response time** | Time booking is sent until arrival of confirmation |
| **B/L performance** | Actual departure time until Final B/L sent |
| **BICEPS Ranking** | A-F as given by the biceps network |

*Table 5: Selected KPIs*

Furthermore, research was conducted into the management of, and the threats to the reliability and validity of data in chapter 3: Theoretical framework. As mentioned before, the LSP acknowledges the limited amount of data available, and therefore research was done into sources that would complement the data already available in the LMS. The results of this research are listed below:

| Source |
|---|
| **INTTRA** |
| **CargoSmart** |
| **Marine Traffic** |
| **Carrier websites** |

*Table 6: Possible data collection sources*

Developing a dashboard which displays the selected KPIs was found to be the best option for the LSP, as it provides great overview for a lot of data at a single glance. As the design of a dashboard largely affects its effectiveness, the dashboard prototype was created based on the 6 components which were created by Cahyadi and Prananto (2015). The requirements and development of the prototype were described in Chapter 5 and 6.

The aim of the LSP is to use up-to-date performance information for the contracting of carriers, booking of orders and sharing the data with customers to improve customers' satisfaction. The developed prototype allows the LSP to view performances of carriers in a certain time period, for a specific destination, area or shipping lane

## 7.1 variables and indicators

In the DSRM it is important to evaluate the designed artefact and measure whether it is an improvement over the current situation. Several indicators were defined that measure if the proposed solution meets the requirements of the LSP. The solution did not involve redesigning a new process, but rather improving the decision making. Therefore, the selected indicators represent the level of quality of decision making, rather than the improvements in time and money. Nonetheless, the result is compared to the current quarterly dashboards, as they provided the only insight into carrier performance.

| | Quarterly dashboard | Prototype |
|---|---|---|
| **Number of KPIs available** | 4 | 6 |
| **Time between the updating of performance** | Quarter | Day |
| **Time to update KPIs** | 4 hours | no human interaction |
| **Maturity model level** | 1 | 3 |
| **Data availability** | Last quarter | All Time |

*Table 7: realized improvements in the prototype*

Firstly, the amount of KPIs available through the dashboard that evaluate a carrier is increased from 4 to 6. The KPIs Average Delay and BICEPS Ranking were not available in the Excel dashboard. Secondly, the updating of the performance KPIs is now performed every day. The old Excel dashboard used by the LSP is manually updated after each quarter with only data of that last quarter. All historical data can now be visualized in the newly developed dashboards. Even when a destination does not have data of the last quarter, older data can be retrieved in the dashboard.

Furthermore, the prototype automatically updates the latest performances every day, which is done at a set time. Whereas the Excel dashboard required an employee to extract all the shipment information from the LMS into the Excel dashboard. This process took at least four hours to complete.

The current Excel dashboards are best classified as reporting analytics in the Arbela maturity model, which is shown in chapter 2. Only once in a quarter is a general performance is generated for the overall performance of carriers and a few specific areas. The prototype developed in Mendix has the most coherence with the Monitoring step of the maturity model. The updates are daily, and analysis of different carriers, areas, shipping lanes and ports can be viewed for different time periods on the different dashboard pages.

From the evaluation of the variables and indicators can be concluded that using a dashboard for visualizing performance is a significant improvement over the current situation. The dashboard can calculate multiple KPIs based on accurate and recent data. However, due to the time limit of this research, not every desired element could be implemented into the prototype and not all the feedback could be processed. Therefore, the limitations of this research and further recommendations are shortly addressed.

## 7.2 Limitations

In this research, the outcome was limited by several factors, of which some were only noticeable during the research. Despite the careful approach, the end product was still affected by these factors and thus they are discussed.

### 7.2.1 Lack of knowledge

The first limitation is the lack of prior knowledge on the application software Mendix and the creation of dashboards. The limitation of background knowledge made it necessary to first follow a Mendix training and conduct research into KPIs and dashboard design. As the project was limited to 10 weeks, it was not possible to become an expert in either field. Thus, the literature research and the development of the prototype has taken longer than originally planned.

### 7.2.2 Time limitation

There was no time available within the ten weeks to extensively test the improvements made by the prototype. Although it provides valuable insights usable for carrier selection and customer informing, quantitative results as cost savings and the improvement on employee workload can only be evaluated after using the dashboards for extensive periods.

The planned ten weeks of this project resulted in an MVP prototype and only an advice on data gathering. Some adjustments must be made to the prototype, to make it ready for the LSP to use it in their processes.

### 7.2.3 Lack of data

Due to the lack or small amount of data on ports with less frequent orders, no substantiated decisions can be made for a carrier on that route. In order to make a well-balanced decision based on the data for these ports, more data must be collected. Fortunately, other ports do provide large amounts of available data, which can already be used for carrier selection and evaluation.

### 7.2.4 Errors in data

Even though data was filtered at multiple stages in the calculation process, data could still contain mistakes. For example, the B/L performance limit was set to 31 days. However, a B/L performance of 30 days could still be invalid as most of the B/L performances are less than 10 days. The other KPIs could contain data errors that are small but still invalid as well. The LSP should look at the performances carefully and check whether the set restrictions could be corrected to improve the quality of the data. By adding checks to the shipments when the information is stored, for example a check when the STA is saved, mistakes are more easily caught and could be prevented.

## 7.3 Recommendations

In this section, recommendations are made to improve the prototype and make it ready for usage by the LSP. Furthermore, additional recommendations for further development or expanding the dashboards are made.

### 7.3.1 Data collection

First of all, as shown in the dashboards and recognized by the LSP the amount of data available for some destinations is limited. Furthermore, several destinations only have performance data of a single carrier, which makes comparisons difficult. By implementing the data from one of the recommended sources in Chapter 4, more data becomes available for comparing carriers.

### 7.3.2 From prototype to production

The prototype is developed as a Minimal Viable Product, which meets the criteria set in the prototype requirements. All the functions were implemented, but the speed of microflows in the prototype was not optimized. When extra data is added to the LMS, the loading time of a dashboard becomes longer based on the quantity of the data. Improving the microflows might lead to a significant time improvement when more data is gathered.

Secondly, a solution must be developed by CAPE for a single Syntax on all ports. Especially in older data, different spellings for a single port will separate the performances into performances of multiple ports. Finally, the LSP must come up with restrictions for the dashboard tab problem routes. more specifically, which KPIs must be present for a performance to be visible on this page and what are the maximum scores of KPIs to be defined 'poor'.

### 7.3.3 Additional functionalities

The dashboard could be expanded to be used for even more processes. For example, monthly reports on On-time performance, Transit time reliability and Average delay could be automatically generated to inform customers on the latest performances. This improves customer visibility and satisfaction of their shipped orders. To improve the information provided with each KPI, order numbers could be attached to each performance, to make them easily traceable in the LMS and find the specific shipments that were delayed.

Additionally, another dashboard page could be added, where the performance can be seen for every customer. It may seem that the destination where a customer is located is doing well, but the customer could be experiencing a lot of delays with their shipments if multiple customers are at the same location. Furthermore, customers with multiple locations can view a combined performance of those locations. A customer dashboard can prevent unsatisfied customers, as frequent delays can be noticed early.

When the carrier contracting process developed by Rasing (2018) is implemented, performance data can be directly available for employees in the contracting process. When selecting a Shipping Lane, performance for that Shipping Lane can easily be retrieved from the database.

### 7.3.4 Further research

The dashboards offer a great overview of the attained performances in the past quarters, which produces a lot of valuable information. Expected arrival dates can be determined based on the averages of historical information. However, this information does not take into account circumstances and events that disrupt the processes of the LSP and carriers. At this moment research is already done into predicting a more reliable ETA based on historical data, which could be implemented in the LMS and make use of the data used in the dashboard. Besides this study, research can be done into port processing times, waiting times etc., which will also influence the expected ETA of a shipment to improve the accuracy of the predictions even further. Research conducted into these topics can increase the level of business intelligence of the LSP from the monitoring stage to the predictive or even prescriptive step.

