The critical areas of information sharing for the improvement of efficiency in the nautical chain

A Port of Rotterdam case study

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by

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Summary

Recently, port competition is increasing and there has been pressure on port authorities to improve the port's performance. In this thesis, the focus is on efficiency as a port performance indicator. To stay competitive, ports must ensure an adequate level of efficiency. Due to trends as increasing vessel sizes and maritime trade volumes, efficiency gains are required, even when a port is currently performing well. The efficiency of a port is determined by the time between arrival and departure of a vessel.

There are many factors, actors and activities that influence the efficiency of a port. In this thesis, the nautical services that are required for the vessel handling in the port area are considered. The nautical services involve the positioning, piloting and mooring of a vessel. These services must be performed sequentially and are therefore referred to as 'the nautical chain'. The efficiency of the nautical chain affects the time between arrival and departure of a vessel, which determines the efficiency of a port. The actors that are involved in the processes of the nautical chain are the Harbour Master, the pilot organization, the tugboat companies, the boatmen organization, the terminal operators and vessel agents. The services provided by the actors are all dependent on each other, which makes cooperation between the actors of the chain essential. In this thesis, cooperation is represented by information sharing between actors of the nautical chain that is relevant to support each other's goals.

Literature shows that cooperation improves the efficiency of a port. Therefore, improving the information sharing between the actors of the nautical chain might lead to an improvement of efficiency in the nautical chain and thereby an improvement of the port efficiency. Although it is recognized that information sharing is required to execute the nautical processes, it is unknown what information is shared between the actors. Consequently, it is unknown what information sharing is crucial to focus on for improving efficiency in the nautical chain. Therefore, this research aims to provide insight into the information sharing between the actors of the nautical chain and to identify the critical areas of information sharing for the improvement of efficiency in the nautical chain. In this research, a case study of the nautical chain in the Port of Rotterdam is performed. The main research question is as follows:

What are the critical areas of information sharing for the improvement of efficiency in the nautical chain in the Port of Rotterdam?

The main research question is answered by analyzing the **processes** and **information sharing** between the actors of the nautical chain and combining this with **frequently occurring delays** in the Port of Rotterdam. Data regarding the processes and information sharing is gathered with desk research, expert input and observational research. The gathered data is processed using the Business Process Modeling and Notation (BPMN) language, which is a Business Process Modeling (BPM) method. The analysis of the frequent delay situations is based on data available on the delays that are recorded by the Harbour Master and supplemented by expert knowledge. A Root Cause Analysis is performed to map the possible delay causes that instigate the delays recorded by the Harbour Master. The research results provide an overview of the information shared in the frequently occurring delays.

Firstly, the **processes** of the nautical chain are visualized using BPMN models. The processes executed in the planning domain of the nautical chain start with a vessel that makes the first operational contact with the Port of Rotterdam (incoming voyage) or when the requested time for departure is ordered by the vessel agent (outgoing voyage). The processes of the operational domain start when the vessel arrives at the pilot station and the pilot boards the vessel (incoming vessel) or when time equals the planned departure time of a vessel and all service providers are present at the departing vessel (outgoing voyage).

Secondly, the analysis of the **information sharing** between the actors of the nautical chain is conducted to provide a visualization of the information shared in the planning and operational domain of the nautical chain. BPMN models display which information is shared between which actors. From the mapped information sharing, it is concluded that the planning and operational domain of different actors are overlapping, because each actor fixes its planning at the minimum time in advance. Furthermore, the information sharing analysis showed that the majority of the communication is bilateral. The mapped information sharing also reveals that communication via the VHF channel does not only serve as a communication tool, but also as a valuable information source on the real-time events for other actors that are connected to the VHF channel. Lastly, the information sharing analysis shows that the boatmen have more information available compared to other actors. This is because the boatmen arrange the pilot transportation, so they are always aware of delayed pilot arrivals. Additionally, the boatmen at the quay are closest to the terminal operations and thereby the first to notice any disruptions at the terminal.

Thirdly, to link the information sharing with the frequently occurring delays in the Port of Rotterdam, the delay causes that are recorded by the Harbour Master are analyzed. Analysis of the delay causes that are recorded by the Harbour Master provides insight into the first-level (direct) causes of a delay. However, including the higher-level (indirect) causes of these recorded causes gives a more realistic understanding of the delay situations that occur in the nautical chain. The highest-level cause of a delay is called the 'root cause'. To gain insights on the higher-level causes of a delay, a root cause analysis is conducted. From expert input on the frequency of the identified root causes, the root causes that are expected to occur relatively frequent are concluded. The **frequently occurring delays** are triggered by the following root causes: (1) A pilot capacity shortage (2) A tug capacity shortage (3) A delayed tug arrival due to a delay of the previous vessel (4) Berth occupied by a barge (5) Berth occupied by a sea-going vessel (6) Unfinished loading activities (7) Unfinished bunker activities (8) Congestion at the fairway due to a peak demand (9) Congestion at the fairway due to the passage of large vessels.

Next, considering delay situations that are caused by the frequent occurring root causes and the information being shared in those situations, critical information sharing areas are distinguished. The information that is shared in the considered situations is validated trough feedback from the pilot organization, boatmen organization and tug company. The information sharing areas enable a reduction of the effects of a delay by helping the actors to be aware of disrupting events and their potential consequences. In **conclusion**, the following critical information sharing areas for the improvement of efficiency in the nautical chain are identified:

(a) Information sharing from the boatmen, tug captain and pilot with their planning departments about disrupting events that occur at the current assignment.
(b) Information sharing from the pilot planning and the tug planning with all planning departments (including the Harbour Master) about updates on the time available for delivering their services.
(c) Information sharing with the pilot planning and the tug planning about the required delivery time and quantity of the nautical services.
(d) Information sharing between the nautical service providers at other assignments in the same sector of the nautical VHF radio about disrupting events that might affect the own assignment.
(e) Information sharing between the nautical service providers about disrupting events that occur during the current assignment.
(f) Information sharing from all actors (other than the nautical service providers present at the current assignment) with the pilot about disrupting events that occur and the to be taken actions.
(g) Information sharing from the pilot of a departing vessel with the pilot of an incoming vessel and the VTS department of the Harbour Master about a delayed departure.

Finally, to improve the efficiency of the nautical chain, **it is recommended** to (1) involve the terminals in the information sharing within the nautical chain, (2) to develop information sharing protocols that ensure that the planning departments are sourced with the required information of the real-time operations within the chain, (3) to develop information sharing protocols that clarify the information sharing route that should be taken between different organizations for a specific situation and (4) to look for possibilities to share information about delayed bunker activities with the nautical service providers before the pilot boards the departing vessel. This will lead to more information shared in the planning domain of the nautical chain. All information that is shared in the planning domain enables the planners to process the information into their planning and thereby prevents that resources are assigned too early or unnecessary. Further research should quantify the effects of information shared within the critical information sharing areas on the efficiency of the nautical chain.

Preface

This thesis is the final deliverable for the completion of the degree of Master of Science in Transport, Infrastructure and Logistics (TIL) at the faculty of Civil Engineering and Geo-sciences at the Delft University of Technology. From the beginning of my Bachelor studies in Technology, Policy and Management, my interest in logistics has grown. Additionally, passion for everything that happens in and around ports arose. Furthermore, I've always preferred to analyze a problem from an improvement perspective. This thesis focuses on the processes within the nautical chain in the Port of Rotterdam and the information sharing that is interesting to consider with regard to efficiency improvements. After all, maybe it was not just luck, but mostly strong motivations that brought me into this topic. I've really enjoyed working on this project. I want to thank Lori Tavasszy for linking me to the right person at the right time. By responding quickly to my e-mails, I came in contact with Shahrzad, who got me excited for the subject of her PhD project. A bit later, I came in touch with Raymond, who made it possible to write my thesis as a graduate intern at the Port of Rotterdam. I am grateful to have had that opportunity.

First, I want to thank Raymond for introducing me to the world that's behind the Port of Rotterdam. The Harbour Master Department has been an inspiring environment and motivating place to work. Above all, I'm thankful for all the provided insights, the patience with answering my questions and the exceptional involvement in the project. It certainly improved the quality of it. Second, I want to thank Shahrzad, Poonam and Jafar, the members of my graduation committee of the TU Delft, for the professional guidance throughout the project. The feedback has always been constructive and clear, which supported the final result of this thesis. Shahrzad, especially thanks for the Friday afternoons of thinking along with me and trying to follow my sometimes messy mind. And of course, I will never forget the incredible experience of the pilot trip we've joint together.

I'm very thankful for the contribution of all people in the nautical environment that supported this research project. This includes colleagues from the Harbour Master Department (HCC and VTS), but also the external parties. Therefore, many thanks to Loodswezen Rotterdam-Rijnmond, Boluda Towage, KRVE Rotterdam Boatmen and ECT Terminals for their participation in the project. I realize that I was completely dependent on input from their side to be able to complete this thesis. Above all, thank you for providing the opportunity for experiencing the nautical chain by joining the operations. Of course, the field trips did not only contribute to my research, but were an unforgettable experience as well.

I'm glad that all the required interviews and observations were finished before the corona crisis started. The last 1,5 months of my thesis project had to be finished from home. Of course, this is not how I imagined it, but I'm happy that everyone is being flexible and that digital solutions provide us with alternatives. Hopefully, it is possible to celebrate the completion of my thesis project with friends and family soon, because they have been an important part of my time studying in Delft.

K.F. Molkenboer
Rotterdam, April 2020

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Abbreviations

BPM	Business Process Modeling
BPMN	Business Process Model and Notation
RCA	Root Cause Analysis
CSOR	Case Study Observational Research
UML	Unified Modelling Language
KRVE	Koninklijke Roeiers Vereniging Eendracht
HCC	Harbour Coordination Center
VRC	Vereniging Rotterdamse Cargadoors
VTS	Vessel Traffic Services
DO HCC	Duty Officer Harbour Coordination Center
DO VTS	Duty Officer Vessel Traffic Services
ADO	Assistent Duty Officer
ETD	Estimated Time of Departure
PTD	Planned Time of Departure
ETA	Estimated Time of Arrival
ETA PS	Estimated Time of Arrival at the Pilot Station
ETA MC	Estimated Time of Arrival at the Maas Center buoy
ETA LL	Estimated Time of Arrival at the Low Light
RTA	Requested Time of Arrival
PTA	Planned Time of Arrival
AC	Administrative Clearance
OC	Operational Clearance
NOA	Notice of Arrival
NOD	Notice of Departure
PCS	Port Community System
HaMIS	Harbour Master Management Information System
LAB	Loods Aantal Boten (estimated number of tugs)
VHF	Very High Frequency
NSP	Nautical Service Providers
PoR	Port of Rotterdam

PIM	Production Information Model
SIM	Service Information Model
DIM	Dynamic performance Index Model
SCD	Supply/Service Chain Dynamic model

Definitions

Nautical chain	All the events of the nautical service providers in the operational domain performed for a vessel during the time that vessel is sailing and the information shared in the tactical domain to support events in the operational domain
Nautical service providers	Pilots, tugboats and boatmen
Vessel agent	Company responsible for administrative tasks in behalf of the vessel, also called shipping agent
Pilot Service Leader	Pilot located at the Harbour Coordination Center (in Dutch: Loodsdienstleider)
Report/reporting/reported	All details shared from the vessel agent with the Harbour Master regarding a planned incoming or outgoing voyage
Order/ordering/ordered	Message from the vessel agent to the Harbour Master that an outgoing voyage is requested to depart at the ordered time
Instruction	Information from the vessel agent that instructs vessels what actions must be taken (in Dutch: orders)
Exchangers	Two vessels that follow after each other for the same berth (in Dutch: uitwisselaars)
Nautical VHF channel	This VHF channel is used by the nautical service providers in a specific sector of the port area
VHF channel of the sector	This VHF channel is used by all vessel traffic and the Vessel Traffic Services of the sector
Internal VHF channel	This VHF channel is used for communication within an organization
Unilateral communication	One-way communication
Bilateral communication	Two-way communication

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1 Introduction

The objective of the Port of Rotterdam Authority is to enhance the port's competitive position as a logistic hub and world-class industrial complex. With a number of approximately 30.000 sea-going vessel visits per year, this is a challenging assignment (Port of Rotterdam, 2019c). The Harbour Master of the Port of Rotterdam is responsible for the safe and efficient handling of all these vessels. To secure the competitive position of the port, the Harbour Master strives for increased port efficiency. The port efficiency is influenced by the efficiency of the nautical chain. The nautical chain consists of all services required to enable a vessel to safely enter or leave the port. Examples of these required services are e.g., piloting, positioning and mooring of a vessel. This thesis investigates the processes within the nautical chain of the Port of Rotterdam and the information sharing between the actors that are involved to improve the efficiency of the nautical processes. In this chapter, background information on port performance and efficiency is provided in section 1.1. Next, the nautical chain is introduced in section 1.2 and section 1.3, followed by an introduction to the Port of Rotterdam in section 1.4. The problem statement, including the research objectives and questions, is presented in section 1.5. Lastly, the research approach, research scope and thesis outline are discussed in section 1.6, section 1.7 and section 1.8.

1.1. Port performance and efficiency

Over the last years, there has been pressure on port authorities to improve their performance due to an increasing competition between ports (Tongzon, 1995). For example, the ports in the so called Hamburg-Le Havre range (e.g. Antwerp, Rotterdam, Amsterdam, Hamburg, Rotterdam) supply overlapping hinterland regions. Efficiency is considered as the key factor that determines the competitiveness of a port (Tongzon, 2009) (Trujillo and Tovar, 2007). In this respect, Rezaei et al. (2019) conclude that the time along the transport chain is one of the dominant factors for the level of competitiveness of a port. The more efficient the port operations, the less time is added to this transport chain. Therefore, ports must ensure an adequate level of efficiency to stay competitive. Next to efficiency, other performance indicators used to determine the port performance are e.g costs, profitability, safety aspects or environmental impact. In this thesis, the focus is on efficiency as an indicator for port performance.

In general, efficiency reflects the output over the input of a system. An output of the port system is the number of handled vessels and the input the number of used resources. Assuming that the resources remain equal, the number of handled vessels must increase to improve the port efficiency. This could be reached by reducing the time between the arrival and departure of a vessel. Yang et al. (2011) confirm this by stating that the efficiency of sea-ports is determined by the time that a vessel stays in the port. This time is referred to as the turnaround time of a vessel.

The volume of maritime transported cargo has grown significantly and forecasts indicate that this volume will continue to grow. In 2017 an annual growth rate of maritime trade volumes of 4% has been noted and the forecast for 2018-2023 shows an annual growth of 3.8% (UNCTAD, 2018). Although future prospects involve a high level of uncertainty, it is assured that the loaded goods for seaborne trade have grown with approximately 40% between 2006 and 2017 (UNCTAD, 2018). Together with this growth comes a growth in vessel traffic and thereby the frequency of port-calls (Olba et al., 2019). The consequence of the increased number of port calls and volumes transported is an increasing pressure on the efficiency of seaports.

Factors and trends that challenge the efficiency level of sea-ports are:

- The maritime trade growth predictions (UNCTAD, 2018)
- Increasing vessel sizes (Swarmport proposal, 2017)
- Increasing frequency and impact of extreme weather conditions (Swarmport proposal, 2017)
- Capacity shortages due to limited feasibility of automation of knowledge-based processes and greying population (Swarmport proposal, 2017)
- Difficulty of the prediction of expected arrival and departure times which may lead to peaks in demand and uncertainty for planners (Swarmport proposal, 2017)

The above factors imply that even when a port is currently performing well, efficiency gains are required to ensure the future competitiveness of a port.

1.2. The nautical chain

Many factors, parties and activities influence the efficiency of a port, for example port infrastructure, terminal handling, external circumstances, customs, legal restrictions and the nautical services (Clark et al., 2004). The focus in this thesis is on the nautical services within a port.

The nautical services in a sea-port involve the positioning, piloting and mooring of a vessel. The services must be performed sequentially. This chain of services is referred to as 'the nautical chain'. The definition of the nautical chain used in this thesis is obtained from Verduijn (2017) and reads as follows: *all the events of the nautical service providers in the operational domain performed for a vessel during the time that vessel is sailing in the port and the information shared in the tactical domain to support events in the operational domain.* The tasks within the nautical chain are all executed by different actors that have their own interests and priorities. At the same time, all these parties are dependent on each other, while there is no central governance that controls the task execution within the chain.

Figure 1.1 shows a simplified visualization of the activities within the nautical chain. Larger vessels require piloting service to safely enter the port area and sail to the destined berth. A pilot boards the vessel and navigates the vessel through the port. Subsequently, tugboats are fastened to assist the vessel with manoeuvring. Once the vessel has arrived at its berth, boatmen make sure that the mooring lines are secured. For an outgoing vessel, the process is reversed. The boatmen unmoor the vessel, the tugboats detach and the pilot disembarks the vessel.

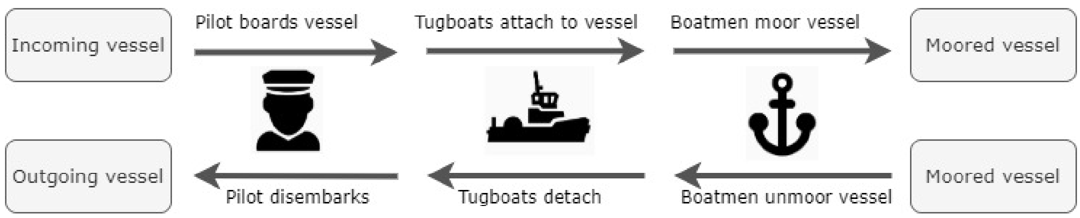


Figure 1.1: Overview of the nautical chain

The vessel is the object of the nautical chain, since it requires support from all actors of the nautical chain to complete its incoming or outgoing voyage. Besides the nautical service providers (pilot, tugboats and boatmen) that execute the operational activities of the nautical chain, the Harbour Master, vessel agent and terminal operator are involved in the process. The Harbour Master must provide clearance for the execution of the voyage and guides the vessel during its port passage if necessary. The vessel agent arranges all administrative tasks in the tactical domain of the nautical chain. The terminal operator must provide a free berth for the vessel and executes the (un)loading operations.

The actors that are involved in the processes of the nautical chain are dependent on each other. This makes cooperation between the different actors of the chain an important aspect of the nautical performances. Cooperation is considered as the sharing of useful information between different actors. Information is shared via the available digital information systems, VHF radio, phone communication or face-to-face.

1.3. Performance and efficiency of the nautical chain

The performances of the nautical services are relevant to consider with regard to the overall port efficiency. First of all, Tavasszy et al. (2011) show that the throughput of a port, which is linked to the level of port efficiency, is directly influenced by the generalized costs of port operations. Subsequently, Davydenko and Fransen (2019) state that 'the quality of the port nautical services directly influences the generalized costs of port operations'. Additionally, Tongzon (2009) defines port efficiency as the 'speed and reliability of port services'.

The performance of the nautical chain depends on the dynamic nature of the demand for services, external circumstances, the available infrastructure, the capabilities of individual actors and the collaboration between them (Swarmport Proposal, 2017). Similar to port performance, one of the indicators of the performance of the nautical chain is the efficiency. As discussed in section 1.1, port efficiency increases when the turnaround time (time between arrival and departure) of a vessel decreases. The turnaround time of a vessel consists of the service time and the dynamic turnaround time. The service time covers the time between arrival and departure from a terminal. The dynamic turnaround time covers the time spent on sailing and manoeuvring. The latter is affected by the efficiency of the nautical chain. To improve the efficiency of the nautical chain, the number of vessels handled in the chain must increase, while the used resources remain equal.

1.4. Port of Rotterdam as a case study

This thesis researches the nautical chain of the Port of Rotterdam. With a throughput of almost 500 million tonnes per year, the Port of Rotterdam is the biggest port in Europe. The port area stretches over a length of 40 kilometers from the center of Rotterdam to the reclaimed Maasvlakte area. A map of the Port of Rotterdam is shown in Figure 1.2. From the Port of Rotterdam, commodities can be transported further via vessel, inland barge, train, truck or pipeline. Within the Port of Rotterdam, The Port of Rotterdam N.V. is responsible for the port areas and infrastructure. This makes the Port of Rotterdam a so called 'landlord' port. In a landlord port, the Port Authority owns the port areas and infrastructure and leases these areas to companies responsible for their own business.

Figure 1.2: Map of the Port of Rotterdam [conducted from (Port of Rotterdam, 2019b)]

As part of the Port of Rotterdam N.V., the Harbour Master of the Port of Rotterdam is responsible for the smooth and safe handling of visiting vessels. Tasks involved are the control of the planning of accessing and exiting vessels, monitoring all vessels that enter and leave the port, inspection work and enforcement of rules and regulations on the water (Port of Rotterdam, 2019a). In 2004 the Port of Rotterdam transformed from a municipal department to an unlisted public company (N.V.). The shareholders are the Municipality of Rotterdam and the Dutch Government. Within this (more) commercial position of the Port of Rotterdam, the Harbour Master remains responsible for the smooth and safe handling of the vessel traffic in the Port of Rotterdam. However, guarding the safety of the traffic in the port area is a public task. For this reason, the Harbour Master is under the supervision of the Municipality of Rotterdam and the Ministry of Infrastructure and Water Management. At the same time, the Harbour Master must report to the Port of Rotterdam N.V., since they provide all the required resources (Port of Rotterdam, 2019d). Figure 1.3 shows a visualization of the position of the Harbour Master.

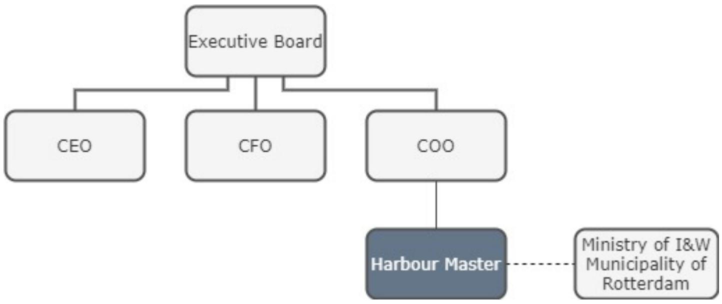


Figure 1.3: Position of the Harbour Master in Port of Rotterdam organization chart

To ensure the future competitive position of the Port of Rotterdam, the Harbour Master strives for increased port efficiency. Additionally, ensuring safe shipping is the priority for the Port of Rotterdam and thereby an important responsibility of the Harbour Master. Therefore, port efficiency can only be increased as long as all safety standards can be assured.

1.5. Problem statement

As described in section 1.1, efficiency gains are required to ensure the future competitiveness of a port. Although multiple factors affect the efficiency of a port, ports are currently working on projects that focus on the ability to share information to increase port efficiency (UNCTAD, 2019). In that context, research shows that there is a positive relation between information sharing and the efficiency of a supply chain (see chapter 2). This relation is assumed to apply to the nautical chain as well, due to its similar characteristics with a supply chain. Since the overall port efficiency is influenced by the efficiency of the nautical chain (see chapter 2), improving information sharing between the actors of the nautical chain can provide opportunities for the improvement of port efficiency. From the available literature is concluded that information sharing is required for the execution of the processes of the nautical chain. However, there exists a research gap regarding the current information that is shared between actors in the nautical chain (see chapter 2). Additionally, research on the possibilities to improve efficiency in the nautical chain is lacking (see chapter 2). Consequently, it is unknown what parts of the information sharing might be crucial to focus on for improving efficiency in the nautical chain.

1.5.1. Research objective

The research objective of this thesis is twofold:

- Provide insight into the information sharing between actors in the nautical chain in the Port of Rotterdam.
- Identify the critical areas of information sharing for the improvement of efficiency in the nautical chain in the Port of Rotterdam.

1.5.2. Research questions

The main research question to be answered is the following:

What are the critical areas of information sharing for the improvement of efficiency in the nautical chain in the Port of Rotterdam?

Several sub-questions are established to answer the main research question:

1. What processes are executed in the planning and operational domain of the nautical chain of the Port of Rotterdam?

2. How does information sharing in the planning domain of the nautical chain of the Port of Rotterdam proceed?

3. How does information sharing in the operational domain of the nautical chain of the Port of Rotterdam proceed?

4. What delays occur frequently in the nautical chain of the Port of Rotterdam?

5. What information sharing links are related with the delays that frequently occur in the nautical chain of the Port of Rotterdam?

1.6. Research approach

Since previous research does not provide any data on the processes and information sharing in the nautical chain, the method used for answering the presented research question involves a qualitative research approach. The required qualitative data is gathered through expert knowledge (interviews and survey) and observations. Figure 1.4 presents an overview of the complete research approach.

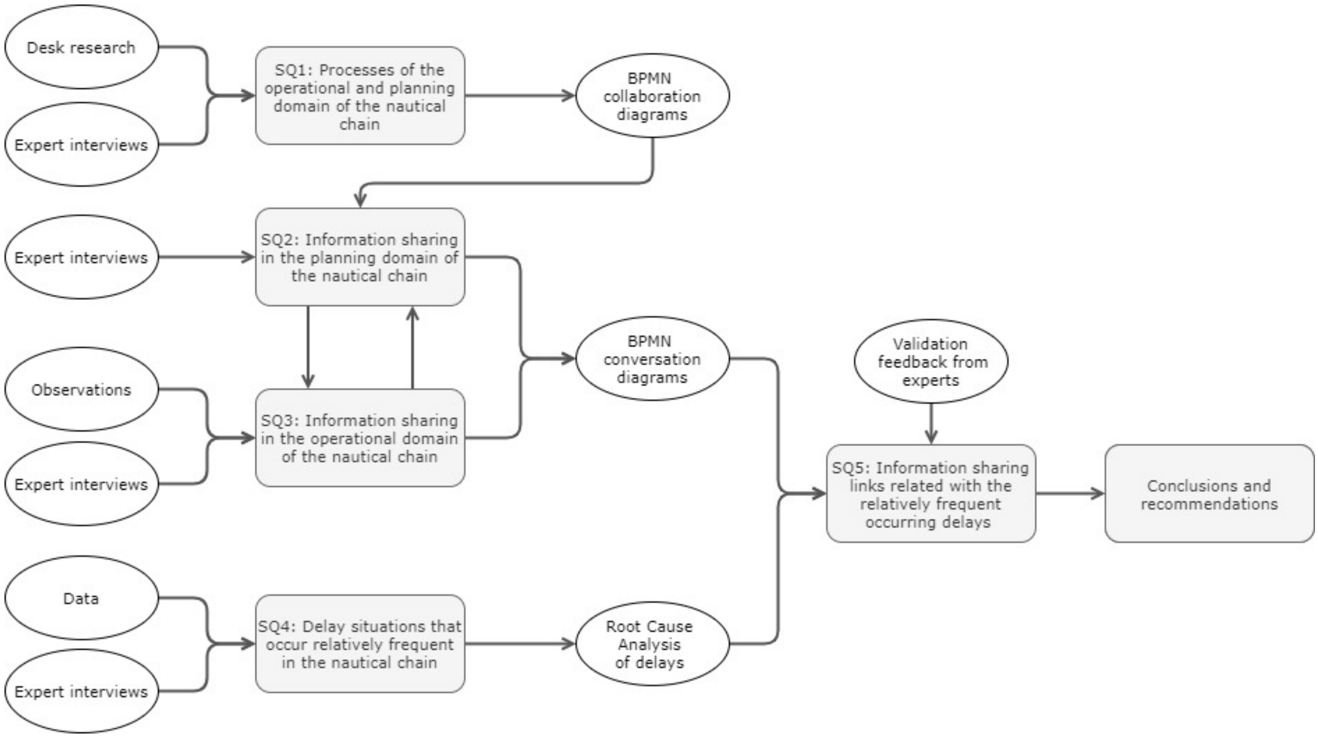


Figure 1.4: Research approach

As can be seen in the figure, next to expert input, desk research supported an initial investigation of the processes of the nautical chain. Furthermore, information sharing within the operations of the nautical chain is researched with both interviews and observations in practice, while information sharing within the planning phase is conducted through expert interviews only. However, during these interviews the planning activities are on-going, which means that insights experienced in practice are discussed in the interview as well. Next, the frequent delay situations that occur in the nautical chain are researched using numerical data of the delays that are recorded by the Harbour Master. This data is used as a starting point for qualitatively researching the underlying causes of these recorded delays with expert input.

The gathered data is processed using Business Process Modeling (BPM) and Root Cause Analysis (RCA). For the Business Process Modeling, the Business Process Model and Notation (BPMN) language is applied. The BPMN language is a standardized language for the description of business processes. Two types of BPMN diagrams are used: the BPMN collaboration diagram and the BPMN conversation diagram. The first is applicable for modeling interactions between multiple processes without central control, the latter provides an overview of which partners share what information on which tasks. With RCA, the different causes that might have led to the recorded cause of a delay are mapped. Lastly, before drawing conclusions, validation feedback on the results from the involved experts has been processed. More information on the applied research methods is provided in chapter 3.

1.7. Research scope

The research scope of this thesis is limited to the nautical chain of the Port of Rotterdam. Furthermore, only the port-calls for sea-going vessels are included. Both incoming and outgoing voyages of the sea-going port calls are considered. The strategic domain of information sharing is out of scope. The strategic domain covers the period before the planning of the processes of the nautical chain has started. The tactical domain and operational domain are included. The tactical domain covers the period of the planning of the nautical processes. The operational domain covers the period of the process execution. Furthermore, this thesis only includes voyages that make use of all nautical services, namely: boatmen, tugboat(s) and a pilot. Lastly, this thesis indicates the focus areas for efficiency improvement by focusing on information sharing. Except for suggestions that are discussed in the recommendations, this thesis does not include the development and evaluation of specific tools and process adaptations.

1.8. Thesis outline

A literature review of the available research on the nautical chain, information sharing and port efficiency is discussed in chapter 2. Next, details on the methods that are applied are discussed in chapter 3. Following, chapter 4 and chapter 5 provide the required background information of the nautical chain in the Port of Rotterdam. An overview of the actors that are involved is provided in chapter 4. An overview of the systems that are used for information sharing is provided in chapter 5. The sub-questions are answered in the analysis part. The first sub-question is answered in chapter 6. In this chapter, the processes of both an incoming and outgoing voyage are elaborated on and visualized. The second sub-question is answered in chapter 7. In this chapter, the planning activities and the shared information of each planning department are described. The third sub-question is answered in chapter 8. In this chapter, the different situations that occur in the operational domain of the nautical chain are discussed, followed by the information shared in these situations for each actor. The fourth sub-question is answered in chapter 9. In this chapter, the causes that frequently induce a delay in the nautical chain are identified. The results of the research, covered with the fifth sub-question, are presented in chapter 10. In this chapter, the results are presented by combining the information sharing analysis with the identified relative frequently occurring delay causes. The conclusions and recommendations that follow from these results are presented in chapter 11.

2
Literature review

In this chapter, a review of the available literature is discussed. A definition of the nautical chain and closely related terms is provided in section 2.1. Next, the relation between the nautical chain and port efficiency is elaborated on in section 2.2. The need for information sharing within the nautical chain is discussed in section 2.3, followed by the effects of information sharing on performance and efficiency in section 2.4. The difference and relation between data, information and knowledge are explained in section 2.5. The chapter ends with presenting a framework used for investigating information sharing in supply chains, which is translated to be applied to the nautical chain, in section 2.6.

2.1. The nautical chain

Previous research of Verduijn (2017) investigated the actors, the environment and the main processes of the nautical chain in the Port of Rotterdam. Verduijn (2017) defines the *nautical chain* as 'all the events of the nautical service providers in the operational domain performed for a vessel during the time that vessel is sailing in the Port of Rotterdam' and 'the information shared in the tactical domain to support events in the operational domain'.

Next to the term nautical chain, terms that are closely related are used in literature. Firstly, Talley (2013) and Lind et al. (2015) define the *maritime transport chain* as a network over which carriers, ports and shippers work together to arrange the movement of cargo. This means that the port as a whole is considered as an actor in the chain, instead of different actors within a port. Secondly, Ascencio et al. (2014) propose a collaborative logistic framework based on the principles of supply chain management for a *maritime port logistic chain*. This chain is defined as all global chains that operate through a seaport. The considered actors are the Harbour Master and nautical service providers, but also e.g. customs, transport companies, freight forwarders and empty container parks. Although this definition is broader than what is considered as *the nautical chain*, the developed framework might be also applicable to the nautical chain, since the research includes actors that operate within a port. Lastly, Talley et al. (2014) introduce an economic theory for evaluating the performance of a port providing port services by using the concept of a *port service chain*. The port service chain is defined as 'a service network utilized by a port's service providers in the provision of the port's services', which interfaces with the definition of the nautical chain of Verduijn (2017).

In this thesis, the definition of the nautical chain of Verduijn (2017) is used. Research on this specific definition of the nautical chain is rare. The term *port service chain* used by Talley et al. (2014) is considered most closely related.

2.2. Port efficiency and the nautical chain

Various researches address the measurement of port performances. One of the methods for measuring performance is to make use of port performance indicators (Talley, 2006) (Bichou, 2006). The used indicators depend on the perspective and objective of a port. According to Bichou (2006), a performance indicator can fall within one or a combination of three main categories, namely input measures, output measures and composite measures. Input measures can be e.g. time, costs or resources. Output measures can be e.g.

production, throughput or profit. Composite measures can be e.g. productivity, efficiency, profitability, utilization or effectiveness. This means that efficiency is considered as an indicator for performance. Bichou (2006) emphasizes that the lack of uniformity on the definition of port performance directed the focus of port performance measurements towards the efficiency dimension. In general, efficiency is defined as the ratio of the output quantity to the input quantity of a system.

In this thesis, the focus is on efficiency as an indicator for the port performance. Studying the efficiency in the port sector is mentioned to be difficult, because ports can not be considered as a homogeneous entity. Multiple activities are carried out by a large variety of actors with different objectives, a different degree of competition or different regulation to which they are subject. González and Trujillo (2009) provide evidence for a need to clearly define the port activity for which an efficiency assessment is being conducted. In this respect, Tongzon (1995) focuses on the efficiency of terminal operations and its relation with the overall port performance. The established model quantifies the contribution of terminal efficiency to the overall port performance (which is measured in terms of throughput). The stronger this relation in comparison to other factors, the more reason to focus on the improvement of terminal efficiency for improving the port performance. Similar research regarding the efficiency of the nautical chain and its relation with the overall performance of a port is lacking. To address this gap, this thesis focuses on the efficiency of the nautical chain.

Focusing research on the efficiency of the nautical chain is promising, because it is expected that the efficiency of the nautical chain significantly affects the port efficiency. First, Tongzon (2009) determines port efficiency as the key factor for port choice and defines port efficiency as the 'speed and reliability of port services', which are partly executed within the nautical chain. Additionally, Rezaei et al. (2019) propose a port performance measurement methodology from a port choice perspective and conclude that one of the dominant factors for port competitiveness is the time along the transport chain, which is influenced by the nautical services within a sea-port. Lastly, Tavasszy et al. (2011) show that the throughput of a port, which is linked to the level of port efficiency, is directly influenced by the generalized costs of port operations. Subsequently, Davydenko and Fransen (2019) state that 'the quality of the port nautical services directly influences the generalized costs of port operations'.

2.3. Information sharing in the nautical chain

Information sharing between the actors of the nautical chain is considered to be an important aspect of the process execution of the nautical services. van der Wiel (2019) discusses the importance of information sharing in the nautical chain by stating that the port-call process, of which the nautical chain is part, is dependent on information exchange between the Harbour Master, the nautical service providers, the terminal, the vessel captain and the vessel agent. Additionally, from available literature on the terms that are closely related to the *nautical chain*, it is concluded that information sharing in the nautical chain is required. First of all, Talley et al. (2014) conclude that a cooperative *port service chain* (which interfaces with the used definition for *nautical chain*, see section 2.1) will always result in a higher level of port effectiveness than would be possible if the port services are provided by a non-cooperative port service chain. Secondly, the need for cooperation in the nautical chain is confirmed by the outcomes of Talley and Ng (2016). In this research, port multi-service congestion is discussed. Port multi-service congestion occurs when port users of two different services provided at the same port node or over the same port link interfere with each other to the extent that they experience congestion at the shared node or link. From the research is concluded that if port multi-service congestion appears at a node or link, the port multi-service congestion can propagate to other nodes and links as long as there is a connecting path. This enhances the influence of the dependencies and thereby the need for cooperation between the actors in the nautical chain.

This thesis focuses on cooperation, which is interpreted as the sharing of useful information between the actors of the nautical chain. Multiple terms that involve information sharing are used in literature, such as collaboration, cooperation and coordination. Above all, these terms do not always have the same definition. Ming et al. (2014) distinguish between coordination, cooperation and collaboration. Coordination refers to the synchronization of activities that are dependent on each other. Cooperation refers to a relationship that is more than only coordination, implying information and knowledge sharing. Collaboration refers to a relationship in which a supply chain participant may choose the overall objective over its own objectives. Furthermore, Roschelle and Teasley (1995) define cooperative work as 'a task that is accomplished by dividing it among participants, where each person is responsible for a portion of the problem solving' and collaborative work as 'the mutual engagement of participants in a coordinated effort to solve the problem together'. In other words, cooperation implies that individual actors exchange relevant information and resources to support each other's goals. Contrary, collaboration implies that the involved actors have a shared vision and that something is created with mutual effort. Regarding the nautical chain, all actors have their own interests and objectives (Verduijn, 2017) (van der Wiel, 2019), which makes the definition of cooperation most applicable. Cooperation might be followed by collaboration.

Although cooperation (and thus information sharing) is considered to be significant for the nautical chain, literature does not provide any details on the shared information. Verduijn (2017) mentions information sharing between the actors of the nautical chain on a tactical level and operational level, but the research in this respect is limited. The used information sharing platforms are mentioned, but it is not clear what data is shared between the actors. Furthermore, Lind et al. (2015) states that the coordination of port-calls is highly fragmented and that, except for some predefined interaction patterns, it is unclear what information is communicated to whom at what time. Lastly, the framework proposed by Ascencio et al. (2014) includes a better coordination of physical and information flows for the *maritime port logistic chain* based on the principles of supply chain management. However, the research does not mention the current ways of information sharing in a nautical environment.

2.4. The effects of information sharing on performance and efficiency

The effects of information sharing on performance have been studied widely in the context of supply chains in general. A supply chain is defined as a chain of different individual actors that are dependent on each other and that are interconnected (Sahin and Robinson, 2002). Due to the similar characteristics, the relation between information and supply chain performance is assumed to apply to the nautical chain as well. Furthermore, the relation is assumed to hold for efficiency, since efficiency is considered as a component of the performance (see section 2.2).

According to Montoya-Torres and Ortiz-Vargas (2014) 'information sharing between the agents of a supply chain is considered to be an effective strategy for improving its global performance'. Additionally, Kumar (2012) state that 'information sharing can increase supply chain efficiency by reducing inventories and smoothing production'. In this respect, Handfield and Bechtel (2002) conclude that effective information sharing between supply chain members enhances visibility and reduces uncertainty. Furthermore, Zhou and Benton Jr (2007) study the integration of information sharing in supply chain management and the results show that effective information sharing significantly enhances the supply chain practice. Moreover, Huang and Gangopadhyay (2004) studied different degrees of information sharing by means of a simulation study. Three levels of information sharing were distinguished, namely: no information sharing, partial information sharing and full information sharing. First of all, the results of the study showed that an increased level of information sharing resulted in decreased inventory levels at the wholesalers. Secondly, from the research is concluded that the benefits of information sharing are higher when the demand is more variable. Comparable research is conducted by Sahin and Robinson Jr (2005), who investigated the impact of information sharing and physical flow coordination in a make-to-order supply chain. The experimental simulation-based results indicate a significant cost reduction when increasing the level of information sharing.

The actors involved in a supply chain are independent agents with individual preferences (Kumar, 2012). However, the performance of each actor is dependent on the performance of the other actors in the chain (Xu and Beamon, 2006) (Sahin and Robinson, 2002). All these actors have different ranges of information available. According to Simatupang and Sridharan (2001), this asymmetric information results in (1) misunderstandings concerning the mutual efforts of collaboration, (2) difficulty in dealing with market uncertainty, (3) sub optimal decisions and (4) opportunistic behaviour. Information sharing is a strategy for achieving coherence amongst the supply chain members and enables decision making that improves the performance of the supply chain.

From the literature discussed in this section is concluded that information sharing can have a positive impact on the performance and efficiency of a supply chain. Currently, research on the effects of collaboration and information sharing in the nautical chain is executed in the context of the 'Swarmport project'. The

Swarmport project started in 2017 with a duration of 4 years. The aim of the Swarmport project is to create process transparency amongst the actors of the nautical chain using a simulation model. The simulation model should be able to test different strategies and evaluate the effects on multiple performance indicators of the nautical chain. Contrary to other simulation models of the nautical processes, the Swarmport simulation model should include the collaboration between the actors of the nautical chain. This collaboration will be included by using an agent-based simulation approach. The proposal of the Swarmport project states that the performance of the nautical chain depends as much on the individual actors within the chain as on the collaboration between them. The potential effect of collaboration (and thus information sharing) on the nautical performances is expected to be significant (Swarmport proposal, 2017).

2.5. Types of information sharing

In literature, different terms that are related to information sharing, but have different meanings, are used. Data represent real-world phenomena such as events, attributes and names by means of numbers, letters or pictures. Data transfers into information when people interpret and attach a meaning to the data. Information transfers into knowledge when a person validated the information and uses the information for immediate problem solving and decisions (Simatupang and Sridharan, 2001). Figure 2.1 visualizes the transformation from data to knowledge. Each state (real-world, data, information or knowledge) can be transformed into the neighbouring states. Decisions are made based on information. Therefore, the focus of this thesis is on information sharing. Most information systems transfer data, which must be translated into information using rules of deduction. Data shared via information systems is included in this thesis under the heading of information sharing.

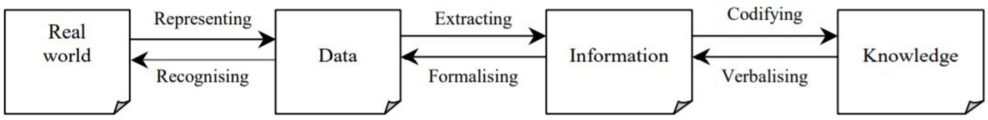


Figure 2.1: An interactive view of information [conducted from (Simatupang and Sridharan, 2001)]

Knowledge can be categorized into *tacit* knowledge and *explicit* knowledge based on the degree of verbalization (Polanyi, 2009) or into *specific* knowledge and *general* knowledge based on the costs of transfer (Jensen and Heckling, 1995). Knowledge that is not easily communicated is called *tacit* knowledge. This makes *tacit* knowledge difficult to recognize or acknowledge. Brockmann and Anthony (2002) define tacit knowledge as 'the work-related practical know-how that is acquired through direct experience and instrumental in achieving goals important to the holder'. On the other hand, *explicit* knowledge consists of information that can be clearly communicated. Regarding the costs of transfer, *specific* knowledge must be shared, while *general* knowledge is available for all users.

Within the nautical chain, tacit knowledge plays a major role, since a lot of information is gained through direct experiences and not centrally registered. Verbalizing tacit knowledge into information is more difficult in comparison to explicit knowledge. Still, if the tacit knowledge consists of validated theories and understanding, the tacit knowledge can be transformed into information (Simatupang and Sridharan, 2001).

2.6. Framework for investigating information sharing in the nautical chain

Huang et al. (2003) established a generic research framework for investigating the information sharing among enterprises in supply chains. The same framework is used by Lau (2007). With the established framework, different levels of information sharing can be developed and tested on their performance. According to Lau (2007), supply chains in which information sharing can be realistically investigated have the following characteristics: (1) supply chain members are independent and autonomous, (2) no single supply chain member has global knowledge of the entire supply chain and (3) supply chain members are willing to cooperate while optimizing their own objectives. Since these characteristics all apply to the nautical chain, the research framework for investigating information sharing in supply chains is used as a reference framework in this thesis. The research framework is shown in Figure 2.2 and consists of the elements discussed below.

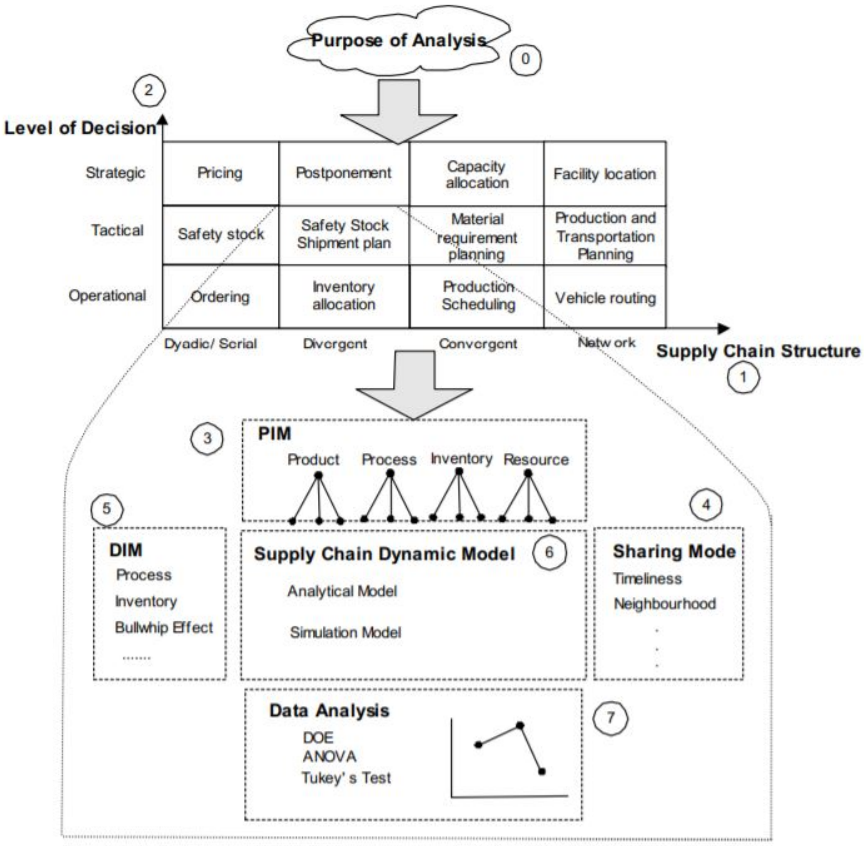


Figure 2.2: Research framework for investigating information sharing in supply chains [conducted from (Huang et al., 2003)]

1. *The Supply Chain Structure* represents how the supply chain members are connected. The different structures are: dyadic, serial, convergent, divergent and networks and can be seen in Figure 2.3. A network structure is a combination of multiple convergent and divergent structures.

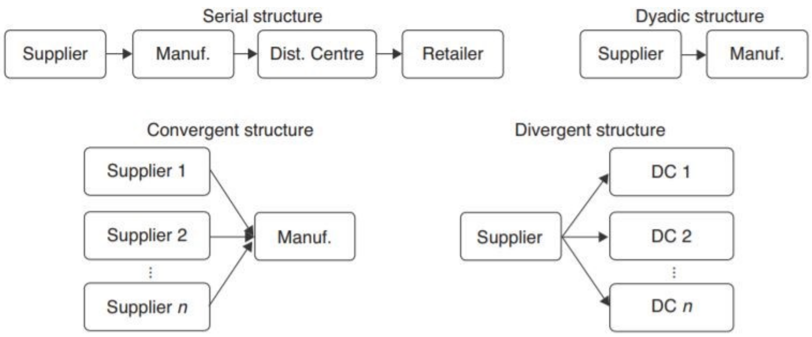


Figure 2.3: Possible structures of the supply chain [conducted from (Montoya-Torres and Ortiz-Vargas, 2014)]

2. *The Level of Decision* differs between the available decision time and scale of the problem. The strategic level concerns long-term decisions, the tactical level concerns medium-term decisions and the operational level concerns the short-term decisions in the day-to-day operations.

3. *The Production Information Model (PIM)* categorizes production information that affects supply chain performance and is shared between the supply chain members.

4. *The Sharing Modes* can be interpreted as the degree of cooperation in a supply chain. The sharing mode specifies the amount of information shared.

5. *The Dynamic performance Index Model (DIM)* reflects the dynamic performance of a supply chain. The DIM consists of a collection of performance indicators that measure the supply chain dynamics.

6. *The Supply Chain Dynamic model (SCD)* measures the interaction between the PIM and the DIM. It describes the effect of the information shared on the performance of the supply chain.

7. *The Data Analysis* identifies the factors in PIM that have a significant effect on specific performance indicators.

To make the framework for investigating information sharing in supply chains applicable to the nautical chain specifically, the focus on production must be replaced by a focus on service provision. This results in the framework presented in Figure 2.4. For an incoming voyage, the nautical services must be provided sequentially (pilot-tugs-boatmen), which can be best represented by a serial structure. For an outgoing voyage, all nautical service providers must be present at the vessel before departing, which can be best represented with a convergent structure. In particular, this research includes the tactical and operational decision level of the nautical chain.

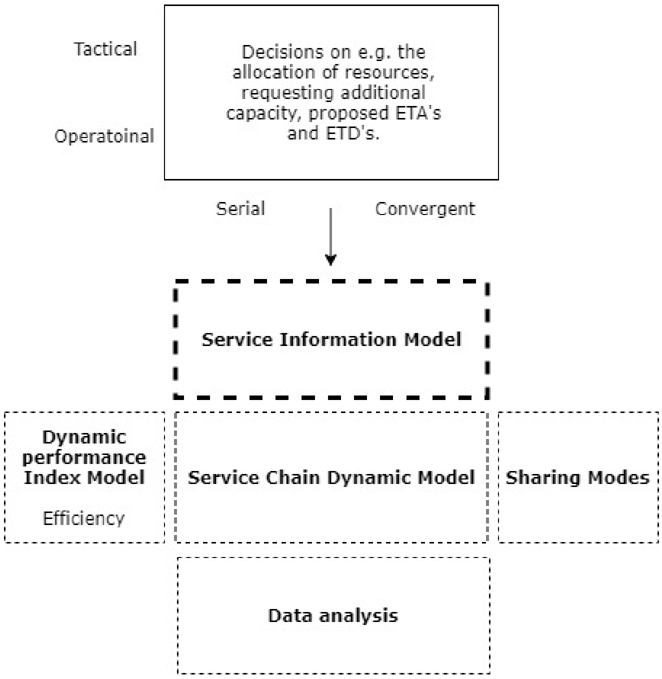


Figure 2.4: Research framework for investigating information sharing in a service chain

The Service Information Model (SIM) forms the core of this research. The SIM involves the information that is shared between the actors of the nautical chain and that is expected to have an impact on the considered performance indicators of the DIM. As discussed in section 2.2, these performance indicators are focused on the efficiency of the nautical services. The Service Chain Dynamic model, Sharing Modes and Data Analysis are not addressed in this research.

3 Methodology

This thesis involves a case-study of the nautical chain of the Port of Rotterdam. According to Yin (1981), the need for case study research arises when a contemporary phenomenon in its real context must be investigated. The variety of data sources of a case-study mentioned are: interviews, agency records, project documents, illustrative materials and on-site observations. The data sources that are used in this research are elaborated on in section 3.1. The methods used to process the gathered data are discussed in section 3.2. The methods used to validate the results are discussed in section 3.3

3.1. Data collection

The data that is required to answer the research question is conducted by applying a qualitative research approach. Qualitative research is a type of scientific research that focuses on non-numerical data (Adi Bhat, 2019). In this respect, qualitative research rather describes variations, relationships and individual experiences than quantifies the variation or predicts the causal relationships. Overall, qualitative research offers more flexibility in comparison to quantitative research methods (Mack, 2005).

3.1.1. Expert knowledge

The processes of the different actors in the nautical chain are not clearly registered. Therefore, expert knowledge is required to gain insights into the activities and information sharing in the nautical chain. The advantages of expert knowledge are that the experts have a high insight on an aggregated or specific subject and that it provides fast access to new knowledge (Van Audenhove, 2007). A person is considered an expert if the researcher assumes that the person possesses information that is not generally accessible (Meuser and Nagel, 2009).

- **Expert interviews:** Bogner and Menz (2009) distinguish between exploratory, systematizing and theory-generating expert interviews. Exploratory expert interviews are used as an initial orientation in new study fields. Systematizing expert interviews focus on knowledge of actions and experience. The theory-generating interviews focus on subjective aspects, such as motives and beliefs. In this thesis, the systematizing expert interview is best applicable. With this type of expert interview, knowledge derived from practical everyday experience can be obtained from the interview. Systematizing interviews use a detailed topic list, but with open-ended questions that allow the interviewee to answer extensively.

- **Expert survey:** Systematizing interviews are not necessarily open, but standardized surveys are applicable as well (Bogner and Menz, 2009). In order to identify the delay causes that are frequently occurring in the nautical chain in practice, a standardized survey in the form of a questionnaire is distributed among field experts. The advantage of a standardized survey over an interview is the fact the answers of all participants are comparable to each other.

3.1.2. Observational research

Observational research has been applied in health and marketing related research (Morgan et al., 2017) (Boyko, 2013) (Lee and Broderick, 2007) (Sinha and Uniyal, 2005) (Mann, 2003). In health care related studies, observations are used to examine communication between health professionals (Sinclair et al., 2009) (Lingard et al., 2004). In this research, observations are conducted to research the information sharing between actors in the nautical chain. The strengths of observational research mentioned by Morgan et al. (2017) are that:

- Observations allow direct examination of behaviour in real time.
- Observations provide information about topics participants may be unaware of.
- Observations allow examination of contextual factors.