Furthermore, the KPIs present in the LMS can be expanded with newly researched KPIs. These KPIs can be related to carrier performance like booking rejections, where too little data was available for. But besides carrier performance, other KPIs might prove useful for the LSP as well. When looking at the Balanced Score Card, especially the Customer and Financial perspective can provide valuable insights into carrier performance but are currently not available in the LMS. For example, the addition of shipping prices provided by the carriers, or the length of internal processes at the LSP, can provide the insight to find possible improvements for these processes.

# 8. Framework for evaluating logistic partners

In this section, a generalized framework is proposed for the visualization and comparison of the performance of logistic carriers. The conceptual framework is shown in figure 20. The framework was developed based on the 6 steps that were taken in the case study done for the Logistic Service Provider. This case study resulted in a dashboard, where different carriers can be evaluated based on several KPIs. The use of specific software and choices made were generalized to fit similar Logistic Service Providers or Small and Medium Enterprises.

The result is a framework consisting of 6 stages that is developed for the transportation sector. The actions performed at each step are based on the literature study performed in chapter 3. The 6 stages provide a generic starting point for designing and developing a visualization of carrier performance. Because earlier steps provide the foundation and input for the subsequent steps, the next step cannot be executed before a previous one has been addressed thoroughly. Each step addresses specific subjects and issues that occur in the development of the visualization.

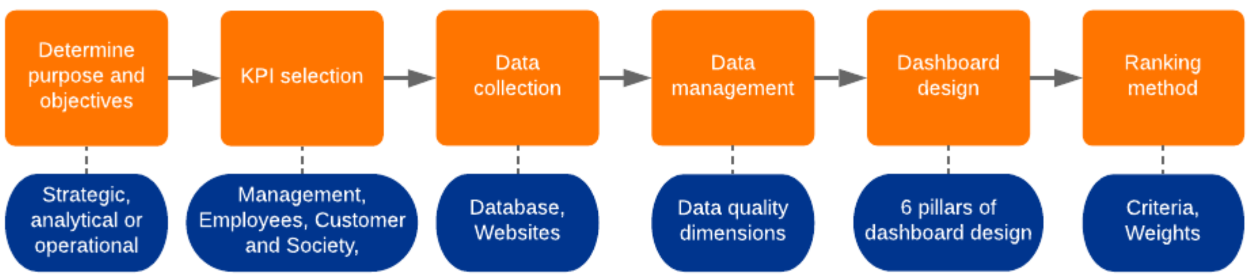



*Figure 19: Framework logistic partner evaluation*

## Step 1 Determine purpose and objectives

First of all, it is important to recognize what the goals and purpose of the visualization are. Although the aim is to rank carriers based on performance, dashboards can still be categorized in several ways. The KPIs that are selected afterwards, strongly depend on this decision. Few (2006) categorizes the dashboard by the type of business activity it supports. Is the visualization Strategic, analytical, or operational like in the case of the LSP?

For example, in strategic dashboards long term relationships are important, whereas in an operational dashboard the focus is on price and on-time performance. Furthermore, the type of visualization depends on the business activity, as Strategic dashboards are used to investigate trends and operational dashboards are more focused on day-to-day averages of performance.

## Step 2 KPI selection

The second step of the framework is the selection of KPIs that will be used for carrier comparison. Krauth et al. (2005) have developed a framework that differentiates points of view in the area of third-party logistics: Management, Employees, Customer and society. These points of view are motivated by the fact that KPIs can be in conflict within a company, as for example customers prefer low prices and management prefers high margins. To make a well-balanced decision for KPIs, different perspectives must be taken into account.

A KPI is selected based on the importance a company gives to the KPI. Numerous studies have addressed important KPIs in performance measurement specific for logistics performance and 3rd party logistics.

These publications, of which some were used in selecting KPIs for the LSP, provide a generic starting point for the selection of relevant KPIs.

The selection of specific KPIs is influenced by several factors. Before a KPI can be selected, the possibility of collecting the specific KPI must be taken into account. KPIs like sustainability are often difficult to collect as little information about vessel emissions is available. Additionally, KPIs must be comparable to each other. For example, terms of payment related KPI is difficult to compare as they are often not expressed in numbers.

It is advised to only select a limited amount of KPIs, as people tend to only focus on 5 to 7 items at once. Therefore, the common argument in performance management is to limit the number of KPIs to that range (Eckerson, 2009). In addition, the 10$^{th}$ or 11$^{th}$ KPI does not change the outcome of carrier rankings although cleaning, processing and calculation of each of these KPIs is required.

### Step 3 Data collection

After KPIs are selected, the sources of these KPIs must be determined. Does the company in question already collect data for the KPIs, or should the data be collected from a different source? If the available data is not sufficient, external sources must be selected. These sources can vary from websites with free information to specifically generated performance dashboards. These sources are likely to vary in prices based on the quantity and quality of the data available. Depending on the data required, the company must make a well-balanced decision in choosing one or more sources.

A second question that needs to be asked, is how often the data is going to be collected or updated. The frequency of collecting depends on the usage and method of collecting. Is the dashboard used every day for key elements of the business process, then frequent collecting is preferred. Is the data only used for quarterly dashboards, then daily updating the KPIs is unnecessary.

Consecutively, the company must decide on the method of data collection. With the current amounts of data used it is likely that automated collection is more cost-effective and less vulnerable for mistakes. However, sometimes with data that is collected occasionally in bulk, manual collection might prove to be more cost-effective.

And lastly, the required systems should be determined. Will the performance be visible in a Logistic Management System like the LSP uses, or will a visualization tool such as PowerBI or Tableau show the performance ranking? Additionally, will the Performance data be part of the company's database, or is a new database required? Whichever tool used will need a connection to the database, such that relevant data can be extracted and visualized whenever required.

### Step 4 Data management

After a decision has been made about the method of collection and the update frequency of the data, the data will need to be managed. The collected data must be stored and filtered to make sure the data is valid and reliable. Using the data quality elements of DAMA (2006) in the development reduces the possibility of errors in data significantly. As discussed in chapter 3: literature research, the data quality elements consist of 6 criteria: Completeness, uniqueness, timeliness, validity, accuracy and consistency. Furthermore, the data must be structured in an efficient way, as was done in the data model in Mendix.

### Step 5 Dashboard design

When data is collected and managed, a dashboard must be designed where the different performances will be visualized and compared. As the design of the dashboard influences its effectiveness, thought should be put into its development. As discussed in chapter 3, Cahyadi and Prananto (2015) have developed 6 components that form the pillars of a dashboard. In the research conducted for the LSP, one extra element was added: Aesthetics. This element was added as visuals can distract or catch the users attention. Making use of and defining the discussed elements help improve the design of the dashboard and improve its effectiveness.

### Step 6 Ranking Method

When the dashboard is designed and it is known which performance will be visible in the form of KPIs, the different carriers must be evaluated on their performances. As it is likely that there are several KPIs in the dashboard, a ranking or choice must be made on multiple criteria (KPIs). Using Multi-Criteria Decision Analysis (MCDA) allows for making a decision between carriers that score well on different criteria.

There is a large number of different MCDA methods available in Literature, which makes it hard to distinguish all the different approaches. A study was conducted by Watróbski et al. (2018), that made a simple tool to select a suitable method based on weights, type of ranking etc. as discussed in chapter 3. It must be kept in mind, that not all available methods were compared in this research. Therefore, the ideal method like the Weighted Sum Method, which was used in the case study, could be absent in this research.

## 8.1 Conclusion

Customers have been demanding an ever-increasing performance of the logistics sector, expecting shorter transit times and fewer delays. The maritime sector has been no exception, but the performance of ocean vessels is lagging behind. Logistic Service Providers are struggling to contract the best performing carriers for their customers. Although Key Performance Indicators for logistics and dashboard design are available in the literature, an approach for visualizing such performance is scarce. The purpose of this chapter was to propose a framework for developing a visualization and comparison of up-to-date carrier performance. Although the framework was developed based on a case study for an LSP in the area of ocean logistics, it can be transferable to other modes of transport such as road and air, as specific decisions are taken by its users. In addition, Appendix F, J and K might prove helpful when using the framework. In Appendix F, the most important and often used KPIs in logistics are listed together with the likelihood of their data availability. In Appendix J and K, the data used and the calculation of the KPIs are stated.

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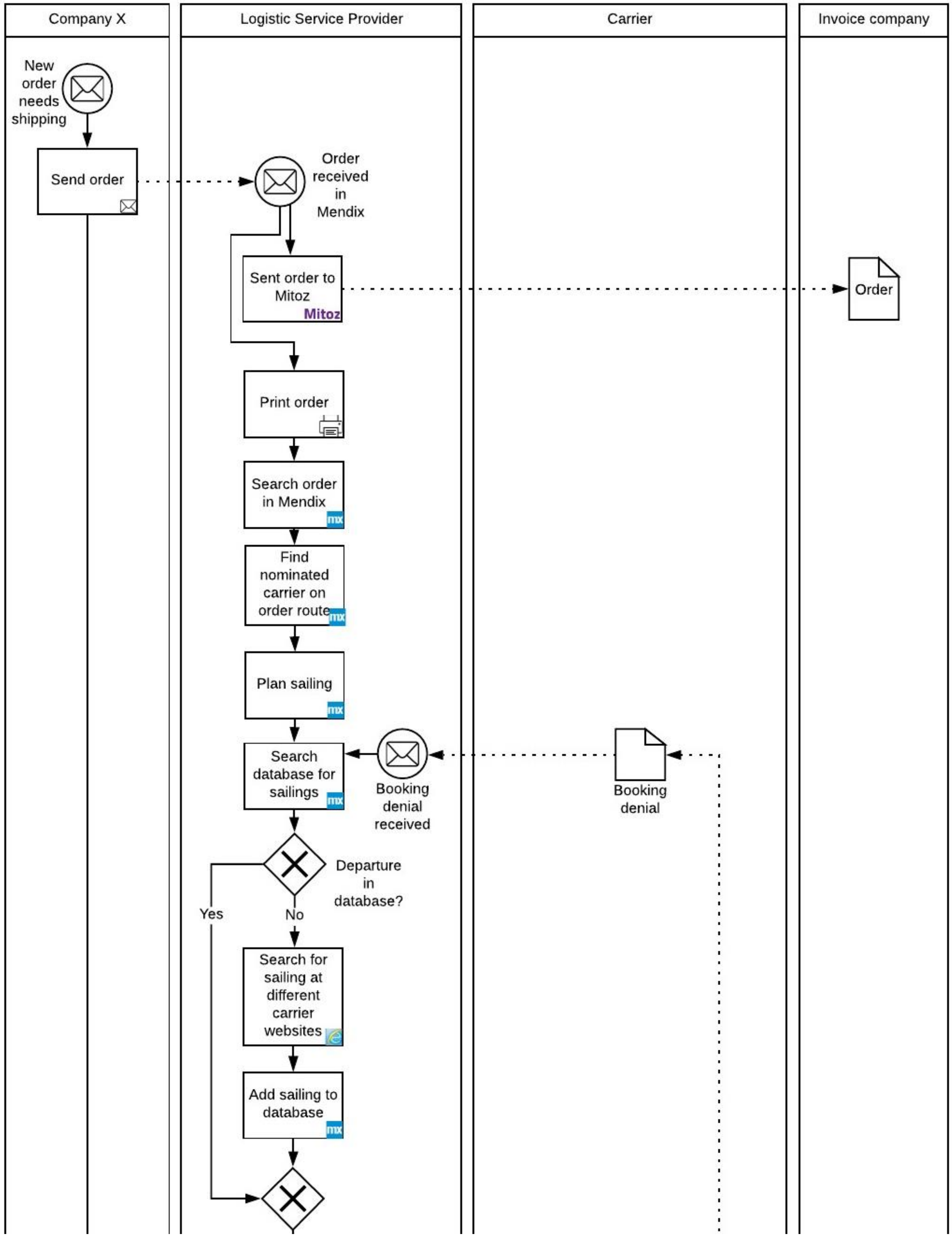
## Appendix A: Current order planning