The use of observational methods can be divided into structured and un-structured observations (Yin, 2003). In this thesis, un-structured observations are used, because the researcher has no expectations of the outcomes of the observation. Un-structured observations do not use a predefined schema. The researcher only records the events and behaviour that are noticed in practice.

3.1.3. Combining observations with expert knowledge

To research the information sharing in the operational domain of the nautical chain, observations are combined with expert interviews. For merging the observation data with the interview data, the CSOR (Case Study Observational Research) framework developed by Morgan et al. (2017) to study inter professional collaboration in primary care is applied. Within the CSOR framework, priority is given to the collection and analysis of observation data in order to support the collection of the non-observation data. Different from the research conducted by Morgan et al. (2017), the number of conducted cases in this thesis is limited to one observation moment for each actor. This means that the observations are not only confirmed, but mainly supplemented, by data collected from interviews. Furthermore, the data from observations is not completely analyzed before gathering the non-observations data, but the data gained during the observations is taken into account and elaborated on during the interviews. The modified version of the CSOR framework that is applied in this thesis is presented in Figure 3.1.

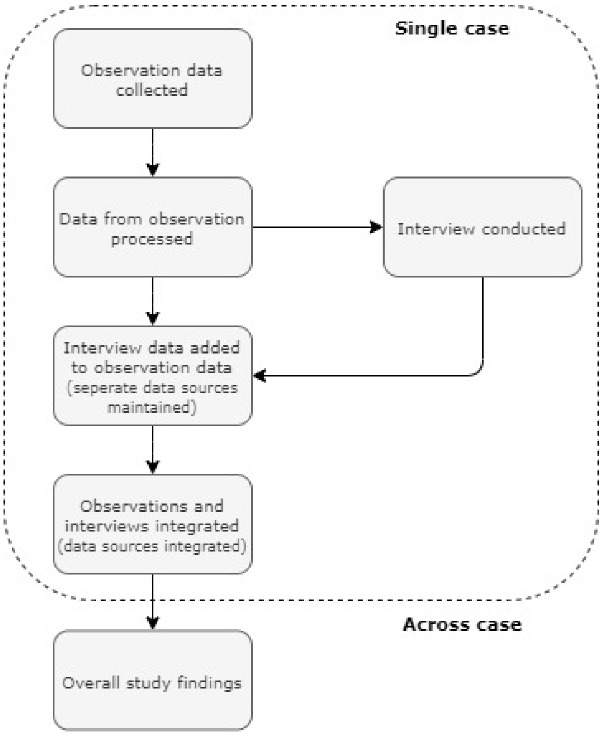


Figure 3.1: Adapted CSOR framework [adapted from (Morgan et al., 2017)]

3.2. Data processing

The gathered data is processed by means of Business Process Modeling (BPM) and Root Cause Analysis (RCA). Both methods are elaborated on in the following sections.

3.2.1. Business Process Modeling (BPM)

A business process is the combination of a set of activities and a structure describing their logical order and dependence (Aguilar-Saven, 2004). Business Process Modeling enables the analysis of a business process by representing the processes of an enterprise. Once processes are understood, they can be improved. This means that understandable models ere essential to represent the analyzed processes (Turetken and Schuff, 2007). Due to a continuing demand for business process analysis, an overload of methodologies, techniques and tools is available (Kettinger et al., 1997). Aguilar-Saven (2004) describe the main BPM techniques and provide a framework for selecting an applicable BPM technique. According to this framework (see Figure 3.2), the Flow Chart technique is applicable to the processes and information sharing in the nautical chain. The strengths of a Flow Chart are its communication ability and flexibility. The weaknesses of a Flow Chart are that different notations are available.

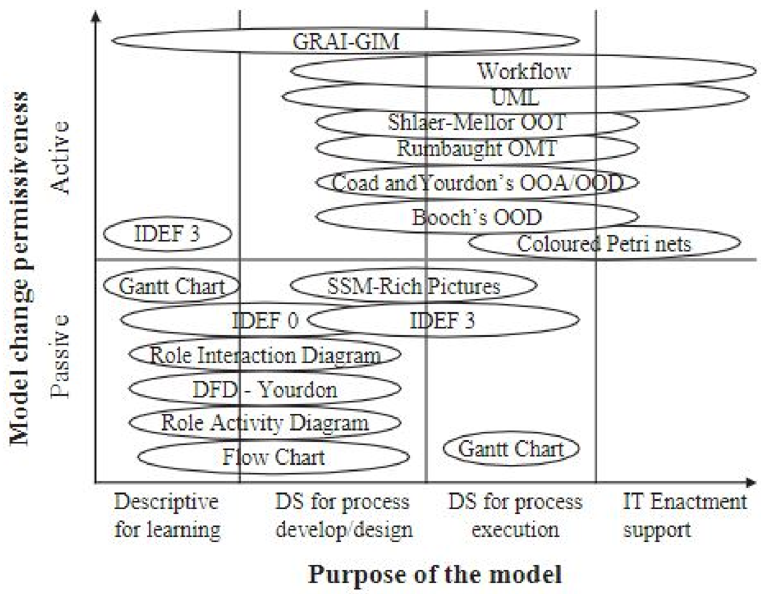


Figure 3.2: Classification framework to select among business process modeling techniques [conducted from (Aguilar-Saven, 2004)]

Two types of Flow Chart notations that are widely used are the Unified Modeling Language (UML) and Business Process Model and Notation (BPMN) (List and Korherr, 2006). Both UML and BPMN are standardized modeling languages that involve a graphical notation. UML follows an object-oriented approach, while BPMN follows a more process-oriented approach. In this perspective, UML is mostly used in software engineering, while BPMN focuses on the modeling of the business processes (Sagar Khillar, 2019). This makes the BPMN language most applicable for this thesis.

The BPMN modeling language enables the modeling of business processes of multiple actors in combination with data sharing. BPMN provides a notation for graphical illustrations of business processes with the primary goal of providing a graph that is easily understandable by all users. BPMN provides three diagram types: the collaboration diagram, the choreography diagram and the conversation diagram. With a collaboration diagram, the process flow can be modelled. With a choreography diagram, data exchange is modelled as an activity. With conversation diagrams, an overview of several partners and their communication can be provided (Allweyer, 2016). In this thesis, the collaboration and conversation diagrams are applied.

A BPMN collaboration diagram consists of flow objects, artifacts, connecting objects and swim lanes. The flow objects include events and activities. The artifacts include data objects and annotations. The connecting objects can be sequence flows, message flows or data associations. Swim lanes are used to structure the different actors that operate in a system (Owen and Raj, 2003). An example of a BPMN collaboration diagram is presented in Figure 3.3. A complete overview of the BPMN modeling language is provided in Appendix F.

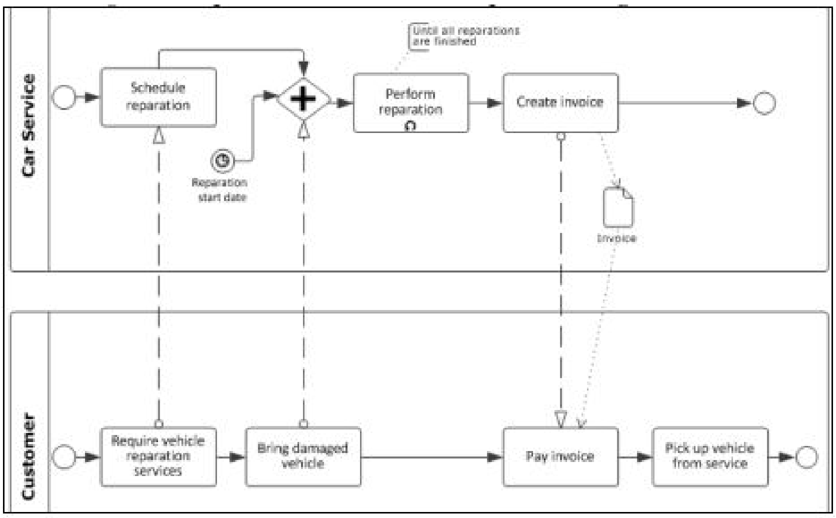


Figure 3.3: BPMN collaboration diagram

A BPMN conversation diagram consists of partners, conversations and conversation links. A single conversation includes a message flow between the connected partners. The contents of the exchanged messages within one conversation should be related with each other. The details of the conversation can be modelled with a choreography or collaboration diagram (Allweyer, 2016). An example of a BPMN conversation diagram is presented in Figure 3.4. A complete overview of the BPMN modeling language is provided in Appendix F.

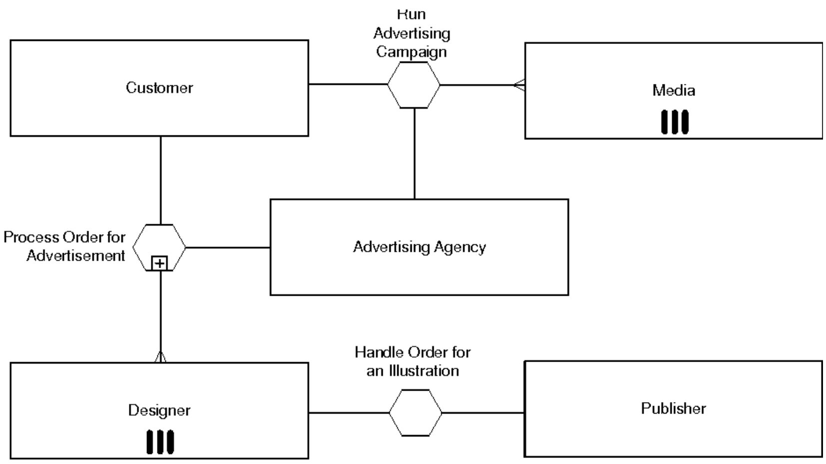


Figure 3.4: BPMN conversation diagram

3.2.2. Root Cause Analysis (RCA)

Root Cause Analysis (RCA) is applied to investigate the root causes of events with safety, health, environmental, quality, reliability and production impacts. In short, a RCA identifies not only what event occurred but also why it occurred (Rooney and Heuvel, 2004). As mentioned by Andersen and Fagerhaug (2006), a problem (in this case a delay) is the result of multiple causes at different levels. A cause affects other causes that create the visible problem. Causes can be categorized into first-level causes, which directly lead to a problem, or higher-level causes, which lead to the first-level causes. The highest-level cause of a problem is identified as the 'root cause' (Andersen and Fagerhaug, 2006). This approach is mainly used to prevent any problems by focusing on effective measures that solve the identified root causes. However, in this thesis, the RCA is used to provide insight into the events that occur before a recorded delay occurs.

3.3. Validation

The subjective element of qualitative research leads to the concern of biased results. There are two types of biases faced by qualitative researchers, namely: participant bias and researcher bias (Dr. Shivanee Shah, 2019). For the possible biases from the perspective of the researcher, triangulation serves as a validity procedure (Creswell and Miller, 2000). Triangulation involves the combination of multiple information sources to study the same phenomenon (Jick, 1979). Different types of triangulation are distinguished by Denzin (1978), namely: across data sources (participants), methods (interviews, observations, documents), theories and among different researches. The triangulation types that are applied in this thesis are triangulation across data sources and methods. The insights from multiple experts on the same research subject are taken into account and observational data is combined with expert knowledge. For possible biases from the perspective of the participating experts, member checking is applied as a validation procedure. With member checking, the data and interpretations are taken back to the experts so that they can confirm the validity of the results (Creswell and Miller, 2000). Due to the limited time that is available for this research, member checking is only applied to the final results of the research.

I

Background

4

The actors of the nautical chain

This chapter provides an overview of the actors that are considered as the actors of the nautical chain in section 4.1. For each actor, a detailed description of their tasks and structure is given. Secondly, the relationships between the actors of the nautical chain are discussed in section 4.2. The information in this chapter is obtained from the previous research of Verduijn (2017) and personal communication with field experts. An overview of the experts and their expertise is shown in Table 4.1.

Organization	Name	Function
Loodswezen Rotterdam-Rijnmond (Pilot Organization)	Elco Oskam	Manager Operations
KRVE Rotterdam Boatmen	Erik de Neef Stefan de Graaf	Chairman Operational Manager
Boluda Towage	Arjen de Vries Timo van der Schee	Operations Manager
HCC	Ruud Hoogsteder	Operational Manager
HCC	Roel Wildeman	Duty Officer HCC
Harbour Master Department	Raymond Seignette	Policy maker
VRC (Association of Rotterdam Agents)	Marco Tak	Director
ECT Terminal	Jeffrey Scheurwater Sander de Jong	Operational Manager Consultant operations

Table 4.1: Involved experts regarding the actors of the nautical chain

4.1. Actors of the nautical chain

Different companies and organizations are involved with the processes of the nautical chain. These involved companies and organizations are referred as the actors of the nautical chain. Actors have their own tasks, interests and resources. An overview of all actors that are related with the nautical chain is presented in Table 4.2. For each actor, a short description of their tasks and responsibilities is given.

Actor	**Description**
Harbour Master	Responsible authority for smooth and safe shipping
Port of Rotterdam NV	Owner of the port area and infrastructure
Vessel agent	Responsible for administrative tasks in behalf of the vessel
Vessel captain	Person in command of the vessel and end responsible for all vessel operations
Shipping company	Company that owns the vessel and arranges the contracts with terminals and maritime and vessel service providers
Pilot organization	Responsible organization for piloting vessels into and out of the port area
Tugboat company	Companies that deliver tugboat services to assist manoeuvring and mooring
Boatmen organization	Responsible organization for the (dis)attachment of the mooring lines of a vessel
Terminal operator	Company that receives vessels and (un)loads the cargo
Bunker and other vessel service providers	Companies that provide bunker oil, waste collection, food supply or other vessel services

Table 4.2: Overview of the actors of the nautical chain

To conclude which actors are important to consider regarding the processes of the nautical chain, a distinction between critical and non-critical actors is made. A critical actor is an actor that can not be replaced and on which the performance of the nautical chain highly depends. An actor is considered irreplaceable when the delivered services and tasks are unlikely to be performed by an other party. In this research, this means that the organization as a whole can not be replaced, but that individual companies can replace each other. The level of dependency of an actor is based on the influence of an actor on the processes of the nautical chain. When the delivered services or tasks are crucial for executing the processes of the nautical chain, the dependency is high and vice versa. In Table 4.3, an overview of all actors and whether the actor is critical or non-critical for the nautical chain is shown. The information in the table is based on the research of Verduijn (2017) and supplemented by expert knowledge.

Individual companies (e.g. terminal operators, tugboat companies) can replace each other. However, the tasks of the industry as a whole are not replaceable by another actor, which makes the actor 'irreplaceable'. This applies to all actors except for the vessel captain and the bunker and vessel service providers. Although it is not desirable, bunker activities can be executed in the previous or next port of call. The vessel captain is indispensable for the vessel voyage, but considering the nautical chain, his activities (the control and command of the vessel) can be performed by the pilot.

The actors on which the nautical chain highly depends are the Harbour Master, the vessel agent, the vessel captain, the pilot organization, the tugboat company, the boatmen organization and the terminal operator. First of all, The Harbour Master is in charge of the rules and regulations. The Harbour Master decides whether the circumstances are safe and vessels are allowed to enter or exit the port area. Secondly, the vessel agent has a high influence, because the planning of the nautical activities depends on the accuracy of the information that the vessel agent provides to the Harbour Master. Furthermore, the nautical service providers (pilot organization, tugboat company and boatmen organization) are crucial to safely receive sea-going vessels in

Actor	Replaceable	Dependecy	Critical actor
Harbour Master	No	High	Yes
Port of Rotterdam NV	No	Low	No
Vessel agent	No	High	Yes
Vessel captain	Yes	High	No
Shipping company	No	Low	No
Pilot organization	No	High	Yes
Tugboat company	No	High	Yes
Boatmen organization	No	High	Yes
Terminal operator	No	High	Yes
Bunker and other vessel service providers	Yes	Low	No

Table 4.3: The critical actors of the nautical chain [based on Verduijn (2017)]

the Port of Rotterdam as they are the core actors of the nautical services. The nautical chain is also highly dependent on the operations of the terminal. Although loading and unloading itself is not part of the nautical processes, the terminal operations have a major influence on the processes of the nautical chain. If terminal operations take longer than expected, the berth remains occupied and is not available for the next arriving vessel. Lastly, although the activities of the vessel captain can be taken over by the pilot, the vessel captain remains responsible for the vessel and must be present to execute the nautical services.

Assuming that the infrastructure and the water depth in the Port of Rotterdam are maintained, the Port of Rotterdam NV does not have a significance influence on the processes of the nautical chain. The same holds for the shipping company and the vessel service providers. The shipping company is crucial to enable the arriving and departing vessel voyages, but as soon as all the required contracts are arranged, the shipping company does not interfere with the nautical processes. The vessel service providers can have an influence on the nautical chain when a departing vessel is delayed, because the provided services are taking longer than planned. However, a fully bunkered vessel is not a requirement for safe arrivals and departures. For that reason, the vessel service providers are of high importance for the vessel itself, but not for the nautical chain.

The actors that are irreplaceable and on which the nautical chain is highly dependent are considered as the actors of the nautical chain. From Table 4.3 can be concluded that the following actors are included:

- Harbour Master
- Vessel agent
- Pilot organization
- Tugboat company
- Boatmen organization
- Terminal operator

4.1.1. Harbour Master

The Harbour Master of the Port of Rotterdam is responsible for the safe and smooth handling of all vessel traffic in his control area. Vessels that want to enter or exit the port are legally obliged to provide the Harbour Master details on the vessel, the cargo and the voyage. Based on the provided information, the Harbour Master decides if the conditions are safe to execute the proposed voyage. Without clearance from the Harbour Master, a vessel is not allowed to enter or exit the port area. During the incoming or outgoing voyage, the Harbour Master monitors all vessel traffic in the port area and provides guidance to vessels when needed. Furthermore, revenues from port dues are collected by the Harbour Master.

The Harbour Master supervises the Harbour Master Division, which is part of the Port of Rotterdam NV. However, the Harbour Master performs a number of public tasks for which accountability to the municipality of Rotterdam and the Ministry of Infrastructure and Water Management is required. These public tasks are transferred to the Harbour Master by the central government and the municipality of Rotterdam, Schiedam, Vlaardingen, Dordrecht, Zwijndrecht and Papendrecht via a public mandate. The required resources and people to execute the Harbour Master tasks are provided by the Port of Rotterdam NV.

The Harbour Master Division consists of multiple teams. The 'Harbour Master Policy' and 'Process Management and Support' teams are responsible for the strategy of the Harbour Master Division. Moreover, a large number of Harbour Master Division employees works in the operations. The operational teams are the Inspection, the Patrol Vessels, the Harbour Coordination Center and the Vessel Traffic Services. The Patrol Vessels are responsible for enforcement and guidance on the water. Inspection is responsible for checking whether vessels comply with the shipping regulations. With regard to the processes of the nautical chain, the Harbour Coordination Center (HCC) and the Vessel Traffic Services (VTS) are the most important. The HCC arranges the planning and admission of all vessel voyages. The VTS is responsible for the operational processing of all vessel traffic in the port area. The HCC and VTS are discussed in more detail in the following subsections.

Harbour Coordination Center (HCC)

The HCC controls the tactical planning of accessing and exiting vessels of the port area. Each service shift, a Duty Officer HCC (DO HCC) and multiple Assistant Duty Officers (ADO) are present. The DO HCC is end responsible for the decision on the vessel clearance. Multiple ADO's process and assess the information that is provided by the vessel agents. Furthermore, a delegate of the Pilot Organization is based at the HCC as an external party. The Pilot Service Leader (in Dutch: Loodsdienstleider) monitors the incoming and outgoing voyages including the number of required tugboats and the available pilot capacity. In case the Pilot Service Leader foresees any problems, this can be discussed with the DO HCC. Multiple Pilot Planners (in Dutch: loodsdienstcoördiantoren) are located next to the HCC. In this way, the link with the Pilot Service Leader and the HCC is short.

Vessel Traffic Services (VTS)

The VTS assist the safe handling of sailing vessels on the operational level. The prior role of the VTS is to provide information on the current traffic situation to vessels and to prevent any possible collision or other dangers. The VTS are located at the Vessel Traffic Center in Hoek van Holland and in the Rotterdam Botlek. Multiple VTS operators deploy these Vessel Traffic Centers. The VTS operators monitor all traffic that is crossing, entering and leaving the Port of Rotterdam. The VTS operators are assisted by a Duty Officer VTS (DO VTS). The DO VTS is responsible for the micro planning of the traffic in the port of Rotterdam. The DO VTS checks whether the operational planning still matches the tactical planning that is provided by the HCC. Recently, the DO VTS is no longer located at the Vessel Traffic Center in Hoek van Holland, but at the HCC next to the DO HCC.

The Port of Rotterdam is divided into multiple VTS sectors. Each sector is handled by a single VTS operator. The western sectors are covered from the Vessel Traffic Center in Hoek van Holland, the eastern sectors from the Vessel Traffic Center in the Rotterdam Botlek. Each sector has its own VHF radio channel. As soon as a vessel enters a sector, the pilot or captain must switch to the VHF channel of the entered sector. The first operational contact between the vessel and the VTS is made as soon as the vessel is in the radio connection range of the VTS. The vessel makes VHF radio contact with the responsible VTS operator of the first VTS sector. From that moment, the vessel will be guided through the different VTS sectors of the Port of Rotterdam. All communication in a specific sector runs on the same VHF channel. In this way, the VTS operator answers messages that are addressed to the VTS operator, but he also follows the other communication in the sector. VTS operators generally do not give any rudder and speed orders, but fulfill an informative role. In the event that VTS operators need to intervene to prevent an incident, the VTS operator is responsible for the actions of the vessel.

4.1.2. Pilot organization

A pilot boards the vessel and assists the vessel captain with entering or exiting the port area. Pilot guidance is mandatory by law for most vessels. Pilot guidance is required, because knowledge on the visited port area is essential to safely enter and leave the port. It depends on the size of a vessel, the destination, the transported cargo and the experience of the vessel captain if a vessel is obliged to pilotage. In general, vessels larger than 75 meter are obliged to be assisted by a pilot. Pilots have different qualifications with regard to the vessel types, sizes and areas they are allowed to pilot. Although the vessel captain always remains responsible for the vessel, in practice, the pilot takes over the communication and control of the vessel. For an incoming voyage, the pilot boards the vessel outside the port area and leaves at the terminal. For an outgoing voyage, vice versa. Three pilot stations for boarding and disembarking the vessels outside the port area are in use. It depends on the size and the transported cargo from which pilot station the pilot enters or leaves the vessel. Transportation to off-shore vessels is executed with pilot tenders. Tenders are fast boats that are owned and operated by the Pilot Organization. In some cases, the helicopter is used for the transportation to off-shore vessels. Transportation of the pilots within the port area is arranged by the Boatmen Organization (see section subsection 4.1.4).

The Pilotage Act ((Raad van State, 2016)) includes that competition in the pilot market is not allowed in order to guard the safety of the profession. Therefore, a single Pilot Organization is responsible for the pilotage of all vessels in the Netherlands. The responsible organization is called Het Loodswezen. From 1988, Het Loodswezen operates independently from the government. Since the pilotage of vessels is mandatory by law, this independent organization serves a public task. Similar to the Harbour Master, the public task of the pilotage of vessels has been assigned to Het Loodswezen via a public mandate. All pilots are autonomous contractors that are registered at the Dutch Maritime Pilots Association and shareholder of het Loodswezen. The fact that pilots are registered and autonomous contractors means that there is no regular management-employee relationship and that each pilot is authorized to make its own decisions on the water. Het Loodswezen supports the registered pilots in their tasks. The Port of Rotterdam is covered by the Rotterdam-Rijnmond region of het Loodswezen. The Rotterdam-Rijnmond region of Het Loodswezen consists of 210 registered pilots. Their working schedule is based on one week on service, followed by one week off service. Depending on the demand, the pilot that has the requested qualifications and the longest resting period is deployed to the ordered voyage.

4.1.3. Tugboat companies

Tugboats are small and strong boats that assist sea-going vessels with manoeuvring in the port. When a vessel is not able to make the required turn, one or multiple tugboats push or pull a vessel in the right position. The use of tugboats, contrary to the use of the pilot service, is not mandatory. Only under specific circumstances as extreme weather conditions, the Harbour Master may oblige a vessel to use tug assistance. Although vessels are not obliged to use a tugboat, practice shows that many vessels are not able to make the required manoeuvres without tug assistance. The tugs connect to the vessel and help the vessel with manoeuvring to the harbour and the berth by reducing the vessel's turning circle and increasing the available power. The tugboat operators follow the orders from the pilot or the vessel captain.

Tugboats are owned and operated by a tugboat company. The tugboat market is open for competition. Currently, multiple tugboat companies are operating in the Port of Rotterdam. Shipping companies that call the Port of Rotterdam have a contract with one of the companies. In this thesis, the tugboat companies are included as a single actor, since their interests and objectives are similar.

4.1.4. Boatmen organization

Boatmen are responsible for the mooring and unmooring of vessels at the terminal. Boatmen sail to an arriving or departing vessel in a small mooring boat. In case of an arriving vessel, they collect the mooring lines and bring the lines to the quay, buoys or jetty. Fastening the mooring lines is partly executed by hand and partly with an assisting winch truck. In case of an departing vessel, the boatmen unfasten the mooring lines.

The boatmen organization in the Port of Rotterdam is called the Koninklijke Roeiers Vereniging Eendracht (KRVE). The KRVE is an independent organization that was established in 1895 and owes its name to the rowing boats that were used to collect the mooring lines ('roeien' is Dutch for rowing). The organization is structured as an association, which means that all 260 boatmen are together responsible for the organization.

The KRVE does currently not have any competitors. In case of a shortage of scheduled boatmen, a stand-by team is called from home. This makes the KRVE flexible and capable of delivering the required boatmen when requested.

Vessels larger than 75 meters are obliged to use the services of the boatmen in the Port of Rotterdam. Some exceptions are made, for example for ro-ro vessels that frequently visit a dedicated berth. Vessels that are smaller than 75 meters, but that carry dangerous cargo, are obliged to use boatmen services by the Harbour Master as well. Next to (un)mooring activities, the KRVE plays an important role in the transportation of pilots trough the Port of Rotterdam. All transportation of pilots over water and road within the port area is arranged by the KRVE. The KRVE uses vessels and nine car taxi's to provide the required transport. This collaboration between the KRVE and Het Loodswezen exists for almost fifty years and is the result of practical reasons. Both nautical service providers are present at the same time and location. Besides, the boatmen have the most accurate information on when a vessel is moored and thereby at what time the pilot wants to be picked up.

4.1.5. Terminal operator

A terminal is a place where cargo is loaded and unloaded of a vessel. The terminal acts as an important transportation node where the cargo can be transshipped to train, truck, barge or another seagoing vessel. Most terminals are dedicated to a specific type of cargo. Different infrastructure, available area and equipment is required for different cargo types. Terminals that operate in the same market segment compete with each other. Both inside the Port of Rotterdam and within a certain range outside the Port of Rotterdam.

A terminal is operated by a terminal operator. The terminal operator is a company that owns and manages all terminal processes. The terminal operator leases the terminal area from the Port of Rotterdam NV. This makes the terminal operator a customer of the Port of Rotterdam NV. The customers of the terminal operator are shipping companies. In order to ensure that the terminal is able to receive the contracted types of vessels, agreements between the terminal operator and the Port of Rotterdam NV are made. For example, the type of quay walls that is required must be installed and the depth of the harbour must be sufficient. It is the responsibility of the Port of Rotterdam NV to maintain the required infrastructure. The terminal operator is responsible for the required equipment and resources for loading and unloading the specific cargo types.

A terminal operator works with a working schedule of multiple team shifts per day. For most terminals, this schedule covers 24/7 operation. The team shifts execute the terminal operations, such as crane controlling and carrier driving. Before the operations are executed, the planning department aims to fit the demand with the available resource capacity at the terminal. The shipping company reports the date and time, the vessel details and the amount of to be loaded or unloaded cargo to the quay planning. Based on this information, the quay planners make the long term terminal planning. Based on the quay planning, the stowage planners make the more detailed stowage planning. The stowage planning indicates the specific location and order of the to be loaded cargo. Eight hours before arrival of a vessel, the coordination is taken over by the resource planner. The resource planner tracks any updates from the arriving vessel or from the ongoing terminal operations of a departing vessel.

4.1.6. Vessel agent

A vessel agent is hired by a shipping company to represent the vessel. While the vessel captain is in charge of the sailing part of a vessel, the vessel agent administratively arranges the connection with the main land. A vessel agent is responsible for notifying the Harbour Master and other authorities before a vessel arrives or leaves the port. This notification is obliged by law. If any changes to the reported times occur, the vessel agent must update the Harbour Master. The vessel agent is partly dependent on information from the vessel captain for these updates.

The vessel agent can be considered as the extension of the vessel captain. The vessel captain communicates with the Harbour Master via the VTS operators, while the vessel agent communicates with the Harbour Master via the HCC. The vessel agent does not only communicate with the Harbour Master in behalf of the shipping company, but also with e.g. terminals and vessel service providers. As a result, the vessel agent has a large amount of information at his disposal. Commercial sensitive information, for example on terminal details, that is not essential for the Harbour Master is not shared with the HCC.

4.2. Relations between actors of the nautical chain

The processes of the nautical chain must be performed in a specific order and are executed by different actors. This means that the actors of the nautical chain are dependent on each other. Figure 4.1 shows a visualization of the relations between actors of the nautical chain on an organizational level. A single pointed arrow represents a hierarchical relation, a double pointed arrow represents a bilateral relation and a dotted arrow represents possible influence of one actor on another actor.

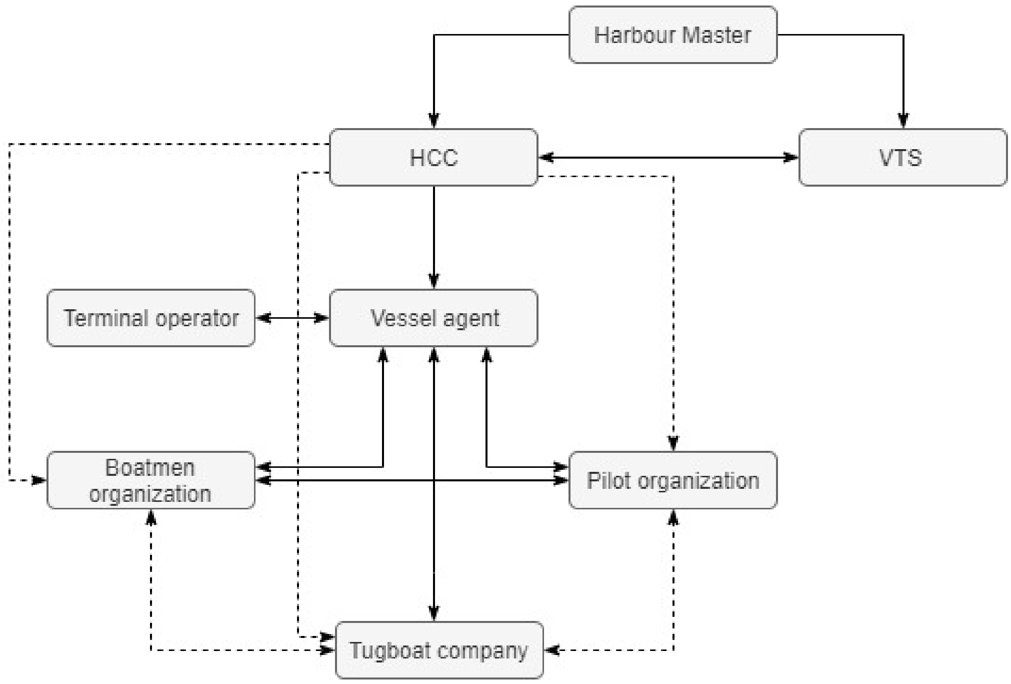


Figure 4.1: Relations between the actors of the nautical chain

The Harbour Master is responsible for the provision of services from the Harbour Coordination Center (HCC) and the Vessel Traffic Services (VTS), which is indicated by a hierarchical relation. In its turn, the HCC has an hierarchical relation with the vessel agent. The vessel agent is obliged to follow instructions given by the HCC to receive clearance for the requested voyage. The instructions are based on the information provided by the vessel agent on the vessel voyage, vessel details and cargo. Furthermore, the HCC can influence the planning of the nautical service providers. The HCC can request, but can not demand actions from the nautical service providers, because all nautical service providers are independent organizations. The HCC and the VTS have a bilateral relation, because together they are responsible for the safe and smooth handling of vessel traffic in the Port of Rotterdam.

The vessel agent has a bilateral relation with the boatmen organization, the pilot organization, the tugboat company and the terminal operator. This relation is based on contracts. The contracts are made between the parties mentioned and the shipping company, but the vessel agent executes the contracts on behalf of the shipping company. The contracts involve e.g. the service tariffs, the latest time to order a service, the consequences of cancelling an order and the consequence of a delayed service.

The nautical service providers all influence each other. The services of the boatmen organization, the tugboat company and the pilot organization are dependent on each other, which means that the available capacity of the nautical service providers influences the planning of the others. Additionally, the boatmen organization and the pilot organization have a bilateral relation, because the boatmen organization is contracted to arrange the pilot transportation.

5

Information systems in the nautical chain

This chapter elaborates on the information sharing systems that are used to support information sharing between the actors of the nautical chain. The required information is gained from personal communication with Cor Koert (Product Owner of HaMIS) and Raymond Seignette (policy maker at the Harbour Master Department).

The Harbour Master receives a large amount of data on the vessels in his nautical control area. Data that is supplied by the vessel agent is mandatory by law and property of the Harbour Master. Although the data is owned by the Harbour Master, sharing these data is bound by governmental regulations. Data that is collected by the Harbour Master is used by the HCC and VTS and partly shared with the nautical service providers and other external parties. These external parties can be either commercial or public. Figure 5.1 shows the digital systems that are used in the nautical chain and in what way they are linked with each other. A single pointed arrow implies that data flows one way, a double pointed arrow implies that data is shared in both directions. The systems will be explained in more detail in the following sections. Besides the digital information sharing systems, conventional systems (e.g. phone and radio communication) are in use.

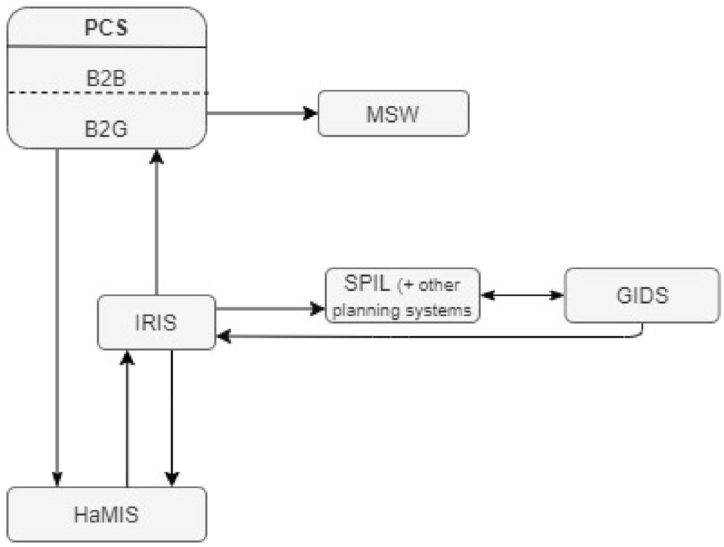


Figure 5.1: Information sharing systems used to support the processes of the nautical chain

5.1. PCS

A Port Community System (PCS) is a digital platform that connects systems operated by different organisations, such as terminals, vessel agents and the Harbour Master. The PCS is a platform that can be used by all parties in the logistic chain. By using a PCS system, the supplied data can be optimally reused. Users of the

PCS need to provide their data only once to the PCS platform, instead of separately to all required organizations. The users of the PCS are both in the public and the commercial domain. The PCS platform ensures that the shared data between parties is in line with the applicable regulations. In order to enable this, the PCS is divided into a business to business (B2B) environment and a business to governance (B2G) environment. In the B2B environment, commercial parties share their data with each other. In the B2G environment, commercial parties deliver the required data to public authorities. The vessel agent provides data of the vessel and the voyage to the Harbour Master via the B2G environment of the PCS platform. Additionally, data from the B2G domain of the PCS is forwarded to the Maritime Single Window (MSW). The MSW is an information gate that collects the required data for e.g. customs, NVWA (Netherlands Food and Consumer Product Safety Authority) and the Koninklijke Marechaussee (border control).

5.2. HaMIS

HaMIS is short for Harbour Master Management Information System. HaMIS is developed and owned by the Port of Rotterdam NV, but designed at request and in cooperation with the Harbour Master. HaMIS collects and saves all data on arriving and departing vessel voyages that is available for the Harbour Master. The data is supplied by the vessel agent via the PCS. Examples of the available information in HaMIS are the estimated arrival and departure times, the destinations of a vessel and whether nautical services have been ordered. HaMIS presents an overview of the reported voyages and their specifications. The data in HaMIS is used by the HCC, by the VTS and by the nautical service providers. The HCC uses the data to assess the administrative clearance of a vessel voyage. The VTS uses the data to support the operational planning of the port. The nautical service providers use HaMIS as an information source for the overview of reported and ordered voyages. The (assistent) DO's HCC and the VTS operators are authorized to update data in HaMIS. The nautical service providers use HaMIS as an external party and are not authorized to update any details.

5.3. IRIS

IRIS is a data filter that is used before the data that is intended for the Harbour Master is forwarded to other parties. The data that passes trough IRIS originates from the HaMIS system. Not all parties that are connected to the platform of the Harbour Master are allowed to receive all data on specific vessel voyages. Via IRIS, data is forwarded to external parties that serve a primary role in the nautical processes. These parties include the nautical service providers.

5.4. SPIL

HaMIS provides data to the individual planning systems of the nautical service providers. SPIL (planning system of the pilot organization) is used to link the available pilots with the ordered voyages. At the same time, the SPIL system is used by the pilots to check their assigned voyage. SPIL is linked with the GIDS system (see section 5.5).

5.5. GIDS

The GIDS system is developed and owned by the pilot organization, but used by the boatmen organization and tugboat companies as well. The system is used to align the deployment of the nautical services and the ETA/ETD of a vessel. The planning systems of each nautical service provider are linked with the GIDS system. In GIDS, the different actors can approve or update a time proposal. In case one of the required nautical service providers can not deliver its service on the proposed time, an updated ETA/ETD will be proposed in GIDS and forwarded to HaMIS.

5.6. Other

The actors of the nautical chain do not only communicate via information systems. Communication tools as phone, e-mail and VHF radio are frequently used as well. The communication takes place between multiple organisations or within an organisation. The major difference between these types of communication and the information systems is that not everything is defined in official procedures. Moreover, the communication is difficult to trace. An exception is e-mail communication, since these conversations are digitally retrievable.

II

Analysis

6 The processes of the nautical chain

In this chapter the first sub-question *'What processes are executed in the planning and operational domain of the nautical chain in the Port of Rotterdam?'* is answered.

This chapter provides a detailed description of the processes in the planning and operational domain of the nautical chain. The planning domain and its processes are discussed in section 6.1. The operational domain and its processes are discussed in section 6.2. Lastly, conclusions are discussed in section 6.3. The information in this chapter is obtained from the previous research of Verduijn (2017), from process maps that are available on the employee page of the Port of Rotterdam and from multiple conversations with field experts. An overview of the experts and their expertise is shown in Table 6.1.

Organization	Name	Function
Harbour Master Department	Arno Grund	Business and Information Analyst
Harbour Master Department	Louis van Waasdijk	Harbour Master Advisor
Harbour Master Department	Raymond Seignette	Policy Maker
Harbour Master Department	Cor Koert	Product Owner of HaMIS
ECT Terminal	Jeffrey Scheurwater Sander de Jong	Operational Manager Consultant Operations

Table 6.1: Involved experts regarding the processes of the nautical chain

6.1. Processes of the planning domain

The planning domain of the nautical chain involves all activities that are necessary to ensure that a vessel can safely enter or exit the port area. The actors that operate in the planning domain are mainly the vessel agent, the HCC, the terminal operator and the nautical service providers. For an incoming voyage, the planning phase starts when the vessel agent reports the vessel voyage to the HCC and ends as soon as the vessel arrives at the pilot station. For an outgoing voyage, the planning phase starts with the received vessel report and ends when time passes the last updated ETD. A description of the planning domain of an incoming voyage is provided in subsection 6.1.1. A description of the planning domain of an outgoing voyage is provided in subsection 6.1.2.

6.1.1. Incoming voyage

For an incoming vessel, the vessel agent is legally obliged to report the vessel to the HCC 24 hours before ETA. The HCC assesses the received information with regard to the nautical safety, port health, security and capacity aspects. If the HCC approves the vessel report, administrative clearance (AC) is provided. If not, additional information is requested from the vessel agent. As soon as the vessel enters the first VTS sector of the Port of Rotterdam, sector Maas Approach, the vessel captain makes operational contact via the VHF radio channel with the VTS operator of the Maas Approach sector. The VTS operator checks the details of the vessel report and registers any updates when necessary. If all details are correct and possible changes are approved by the HCC, the VTS operator provides the vessel operational clearance (OC). In the meantime, the nautical service providers (pilot organization, tugboat company and boatmen organization) are responsible for their own planning. If the operational clearance is provided, the vessel is allowed to further enter the port area and approaches the pilot station.

Figure 6.1 shows a BPMN diagram (see Appendix F) that presents an overview of the executed activities of all actors and the collaboration between them for the planning domain of an incoming vessel voyage. The processes are discussed in more detail for each actor involved.

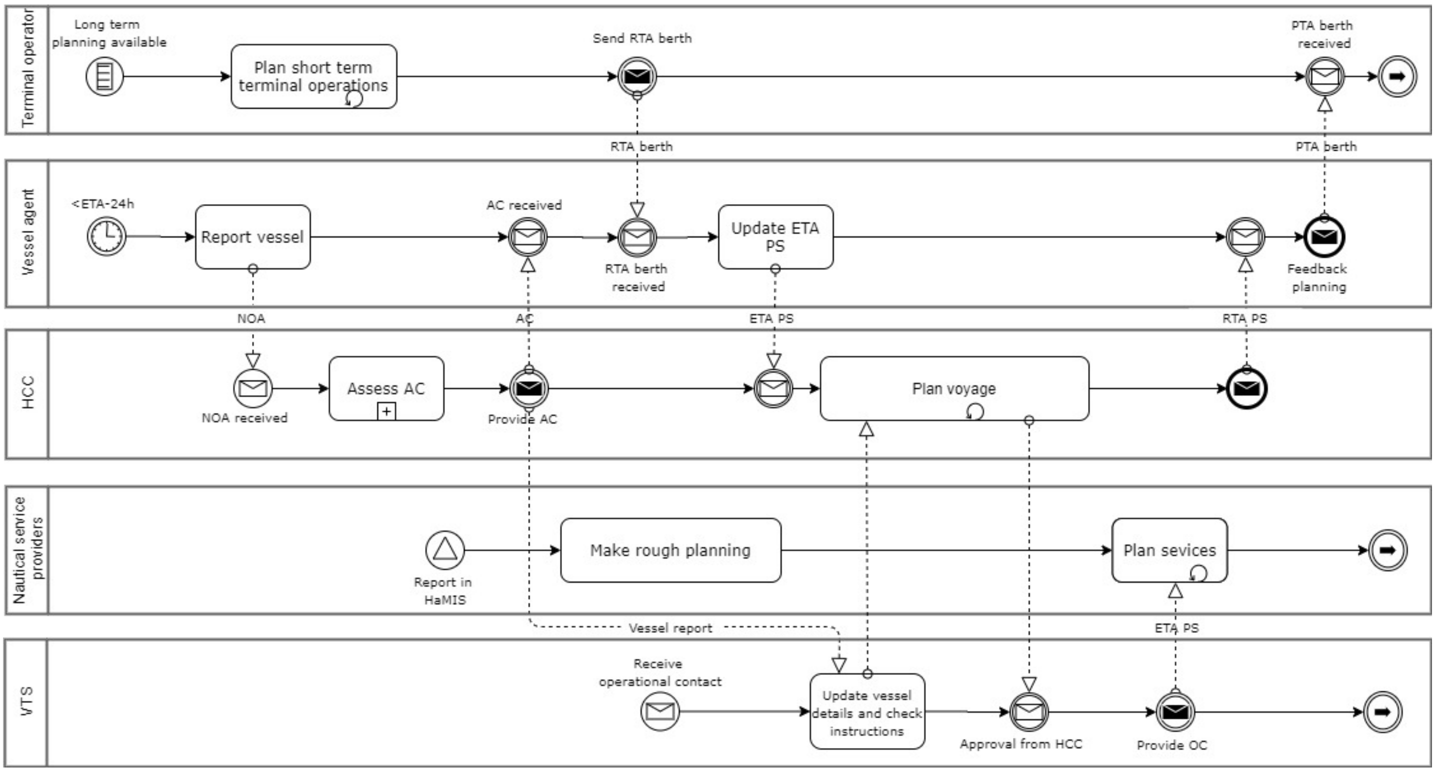


Figure 6.1: BPMN collaboration diagram: planning domain of incoming voyage

Terminal operator

The terminal operator continuously plans the terminal operations. The planning starts with the long term quay planning. As soon as this planning is available, the stowage planners and resource planner aim to match the requested demand as efficient as possible with the available resources. Any disruptions that ask for adaptations in the planning are processed. For that reason, the short term terminal planning is a looped process. The last updated planning defines the requested time of arrival (RTA) of the incoming vessel. This time is communicated with the vessel agent. The vessel agent reports this time to the Harbour Master and nautical service providers. As soon as all actors finish their planning activities, the planned time of arrival (PTA) at the berth is received from the vessel agent. The PTA can be equal or later than the RTA, not earlier.

Vessel agent

The vessel agent reports the voyage to the HCC via an electronic report, which is called the Notice Of Arrival (NOA), via the Port Community System. In this notification, information regarding the ETA of the vessel, hazardous goods and the type of cargo must be included. Each time the ETA of a vessel changes, the vessel agent should communicate the updated time with the HCC. When the reported voyage is approved by the HCC, administrative clearance (AC) is provided and received by the vessel agent. Administrative clearance means that the vessel meets all conditions for admission to the port. If barriers still exist, the vessel agent will be informed on what actions need to be taken. When the vessel agent receives the requested time of arrival at the berth from the terminal operator, the vessel agent can recalculate this time to the time that the vessel wants to be piloted at the pilot station. An update on this estimated time of arrival at the pilot station (ETA PS) is shared with the HCC and used as a starting point for the planning of the voyage. When alignment on the planning has been reached, the vessel agent receives the time that the vessel is requested to arrive at the pilot station (RTA PS). This time can cause an arrival at the berth later than the terminal requested, so the final planning is shared with the terminal operator.

HCC (Harbour Coordination Center)

When the NOA is received at the HCC, the administrative assessment of the reported vessel voyage starts. The sub-process 'Assess AC' is presented in more detail in Figure 6.2.

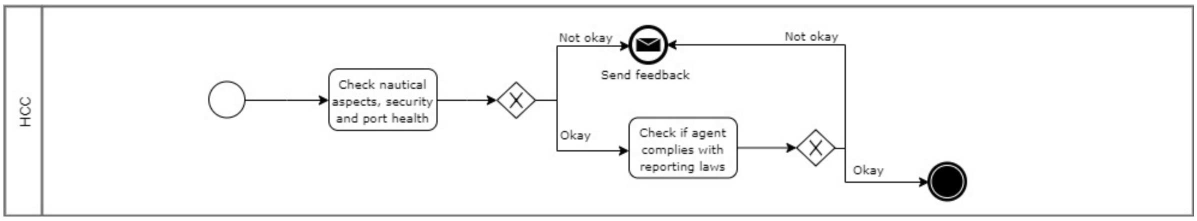


Figure 6.2: BPMN collaboration sub-process: 'Assess AC'

The assessment of the administrative clearance includes all administrative activities carried out by the Harbour Master for the assessment of the vessel visit and associated vessel activities. The process starts when a new or amended NOA is received or when exceptional circumstances necessitate a re-assessment of the vessel visit. If the vessel does meet all security, port health and nautical conditions to safely execute the voyage, administrative clearance (AC) can be provided to the vessel agent. If administrative clearance can not be provided, feedback on the NOA is communicated with the vessel agent.

Next to the administrative assessment of all vessel visits, the HCC is responsible for the macro planning of all vessel traffic. The HCC checks if the vessel route within the port is accessible for the specific vessel. Furthermore, the waterway capacity of critical waterways is being checked. Extra attention is required for vessels that are dependent on tidal ports or when an incoming and outgoing vessel of the same harbour basin are not able to pass each other. If the weather circumstances require exceptions, these will be taken into account in the planning. For example, wind or wave restrictions do not allow vessels of certain size classes to enter the port. If there is alignment between the nautical planning and the macro planning of all vessel traffic, the final planning can be communicated to the vessel agent.

Nautical service providers

The nautical service providers are responsible for their own service schedule. All nautical service providers are linked to the system of the HCC (HaMIS) and receive an overview of the reported voyages. Based on this reports, the nautical service providers start with making a rough planning of the requested services. This rough planning involves a long term forecast on the required capacity, but not yet the deployment of their services. When the vessel receives operational clearance, the pilot organization assigns a pilot to the voyage. The resources of the tug company and boatmen are assigned after the RTA PS has been defined. When the pilot boards the vessel and orders the final number of tugboats, the tug company assigns the tugboats. Lastly, when the vessel approaches the quay, the boatmen organization assigns the boatmen.

VTS (Vessel Traffic Services)

The VTS operator of the first sector (sector Maas Approach) receives the first operational contact of a vessel captain via the VHF radio. When the HCC provided the administrative clearance, a vessel report that contains the details of the approved voyage is available for the VTS operator. As soon as the operational contact with the vessel captain is made, the VTS operator updates the vessel report where necessary. The VTS operator asks the vessel captain for the vessel's most accurate data, for example the draught of the vessel. If the provided details deviate from the vessel report, the VTS operator will update the file. The updates can be seen by the HCC and are used as the input for the voyage planning.

A vessel that enters the Maas Approach sector either wants to enter the port area or has received other instructions (in Dutch: orders) from his vessel agent. There are two ways in which this instructions can reach the vessel. The instructions can be either shared via the Dirkzwager service or directly to the vessel captain. Dirkzwager is a company that used to be involved in the reporting process of vessels to the Harbour Master of the Port of Rotterdam. Nowadays, this link has been erased from the process, but Dirkzwager still offers their 24/7 service for sharing instructions from vessel agents. Instructions that are shared via Dirkzwager are visible for the VTS operator, while instructions that are directly shared with the vessel captain are invisible for the VTS operator. This means that instructions, for example waiting in the anchorage area, that are shared via Dirkzwager are known before the vessel is in operational contact. Consequently, the Harbour Master knows that the incoming voyage of the vessel does not have to be planned yet. When the vessel makes the first operational contact, the VTS operator of Maas Approach shares the given instructions with the vessel captain. With instructions that are not arranged via Dirkzwager it is the other way around. This instructions must be shared with the VTS operator when the first operational contact is made.

6.1.2. Outgoing voyage

The planning process of an outgoing voyage differs from an incoming voyage. The main difference is that an outgoing voyage must be ordered by the vessel agent. Before ordering the voyage, the voyage can be reported. Reporting a voyage means that the departure of a vessel is announced to the HCC. This announcement, the notice of departure (NOD), can be updated by the vessel agent when needed. Based on the information provided with the NOD, the HCC assesses the administrative clearance (AC). Ordering a voyage means that the vessel agent engages in a transaction with the required nautical service providers for the requested ETD. The voyage order must be done at least 2 hours before ETD via a digital file. Any changes within this 2 hours ordering time can be charged by the nautical service providers to the vessel agent as waiting time. An overview of the reporting and ordering period for an outgoing voyage can be seen in Figure 6.3.

Figure 6.3: Difference between reporting and ordering a voyage

After the departure has been ordered by the vessel agent, the nautical service providers have half an hour to schedule their services and 1,5 hour to get the required resources to the departing vessel. The vessel agent is dependent on a sign from the terminal, approximately 2 hours before loading is finished, for ordering the voyage. Based on the voyage order, the HCC and the nautical service providers arrange their planning. The final planning is communicated as the planned time of departure (PTD) to the vessel agent and the nautical service providers. The vessel agent shares the final planning with the terminal. As soon as a vessel is ready for departure, which means that all required nautical service providers are present and the loading activities of the terminal are finished, the pilot makes operational contact with the VTS operator. Similar to an incoming voyage, the VTS operator checks the reported vessel details. Contrary to an incoming voyage, this check is executed after the planning is made. In case a change in the details requires adaptations in the planning, the voyage must be re-planned.

Figure 6.4 shows a BPMN diagram (see Appendix F) that presents an overview of the executed activities of all actors and the collaboration between them for the planning domain of an outgoing vessel voyage. The detailed description of of the activities for each actor corresponds with the explanations provided for an incoming voyage (subsection 6.1.1).

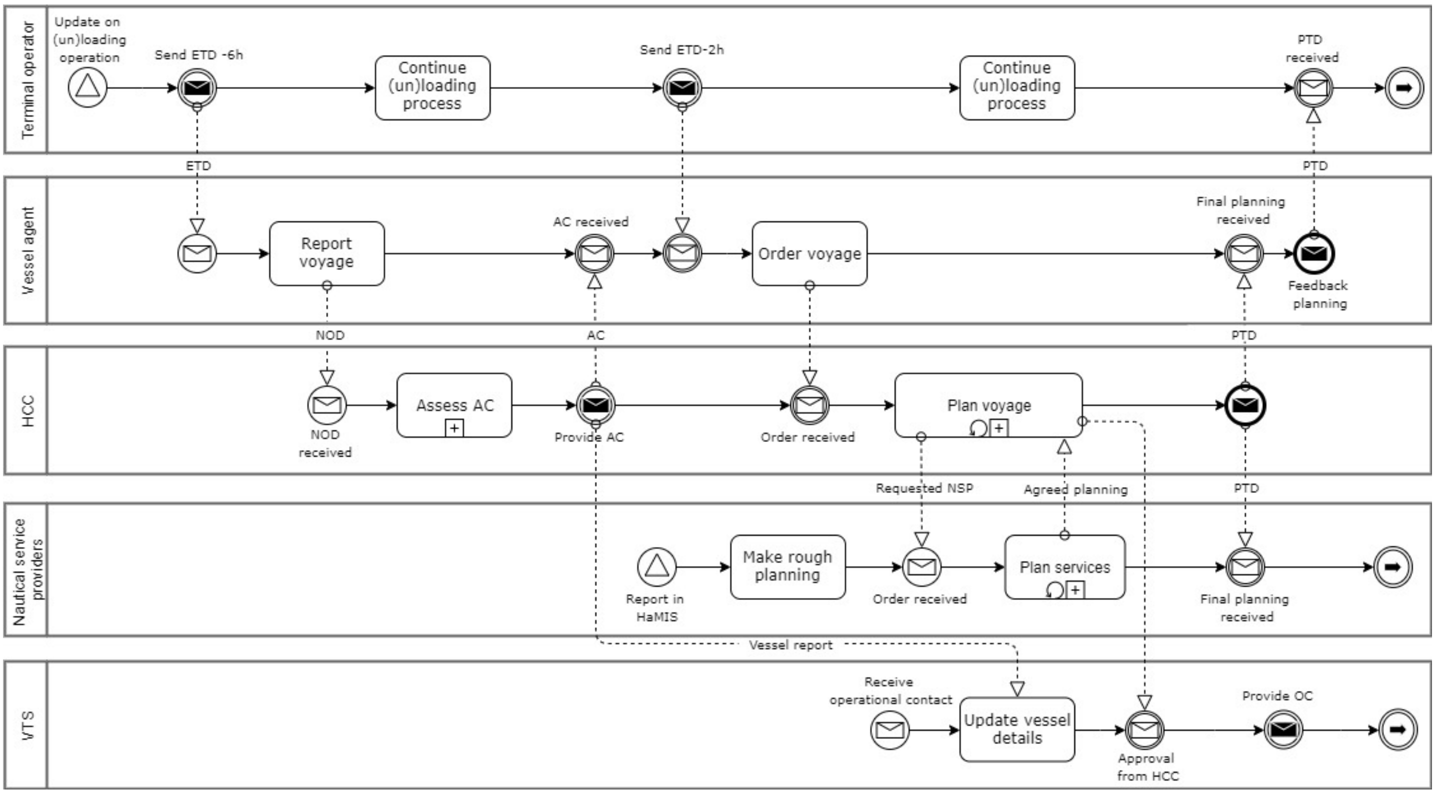


Figure 6.4: BPMN collaboration diagram: planning domain of outgoing voyage

The sub-process of assessing the administrative clearance by the HCC is similar as for incoming voyages (subsection 6.1.1). Due to difference in ordering the voyage, the planning of the nautical service providers is arranged slightly different. For outgoing voyages, the planning of the nautical service providers is aligned via GIDS (see chapter 5). A detailed description of the sub-process 'Plan services' is presented in Figure 6.5. As soon as a vessel is ordered for departure by the vessel agent, the order is received by all nautical service providers and the planning starts. Via digital communication software (GIDS), the different actors can approve or reject the proposed time for delivering their services. In case one of the involved actors rejects the proposed time, a new time at which the actor can provide the requested capacity is proposed. This process is repeated until an agreement on the proposed planning has been reached. This planning is then forwarded to the HCC to check if the voyage can still be executed on the agreed time.

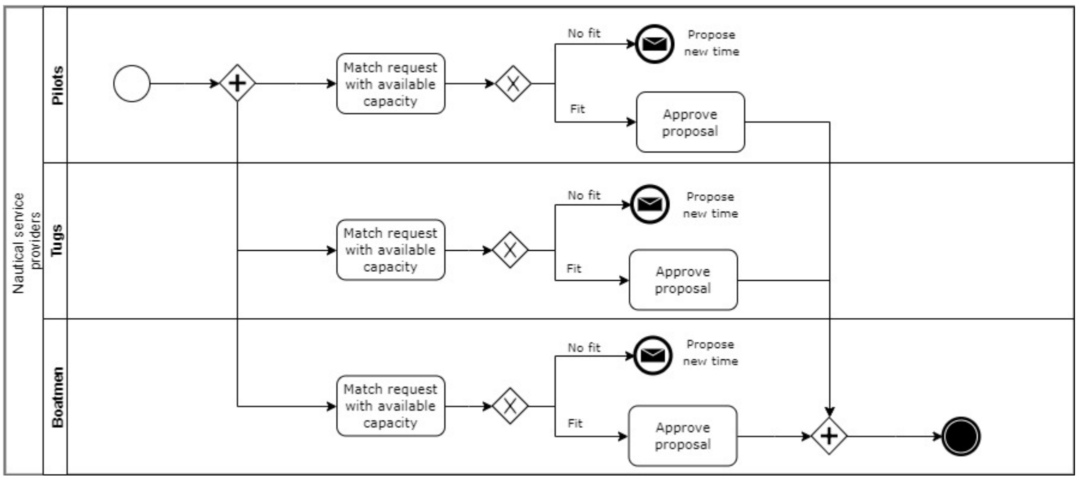


Figure 6.5: BPMN collaboration sub-process: 'Plan services'

6.1.3. Current developments

The Harbour Master, together with the involved parties, is currently working on the optimization of the planning process of incoming voyages. The Harbour Master aims to structure all data provision from the vessel agent via electronic reports. The main development will be the introduction of an explicit ordering moment for the incoming voyages, similar to the ordering process of outgoing voyages (see subsection 6.1.2). This means that there must be a clear difference between reporting the incoming voyage and ordering the incoming voyage. The expectation is that the chance on errors in the planning decreases, because there is a timely and better insight into the status of an incoming vessel. The vessel agent is in charge of delivering the required data on time and placing the order. Also when the vessel does not require nautical services, the vessel agent must order the voyage. In this sense, the vessel agent 'orders' the waterway capacity. Additionally, the use of vessel instructions from the vessel agent (see more information on vessel instructions in Figure 6.1.1) is no longer necessary. The intentions of a vessel with regard to entering or staying outside the port area can be reported to the Harbour Master without using official vessel instructions. The goal is to avoid misunderstandings about the order status of incoming voyages. The structure of the new process is currently being discussed with the pilot organization, the tugboat companies, the boatman organization and the vessel agencies.

6.2. Processes of the operational domain

In the operational domain of the nautical chain, the processes that have been planned in the planning domain are executed. The operational domain involves the physical movement of a vessel into or out of the port area. The actors that operate in the operational domain are mainly the VTS operators and the nautical service providers. Additionally, the terminal operator works on the loading or unloading operations. For an incoming voyage, the operational domain of the nautical chain starts when the vessel arrives at the pilot station. For an outgoing voyage, the operational domain of the nautical chain starts when time passes the ETD of the ordered voyage. A description of the operational domain of an incoming voyage is provided in subsection 6.2.1. A description of the operational domain of an outgoing voyage is provided in subsection 6.2.2.

6.2.1. Incoming voyage

After operational clearance is given, the vessel is allowed to further enter the port area. The vessel is guided by VTS operators of the different sectors, while the vessel traffic is being monitored. Before the port entrance, the pilot boards the vessel at the offshore pilot station and guides the vessel to its destined berth. As soon as more complex manoeuvres are necessary, the tugboats must be present to assist the pilot. It depends on the destined harbour basin at which location the tugs connect. During the mooring process, the tugboats follow the orders from the pilot to safely manoeuvre the vessel to its berth. Lastly, the boatmen attach the boat to the quay.

Figure 6.6 shows a BPMN diagram (see Appendix F) that presents an overview of the executed activities of all actors for the operational domain of an incoming vessel voyage. The processes are discussed in more detail for each actor involved.

Terminal operator

As soon as it is clear that the berth will be available for the arriving vessel, the terminal finishes the terminal operations of a previous vessel and waits for the vessel to arrive and be moored. The unloading and loading operations start as soon as possible after the vessel is moored at the quay.

VTS (Vessel Traffic Services)

When the operational clearance is provided and the vessel starts its voyage, the VTS operators guide the vessel and monitor the traffic. Physical guidance can be provided by the patrol vessels, remote guidance is provided by the VTS operators at the two Vessel Traffic Centers in Hoek van Holland and the Botlek. The VTS operators of each sector make sure that a vessel can safely enter the VTS sector by providing information on the traffic situation to the pilot or vessel captain. The VTS operator checks the real-time location of the vessel and the agreed voyage plan. If necessary, the VTS operator recommends corrective measures from the vessel. When the pilot sends a notification that the vessel is berthed and the voyage ended, the vessel guidance ends. Officially, the contact between the Harbour Master and the vessel is executed via the VTS operator and the vessel captain. In practice, the pilot takes over the communication when boarded. However, the vessel captain always remains end responsible for the vessel.

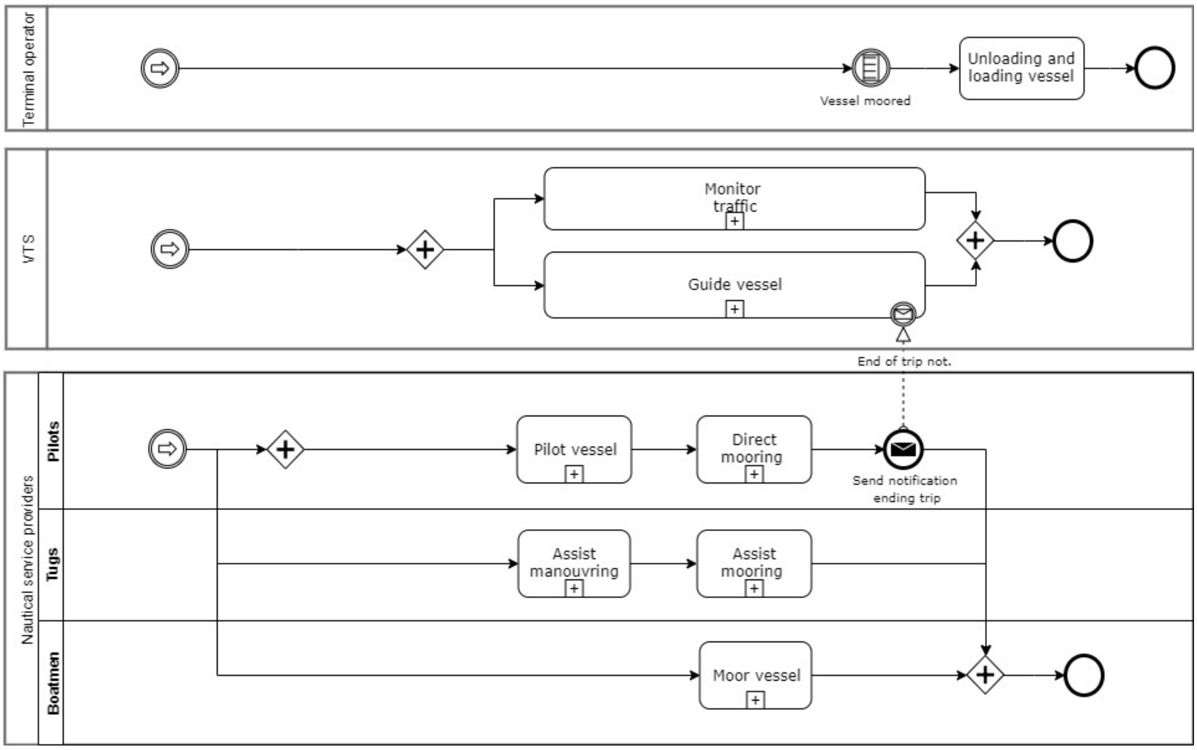


Figure 6.6: BPMN collaboration diagram: operational domain of incoming voyage

Nautical service providers

The first nautical service provider that assists the vessel is the pilot. The pilot boards the vessel offshore at one of the pilot stations and navigates the vessel into the port area. The tugboats are fastened before the vessel turns into the harbour basin. As soon as the harbour basis is reached, the main focus of the pilot switches from navigating to manoeuvring. The tug operators assist the pilot with manoeuvring by decreasing the turning circle of the vessel. Lastly, the boatmen moor the vessel safely on the destined berth.

6.2.2. Outgoing voyage

The operational domain of the nautical chain of an outgoing voyage consists of the same processes as an incoming voyage, but the activities are performed backwards. The main difference with the incoming operations is that all nautical service providers must be present at the same location, before a vessel can start its departure. When the pilot, the tugs and the boatmen are present, the pilot starts with the unmooring process. First, the boatmen detach the mooring lines and leave. The tugboats take over the forces of the mooring lines and assist the pilot with manoeuvring from the berth. As soon as manoeuvring is not required anymore, the tugboats leave. The pilot stays on board of the vessel till the vessel left the port area. The pilot is picked up by one of the pilot tenders at the pilot station.

Figure 6.7 shows a BPMN diagram (see Appendix F) that presents an overview of the executed activities of all actors for the operational domain of an outgoing vessel voyage. The detailed description of of the activities for each actor corresponds with the explanations provided for an incoming voyage (subsection 6.2.1).

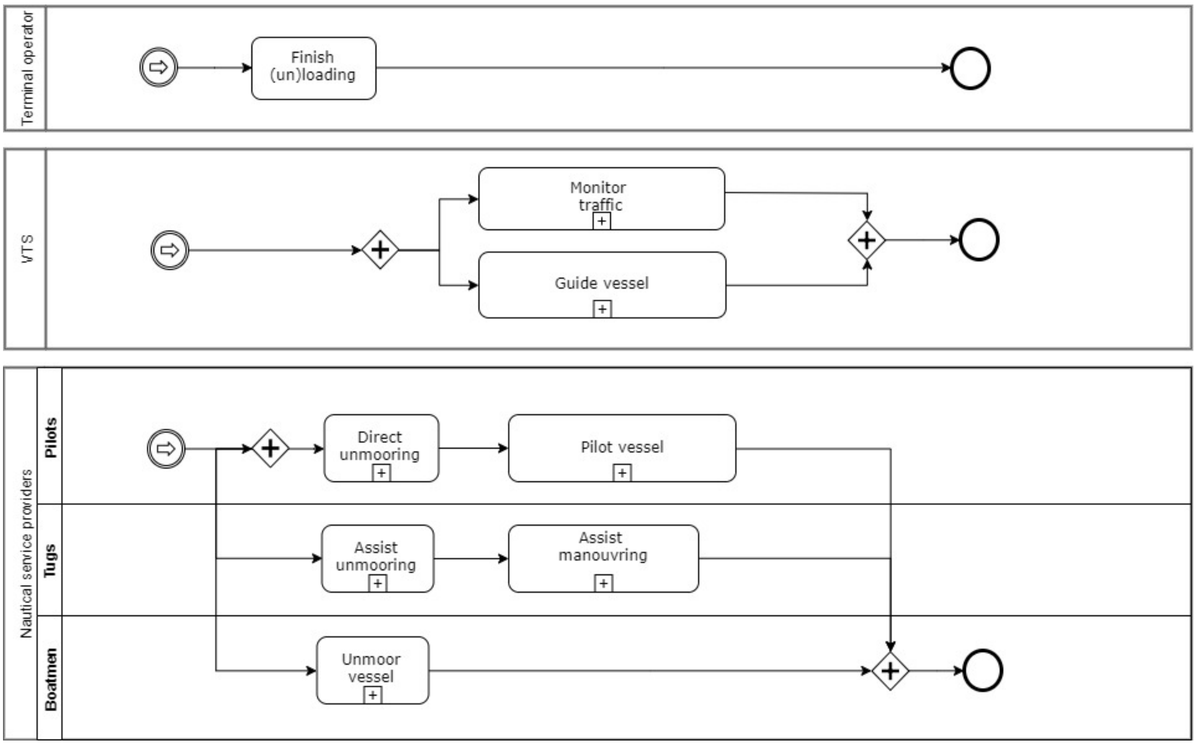


Figure 6.7: BPMN collaboration diagram: operational domain of outgoing voyage

6.3. Conclusion

This chapter discusses the processes of the planning and operational domain of the nautical chain. The processes that are executed in the planning domain of an incoming voyage are presented in the light grey area of Figure 6.8, the processes that are executed in the operational domain in the dark grey area. The requirements for the defined ETA PS are the 'expected' availability of a pilot, the tugboats, the boatmen and the berth. 'Expected' implies that the requirements are available according to the current planning of the pilot planning, the tugboat planning, the boatmen planning and the terminal planning. A requirement for entering the port area is a confirmed availability of the tugboats. When this requirements is confirmed, it is assumed that the tugboats arrive on time at the location for attachment. The requirements for mooring the vessel are that the boatmen are present and that the berth is available as agreed on in the planning.

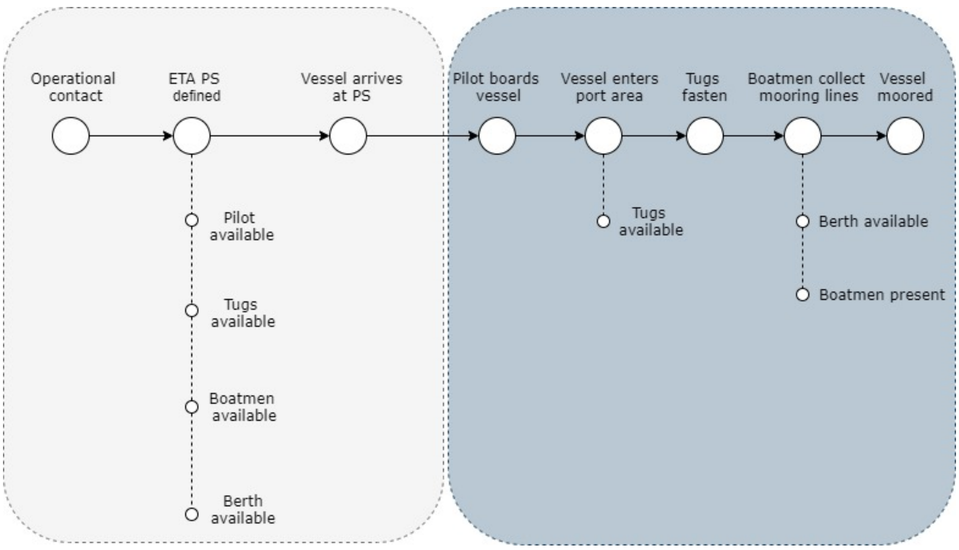


Figure 6.8: Activities of an incoming voyage in the planning and operational domain

The processes that are executed in the planning domain of an outgoing voyage are presented in the light grey area of Figure 6.9, the processes that are executed in the operational domain are presented in the dark grey area. A requirement for the requested ETD is the 'expectation' that the terminal operations are finished at the requested ETD. Again, 'expectation' implies that according to the current planning of the terminal, the operations should be finished. The requirements for the scheduled ETD are the 'expected' availability of a pilot, the tugboats and the boatmen according to the pilot planning, the tugboat planning and the boatmen planning. The requirements for leaving the berth are the presence of the tugboats, the boatmen, the pilot and finished terminal operations.

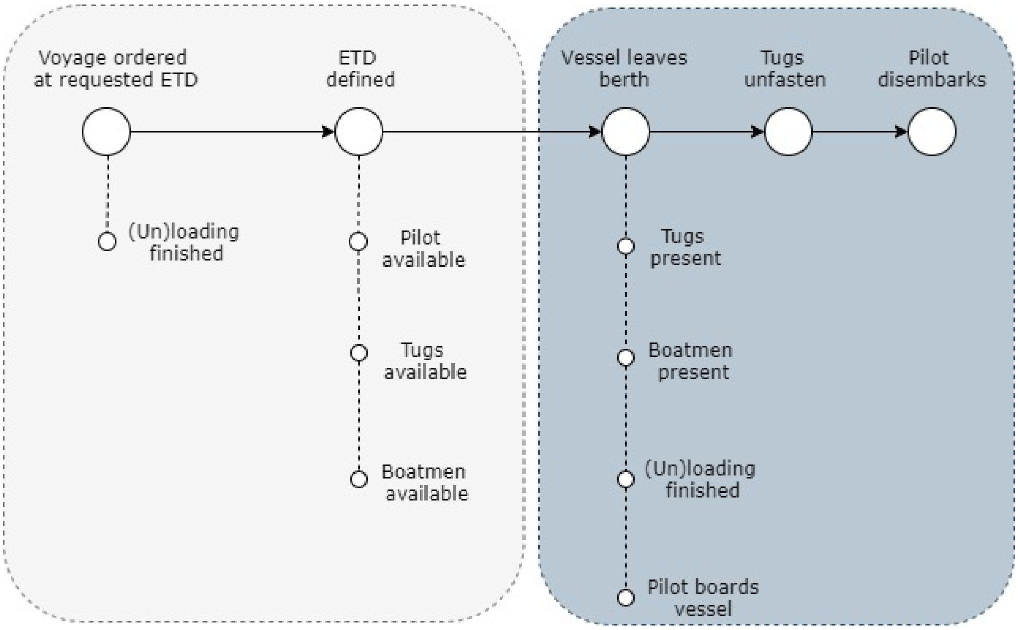


Figure 6.9: Activities of an outgoing voyage in the planning and operational domain

7 Information sharing in the planning domain of the nautical chain

In this chapter the second sub-question '*How does information sharing in the planning domain of the nautical chain of the Port of Rotterdam proceed?*' is answered. For a visualization of the activities of the planning domain of the nautical chain see Figure 6.8 and Figure 6.9 in chapter 6.

The information for the analysis presented in this chapter is gathered through interviews with the planning departments of the pilot organization, the boatmen organization, the tugboat company and the Harbour Master (Harbour Coordination Center and the Vessel Traffic Center). The interviews are conducted while the planning activities were on-going, which means that the interviews are complemented by practical examples. The interviews are available in Appendix D.

This chapter includes a section for the pilot planning (section 7.1), the tugboat planning (section 7.2), the boatmen planning (section 7.3), the terminal planning (section 7.4) and the Harbour Master planning (section 7.5). In each section, a general explanation of the involved tasks and responsibilities for the specific planning process is provided. This general explanation is followed by a description of the planning process of an incoming voyage and an outgoing voyage. Also, the main information sharing tools (e.g. phone, VHF channel) and the information sources of a specific actor are mentioned. Each section ends with an overview of the communication that takes place between actors in the planning process of the considered actor. A conclusion is provided in section 7.6.

7.1. Pilot planning

Three pilot planners are responsible for the pilot planning of the Rotterdam-Rijnmond region. Pilot planner 1 is responsible for the job assignment of departing voyages. Furthermore, pilot planner 1 manages the list of available pilots. In case there are not enough pilots available at sea for incoming voyages, pilot planner 1 calls a pilot from home. Pilot planner 2 is responsible for all communication with the currently active pilots. Pilots who finished their voyage report to pilot planner 2 that their trip is finished. Pilot planner 3 is responsible for the job assignment of incoming voyages. The planning department is located next to the HCC. This makes the link with the Pilot Service Leader (located at the HCC) short.

Planning of incoming voyages

Pilot planner 3 (incoming voyages) considers the vessel report of vessels that are 3 to 4 hours before their reported ETA MC (see Appendix H for more information on the ETA locations). This ETA is reported by the vessel agent and is not always accurate. Accurate ETA's are required to efficiently assign a pilot with the required qualifications to a vessel. The fatigue level of pilots plays a role herein as well. For more accuracy, the pilot planner looks for the specific vessel on the map and evaluates whether the registered ETA MC provided by the vessel agent is realistic. To plan all incoming vessels properly, the pilot planner makes an inventory of how many pilots are needed at sea. In case pilot planner 3 expects that more pilots are needed at sea, his colleague (pilot planner 1) is asked to call pilots from home. At this moment, the vessel has not made operational contact with the VTS yet. Before a vessel makes operational contact, it is not assured if all vessel agent instructions for a vessel are known. It might happen that it appears that an incoming vessel must remain outside after the operational contact with the VTS operator of Maas Approach is made. In this case, not all pilots located at sea are needed.

As soon as the vessel makes contact with the VTS operator of Maas Approach and the vessel does not have any instructions from his vessel agent to remain outside, the VTS operator of Maas Approach registers the ETA PS. This information is available for the pilot planner via HaMIS. When a vessel has the status 'operational contact' and a registered ETA PS, the pilot planner assigns a pilot with the required qualifications. The assigned pilot is either called from home (by his colleague pilot planner 1) or the pilot is already available at the pilot station vessel at sea. When a pilot must be called from home, the pilot has 1,5 hour to go to the Pistoolhaven and 1 hour to be transported to the MC pilot station (see Appendix H). Therefore, the job assignment for incoming voyages must be finished 2,5 hours before the registered ETA PS. This means that vessels should make operational contact with the VTS operator of Maas Approach at least 3 hours before arrival at the pilot station.

In general, vessels use the MC buoy as the pilot station. However, vessels that are bounded by length and draft (semi-geulers and geulers) and LNG tankers must receive their pilot earlier (see Appendix H). For these vessels, the pilot must travel a longer distance at sea. This means that the pilot must be mobilized before the vessel makes operational contact. For this type of vessels, the pilot planner checks if all the required details of the vessel voyage are available in the vessel report. In case, for example, the boulder numbers at the berth are not available, the pilot planner might doubt the intention of the vessel to immediately enter the port area. When all the required details are available in the vessel report, the pilot planner assigns a pilot with the required qualifications.

Planning of outgoing voyages
Pilot planner 1 (outgoing voyages) only considers the voyages that are ordered by the vessel agent (see chapter 6 for the difference between a reported and ordered voyage). When the HCC approves the ordered departure, the voyage appears in the pilot planning system (SPIL). The pilot planner has half an hour to assign a qualified pilot. After the job assignment, the pilot that is called from home has 1,5 hours to go to the departure location of the vessel. The pilot chooses the location for pick up by the taxi service of the boatmen. Pilot planner 1 registers this location and time in the SPIL system, via which it is shared with the boatmen planning.

Information sharing tools and sources
The systems used by the pilot organization are HaMIS, SPIL and GIDS. For more information on the used systems see chapter 5. Additionally, the phone is used as a communication tool to communicate with pilots on the water and other organizations.

Information shared in the planning process
Figure 7.1 shows the BPMN conversation diagram (see Appendix F) of the pilot planning. An explanation of the diagram is provided in this section. Most conversations involve bilateral communication. The exceptions, in which only unilateral communication takes place, are indicated with an 'arrow sign'. Conversations in which the linked actor does not take part, but only listens to the conversation as an information source, are indicated with an 'ear sign'. For a visualization of the sub-conversation, see Appendix G.

- **Conversation 1,2,8,9:** The pilot planners together discuss the pilot availability [1]. When pilot planner 3 needs a pilot from home, this is communicated with pilot planner 1. Also, when pilot planner 2 receives the message that a pilot is finished later than expected [2], it might be crucial for pilot planner 1 to know that an additional pilot from home is required [1]. The Pilot Service Leader focuses on the planning of the (semi-)geulers and LNG tankers at the HCC. Situations that require attention of the pilot planners are discussed between the Pilot Service Leader and the pilot planners [8]. Also, when it is known at the HCC that the tug availability regarding incoming voyages is an issue, the Pilot Service Leader shares this information with the pilot planners. This communication usually happens face-to-face [9].

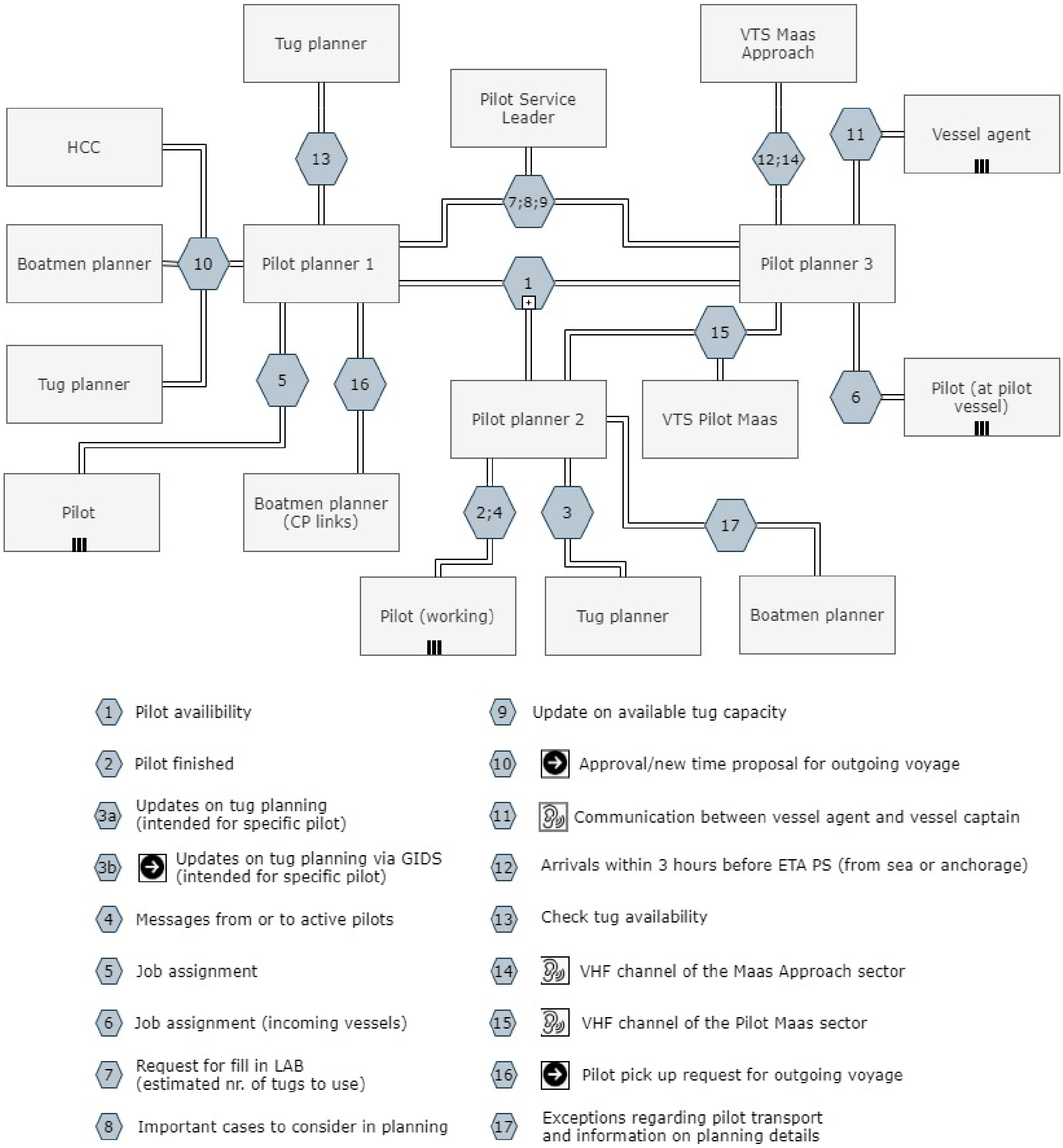


Figure 7.1: BPMN conversation diagram: pilot planning

- **Conversation 5,6,16:** The job assignment for incoming voyages of pilots that are located at sea are communicated by pilot planner 3. This communication is executed via the VHF channel with the pilot vessel [6]. The pilots also receive the job assignment in the GIDS application on their phone. The job assignment for outgoing voyages and incoming voyages for which a pilot must come from home are communicated by pilot planner 1. Pilot planner 1 gives the pilot a call and shares the departure location or destination and the ETD or ETA of a vessel [5]. After the call, the pilot receives a message from the GIDS system as well. Via SPIL, the time and location for the pilot pick up becomes available for the boatmen planning [16].

- **Conversation 12,14,15:** In case the arriving vessel makes operational contact within less than 3 hours before his ETA PS, the pilot planning is called by the VTS operator of Maas Approach to check whether the pilot organisation is able to deliver their service on the requested ETA PS [12]. Also, the VHF channels of the Pilot Maas sector and Maas Approach sector are listened to as an information source [14;15].

Via the VHF channel of Maas Approach, the pilot planners can notice when a vessel makes operational contact. Via the VHF channel of Pilot Maas, the pilot planners can notice when a pilot for an incoming voyage boarded or disembarked the vessel.

- **Conversation 11:** Some vessel agents share their communication with the vessel captain with the pilot planners via e-mail. In this way, vessel agent instructions that are not handled via the Dirkzwager service are available for the pilot planning of incoming voyages [11]. However, processing these e-mails is almost impossible.

- **Conversation 3,4,10,13:** For outgoing voyages, an approval or new time proposal for the ordered ETD must be registered in GIDS. Via the GIDS system, the approval or proposal is shared with (or received from) the other nautical service providers and the HCC [10]. When pilot planner 1 must wait for the approval for an outgoing voyage of the tug company longer than the available 30 minutes, pilot planner 1 can call the tug planner [13]. Any updates from the tug planner on the tug planning are communicated with pilot planner 2. Especially regarding incoming voyages, a delayed tug arrival is important to know for the boarded pilot, since the pilot does not want to enter the channel when the tugs are not available. For communication on any deviations from the planning, the pilot planner is either called by the tug planner or receives a message via the GIDS system [3]. This message is also directly send to the pilot assigned to the specific voyage. However, the pilot planner calls the assigned pilot to make sure that the message had been received in good order and to check if the pilot agrees with any propositions of the tug company [4].

- **Conversation 17:** Any exceptions regarding the pilot transport are discussed by phone. Also, it happens that the pilot planners contact the boatmen planning to discuss more detailed planning information. For example, if a pilot of an incoming vessel is scheduled for a next outgoing vessel, but the planning is tight and the pilot planner doubts the registered expected gangway down time of the incoming vessel, the boatmen planning is called for information. The boatmen have more detailed information available on how long they expect to be working on the mooring activities of the incoming vessel and the pilot transportation to the next vessel. Any other information that is noticed by the boatmen planners and of value for the pilot planners is shared as well [17].

7.2. Tugboat planning

Shipping companies have a contract with one of the available tugboat companies in the Port of Rotterdam. The tugboat companies are not allowed (due to restrictions of the Authority for Consumers and Markets) to share their capacity. Each tugboat company takes care of its own planning. The interviewed company has 1 tugboat planner located at their office. This tugboat planner is responsible for the job assignment of vessels with a contract with their company in the Port of Rotterdam.

Planning of incoming voyages

The incoming vessels that have operational contact are monitored by the tug planner. By monitoring the incoming vessels, the planner can make a rough estimation of the required tug capacity. The number of required tugs per vessel is either estimated by the Pilot Service Leader or ordered by the vessel agent. In case the tugboat planner knows that the available capacity can not provide the requested tug assistance to all incoming vessels, the HCC must be contacted to request delayed ETA PS's.

The tug assignment for incoming voyages starts as soon as the pilot has boarded the vessel. Although the vessel agent ordered a number of tugboats or the Pilot Service Leader registered the expected number of tugboats, the pilot may decide that an extra tugboat is required. The boarded pilot orders the number of needed tugboats via GIDS. As soon as the ordered number of tugs is processed in the GIDS system, the tug planner assigns the specific tugboats to the voyage. Most of the time, the tug planner already considers the available options before the pilot orders the tugboats. However, the specific assignment only takes place after the order is received via GIDS.

Planning of outgoing voyages

The tug planner only considers the voyages that are ordered by the vessel agent. The planer has half an hour to confirm the ordered ETD or to propose a delayed ETD via GIDS. When confirming the ETD in GIDS, the tug planner either confirms that the requested resources are available and immediately assigns the specific tugboats to the vessel or the specific tugboats are assigned later. The latter is done when the tug planner is sure that there are tugboats available, but not sure if the tugboats he prefers (tugboats that are working closest to the location of the departing vessel) finish their current assignment on time.

Information sharing tools and sources

The tug planner uses the GIDS system, HaMIS and the tug companies own plannings system. GIDS only shows the voyages with a pilot, while the tug company also serves clients that do not make use of the pilot service. For that reason, the tug planner mainly uses his own planning system as an information source and GIDS as a communication tool with the other nautical service providers. Except for notifying the other service providers on the tug deployment via GIDS, additional messages can be send with the system. By delaying a voyage with a few minutes, the tug planner is sure that the planners of the other nautical services will receive a notification of the sent message. Next to the used systems (for more information on the used systems see chapter 5), the tug planner uses the phone for communication with other organizations. For internal communication with tug captains, the tug planner uses the internal VHF channel. However, all tugboats are also equipped with a phone. When tugboats are in their resting period, the assignment or any urgent matter is communicated via phone instead of the VHF channel.

Information shared in the planning process

Figure 7.2 shows the BPMN conversation diagram (see Appendix F) of the tugboat planning. A description of the diagram is provided in this section. Most conversations involve bilateral communication. The exceptions, in which only unilateral communication takes place, are indicated with an 'arrow sign'. Conversations in which the linked actor does not take part, but only listens to the conversation as an information source, are indicated with an 'ear sign'.

- **Conversation 8,9:** The tug planner communicates the job assignment with the tugboat captain of the assigned tugboat via the internal VHF channel (or via phone when the specific tugboat is in his resting period) [9]. Tugboat captains also report that their current job is finished via the VHF channel. In general, the tugboat captains try to assist the tug planner with making the planning. The tugboat captains can make suggestions or give an estimate on how much time it will take before arrival at the next job. When tugboats are assigned to an outgoing vessel and the pilot communicates that the vessel is delayed, the tugboat captain informs the tug planner on the delay [8].
- **Conversation 2,3,4,13:** For outgoing voyages, requested delays of an ordered ETD are communicated with the HCC and other nautical service providers via the GIDS system [13]. For incoming voyages, a lack of available tug capacity is shared with the DO HCC by phone [3]. At the same time, the DO HCC informs the tug planner when delays at a departing vessel occur with regard to e.g. customs or inspection occur [4]. Although the chance is big that the tugboats are already present at the departing vessel, this information is used by the tug planner for making the further planning.
- **Conversation 6,7,12:** Messages intended for pilots on board of a vessel are either communicated via the pilot planners or, when the message is more urgent, directly with the specific pilot via phone contact [6;7]. For phone contact with the specific pilot, the tug planner sees which pilot is assigned to the vessel in the GIDS system and has an Excel file available with names and phone numbers of all pilots [7]. Besides, messages are shared with the pilot planner. This message can be either shared via phone communication or by sending a message via GIDS [6]. The latter is automatically available for the assigned pilot. However, the pilot planner always calls the assigned pilot to check if the message had been received in good order. Other information shared between the pilot and the tug planner for an incoming voyage are the number of ordered tugboats and the ETA LL via GIDS (see Appendix H for more information on the ETA locations). Updated ETA's by the pilot are processed via the GIDS system and available for the tug planner as well [12]. Next, the pilot receives details on the assigned tugboats via a GIDS message. This message can also contain details of the vessel from which the assigned tugboats should arrive [15].

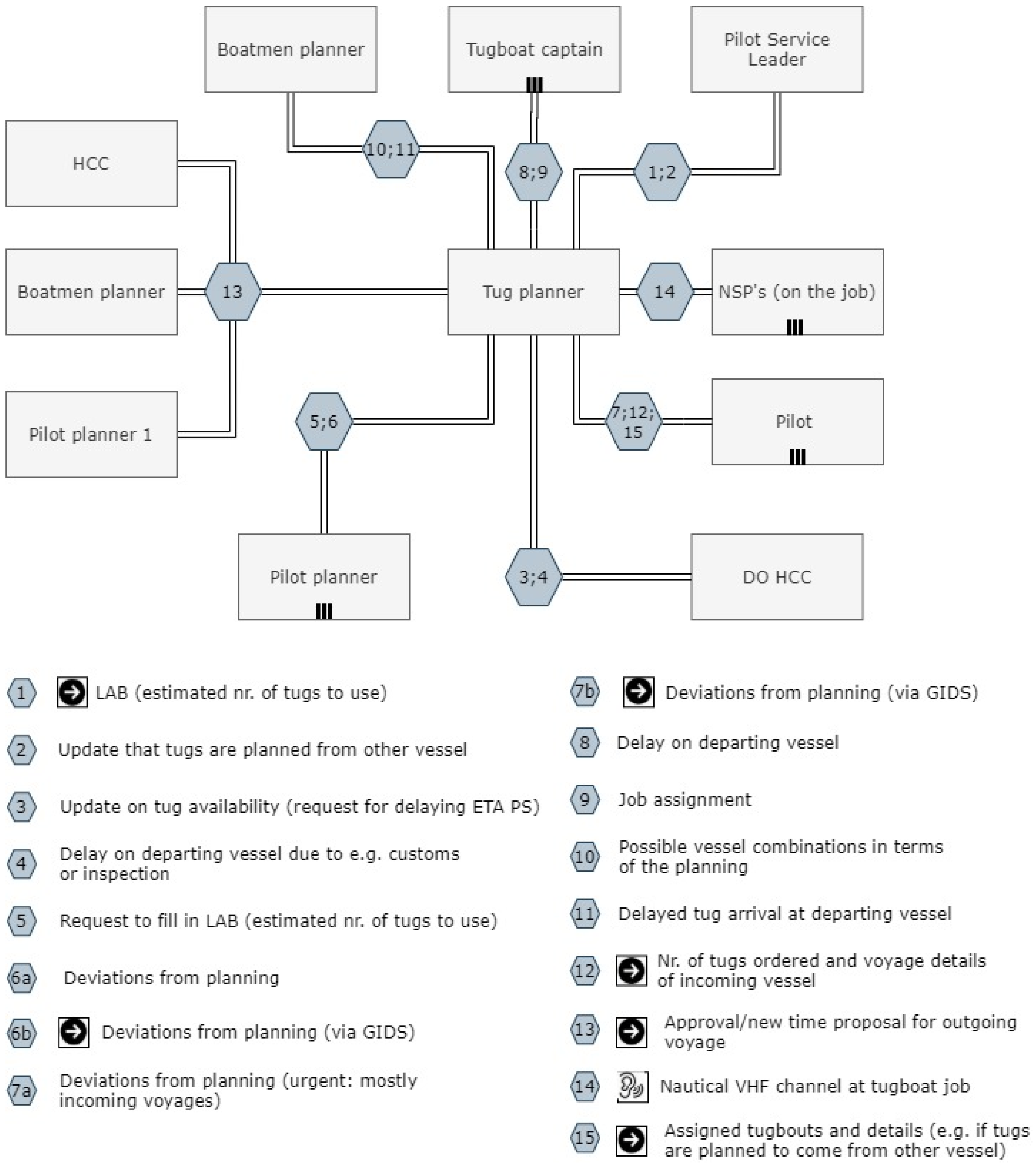


Figure 7.2: BPMN conversation diagram: tugboat planning

- **Conversation 10,11:** If the tug planner has the time, the boatmen planning is informed on a delayed tug arrival at a departing vessel [11]. However, in general, the boatman are informed about a delayed tug arrival via an updated ETD in the GIDS system. Additionally, when it is busy, the tug planner is sometimes called by the boatmen planning with the question what voyages are planned to be executed with the same tugboats [10]. This information is valuable for the boatmen planning, since the boatmen planner can combine the same voyages for one boatmen team.

- **Conversation 14:** The tug planner listens to the nautical VHF channel. Via this VHF channel, the tug planner can extract information on the real-time operations. For example, a delay at a departing vessel at which the tugboats are already present [14].

- **Conversation 1,2,5:** The number of estimated tugs is registered in GIDS by the Pilot Service Leader [1]. In case the tug planner needs the information, but the information has not been registered in the GIDS system yet, the tug planner calls the pilot planner [5]. Then, the pilot planner can contact the Pilot Service Leader. Furthermore, the tug planner can inform the Pilot Service Leader on tugboats that must arrive from another vessel [2].

7.3. Boatmen planning

The boatmen planning in the Port of Rotterdam is divided into 4 regions, namely: Maasvlakte, Europoort, Botlek and Waalhaven. Each of this regions has its own boatmen planner. The planners are located at 3 posts (Europoort, Botlek and Waalhaven). The boatmen planner of the Maasvlakte region is located at the Europoort post. The boatmen planner of a region is responsible for the job assignment in his region. At the Europoort and Waalhaven post an additional planner (CP links) who is responsible for the planning of the pilot taxi service is located. Furthermore, at the Waalhaven post the 'CP rechts' is located. The 'CP rechts' monitors the planning of all regions and is responsible for a redistribution of the capacity when needed. When more capacity is required, the CP rechts calls boatmen from home.

Planning of incoming voyages

In HaMIS all reports and details of an incoming vessel are available. From this information, the boatmen planning system extracts the important information for the boatmen planning. This information includes the ETA PS, the boarding time of the pilot, the ETA LL registered by the pilot, the ETA harbour registered by the pilot, the time that a vessel passes the LL and updates on following passage lines that are crossed by the vessel. As a reminder, the planning system shows a pop-up when a vessel crosses a new passage line. The boatmen planner must approve the pop-up to ensure that the message had been noticed. An incoming vessel is planned based on the crossing of these passage lines. When the vessel crosses a passage line at about half an hour sailing distance from its destination, boatmen are assigned to the job.

Planning of outgoing voyages

The job assignment for an outgoing voyage is based on the ordered ETD's. The departing job is assigned to specific boatmen about half an hour before the ETD. This means that, although the planning of outgoing vessels is jointly coordinated via the GIDS system, the boatmen assign their capacity 1 hour later than the pilot planning and tugboat planners. The boatmen make sure that they deliver their capacity on time, which means that all voyages are confirmed in advance of the job assignment. Any delayed ETD proposals from the pilot planning or tugboat planning are available for the boatmen planning via GIDS, but do not have any effect since the job assignment of the boatmen is done after both the pilot planning and tugboat planning are fixed.

Information sharing tools and sources

The boatmen use their internal VHF channel for communication between the planners and boatmen on the water. For communication between the planners of the different planning regions, phone communication is used.

Information shared in the planning process

Figure 7.3 shows the BPMN conversation diagram (see Appendix F) of the boatmen planning. A description of the diagram is provided in this section. Most conversations involve bilateral communication. The exceptions, in which only unilateral communication takes place, are indicated with an 'arrow sign'. Conversations in which the linked actor does not take part, but only listens to the conversation as an information source, are indicated with an 'ear sign'.

- **Conversation 1,9:** The CP rechts is located next to the boatmen planner of the Waalhaven region. This means that when more capacity at the Waalhaven region is needed, the boatmen planner and CP rechts discuss the planning face-to-face [1]. Regarding the capacity in the other planning regions, the CP rechts monitors the planning in the system and is in contact via phone with the boatmen planners of the Botlek, Maasvlakte and Europoort [1]. In case more capacity is needed for all regions, the CP rechts calls boatmen from home [9].

- **Conversation 2,4,5,8:** The CP links receives the taxi requests for outgoing vessels from the pilot planning. A pilot can choose from 3 different pick-up locations. The chosen location is registered by the pilot planner in SPIL and shared with the boatmen planning [4]. For the return trip of the pilot, the boatmen that assist the pilot with the mooring process ask to which pick-up location the pilot must be transported. The boatmen communicate the time and location with the CP links via the internal VHF channel [5]. When the CP links receives a transportation request, the boatmen drivers or boatmen taxi's

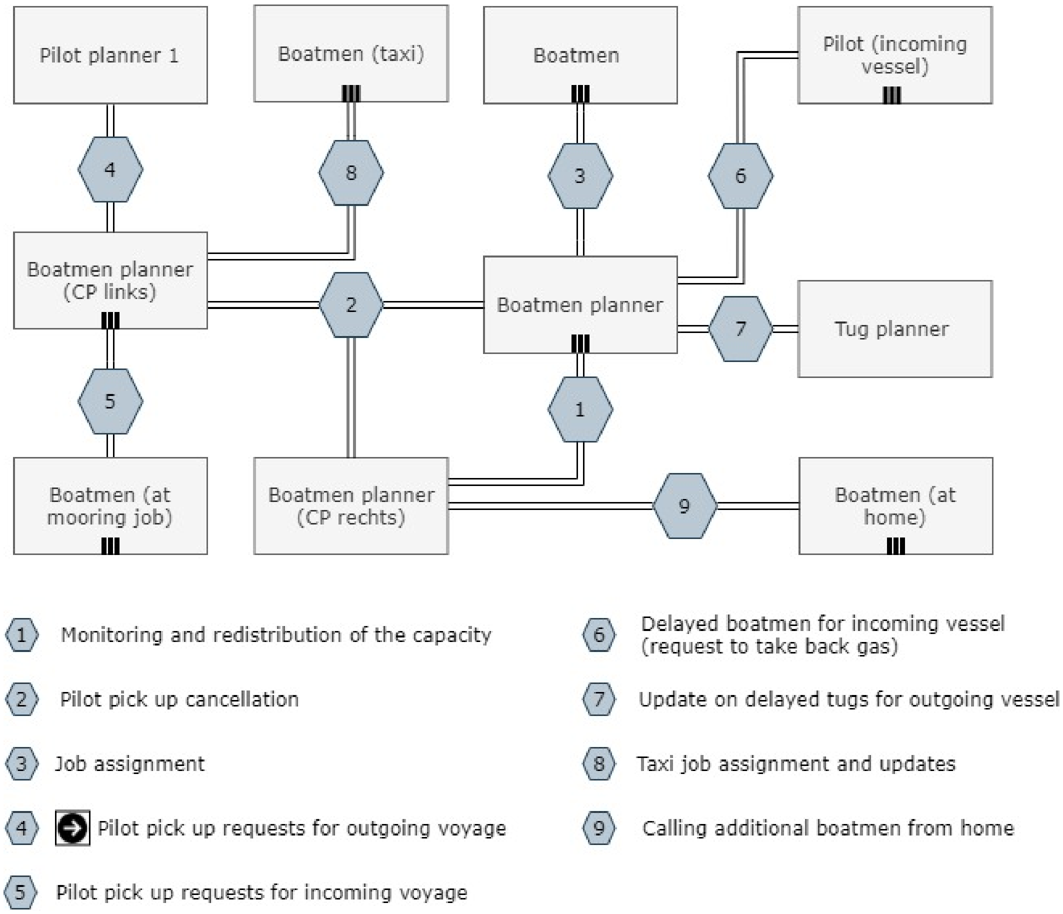


Figure 7.3: BPMN conversation diagram: boatmen planning

are assigned and contacted [8]. In case the CP links receives information on a pilot pick-up cancellation, this information is shared with the boatmen planner of the region, since a cancelled pilot means that boatmen do not have to be assigned for the specific vessel [2].

- **Conversation 3,6,7:** The boatmen planner of the region communicates the job assignment with the boatmen. The job assignment is shared via the internal VHF channel with the boatmen outside . The job assignment with the boatmen waiting at the post is shared face-to-face. The assignment is also available on a phone application. The boatmen on the water assist the planner with the job assignment where possible. The boatmen provide updates on the execution of the current (un)mooring job. The planner might ask a boatmen team if they expect to make it to another vessel at a certain location on time [3]. In the exceptional case that a boatmen team will not make it to an incoming vessel on time, the pilot of the vessel is contacted to take back gas [6]. With outgoing vessels it sometimes happens that the tug planner calls the boatmen to share that the tugboats will arrive delayed at the departing vessel [7]. The boatmen planner can decide whether he assigns the boatmen crew to another job in the mean time. In some cases, the boatmen planner already notice that the tugboats will arrive late by looking at the AIS map. Then, the boatmen planning calls the tug planning to ask how long it will take. This is especially important when it is busy.

7.4. Terminal planning

The terminal planning is divided into the quay planning, the stowage planning and the resource planning. The planning starts with the quay planning. The quay planning indicates what vessels must be moored at the quay at what time. The quay planning also indicates the cranes that must be used for the (un)loading operation. The quay planning is made months in advance and updated as the vessel approaches. After the quay planning is made, the stowage planning determines the order in which the containers must be loaded and unloaded to and from the vessel. Finally, the resource planner keeps track of the last 8 hours before arrival of a vessel. The resource planner does not make a planning anymore, but is responsible for executing the planning made as efficient as possible in order to maximize the quay occupancy rate. To ensure an efficient execution of the planning made, the resource planner aims to align the departing and arriving vessels as tight as possible. In that respect, the resource planner is in contact with the vessel agent of the departing vessel about the time that the vessel is ready to depart and in contact with the vessel agent of the incoming vessel about what time the vessel can be moored at the terminal quay.