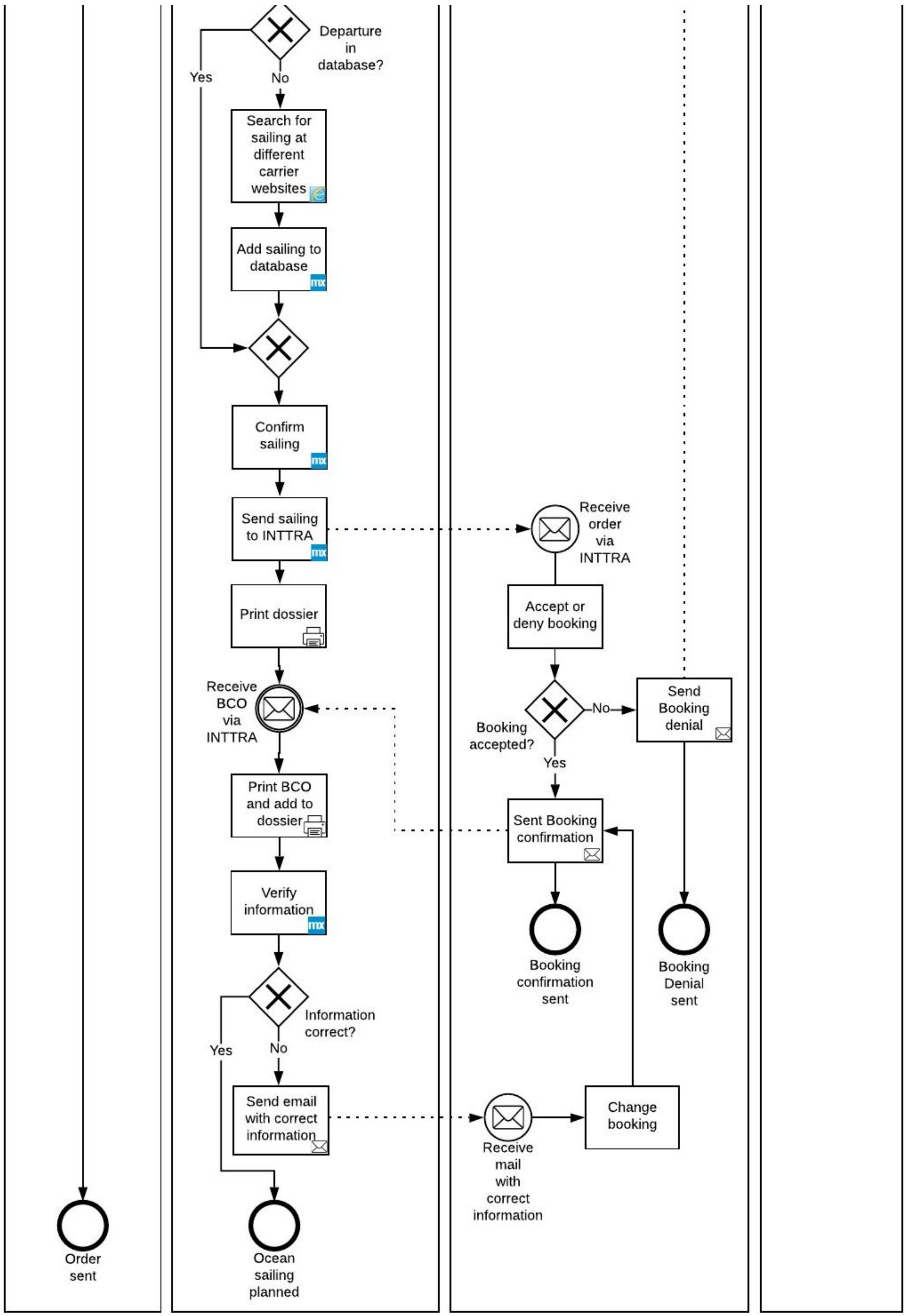
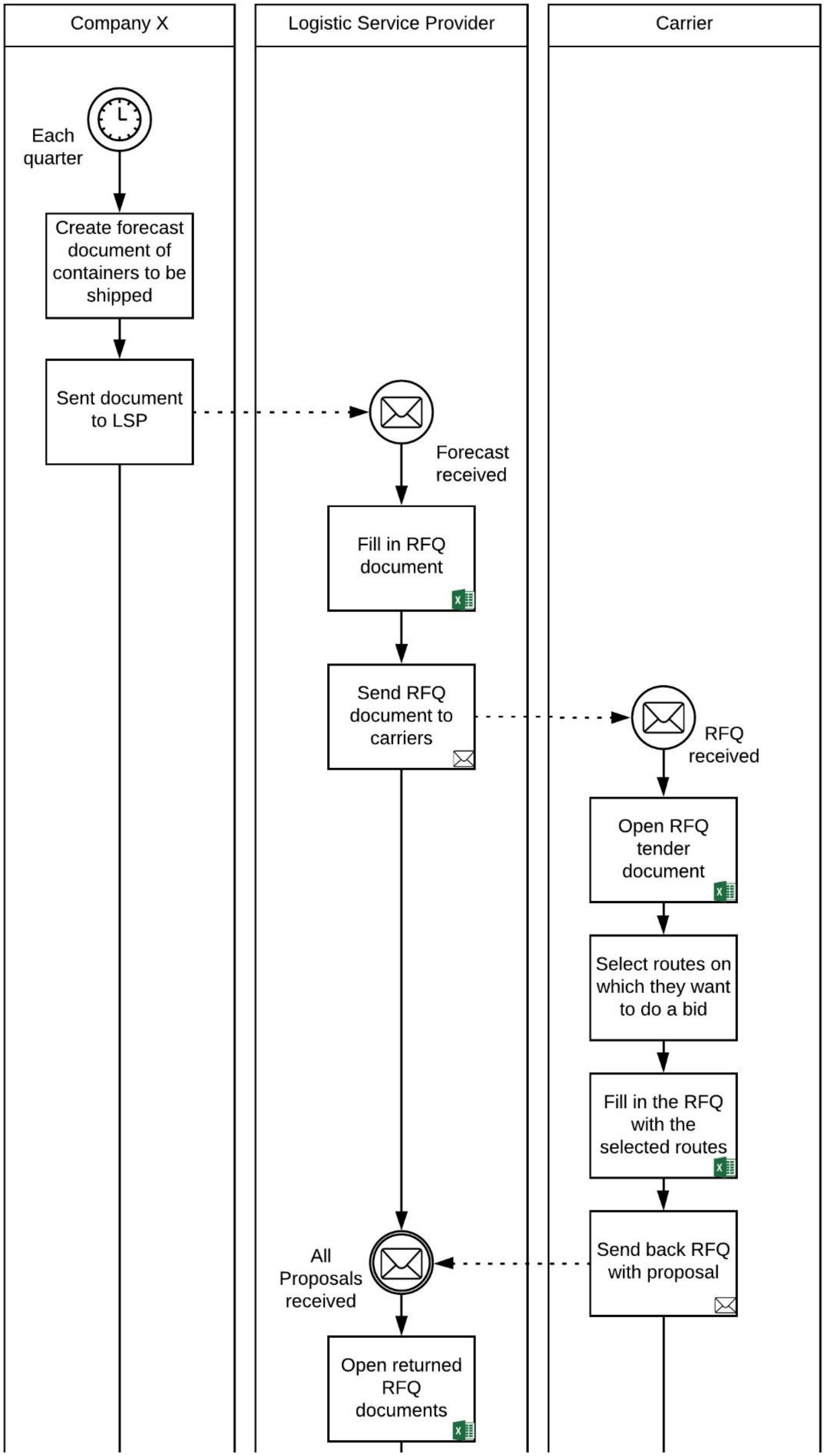