Planning of incoming voyages

Regarding the scheduled incoming vessels, the resource planner monitors if the vessels are approaching as has been agreed on in the quay planning. The resource planner receives the expected time of arrival from the vessel agent of the incoming vessel. Updates from the terminal side are discussed with the vessel agent of the incoming vessel as well. These updates are important for the vessel agent, since it determines the actions to be taken by the vessel. In case the destined berth of an incoming vessel is available earlier than expected and the vessel is approaching the Port of Rotterdam, the vessel agent might want to speed up the incoming vessel and arrive earlier. At the same time, when the destined berth of an incoming vessel is available later than expected, the vessel agent wants to know that the incoming vessel can slow down or must wait before entering the port area. As soon as an outgoing vessel is ordered for departure, the vessel agent of the incoming vessel is informed that the quay will be available. The resource planner shares the time, the boulder numbers and if the vessel should moor starboard-side or port-side with the vessel agent of the incoming vessel.

Incoming vessels that are destined for the berth of an outgoing vessel and planned for arrival immediately after the outgoing vessel departs are called 'exchangers' (in Dutch: uitwisselaars). As soon as the outgoing vessel is ordered for departure, the incoming vessel can be requested to enter the port area. In general, the incoming vessel is already present and waiting in the anchorage area. Concerning 'exchangers', the vessel agent of the incoming vessel is informed that his vessel must exchange with a specific outgoing vessel. The vessel agent must register this exchange in the PCS and receives an automatic message when the outgoing vessel is ordered for departure. In some cases, the resource planner still calls the vessel agent of the incoming vessel, because the resource planner is not able to check whether the exchange status is registered correctly in the PCS by the vessel agent.

Planning of outgoing voyages

Outgoing voyages must be ordered with the Harbour Master and nautical service providers at least 2 hours before departure. It is the task of the resource planner of the terminal to inform the vessel agent of an outgoing vessel about 2 hours before the terminal operations are finished that the vessel will be ready and can be ordered for departure. Informing the vessel agent on the planned ETD more than 2 hours in advance is possible as well. However, the larger the time window, the larger the chance on any disruptions that affect the ETD. This is not advantageous for the terminal, since a delay on terminal operations is charged to the terminal. Considering the aim for a high quay occupancy, the terminal wants to order the departures as tight as possible. Ordering the departure too tight means that the terminal operations might not be finished at the ordered ETD and that the nautical service providers are already present, which causes costs for the terminal. Ordering the departure less tight means that there is a chance that the terminal must wait for the nautical service providers when the terminal operations are already finished. In summary, the requested ETD for ordering the vessel is a trade-off between including a large safety marge on the estimated ETD (minimizes the chance on a delay from the terminal side) and including a small safety margin on the estimated ETD (the terminal prefers a vessel ready to depart as soon as the terminal operations are finished). The above description only holds for sea-going vessels that require nautical services. Inland barges do not have to be ordered for departure with the Harbour Master and can therefore be asked to leave last-minute.

Information sharing tools and sources

Terminals do not have access to the information provided in HaMIS. All information on incoming voyages must be provided to the terminal operators by the vessel agents and shipping companies. The terminals use their own planning systems for making the planning. The resource planner uses phone and e-mail for communication with the vessel agent. For communication with other parties, phone communication is used.

Information shared in the planning process

Figure 7.4 shows the BPMN conversation diagram (see Appendix F) of the terminal planning. A description of the diagram is provided in this section. Most conversations involve bilateral communication. The exceptions, in which only unilateral communication takes place, are indicated with an 'arrow sign'. Conversations in which the linked actor does not take part, but only listens to the conversation as an information source, are indicated with an 'ear sign'.

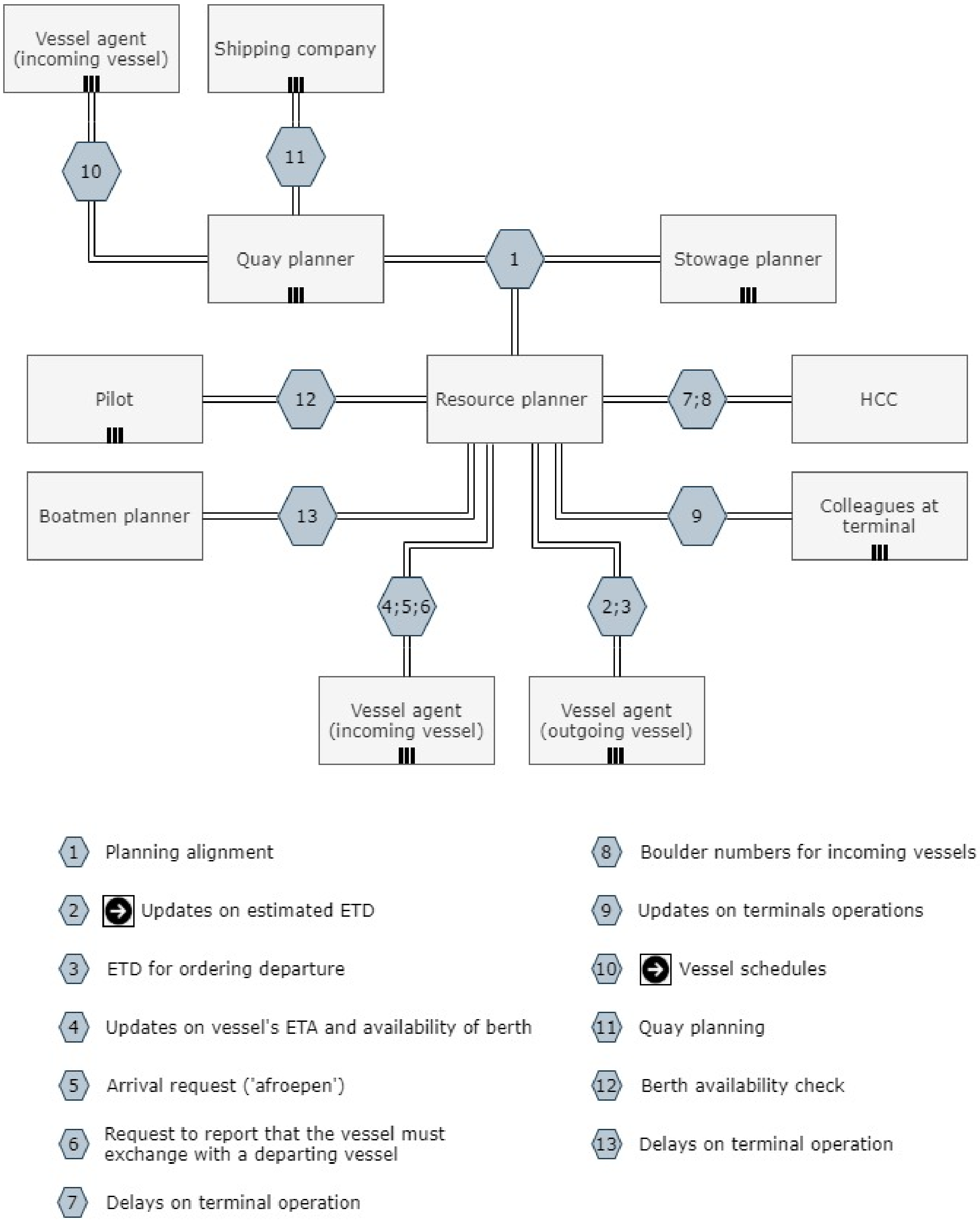


Figure 7.4: BPMN conversation diagram: terminal planning

- **Conversation 1,10,11:** The resource planner, the quay planners and stowage planners are located in the same room and communicate with each other in order to align the planning [1]. A change in the stowage planning might affect the quay planning and vice versa. The resource planner continues with the planning made by the quay and stowage planners. The resource planner links any changes that occur in the last 8 hours before arrival of a vessel back to the stowage and quay planning. The initial quay planning is based on a request of the shipping company [11]. The more the arrival date approaches, the more accurate the quay planning becomes. Closer to the scheduled arrival date, vessel schedules are shared by the vessel agent (in behalf of the shipping company) with the quay planning [10].

- **Conversation 4,5,6,7,8 :** Around 8 hours before arrival of a vessel, the resource planner takes over the contact with the vessel agent of an incoming vessel from the quay planners. The resource planner checks with the vessel agent if the arriving vessel is on schedule [4]. If not, there might be time to schedule an extra barge in the mean time. On the other hand, updates on the berth availability from the terminal side are shared with the vessel agent [4]. If the berth is available later than had been agreed on, the resource planner informs the vessel agent of the incoming vessel on the delay (and sometimes also the HCC[7]). This communication with the vessel agent is executed via phone or e-mail. As soon as the berth is (or will be) available, the resource planner informs the vessel agent of the incoming vessel that the vessel is allowed to come for the quay (in Dutch: 'afroepen'). The resource planner informs the vessel agent about the boulder numbers and if the vessel must arrive star- or larboard at the quay. The resource planner shares this information by phone and confirms the conversation with an e-mail to the vessel agent [5]. The same holds when a vessel must 'exchange' with a departing vessel [6]. The vessel agent is responsible for reporting the provided information via the PCS to the Harbour Master. Since experience shows that miscommunication on the boulder number occurs, the resource planner also has contact with the HCC (ADO incoming) about the boulder numbers [8].

- **Conversation 2,3,9:** The resource planner informs the vessel agent of an outgoing vessel on the requested ETD [3]. This requested ETD is based on timelines that are provided by the stowage planning and on additional information collected from colleagues at the terminal (e.g. status update of the lashing activities on board of the vessel) [9]. The requested ETD is communicated with the vessel agent by phone contact [3]. The vessel agent of the departing vessel might request a delayed ETD, due to e.g. bunker activities. Before ordering the vessel for departure, the resource planner provides the vessel agent of the outgoing vessel with updates on the estimated ETD via e-mail [2].

- **Conversation 12:** The pilot of an incoming vessel sometimes calls the resource planner to check the berth availability. The pilot might have received information from the boatmen about a barge occupying the quay [12].

- **Conversation 13:** In some cases, the resource planner calls the boatmen planner of the region to inform the boatmen on delayed terminal operations [13]. The boatman planner can use this information to optimize the planning and will probably share the information with the pilots.

7.5. Harbour Master planning

The Harbour Master planning is executed at the HCC and the Vessel Traffic Center at Hoek van Holland. At the HCC, the long term planning of all vessel traffic in the Port of Rotterdam is coordinated. The ADO's, the DO HCC, the DO VTS and Pilot Service Leader are all located at the HCC and fulfill their role in the planning process. The ADO's assess the vessel reports of both incoming and outgoing voyages that are provided by the vessel agents. The DO HCC is end responsible for the assessment of the admission policy and the long term planning of the vessel traffic in the Port of Rotterdam. The DO HCC, in cooperation with the Pilot Service Leader, focuses on the planning of vessels bounded by length and draft (semi-geulers and geulers) and LNG tankers. This type of vessels asks for their attention, because these vessels are not able to pass each other or turn around within the port area. For incoming voyages, part of the clearance process is executed by the VTS operator of the Maas Approach sector. The VTS operator of Maas Approach is the VTS operator of the first sector of the Port of Rotterdam and located at the Vessel Traffic Center in Hoek van Holland. After an ETA Pilot Station is given for an incoming vessel or a confirmed ETD is given for an outgoing vessel, the HCC planning is fixed. Then, the execution of the planning is taken over by the VTS. The DO VTS and DO HCC are located next to each other. In this sense, the transition between the strategic planning (DO HCC) and tactical planning (DO VTS) can be communicated easily.

Planning of incoming voyages

The planning process at the HCC starts when a vessel agent reports a voyage (at least 24 hours before ETA). The ADO's responsible for incoming voyages start with the assessment of the reported voyage by checking if the reported details (e.g. length of a vessel, draft of a vessel, cargo carried) are suitable for the reported destination and comply with the regulations. Furthermore, the ADO's check if the vessel requires a tidal window. When all vessel- and voyage details are known and confirmed, the vessel approaches the VTS sector of Maas Approach. In the Maas Approach area, the vessel captain makes operational contact via the VHF channel with the VTS operator of Maas Approach. During the first operational contact, the VTS operator of Maas Approach checks some of the registered details (e.g. the draft of the vessel) with the vessel captain. Additionally, the VTS operator is informed by the vessel captain if the vessel has any instructions from his vessel agent to remain outside. In case the vessel wants to remain outside, the VTS operator of Maas Approach gives the vessel the 'operational contact' status in HaMIS, but does not register an ETA PS. In case the vessel wants to enter the port area, the time that the vessel expects to be at the appointed pilot station (see Appendix H for the pilot station locations) is asked to the vessel captain. Before the ETA PS is registered in HaMIS, the VTS operator of Maas Approach checks if the destined berth of the incoming vessel is available (or that the vessel at the berth is ordered for departure) and if the incoming vessel has a tidal window. In case the requirements for entering the port area are not met, the requested ETA PS is delayed. Everything must be approved and arranged before a vessel leaves the Maas Approach sector.

Planning of outgoing voyages

The vessel reports of outgoing vessels are assessed by the ADO's responsible for departing voyages. When all vessel- and voyage details are assessed and the vessel is ordered for departure by the vessel agent, the HCC must give its final approval. In case one of the nautical service providers proposes a delayed ETD via GIDS, this new ETD is available in HaMIS and must receive approval of the HCC again. When a vessel is ready for departure, the boarded pilot reports to the DO VTS that the vessel is ready for departure. The DO VTS must provide operational clearance before a vessel is allowed to leave.

Information sharing tools and sources

The main information source that is used for the Harbour Master planning is the HaMIS system. The Harbour Master employees (HCC and VTS) are able to register and adjust information in the HaMIS system. The registered information becomes available in the HaMIS version of the nautical service providers. This makes that the HaMIS system is not only an information source for the Harbour Master, but also a communication tool. Additionally, phone communication is used for communication with other parties involved. The VTS operator of Maas Approach also communicates with the HCC via phone and vice versa. Also, the VTS operator of Maas Approach uses the VHF channel of the Maas Approach sector to communicate with the vessels in the sector. Lastly, the DO VTS uses VHF channel 11 to provide operational clearance to departing vessels.

Information shared in the planning process

Figure 7.5 shows the BPMN conversation diagram (see Appendix F) of the Harbour Master planning at the HCC. Figure 7.6 shows the BPMN conversation diagram of the VTS operator of Maas Approach. Most conversations involve bilateral communication. The exceptions, in which only unilateral communication takes place, are indicated with an 'arrow sign'. Conversations in which the linked actor does not take part, but only listens to the conversation as an information source, are indicated with an 'ear sign'. A description of the diagrams is provided in this section. For a visualization of the sub-conversations, see Appendix G.

- **Conversation 2,5:** The DO HCC has a short communication line with the DO VTS [5]. The DO's are both experienced with the port planning process, which provides the possibility to discuss striking traffic situations together. Also, traffic situations that are on the edge of the long term and short term planning are discussed to align the macro planning with the micro planning. Additionally, the more complicated planning cases are also discussed with the Pilot Service Leader. For example, LNG tankers and (semi-)geulers must be piloted at sea with the helicopter. The DO HCC and Pilot Service Leader together make the voyage plan for these type of vessels. The Pilot Service Leader checks with the pilot planning if the required pilots and resources are available [2].

- **Conversation 3,4,11:** The voyage reports and orders are first assessed by the ADO's. These reports are provided by the vessel agent in the PCS and available for the Harbour Master employees via HaMIS [11]. The DO HCC has contact with a vessel agent in case of any exceptions, for example an incoming vessel with engine problems [4]. The DO HCC is located close to the ADO's, so in case of any doubts or uncertainties, the DO HCC asks the ADO's for comments [3].

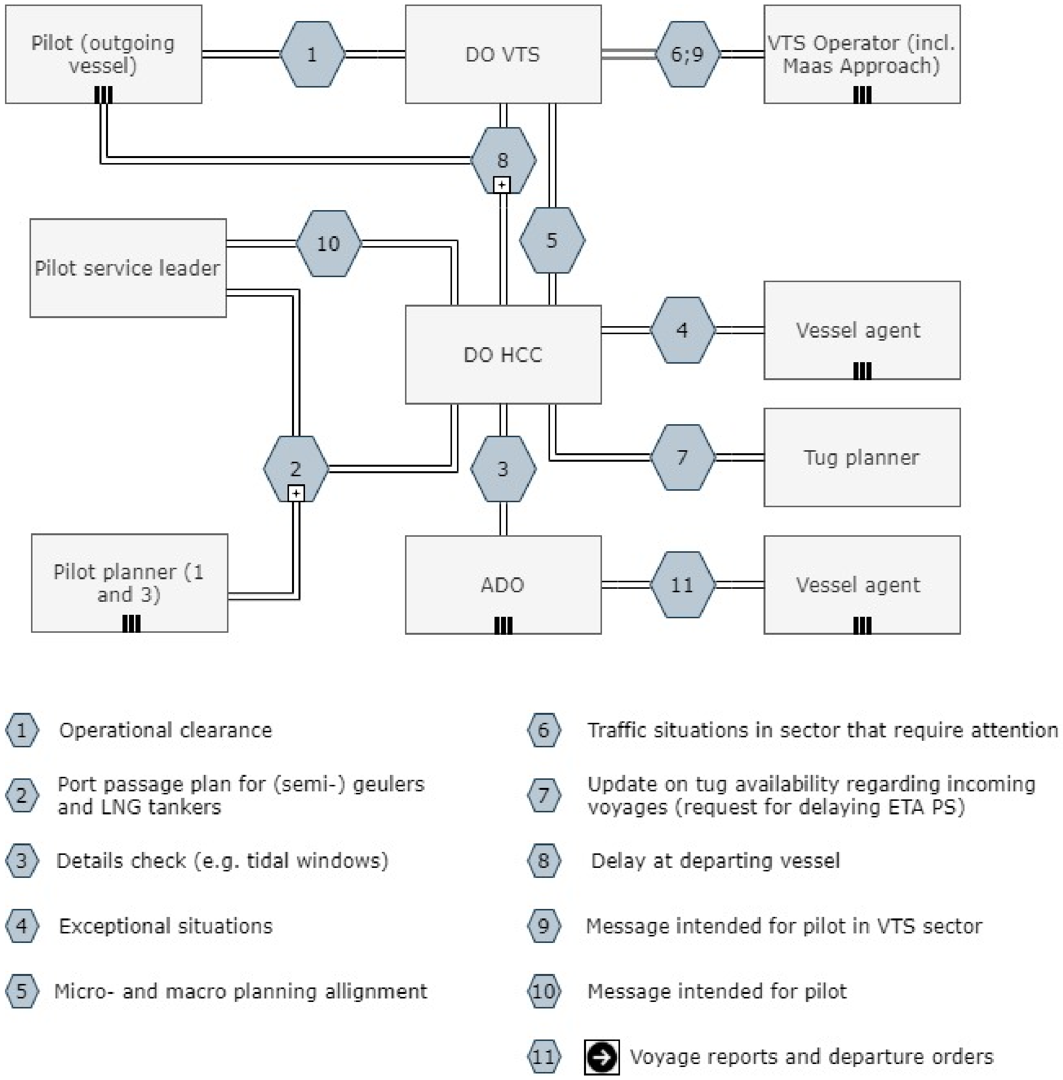


Figure 7.5: BPMN conversation diagram: HCC planning

- **Conversation 1:** Departing vessels must report to the DO VTS via VHF channel 11 that they are ready for departure. Before a vessel is allowed to depart, the DO VTS must provide operational clearance. Also, any delays at a departing vessel must be communicated from the boarded pilot to the DO VTS via VHF channel 11. For the Harbour Master, only delays of more than 30 minutes are considered as a delay. This means that the pilot must depart within 30 minutes after receiving operational clearance [1].

- **Conversation 6,8,9,10:** In case a delay might cause a critical traffic situation, this delay is communicated with the DO HCC [8]. The DO HCC and DO VTS check the consequences of the delayed departure. This check is mostly done with regard to the relatively bigger vessels. One of the consequences can be that an arriving vessel destined for the berth of the delayed outgoing vessel can not enter the port area. This message must be communicated with the pilot on board of the arriving vessel. This message is either shared with the boarded pilot via the Pilot Service Leader [10] or via the VTS operator of the sector in which the arriving vessel is sailing [9]. Communication with the VTS operator is (officially) always executed via the DO VTS [6].

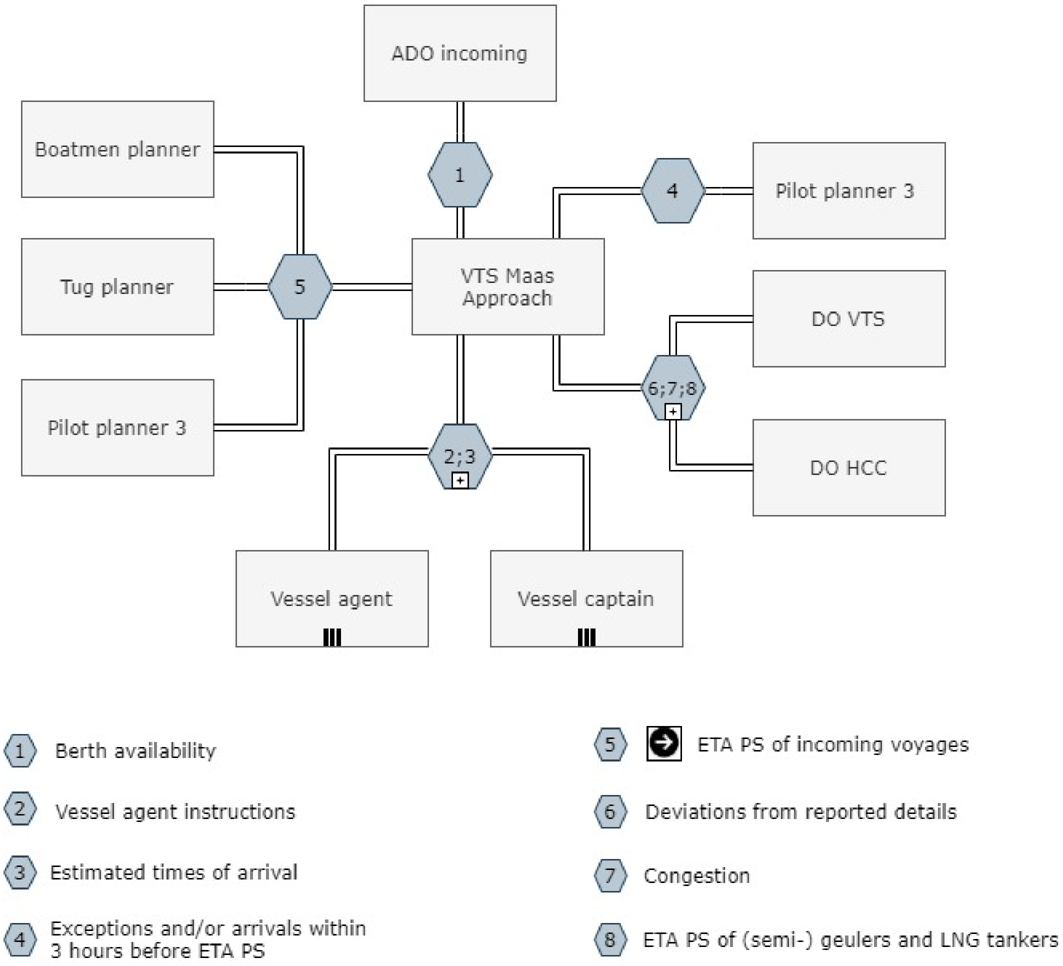


Figure 7.6: BPMN conversation diagram: VTS Maas Approach planning

- **Conversation 1,6:** The VTS operator of Maas Approach contacts the ADO's responsible for incoming voyages in case the berth of an incoming vessel is not available or ordered for departure when an incoming vessel makes the first operational contact [1]. Additionally, in a situation in which it appears that the details discussed with the vessel captain deviate significantly from the registered details in the vessel report, the VTS operator of Maas Approach contacts the HCC. This communication starts with a phone call to the DO VTS, who can discuss the situation with the DO HCC [6].

- **Conversation 7:** When either the VTS operator of Maas Approach, the DO HCC or DO VTS notices that the waterway capacity is insufficient for a safe and smooth port passage, the situation is discussed at the HCC. For example, vessels (especially the larger vessels) must have a sufficient distance from each other and can not all have the same ETA PS. If necessary, the VTS operator of Maas Approach is asked to delay certain ETA PS's [7].

- **Conversation 8:** The ETA PS of (semi-)geulers and LNG tankers (these vessels must receive their ETA PS before operational contact is made, see Appendix H) is not determined by the VTS operator of Maas Approach, but by the port passage plan made by the DO HCC and Pilot Service Leader. The DO HCC communicates the requested ETA PS that follows from the port passage plan to the DO VTS. The DO VTS calls the VTS operator of Maas Approach to request if the VTS operator can register the ETA PS for the incoming vessel. In practice, this communication is not always being executed via the DO VTS, but also directly from the DO HCC to the VTS operator of Maas Approach [8].

- **Conversation 2,3:** Instructions from a vessel agent are either communicated to the VTS operator of Maas Approach by the vessel captain when making the first operational contact or the vessel agent provides its instructions to Dirkzwager (see chapter 6 for more information on the Dirkzwager activities).

Vessel instructions that are provided via Dirkzwager are available for the VTS operator via HaMIS, which only involves unilateral communication. Subsequently, the vessel instructions are communicated from the VTS operator to the vessel captain when the first operational contact is made [2]. Besides the vessel instructions, the vessel agent shares the ETA MC (see Appendix H for the different ETA locations) of a vessel. The vessel agent must be updated by its vessel captain on the accurate ETA of the vessel and provides this information via the PCS [3].

- **Conversation 4,5:** As soon as the VTS operator of Maas Approach gives a vessel the 'in operational contact' status in the HaMIS system and a specific pilot station with an ETA PS, this details are available for the nautical service providers in their own HaMIS version [5]. Since the pilots need time to transport a pilot to the location at sea, the VTS operator of Maas Approach calls the pilot planning when the ETA PS is registered within less than 3 hours before the ETA PS [4]. This is mostly the case with vessels coming from the anchorage area. When the pilot organization is not able to deliver on the short term, the ETA PS of the incoming vessel is delayed by the VTS operator of Maas Approach. The registered ETA PS is also shared with the vessel agent (via HaMIS to the PCS). In this way, the vessel agent can notice any unplanned activities due to misunderstood instructions [5].

7.6. Conclusion

The discussed BPMN diagrams in the previous sections provide insight into the information sharing of the different actors in the planning domain of the nautical chain. Conclusions that are drawn from these insights are:

- Some of the conversation links represent a conversation that links the planning domain with the operational domain. For example, the tug planner that updates the pilot planners and pilot an a delayed tug arrival. This leads to the conclusion that the planning phase of one actor overlaps with the operational phase of another actor. For incoming voyages, the pilot operations start before the tug planner and boatmen planner make their planning. For outgoing voyages, the tug planner and pilot planners have the same time to define their planning. However, the tug planner and pilot planner finish their planning before the boatmen planner makes his planning. This difference in the planning moment can be accounted to the fact that each nautical service provider fixes its planning at the minimum time in advance.

- The main communication mode used for communication between the planning departments of different actors is the phone. Communication within an organization is mainly executed via internal VHF channels. However, the pilot planners are in contact with their pilots via phone. This also means that most links involve bilateral communication. Although the main message is shared from the one actor to the other (e.g. the job assignment from the pilot planner to a pilot), the receiver of the message is always able to directly ask for clarification.

- The boatmen planner has more information available on the pilot planning in comparison to other actors, due to the pilot transportation activities. The boatmen planning is immediately updated when a pilot is assigned for a departing vessel, because the pilot transportation is requested. This link between the pilots and the boatmen is also noticed by the terminal. The terminal sometimes communicates a delay on terminal operations with the boatmen planning assuming that the boatmen will pass the message on to the pilot planning.

- The actors that are considered as the actors of the nautical chain work with the same information sources, except for the terminal operator. The Harbour Master and nautical service providers use the HaMIS system which is supplied with information from the PCS. The terminal operators do not have access to HamIS or to the vessel report that are provided by the vessel agent via the PCS, but only communicate with the vessel agents and shipping companies via phone or e-mail contact. Information that is provided by the terminal must be processed in the PCS by the vessel agent. The terminal operators are not able to check if the shared information is correctly registered in the PCS.

8 Information sharing in the operational domain of the nautical chain

In this chapter the third sub-question '*How does information sharing in the operational domain of the nautical chain of the Port of Rotterdam proceed?*' is answered. For a visualization on the activities of the operational domain of the nautical chain see Figure 6.8 and Figure 6.9 in chapter 6.

The information used for answering this sub-question is gathered through interviews with the boatmen, pilots, tug operators and VTS operators and observations of their operations in practice. The information obtained from interviews is presented in Appendix C. The information obtained from observations is presented in Appendix B.

In the operational domain, the events do not always proceed as has been agreed on in the planning domain. The variability in the operational domain of the nautical chain is discussed in more detail in section 8.1. When analyzing the information sharing between actors in the operational domain of the nautical chain, the fact that operations in the nautical chain are subject to variability should be included. Therefore, the situations that occur in the operational domain are analyzed and translated into 'operational situations'. These situations are discussed in section 8.2 for both incoming and outgoing voyages. The 'operational situations' are used to create a complete overview of the operational information sharing. section 8.3 provides details on the information sharing in the operational domain from the perspective of the pilots, the boatmen, the tug operators and the VTS operators. The chapter ends with a conclusion in section 8.4.

8.1. Variability in the operational domain

The processes of the nautical chain have to deal with variability. This variability can be linked to variability in the pattern of arriving and departing vessels as well as uncertainty regarding the service time of the processes (Ascencio et al., 2014). Additionally, an unexpected event in the beginning of the nautical chain could have a cascade effect down the chain of events, because multiple actors and processes are dependent on each other. A factor that enhances variability in the service times of processes is that complex systems, such as port logistics, are sociotechnical systems. In a sociotechnical system, humans are essential to facilitate process operations and decision making (Zhang et al., 2015). Humans make decisions on knowledge-based or rule-based behaviour. Within the operational domain of the nautical chain, decisions are mostly based on knowledge-based behaviour. While rule-based behaviour is based on specific rules that can be generically applied, knowledge-based decisions differ per person (Rasmussen, 1983).

At the same time, the nautical chain can be referred to as a complex system. The context of a complex system can be divided into three elements, namely: humans, the physical system and the environment (Zhang et al., 2015). The complexity of a system can not be accounted only to the operating environment, the system itself or the human activities, but also depends on the interaction between these three elements. With regard to the nautical chain, the three elements can be translated into the following:

- **Physical system:** All sub-processes that are executed in the operational domain of the nautical chain.
- **Humans:** All individual actors that operate in the operational domain of the nautical chain.
- **Environment:** External weather conditions and influences. This includes the variability in the demand of arriving vessels.

As visualized in Figure 8.1, these three elements continuously interact with each other and themselves. For example, a pilot interacts with a tugboat captain (human-human interaction) and the performance of the tugboats influences the mooring process (subprocess-subproccess interaction).

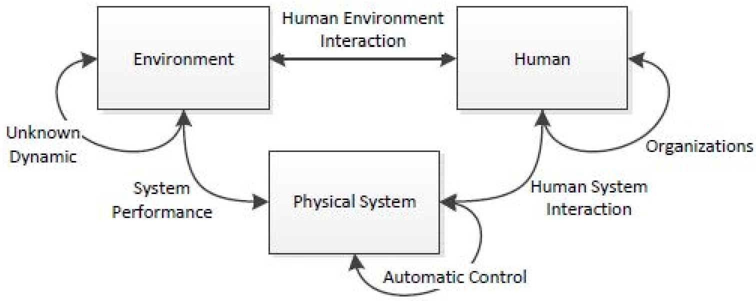


Figure 8.1: The elements of a complex system [adapted from Zhang et al. (2015)]

From Figure 8.1, it can be concluded that the sub-processes of the nautical chain (physical system) are influenced by the actors of the nautical chain (humans) and the environment. How the actors and the environment exactly influence the sub-processes is unknown. However, the impact of these influences on the physical system is reflected by a disruption in the sub-processes. In case the impact of such a disruption is large enough, the disruption becomes visible in a delay. Therefore, the delays that occur in the nautical chain are investigated to identify different states of the physical system. Consequently, these different states of the physical system cause certain actor behaviour (including information sharing). The different states of the physical system are referred to as the 'operational situations'.

8.2. Analysis of the situations that occur in the operational domain

To identify the 'operational situations', the situations that are regularly noticed in practice are determined based on the delays that have occurred. Data from October 2018 till October 2019 on incoming and outgoing voyages, incoming and outgoing voyages with pilot guidance and incoming and outgoing voyages with a recorded delay are used. Details on the data analysis are provided in Appendix E.

The main conclusion from the data analysis is that the percentage of recorded delays is low, especially with regard to the incoming voyages. An explanation for the low percentage can be found in the method for recording the delays. Delays for both the incoming and outgoing voyages are manually recorded in the HaMIS system. This means that a delay is only recorded as a delay if the responsible DO considers the situation as a delay. Furthermore, there is a major difference between the number of recorded delays for an incoming and outgoing voyage. For outgoing voyages, the vessel agent must 'order' the vessel voyage (see chapter 6). The difference between the ATD and the ETD provided with the voyage order is clear. This specific 'order' moment is not applicable to incoming voyages. This allows the ETA to be updated until the vessel almost enters the Maas Approach sector of the Port of Rotterdam. This makes the recording of outgoing delays more straight forwarded in comparison to incoming delays. When the ETD of an outgoing vessel has passed, the HaMIS system marks the voyage yellow. The delay window that can be opened by the responsible DO proposes the delay time of the vessel based on the difference between the ETD and the current time. The DO can accept or adapt the delay time and add a delay cause. Incoming delays are assessed based on a noticed reason for a delay. Subsequently, the delay time is approximated.

Overall can be stated that the available data on delays contains inadequacies. Therefore, it is important to clarify that the data is used to either confirm or deny that an event is occurring in practice, without including specific numbers. The available data provides a delay cause for all the recorded delays. This delay cause might not be the initial cause of a certain delay, but it is sure that a disruption in the specific event has been noticed. The used data, together with expert knowledge, leads to an examination of which events occur in practice. The occurrences of these events indicate the different states of the physical system of the nautical chain, which are translated to the 'operational situations'. The operational situations that are considered for an incoming voyage are discussed in subsection 8.2.1. The operational situations that are considered for an outgoing voyage are discussed in subsection 8.2.2.

8.2.1. Operational situations for incoming voyage

The first event in the operational domain where a delay can be noticed is the pilot boarding the vessel. Then, before the pilot enters the port area, it must be assured that the other services can be delivered as has been agreed on and that the berth is available. It is assumed that when the tugboats and the boatmen confirm their availability before the pilot enters the port area, the tugboats arrive on time and the boatman are available at the terminal. The same holds for the confirmation of the berth availability. This means that the next possible delays occur when the tugboats must confirm their availability, when the boatman must confirm their availability or when it must be confirmed that the berth is available.

In summary, the following event nodes are relevant to consider with regard to the occurring operational situations: pilot boards vessel (A), tugs available when vessel enters port area (B), boatmen available at the berth (C), berth available when vessel approaches (D) and vessel moored at terminal (E). Events that are executed later than planned can cause a delay for the arrival of the vessel at the terminal. Another effect of a delay at a specific node can be that the availability of the other services providers is not assured anymore. Figure 8.2 provides a visualization of the considered events and relations between them.

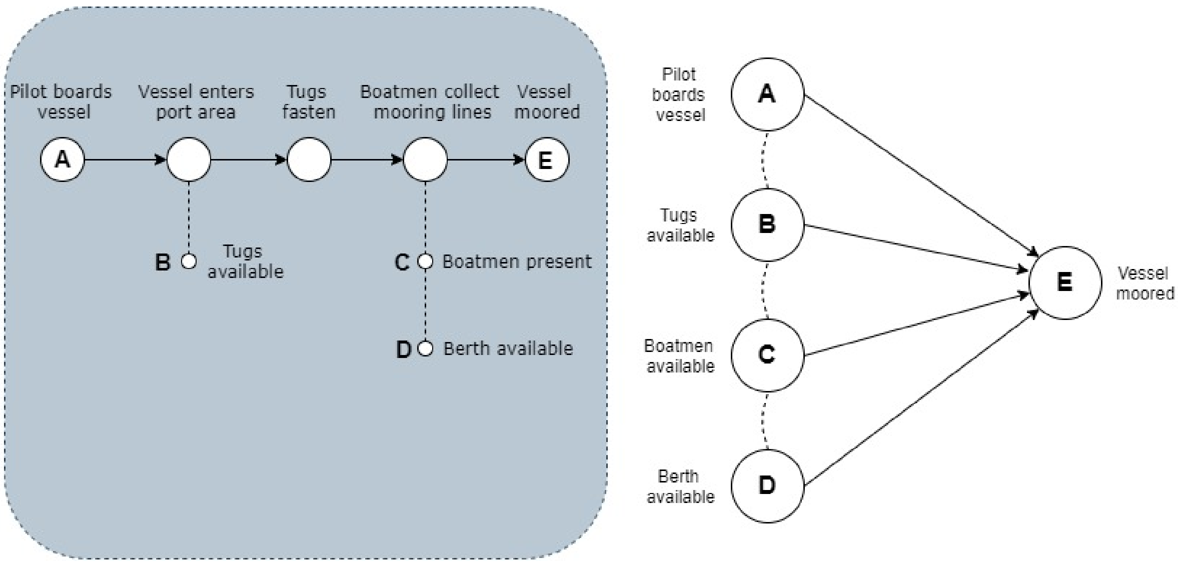


Figure 8.2: The event nodes of an incoming voyage to consider with regard to the occurring operational situations

From data analysis, it is concluded (see for a detailed description on the data analysis Appendix E) that the disruptions noticed in practice mainly occur at event node A (pilot boarding), B (tug availability) and D (berth availability). It is assumed that a disruption in any of these nodes always leads to a delay at event node E (vessel moored). An overview of the operational situations that follow is shown in Figure 8.3.

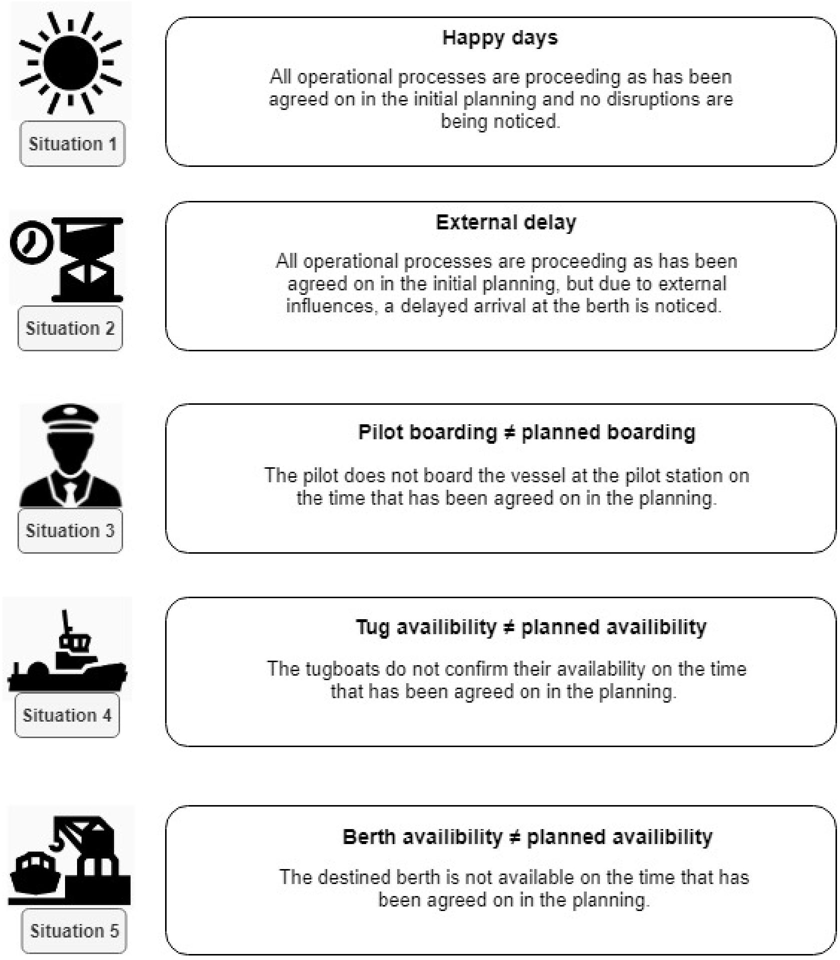


Figure 8.3: The operational situations of an incoming voyage

8.2.2. Operational situations for outgoing voyage

Similar to the incoming voyage, delays and disruptions can occur at different event nodes. Contrary to an incoming voyage, it is not necessary to assure that all service providers are still available on the initial planned departure time (PTD). In fact, all service providers must be present at the same time and location before the vessel can start its departure. An additional requirement before leaving is that the (un)loading operations of the terminal are finished.

In summary, the following event nodes are relevant to consider with regard to the occurring operational cases: pilot boards vessel (A), tugs present (B), boatmen present (C), terminal operations finished (D) and vessel leaves berth (E). Events that are executed later than planned can cause a delay for the departure of the vessel and for the arrival of an other vessel by occupying the berth longer than planned. Another effect of a delay at a specific node can be that the availability of the other service providers is not assured anymore. Figure 8.4 provides a visualization of the considered events and relations between them.

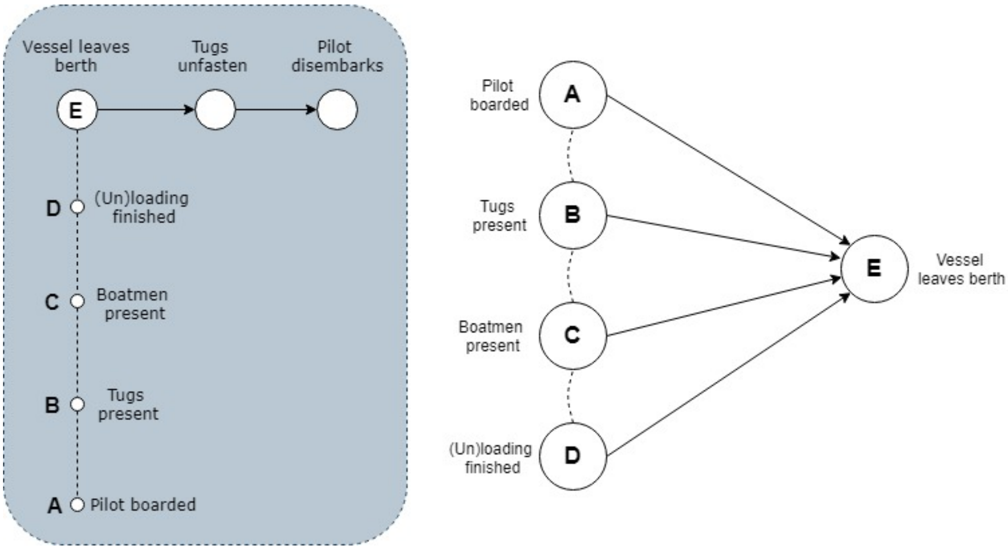


Figure 8.4: The event nodes of an outgoing voyage to consider with regard to the occurring operational situations

From data analysis, it is concluded (see for a detailed description on the data analysis Appendix E) that the disruptions noticed in practice mainly occur at event node A (pilot boarding), B (tugs present) and D (loading finished). It is assumed that a disruption in any of these nodes always leads to a delay at event node E (vessel leaves berth). An overview of the operational situations concluded from the data analysis is shown in Figure 8.5.

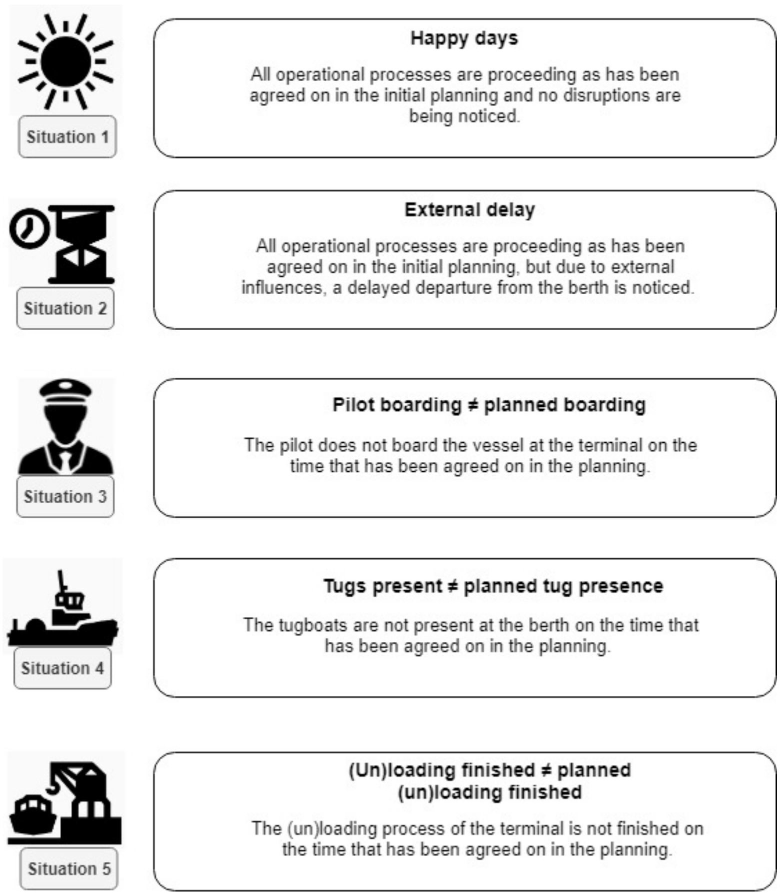


Figure 8.5: The operational situations of an outgoing voyage

8.3. Information sharing in the operational domain

In this section, a description of the information sharing of the pilots, the tugboats, the boatmen and the VTS operators in the operational domain of the nautical chain is provided. Each section includes a general description of the communication tools that are used. Additionally, an overview of the information sharing links is provided and discussed for each of the included 'operational situations' (see section 8.2 for a description of the operational situations).

8.3.1. Pilot

The pilot uses different modes of communication. The nautical VHF channel is used for communication with the nautical service providers in the same region. The VHF channel of the sector is used for communication with the VTS operator of the sector. VHF channel 11 is used to ask the DO VTS for operational clearance for departure. Furthermore, phone contact is used for communication with pilot colleagues. If a pilot colleague is located in another VTS sector, phone contact is the only possible communication mode. If pilots are located in the same region, the nautical VHF channel or sector VHF channel can be used as well. The pilot also uses the phone for communication with the pilot planners and tug planner. However, messages between the tug planner and the pilot can be shared via the GIDS system as well. For an incoming voyage, the number of ordered tugs is send by the pilot to the tug planner via GIDS. The pilot receives a confirmation on the ordered tugboats via a text message generated by GIDS.

Information shared in the pilot process

Figure 8.6 shows the BPMN conversation diagram (see Appendix F) of the pilot process for both incoming and outgoing voyages. Each letter (A till K) represents multiple conversations, which are described in this section for each operational situation. Most conversations involve bilateral communication. The exceptions, in which only unilateral communication takes place, are indicated with an 'arrow sign'. Conversations in which the linked actor does not take part, but only listens to the conversation as an information source, are indicated with an 'ear sign'.

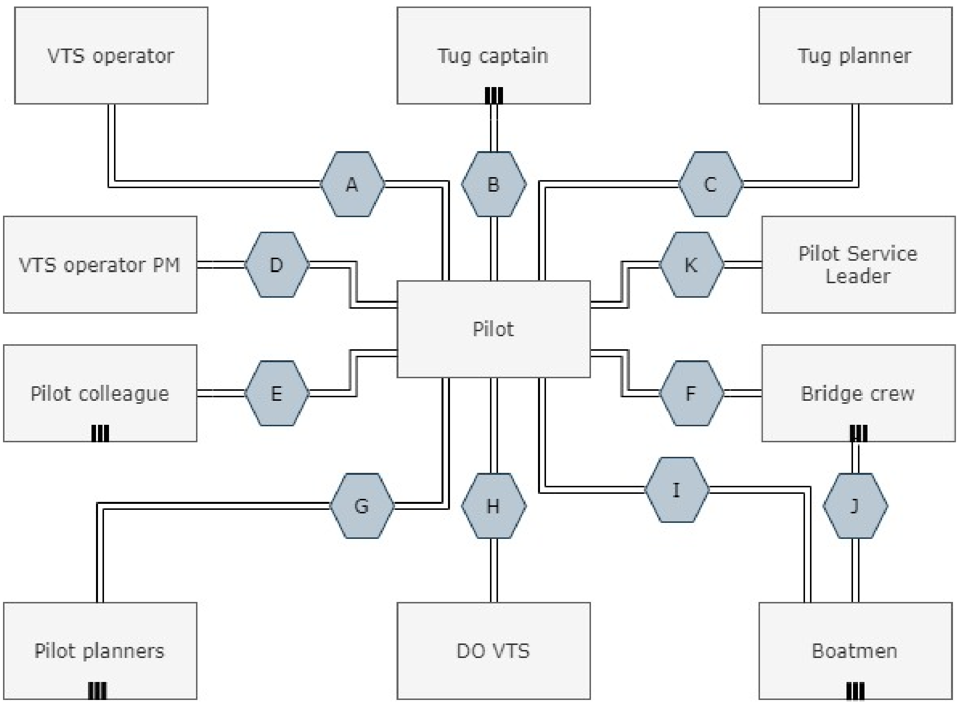


Figure 8.6: BPMN conversation diagram: pilot

The next overview presents the conversations that take place in **situation 1 (happy days)** for an incoming and outgoing voyage. A pilot boards the vessel and communicates with the bridge crew of the vessel. This communication is executed face-to-face. The pilot asks the bridge crew to test the engine and discusses the tug arrangement with the vessel captain. During the voyage, the pilot gives orders to the bridge crew on the power and direction of the vessel. Furthermore, the pilot communicates orders for navigation and manoeuvring to the tugboat(s) and the boatmen via the nautical VHF channel. The pilot is in contact with all tug captain(s) and boatmen that are located in the same VHF region via this VHF channel. Therefore, when calling each other via the nautical VHF channel, the name of the vessel, the location of the vessel or the name of the tugboats is mentioned to make clear to which vessel the communication refers. Via the VHF channel of the sector, the pilot informs the VTS operator of the sector on the departure. During the voyage, the VTS operator provides the pilot with information on the dynamic traffic situation. For incoming voyages, the VTS operator of the Pilot Maas sector is updated when the pilot boarded the vessel. Next to the VTS operator of the sector, the DO VTS is always asked for permission for departure. For incoming voyages, the pilot is only in contact with the DO VTS if exceptional situations occur. Communication with the DO VTS, who is located at the HCC, takes place via VHF channel 11. Lastly, the pilot is in contact with the pilot planning department and the tug planner. The pilot planning communicates possible next job assignments to the pilot. The tug planner receives the tug order from the pilot via GIDS. When the specific tugboats are assigned by the tug planner, the pilot receives a confirmation and details of the specific tugs via a text message.

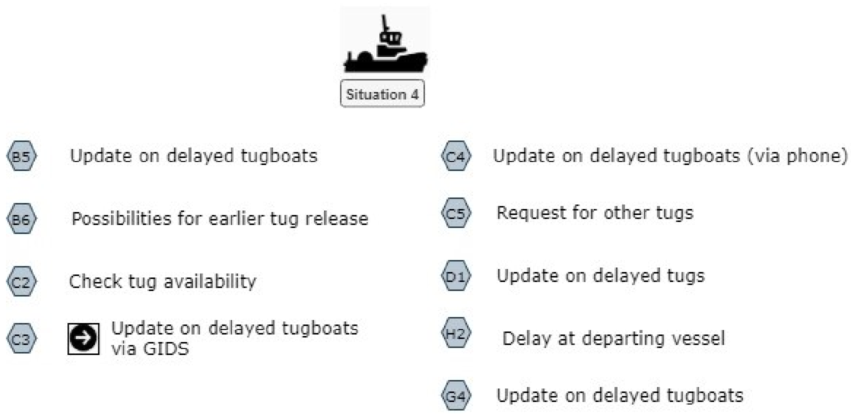
- A1 Departure notification
- A2 Traffic information
- B1 Tug arrangement
- B2 (Dis)connecting tugs instructions
- B3 Tug orders
- C1 Tug order and confirmation
- D1 Pilot boarded update
- F1 Engine test
- F2 Power and direction orders
- F3 Tug arrangement
- G1 Voyage details (e.g. boarding time, vessel draft, ETA LL)
- G2 Next job assignment
- H1 Operational clearance (departure)
- I1 Instructions to release mooring lines
- I2 Mooring arrangement and pilot drop off location

The next overview presents the conversations that take place in **situation 2 (external delay)** for an incoming and outgoing voyage. In case that a crowded traffic situation requires attention, the VTS operator provides information to the pilot. However, pilots also contact each other to gather information and discuss specific situations. Pilots decide, for example, which vessel departs or enters first or where the vessels can safely pass each other. This discussion can take place via the nautical VHF channel when the pilots are in the same region. Communication via the nautical VHF channel can be followed by other nautical service providers in the region. Communication between pilots also takes place via phone contact. Decisions made after contact between pilots should be communicated on the VHF channel of the sector. In this way, the agreement becomes 'official' and available for other traffic in the sector and the VTS operator. Lastly, in case of a delay, the pilot tells the tug captain(s) how much delay time they can record.