*Figure 20: Current shipment planning process*

## Appendix B: Current carrier contracting



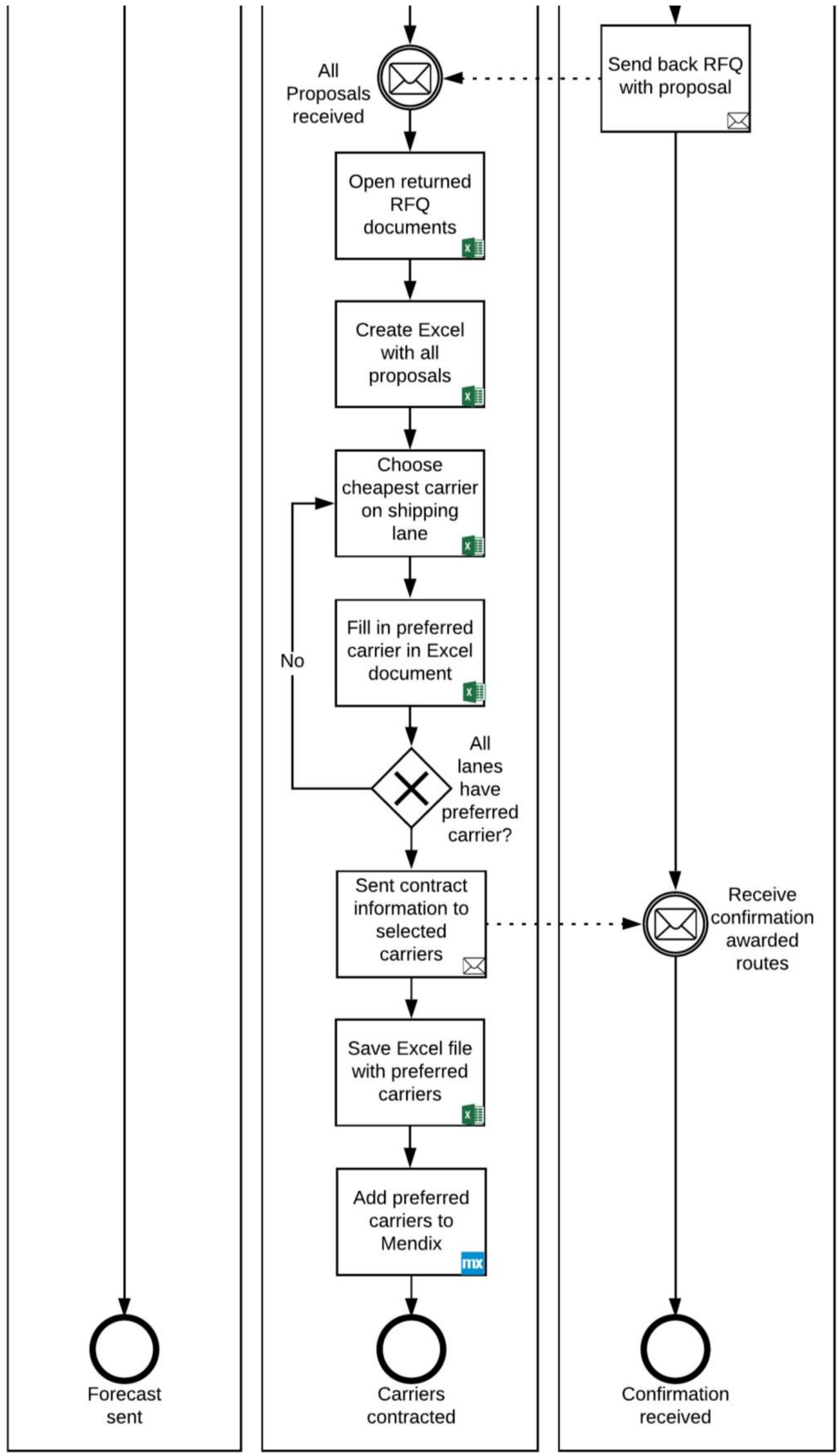



*Figure 21: Current Carrier contracting process*

## Appendix C: Sales areas

| Sales area | Description |
|---|---|
| **1** | North Europe |
| **2** | South Europe |
| **3** | United Kingdom |
| **4** | Middle/East Europe |
| **5** | East + South Asia + Australia + New Zealand |
| **6** | Central Asia |
| **7** | Africa/Middle East |
| **8** | Central America + South America |
| **9** | - |
| **10** | North America |

*Table 8: Different sales areas*

## Appendix D: Systematic literature review

| Search string | Search engine | Scope | Date of search | Date range | Number of entries |
|---|---|---|---|---|---|
| KPI AND transport | Scopus | Title, keywords and abstract | 21-11-2018 | 1990-21/11/2018 | 93 |
| KPI AND logistics | Scopus | Title, keywords and abstract | 21-11-2018 | 1990-21/11/2018 | 85 |
| KPI AND carriers | Scopus | Title, keywords and abstract | 21-11-2018 | 1990-21/11/2018 | 33 |
| KPI AND carrier AND logistics | FindUT | Trefwoord | 28-11-2018 | 1990-21/11/2018 | 18 |
| KPI AND carrier AND transport | FindUT | Trefwoord | 28-11-2018 | 1990-21/11/2018 | 63 |
| | | | | **Total entries** | 292 |
| | | | | **Removed based on include and exclude criteria** | 269 |
| | | | | **Total sources read** | 23 |
| | | | | **sources selected after reading** | 10 |

*Table 9: Search string and found sources*

| Inclusion and exclusion criteria | |
|---|---|
| **Include if:** | **Reason for inclusion** |
| **Subject is about transport KPIs** | **Often found Keywords:** transport, logistics, performance, carriers, KPIs, assessment, evaluating, optimization, |
| | |
| **Exclude if:** | **Reason for exclusion** |
| **Subject is not in the subject area of carriers and logistics** | **Found subjects:** manufacturing, career opportunities, protein, energy conservation, regional airport performance |
| **No open access** | Not accessible without paying |
| **Source is in a foreign language** | I cannot understand texts that are not in English, Dutch or German |
| **Source is a duplicate** | Source already found |
| **Source is not about KPIs** | Not relevant as the goal was to find carrier performance KPIs |

*Table 10: Inclusion and exclusion criteria*

## Appendix E: Literature review KPI per source

| Perspective → / Source ↓ | **Internal** | | **External** | | |
|---|---|---|---|---|---|
| | Management | | Customer | | Society |
| **Performance measurement and control in logistics service providing (Krauth et al., 2005)** | Perfect order fulfilment ↑ | Morale/motivation personnel ↑ | Transportation price ↓ | Response time ↓ | Level of CO2 emission ↓ |
| | Continuous improvement rate ↑ | Number of customer complains ↓ | Goods safety (number of accidents) ↑ | Transparency for a customer ↑ | Disaster risk ↓ |
| | On time delivery performance ↑ | Up-to-date performance information availability ↑ | Timeliness of goods delivered ↑ | Flexibility ↑ | Reputation ↑ |
| | Market share | Successful deals ↑ | | | Innovation technologies |
| | Number of markets (destinations) | | | | Cooperation with other companies |
| **Adaptation and value creating collaborative networks (Camarinha-Matos et al., 2011)** | Payment terms | Customer satisfaction ↑ | Customer service ↑ | Quality of product ↑ | Reputation ↑ |
| | Delivery on time ↑ | Availability ↑ (frequency) | Trust ↑ | Collaboration ↑ | |
| | Transit time ↓ | | Communication | The time between order an delivery ↓ | |
| **The transport performance evaluation system building of logistic enterprises (Wang et al., 2013)** | Customer satisfaction ↑ | Cargo damage rate ↓ | On time delivery ↑ | Service quality ↑ | |
| | Market share | | Communicate ability ↑ | Flexible delivery ↑ | |
| | | | Order tracking ability ↑ | Service costs ↓ | |
| **A framework for purchasing transport services in small and medium size enterprises (Holter et al., 2008)** | Transport rates ↑ | Customer service | Transit visibility ↑ | On-time delivery ↑ | |
| | Cost of transport management (tasks like chasing updates, preparing customs and administration) ↓ | | Transit time ↓ | Transport rates ↓ | |
| **Integrating KPIs for improving efficiency in road transport (Garcia-Arca et Al.,2018** | Number of complaints ↓ | Customer satisfaction ↑ | Transport cost ↓ | Perfect order fulfilment ↑ | |

| | | | | | |
|---|---|---|---|---|---|
| | Average delay ↓ | Errors in orders ↓ | Processing time for orders ↓ | On-time delivery ↑ | |
| **Performance-based contracting for advanced logistics services (Selviaridis & Norrman, 2015)** | Product damages ↓ | Customer satisfaction ↑ | Delivery accuracy ↑ | Perfect orders ↑ | CO2 emissions ↓ |
| **A comprehensive framework for measuring performance in a third-party logistics provider (Domingues et al., 2015)** | Accident number ↓ | Claims due to quality/out of time/costs ↓ | On-time performance ↑ | Delivery frequency ↑ | |
| | Loading/unloading time ↓ | Loss/damage frequency ↓ | Capacity ↑ | Transit time ↓ | |
| | Cargo theft ↓ | | | | |
| **Development of performance evaluation software for road freight transport activity (Kovàcs, 2017)** | Number of claims ↓ | Number of stops per trip ↑ | On time delivery ↑ | Shipment traceability ↓ | Greenhouse gas emitted ↓ |
| | Damages as % of throughput ↓ | % of orders arrives at the right location ↑ | Number of stops per trip ↓ | Transit time ↓ | |
| | | Number of handling points ↓ | Loading/unloading times ↓ | On time pickups/departure ↑ | |
| **Determinants of carrier selection: updating the survey methodology into the 21st century (Solakivi & Ojala, 2017)** | | Financial stability | Transportation rate | Transit Time | Carrier reputation |
| | Provided information | Frequency of service | Claim settlement | Number of damaged or lost shipments | |
| | Handling of special requests | Track and trace possibilities | Invoice accuracy | Geographic coverage | |
| **Carrier selection: Do shippers and carriers agree, or not? (Murphy, Daley & Hall, 1997)** | Financial stability | Frequency of service | Transit Time reliability | Transport Rates | |
| | Quality of personnel | Equipment availability | Claim processing | Negotiation process | |
| | | | Tracing options | Transit time length | |