- A2 Traffic information
- A3 Agreements made via phone contact between pilots
- B4 Delay time that can be registered
- E1 Traffic situations and decisions (via phone or VHF)
- H2 Delay at departing vessel

The next overview presents the conversations that take place in **situation 3 (pilot boarding time not equal to planned boarding time)** for an incoming and outgoing voyage. When a pilot knows that he will arrive delayed at his pick up location or at the vessel, the pilot contacts the pilot planning. The pilot planners can decide whether it is necessary and possible to send another pilot or to inform the other nautical service providers. Since the boatmen arrange the pilot transportation, the boatmen are aware of the delayed pilot. The delay either occurs while the pilot is next to a boatman in the taxi or the boatman notices that the pilot is late for the pick up. The pilot can ask the boatman in the taxi to inform his colleague boatmen at the quay and ask if they can inform the bridge crew.

The next overview presents the conversations that take place in **situation 4 (tug availability not equal to planned tug availability)** for an incoming and outgoing voyage. When the tugboat(s) are in the same VHF region as the vessel, the tug captain communicates a delay of the tugboats via the nautical VHF channel with the pilot. If the delay earlier occurs, the pilot is informed on the delayed tugs by the pilot planners (who are informed by the tug planner) or directly by the tug planner. The latter can happen via a phone call or via a message in GIDS. The message includes from which vessel the assigned tugboats must arrive and the ETD or ETA LL (see Appendix H) of that specific vessel. Especially with incoming voyages, the pilot wants to be sure that the tugboats arrive on time. When the pilot does not see the tugboats on the AIS chart, the pilot calls the tug planner to check the tugboat status. For incoming vessels, the VTS operator of the sector Pilot Maas (this VTS sector is managed by a pilot) provides additional nautical info, such as delayed tugboats. For outgoing voyages, a delay of more than 10 minutes is communicated to the DO VTS. For incoming voyages, the pilot updates the recorded ETA LL when the delay is more than 10 minutes. The pilot planning is also updated on the occurring delay.



The next overview presents the conversations that take place in **situation 5 (berth availability/terminal operations not available/finished as planned)** for an incoming and outgoing voyage. When the VTS operator of the sector is aware of the fact that the berth of an incoming vessel is occupied by a barge, the VTS operator informs the pilot of the incoming vessel. In case the consequences of the situation are complicated, the VTS operator asks the pilot to come to channel 11 and discuss the situation with the DO VTS and possible other traffic participants. When a pilot of an incoming vessel is informed on an occupied berth by a barge, the pilot contacts the boatmen when approaching the quay. The boatmen on the quay can check the situation with the terminal and update the pilot of the incoming vessel. It also happens that the boatmen are the first who notice a barge occupying the berth. In that case the boatmen inform the pilot of the incoming vessel and take action at the terminal. A delay at a departing vessel is communicated with the DO VTS. The DO VTS can discuss the situation with the DO HCC. In case the delay causes that an incoming vessel must wait with entering the port area, the pilot of the incoming vessel (or vessel captain in case the vessel is still in the Maas Approach sector) is informed via the VTS operator or the Pilot Service Leader. Then, the pilot of the incoming vessel calls the pilot of the outgoing vessel. The pilot of the incoming vessels asks the expected ETD and manoeuvre of his colleague.

8.3.2. Tugboat operators

Each tugboat has 3 crew members, namely: a captain, a mate and an engineer. The captain is in charge of the operations and communication, the tug mate assists on deck when (dis)connecting the tugboats and the engineer is responsible for all equipment on board. The crew members have a short face-to-face communication link. Furthermore, hand signals are used for communication with the deck crew. The tug captain uses the nautical VHF channel for communication with the pilot. Except for his own communication, the tug captain listens to communication between other nautical service providers in the sector. Lastly, the tug captain uses an internal VHF channel for communication with the tug planner.

Information shared in the tug process

Figure 8.7 shows the BPMN conversation diagram (see Appendix F) of the tug process for both incoming and outgoing voyages. Each letter (A till G) represents multiple conversations, which are described in this section for each operational situation. Most conversations involve bilateral communication. The exceptions, in which only unilateral communication takes place, are indicated with an 'arrow sign'. Conversations in which the linked actor does not take part, but only listens to the conversation as an information source, are indicated with an 'ear sign'.

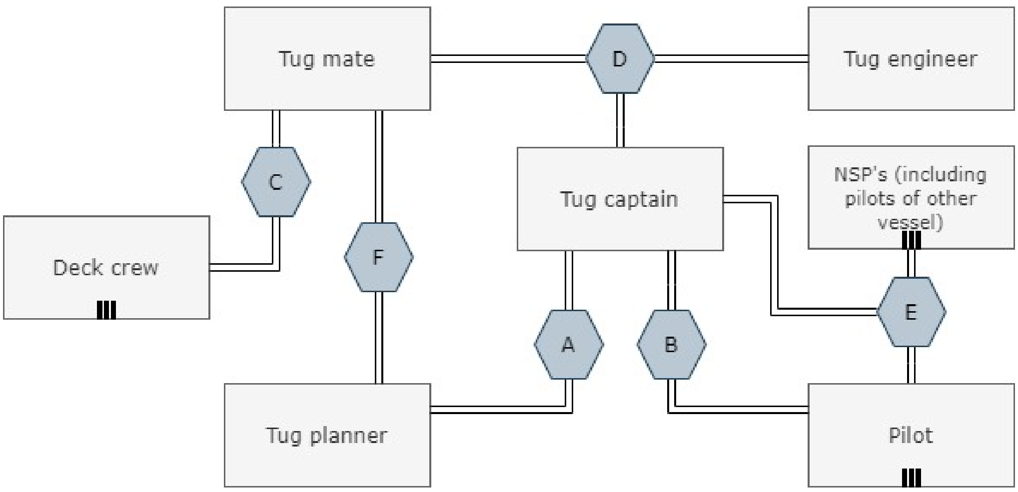
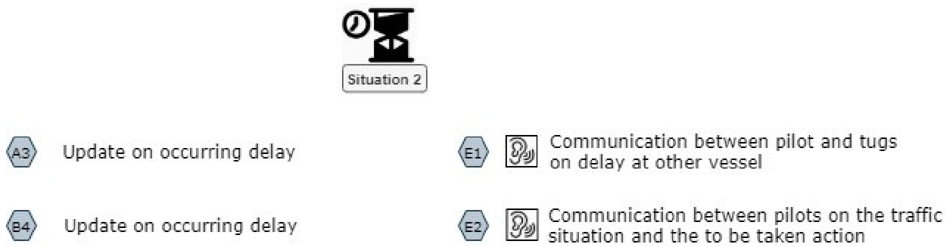


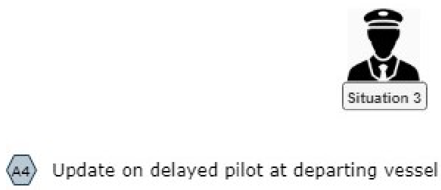
Figure 8.7: BPMN conversation diagram: tugboat

The next overview presents the conversations that take place in **situation 1 (happy days)** for an incoming and outgoing voyage. The tug planner shares the job assignment with the tug captain via the internal VHF channel. However, when the tugboat is in its resting period, the job assignment is shared via phone. After the job is assigned, the voyage details are available via the software system. The tug mate processes the information and records additional details (e.g. time of mobilization or time of arrival). After a job is finished, the tug planner updates the tug planner via the internal VHF channel. Together they discuss the next job assignment. While the tugboat is assisting a vessel, the pilot provides orders regarding the tug arrangement, the moment of attachment, orders while manoeuvring and the moment that the tugboats may be released. The tug captain always repeats the pilot message in order to confirm that the message had been received and understood. With (dis)connecting the tug, it is important that the attachment or release is confirmed by the deck crew. The tug mate receives hand signals from the deck crew and passes it on to the tug captain.

The next overview presents the conversations that take place in **situation 2 (external delay)** for an incoming and outgoing voyage. First of all, a delay that is noticed by the tug crew is always communicated to the tug planner. In this way, the tug planner remains up to date on its available capacity for following voyages. The tug captain notices a delay by experiencing the delay in practice, from information shared by the pilot or from communication between other nautical service providers on the nautical VHF channel. For example, a pilot at another departing vessel that communicates a delay to its tugboats or two pilots that discuss the to be taken actions due to a crowded traffic situation.

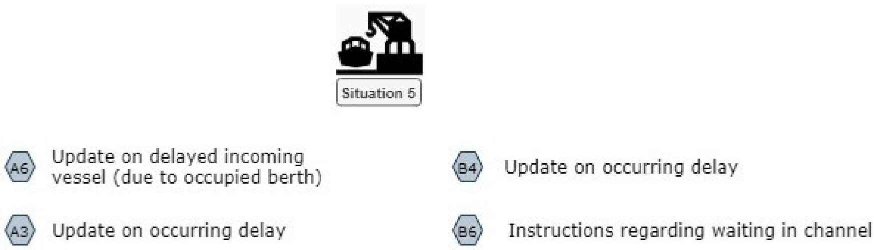


The next overview presents the conversations that take place in **situation 3 (pilot boarding time not equal to planned boarding time)** for an incoming and outgoing voyage. The crew members of the tugboat are updated on a delayed pilot by the tug planner. The tug planner, on its turn, should receive this update from the pilot planning. Of course, when tugboats are present at a departing vessel and notice that the pilot has not arrived yet, the tugboats can also contact the tug planner for information.



The next overview presents the conversations that take place in **situation 4 (tug availability not equal to planned tug availability)** for an incoming and outgoing voyage. In case something unexpected causes a delayed tug arrival (for an incoming or outgoing voyage), the tug captain informs the tug planner. The tug planner can decide to send another tug or to inform the other nautical service providers. In most cases, the tug planner already notices that the assigned tugs will experience difficulties with being on time (via updates on the previous job or their location on the AIS chart). When the tugboat(s) are in the same VHF region as the vessel, the tug captain also communicates the delay of the tugboats directly to the pilot via the nautical VHF channel.

The next overview presents the conversations that take place in **situation 5 (berth availability/terminal operations not available/finished as planned)** for an incoming and outgoing voyage. If the pilot is informed about the occupied berth when the tugs are already connected, and the situation requires the vessel to wait, the pilot gives instructions to the tugboats that the vessel must wait at the channel. The tugboats assist with manoeuvring and holding the vessel in position. This delay time time (in Dutch: 'gaande houden') is calculated as waiting time. At a departing vessel, delays on terminal operations are communicated to the tugs by the pilot and passed on to the tug planner by the tug captain.



8.3.3. Boatman

Each boatmen vessel has 2 boatmen on board. It depends on the job how many boatmen teams are needed per vessel. The boatmen have a VHF radio in all their vessels, winch cars, taxi cars, taxi boats and on their jacket. In this way, all boatmen are always connected to the VHF radio. The boatmen use an internal VHF channel for sharing the job assignment and communication about the pilot pick up for incoming pilots. Besides, the nautical VHF channel is used for communication with the pilot during an assignment. Lastly, the boatmen communicate with the deck crew of the vessel and terminal employees with hand signals and face-to-face communication.

Information shared in the boatmen process

Figure 8.8 shows the BPMN conversation diagram (see Appendix F) of the boatmen process for both incoming and outgoing voyages. Each letter (A till G) represents multiple conversations, which are described in this section for each operational situation. Most conversations involve bilateral communication. The exceptions, in which only unilateral communication takes place, are indicated with an 'arrow sign'. Conversations in which the linked actor does not take part, but only listens to the conversation as an information source, are indicated with an 'ear sign'.

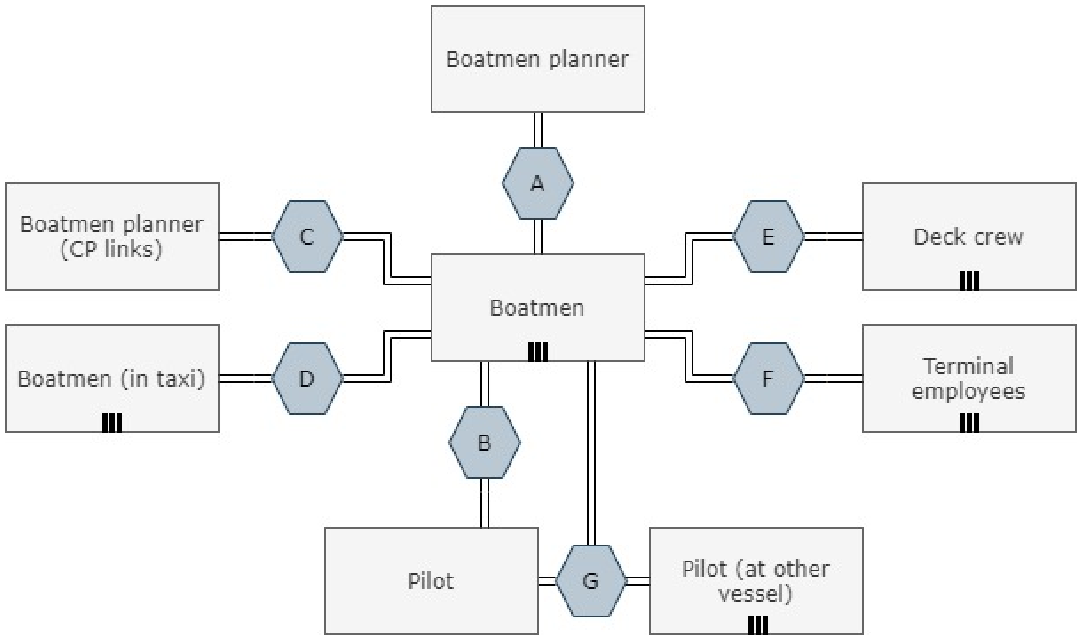


Figure 8.8: BPMN conversation diagram: boatmen

The next overview presents the conversations that take place in **situation 1 (happy days)** for an incoming and outgoing voyage. The boatmen planner communicates the job assignment to the boatmen. At the post, the boatmen receive a sign from the planner when it is time to leave. However, the boatmen keep track of this theme selves as well. When a job is finished, the boatmen update the planner. The planner either asks the boatmen if they can make it on time to the next job or informs the boatmen that they can return to the post. During a departing job, the pilot informs the boatmen when to unmoor the mooring lines. The boatmen always give a confirmation when the lines are attached or released. During an incoming job, the pilot communicates the mooring arrangement and the location where the pilot wants to be dropped off by the boatmen transport. The boatmen pass this message on to the CP links (taxi transport planner) via the internal VHF channel. During the mooring of an incoming vessel, the boatmen can communicate with the deck crew of the vessel by means of hand signals to check the mooring arrangement or to ask more slack in the mooring lines.

The next overview presents the conversations that take place in **situation 2 (external delay)** for an incoming and outgoing voyage. The boatmen communicate any occurring delay to their boatmen planner. These updates are relevant for the planner in order to have an overview of the available capacity for the following jobs. The boatmen notice the occurring delay by experiencing the delay in practice or are informed by the pilot.

The next overview presents the conversations that take place in **situation 3 (pilot boarding time not equal to planned boarding time)** for an incoming and outgoing voyage. For an incoming vessel, a delayed pilot arrival is not relevant for the boatmen, since the boatmen planning starts after the pilot boarded the vessel. For an outgoing vessel, a delayed arrival of the pilot is noticed by the boatmen at the quay. First of all, a delay is always communicated with the boatmen planner. Secondly, the boatmen at the quay know that the pilot should be in the taxi (car or boat) with one of their colleagues. This means that the boatmen at the quay can ask information on the delayed pilot via their internal VHF channel. At the same time, the boatmen in the taxi can provide information on the delay, when the boatman in the taxi hears that a boatmen team outside has difficulties with being on time for the job.

The next overview presents the conversations that take place in **situation 4 (tug availability not equal to planned tug availability)** for an incoming and outgoing voyage. The boatmen provide the boatmen planner with information of the occurring delay. The boatmen either see the situation happening theme selves or are informed by the pilot on board of the departing vessel. Furthermore, the pilot of another vessel might ask what the situation is of the vessel of his pilot colleague via the nautical VHF channel, because the pilot must wait for his tugboats. From this information sharing, the boatmen can conclude that the tugs used at the job they are working on are scheduled for another vessel. In that case, the boatmen team informs the boatmen planner. In this situation, the boatmen team can follow the tugboat to be on time for the next job, since the next vessel must wait for these tugboats. This means that no additional boatmen team is required.

The next overview presents the conversations that take place in **situation 5 (berth availability/terminal operations not available/finished as planned)** for an incoming and outgoing voyage. The boatmen are physically closest to the terminal operations and in contact with the pilot via the nautical VHF channel. In this position, the boatmen can share information from the terminal with the pilot and vice versa. For an incoming voyage, the boatmen can request information on a barge occupying the berth of an incoming vessel. For an outgoing vessel, the boatmen can request information on the terminal operations. The communication with the terminal takes place face-to-face. The gathered information is then shared with the pilot. Any occurring delays for both incoming or outgoing vessels are shared with the boatmen planner.

8.3.4. VTS operator

The VTS operators of the first two sectors of the Port of Rotterdam, namely Maas Approach and Pilot Maas, have additional tasks. The VTS operator of Maas Approach takes care of a part of the admission policy for incoming vessels. The VTS operator of Pilot Maas works as a pilot and VTS operator simultaneously. In that function, the VTS operator of Pilot Maas is the only VTS operator that is allowed to give rudder and propeller orders. This is needed, because tender boats of the pilot organization must be able to safely drop off or pick up a pilot in the Pilot Maas sector. The DO VTS is in contact with all the VTS operators. This communication is executed via phone. The VTS operators are in contact with the pilots that are sailing in their sector via the VHF channel of the sector. Vessels sailing in the Maas Approach sector do not have a pilot on board. Therefore, the VTS operator of Maas Approach communicates with the vessel captain of the vessel via the VHF channel of the sector.

Information shared in the VTS process

Figure 8.9 shows the BPMN conversation diagram (see Appendix F) of the boatmen process for both incoming and outgoing voyages. Each letter (A till F) represents multiple conversations, which are described in this section for each operational situation. Most conversations involve bilateral communication. The exceptions, in which only unilateral communication takes place, are indicated with an 'arrow sign'. Conversations in which the linked actor does not take part, but only listens to the conversation as an information source, are indicated with an 'ear sign'.

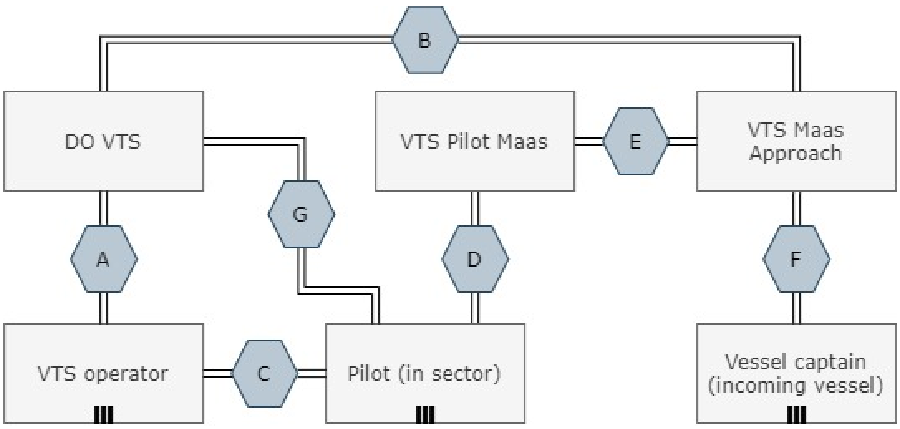


Figure 8.9: BPMN conversation diagram: Vessel Traffic Services (VTS)

The next overview presents the conversations that take place in **situation 1 (happy days)** for an incoming and outgoing voyage. Pilots (or vessel captain in case no pilot is on board) must report to the VTS operator when the vessel enters the sector. The pilot informs the VTS operator on its intentions and destination. The VTS operator informs the pilot on the dynamic traffic situation in the sector. The VTS operator of Pilot Maas, who is working for the pilot organization, is updated when a pilot boards or disembarks a vessel in the Pilot Maas sector.

C1 Traffic information

D1 Update on boarded or disembarked pilot

G1 Operational clearance

The next overview presents the conversations that take place in **situation 2 (external delay)** for an incoming and outgoing voyage. A significant delay (more than 30 minutes) at a departing vessel is discussed between the DO VTS and VTS operator of the sector. This delay is either communicated from the pilot to the VTS operator or the delay is communicated to the DO VTS and passed on to the VTS operator. In case the delay of the departing vessel causes a congested traffic situation, the DO VTS can decide to refuse a vessel permission for departure. This is exceptional, but mostly the case with regard to vessels bounded to the channel or a tidal window. When the decision to delay a departing vessel is made, the DO VTS updates the VTS operator of the sector who can inform the pilot of the vessel. Mostly, the pilot of the departing vessel is already informed by the Pilot Service Leader. The VTS operator is not authorized to prohibit the departure of a vessel (which the DO VTS can do by refusing the request for operational clearance). However, the VTS operator can inform the pilot about the traffic situation. For incoming voyages, the VTS operators of the Pilot Maas and Maas Approach sector might notice that a vessel will not meet the recorded ETA PS with its current sailing speed. The VTS operators are located next to each other at the Vessel Traffic Center and discuss this situation face-to-face. If needed, the VTS operator of Maas Approach calls the incoming vessel via the VHF channel of the sector to suggest an adjusted sailing speed. If speeding up is not possible, the VTS operator of Maas Approach can suggest a delayed ETA PS.

A1 Delay at departing vessel

A2 Refused operational clearance situation

C2 Delay at departing vessel

C3 Advice to wait at the quay

E1 Required speed adjustments for vessel in MA sector

F1 Speed instructions or adjusted ETA PS

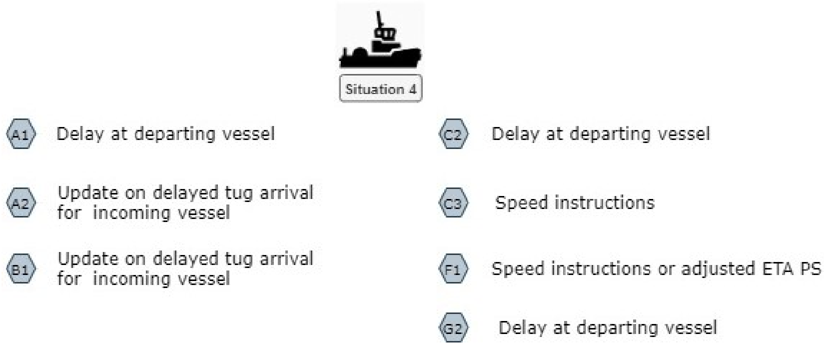
G2 Delay at departing vessel

The next overview presents the conversations that take place in **situation 3 (pilot boarding time not equal to planned boarding time)** for an incoming and outgoing voyage. In case the pilot boards a departing vessel delayed, the VTS operator updates the DO VTS. In case the pilot of an incoming vessel will arrive delayed, the VTS operator of Pilot Maas (who is working of the pilot organization) asks the VTS operator of Maas Approach to inform the vessel captain to reduce speed.

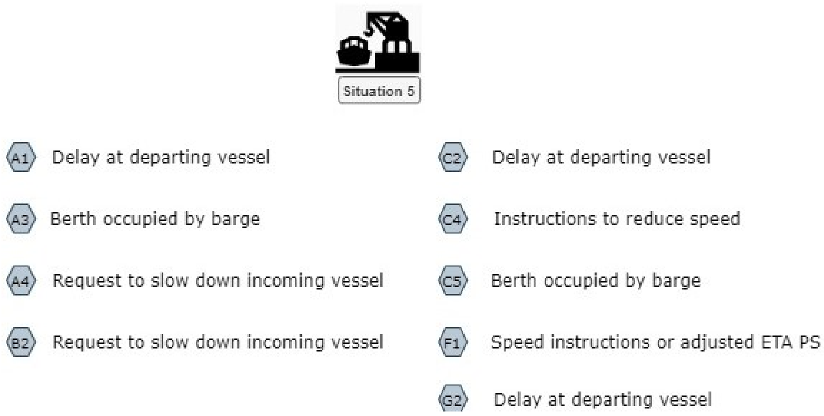
A1 Delay at departing vessel

E1 Speed adjustments for vessel in MA sector

The next overview presents the conversations that take place in **situation 4 (tug availability not equal to planned tug availability)** for an incoming and outgoing voyage. For outgoing vessels, a delayed tug arrival that is noticed by the VTS operator on the AIS chart is shared with the DO VTS. For incoming vessels, if the DO VTS is aware of a tug delay, the DO VTS contacts the VTS operator of the sector in which the vessel is sailing. The VTS operator of the sector can call the incoming vessel via the VHF channel to inform the pilot on the delayed tug arrival. If the vessel is still in the Maas Appraoch sector, the ETA PS can be delayed. If the vessel is in the Pilot Maas sector, the pilot can decide to reduce speed or turn around.



The next overview presents the conversations that take place in **situation 5 (berth availability/terminal operations not available/finished as planned)** for an incoming and outgoing voyage. A delay at a departing vessel is shared between the pilot, the DO VTS and the VTS operator of the sector. In case the delay of an outgoing vessel requires an incoming vessel for that berth to slow down, the VTS operator can contact the pilot of the incoming vessel to reduce his speed. If the VTS operator notices that the berth of an incoming vessel is occupied by a barge (via the AIS chart), the VTS operator informs the DO VTS via phone and the pilot on the vessel via the VHF channel of the sector.



8.4. Conclusion

The discussed BPMN diagrams in the previous sections provide insight into the information sharing of the different actors in the operational domain of the nautical chain. Conclusions that are drawn from these insights are:

- The communication within an organization (e.g. between pilot and pilot planner) is mainly focused on updates of the operations to ensure that the planner is up to date of the available capacity for following jobs.
- Communication in the operational domain is mainly executed via phone or VHF radio. This means that most conversations involve bilateral communication. Only the voyage details recorded by the pilot, the details of the assigned tugboats and any deviations in the tug planning shared via a message in GIDS are shared unilateral.
- The actors of the nautical chain do not only use the VHF channel to communicate with each other, the VHF channels are also used as a valuable information source. From information that is shared on the nautical VHF channel, relevant conclusions (such as a delay at another departing vessel or continuous scheduled tugboats) for the further operations can be drawn. In that respect, pilots that communicate via the nautical VHF channel provide more information than pilots that communicate via phone contact. The fact that VHF channels are subject to the limits of the channel range is in obstacle in this respect, since there is no other option than phone contact for pilots located in different VHF sectors.

- Each actor is aware of the fact that a situation must be communicated if the own planning is affected. Therefore, it is expected that an occurring delay is always shared with the planning department of the own organization. However, the communication on delays with other organization is more complicated. Multiple routes for sharing the same message are possible. This makes it less certain that the information sharing always takes place.
- Similar as in the planning domain, the boatmen have more information available in comparison to the other actors. In case a pilot arrives late at a departing vessel, the boatmen at the quay are already updated by their colleagues in the taxi or they can easily contact their colleagues to ask information. At the same time, the boatmen have the shortest link with the terminal employees. In that position the boatmen can act as a communication gateway between the pilot and the terminal.

9

The frequent delays in the nautical chain

In this chapter the fourth sub-question *'What delays occur frequently in the nautical chain of the Port of Rotterdam?'* is answered.

In this thesis, the considered indicator for the efficiency of the nautical chain is the dynamic turnaround time of a vessel. More detail on this efficiency indicator is provided in section 9.1. An efficiency improvement can be reached by minimizing the effects of occurring delays on the dynamic turnaround time of a vessel. An analysis of the delays that are recorded by the Harbour Master is discussed in section 9.2. The recorded delays do only provide insight into the first-level delay causes. A Root Cause Analysis (RCA) is performed to identify the higher-level causes that might occur before the recorded delay is experienced. Consequently, the causes that do occur relatively often are indicated and elaborated on in section 9.3. These indicated causes are considered as the areas where improvement of the nautical performance can be gained in terms of efficiency. Lastly, the conclusions of the analysis are discussed in section 9.4.

9.1. Efficiency indicators

One of the indicators for performance is efficiency. To measure the efficiency of a port, different methods can be applied. A method for measuring port efficiency that is frequently discussed in literature is Data Envelopment Analysis (DEA). DEA is a technique for measuring the relative efficiency of a 'decision-making units', e.g. a port, that use similar inputs and outputs (Lee et al., 2005). However, in this thesis, the absolute efficiency is considered rather than the relative efficiency of a port.

Furthermore, Talley and Ng (2016) state that, traditionally, ports evaluate their efficiency by comparing their actual and optimum throughput. The optimum throughput indicates the maximum throughput that a port can physically handle. The relationship between the port's maximum throughput and the level of used resources (*port productive resources* e.g. labor, cranes, fuel, berths) is presented as: Maximum Port Throughput = f (Port Productive Resources). If the port achieves the maximum throughput for a given levels of resources, the port is considered efficient.

Lastly, different indicators for port efficiency can be applied. The Maritime Transport Review of 2019 (UNCTAD, 2019) considers shipping connectivity and the turn around time of a vessel as indicators for port efficiency. The shipping connectivity is explained as 'the position of a country or port in the global container shipping network' (UNCTAD, 2019). The turnaround time of a vessel is the time between the arrival and departure of a vessel in the port. Since the scope of this thesis is not on the position of the port within in a network, but on the processes of the nautical chain within the port, this thesis focuses on the turn around time of a vessel. A reduction of the average turn around time within a port makes it possible to handle more vessels with the same number of resources. This means that a reduction of the turn around time will contribute to the efficiency of a port as explained by Talley and Ng (2016).

The turnaround time of a vessel consists of the dynamic turnaround time, which covers the time spent on sailing and manoeuvring, and the service time of a vessel at a terminal. For indicating the efficiency of the nautical chain, only the dynamic turnaround time is considered.

In this thesis, the aim is not to reduce the dynamic turnaround time itself to a minimum, but to reduce the effect of delays on the dynamic turn around time to a minimum. Reducing the delays (or at least the effect of delays) minimizes the total dynamic turnaround time and thereby positively influences the efficiency of the nautical chain. Therefore, the delays and the causes that might lead to the occurring delays are investigated and considered as the areas where improvement of the nautical performance can be gained in terms of efficiency. In this respect, the Harbour Master of the Port of Rotterdam states that 'to be a front runner in efficiency, the chance on delays must be minimized' (Port of Rotterdam, 2019a).

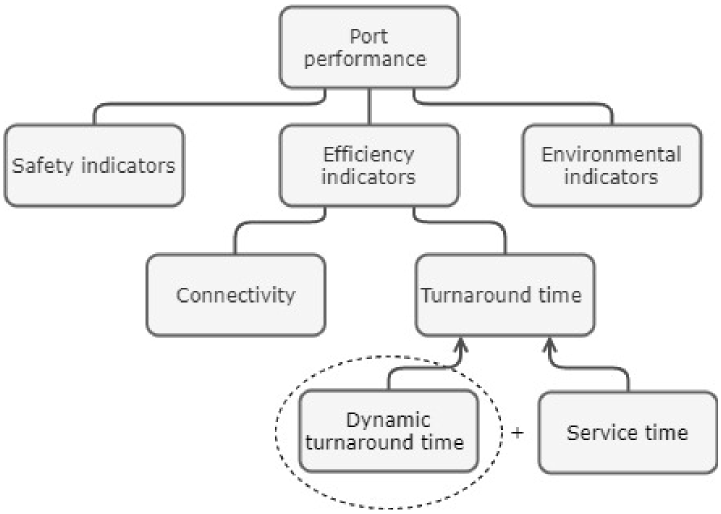


Figure 9.1: Port performance and efficiency indicators

9.2. Analysis of the recorded delays

The Harbour Master records delays of more than 30 minutes and their causes. This delay recording only covers the direct cause (first-level cause) of a delay and does not involve the fact that other indirect causes (higher-level causes) might have led to the recorded cause. Additionally, the recording method of these delays does not ensure that all delays are recorded consistently (see Appendix E). Still, the recorded delays provide a first insight into the first-level delay causes that occur in the nautical chain. The recorded delays of an incoming voyage are discussed in subsection 9.2.1. The recorded delays of an outgoing voyage are discussed in subsection 9.2.2.

9.2.1. Incoming voyage

A delay for incoming voyages is defined as a deviation from the initial ETA PS or a delay occurring during the port passage between arrival at the Pilot Station and arrival at the berth. Figure 9.2 presents an overview of the delay causes that are recorded by the Harbour Master for an incoming voyage. The recorded causes do not deviate between delays that occur before the pilot or tugs are assigned to a vessel (*service provider not available*) and delays that occur once the services are assigned to a vessel (*service provider boards or arrives delayed*). Therefore, the recorded delays that are accounted to a pilot or tug delay are applicable to both direct delay causes. More details on the data analysis are provided in Appendix E.

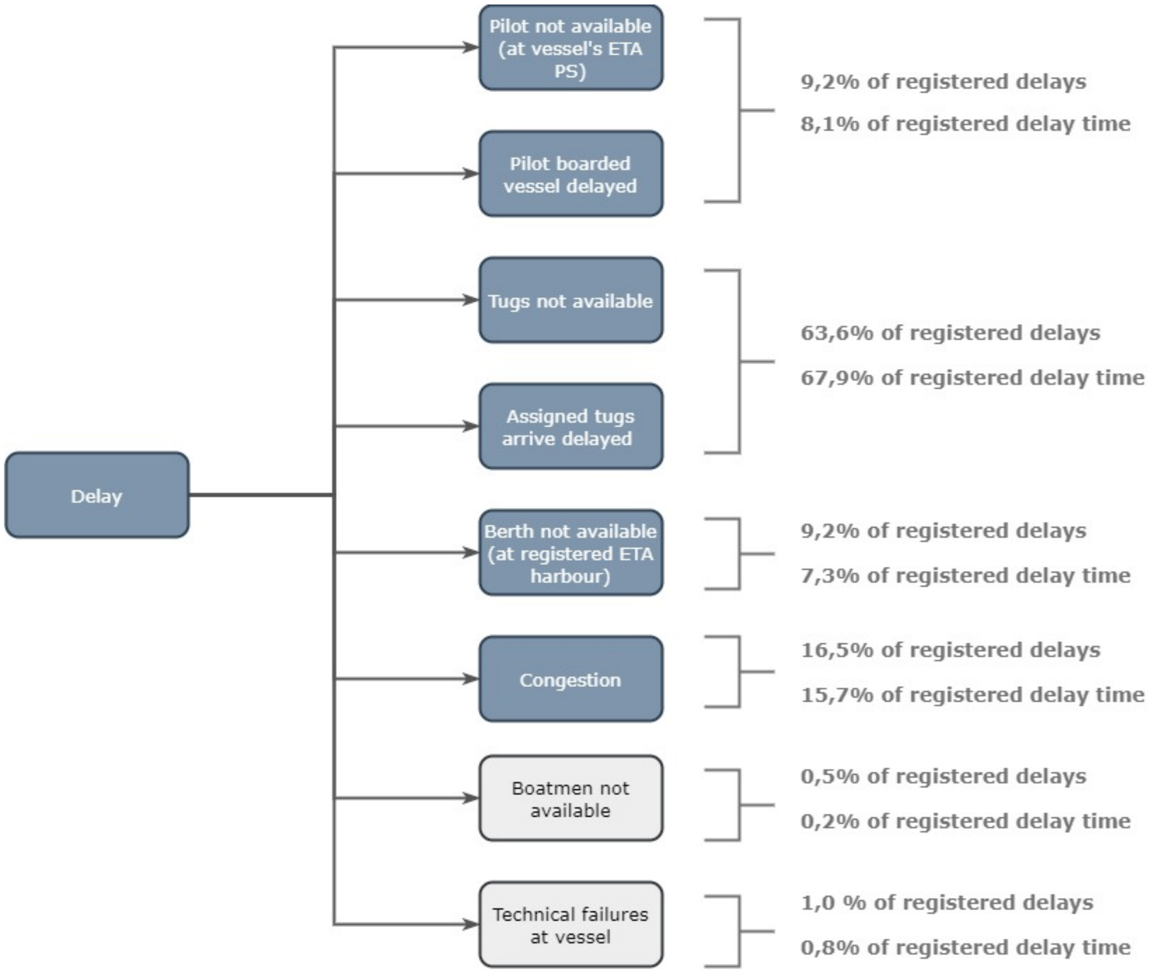


Figure 9.2: Delay causes for an incoming voyage recorded by the Harbour Master

The recorded data only reveal the number of delay recordings of the Harbour Master. However, these recorded data only provides insight into the first-level delay causes. Considering the higher-level causes that instigate the first-level causes of a delay provides a more realistic insight into the causes of a delay. Therefore, a Root Cause Analysis (see chapter 3) is performed for the following first-level delay causes:

- Pilot not available (at vessel's ETA PS)
- Pilot boarded vessel delayed
- Tugs not available
- Assigned tugs arrive delayed
- Berth not available (at recorded ETA harbour)
- Congestion

The frequency and impact of delays accounted to the unavailability of the boatman (0,5% and 0,2%, see Figure 9.2) or technical failures at an incoming vessel (1,0% and 0,8%, see Figure 9.2) are considered insignificant and therefore excluded from the RCA. The RCA diagrams can be seen in the next section of this chapter.

9.2.2. Outgoing voyage

A delay for outgoing voyages is defined as a deviation from the initial ETD. Figure 9.3 presents an overview of the delay causes that are recorded by the Harbour Master with regard to an outgoing voyage. The recorded causes do not deviate between delays that occur because one of the nautical service providers has no available capacity and proposes a delayed ETD time (*service not available at ordered ETD*) and delays that occur once the ETD is confirmed by all nautical service providers (*service provider arrives delayed at vessel*). Therefore, the recorded delays that are accounted to a pilot and tug delay are applicable to both direct delay causes. More details on the data analysis are provided in Appendix E.

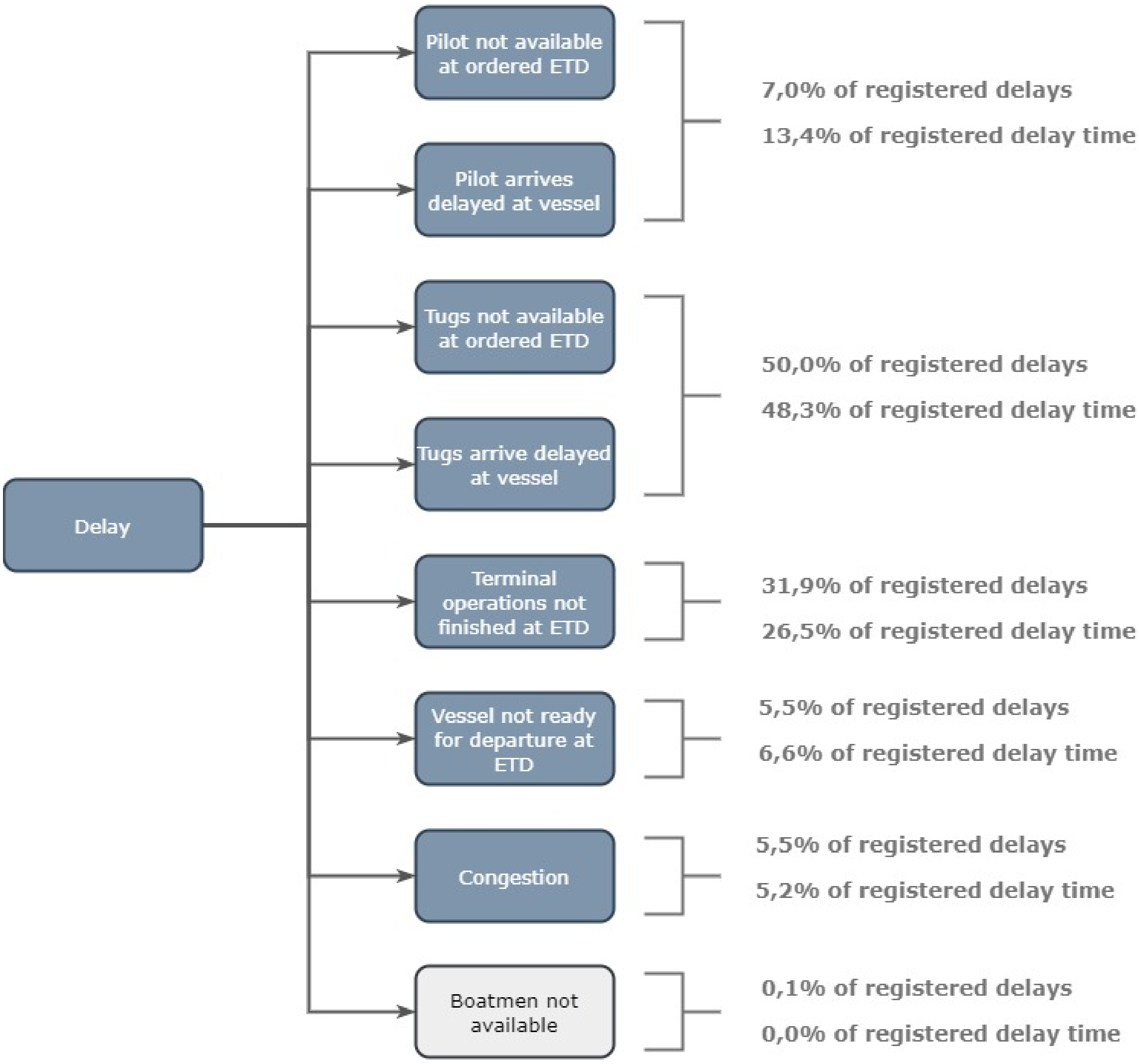


Figure 9.3: Delay causes for an outgoing voyage recorded by the Harbour Master

The recorded data only reveal the number of recordings of the Harbour Master. However, these recorded data only provides insight into the first-level delay causes. Considering the higher-level causes that instigate the first-level causes of a delay provides a more realistic insight into the causes of a delay. Therefore, a Root Cause Analysis (see chapter 3) is performed for the following first-level delay causes:

- Pilot not available at ordered ETD
- Pilot arrives delayed at vessel
- Tugs not available at ordered ETD
- Tugs arrive delayed at vessel

- Terminal operations not finished at ETD
- Vessel not ready for departure at ETD
- Congestion

The frequency and impact of delays accounted to the unavailability of the boatmen (0,1% and 0,0%, see Figure 9.2) is considered insignificant and therefore excluded from the RCA. The RCA diagrams can be seen in the next section of this chapter.

9.3. The frequently occurring root causes of the recorded delays

The higher-level causes of the recorded delays are not available in the data. Therefore, the higher-level causes of the recorded delays are investigated by means of expert input from Raymond Seignette (Policy Maker at the Harbour Master Department) and Hans Aarts (Manager VTS). The highest-level cause of a delay is referred to as the 'root cause'. Since the root causes are identified based on qualitative experiences from experts, the minimum delay time is not specified when identifying the root causes.

The higher-level causes and root causes of the recorded delays are only researched qualitatively. Above all, the interviewees do not represent a reflection of all involved actors. Therefore, **the RCA diagrams must be interpreted as a proposition of the root causes of the recorded delays**. In order to confirm the proposed higher-level causes behind the recorded delays, additional research is required. In this respect, the RCA is not used to identify the root causes that must be solved, but only to provide insight into all causes that might have led to the causes that are recorded. For this reason, the diagrams do not distinguish between internal and external factors. Furthermore, it is assumed that current capacities are dealt with. In other words, a delay can not be accounted to the fact that the current number of people and equipment is insufficient. However, most root causes that are mentioned (e.g. a delay of a departing vessel) in the RCA diagrams do only cause a delay when the capacity is at stake.

The root causes of the delays differ in the frequency they occur and in the impact they have. Since the frequency of a delay cause is considered easier to approach than the impact, experts are asked to score the root causes on their relative occurrence. Above all, insights of the recorded Harbour Master data do not suggest a major difference between the frequency and the impact of the recorded delays (see Appendix E). The expert input on the root cause frequency is presented in Appendix I. Following from this expert input, the following propositions are made:

- Frequently occurring root causes of a recorded delay (incoming and outgoing voyage) accounted to **'pilots'** are proposed as follows:

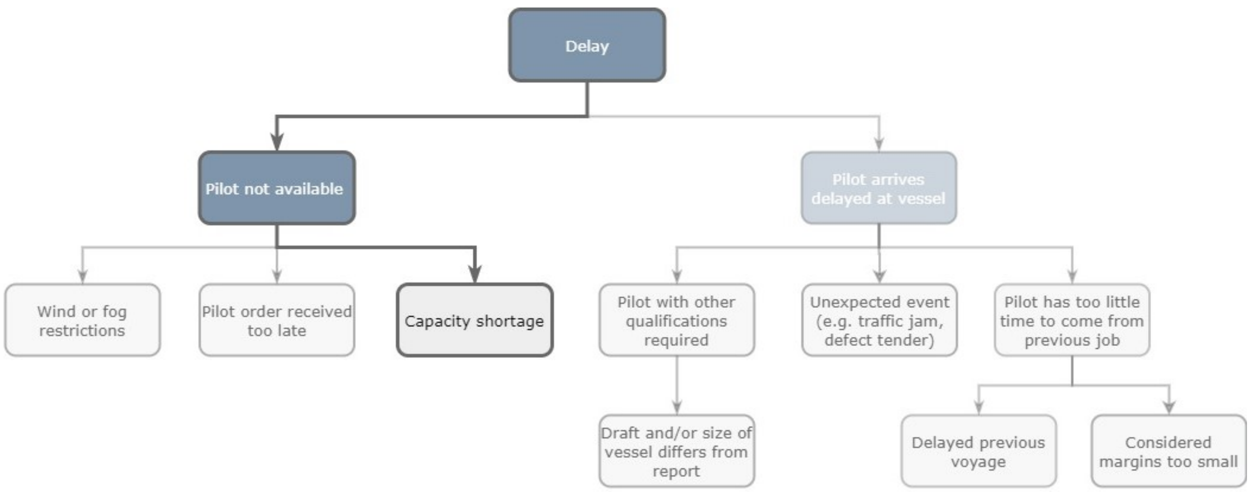


Figure 9.4: RCA diagram of the recorded delays that are accounted to delayed 'pilots'

  - A pilot that arrives delayed due to *too little time to come from a previous job* is accounted more often to a *delayed previous voyage* than to the fact that the *considered margins between the two assignments are too small.* However, overall, a *delayed previous voyage* is not scored convincingly as a frequent cause of delay.
  - A *capacity shortage* for the demanded pilot services is considered as occurring relatively frequent.

- Frequently occurring root causes of a recorded delay (incoming and outgoing voyage) accounted to **'tugboats'** are proposed as follows:

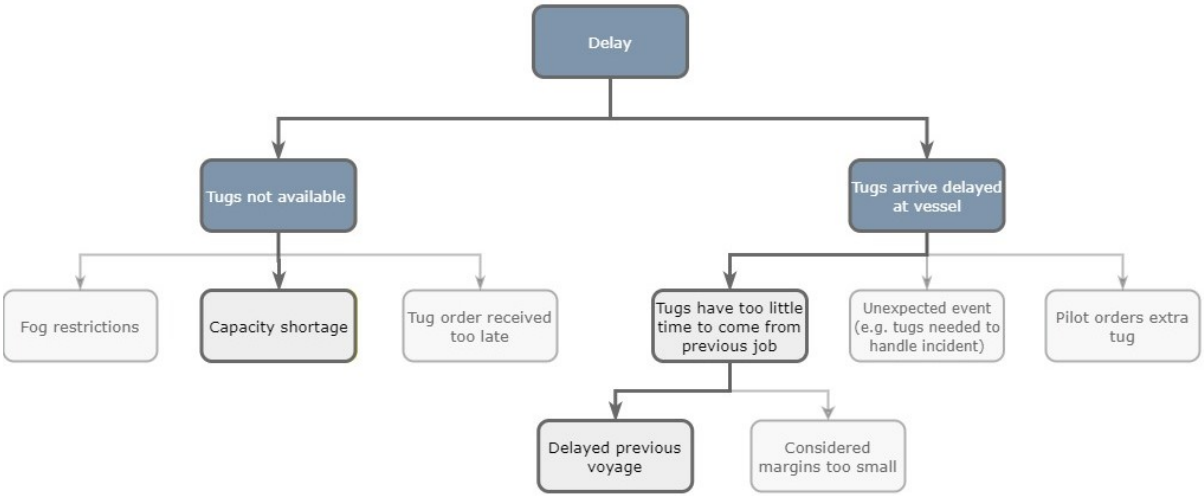


Figure 9.5: RCA diagram of the recorded delays that are accounted to delayed 'tugboats'

  - Similar as with the availability of pilots, a *capacity shortage* is assumed to cause a delay relatively frequent.
  - The cause *tugs have too little time to come from previous job* is considered to occur relatively frequent. This cause is mainly accounted to the root cause of a *delayed previous voyage.*

- Frequently occurring root causes of a recorded delay (incoming voyage) accounted to **'berth occupied'** are proposed as follows:

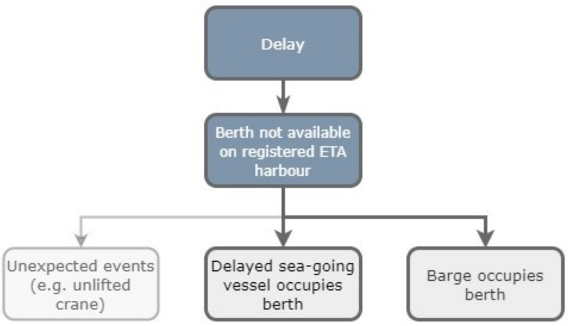


Figure 9.6: RCA diagram of the recorded delays that are accounted to an 'occupied berth'

  - The root cause *barge occupies the berth* is mainly considered as occurring relatively frequent.
  - The root cause *a delayed sea-going vessel occupies the berth* is considered as occurring relatively frequent.

- Frequently occurring root causes of a recorded delay (outgoing voyage) accounted to **’unfinished terminal operations’ are proposed as follows**:

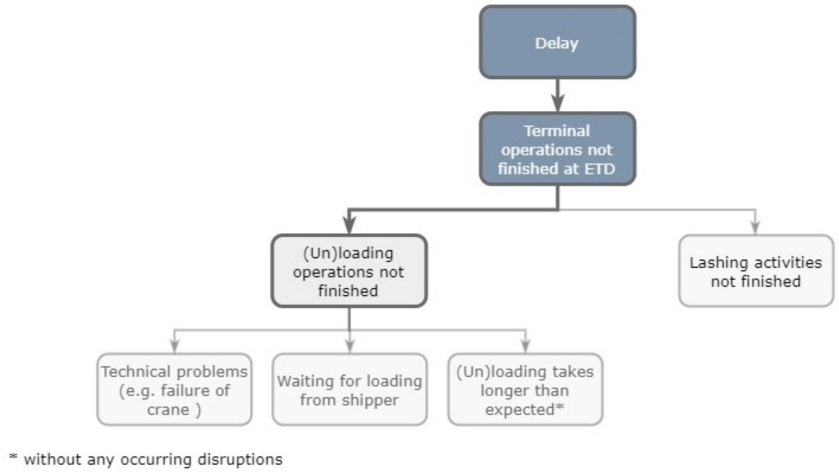


Figure 9.7: RCA diagram of the recorded delays that are accounted to ’unfinished terminal operations’

  - The root cause *(un)loading takes longer than expected* is considered to occur relatively frequent.
  - Overall, delays on *(un)loading activities* are considered to occur more frequent than delays on *lashing activities*.
  - The root causes related to the terminal operations are not filled in completely by multiple respondents. Therefore, it is expected that the respondents do not have enough insight into the (un)loading process. Mostly, the actors of the nautical chain (except for the terminal operator himself) are just informed about the terminal delay and are not informed about any reason behind this delay. Therefore, the considered root cause regarding terminal operations is *(un)loading operations not finished*.

- Frequently occurring root causes of a recorded delay (outgoing voyage) accounted to **’vessel not ready for departure’** are proposed as follows:

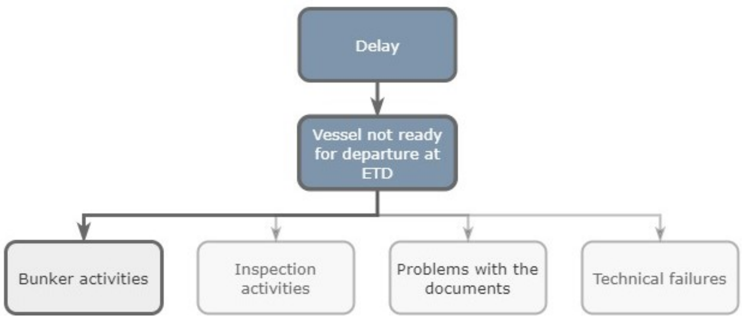


Figure 9.8: RCA diagram of the recorded delays that are accounted to a ’vessel not ready for departure’

  - The root cause *bunker activities not finished* is considered as occurring relatively frequent.