*Table 11: KPIs retrieved from literature and grouped by perspective*

## Appendix F: Complete list of distinct KPIs for carrier performance

| KPI | In final KPI selection | Data already available | Data collectable from other sources |
|---|---|---|---|
| **On-Time Performance %** | V | V | V |
| **Price** | - | - (prices are available but not in the LMS) | V |
| **Transit Time reliability %** | V | V | V |
| **Transit Time Length** | - | V | V |
| **Perfect orders %** | - | V | - |
| **Personnel satisfaction** | | - | - |
| **Continuous improvement/ innovation** | - | - | - |
| **Number of complaints** | - | V | - |
| **Shipment tracking** | - | - | V |
| **Up-to-date Information and active sharing** | - | (partial e.g. ETA + ATA updates) | V |
| **Market share** | - | - | V |
| **Number of destinations** | - | - | V |
| **Payment terms** | - | - | V |
| **Customer satisfaction** | - | - | (Only sources based on surveys) |
| **Booking Response time** | V | V | - |
| **Sustainability/ emissions** | V (BICEPS ranking) | - | V |
| **Number of accidents/ damages** | - | - | - |
| **Flexibility** | - | - | - |
| **Cooperation with other carriers (Alliances)** | - | - | V |
| **Reputation** | - | - | - |
| **Transparency of the complete process** | - | - | V |
| **Frequency of sailings** | - | - | V |
| **Service costs** | - | - | V |
| **Customer service** | - | - | V |
| **Cost of transport management** | - | - | V |
| **Average delay** | V | V | V |
| **Order processing time** | - | V | - |
| **Container capacity on a route** | - | - | V |
| **Number of intermediate ports** | - | - | V |
| **Financial stability of the carrier** | - | - | V |
| **Special request handling** | - | - | - |
| **Billing accuracy** | V (B/L performance) | V | - |
| **Claim processing** | - | - | - |
| **Negotiation process** | - | V | - |
| **Booking Rejections** | - (rarely occurs therefore not selected) | V | V |

*Table 12: Distinct KPIs, availability and collectability*

## Appendix G: Mock-ups

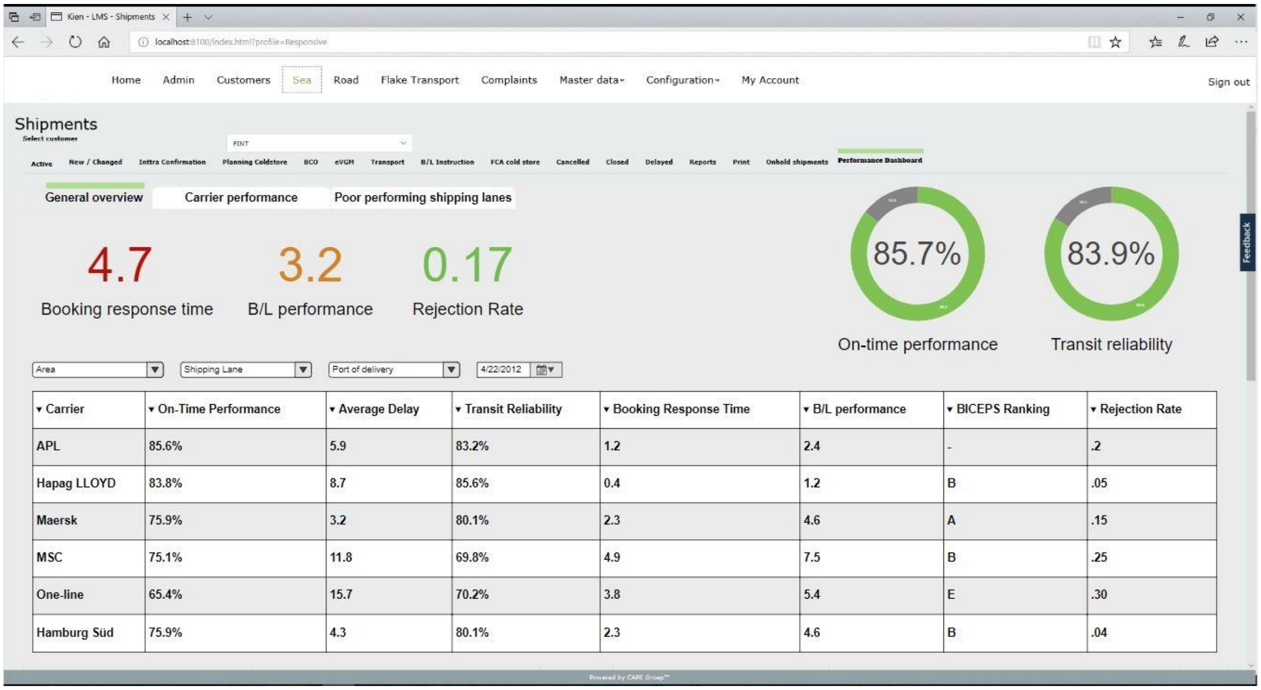



*Figure 22: Mock-up General dashboard*

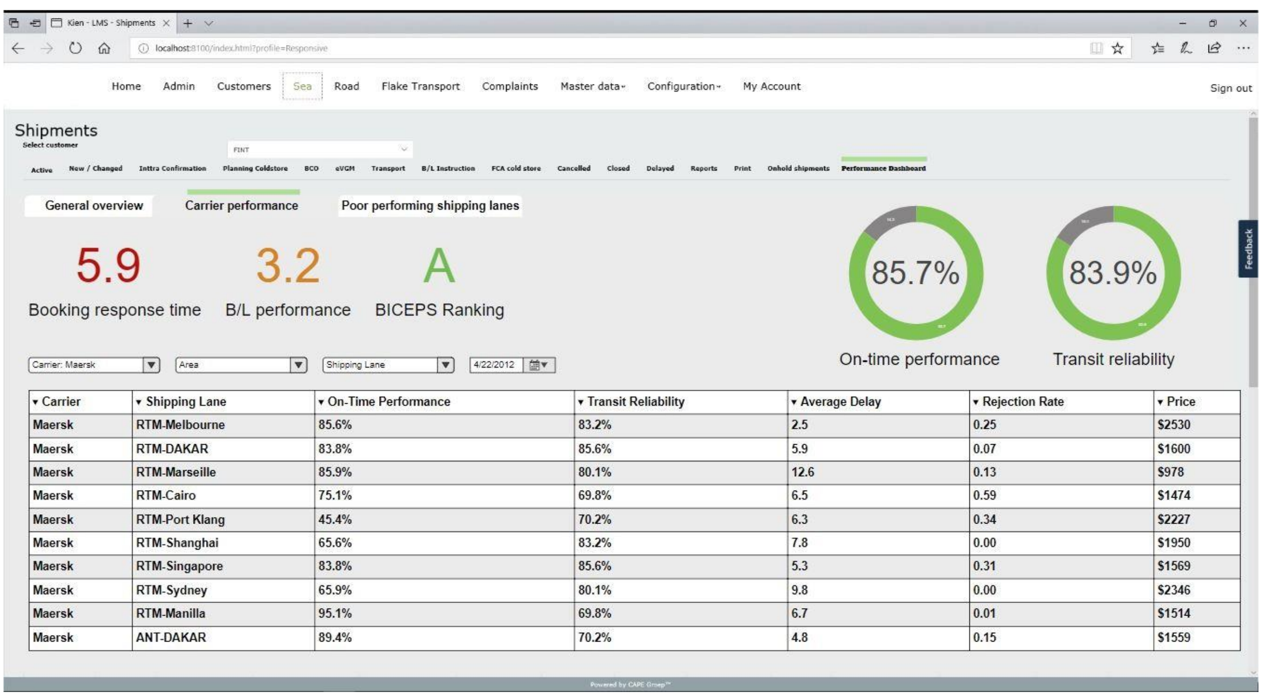
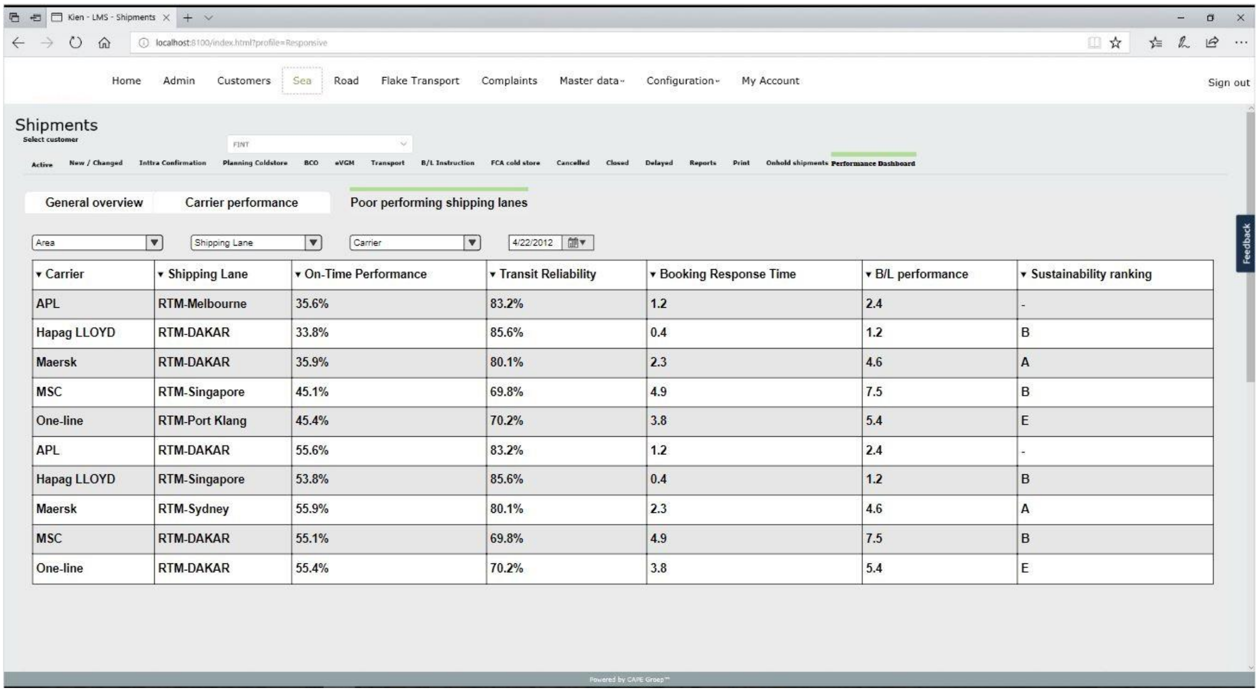