- Frequently occurring root causes of a recorded delay (incoming and outgoing voyage) accounted to **'congestion'** are proposed as follows:

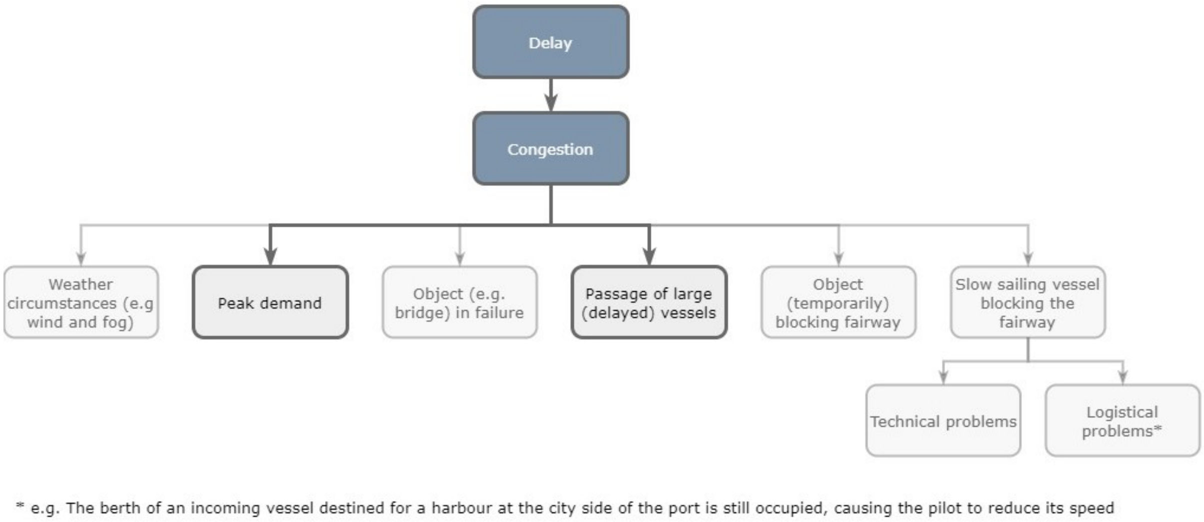


Figure 9.9: RCA diagram of the recorded delays that are accounted to 'congestion'

  - The root cause *passage of large vessels* is considered to occur relatively frequent.
  - A *peak demand* that leads to a high traffic volume is considered to happen relatively frequent.

9.4. Conclusion

In this chapter, root causes of the delays that are recorded by the Harbour Master are investigated. Subsequently, the root causes that are considered to occur relatively frequent are identified. It is important to keep in mind that the presented RCA diagrams are a **proposition of the root causes of the recorded delays**. This means that none of the presented causes is proven to occur, but that the presented causes might be expected to occur. In this perspective, two conclusions are drawn from the RCA:

1. From the RCA of both incoming and outgoing voyages can be concluded that the type of possible causes that precedes a delay vary. First of all, the possible root causes involve external causes, such as weather circumstances and fluctuating demand. Secondly, the possible root causes involve external circumstances for the considered actor (but not external for the nautical chain as a whole), such as a delay of another vessel or an order that is received too late. Lastly, the possible root causes involve internal causes, such as applying small margins between two job assignments.

2. The fact that the possible root causes of a delay include external causes from the perspective of the considered actor, but not from the perspective of the nautical chain as a whole, leads to a reduction of the value of the recorded delay causes. The reason behind is the risk of double counting an occurring delay cause. For example, a delay caused by delayed terminal operations causes a delay for the arrival of the connected tugboats for their next assignment. This delay is then counted for an outgoing vessel as 'terminal operations not finished at ETD' and for an incoming voyage as 'tugs arrive delayed'.

From the results on the relative occurrence of the identified root causes, the root cause links that are assumed to occur frequently are concluded. Since all 'direct causes' are related with each other, no distinction is made between the root causes that are related with 'direct causes' that are recorded to occur more frequent than others. The identified *frequent delays of the nautical chain* are as follows:

1. **Pilot capacity shortage:** The ETA PS or ETD can be delayed, because the pilot organization has a capacity shortage. This capacity shortage is caused by a high demand for the pilot services.

2. **Tug capacity shortage:** The ETA PS or ETD can be delayed, because the tug company has a capacity shortage. This capacity shortage is caused by a high demand for the tug services.

3. **Delayed tug arrival due to a delay of the previous served vessel:** A tug that is assigned to an outgoing vessel can arrive delayed because of a delayed shifting voyage or delayed incoming voyage. A tug that is assigned to an incoming vessel can arrive delayed because of a delayed outgoing voyage.

4. **Berth occupied by barge:** The berth can be occupied by a barge. Barges do not have to report and order an outgoing voyage and their departure is therefore not available in the HaMIS system.

5. **Berth occupied by sea-going vessel:** Sea-going vessel must be ordered for departure. Therefore, an incoming vessel is not allowed to enter the port area as long as the vessel at its destined berth has not been ordered for departure. However, if a delay occurs in the time frame between the ordering moment and the ETD, the berth is still occupied when the incoming vessel starts its voyage.

6. **Unfinished (un)loading activities:** Terminal operations can take longer than expected. There are different causes that lead to delayed (un)loading activities.

7. **Unfinished bunker activities:** A vessel that is not ready for departure is mainly accounted to delayed bunker activities. Bunkerering is a vessel service that is arranged by the vessel agent.

8. **Congestion at the fairway due to peak demand:** Congestion at the fairway can be accounted to an accumulation of the vessel traffic due to previous weather restrictions or to the fluctuating demand.

9. **Congestion at the fairway due to passage of large vessels:** Congestion at the fairway can be caused by the passage of a large, possibly delayed, vessel.

III

Results

10

Information sharing in the frequent delays of nautical chain

In this chapter the fifth sub-question *'What information sharing links are related with the delays that frequently occur in the nautical chain of the Port of Rotterdam?'* is answered.

The results that are discussed in this chapter are a combination of the investigated *information sharing links* (see chapter 7 and chapter 8) and the investigated *frequent delays that occur in the nautical chain* (see chapter 9). A complete overview of all information sharing links that are related with the frequent delay situations is presented in Appendix J. The information sharing is discussed in section 10.1. The results are validated by taking the interpretations back to the experts (see chapter 3). Validation feedback on the identified information sharing links has been received from the boatmen, the pilot and the tugboat company and is elaborated on in section 10.2. Conclusions that follow from the results presented in this chapter are discussed in section 10.3.

10.1. The used information sharing links

A complete overview of the information sharing links that are related with the frequent delays is presented in Appendix J. In this section, the main results for each of the individual delay situations are discussed.

1. **Pilot capacity shortage:** The initial notice of a capacity shortage depends on the information that is available for the pilot planners with regard to the demand for pilot services and the available pilot capacity:

    - Next to the reported details that are available in HaMIS in advance of a port-call, demand related information is extracted from the registered ETA PS's in HaMIS and information that the *pilot planner* receives from the *VTS operator of Maas Approach* if a vessel makes operational contact within less than 3 hours before the ETA PS. Additionally, the VHF channel of the Maas Approach sector provides information on approaching incoming vessels to the *pilot planner*.
    - With regard to the available pilot capacity, the *pilot* shares (and updates) the expected gangway down time of a vessel via the GIDS system with the *pilot planners* and updates the *pilot planners* by phone when the pilot finishes his current job. The pilot planners together discuss if it is needed to call an additional pilot from home.

    The actions that are taken after notifying a capacity shortage involve requests for a delayed ETA PS or ETD of a vessel:

    - A request for a delayed ETA PS of an incoming vessel is communicated from the *pilot planner* to the *VTS operator of Maas Approach*.
    - A request for a delayed ETD is shared by the *pilot planner* to the *HCC* and the other *nautical service providers* via the GIDS system.

2. **Tug capacity shortage:** The initial notice of the capacity shortage depends on the information that is available for the tug planner with regard to the demand for tug services and the available tug capacity:

    - Next to the reported details that are available in HaMIS, the information with regard to the demand for tug services depends on the estimated numbers of tugs to use (in case the vessel agent does not order a specific number of tugs). The estimated number of tugs is provided by the *Pilot Service Leader* via the GIDS system to the *tug planner*.
    - The time that the tugboats should meet an incoming vessel depends on the ETA PS and destination of a vessel. The ETA PS is registered by the *VTS operator of Maas Approach* and via HaMIS made available to the *tug planner*. The destination of a vessel is available in HaMIS as well.
    - When the *pilot* boarded the vessel, the pilot defines the final number of tugs to use in agreement with the vessel captain and shares this order and the ETA LL of the incoming vessel with the *tug planner* via GIDS.
    - The *tug captain* updates the *tug planner* on occurring delays at the current assignment.

    The actions that are taken after notifying a capacity shortage involve requests for a delayed ETA PS or ETD of a vessel:

    - An update on difficulties with regard to the availability of tugboats for incoming vessels can be shared from the *tug planner* to the *DO HCC* via phone.
    - A request for delaying an ETD is shared by the *tug planner* to the *HCC* and the other *nautical service providers* via the GIDS system. If the tug planner does not approve the ordered ETD or request a delayed ETD within the agreed 30 minutes after the voyage order had been received, the *pilot planner* might call the tug planner.

3. **Delayed tug arrival due to a delay of the previous served vessel:** The initial notice of a delayed other vessel depends on the information on occurring delays that is available for the tug captain and the tug planner and the communication between them:

    - The *tug captain* receives information on occurring delays from the *pilot* on board of the vessel or from communication between other *nautical service providers* in the sector via the nautical VHF channel.
    - The *tug captain* updates the *tug planner* on delays that occur at their assignment.
    - Except for updates from the tug captain, the *tug planner* receives information on occurring delays via communication between other *nautical service providers* on the nautical VHF channel.
    - The *tug planner* might inform the *Pilot Service Leader* or the assigned pilot at a vessel with a notification via the GIDS system about tugboats that must come from another vessel.

    The actions that are taken after notifying a delay at another vessel, which causes a delayed tug arrival, are mainly focused on communicating the tug delay to other nautical service providers:

    - The *tug planner* updates the *pilot planners* on a delayed tug arrival. For this information, a GIDS notification is used as the primer communication tool, but phone can be used as well. The pilot planners update the specific *pilot* or the *VTS operator of the Pilot Maas* sector.
    - The *tug planner*, if there is time, updates the *boatmen planners* on a delayed tug arrival. However, in general, the tug planner delays the ETD in the GIDS system. Via the GIDS system, the boatmen planning is informed on a delayed ETD. This is only relevant for departing vessels, since the boatmen plan on the real-time sailing data for incoming voyages.
    - The *tug planner* can also inform the *pilot* of a specific vessel directly by phone or a notification via GIDS on a delayed tug arrival (communication via phone is rare, mostly an update is shared via the GIDS system). Vice versa, the pilot calls the tug planner if the tugs are not present on time.
    - In case the tugboats are already in the same sector as the vessel, the *tug captain* directly contacts the *pilot* on board of the vessel via the nautical VHF channel to inform the pilot about a delayed tug arrival. Still, most of the time, delays of 5 till 10 minutes are also passed on with a GIDS message.

- In case the *DO VTS* is up to date on a delayed arrival of tugboats for an incoming voyage, the DO VTS calls the *VTS operator* of the sector in which the incoming vessel is sailing. The VTS operator communicates the message to the *pilot* on board of the incoming vessel via the VHF channel of the sector.

4. **Berth occupied by barge:** The initial notice of a barge that occupies the quay depends on information from the terminal resource planner, the boatmen at the quay or the VTS operator:

   - The *boatmen* update the *pilot* when they notice that the berth of an incoming vessel is still occupied by a barge or the pilot asks the boatmen to check if the berth is available.
   - The *boatmen* at the quay might ask the *terminal employees* for more details about the occupied berth and the to be taken actions.
   - The *VTS operator* of the sector might notice that the berth of an incoming vessel is occupied by a barge via the AIS chart and shares that information with the *pilot* of the incoming vessel.

   The information shared after notifying that the berth is occupied by a barge when the incoming vessel arrives is related with informing the pilot of an incoming vessel to adapt its speed or with updating the planning departments on the occurring delay:

   - The *pilot* informs the *tug captain* on the situation and if the vessel will reduce speed or must wait at the channel.
   - The *pilot*, the *tug captain* and the *boatmen* inform the *pilot planners*, the *tug planners* and the *boatmen planners* on the current situation.

5. **Berth occupied by sea-going vessel:** The initial notice of a berth that is still occupied by a sea-going vessel depends on detecting a delay at a departing vessel and sharing this information:

   - In case a departing vessel is not ordered for departure when an incoming vessel for the same berth wants to enter the port area, the *VTS operator of Maas Approach* calls the *ADO's* that are responsible for incoming voyages. The ADO's can check the details of the expected departure with the terminal. It depends on their feedback if a delayed ETA PS is given to the incoming vessel.
   - The *pilot* communicates a delay at a departing vessel to the *DO VTS*. The *VTS operator* of the sector is informed by the pilot or by the DO VTS.

   The information shared after notifying a delayed departure of a sea-going vessel, which occupies the berth of an incoming vessel, is related with informing the pilot of the incoming vessel to adapt his speed. Also, information is shared to update the planning departments on the occurring delay:

   - The *pilot* on board of the delayed departing vessel calls his *pilot colleague* on board of an incoming vessel to inform the pilot of the delayed departure and the occupied berth. Together they discuss the details of the occurring delay and any possibilities to pass each other during sailing and manoeuvring in the port. If the pilots have contact via phone, one of the pilots must update the *VTS operator* of the decisions made.
   - If the delayed departure and thereby occupied berth are known at the HCC (via the *DO VTS*), the *Pilot Service Leader* might call the *pilot* on board of the incoming vessel to inform the pilot on the situation.
   - The *DO VTS* calls the *VTS operator* of the sector in which an incoming vessel for a destined berth with a delayed departing vessel is sailing. The VTS operator informs the incoming vessel (*pilot* or vessel captain) to reduce its speed via the VHF radio.
   - The *pilot* informs the *tug captain* about the delay situation and if it is needed to reduce speed or wait at the channel.
   - The *pilot* and the *tug captain* inform their planning department about the current situation.

6. **Unfinished (un)loading activities:** The initial notice of unfinished (un)loading activities depends on the information from the terminal that is available to the bridge crew and the pilot and on information from the boatmen at the quay:

- Delays that are known by the *bridge crew* are shared with the *pilot* as soon as the pilot boards the vessel. Additional information can be provided by the *boatmen* at the quay, who receive information from the *terminal employees* at the quay.

The information that is shared after notifying the delay involves updates from the pilot to the other nautical service providers and updates to the planning departments:

- The *pilot* updates the *DO VTS*, the *VTS operator* of the sector, the *tug captain* and *boatmen* via the nautical VHF channel and the *pilot planners* on the occurring delay at the departing vessel.
- The *boatmen* and *tug captain* inform the *boatmen planners* and *tug planner* on the occurring delay.

7. **Unfinished bunker activities:** The initial notice of unfinished bunker activities depends on information that is available to the bridge crew and shared with the pilot:

    - The *pilot* is informed about unfinished bunker activities by the *bridge crew* when boarding the vessel.

    The information that is shared after notifying the delay is similar to the information that is shared in case of **delayed terminal operations due to unfinished (un)loading activities**.

8. **Congestion at the fairway due to peak demand:** The situation can be estimated in advance based on the available vessel reports provided by the vessel agents. In case the situation has not yet been foreseen and must be handled ad-hoc, noticing the situation depends on the information that is available on the current traffic situation:

    - The *VTS operator* and *DO VTS* communicate if traffic situations in the sector require attention. From this information, the DO VTS can conclude that the fairway capacity is at stake.
    - Communication between *pilots on different vessels* in the sector via the nautical VHF channel is a sign for a *tug captain* that the fairway capacity is at stake and that delays might occur.

    After notifying that a high traffic demand pressures the fairway capacity, the information that is shared is associated with deciding if vessels are still allowed to arrive and depart, with deciding what manoeuvres to make and with informing the planning departments:

    - The *DO VTS* and *DO HCC* together discuss the alignment between the macro- and micro planning of all vessel traffic. The DO VTS can decide to refuse to provide a departing vessel operational clearance. In that case, the DO VTS also updates the *VTS operator* of the sector of the departing vessel. For incoming vessels, the DO VTS asks the *VTS operator of Maas Approach* to delay the ETA PS of certain vessels.
    - The *VTS operator* of the sector is responsible to update the *pilot* on the current traffic situation. If needed, the VTS operator can advise the pilot to wait at the quay. However, this situation is rare. The pilot mostly takes the information into consideration for the navigation plan.
    - *Pilots* contact each other via phone or VHF channel to discuss the traffic situations and any possibilities to pass each other during sailing and maneuvering. If the pilots have contact via phone, one of the pilots must update the *VTS operator* on the decisions made.
    - The *pilot* updates the *tug captain* and *boatmen* (in case of a departing voyage) via the nautical VHF channel on the situation.
    - The *pilot*, the *tug captain* and the *boatmen* inform the *pilot planners*, the *tug planners* and the *boatmen planners* on the current situation.

9. **Congestion at the fairway due to passage of large vessels:** The notice of this situation is related with the available information on the current traffic situation, information on the planned arrivals and departures of the larger vessels and occurring delays at departing vessels:

    - Any delays that occur at a departing vessel are communicated from the *pilot* to the *DO VTS* and *VTS operator*.

- The *tug captain* (and in case of an outgoing vessel also the *boatmen*) can notify congested situations via communication about a delay between the *pilot* and *nautical service providers* at another vessel in the sector or the communication between *pilots of different vessels* in the sector.

The information that is shared after it is noticed that there is pressure on the fairway capacity is similar to the information that that is shared in case of **congestion at the fairway due to peak demand**.

10.2. Validation

The results presented in the previous section are validated through feedback from the boatmen organization, the pilot organization and the tug company. Each of the involved actors received a document containing statements about the information that is shared from or to the specific actor (for more information on the validation methods, see chapter 3). Feedback on these statements is discussed with the specific actor via phone and e-mail and processed into the results. With the received feedback, incorrect interpretations are corrected and nuances are added where needed.

The received validation feedback emphasizes that communication between pilots on the VHF channel can indeed be a sign for the tug captain that the fairway capacity is at stake, but that communication between pilots via phone forms a blind spot. Furthermore, it is emphasized that the tugboat planner indeed informs the DO HCC about difficulties with regard to the tug availability, but that this information sharing is not captured in a fixed agreement. Additionally, the pilot organization emphasized that a message from the tug planner via a notification in the GIDS system, which is received by the pilot as a text message on his phone, could be missed during navigating. Missing this message can have a great impact on the process. Therefore, the pilot planners sometimes make an additional call. Also, it is mentioned that it is rare that the tug planner directly calls the pilot on board of a vessel. Both the tug company and the pilot organization highlight that the main communication tool that is used is the GIDS system. Lastly, it is emphasized that the VTS operator provides the pilot with current traffic information that can be taken into account in the navigation plant, but that it is rare that the VTS operator advises the pilot to wait at the quay due to the current traffic situation.

10.3. Conclusion

In this chapter, the information that is shared in the frequent delay situations of the nautical chain is discussed. From the results, several conclusions are drawn. First of all, information sharing contributes to the initial notice of a delay and to spreading the fact that this delay occurs to others. Based on the available information, the to be taken actions can be discussed. Information that is shared as a consequence of an occurring delay (e.g. the delayed departure of a vessel due to unfinished bunker activities) is the trigger for the notification of another situation (e.g. an occupied berth by a sea-going vessel). This emphasizes the interrelations of the different delay situations that occur in the nautical chain.

Secondly, in most cases, the pilot is involved with the initial notice of a delay cause. Consequently, it is the pilot who communicates updates on an occurring delay to the tug captain and the boatmen. All operational actors update their own planner as soon as they notice or are informed of a delay situation.

Lastly, the terminal resource planner is not involved in the information sharing that is related with the frequent delays that occur in the nautical chain. For noticing any delay situation, the terminal resource planner depends on information provided by the vessel agent. Conversely, the nautical service providers require additional sources for noticing terminal related delays (e.g. the boatmen at the quay).

IV

Conclusions

11

Conclusion and recommendations

In this chapter, the final conclusions are presented in section 11.1. Next, the scientific and practical contributions of the research are discussed in section 11.2 and section 11.3, followed by the recommendations for practice in section 11.4. The limitations of the research are reflected upon in section 11.5. Lastly, the recommendations for further research are discussed in section 11.6.

11.1. Conclusion

The objective of this thesis is to provide insight into the information sharing between the actors of the nautical chain in the Port of Rotterdam and to identify the areas within this information sharing that are critical for the improvement of the efficiency of the nautical chain. The main research question to be answered in this thesis is:

What are the critical areas of information sharing for the improvement of efficiency in the nautical chain in the Port of Rotterdam?

Information sharing is considered critical for efficiency improvements if the shared information contributes to decisions that reduce the cascade effect of a delay trigger. To reduce the effect of a delay, the resources of all service providers should always be employed as efficient as reasonably practicable at a specific moment in time. This requires all actors to be aware, as far as possible, of disrupting events and their potential consequences. For the actors to be informed about the delays and disruptions that occur in the nautical chain, critical areas of information sharing are identified. The identified critical areas of information sharing follow from the results that are presented in chapter 10, which are validated through feedback from the pilot organization, boatmen organization and tugboat company. Table 11.1 lists the individual information links that are used (or might be used) in case of frequently occurring delay situations. The information links are classified into the following 'critical areas of information sharing':

(a) Information sharing from the boatmen, tug captain and pilot with their planning departments about disrupting events that occur at the current assignment.
(b) Information sharing from the pilot planning and the tug planning with all planning departments (including the Harbour Master) about the time available for delivering their services.
(c) Information sharing with the pilot planning and the tug planning about the required delivery time and quantity of the nautical services.
(d) Information sharing between the nautical service providers at other assignments in the same sector of the nautical VHF radio about disrupting events that might affect the own assignment.
(e) Information sharing between the nautical service providers about disrupting events that occur during the current assignment.
(f) Information sharing from all actors (other than the nautical service providers present at the current assignment) with the pilot about disrupting events that occur and the to be taken actions.
(g) Information sharing from the pilot of a departing vessel with the pilot of an incoming vessel and the VTS department of the Harbour Master about a delayed departure.

Shared from	Shared to	Shared information	Tool	
Pilot	Pilot planner	Update on expected time that the current assignment is finished and updates on the current situation	GIDS and phone	a
Tug captain	Tug planner	Update on expected time that the current assignment is finished and updates on the current situation	Internal VHF channel	
Boatmen	Boatmen planner	Update on expected time that the current assignment is finished and updates on the current situation	Internal VHF channel	
Pilot planner	VTS MA	Request for delayed ETA PS	Phone	b
Tug planner	DO HCC	Request for delayed ETA PS	Phone	
Pilot planner	HCC & Boatmen planner & Tug planner	Request for delayed ETD	GIDS	
Tug planner	HCC & Boatmen planner & Pilot planner	Request for delayed ETD	GIDS	
Tug planner	Pilot Service Leader	The tug planner informs the Pilot Service Leader if tugboats are planned to arrive from another vessel	Phone	
Tug planner	Pilot planner & Boatmen planner	Update about the delayed arrival of tugboats at a scheduled assignment	GIDS (and phone by exception)	
VTS MA	Pilot planner	Arrival of a vessel that makes operational contact within 3 hours before arrival at the ETA PS	Phone	c
Pilot Service Leader	Tug planner	Estimated number of tugs	GIDS	
Pilot	Tug planner	Final number of tugs ordered and ETA LL	GIDS	
Pilot at other vessel	Tug captain and boatmen at other vessel	Communication at another vessel between the pilot and the nautical service providers provides information on occurring delays	Nautical VHF channel	d
Pilot at other vessel	Pilot at other vessel	Communication between pilots of other vessels in the sector provides information about the current traffic situation	Nautical VHF channel	
Pilot	Tug captain & Boatmen	If the pilot boarded the vessel, any occurring delays are shared with the tug captain and (in case of an outgoing voyage) with the boatmen	Nautical VHF channel	e
Boatman	Pilot	Boatmen share information on terminal operations (outgoing voyage) or a barge that occupies the berth (incoming voyage) with the pilot	Nautical VHF channel	
Tug captain	Pilot	The tug captain contact the pilot of a vessel about a delayed tug arrival when the tug boat is in the same VHF sector	Nautical VHF channel	
Pilot	Pilot	In congested traffic situations pilots discuss the possibilities to pass each other and the to be taken manoeuvres to minimize the delay time	Phone or VHF channel of sector	f
Bridge crew	Pilot	The bridge crew informs the pilot of an outgoing vessel about unfinished bunker activities or terminal operations when the pilot boards the vessel	Face-to-face	
DO VTS → VTS operator	Pilot	The VTS inform the pilot on a delayed tug arrival or an occupied berth	VHF channel of the sector	
VTS operator	Pilot	The VTS operator informs the pilot on the current traffic situation and (if the VTS operator notices) on a barge that occupies the berth of an incoming vessel	VHF channel of the sector	
VTS operator → DO VTS	Pilot	Congested traffic situation and the request to wait at the berth	VHF channel of the sector	
Tug planner	Pilot	The tug planner can inform the pilot that tugboats must arrive from another vessel when sharing which tugboats are assigned to the voyage	GIDS	
Tug planner	Pilot	The tug planner updates the pilot that is assigned to a vessel about a delayed tug arrival	GIDS (and phone by exception)	
Pilot	DO VTS & VTS operator	Delayed departure of an outgoing vessel	VHF channel 11 and of sector	g
Pilot	Pilot	The pilot of a delayed departing vessel informs his colleague on an incoming vessel that the berth is still occupied and they discuss the possibilities to pass each other	Phone	

Table 11.1: Information sharing links related with the frequent delays

Figure 11.1 provides an overview of the critical information sharing areas. The figure shows that the identified areas of information sharing are dependent on each other. An arrow between two squares indicates that the information shared in the 'receiving' square is dependent on information that is shared in the 'sending' square. For example, information shared about any disrupting events that occur at a departing vessel by the bridge crew with the pilot [f] can then be shared by the pilot with the other nautical service providers at the assignment [e]. Next, this information is used by the tug captain to update the tug planner on a delay that occurs at the current assignment [a]. Lastly, the tug planner can conclude if any of the next scheduled assignments might experience difficulties and if needed inform the other planning departments [b].

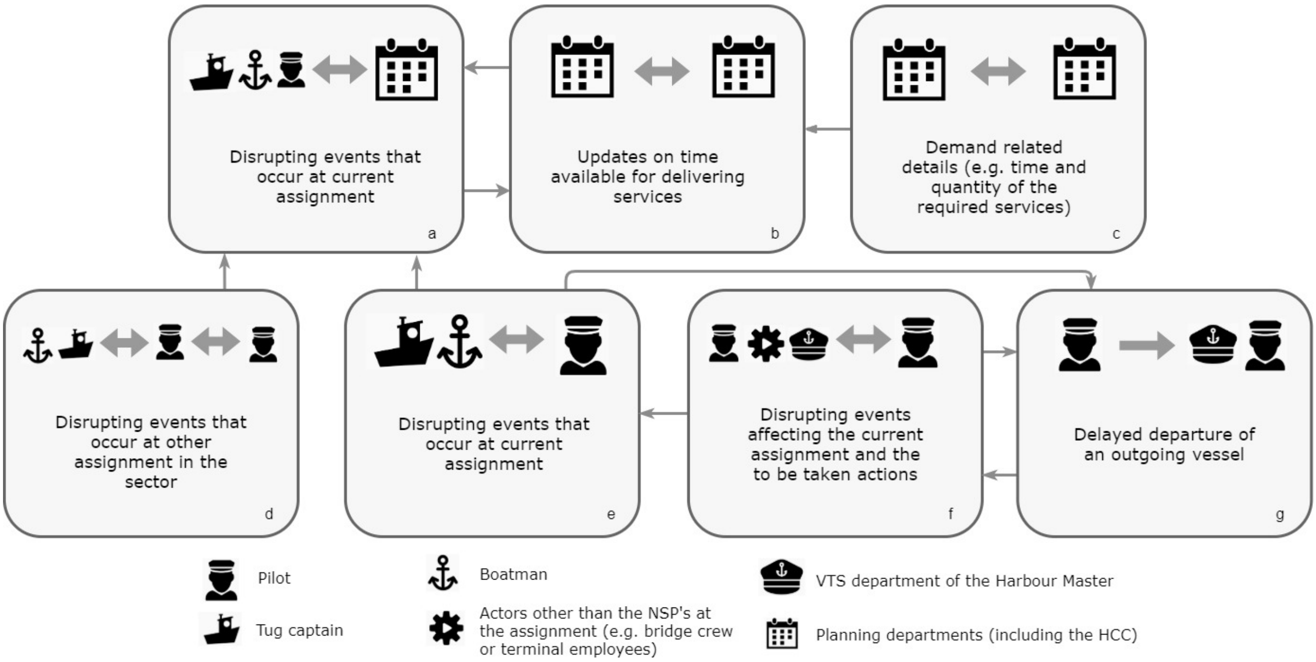


Figure 11.1: The critical areas of information sharing

(a) **Information sharing from the boatmen, tug captain and pilot with their planning departments about disrupting events that occur at the current assignment.**

With this information, the planners can make sure that the available capacity for the next assignments is employed sufficient. Furthermore, the planner can conclude whether capacity that has already been assigned to a next voyage will possibly be delayed. Vice versa, any information that affects the current planning can be shared from the planners to the operational nautical service providers (e.g delayed arrival of tugboats for an incoming voyage).

(b) **Information sharing from the pilot planning and the tug planning with all planning departments (including the Harbour Master) about the time available for delivering their services.**

This information sharing can prevent service providers from being assigned to a voyage too early or unnecessarily, which decreases the available capacity. The information shared involves communication on adapted ETD's or ETA PS's between the different actors, but also information shared on any disruptions that occur after the assignment has been done.

(c) **Information sharing with the pilot planning and the tug planning about the required delivery time and quantity of the nautical services.**

Except for the vessel- and voyage details that are provided by the vessel agent, information related to the demand for services should be shared between the other actors of the nautical chain. Examples of this information are the number of estimated tugboats to use (pilot planning-tug planning), the number of ordered tugboats and the ETA LL (pilot - tug planning) or incoming voyages that make the first operational contact within 3 hours before their ETA PS (VTS MA - pilot planning).

(d) **Information sharing between the nautical service providers at other assignments in the same sector of the nautical VHF radio about disrupting events that might affect the own assignment.**

Information that is shared via the nautical VHF channel serves as a valuable information source of the real-time events that occur in the nautical chain. Especially for outgoing voyages where the pilot has not yet boarded the vessel, communication on the VHF channel between the nautical service providers at another assignment provides the nautical service providers at the current assignment (especially the tugboats) with information. From this information can be concluded that there might be a chance on a delay at the own assignment.

(e) **Information sharing between the nautical service providers about disrupting events that occur during the current assignment.**

Information sharing between the nautical service providers (pilot, tug captain and boatmen) at an assignment about disrupting events that occur during the current assignment is crucial to remain all nautical service providers up to date on events that may cause a delay. The nautical service providers can then share this information with their planning departments.

(f) **Information sharing from all actors (other than the nautical service providers present at the current assignment) with the pilot about disrupting events that occur and the to be taken actions.**

For outgoing voyages, the pilot is updated by the VTS or the bridge crew on occurring events that may lead to delays in operation. For incoming voyages, the pilot is updated by the VTS or the tug planner on occurring events that may lead to delays in operation. The information shared with the pilot of an incoming vessel (e.g. berth occupied) is even more crucial, since it might involve actions such as reducing the speed of the vessel or not entering the port area. If needed, pilots of an incoming and outgoing vessel also discuss the possibilities to safely pass each other and minimize the delay time.

(g) **Information sharing from the pilot of a departing vessel with the pilot of an incoming vessel and the VTS department of the Harbour Master about a delayed departure.**

Any delay at a departing vessel is important to be known by the VTS department of the Harbour Master. The VTS can check whether an incoming vessel is approaching for the occupied berth and if actions are required. Furthermore, the pilot on board of the departing vessel can directly inform his pilot colleague on board of an incoming vessel about the delayed departure.

11.2. Scientific contribution of the research

First of all, research that focuses on the nautical chain within a sea-port is rare. The literature that is currently available states that cooperation between the actors of the nautical chain is required (see chapter 2). This thesis provides an extra dimension to the knowledge of this cooperation by adding the operational and tactical information exchange between the actors of the nautical chain in the Port of Rotterdam. Additionally, research on port efficiency by focusing on the efficiency of the nautical chain is not yet widely available. This thesis provides the first step by identifying information sharing areas that can be considered critical with regard to the efficiency of the nautical chain.

Furthermore, the outcomes of this thesis contribute to the development of the Service Information Model (SIM) of the nautical chain. The SIM is one of the elements of the research framework for investigating information sharing in service chains (see chapter 2). The SIM categorizes information that is expected to affect the performance of the service chain. The critical areas of information sharing that are identified in this thesis serve as the categories of information sharing of the SIM.

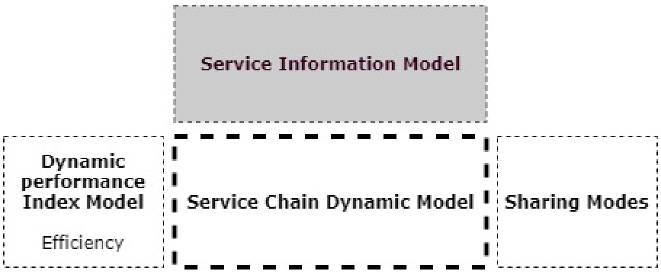


Figure 11.2: Relation between SIM and Service Chain Dynamic model

The SIM of the nautical chain can be used as the input for a Service Chain Dynamic Model (see chapter 2). Such a model should measure the service chain dynamics by measuring the effect of the shared information on identified performance indicators. The agent-based simulation model of the Swarmport project [1] can be used to fulfill the role of this model. Additionally, the detailed insights into the planning and operational activities of the nautical chain provided in this thesis can be used in the Swarmport project to improve the credibility of the agent-based simulation model.

11.3. Practical contribution of the research

Knowledge of the nautical processes is divided over all different organizations that are involved in the nautical processes. Above all, tacit knowledge plays a major role in the nautical chain. Tacit knowledge is defined by Brockmann and Anthony (2002) as 'the work-related practical know-how that is acquired through direct experience'. Concerning the nautical chain, this involves information that is available 'in the head' of the planners and operational nautical service providers, but that is not centrally registered and available. By observing the real-time operations of the nautical chain and complementing this with validated expert input, this thesis provides an overview of the processes and information sharing amongst all actors of the nautical chain. This can be used to evaluate the entire nautical process instead of the individual processes of each actor. The overview of the processes and information sharing amongst all actors can serve as a valuable information source for the nautical actors to better understand each other's activities and to review the overall process structure.

11.4. Recommendations for practice

The recommendations that can be translated into practice that follow from this thesis are the following:

- **Improve the recording method of the delays that occur in the nautical chain:** It is recommended to increase the accuracy of the recorded delay data of the Harbour Master by reviewing the current recording method. First of all, the used categories of the delay causes are not consistently used by all operators. Secondly, it is expected that currently not all delays are recorded, since the difference between the number of recorded delays for outgoing voyages is significantly higher than the number of recorded delays for incoming voyages. Lastly, the recorded data does not reveal if the delay involves a delayed ETA PS or ETD or if the delay occurred after the nautical services had been assigned. A more accurate recording of the data could enable more detailed insights into the frequently occurring delay situations that occur in the nautical chain.

- **Enhance information sharing between the planning departments of different actors within the nautical chain:** Information sharing between the planning departments of the nautical service providers and the HCC prevents that any capacity of the nautical services is assigned too early or unnecessarily. Information sharing between the operational actors and their planning departments only prevents that unavailable capacity is assigned to the next assignment. This means that all information that is shared in the planning phase of the actor has more effect on the accuracy of the planning than information that is shared in the operational phase of an actor. Therefore, it is recommended to enhance the information sharing between all planning departments of the nautical chain. By sharing information between the planning departments, disruptions might be noticed earlier and can be processed into the planning.

  - **Involve the terminals in the information sharing within the nautical chain:** The terminal does not have access to the same information sources and tools as the other actors. To improve the planning alignment with the other actors, it is recommended to increase the participation of the terminals into the information sharing within the nautical chain. This participation should be activated in two directions. First, the terminal can contribute to the nautical processes by sharing relevant information on the terminal operations. Second, the nautical service providers and the Harbour Master can contribute to the terminal processes by sharing any disruptions in the nautical planning with the terminal. Complete transparency might be an unrealistic goal, given the different (commercial) interests of the terminal. However, investigating the information details that both improve the terminal planning and the nautical planning is expected to be valuable. Hereby, information that is currently shared between the operational actors (information sharing

[1] The Swarmport Project is a 4-year research that started in 2017 and is executed by the TU Delft in collaboration with the Harbour Master of the Port of Rotterdam, TNO, Maastricht University, Intertransis, ECT and SmartPort. The Swarmport project aims to test the effect of different strategies on the performance of the nautical chain by means of an agent-based simulation model.

area e and f in Figure 11.1) is shifted to information shared between the planning departments (information sharing area b in Figure 11.1).

- **Develop information sharing protocols that ensure the planning departments of the required information from the operations:** The information shared between the planning departments depends on accurate information of the demand for services and continuous feedback from the operations about any disrupting events that occur. Therefore, it is recommended to assure that the planning departments receive the relevant information from the real-time operations and demand for services by developing applicable information sharing protocols. It is expected that information sharing between the operational and planning department within an organization is rather common, since this information optimizes the performance of the own organization. Still, information sharing protocols can clarify the shared information for all actors.
- **Develop information sharing protocols that clarify the to be taken information sharing route between organizations in the nautical chain:** Currently, information sharing between different organizations about any disruptions that occur in the nautical chain is executed via many different routes. Above all, it is not assured that all actors have the same information. For example, the boatmen are up to date on a delayed pilot arrival at a departing vessel since the boatmen arrange the pilot transportation, while the tugs that are already present do not have this information available. The chosen information route depends on the specific operator, but also on the time that is available for sharing information. In busy periods, it seems to have priority to arrange the internal planning instead of sharing valuable information with other organizations. It is recommended to develop information sharing protocols, in collaboration with the involved actors, that structure and clarify the available information sharing routes. In that way, each actor is aware of the information that must be shared to whom in which situation. Subsequently, all planning departments will become aware of the same facts and details. Communication via the nautical VHF channel between the nautical service providers at an other assignment in the sector can still serve as an information source, but consciously rather than unconsciously. To improve the information value of the VHF channel, pilots at different vessels should communicate with each other via the VHF or at least share decisions that are made via phone on the VHF channel.

- **Look for possibilities to share delayed bunker operations with the nautical service providers at an earlier stage:** Although bunkerers are not considered as an actor of the nautical chain, unfinished bunker activities are identified as a frequent delay cause of an outgoing voyage. This means that the bunkering process significantly influences the nautical processes of an outgoing vessel. Currently, the pilot is informed about delayed bunker activities by the bridge crew when boarding the vessel. It is recommended to investigate the possibilities for a more direct information sharing link between the bunkerers, bridge crew, terminal operator or vessel agent and the nautical service providers to share updates on delayed bunker operations. As a result, the occurring delay can be known at an earlier stage and be included in the planning of the nautical services.

11.5. Limitations of the research

The research presented in this thesis is mainly based on qualitative data, such as expert interviews and observations. As discussed in chapter 3, qualitative data is sensitive for biases of the researcher or the respondent. The risk of bias has been minimized within the available time and resources (by combining interviews with observations and by validating the final results with experts). However, it can not be assured that any bias is completely avoided. Limited observations have been applied for each actor and per involved organization only one operational and one planning expert have been interviewed. Also, single companies are used to represent the activities of the sector (e.g. the tug company and terminal operator).

Furthermore, the expert input on the identification of the frequently occurring root causes lacks detail. A larger group of respondents that better reflects all involved actors should improve the research outcomes. For that reason, it must be clear that the current outcomes must be considered as a 'proposition'. However, the outcomes of this 'proposition' are influencing the final results of this thesis. Therefore, other critical information sharing areas than identified in this research should not be excluded.

Lastly, it is expected that there is a difference between information within the critical information sharing areas that is frequently shared and information that is less frequently shared. Data regarding the frequency of shared information is not included in this research. Although this difference does not have an effect on what information sharing is critical for an improvement of the efficiency of the nautical chain, the frequency of shared information can highlight what information sharing links need more attention.

11.6. Recommendations for further research

The recommendations for further research that follow from this thesis are the following:

- **Investigate the role of the vessel agent:** The vessel agent is considered as a significant actor of the nautical chain, but is not included in the information sharing research, since most of the details that are provided by the vessel agent are provided to the Harbour Master via the PCS in advance of the port-call. However, the trigger message from the vessel agent to start the planning process of an incoming or outgoing voyage depends on information sharing between the vessel agent and the terminal operator. By investigating this information sharing, a more complete overview of the cooperation and dependencies in the nautical chain will be created.

- **Quantitatively examine the effect of the critical information sharing areas for the efficiency of the nautical chain:** As this thesis only identifies the information sharing areas qualitatively, further research should assess their effects on the efficiency of the nautical chain quantitatively. With regard to supply chains, research shows a positive relations between information sharing and performance (see chapter 2). This relation is assumed to be applicable to the nautical chain as well. A quantitative assessment of the effect of the critical information sharing areas on the efficiency of the nautical chain should confirm if this statement applies to the nautical chain of the Port of Rotterdam.

- **Conduct research to complement and further specify the proposition of the root causes of delays:** In this thesis, the root causes of the recorded delays are researched qualitatively based on expert input. The outcomes of the analysis are presented as a 'proposition' of the root causes of the recorded delays. Further research is required to complement and further specify this proposition. Therefore, it is required to include a bigger pool of experts that reflect all actors that are involved in the nautical processes. Additionally, a more quantitative research approach will contribute to a better deviation between the root causes that occur relatively frequent or less frequent and between root causes that cause relatively much delay time or less delay time.

- **Perform a case-study of the nautical chain in other sea-ports and compare them with each other:** Similar research as conducted in this thesis can be applied to the nautical processes of other sea-ports. By comparing multiple outcomes with each other, it can be concluded if similar information sharing areas are critical for other sea-ports. Additionally, it is recommended to investigate a valid benchmark method for the efficiency of the nautical chain of the selected sea-ports. Due to the differences in vessel traffic, the role of the Harbour Master and the organization of the nautical services this asks for an advanced methodology. It is recommended to focus on quantitative measurements. An example is the dynamic turnaround time versus the theoretical dynamic turn around time of a vessel. By comparing the level of efficiency and the level of information sharing of the selected sea-ports, the relation between the level of information sharing and the level of efficiency of the nautical chain of a sea-port can be plotted.

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A
Scientific paper

Critical information sharing for efficiency improvement in the nautical chain
A case-study of the Port of Rotterdam

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Abstract

Recently, pressure on port authorities to improve port efficiency is increasing due to port competitiveness. Multiple activities within a port influence the efficiency of a port. In this research, the processes of the 'nautical chain' are considered. The nautical chain consists of piloting by a pilot, positioning by tugboats and (un)mooring by boatmen. The provided services are dependent on each other, which makes information sharing between the actors of the nautical chain essential. Enhancing information sharing in the nautical chain could provide opportunities for efficiency improvements. However, current literature does not provide any details on information sharing in the nautical chain. Consequently, it is unknown what parts of the information sharing might be crucial to focus on for improving its efficiency. This research aims to fill this gap, by researching the information that is shared in the nautical chain of the Port of Rotterdam in the delays that frequently occur through expert interviews and observations. The information that is shared in the frequent delay situations is considered critical for efficiency improvements, because the shared information contributes to decisions that reduce the cascade effect of a delay trigger. Following from the identified information sharing in the frequent delays, several categories of critical information sharing are distinguished.
Keywords: Port of Rotterdam, nautical chain, port services, port efficiency, information sharing

1 Introduction

Over the last years, there has been pressure on port authorities to improve their performance due to an increasing competition between ports [1]. For example, the ports in the so called Hamburg-Le Havre range (e.g. Antwerp, Rotterdam, Amsterdam, Hamburg, Rotterdam) supply overlapping hinterland regions. Efficiency is considered as the key factor that determines the competitiveness of a port [2] [3]. Therefore, ports must ensure an adequate level of efficiency in order to stay competitive. Due to trends as increasing vessel sizes and maritime trade volumes, efficiency gains are required, even when a port is currently performing well.

In general, efficiency reflects the output over the input of a system. With regard to a port system, the output can be reflected by the number of handled vessels and the input by the number of used resources. Assuming that the resources remain equal, the amount of handled vessels must increase to improve the port efficiency. This could be reached by reducing the time between arrival and departure of a vessel. Yang et al. [4] confirm this by stating that the efficiency of sea-ports is determined by the time that a vessels stays in the port. This time is referred to as the turnaround time of a vessel.

There are many factors, actors and activities that influence the efficiency of a port. Studying the efficiency in the port sector is mentioned to be difficult, because ports can not be considered as a homogeneous entity. Multiple activities are carried out by a large variety of actors with different objectives, a different degree of competition or different regulation to which they are subject. Gonzalez and Trujillo [5] provide evidence for a need to clearly define the port activity for which an efficiency assessment is being conducted. In this respect, Tongzon [1] focuses on the efficiency of terminal operations and its relation with the overall port performance. The established model quantifies the contribution of terminal efficiency to the overall port performance. The stronger this relation in comparison to other factors, the more reason to focus on the improvement of terminal efficiency for improving the port performance. Similar research regarding the efficiency of the nautical services that are required for the vessel handling in the port area is lacking. To address this gap, this research focuses on the efficiency of the nautical services within the port.

The nautical services involve the positioning, piloting and mooring of a vessel. In most cases, the provision of nautical services is mandatory. The services must be performed sequentially and are therefore referred to as 'the nautical chain'. The nautical service providers are the pilots, the tugboats and the boatmen (see Figure 1). Other actors that are involved in the processes of the nautical chain are the Harbour Master, the terminal operators and vessel agents. The Harbour Master must provide clearance for the execution of the voyage and provides guidance to the vessel during its port passage if necessary. The vessel agent arranges all administrative tasks in the tactical domain of the nautical chain. The terminal operator must provide a free berth for the vessel and executes the (un)loading operations. The services provided by the actors are all dependent on each other, which makes information sharing between the actors of the chain essential.

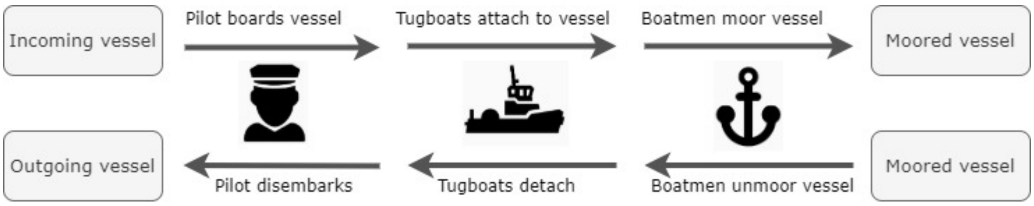

Figure 1: The nautical chain

Literature shows that information sharing has a positive impact on efficiency in a supply chain context [6] [7] [8] [9] [10] [11]. The actors involved in a supply chain are independent agents with individual preferences [7]. However, the performance of each actor is dependent on the performance of the other actors in the chain [12] [13]. All these actors have different ranges of information available. According to Simatupang and Shridharan [14], this asymmetric information results in (1) misunderstandings concerning the mutual efforts of collaboration, (2) difficulty in dealing with market uncertainty, (3) sub optimal decisions and (4) opportunistic behaviour. Information sharing is a strategy for achieving coherence amongst the supply chain members and enables decision making that improves the performance of the supply chain. Due to the similar characteristics, the relation between information and supply chain performance is assumed to be applicable to the nautical chain as well. In this respect, Talley [15] concludes that a cooperative *port service chain* (which interfaces with the used definition for *nautical chain*) will always result in a higher level of efficiency than would be possible if the port services are provided by a non-cooperative port service chain.

Since the overall port efficiency is influenced by the efficiency of the nautical chain, improving information sharing between the actors of the nautical chain can provide opportunities for improvement of port efficiency. Although information sharing is considered to be significant for the nautical chain, literature does not provide any details on the shared information. Verduijn [16] mentions information sharing between the actors of the nautical chain on a tactical level and operational level, but the research in this respect is limited. The used information sharing platforms are mentioned, but it is not clear what data is shared between the actors. Furthermore, Lind et al. [17] state that the coordination of port-calls is highly fragmented and that, except for some predefined interaction patterns, it is unclear what information is communicated to whom at what time. Consequently, it is unknown what parts of the information sharing might be crucial to focus on for improving the efficiency of the nautical chain.

This research aims to provide insight into the information sharing between actors in the nautical chain and to identify information sharing within the current processes that is critical for the improvement of efficiency in the nautical chain. The research follows a qualitative research approach, including expert interviews and observational research, which is applied to a case-study of the Port of Rotterdam.

First, the methodology of the research is discussed in section 2. Next, the context of the case-study is provided in section 3, followed by the the case-study findings in section 4. Finally, conclusions and recommendations for further research are presented in section 5.

2 Methodology

In this research, the framework for investigating information sharing in supply chains developed by Huang et al. [18] is used as a reference framework. The framework is used to investigate and test different levels of information sharing on their performance. The framework, presented in Figure 2, consists of the following elements:

- *The Supply Chain Structure* represents how the supply chain members are connected to each other.
- *The Level of Decision* differs between the available decision time and scale of the problem. The strategic level concerns long-term decisions, the tactical level concerns medium-term decisions and the operational level concerns the short-term decisions in the day-to-day operations.
- *The Production Information Model (PIM)* categorizes production information that affects supply chain performance and is shared between the supply chain members.
- *The Sharing Modes* can be interpreted as the degree of cooperation in a supply chain. The sharing mode specifies the amount of information shared between supply chain members.
- *The Dynamic performance Index Model (DIM)* reflects the dynamic performance of a supply chain. The DIM consists of a collection of performance indicators that measure the supply chain dynamics.
- *The Supply Chain Dynamic model (SCD)* measures the interaction between the PIM and the DIM. It describes the effect of the information sharing between supply chain members on the performance of the supply chain.
- *The Data Analysis* identifies the factors in PIM that have a significant effect on specific performance indicators.

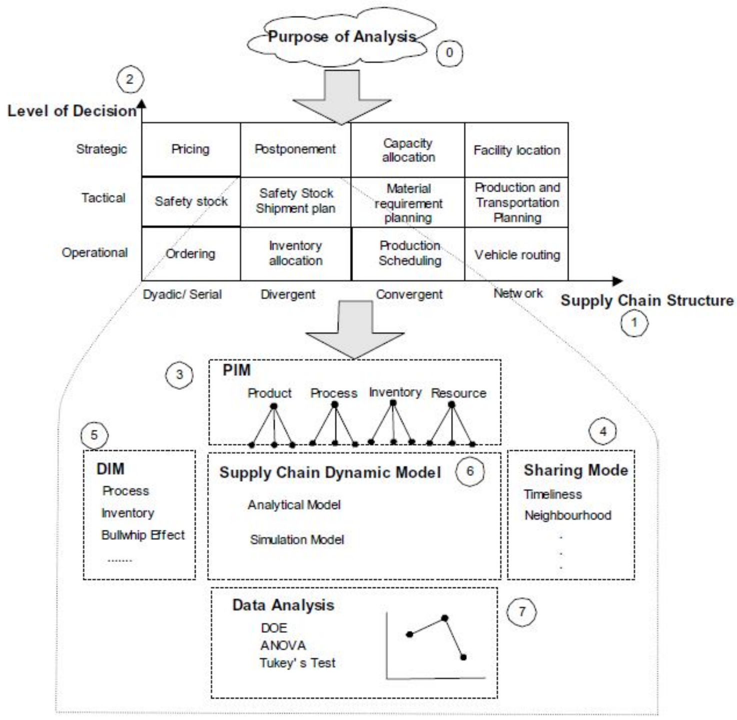

Figure 2: Research framework for investigating information sharing in supply chains

To make the framework for investigating information sharing in supply chains applicable to the nautical chain specifically, the focus on production must be replaced by a focus on service provision. This results in the framework presented in Figure 3. For an incoming voyage, the nautical services must be provided sequentially (pilot-tugs-boatmen), which can be best represented by a serial structure. For an outgoing voyage, all nautical service providers must be present at the vessel before departing, which can be best represented with a convergent structure. In particular, this research includes the tactical and operational decision level of the nautical chain.

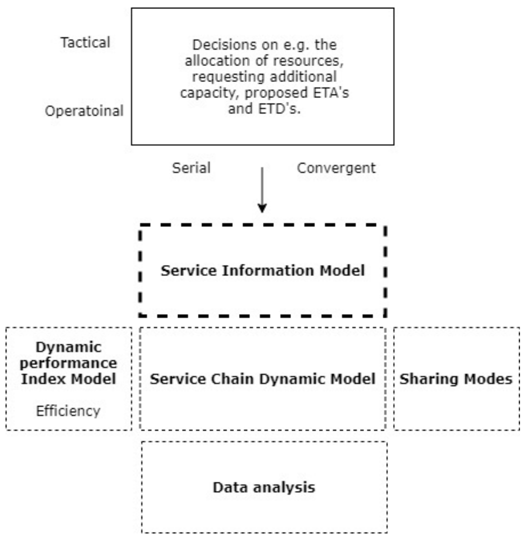

Figure 3: Research framework for investigating information sharing in a service chain

The Service Information Model (SIM) forms the core of this research. The SIM involves the information that is shared between the actors of the nautical chain and that is expected to have an impact on the considered performance indicators of the DIM. These performance indicators are focused on the efficiency of the nautical services. The Service Chain Dynamic model (SCD), Sharing Modes and Data Analysis are not addressed in this research.