*Figure 23: Mock-up Carrier dashboard*




| Carrier | Shipping Lane | On-Time Performance | Transit Reliability | Booking Response Time | B/L performance | Sustainability ranking |
|---|---|---|---|---|---|---|
| APL | RTM-Melbourne | 35.6% | 83.2% | 1.2 | 2.4 | - |
| Hapag LLOYD | RTM-DAKAR | 33.8% | 85.6% | 0.4 | 1.2 | B |
| Maersk | RTM-DAKAR | 35.9% | 80.1% | 2.3 | 4.6 | A |
| MSC | RTM-Singapore | 45.1% | 69.8% | 4.9 | 7.5 | B |
| One-line | RTM-Port Klang | 45.4% | 70.2% | 3.8 | 5.4 | E |
| APL | RTM-DAKAR | 55.6% | 83.2% | 1.2 | 2.4 | - |
| Hapag LLOYD | RTM-Singapore | 53.8% | 85.6% | 0.4 | 1.2 | B |
| Maersk | RTM-Sydney | 55.9% | 80.1% | 2.3 | 4.6 | A |
| MSC | RTM-DAKAR | 55.1% | 69.8% | 4.9 | 7.5 | B |
| One-line | RTM-DAKAR | 55.4% | 70.2% | 3.8 | 5.4 | E |

*Figure 24: Mock-up Poor performing shipping lanes*

## Appendix H: Scrum

As described earlier, Scrum is an agile methodology which contributes to faster market times, greater flexibility higher-quality products, and higher customer satisfaction. In this part, the different roles within Scrum and the workflow of Scrum will be discussed as it is an important part of the development of the prototype.

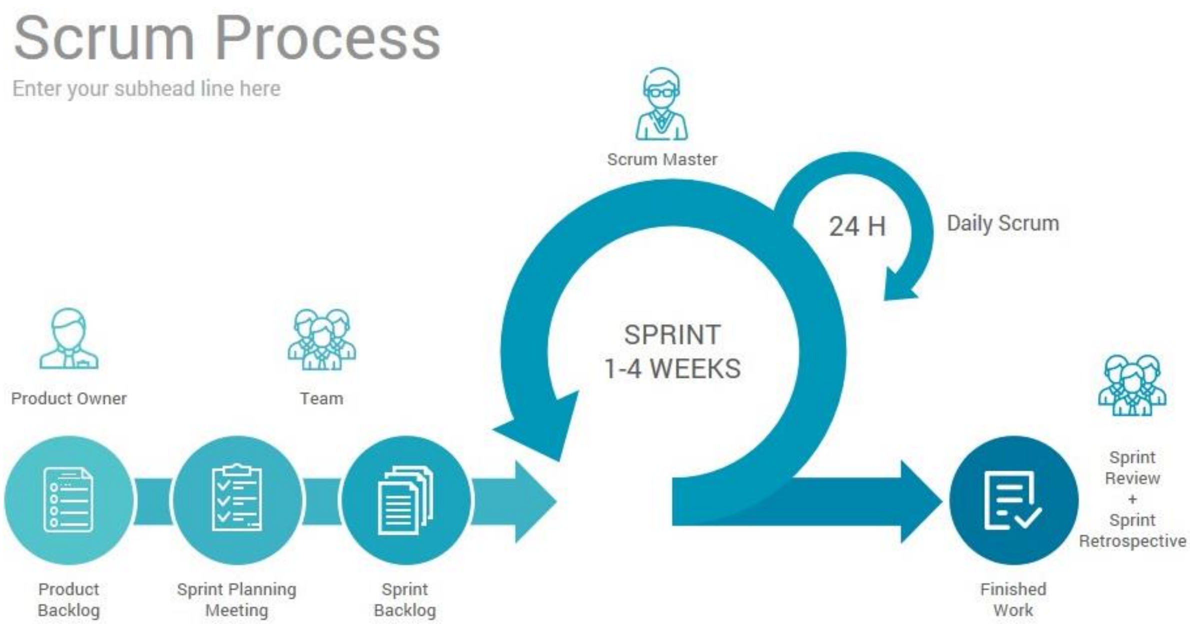



*Figure 25: Scrum Process*

A Sprint is a fixed period between one week and a month, for which a sprint goal is defined. Each sprint starts with a Sprint Planning, in which the Sprint Backlog is defined with the whole team. After each sprint, a sprint review and sprint retrospective take place, to review the progress made and possible improvements for next sprint.

Each day, the Daily Scrum takes place, in which 3 questions are answered: what did I complete yesterday, what am I going to do today, and are there any impediments, which could prevent the team from reaching the sprint goal.

The sprint review is carried out after the Sprint is completed. An evaluation of the work done in the Sprint is made and the work left over from the sprint. When necessary the Product Backlog is adapted based on the feedback.

The Sprint Retrospective takes place between the Sprint Review and the New Sprint Planning. The team reflects on the last sprint and identifies which things went well and which did not. They agree on actions of continuous improvement that will improve the team's productivity.