2.1 Case-study of the Port of Rotterdam

To investigate the information sharing in the nautical chain and examine what information sharing is expected to have an impact on the efficiency of the nautical chain, a case-study of the nautical chain in the Port of Rotterdam is performed.

According to Yin [19], the need for case-study research arises when a contemporary phenomenon in its real context must be investigated, which is applicable to the processes and information sharing within the nautical chain. The processes of the different actors in the nautical chain are not clearly registered. Therefore, the required case-study data is conducted by applying a qualitative research approach involving expert knowledge (interview and survey) and observational research:

- *Expert knowledge*: A person is considered an expert if the researcher assumes that the person possesses information that is not generally accessible [20]. Expert knowledge is acquired through expert interviews and a survey. The interview type that is applicableis the systematizing expert interview [21]. This type of expert interviews focuses on knowledge of actions and experience by applying a detailed topic list, but with open-ended questions that allow the interviewee to answer extensively. Systematizing interviews are not necessarily open, but standardized surveys are applicable as well [21].

- *Observations*: Observational research has been applied in health and marketing related research [22] [23] [24] [25] [26]. In health care related studies, observations are used to examine communication between health professionals [27] [28]. In this research, observations are conducted to research the information sharing between actors in the nautical chain. The use of observational methods can be divided into structured and un-structured observations [29]. In this research, un-structured observations are used, because the researcher has no expectations of the outcomes of the observation. Un-structured observations do not use a predefined schema. The researcher only records the events and behaviour that are noticed in practice. The strengths of observational research mentioned by Morgan et al. [22] are that (1) observations allow direct examination of behaviour in real time, (2) observations provide information about topics participants may be unaware of and (3) observations allow examination of contextual factors

Figure 4 presents the approach that is applied to this research. First, information sharing in the operational phase and the planning phase of the nautical services are researched. Information sharing within the operations of the nautical chain is researched with both interviews and observations in practice, while information sharing within the planning phase of the nautical services is only conducted through expert interviews. However, during these interviews the planning activities are on-going, which means that insights experienced in practice are discussed in the interview as well.

Furthermore, in this research, the delays and the causes that might lead to the occurring delays are considered as the areas where improvement of performance can be gained in terms of efficiency. The efficiency of a port can be indicated by the turnaround time of a vessel [4] [30]. A reduction of the average turn around time within a port makes it possible to increase its efficiency by handling more vessels with the same number of resources. The turnaround time of a vessel consists of the dynamic turnaround time, which encompasses the time spent on sailing and manoeuvring, and the service time of a vessel at a terminal. With regard to the nautical chain, only the dynamic turnaround time is considered to indicate the efficiency. Reducing the delays (or at least the effect of delays) minimizes the total dynamic turnaround time and thereby positively influences the efficiency of the nautical chain.

Expert interviews provide insight into all possible delay causes that can instigate a delay cause that is recorded by the Harbour Master. Subsequently, a standardized survey in the form of a questionnaire is distributed among field experts to score the identified delay causes on their frequency of occurrence.

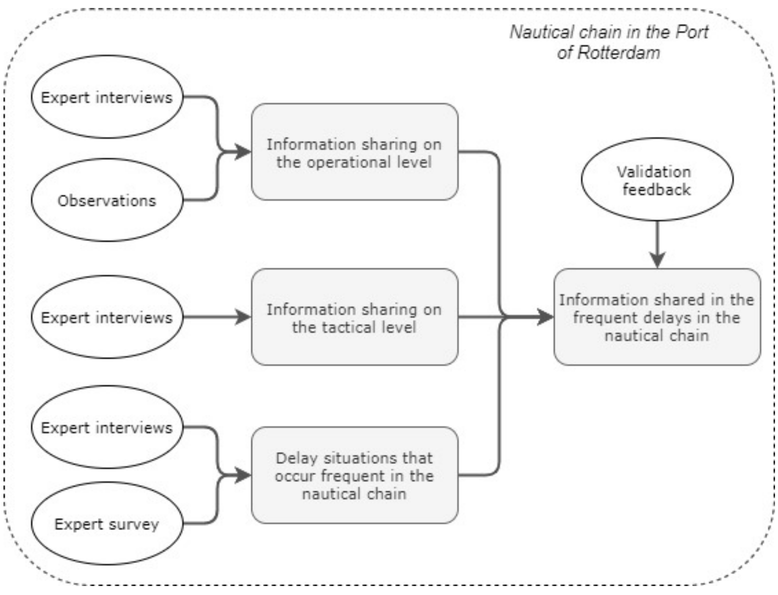

Figure 4: Research approach

2.2 Validation

In qualitative research, both the researcher and the experts use their own perspectives. Therefore, the validity of the research must be assured. For the possible biases from the perspective of the researcher, triangulation serves as a validity procedure [31]. Triangulation involves the combination of multiple information sources to study the same phenomenon [32]. Different types of triangulation are distinguished by Denzin [33], namely: across data sources (participants), methods (interviews, observations, documents), theories and among different researches. The triangulation types applied in this research are triangulation across data sources and methods. The insights from multiple experts on the same research subject are taken into account and observational data is combined with expert knowledge. For the possible biases from the perspective of the participating experts, member checking is applied as a validation procedure. With member checking, the data and interpretations are taken back to the experts so that they can confirm the validity of the results [31].

3 Case-study background

3.1 The actors of the nautical chain

Different companies and organizations are involved in the services provided within the nautical chain. The involved companies and organizations are referred as the actors of the nautical chain. An overview of these actors is presented in Table 1. For each actor, a short description of their tasks and responsibilities is provided.

Actor	Description
Harbour Master	Responsible authority for smooth and safe shipping
Vessel agent	Responsible for administrative tasks in behalf of the vessel
Pilot organization	Responsible organization for piloting vessels into and out of the port area
Tugboat company	Companies that deliver tugboat services to assist manoeuvring and mooring
Boatmen organization	Responsible organization for the (dis)attachment of the mooring lines of a vessel
Terminal operator	Company that receives vessels and (un)loads the cargo

Table 1: The actors of the nautical chain

The processes of the nautical chain are executed by different actors. However, the dependencies between the services cause that actors are related to each other. Figure 5 shows a visualization of the relations between actors of the nautical chain. A single pointed arrow represents a hierarchical relation, a double pointed arrow represents a bilateral relation and a dotted arrow represents a possible influence of one actor on another actor.

The Harbour Master is responsible for the provision of services from the Harbour Coordination Center (HCC) and the Vessel Traffic Services (VTS). The HCC applies the admission policy of the Harbour Master and arranges the administrative clearance of all vessels. The VTS is responsible for guiding vessel traffic in the port area to facilitate a safe and smooth port passage. The vessel agent is obliged to follow instructions given by the HCC to receive clearance for the requested voyage. The instructions are based on the information provided by the vessel agent about the vessel voyage, vessel details and cargo. Furthermore, the HCC can influence the planning of the nautical service providers. The HCC can request, but can not demand actions from the nautical service providers, because all nautical service providers are independent organizations. The HCC and the VTS have a bilateral relation, because together they are responsible for the safe and smooth handling of vessel traffic in the Port of Rotterdam.

The vessel agent has a bilateral relation with the boatmen organization, the pilot organization, the tugboat company and the terminal operator. This relation is based on contracts. The contracts are made between the parties mentioned and the shipping company, but the vessel agent executes the contracts on behalf of the shipping company. The contracts involve e.g. the service tariffs, the latest time to order a service, the consequences of cancelling an order and the consequence of a delayed service.

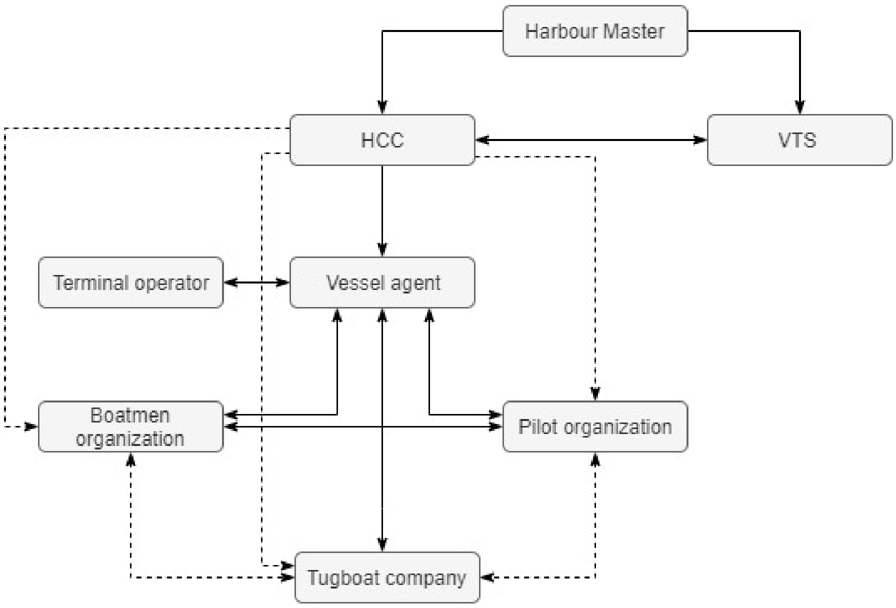

Figure 5: Relations between the actors of the nautical chain

The nautical service providers all influence each other. The services of the boatmen organization, the tugboat company and the pilot organization are dependent on each other, which means that the available capacity of the service providers influences the planning of the others. Additionally, the boatmen organization and the pilot organization have a bilateral relation, because the boatmen organization is contracted to arrange the pilot transportation.

3.2 The processes of the nautical chain

The processes executed by the actors of the nautical chain involve the navigating, manoeuvring and (un)mooring of a vessel. For an incoming voyage, the process starts when a vessel enters the first port sector and makes operational contact with the VTS of the Port of Rotterdam. If the vessel confirms its intentions to enter the port area, the Estimated Time of Arrival at the Pilot Station (ETA PS) is defined by the Harbour Master. At the defined ETA PS, a pilot, the tugboats, the boatmen and the berth must be available according to the current planning. After the vessel received an ETA PS, the vessel starts its voyage and arrives at the pilot station, where the pilot boards the vessel. Before the pilot enters the port area, the availability of the tugboats at the planned meeting location in the port should be confirmed. As soon as the pilot is assured of the tug availability, the pilot enters the port area and the tugs attach to the vessel. Lastly, the mooring process starts and the mooring lines are fastened by the boatmen.

For an outgoing voyage, the process starts when the voyage is ordered by the vessel agent on the requested time of departure that is provided by the terminal. When the Estimated Time for Departure (ETD) requested by the vessel agent is clear, the scheduled ETD is defined by the Harbour Master. At the defined ETD, a pilot, the tugboats, the boatmen must be available and the terminal operations must be finished according to the current planning. As soon as all service providers are present and the terminal operations are finished, the boatman unmoor the vessel. After manoeuvring out of the harbour, the tugboats are released. The process ends when the pilot disembarks the vessel and the VTS stops monitoring the vessel.

3.3 Information sharing tools used in the nautical chain

Multiple information sharing systems support the information sharing between the actors of the nautical chain on a tactical level. An overview of the main systems is presented in Figure 6.

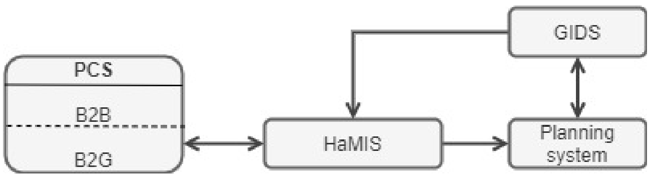

Figure 6: Information systems used in the nautical chain

The vessel agents provide the pre-notifications of the vessel's visit to the Harbour Master via the business to governance environment (B2G) of the Port Community System (PCS). Via the PCS, the provided details are collected in HaMIS. In

HaMIS, an overview of the reported voyages and their specifications, such as the destination, vessel size and draft, are available to the Harbour Master. The HCC uses the data to assess the administrative clearance of a vessel voyage. The VTS use the data to support the operational planning of the port. Additionally, the data is partly shared with the nautical service providers. The nautical service providers use HaMIS as an information source for the overview of reported and ordered voyages. Contrary to the HCC and VTS, the nautical service providers are not authorized to update any details in the HaMIS system. However, HaMIS is linked with the individual planning systems of the nautical service providers. Additionally, these individual planning systems are all linked with the GIDS system. In GIDS, the nautical service providers can approve or update a time proposal for outgoing voyages in order to align their planning with each other. GIDS is connected with HaMIS, so that any changed Estimated Times of Departure (ETD) are updated in the HaMIS system. The HCC will re-asses the proposed ETD and inform the vessel agent. For incoming voyages, the GIDS system is not yet in use.

Besides the digital information sharing systems, conventional communication tools, such as phone and VHF radio, are in use. On the operational level, the information sharing is mainly executed via phone and VHF radio. Additionally, updates that are processed in the GIDS system can be automatically send as a text message notification to both planners and operational actors.

4 Case-study results

4.1 Information sharing in the nautical chain

An overview of the identified information sharing links between the actors of the nautical chain is presented in Figure 7. The overview is presented with a BPMN conversation diagram. A BPMN conversation diagram consists of partners, conversations and conversation links. A single conversation includes a message flow between the connected partners. The contents of the exchanged messages within one conversation should be related with each other. In Figure 7, multiple conversations between the connected communication partners might exist.

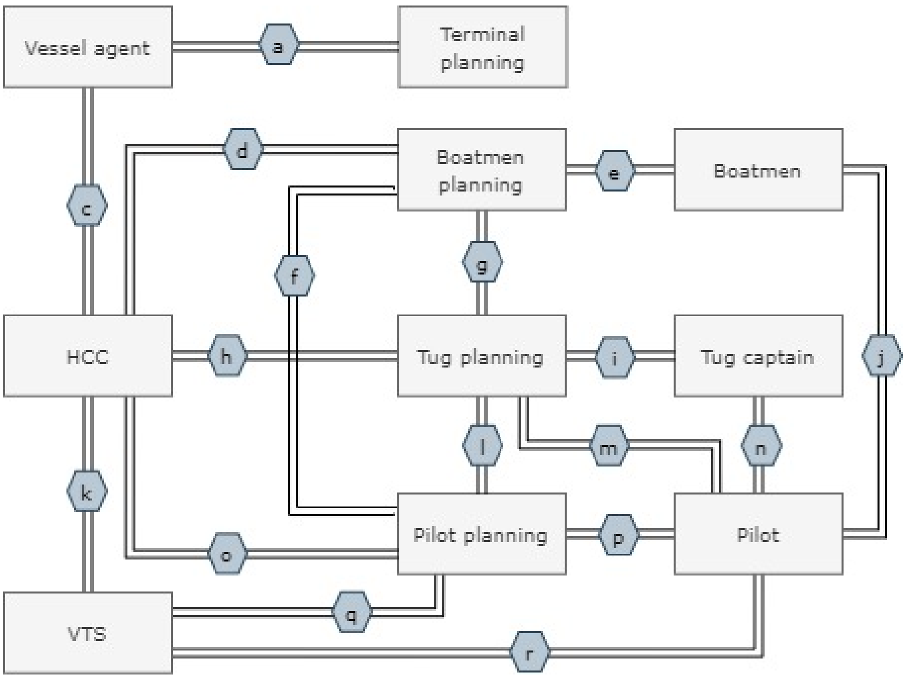

Figure 7: Information systems used in the nautical chain

Conversation e, i, p: The boatmen planning, tug planning and boatmen planning share the details of the next scheduled assignment with the boatmen, the tug captain and the pilot. For the pilot planning and the boatmen planning, it differs if people must be called from home or not. Vice versa, updates of the current operations are shared from the boatmen, the tug captain and the pilot to their planning departments.

Conversation h, f, g, l, d, o: The boatmen planning, the pilot planning, the tug planning and the HCC are all linked with each other. The information that is shared mainly involves updates on the proposed ETD or ETA of planned vessels. For outgoing voyages, the nautical service providers can approve or propose a new time in the GIDS system. For incoming voyages, new time proposals are communicated via phone to the HCC or VTS operator of the first port sector (sector Maas Approach). Additional information that is shared between the different planning departments includes updates on delayed arrivals of planned services and requests for confirmations when needed. Information from the tug planner about a delayed arrival of the planned services that is shared with the pilot planning via the GIDS system, is automatically available for the assigned pilot. Besides, in some cases, the pilot planning estimates the required number of tugboats for a voyage. This information is shared with the tug planning via GIDS. Furthermore, the pilot planning and the boatmen planning are linked, because the boatmen arrange the pilot transportation in the port area. Lastly, in busy times, the boatmen planning is interest in which voyages are planned to be served by the same tugboat. The boatmen planner can then combine the same voyages for one boatmen team, since the next voyage will not be served before the assigned tugboat is available.

Conversation c, a, m: Besides a link with the nautical service providers, the HCC is linked with the vessel agents. The vessel agents are obliged to provide details about the vessel and the voyage to the Harbour Master via the PCS (see subsection 3.3). Simultaneously, the vessel agent is in contact with the terminal planning. The terminal planning uses updates from the vessel agent of an incoming voyage and updates of the current terminal operations to optimize the terminal planning. In case the terminal operations are delayed, the terminal planning informs the vessel agent of the departing vessel and if needed the vessel agent of an incoming vessel for its berth. The information that is communicated by the terminal planning to the vessel agent, e.g. boulder numbers or the requested ETD, must be shared with the HCC by the vessel agent.

Conversation j, n, r: When multiple nautical service providers are present at an assignment to provide the requested services, the pilot coordinates the nautical processes. Instructions from the pilot to the boatmen and the tug captains are shared via a VHF radio channel that is only available for the nautical service providers that are present in the sector. The boatmen and tug captain respond by repeating the instruction to confirm that the message is understood. Communication between nautical service providers at other assignments in the same VHF sector is used for further awareness of the traffic conditions. From these communication can be extracted if delays at another vessel, that might impact the own assignment, occur. Furthermore, the pilot and VTS operator of the port sector in which the vessel is located are in contact to exchange traffic related information and vessel intentions. Additionally, when a departing vessel is delayed, the pilot informs the duty officer VTS.

Conversation k, q: Lastly, the HCC is in contact with the VTS to align the macro- with the micro planning. Contact between VTS operators and the HCC is generally executed via the Duty Officer VTS, who is located at the HCC. Messages from the HCC that are intended for a pilot in a specific sector are shared from the DO VTS to the VTS operator of that specific VTS sector. The pilot planning itself is also linked with the VTS. This connection involves updates from the VTS operator of the first port sector (sector Maas Apprach) if a vessel reports within less than 3 hours before arrival at the pilot station. Vice versa, the pilot planners call the VTS operator of the first port sector (sector Maas Approach) to request a delayed ETA PS for an incoming vessel if the pilot capacity is at stake.

4.2 Frequently occurring delays in the nautical chain

A delay for incoming voyages is defined as a deviation from the initial ETA PS or a delay occurring during the port passage between arrival at the Pilot Station and arrival at the berth. A delay for outgoing voyages is defined as a deviation from the initial ETD. The Harbour Master records delays of more than 30 minutes and their causes. This delay registration only covers the direct cause (first-level cause) of a delay and does not involve the fact that other indirect causes (higher-level causes) might have led to the recorded cause. The highest-level cause of a delay is referred to as the 'root cause'. Considering the higher-level causes that instigate the first-level causes of a delay provides a more realistic insight into the causes of a delay. Therefore, a Root Cause Analysis based on expert interviews with two Harbour Master employees is performed. The RCA is not used to identify the root causes that must be solved, but to provide insight into all causes that might have led to the causes that are recorded by the Harbour Master. For this reason, no distinction is made between internal and external factors.

The root causes of the delays differ in the frequency they occur and in the impact they have. Since the frequency of a delay cause is considered easier to approach than the impact, experts are asked to score the root causes on their relative occurrence. Above all, insights of the recorded Harbour Master data do not suggest a major difference between the frequency and the impact of the recorded delays. Following from the expert input, the root causes that are frequently considered as the instigator of delays are identified: (1) A pilot capacity shortage (2) A tug capacity shortage (3) A delayed tug arrival due to a delay of the previous vessel (4) Berth occupied by a barge (5) Berth occupied by a sea-going vessel (6) Unfinished loading activities (7) Unfinished bunker activities (8) Congestion at the fairway due to a peak demand and (9) Congestion at the fairway due to the passage of large vessels.

4.3 Information shared in the frequently occurring delays of the nautical chain

Information sharing contributes to the initial notice of a delay and to spreading the fact that this delay occurs to others. Information that is shared as a consequence of an occurring delay (e.g. the delayed departure of a vessel due to unfinished bunker activities) is the trigger for the notification of another situation (e.g. an occupied berth by a sea-going vessel). Based on the available information, the to be taken actions can be discussed.

Information that is shared in the identified frequent delays, as discussed in subsection 4.2, involves information sharing between the different planning departments, between the different operational actors and between the planning departments and operational actors:

- **Inter-organizational information sharing on tactical level**
  - *Requests for a delayed ETA or ETD [f, g, l, d, h, o]:*
    In case the pilots have no resources available for an incoming voyage, the pilot planning contacts the VTS operator of the first port sector (sector Maas Approach) to request a delayed ETA PS. In case the tug company does not have resources available for an incoming voyage, the tug planner contacts the HCC. For outgoing voyages, 1,5 hours before ETD, the pilot planning or tug planning can communicate a new ETD via the GIDS system. The boatmen do not participate in this information sharing, because they plan about half an hour in advance and increase their capacity by calling boatmen from home if needed.
  - *The number of estimated tugs that is required [l]:*
    When the vessel agent does not order a specific number of tugboats, the pilot planning must estimate the number of tugs to use. This number is shared via GIDS with the tug planner.
  - *Update about vessels that arrive at the pilot station earlier than expected [q]:*
    Exceptions regarding vessels that make the first operational contact with the VTS of the Port of Rotterdam, are shared from the VTS operator of the first port sector (sector Maas Approach) with the pilot planning. The pilot planning needs about three hours to plan their services if a pilot must be requested from home. Therefore, vessels that make the first operational contact within in less than 3 hours before arrival at the pilot station might affect the planning. The tug planning and boatmen planning fix their planning later.
- **Inter-organizational information sharing on an operational level**
  - *A delayed arrival of tugboats at a scheduled assignment [l, m]:*
    The tug planner contacts the pilot planning in case a tugboat that has already been assigned to a voyage will arrive delayed. The tug planner can either call the pilot planner or send a text message via the GIDS system. The latter is automatically available for the assigned pilot of the affected voyage. In both cases, the pilot planner informs the pilot to make sure that the message is received. Generally, the shared message contains from which vessel the assigned tugboat should arrive and the ETD of that vessel.
  - *Delays at the current assignment [r, n, j]*:
    Delays that occur at the current assignment are communicated between the pilot, the tug captain and the boatmen. The boatmen could have additional information available from terminal employees. Above all, with an incoming voyage, the boatmen are the first to be present at the terminal and notice e.g. a barge that occupies the quay or an unlifted crane. The pilot can have additional information available from the bridge crew or the VTS operator. Simultaneously, the pilot shares any occurring delays at a departing vessel with the VTS department.
  - *Communication between other vessels via the nautical VHF channel [n, j]*:
    Information between the nautical service providers is shared via a VHF radio channel that is used by all nautical service providers in a specific sector. Therefore, communication between the nautical service providers at another assignment in the same sector is available as an information source. From these communication can be extracted if delays at another vessel, that might impact the own assignment, occur.
- **Intra-organizational information sharing between tactical and operational level**
  - *Updates about the operations [e, i, p]:*
    The boatmen, tug captain and pilot all share updates of the processes at the current assignment with their planning departments. The planners use this information to avoid that delayed resources are assigned to a next voyage.

5 Conclusions and recommendations for further research

The results of this research reveal the information that is shared between the actors of the nautical chain in the frequently occurring delays. This information sharing is assigned as being critical for the efficiency of the nautical chain, because the shared information contributes to decisions that reduce the cascade effect of a delay triggering event. To reduce the effect of such an event, the resources of all service providers should always be employed as efficient as reasonably practicable at a specific moment in time. This requires all actors to be aware, as far as possible, of disrupting events and their potential consequences. In conclusions, the following categories of information sharing that are important concerning the efficiency of the nautical chain can be distinguished:

1. Information sharing between the nautical service providers and VTS about disrupting events that occur during the current assignment.
2. Information sharing from the boatmen, tug captain and pilot with their planning departments about disrupting events that occur at the current assignment.
3. Information sharing from the pilot planning and the tug planning with all other planning departments about the time available for delivering their services.
4. Information sharing between the nautical service providers at other assignments in the VHF sector about disrupting events that might affect the own assignment.
5. Information sharing with the pilot planning and the tug planning about the required delivery time and quantity of the nautical services.

Furthermore, it can be concluded that the terminal is not involved in the information shared in frequent delay situations. Consequently, the nautical service providers require additional information sources to be aware of disruptions at the terminal planning. However, information about any disruptions at the nautical side is not shared with the terminal as well. Since the boatmen are the first to be present at the quay and closest to the terminal operations, the boatmen have additional information available for the other nautical service providers concerning the terminal operations.

The results of this research contribute to the development of the Service Information Model (SIM) of the nautical chain. The identified information that is shared in the frequent delays of the nautical chain serves as the categories of information sharing that are considered important for the performance of the nautical chain. The SIM of the nautical chain can be used as the input for a Service Chain Dynamic Model. Such a model should measure the supply chain dynamics by measuring the effect of the shared information on identified performance indicators.

Further research is required to quantitatively assess the effects of the identified information sharing on the efficiency of the nautical chain. Furthermore, additional research is required to further complement and specify the identified frequent delays. A larger group of respondents that better reflects all involved actors should improve the research outcomes.

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B

Observations of the operational domain of the nautical chain in the Port of Rotterdam

B.1. Boatmen

Observations conducted on 12-12-2019 with the KRVE.

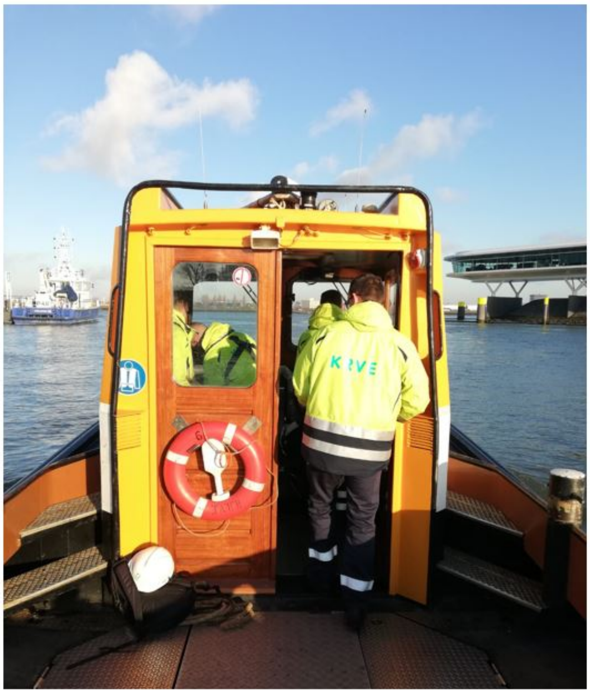


Figure B.1: Boatmen observation

Observation 1

- Boatmen leave the Heijplaat location.
- Pilot dropped off at a vessel at the Parkkade.
- Continued trip to another vessel at the Parkkade.
- 8:56 AM arrival at vessel.
- Water bunker is still attached to the vessel.

- Vessel should depart at 9:00 AM.
- Boatman asks the man on the bunker ship how long it will take.
- The man on the bunker ship answers that it will take around 10 minutes.
- Boatman calls his planner via the internal VHF channel and updates him that the vessel is still busy but will probably be ready for departure in 10 minutes.
- Pilot calls over the VHF *(channel only available for the nautical service providers)* 'Roeiers Parkkade, we zijn bijna klaar'
- Boatman answers: 'He loods, okee'
- At 9:06 AM the pilot says that the vessel is ready to be unmoored and which line must be released last *(with that information, the boatman immediately knows which manoeuvre is going to be performed)*.
- 9:13 vessel leaves and boatman sail back to the Heijplaat location.

Observation 2

- Boatman are waiting for their job at the Botlek location.
- At the Botlek location *(same for the other locations)* a computer screen shows the planned voyages. For incoming voyages, the estimated time of arrival at the berth that is registered by the pilot is shown. The boatman plan by following the sailing vessel instead of the registered ETA. The vessel crosses several passage lines and is visible on the map.
- The incoming vessel X of 119 meters must be moored on piles in the Botlek.
- When the vessel crosses a certain passage line, the boatman receive a sign that it is time to leave. At the same time, the boatmen follow the vessel on the screen theme selves *(and sometimes by looking outside)*.
- Boatmen leave to the Amanda.
- When arrived at the Amanda, the vessel just arrives and the pilot calls over the nautical VHF: 'He roeiers in de Botlek, graag 2 om 2 en naar de Lekhaven'.
- The boatman communicate the destination of the pilot via their own VHF channel to their CP links *(arranges all the taxi transport)*: 'Loods wil naar de Lekhaven'.
- The boatmen mention on the VHF channel that they will start to collect the mooring lines. They wait for a confirmation of the pilot. *(Reason for this communication is to be sure that the pilot will not give any speed, when collecting the mooring lines close to the engine)*.
- During the collection of the mooring lines, the boatmen communicate verbal and non-verbal with the people on deck. For example that the mooring lines need more slack. When more slack is needed, the boatman in the front of the boat waves his arm in a circle above his head.
- During the job, the planner calls the boatmen team via the internal VHF channel if they can make it on time to a vessel in a harbour close by. The boatman behind the rudder does not answer an exact time that they will arrive, but is able to judge if they can make it in time to the next vessel. He answers that it is possible.
- The Amanda is positioned next to the quay. Lastly, the front and back mooring lines are collected.
- The boatmen call the pilot on the VHF channel: 'Loods bedankt, de lijnen zitten vast met 2 om 2. De rhib komt je zo ophalen om naar de Lekhaven te gaan'
- Pilot answers: 'Bedankt, fijne dag'
- The boatmen team leaves to be on time for the next job.

Observation 3

- The boatmen team arrives just in time to manoeuvre their boat in between the arriving vessel and the quay.
- The arriving vessel is relatively small and does not have a pilot on board.
- The boatmen collect the mooring lines. With verbal and non-verbal communication, such as pointing, with the people on deck the mooring configuration is checked.
- When finished, a piece of paper *(the invoice)* is handed to the captain. *(When a pilot is on board, the pilot asks for a signature of the captain).*
- The boatmen return to the Botlek location.

Observation 4

- A vessel is arriving for the Botlek with assistance of 1 tugboat in the back.
- The vessel approaches its harbour.
- Without orders of the pilot, the tugboat assists the vessel to sail straight.
- When approaching the berth, the pilot calls the boatman: 'He Roeiers, graag 4-2 en naar de Steensteiger'
- The boatman answer the pilot by replying the message and communicate the destination of the pilot via their own VHF channel to CP links *(arranges all taxi transport)*.
- During the manoeuvre, orders are given from the pilot to the tugboat.
- The pilot communicates: 'motor is uit' (engine is off).
- The 'steigerbaas' positions the vessel and counts the remaining meters on the VHF channel with all nautical service providers. *(At container terminals, the boatman do this job).*
- When the lines are collected and moored, the boatman sign to the deck crew that the lines can be rolled-in.
- The boatman call the pilot: 'Bedankt loods, de lijnen zitten vast 4-2 en er komt een auto aan om je naar de Steensteiger te brengen'
- The pilot answers: 'Bedankt, tot de volgende'
- The boatmen sail back to the Botlek location.

Observation 5

- Departing vessel with ETD 3:00 PM.
- A few minutes before 3:00 PM the boatmen arrive.
- 2 tugboats are already present and are pushing in the side of the vessel.
- Pilot is not present yet, but arrives around 3:00 PM.
- Pilot calls over the VHF: 'sleepboot in de zij'.
- The boatmen see which lines are getting slack and unmoor these lines.
- When all lines are unmoored, the boatmen call over the VHF: 'Loods, alle lijnen zijn los'

B.2. Pilot

Observations conducted on 21-01-2020 with Loodswezen Rotterdam-Rijnmond.

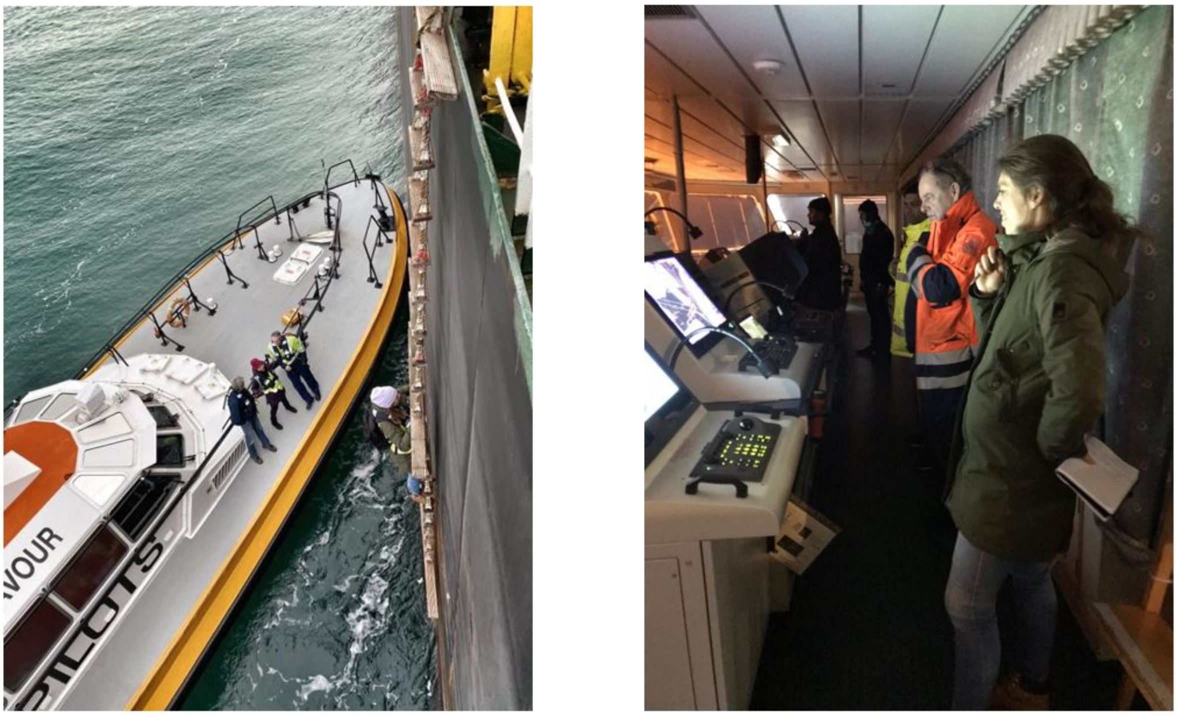


Figure B.2: Pilot observation

Observation 1

- 6:48 boarding the boatmen rhib at the Pistoolhaven.
- 7:00 boarding container vessel (on time).
- Boatmen and tugs are present.
- Pilot informs tugboats via the nautical VHF channel that the vessel is about to leave.
- Pilot asks the bridge crew to test the engine.
- Pilot calls the Harbour Master via VHF channel 11 that the vessel is ready for departure, that the draught is X meters and the location of departure.
- The Harbour Master *(DO VTS)* answers 'goede reis'.
- Pilot calls boatmen via the nautical VHF channel 'roeiers van schip X, we gaan zo voor en achter los gooien'.
- The bridge crew confirms that the engine is in order.
- Pilot records the time on board, the draught and the expected time of arrival at the Lage Licht in the GIDS app. The expected Lage Licht time is 8:00.
- Pilot calls over the VHF channel of the VTS sector 'sector Europoort, hier de X, ik vertrek van haven X over stuurboord. The VTS operator answers 'okee dat is begrepen'.
- Crew member at the bridge mentions that the tugs are fastened.
- Vessel leaves the berth.

- Pilot receives information via the nautical VHF channel from the tugboats that 2 large vessels are visible on the radar and coming in. The tugboats were updated via the VHF channel of the VTS sector. The pilot was temporary out of the connection.
- Pilot answers ’okee dan draaien we eerst naar achter, tugboat X je mag stoppen met duwen’.
- Pilot manoeuvres the vessel from the quay and communicates with the tugboats ’Tugboat X en Tugboat Y, beiden kwartje af’. The tugboats repeat the order to confirm that they have understood the pilot.
- Pilot calls via the VHF channel of sector Europoort ’sector Europoort, de X is los aan het varen’. The VTS operator of sector Europoort answers ’okee dat is begrepen’ and provides some traffic information.
- Pilot mentions on the sector VHF channel ’de X gaat in achteruit’.
- In the meantime there is continuous communication with the tugboats and the bridge crew. For example ’engine astern’ to the bridge crew and ’halfje af’ to the tugboats.
- At 7:30 the vessel is about 20 metres from the quay.
- Pilot receives phone call from pilot colleague on incoming vessel: ’ik kom nu het Beerkanaal uit, zit jij op die binnenkomer?’. Colleague answers something. ’Okee ik denk dat ik dan moet wachten, want er komen er nog 2 aan’.
- Pilot calls the VTS operator via the VHF sector channel ’Vessel X for sector Europoort’. VTS operator provides an update on the crowded traffic situation. Pilot answers ’okee begrepen, wij gaan het Beerkanaal in’.
- Pilot informs the tugboats ’sleepboten jullie mogen stoppen, er komen 4 grote binnenkomers aan waar we op moeten wachten’.
- Tug over the VHF channel: ’ik ben doorgepland op een binnenkomer. Ik weet alleen nog niet welke’. Pilot and tug captain discuss a possible solution together. Maybe the tugboat can be released earlier.
- The vessel captain asks the pilot what is going on. Pilot answers ’4 large vessels are coming in. One from this side, which waits for our tugboat. Therefore this tugboat will be released there and assist the incoming vessel’.
- Pilot calls tugboat and says ’Tugboat X jij kan los’. Tugboat X confirms to the pilot that they are released and they wish each other a good day.
- The expected Lage Licht time was 8:00. At 7:56 the pilot informs the captain ’4 big vessels are coming in, I think that we can go after the 3rd one’.
- Around 8:00 the pilot checks in the GIDS app to which harbour the incoming vessels sail. The pilot checks if the vessels cross the route of his vessel. With this information the pilot makes a decision where to enter the channel, namely after the 3rd incoming vessel.
- Pilot is in contact with the VTS operator who confirms the idea of entering after the 3rd incoming vessel.
- Pilot tries to reach his colleague on the incoming vessel by phone, but his colleague does not pick up the phone.
- Sector Europoort calls via the VHF channel ’schip X, de Y maakt wat meer vaart dus de afstand om er tussen te kruipen wordt kleiner’. Pilot answers ’ja ik probeer mijn collega te bellen, maar krijg geen gehoor’. VTS operator of Europoort: ’okee wachten dus?’ Pilot: ’ja’.
- Pilot calls the tugboat via VHF and asks ’hebben jullie dat meegekregen? Het gat tussen de schepen is kleiner geworden, dus we moeten ook nog wachten op de volgende’. The tugboat answers ’okee we zijn voor dat schip bestemd, dus dat komt goed uit. Pilot says: ’okee ja ik hoop er dan inderdaad echt uit te zijn’.
- While waiting, the pilot sometimes asks the VTS operator for traffic information. For example where a specific vessel is going to.

- Pilot calls via VHF channel of the sector ’schip X gaat zo het kanaal in en onze sleepboot moet naar de volgende binnenkomer Y’.
- 8:53 ready for entering the channel.
- VTS operator sector Europoort asks if the X is starting its way to the channel and provides some additional traffic information.
- The pilot tells the tugboats that they may register 70 min of delay.
- 9:03 pilot says to captain ’we’re going to speed up’.
- 9:08 contact with the tugboat that they may be released.
- 9:15 entering sector Maas Mond. Communication with VTS while sailing.
- 9:46 tender arrives for picking up pilot and transport to pilot vessel.

Observation 2

- Picked up by pilot tender boat from the pilot vessel.
- 12:00 boarding the vessel at sea.
- Vessel appears to have more draught than initially registered. This difference of 20 centimeters makes the vessel a semi-geuler, which requires specialized pilots. The pilot is qualified to also pilot semi-geulers, so no action is needed.
- The pilot calls over the VTS sector channel that the vessel is a semi-geuler and that the vessel will take the geul.
- The pilot records the boarding time, the ETA berth, the ETA Lage Licht, that he wants to use 2 tugboats (initially 3 were ordered, but 2 must be sufficient) and the gangway down time in the GIDS app.
- 10 minutes after registering in GIDS the pilot receives a SMS from the GIDS system that the tugboats are confirmed. The name and the power of the tugboats are included in the message.
- Tugs call via the nautical VHF channel that they have a delay of 10 minutes. Pilot updates the expected Lage Licht time from 13:15 to 13:25.
- 13:07 contact with the tugboats on where to attach and check of the safe working load with the vessel captain.
- 13:12 the tugs arrive and at 13:16 the front tug is fastened. The pilot answers: ’okee bedankt, dat ging snel’. 13:17 the tug in the back is fastened as well.
- 13:25 the vessel passes the Lage Licht.
- 13:50 approaching the berth. Pilot and captain are next to each other. Captain coordinates its crew and pilot coordinates the manoeuvre. Pilot in contact with the terminal man *(’steigerbaas’)* about which loading arms will be used and where the vessel must be positioned exactly.
- Pilot to the captain: ’you can tell the guys to lower the lines 1 meter above the water, the boatmen will pick them up by boat’.
- 13:57 pilot calls boatmen via the VHF ’4-4-2 en naar de Steensteiger alsjeblieft’.
- 14:30 vessel at the quay. Boatmen are working to attach all mooring lines.
- 15:00 gangway down and pilot leaves vessel.

B.3. Tugboat

Observations conducted on 23-01-2020 with Boluda Towage.

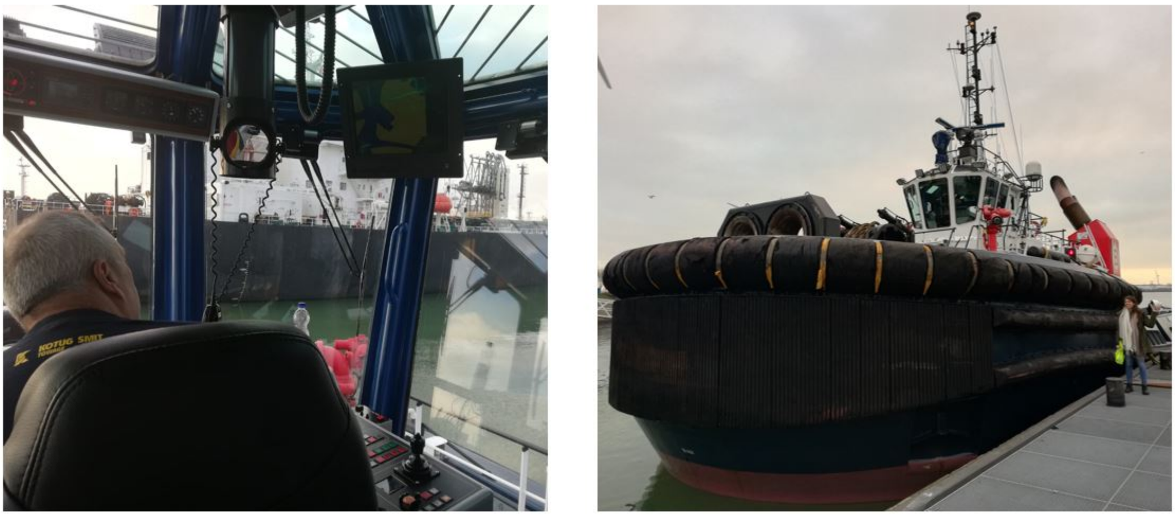


Figure B.3: Tug observation

Observation 1

- 3 crew members on board of the tugboat. One captain, one mate and one engineer *(the captain is responsible for the communication)*.
- The crew members are in their resting period *(after a work shift they have a resting period of maximum 10 hours and minimum 6 hours, always a total of 10 hours per day)*. The captain receives a call from the planner as soon as the tugboat must leave for a job. In this call the name of the vessel, the expected Lage Licht time and the destination are communicated. *(From experience the captain knows were the tugboat must meet the vessel. The planning only communicates the Lage Licht time and destination.)*
- The crew members take their breakfast and make the tugboat ready for departure.
- When approaching the incoming vessel, the pilot calls at 11:12 via the nautical VHF channel were the tugboats should be attached. The vessel uses 2 tugboats. The tugboat name that is mentioned first answers the pilot and confirms that the instructions are understood.
- Tugboats are fastened at 11:20. The crew on board of the vessel confirms this with a hand signal to the mate on deck of the tugboat, who communicates it to the tug captain.
- The tug captain calls via the VHF: 'Loods, tugboat X achter vast'. The pilot answers: 'okee, dankjewel'.
- During the voyage, the tugboat follows the vessel. No orders from the pilot are given when no manoeuvring is needed.
- During the voyage, the mate registers information in the software system. Namely; the time that the tugboat received the call from the planner, the time that the tugboat started its trip, the time of arrival at the vessel, the time that the tug is connected, the time that the tug is released and the ending time of the tugboat trip. The same system also shows some details of the to be executed trip, such as the type of vessel and the destination.
- During the manoeuvre into the harbour, the tugs follow the orders from the pilot. The tug captain repeats the message to confirm that the message from the pilot is understood.
- The tugboat captain calls the pilot via the nautical VHF channel 'Loods, de roeiers hebben last van mijn schroefwater, dus ik stel voor dat ik even over ga op duwen'. The pilot answers that he agrees.

- The boatmen ask the pilot if he is planning to go forward and use the engine. The pilot answers that he is and that after that the boatmen can collect the mooring lines.
- 12:41 the pilot calls the tugboat and informs that they can leave.
- 12:46 the captain of the tugboat calls via the VHF: 'Tugboat X is los loods. Bedankt en tot de volgende'.
- 12:47 the tugboat captain calls via the internal VHF channel to the planner that they finished their job. The planning informs the captain that they have to go to an outgoing vessel at 13:30 at harbour X. The tugboat captain confirms *(after his confirmation, the voyage is also visible in their software system)*.

Observation 2

- The harbour of the outgoing vessel is close by and the tugboat has enough time to reach the vessel before 13:30. To safe some fuel, the tugboat slowly moves to the outgoing vessel.
- A vessel that must leave from a berth further into the harbour is delayed for 45 minutes. The tugboat captain knows this information, because the pilot of that vessel communicates via the nautical VHF with its connected tugboats. The tugboat is in the same region and therefore connected to the same VHF channel.
- At 13:15 the pilot of the outgoing vessel has not boarded yet. The tugboat captain expects that the voyage will be delayed, because the other delayed vessel must pass. He expects that as soon as the pilot is present, he and his colleague on the other vessel will discuss it.
- At 13:38 the pilot calls via the VHF channel which manoeuvre he is planning to do and what the maximum work load of the vessel is.
- A moment later, the pilot discusses with the pilot of the delayed outgoing vessel and another pilot on an incoming vessel who goes first. The tugboat is able to follow this *(this communication can also be executed via phone)*.
- The conclusion of the pilots is that first the incoming vessel must pass, then this vessel quickly enters the channel and that then the delayed outgoing vessel follows.
- At 14:10 the vessel is away from the quay.
- A 4th pilot enters the conversation on the nautical VHF channel. This pilot is on an incoming vessel at sea and the conclusion is that he should make another round outside of the port area. The pilots use each others names *(instead of vessel names)*, so the tug captain is not able to easily follow the conversation.
- During the trip, the tugboat captain receives the question via the internal VHF channel from the planner if the tugboat can make it to another outgoing vessel at 14:30 at harbour X. The tugboat captain confirms that it is possible and receives the voyage in the system.
- The tugboats are called by the pilot to be released and they wish each other a good day.

Observation 3

- Arrival at 15:00 at outgoing vessel. The vessel is ordered for 15:15.
- Pilot and boatman have not arrived yet.
- 15:20 the pilot arrives and boards the vessel. The pilot communicates via the nautical vHF channel that the voyage is about to start and that the tugs can be connected.
- At 15:38 the tug captain communicates 'Loods, tugboat X achter vast en gaat in de zij'.
- The vessel should be able to leave around 15:45, but the pilot communicates with the pilot of a departing vessel at the other side of the harbour. In the end it appears that the pilot waits for his colleague at the other side of the harbour to depart.

- During the voyage, the tugboat captain contacts the planner via the internal VHF channel and asks if his tugboat is destined for a specific incoming voyage. The tugboat captain followed the AIS signals and helps the planner a bit. The planner answers that he will indeed be assigned to that incoming vessel.
- At 16:20 the tugboat receives the instruction that the tugboat may be released.
- At 16:23 the tugboat is released and the tugboat captain says via the VHF channel 'tugboat X is los loods, tot de volgende'. The pilot answers 'okee bedankt'.
- At 16:25 the tugboat captain contacts the planner via the internal VHF channel to update him that the job is finished and to recheck if he must continue to the incoming vessel.

B.4. VTS operations

Observations conducted on 28-10-2019 at Vessel Traffic Center Hoek van Holland.

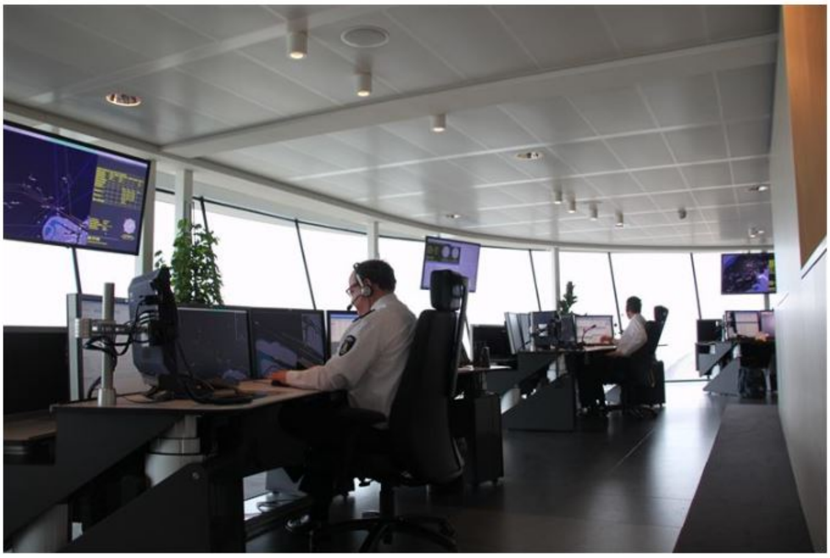


Figure B.4: Vessel Traffic Center at Hoek van Holland [conducted from westlanders.nu]

Observation of the Vessel Traffic Center at Hoek van Holland

- At the Vessel Traffic Center in Hoek van Holland 5 VTS operators are located next to each other.
- Each VTS operator is responsible for one of the following port sectors: sector Maas Approach, sector Pilot Maas, sector Maas Entrance, sector Europoort or sector Rozenburg.
- The work stations follow the order of the port sectors in the port. Most right is the work station that operates the Maas Approach sector. Most left is the work station that operates the Rozenburg sector.
- 6 VTS operators switch every hour to the next work station. 1 VTS operator has a break of 1 hour.
- If needed, VTS operators communicate information to the VTS operator of the previous or next sector located next to them.
- The VTS operators have HaMIS, ARAMIS and hydraulic information on their screen. HaMIS is used for vessel details, destination and planning information. The VTS operators use ARAMIS for the real-time traffic information. ARAMIS provides an overview of all the vessel traffic and calculates if vessel cross each other. Some VTS operators also use webcam information or look outside.
- Each VTS operator uses the specific VHF channel of the sector for communication with the vessels in the sector. The VTS operator does not only communicate on the channel, but also listens to communication between vessels on the channel.