There are 3 different types of roles within Scrum: Product Owner, Development team and Scrum master. The Product Owner is responsible for the backlog of the product and thrives to maximize the value that the Scrum team delivers. A Product Owner identifies the Backlog items, prioritizes them, and making clear every team member understands the product backlog.

The development team is responsible for delivering the sprint goal, which is a short description of the intended deliverables, at the end of the sprint. Most likely, the team will consist of members who are specialized in different disciplines; however, they are called developers in Scrum.

The scrum master is responsible for the team to cooperate well and make sure the team deliver the product goals and deliverables. The Scrum master must make sure the team follows the Scrum framework and encouraging them to improve their functioning.

# Appendix I: User Stories

On-Time performance KPI
• ID 2344532 • Details • Comment

Average number of days late KPI
• ID 2344610 • Details • Comment

Transit time reliability KPI
• ID 2344615 • Details • Comment

B/L performance KPI
• ID 2344674 • Details • Comment

Booking Response Time KPI
• ID 2344698 • Details • Comment

BICEPS ranking KPI
• ID 2344706 • Details • Comment

*Figure 26: User stories for Sprint 1*

As a user, I want the KPIs to be automatically calculated each day/period, so that the KPIs are up-to-date
• ID 2344731 • Details • Comment

As a user, I want to be able to change the weight for each KPI, so that when my preferences change the dashboard ranking is still accurate
• ID 2344798 • Details • Comment

As a user, I want the carriers ranked in each dashboard based on weights given to the KPIs, so that the best performing carrier is on top
• ID 2344762 • Details • Comment

As a user, I want to be able to add or change the shipping lanes, so I can save the performance of carriers for new destinations
• ID 2344732 • Details • Comment

As a user, I want to have a list of poor performing shipping lanes, so I can see which shipments are most likely to arrive late
• ID 2344503 • Details • Comment

As a user, I want to have a dashboard with performance of a carrier on a lane, so I can compare different lanes with eachother for every carrier
• ID 2344486 • Details • Comment

As a user, I want to have a general performance dashboard, so I can compare the different carriers on performance
• ID 2344470 • Details • Comment

*Figure 27: User Stories for Sprint 2*

| |
|---|
| As a user, I want the KPIs in the table sorted based on their weight, so that the most important KPI is presented first. |
| As a User, I want the colour red, orange or green around the value, so that I can see immediately if the performance was good or bad. |
| As a User, I want the doughnut chart value to have a red contour, so I can read the value on the grey background. |

*Figure 28: User stories for sprint 3*

## Appendix J: Data used

| Data used | Filters | Usage | Details usage |
|---|---|---|---|
| **STD** | - Completeness<br>- Consistency | KPI calculation | - Transit Time reliability |
| **ATD** | - Completeness<br>- Consistency | KPI calculation + Dashboard Filtering | - Transit Time reliability<br>- B/L performance<br>- Filtering<br>If the ATD of a shipment is within the selected date range in the dashboard, the B/L performance KPI and Booking Response Time KPI of a shipment will be visible in the dashboard. |
| **STA** | - Completeness<br>- Consistency | KPI calculation | - Average Delay<br>- On-Time Performance<br>- Transit Time reliability |
| **ATA** | - Completeness<br>- Consistency | KPI calculation + Dashboard Filtering | - Average Delay<br>- On-Time Performance<br>- Transit Time reliability<br>- Filtering<br>If the ATA of a shipment is within the selected date range in the dashboard, the On-Time, transit-time reliability and average delay KPI of a shipment will be visible in the dashboard. |
| **ETA** | - Completeness<br>- Consistency | KPI calculation | - On-Time performance<br>(only used if the ATA is not available) |
| **POL** | - Completeness<br>- Consistency | Dashboard Filtering<br>Shipping Lane retrieval | - Shipping lane retrieval |
| **POD** | - Completeness<br>- Consistency | Dashboard Filtering<br>Shipping Lane retrieval | - Filtering<br>- Shipping Lane retrieval |
| **Carrier** | - Completeness<br>- Consistency<br>- No Master carrier (Uniqueness) | Dashboard Filtering | - Filtering |
| **Shipping Lane** | - Completeness | Dashboard Filtering | - Filtering |
| **Sales Area** | - Completeness | Dashboard Filtering | - Filtering |
| **Final B/L sent date** | - Completeness<br>- Within 30 days of ATA of a shipment (consistency) | KPI calculation | - B/L performance |
| **Holiday + weekends** | - Completeness | KPI calculation | - B/L performance<br>- Booking Response Time |
| **Booking Sent to Booking Platform** | - Completeness | KPI calculation | - Booking Response Time |
| **Booking Confirmed by Booking Platform** | - Completeness<br>- Within 30 days of Booking sent to the platform (consistency) | KPI calculation | - Booking Response Time |
| **BICEPS Ranking** | - Completeness | KPI calculation | - BICEPS Ranking<br>Emptiness is checked, but still used in the calculations |

*Table 13: Data used for KPI calculations*

## Appendix K: KPI calculations

| KPI | Used data | Calculation | Remarks | Min + Max value | Ranking Score | Target values |
|---|---|---|---|---|---|---|
| **On-Time Performance** | STA<br>ATA (of ETA) | Shipment is On-time when:<br>ATA > STA and difference < 7 days<br>Or when ATA < STA and difference < 4 days | When no ATA is available, then the ETA will be used instead of the ATA | Max: 100%<br>Min: 0% | 100% = 1<br>87.5% = .875<br>0% = 0 | Green: > 85%<br>Orange: 80 t/m 85%<br>Red: <= 80% |
| **Transit-Time reliability** | STD<br>STA<br>ATD<br>ATA | On-time when difference between STT en ATT < 7<br>STT = days between STD and STA<br>ATT = days between ATD and ATA | | Max: 100%<br>Min: 0% | 100% = 1<br>87.5% = .875<br>0% = 0 | Green: > 90%<br>Orange: 85 t/m 90%<br>Red: <= 85% |
| **B/L Performance** | FinalBLSentDate<br>ATD | Time between departure of the vessel (ATD) and sending the FINAL B/L | Saturday and Sunday + every day defined as holiday | Max: 30<br>Min: 0 | 30 = 0<br>7 = .76666<br>0 = 1 | Green: < 2 days<br>Orange: 2 till 3 days<br>Red: >= 3 days |
| **Booking Response Time** | Activity Log:<br><br>BOOKING_SENT_TO_INTTRA<br><br>INTTRA_BOOKING_CONFIRMED | Time between BOOKING_SENT_TO_INTTRA and INTTRA_BOOKING_CONFIRMED | Saturday and Sunday + every day defined as holiday<br>In the case of a confirmation in the weekends, it is possible to have a negative booking response time. in that case, the Booking Response time will be 0. | Max: 30<br>Min: 0 | 30 = 0<br>7 = .76666<br>0 = 1 | Green: <= 1 days<br>Orange: 1 t/m 2 days<br>Red: > 2 days |
| **Average Delay** | STA<br>ATA | The time between STA and ATA in days | | Max: ∞ (longest delay)<br>Min: -∞ | >= 30 days = 0<br>7 days = .766<br>0 days = 1<br>-12 days = .6<br><= -30 days = 0 | Green: -2 to 4 days<br>Orange: -4 t/m -2 days and 4 till 7 days<br>Red: >= 7 and <= -4 days |
| **BICEPS Ranking** | Carrier: BICEPS_Ranking | Rating as given by BICEPS Network | BICEPS Ranking is updated manually in the LMS | A - F | A = 1.0, B = 0.8,<br>C = 0.6, D = 0.4<br>E = 0.2, F = 0<br>None = 0 | Green: A + B<br>Orange: C + D<br>Red: E + F |

*Table 14: KPI calculations*