C

Interviews of the operational domain of the nautical chain in the Port of Rotterdam

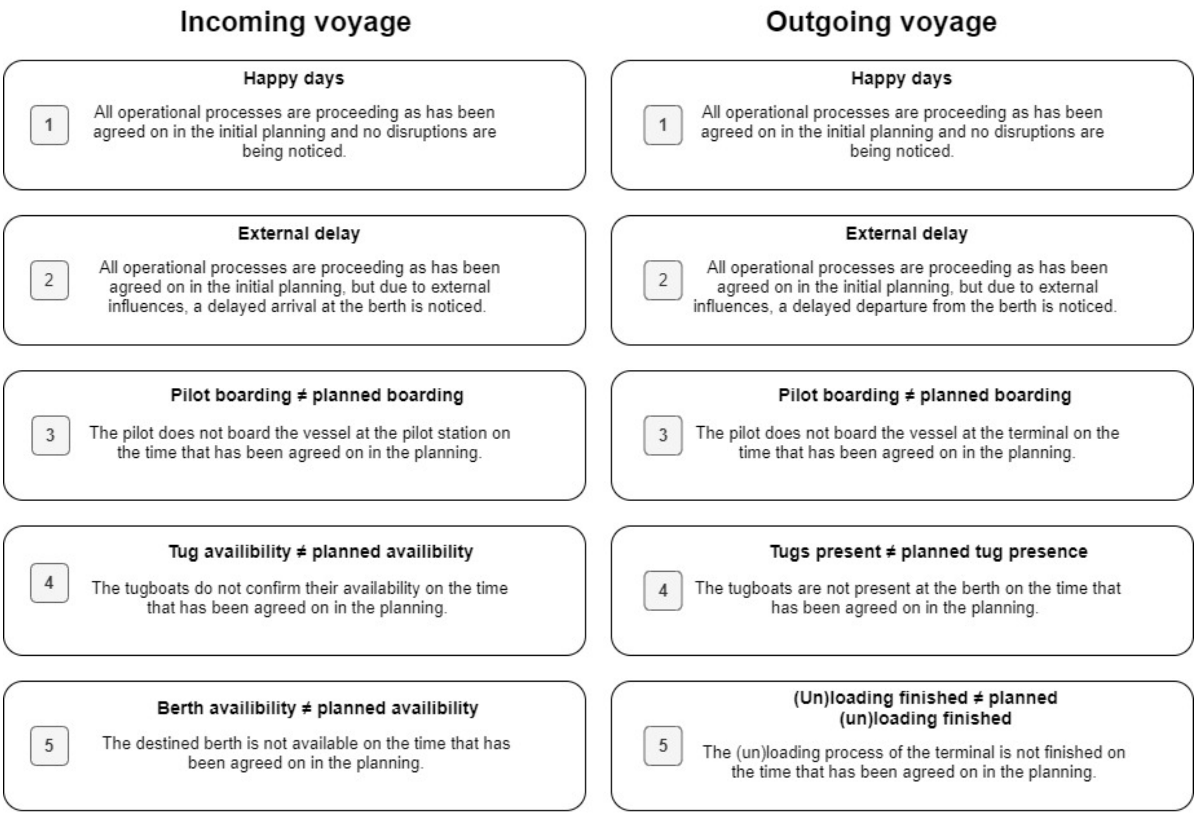


Figure C.1: Operational situations for incoming and outgoing voyage

C.1. Boatmen

Interview conducted on 15-01-2020 with the KRVE.

Departure situation 1: 'Happy days'

- Zodra de loods aan boord is gaat het hele circus beginnen. In de ideale situatie staat de kapitein hem op te wachten. Loods gaat als eerste aan de sleepboten doorgeven dat hij de sleepboten wil koppelen aan het schip. Als de sleepboten worden opgeroepen, horen de roeiers dat ook over hetzelfde open kanaal. Dit kanaal is verdeeld over 6 regio's in de haven. Op die manier wordt de kans om communicatie te missen of op bezette kanalen kleiner.

- De loods noemst als hij de sleepboten oproept de namen van de sleepboten. 'Aan sleepboot 1 en sleepboot 2, hier schip X met loods X, we gaan zo beginnen. De sleepboten koppelen dan terug: 'Okee we zijn er klaar voor'.
- De loods zegt: 'Okee sleepboot 1 voor en sleepboot 2 achter, laat ze maar eronder komen'. Als de sleepboten dan vast zitten koppelen de sleepboten terug: 'ik zit vast'.
- Daarna roept de loods de roeiers op 'roeiers we gaan beginnen'. Dit zegt hij echter niet altijd. Als de loods geen seintje geeft zien de roeiers zelf wanneer ze los moeten gooien, namelijk als de lijnen gevierd worden. De roeiers zien het hele spel al beginnen. We zien dat de sleepboten worden vastgemaakt en dat er bemanning is op het dek, dus je weet eigenlijk al dat er zo wel iets zal moeten gaan gebeuren. De grootste beweging die wij zien om in actie te komen is als trossen die eerst strak staan gevierd worden.
- Als de trossen zijn los gegooid en het schip vertrekt, roepen de roeiers hun eigen werkverdeler op. Van de planning krijg je dan door of je terug moet komen naar de post of naar een volgende klus moet. Af en toe wordt er ook een melding tussendoor aan de werkverdeler gedaan, nadat de loods heeft gezegd dat we gaan beginnen. Op die manier weet de werkverdeler wat de status van onze klus is. Dit is natuurlijk nog interessanter om te weten als dingen uitlopen.
- Roeiers weten pas als ze klaar zijn met een klus waar ze daarna naartoe gaan. We zouden het wel eerder kunnen zien in de app, maar dat kan allemaal nog veranderen. In principe krijg je gewoon van de werkverdeler via het interne kanaal door wat je volgende klus is.

Departure situation 2: 'External delay'

- In zwaar weer gaat de communicatie eigenlijk gewoon hetzelfde. De scherpte op hoe veilig je blijft werken blijft ook gewoon hetzelfde.

Departure situation 3: 'Pilot boarding time not equal to planned boarding time'

- De roeiers ploeg ziet pas dat de loods er niet is als ze aankomen bij het schip. Het voordeel voor de roeiers is dat we zelf de loodsen vervoeren. Wij horen dan dus via ons eigen kanaal al 'loods is nog onderweg, hij staat in de file'. Ook al weet de roeier waarbij de loods in de auto of aan boord zit op een gegeven moment dat de loods te laat gaat komen, zal hij dat niet snel zelf communiceren. Het komt wel voor dat je door ervaring in die auto weet dat je de vastgestelde tijd niet meer gaat halen en je dan over het kanaal hoort dat collega's buiten ergens nog niet klaar zijn om naar die klus toe te gaan. Dan kan jij over het kanaal zeggen dat dat niet uitmaakt, omdat jij toch nog met de loods voor de botlekbrug staat bijvoorbeeld. Dat is het samenspel van ons als collega's, dan gaan we wel communiceren. Als er al een roeiers ploegje is bij een schip waarvan de loods er nog niet is gaan die ook over het kanaal vragen 'he is die loods al in de buurt'. Het gebeurt vaak dat de roeiers al bij het schip zijn voordat de loods er is.

Departure situation 4: 'Tug availability is not equal to the planned tug availability'

- De loods aan boord krijgt een seintje, ik weet niet hoe, dat de sleepboten nog aan een ander schip vastzitten en niet op tijd gaan komen. De loods gaat dan ons oproepen, op het gedeelde VHF kanaal, en zegt dan 'roeiers bij schip X, de sleepboten zitten nog bij een andere boot en het gaat nog een half uurtje duren'. Wij roepen dan weer onze werkverdeler op om door te geven dat het langer gaat duren. Tussendoor dan nog een andere klus doen zal niet snel gebeuren, omdat de afstanden te groot zijn. Het voordeel is vooral dat de werkverdeler dan weet of we wel of niet doorgepland kunnen worden op een volgende klus.
- Tijdens de operatie zal een roeier niet, en andersom ook niet, contact opnemen met een sleepboot. De roeiers en de slepers hebben tijdens het proces geen communicatie nodig met elkaar. Behalve natuurlijk bij gevaarlijke situaties. Sleepboten en roeiers luisteren eigenlijk beide naar de loods, die de dirrigent is van het hele orkest.

- Het belangrijkste doel van communiceren is de veiligheid. Daarna is het handig om met de werkverdeler te communiceren voor het optimaliseren van de planning.

Departure situation 5: 'Time loading finished is not equal to planned time loading finished'

- Deze situatie komt vaak voor. De roeiers gaan dan informeren bij de terminal. Het zou kunnen dat de werkverdeler bij mij *(roeier)* informeert hoe lang het nog gaat duren tot het schip los is. De roeier zegt dan 'weet ik niet, ik moet dat even informeren'. Vervolgens vraagt hij aan de loods 'loods hoe lang duurt het nog denk je?'. De loods antwoord dan bijvoorbeeld 'ik denk nog 5 containers, of 7, ik weet het niet precies'. Het duurt ongeveer 5 minuten per container dus dan weet je al hoe laat het is en ga je actie ondernemen. Je loopt dan meestal even naar iemand op de kade toe. Meestal is daar wel iemand die ook bij een computer zit. Dan vraag je aan die man hoe het ervoor staat en reageert hij bijvoorbeeld 'gaat nog wel half uurtje duren want containers zijn kwijt in de stack'. De roeier gaat dan de loods informeren via het VHF kanaal: 'loods, ik heb door gekregen dat het nog wel een half uurtje gaat duren'. Dan ga je daarna ook weer je eigen werkverderler op de hoogte brengen.
- Roeiers zitten bij de terminal eigenlijk het dichtsbij de informatie bron en helpen daarmee dus de loods, en zichzelf. De informatie verkregen van de terminal wordt gedeeld met hun eigen werkverdeler en de loods. De sleepboten kunnen dit mee luisteren en dan zeggen of ze nog even in de rust gaan.

Arrival situation 1: 'Happy days'

- Het schip komt in de buurt van de locatie. 9 vd 10 keer neemt de loods contact op met de roeiers. De loods stelt zich voor aan de roeiers en zegt wat het plan is, bijvoorbeeld 4-4-2 en de springen eerst. Daarbij geeft hij aan waar hij zelf naartoe vervoert wil worden. Loods: 'roeiers ik wil graag 4-4-2 vastmaken en daarna wil ik graag naar de steensteiger'. Roeiers communiceren dat ook altijd even terug. Daarna koppelen de roeiers terug dat de lijnen vast zitten. De loods bedankt de roeiers en de roeiers contacten hun werkverdeler om te vragen of ze door moeten naar een volgende klus. Contact tussen roeiers en loodsen verloopt prettig. Wensen elkaar een goede dag en goede reis.

Arrival situation 2: 'External delay'

- In zwaar weer gaat de communicatie eigenlijk gewoon hetzelfde. De scherpte op hoe veilig je blijft werken blijft ook gewoon hetzelfde.

Arrival situation 3: 'Pilot boarding time not equal to planned boarding time'

- Wij krijgen eigenlijk pas de goede planning door als de loods aan boord is. Via elektronische wegen krijgen we een singaal dat de loods aan boord is en dan is er eigenlijk nog niet echt een ETA berth. Die loods gaat dat berekenen en doorgeven aan de instanties. Die koppelen dat weer terug naar de roeiers. Als een schip buiten op zee is en de loods is nog niet aan boord, dan doen wij er eigenlijk gewoon niks mee. We merken ook niet of dat nou een half uur later is dan initieel gepland was.

Arrival situation 4: 'Tug availability is not equal to the planned tug availability'

- Ja dat krijgen wij wel mee. De sleepboten komen soms namelijk ook pas vrij laat in het spel. Als de sleepboten de afgesproken tijd niet halen moet een schip onderweg vaart minderen. Afstand van Hoek van Holland tot de Botlek is ongeveer een uur varen. Net voor de Botlek komen de sleepboten er pas bij. Als de loods weet dat die er dan niet zijn, dan gaat de loods terug rekenen dat hij langzamer moet gaan varen. Die rit die normaal een uur duurt, duurt dan bijvoorbeeld opeens een uur en 20 min. Het lijkt alsof wij dat niet mee krijgen, maar wij krijgen dat wel mee in onze planning, want de verwahte aankomsttijd die wordt steeds later. De loods gaat die tijd namelijk bijstellen. Daarnaast is het zichtbaar dat het schip de passage lijnen langzamer kruist. Het wordt niet mondeling met de roeiers gedeeld.
- De roeiers weten ook wel eens voordat de loods iets heeft aangepast dat de sleepboten te laat pas beschikbaar zijn, door ervaring en door visueel ingesteld te zijn. Je hoort bijvoorbeeld dat er een schip binnenkomt waarvan je weet dat er sleepboten aan moeten, maar die sleepboten zitten nog vast aan de klus waar je zelf mee bezig bent. Dan weten de roeiers dus al dat die sleepboten niet op tijd bij het ingaande schip gaan komen. Dat zou effect kunnen hebben op de wachttijd van het volgende schip. Het schip dat we aan het vastleggen zijn is bijvoorbeeld niet voor 9 uur vast. Dan weten we dat het schip dat

om 9 uur weg zou moeten niet om 9 uur weg gaat, want de sleepboten zijn nog niet beschikbaar. Het heeft voor ons wel voordelen, want dan hoeven we geen andere ploeg naar dat schip te sturen. Ik kan dan met de sleepboot mee varen en dan ben ik altijd op tijd. We staan dan niet onnodig bij de volgende klus te wachten.

- De verschillende roeiers ploegen van het uitgaande en ingaande schip communiceren eigenlijk met elkaar via de planning. We krijgen dan bijvoorbeeld te horen 'dat bootje gaat zo meteen weg, maar hij krijgt de sleepboten die aan het schip waar jullie nu mee bezig zijn vast zitten, dus dat komt wel goed'.
- Er wordt niet specifiek aan ons doorgegeven welke sleepboot aan welk schip moet. Dat is ervaring. Er varen maar een x aantal sleepboten in een bepaald gebied, dus op een gegeven moment ken je ze allemaal. Daarnaast communiceren de loodsen met elkaar 'he hoe sta jij ervoor, want ik krijg jouw sleepboten'. Onze oren gaan dan ook open staan. Als de roeiers dat opvangen gaan ze de werkverdeler oproepen en zeggen ze 'de sleepboten die aan onze boot vastzitten die gaan zo naar de volgende, dus je kan mij ook voor die klus indelen'.
- Sleepboten die te laat zijn of zijn doorgepland naar een ander schip wordt niet specifiek met de roeiers gedeeld. Heel af en toe, maar dat gaat dan wel via de planning en niet via dat open kanaal, gebeurt het ook dat de sleepdienst planning onze planning belt. Die zegt dan 'de sleepboten van schip A die krijgen ook schip B'. Dan legt de werkverdeler de telefoon neer en gaat ons direct oproepen. Allemaal in het belang van die planning.

Arrival situation 5: 'Berth availability is not equal to planned berth availability'

- De roeiers zien dit vrij snel, want die zijn meestal al ter plaatse. De loods op het binnenkomende schip gaat dan vragen 'he roeiers ik zie daar nog een binnenvaart schip op mijn plek liggen, kunnen jullie eens informeren hoe het ervoor staat?'. Of we hebben dan zelf al actie ondernomen of we gaan actie ondernemen. We vragen aan iemand op de kade, wie daar ook staat, of het geregeld kan worden en koppelen dat weer terug naar de loods. Als de loods er niet naar vraagt gaan de roeiers meestal ook wel zelf actie ondernemen. De roeiers geven dan door 'he loods de ligplaats is bezet en het gaat nog wel een kwartiertje duren'. Wat de loods dan doet is aan hem.
- Met de terminal is communicatie allemaal mondeling. Tegenwoordig hebben de terminals ook hier en daar een portofoon. Dan stappen wij er tussen uit en communiceren ze zelf mee op het dienstverleners kanaal.

C.2. Pilot

Interview conducted on 21-01-2020 with Loodswezen Rotterdam-Rijnmond.

Departure situation 1: 'Happy days'

- This is similar to an incoming situation, except that all service providers must be present before leaving. When boarding the vessel I report to channel 11 that we are ready for departure and the ETA Lage Licht. He *(DO VTS)* responses if I'm allowed to depart. After that, I report on the VHF channel of the VTS sector that we are leaving.

Departure situation 2: 'External delay'

- This morning I was reporting to channel 11 and the DO VTS asked me at what time I would be at the Lage licht and I answerd 8:05. He allowed me to leave, while multiple big vessels were coming in.
- I go through the list with incoming vessels in the GIDS app to check what's coming. When I would have known in advance that there was not one big vessel coming in but 4 big vessels, we would have stayed along side. Normally I always go through the list, but this morning there was no time. I know for sure that especially the pilots on the big ships do this, because you want to know what traffic is coming.

Departure situation 3: 'Pilot boarding time not equal to planned boarding time'

- I can only inform the planning department. They will inform the boatmen. Or the boatman in the car sitting next to me can call the boatmen at the ship and ask them to inform the boat crew that the pilot will be late. The planning department can call the tugboat planning.

Departure situation 4: 'Tug availability is not equal to the planned tug availability'

- They can inform me that the tugboats are for example 15 minutes later. The pilot planning department informs me about that. They are called by the planning department of the tugboats. It depends on the pilot planner if they call or send a text message via GIDS to update me. They know that when you are busy you do not look on your phone all the time.
- The other way to find out is when arriving at the vessel and tugs are not there.
- If for example the tugboats are not available for x hours. I call the pilot planning department and they might say that I have to go to another ship. It is the planning department who decides to stay on board or go off. Not the pilot.

Departure situation 5: 'Time loading finished is not equal to planned time loading finished'

- When the vessel has more than 10 minutes delay I inform channel 11.
- You just come on board and report to the planning department. I receive the delay from the terminal chief officer who is on board of the vessel or ask the captain.
- When the boat crew says that they have no idea, I ask the boatmen to go to the foreman and ask. When I got this information, I will inform channel 11 that there is a delay on cargo loading. They will inform an other vessel that is coming to my berth if needed.
- A pilot colleague on the incoming vessel will then call me by phone to for example ask if we shall meet in the Beerkanaal. Then I can say 'okay I will not swing here, I will move backwards and swing there so that you can come in'.

Arrival situation 1: 'Happy days'

- We were on the departing vessel X. I received a message: you're planned for incoming vessel Y with ETA 11:00. For this trip the number of tugboats is estimated on 3 *(SMS message)*.
- When I'm not on the pilot boat, I have to go to the app of our planning system and click on 'planned'.
- In the app I can see the trip that is assigned to me. For example the name of the vessel, the length of the vessel, the width, the draft and the destination. You can press on the name of the vessel and then you see the information of the vessel. This is coming from the Port Authority.
- Then you come on board and you register the time you are on board in the GIDS app. The tender registers the time he dropped you off at the ladder.
- Then the pilot registers the time he expects to be at the Lage Licht and the gangway down time and that I need boatmen and 2 tugboats.
- Then I receive a message back when the tugboats are confirmed. You receive the name of the tugboats and their power.
- I only report to Pilot Maas on the VTS that I am on board. Besides that, I register the times in the GIDS app.
- When you are on the bridge you order your tugboats. Then, the tugboats are coming on the estimated time and position. You arrange the tugboat arrangement with the captain. You ask him what the possibilities are in the bow and the stern of the vessel. Then you say to the tugboats which one you want in the bow and which one in the stern. Sometimes the tugboats propose it themselves, but the layout is the pilots responsibility.
- Then the tugboats are attached and you start sailing. Then you give instructions to the tugboats.
- When arriving at the berth, the boatmen are always there.

Arrival situation 3: 'Pilot boarding time not equal to planned boarding time'

- I call the pilot planning department. They can make the decision to send another pilot or that they call the boatmen and they will go up to tell the captain that the pilot is 15 minutes late or so.
- Sometimes you are in the car of the boatman and then the traffic jams. So you're calling the boatmen at the vessel and sometimes they are also in the traffic jam.
- When you don't have a reason to be late on board and the captain complaints, it's a 900 euro fee. So everybody has a reason to be on time.
- I do not communicate anything with the tug companies. That is the task of the planning department.

Arrival situation 4: 'Tug availability is not equal to the planned tug availability'

- When you have a vessel with 14.40 meters draft (a semi-geuler) and there are no tugboats, I will not swing into the channel. With a smaller vessel it depends on the wind. If you are still able to swing out of the channel it is possible, but with a semi-geuler that is not possible and you are looking for an hazardous situation.
- When you get assigned 2 tugboats, but as a pilot you think that you need more tugboat power, you discuss this with the vessel captain. In case the captain remains saying that he wants 2, because 3 is too expensive, and you get assigned 2 small tugboats, you can come back and say that you need 2 other tugs and that you are not coming in otherwise. When you come in with a large container vessel and wind and with 2 small tugboats and something happens, they will say to the pilot 'why did you enter, while you knew you had too few tugboat power?'.
- After ordering the tugboats when you boarded the vessel, you receive the message that the number of tugboats is confirmed on time X at the Lage Licht. At some point I check if they are really there. I check on the chart if they are visible.
- When you are at the MC buoy and you receive a message that the tugboats are not available, you must turnaround to the outgoing traffic.
- If the tugboats are late you either get a message from GIDS *(sometimes they also give a call)* or you hear it via the VHF from the tugboats themselves. The message mentions from which vessel the tugboats should come and the time of departure of that vessel. The message had been sent by a pilot planner *(via GIDS)*. More and more it happens via GIDS.

Arrival situation 5: 'Berth availability is not equal to planned berth availability'

- A change of the berth is passed on via the GIDS app *(including an SMS)* and via the VHF channel by the VTS operator.
- An occupied berth is a huge problem. Most of it is barges. The Port Authority only says that the berth is free of seagoing ships and there is no communication with the terminal. So when a seagoing vessel is coming, the berth is occupied. Sometimes it can be 5 minutes, but it can also be 1 hour. And then for 1 hour you are blocking the fairway.
- I either see the barge *(on the AIS chart)* or the boatmen are calling me.
- Mostly you receive this information when you are almost in front of the berth.
- Sometimes the captains of the barge are sleeping.
- I can call the boatmen or I can ask the Harbour Master to send a patrol vessel to check.
- I do not double check if the berth is available, because as soon as the Harbour Master knows that the berth is not available he will inform me. But the Harbour Master does not always have all the information from the terminals. The first who see are the boatmen.

- Sometimes you are coming in and then you hear on the VHF channel that the VTS operator asks if you can come to channel 11. Then I'm on the line with the DO VTS and he says for example that he had just spoken with my colleague and that there are X minutes of delay, they have to load more containers, so then I make the decision to turn around.
- Calling the pilot on the outgoing vessel also happens. When the VTS operator is saying that there is some delay, I will call the pilot and ask how many containers he must load. I can then for example calculate to lower my speed and be half an hour later or I want to know what his manoeuvre is.

C.3. Tugboats

Interview conducted on 23-01-2020 with Boluda Towage.
Written notes were made and translated into this document.

Departure situation 1: 'Happy days'

- The tugboat crew receives a call from the planner in case they are in their resting period or a call via the internal VHF channel in case they are already operating.
- For a departure, the planner communicates the location of the departure and the ordered time. After this contact, the voyage is also assigned to the tugboat in the software system and visible on the laptop. The system shows the type of vessel and the location.
- The tugboat moves to the job and waits till the pilot calls over the VHF channel.
- During the job, the tugboats follow the orders given by the pilot, assist when needed and repeat everything that the pilot says in order to confirm that the order is received and understood.
- After the job is finished, the tugboat captain contacts the planner via the internal VHF channel to update him that the tugboat is done. The planner gives the tugboat a new assignment.

Departure situation 3: 'Pilot boarding time not equal to planned boarding time'

- When the pilot boards the vessel later than planned, the tugboat captain updates the planner.

Departure situation 4: 'Tug availability is not equal to the planned tug availability'

- The tugboat captain communicates this with his own planner. The planner can contact the pilot organization. In case the pilot already boarded the vessel, the tugboat captain also communicates his delay to the pilot.

Departure situation 5: 'Time loading finished is not equal to planned time loading finished'

- The delay information is received from the pilot. The pilot communicates this delay via the nautical VHF channel. The tugboat captain then communicates the delay to his own planner. Most of the times, the tugs are not assigned to another job during the delay. The customer pays for the waiting time and wants to be sure that the tugs are available for him as soon as the vessel is ready to leave.

Arrival situation 1: 'Happy days'

- The tugboat crew receives a call from the planner in case they are in their resting period or a call via the internal VHF channel in case they are already operating.
- For an arrival, the planner only communicates the expected time of arrival at the Lage Licht. After this contact, the voyage is also assigned to the tugboat in the software system and visible on the laptop. The system shows the type of vessel and the location.
- The tugboat moves to the job and waits till the pilot calls over the VHF channel.
- During the job the tugboats follow the orders given by the pilot, assist when needed and repeat everything that the pilot says in order to confirm that the order is received and understood.
- After the job is finished the tugboat captain contacts the planner via the internal VHF channel to update him that the tugboat is done. The planner gives the tugboat a new assignment.

Arrival situation 3: 'Pilot boarding time not equal to planned boarding time'

- This is not relevant for the tugboats. The planning is made with the expected time of arrival at the Lage Licht, which the pilot estimates as soon as he boards the vessel.
- For vessels that are bounded to the channel, the Lage Licht time must be registered 6 hours in advance by the HCC. This vessels have a longer planning period and have the priority, so most of the time everybody is on time to deliver.

Arrival situation 4: 'Tug availability is not equal to the planned tug availability'

- When the planner asks if the tugboat captain is able to be at the next job within 30 minutes, the tugboat operator can ask to change that to 40 minutes.
- In case something happens and this 40 minutes can not be reached, the tugboat captain informs the tug planner. The tug planner updates the arrival time in GIDS.
- In some cases, the tug captain calls the pilot of the vessel directly via the nautical VHF channel.

Arrival situation 5: 'Berth availability is not equal to planned berth availability'

- The pilot must receive this information. He communicates this to the tugboats. In case the tugs are already connected and the vessel entered the port, the pilot decides to wait at a safe place in the channel. This is called 'gaande houden' and means for the tugboats the same as waiting time.
- In case the pilot knows that the berth is occupied before the tugs are connected to the vessel, the pilot calls the tugboat planning. The planner then contacts the tugboat captain and updates him on the situation and gives instructions. The tugboat can be either send to another job or slowly moves to the delayed job. In case the tugs had not been connected to the vessel yet, no waiting time can be charged to the client.

C.4. VTS operator

Interview conducted on 28-01-2020 with VTS operators at Vessel Traffic Center Hoek van Holland.

Departure situation 1: 'Happy days'

- Achter de VTS sector is het je taak om het dynamische verkeer in goede banen te leiden. Schepen komen aan de sector grenzen het gebied binnen. Het schip meldt zich dan aan de sector en zegt 'ik vaar hier en ik ga daar en daar naartoe'. Wat wij dan doen is het verkeer in de buurt van hem aan hem uitleggen. Zo van dit is de situatie, daar zijn werkzaamheden, daar komt uitvaart en die gaat daar naar toe. En bemiddelen met afspraken. We proberen de vaarweg veilig te houden. Geen verschil tussen ingaande en uitgaande reizen.

Departure situation 2: 'External delay'

- Als een schip om een bepaalde reden niet weg kan, wordt het aan de VTS'er van de desbetreffende sector doorgegeven door de loods. Daarnaast wordt het ook op kanaal 11 meegegeven aan de verkeerscentrale Rotterdam. Die loods die doet dat zelf. Wij melden zelf niks op 11. Dat is voor de boten en het verkeer.
- De DO VTS kan beslissen dat een vertrekkend schip voor dat moment geen toestemming krijgt om te vertrekken. Dit wordt weleens gedaan in verband met geul gebonden schepen. Als er een grote vertrekker is en er moet iets naar binnen, dan is het afhankelijk van tijpoorten of die vertrekker eerst komt of dat de inkomer eerst moet. Dit bespreekt de DO VTS dan met de DO HCC en de Loodsdienstleider. Ik krijg dat dan via de telefoon te horen van de DO VTS. Meestal heeft de Loodsdientleider al aan de loods op het schip doorgegeven wat er gaande is.

Departure situation 3: 'Pilot boarding time not equal to planned boarding time'

- Wij krijgen het mee als het al gebeurd is. We krijgen geen belletje dat de loods een half uur later is. Pas als hij aan boord komt wordt dat aan ons medegedeeld. Of er moet echt een uitwissel actie aan de gang zijn. Als de loods dan later is moeten wij het schip dat naar die ligplaats gaat even in de rem houden. Dit krijgen we dan door via de DO VTS. Die zit op het HCC kort op de Loodsdienstleider die dat dan samen kunnen bespreken. Het enige wat wij dan kunnen doen is informeren. Wij hebben geen bindende middelen om iemand tegen te houden.
- Wij bellen het ook door naar de DO VTS als wij aan onze kant wat over de vertraging gehoord hebben. Het is een beetje een samenspel tussen wat ze op het HCC horen en van wat wij hier horen.
- Als er een vertraging is wordt er niks real-time veranderd. Je kijkt natuurlijk wel in je sector of er niet een andere grote boot vertrekt, maar de planning wordt niet opnieuw gedaan. Achter Maas Aanloop gebruik je HaMIS voor administratie en achter de andere sectoren heeft het alleen een controle functie.
- Het is afhankelijk van de maat van het schip of er opnieuw wordt bekeken of het schip kan vertrekken. Bij een bepaalde maat schip zou het dus kunnen dat als hij te laat vertrekt, dat hij teruggekoppelt krijgt dat hij nog even aan de kade moet blijven door het verkeer. Maar dat is uitzonderlijk.
- Dat wachten wordt bepaald door de VTS operator achter de sector. De verantwoordelijkheid voor de sector ligt in principe bij de VTS operator zelf. Je legt dat dan wel weer even terug naar de DO VTS.

Departure situation 4: 'Tug availability is not equal to the planned tug availability'

- Dit is hetzelfde verhaal als met de loodsen, behalve dat de sleepdienst geen afgevaardigde op het HCC heeft. Ik krijg wederom van de DO VTS te horen als een schip moet wachten op sleepboten. Wij krijgen dat over het algemeen wel te horen, maar het is niet dat wij er echt iets mee doen.

Departure situation 5: 'Time loading finished is not equal to planned time loading finished'

- Deze informatie gaat via het HCC. Wij zien niet of een terminal vertraging heeft. Wij zien in HaMIS wat er zou moeten vertrekken aan zeevaart. Op basis daarvan kunnen we een beetje inschatten wat er gaat gebeuren. Als we dan via de DO VTS te horen krijgen dat een schip vertraging heeft, dan letten wij een beetje op wat er in het blok zit.

Arrival situation 1: 'Happy days'

- Achter de VTS sector is het je taak om het dynamische verkeer in goede banen te leiden. Schepen komen aan de sector grenzen het gebied binnen. Het schip meldt zich dan aan de sector en zegt ik vaar hier en ik ga daar en daar naartoe. Wat wij dan doen is het verkeer in de buurt van hem aan hem uitleggen. Zo van dit is de situatie, daar zijn werkzaamheden, daar komt uitvaart en die gaat daar naar toe. En bemiddelen met afspraken. We proberen de vaarweg veilig te houden. Geen verschil tussen ingaande en uitgaande reizen.

Arrival situation 3: 'Pilot boarding time not equal to planned boarding time'

- De VTS operator achter Maas Aanloop vult de ETA PS in. In het systeem kan een peiling gemaakt worden en aan de hand daarvan kan de VTS operator precies zien wanneer het schip bij zijn pilot station aan zou komen met de huidige vaar snelheid. Je kan het ook een klein beetje inschatten. Het enige wat wij doen is het controleren. Aan de hand daarvan kunnen we aan de loods achter Pilot Maas meegeven 'hij gaat het niet redden'. Of andersom, dat Pilot Maas zegt 'he hij gaat het niet redden, dus kan hij wat meer opvoeren'.
- Als een loods om een bepaalde reden later aan boord gaat krijgt de VTS operator van Maas Aanloop dat mee van de loods die achter VTS sector Pilot Maas zit. De VTS'er van Maas Aanloop geeft dan door aan het schip wat de bedoeling is.
- Als het schip te langzaam vaart om op tijd op de afgesproken tijd op zijn pilot station te zijn roept de VTS'er Maas Aanloop eerst het schip op om te checken of hij harder kan varen. Zo niet, vraagt de VTS'er toestemming om de ETA PS te verlaten. In dit geval wordt contact opgenomen met de loods planners.

Arrival situation 4: 'Tug availability is not equal to the planned tug availability'

- Dit krijgen wij te horen van het HCC via de DO VTS. Die belt dan even op met het bericht dat een bepaald schip wat later moet komen omdat er geen sleepboten beschikbaar zijn, want die krijgt de sleepboten van schip X. Aan de hand van die informatie wordt er dan een tijd doorgegeven. Er is in dit geval dus al een ETA PS ingevuld. In dit geval wordt er dus door de DO VTS gebeld dat die tijd niet gaat lukken, dus dat hij moet worden veranderd naar later. De VTS Maas Aanloop roept vervolgens het schip op om de informatie door te geven. In het systeem passen we dan de ETA PS aan. In het opmerkingsveld kan worden toegevoegd dat de tijd is aangepast in verband met de slepers beschikbaarheid.
- Daarnaast kunnen wij zelf zien op de AIS of de sleepboten al in de buurt zijn. Als ze nog niet in de buurt lijken te zijn dan bel ik de DO VTS.

Arrival situation 5: 'Berth availability is not equal to planned berth availability'

- Alle zeevaart is geregistreerd in HaMIS. Binnenvaart staat niet in de systemen. Het enige wat wij dus kunnen zien is of een ligplaats bezet is door zeevaart. Als dat zo is, dan kun je hem opvoeren *(dat doet alleen de VTS'er achter Maas Aanloop)*.
- Als later blijkt dat de kade toch bezet is door een zeevaart schip, dan heeft de agent dus iets fout gedaan of er is op het HCC een foutje, dan wordt er gebeld door het HCC.
- Voor de binnenvaart is de enige manier om op de AIS mee te kijken en het schip te informeren dat er nog wat op zijn ligplaats ligt. Het enige wat wij kunnen doen is bijvoorbeeld een patrouille vaartuig dat in de buurt is er even heen sturen. Of je belt de DO HCC of doet dat via DO VTS, dat ze even contact op moeten nemen met de terminal dat dat schip weg moet. Verder via de VHF het schip informeren.

D

Interviews of the planning domain of the nautical chain in the Port of Rotterdam

D.1. Pilot planners

Interview conducted on 28-10-2019 at pilot planning of Loodswezen Rotterdam-Rijnmond.

Figure D.1: Pilot planning [conducted from loodswezen.nl]

Pilot planning process

- Bij uitgaande reizen is er een bestel moment. Ingaande reizen moeten zich alleen een x aantal uur van te voren melden. Het kan voorkomen dat er een boot een uur eerder aankomt. Die boot meldt zich dan te laat. Dan mogen de loodsen hem wel later maken, want er is een minimum aantal uur nodig voor het inplannen van de loods.
- Uitgaand heb je 2 uur bestel tijd. De afspraak is dat wij bellen op 1,5 uur van te voren. Er is dus een half uur de tijd voor alle diensten om te plannen en bepalen of op de bestelde tijd geleverd kan worden. Het inkomende process is grilliger. De slepers gaan pas wat doen als het schip beloodst is.
- Voor een uitgaande reis die besteld is om half 1 ga ik om 11 uur iemand van huis bellen. Via de telefoon wordt dan doorgegeven welke reis iemand gaat doen. Loods geeft door waar hij opgepikt wil worden. Er zijn 3 opstap locaties waar vandaan de roeiers het vervoer regelen. Die locatie vult de lodico achter tafel 1 in in SPIL in een opmerking. Die opmerking komt bij de roeiers terecht via GIDS. De loods heeft

een GIDS app dus krijgt daarna nog een berichtje via de app. De wens is om eerst te bellen en daarna te koppelen in de app. Diezelfde app wordt ook gebruikt om bij het vertrek om half 1 in te vullen: tijd aan boord, diepgang, lage licht tijd. Die informatie loopt dat weer terug naar GIDS en dan naar HaMIS. Bij slechte verbinding belt de loods en komt het binnen via de communicatie tafel *(tafel 2)*.

- De tijd dat een loods wordt ingepland voor ingaand hangt ervan af of de loods al op de loodsboot is of nog van huis moet komen. Als ze van huis moeten komen is er 2,5 uur voor nodig. Ideale wereld is dat schepen zich 3 uur van te voren melden.
- Het komt voor dat een loods al is besteld en dat het schip zich meld en zegt 'ik heb orders (*instructions from the vessel agent*) dus ik moet buiten blijven'. Loods wordt soms dus zelfs al ingepland voordat schepen in operationeel contact zijn. Dat moeten we wel doen, anders kunnen ze vanaf huis nooit op tijd bij de pilot station zijn.
- Voor het plannen moet je een paar uur van te voren een inventarisatie maken van hoeveel loodsen je nodig hebt, want anders dan ben je te laat. Als je er x aantal nodig hebt en er zijn er x aantal al buiten, maar je komt er nog 3 te kort, dan bestel je er bijvoorbeeld 3 loodsen bij. Als ik dan de schepen heb opgezocht en ik zie ze varen en dat de ETA nagenoeg klopt via marine traffic maak ik op basis daarvan een inschatting van wat ik nodig heb. Als de schepen dan in de verbinding komen zie je of je goed besteld hebt of niet.
- Het HCC moet checken of een ligplaats voor een inkomende reis vrij is, maar ondertussen checken wij eigenlijk ook al of een van onze loodsen is ingezet op een reis vanaf die bepaalde ligplaats.
- De melding van een binnenkomend schip moet 3 uur van te voren worden gedaan. 30 min plan tijd. 1,5 uur van huis tot de pistool haven. 1 uur van de pistool haven tot Maas Center. Als de loods al op de loodsboot zit is er natuurlijk minder tijd nodig, dus dan kan een schip dat zicht te laat meldt eventueel wel bediend worden. Dit heeft dan wel invloed op de beschikbaarheid. Eerder dan 3 uur bestellen zou kunnen als alle info accuraat is, maar dat is niet het geval, dus wordt de minimale tijd om een loods van huis te halen aangehouden. 3-4h van te voren is er redelijke zekerheid. Grote schepen waar specialismen voor nodig zijn wil je 6h van te voren weten.
- Een uitgaande reis gaat als volgt: de angent bestelt de reis via PCS > de reis komt door in HaMIS > het HCC gaat de reis beoordelen > als alles okee is zet het HCC het vinkje van de reis op groen en komt de reis door in SPIL > Er wordt een loods op de reis ingedeeld > 1,5 uur van te voren wordt de loods gebeld en via de app krijgt hij door waar hij naar toe moet > de loods kiest een opstappunt > het vervoer verzoek van de loods gaat via GIDS naar de roeiers toe > als de loods aan boord is doet hij daar een melding van via zijn app in GIDS.
- Een ingaande reis gaat als volgt: in HaMIS kijken naar de meldingen met 4 tot 3 uur voor ETA > schip opzoeken op marine traffic of de extra kaart van SPIL > beoordelen of het schip de ETA die in HaMIS staat inderdaad gaat halen > checken of alle info (paalnummers) van het schip beschikbaar is > de loods inzetten: van zee of van huis bellen > schip komt in operationeel contact > sommige VTS operators bellen dan om eventuele orders van het schip door te geven, maar sommige ook niet.

Pilot planners and Pilot Service Leader

- De lodico's *(= pilot planners)* zitten altijd met zijn 3'en *(located next to the HCC)*. Tafel 1 heeft de beschikbare beurtrol waar de loodsen opstaan die thuis zitten of die nu bezig zijn maar nog doorgepland kunnen worden. De planner achter deze tafel gaat over de uitgaande reizen, de verhalende reizen en belt mensen van huis wanneer nodig. Tafel 2 is verantwoordelijk voor de communicatie met onder andere de loodsen op het water en het afmelden om naar huis te gaan. Tafel 3 is verantwoordelijk voor de inkomende reizen. Als tafel 1 extra loodsen nodig heeft vraagt hij aan tafel 1 of hij die beschikbaar heeft. Tafel 1 kan dan mensen doorzetten die al aan het varen zijn of een loods van huis bellen. Verder zit er op het HCC ook de Loodsdienstleider *(= Pilot Service Leader)*. De loodsdienstleider moet het LOA (Loods Aantal Boten) inschatten en invoeren in GIDS en daarnaast de reizen controleren in HaMIS. Hij kijkt onder andere of er gekke dingen tussen zitten als geulers, tijschepen of grote transporten. Hij maakt afspraken met de DO HCC over bepaalde reizen.

- Onderlinge communicatie onder de 3 loods planners is ook van belang. Als aan de midden tafel wordt doorgegeven dat een loods later klaar is, dan hoort de tafel rechts dat hij in plaats van die loods door te zetten toch een nieuwe loods nodig heeft en weet de tafel links dat er iemand van huis gebeld moet gaan worden.
- De lodico achter tafel 1 belt mensen van huis ook voor tafel 3. Als het druk is inkomend heb je je aandacht wel nodig, zeker met een aangepaste dienst. Tafel 3 kan mee spieken met wat tafel 1 binnen krijgt en daarop anticiperen. Bijvoorbeeld dat tafel 1 de juiste loodsen *(met juiste qualificaties)* naar zee stuurt.

Pilot planners and vessel agents

- De informatie waarop gepland moet worden klopt niet altijd. Een schip van 400 meter staat in de lijst met binnenkomende schepen, maar ligt in werkelijkheid nog in Bremerhaven. Als ik het schip niet op zoek en er gewoon vanuit ga dat hij komt zou ik daar dus een loods op in plannen. Voorheen was Dirkzwager er. Dirkzwager werkte als een filter op die meldingen. Daar vroegen ze een comissie voor aan de rederijen, opdat hun info geupdate werd.
- Meldingen voor inkomende reizen worden nagezocht op internet of door agentschappen te bellen. Eigenlijk doen wij nu ook een beetje het werk wat Dirkzwager voorheen deed. Voor een deel kunnen we dingen ook zelf checken, maar orders *(instructions from the vessel agent)* die zijn wij niet. Vroeger kon je bij Dirkzwager verifieren 'he hoe zit het, gaat dat schip nog komen'.
- Accurate ETA tijden zijn nodig om loodsen efficient in te zetten. Ook qua fatique niveau. Niet elke loods kan elke reis doen. Het is dan een puzzel om de goeie loodsen op de goeie schepen te zetten. We zijn best flexibel in de ruimte die we hebben, maar op een gegeven moment dan houdt het op.
- Voorheen filterde Dirkzwager de meldingen. De agent zou het ook zelf moeten kunnen doorgeven als hij goed contact heeft met de kapitein. We krijgen nu wel mails van agent X over de correspondentie tussen kantoor en de kapitein aan boord. Eigenlijk zouden wij alle mails van agent X moeten checken, dan gaan we het schip opzoeken in de inkomende lijst en als de de kapitein zegt 'ik ben er morgen om 14:00' dan zouden wij eigenlijk die inkomende reis moeten gaan updaten. Onmogelijk om van alle agentschappen orders (*instructions from the vessel agent* bij te houden via de mail.
- HaMIS berekent af en toe de ETA MC op basis van AIS data, maar die klopt heel vaak niet, dus wordt eigenlijk niet gebruikt. De data is ook niet beschikbaar voor alle schepen. Met een toevoeging van SPIL kan worden uitgerekend hoe lang het ongeveer nog duurt voordat een schip bij het loods station is. Voorbeeld: dit schip is voorgemeld op 12:30, door HaMIS uitgerekend op 13:45 maar uitpijling in SPIL geeft 13:00. Ik ga dan uit van 13:00. Ik plan op wat het schip werkelijk vaart.
- Veel schepen die gaan binnen komen en die we zien varen daar staan geen paalnummers bij. Die info wordt dan niet gedeeld. Door het havenbedrijf, de terminal of de agent. Als dat niet gedeeld wordt, dan zien wij hem varen en willen we er een loods voor reserveren, maar misschien komt dat schip wel helemaal niet door. Dat maken we vaak mee, dat dat schip uiteindelijk helemaal niet naar binnenkomt. Of later pas.

Pilot planners and VTS operator

- Een uur van te voren moet ik een tender bellen om de loods op tijd op zee te hebben vanaf de pistoolhaven. Van huis kost het 2,5 uur om een loods op zee te krijgen. Het is een werkafspraak dat alle veranderingen binnen de 2,5 uur door gebeld moeten worden door de VTS operator van Maas Aanloop. In het systeem is deze aanpassing ook wel te zien, maar je bent niet continue aan je scherm geplakt. Zeker op adhoc basis is het fijn om naast een update in het systeem een belletje te krijgen.
- De VHF kanalen met Maas Aanloop en Pilot Maas staan aan. Dan hoor je wanneer schepen in operationeel contact komen. Je kunt dan schepen horen die in de verbinding komen en dan weet je 'he hij komt eraan'. In het systeem wordt dat ook geupdate.
- De loods op zee krijgt van de loods achter de VTS sector Pilot Maas te horen 'je sleepboten komen van uitgaand schip X, maar die heeft nog 15 dozen te laden dus doe maar rustig aan en verlaat je ETA'. De Pilot Maas loods geeft nautische info en sleepboot info door.

Pilot planners and other nautical planners

- Voor uitgaande en verhalende reizen vindt die afstemming veel meer plaats. De dienstverleners hebben allemaal een half uurtje om samen de diensten af te stemmen. Als de tijd naar voren wordt verplaatst dan belt het HCC dat door naar de agent.

- Via GIDS krijgt iedereen dezelfde informatie. De enige ruis kan zijn omdat partijen zelf hun planning niet delen.

- 1,5 uur van te voren ga ik een loods bellen. Ik ga dan niet kijken of het vinkje van de slepers groen of oranje is. Eigenlijk zou ik nu *(kijkend naar een oranje vinkje)* de sleepdienst moeten bellen met de vraag 'ik zie dat het vinkje nog oranje staat gaat het nou nog door'. Het zou dus kunnen dat er een loods wordt ingedeeld op een reis, waarvan uiteindelijk niet alle vinkjes groen worden. Dan is het 1 uur en 15 min van te voren en is de loods al onderweg en dan verandert het. In theorie wordt het dan een afbestelling.

- Het verschil tussen ingaande en uitgaande reizen is dat uitgaand wordt besteld en ingaand niet. Uitgaand is er meer contact met slepers en agentschappen. Inkomend zetten loodsen hun planning vast voordat de sleepboten dat doen. Dat moet inkomend ook wel, want er is 3 uur nodig om een loods van huis op locatie te krijgen.

- De Havenmeester checkt wel de bezette ligplaats, maar niet of de sleepboten ook echt hun akkoord hebben gegegeven. Uit ervaring checkt de loods dat, omdat hij niet de Maas op wil varen zonder sleepboten die er klaar voor zijn. Dan kijkt iedereen naar de loods zo van los het nou maar op. Ook met een oranje vinkje in GIDS komt de loods dus gewoon aan boord. Sleepdiensten krijgen of van de agent het aantal bestelde boten of van de Loodsdienstleider het aantal geschatte boten, maar gaan pas plannen als de loods aan boord zit. De loods die aan boord komt kan ook nog zeggen dat hij toch een boot extra wil.

D.2. Tugboat planner

Interview conducted on 31-01-2020 at tug planning of Boluda Towage.

Tug planning process

- Stap 1 is dat de loods aan boord komt. Dan gaan we nu even uit van de binnenkomende schepen. Die doet dan een bestelling via GIDS. Wij schatten van tevoren dan wel al in hoeveel sleepboten hij wil gaan gebruiken. Dat doet de Loodsdienstleider ook. Pas als de loods aan boord daadwerkelijk een bestelling gedaan heeft dan ga ik er boten op inzetten.

- Ik zie wel al dat bijvoorbeeld schip X daar aankomt. Daarvan zegt de Loodsdienstleider dat hij 2 boten nodig heeft. Ik weet vanuit mijn ervaring dat hij inderdaad waarschijnlijk gewoon 2 boten gaat gebruiken. Er staat een beetje wind. Schip komt altijd binnen met 2 boten. Of er moet echt een boegschroef kapot zijn waar ik niks vanaf weet, dan zal hij misschien een derde willen. Maar anders pakt hij er gewoon 2.

- De opgegeven ETA wordt ook pas accurater als de loods aan boord is, maar ik volg het schip al lang van te voren. Ik zie nu dat hij hier zit, dus over een half uur zit hij gewoon op Maas Center. Er komt verder niet heel veel aan dus hij zal gewoon om 12 uur beloodst worden. Zoals de bedoeling is. Ik zie ook dat hier 2 loodsboten in de buurt zijn, dus er moet wel iets heel geks gebeuren wil hij niet op tijd beloodst worden. Als de loods aan boord van het schip is verschijnt er op de kaart *(in het systeem)* een stipje op het schip.

- In GIDS en in het eigen systeem kan ik zien hoe laat de loods gepland is om aan boord te gaan.

- Het schip dat om 12 uur beloodst wordt is om 13 uur aan het Lage Licht, daar heb ik dan nu wel al 2 boten voor in gedachte. Pas als de loods de sleepboten werkelijk besteld via GIDS ga ik ze dan indelen.

- Als de loods zijn bestelling doorgeeft voor de inkomende reis wordt het balletje in GIDS rood en ga ik er wat mee doen. Dan kan ik er op klikken en hang ik er boten aan en wordt hij groen.

- Vertrekkend en verhalend doe ik niks met meldingen, daar ga ik echt pas naar kijken als ze besteld zijn. Anders ga je je druk zitten maken om niks. Inkomend begint met operationeel contact. Bijvoorbeeld schip X staat in GIDS op 12:00 beloodsen. Dat is ten eerste al geweest en als ik dan hier in mijn eigen systeem ga kijken zie ik dat het schip nog helemaal geen operationeel contact heeft. En als je dan weer verder gaat kijken zie je dat hij een order *(instruction from the vessel agent)* heeft, namelijk tot nader order buiten blijven, prospect 2 februari. Als een schip nog geen operationeel contact heeft doe ik er dus niks mee. Zodra dat er wel is, dan kan je eens gaan kijken hoe laat het echt gaat worden. En of je daar al over na moet gaan denken, want voordat je de sleepboten echt indeelt duurt nog wel even.
- Als er te veel verkeer in 1 keer binnenkomt liggen er op veel plekken sleepboten even een half uurtje te wachten. Dat gebeurt zo veel. Uiteindelijk gaat dat ten koste van een heleboel van onze capaciteit. Wachttijd bij terminals is ook killing. Die weet je ook niet van te voren. Dat hoor je pas als je aan komt bij een job. Er is meestal te weinig tijd om tussendoor nog wat anders te gaan doen. Als de loods aan boord komt constateert hij in overleg met de kapitein dat het schip nog niet klaar is. De loods gaat dat dan met de roeiers en de sleepboten communiceren, maar dan is iedereen er al.

Tug planner and other nautical planners

- Hier komt bijvoorbeeld schip X aan. Die heeft net een loods aan boord. Die moet nog zijn bestelling doorgeven. Ik heb in de buurt van zijn kade een vertrekker waar boten bezig zijn die daar nu net weg varen. Ik heb van te voren al aan het HCC doorgeven dat schip X de boten krijgt van de vertrekker. Als het goed is geven zij het dan door aan de loodsdienst en die zou het dan weer door moeten geven aan de betreffende loods.
- We geven het dus in principe mondeling aan als boten moeten komen van een ander schip aan het HCC. Die spreken dat dan weer door. Ik kan het ook nog wel in GIDS zetten. Als het echt spannend wordt zou ik het in GIDS zetten. Maar ik hou nu dat schip in de gaten en ik luister ook mee op de dienstverleners kanalen, dan hoor ik het dus gelijk als ze ergens willen gaan beginnen en er zit wachttijd op een schip. Als ik er dan achterkom dat er ergens wachttijd op zit zou ik in GIDS een opmerking erbij zetten 'loods je krijgt de boten van die vertrekker en daar zit wachttijd op'. Dan weet de loods op de binnenkomer dat hij eigenlijk even contact moet opnemen met zijn collega om af te stemmen hoe laat zijn boot vertrekt.
- Voor inkomende reizen wordt de specifieke sleepboot pas ingedeeld als de loods aan boord komt. Dan maak ik dus namens de sleepdienst het balletje groen in GIDS. Als ik hier nu al zie dat er 5 naar binnen gaan komen en ik weet dat ik daar niet allemaal boten voor heb, dan ga ik vantevoren bij het HCC aan de bel trekken dat ze er een aantal een paar uur later moeten beloodsen. Dat gaat dus niet via het systeem, maar als ik zie dat wat er nu op me af komt niet te handelen is dan bel ik het HCC. Dan moeten zij dus schepen later gaan beloodsen, anders zitten die weer uren voor niks aan boord.
- Bij verhalend en vertrekkend als ik nu denk dat ik ergens niet op tijd boten voor heb kan ik in het systeem een nieuw tijdsvoorstel doen in GIDS. Als ik bij inkomend zie aankomen dat het te druk wordt dan bel ik het HCC. Dan zeg ik beloods maar X tijd later.
- Lodico's *(= pilot planners)* heb ik aan de lijn als het LOA niet op tijd wordt ingevuld. Bij vertrekkend of verhalend moet een loods 1,5 uur van te voren aangeven hoeveel sleepboten hij wil. Als dat niet bijtijds wordt gedaan, kan ik niet bijtijds mijn planning maken. Ik kan het wel inschatten, maar dan zit je er soms naast.
- Als er een binnenkomer op de rivier zit en er gebeurt opeens iets met een vertrekker waar zijn boten vandaan moeten komen, dan vraag ik aan de lodico's of die de loods kunnen bellen. Voorkeur is om direct de loods aan de lijn te krijgen, maar anders doe ik het via de lodico's. De loods kan dan nog gas terug nemen.
- Bij het voorbeeld waar we het net over hadden, dat schip dat 1 sleepboot bij het Lage Licht krijgt en de tweede die wat later aan haakt en van schip X af moet komen, dan maak ik hem 5 minuten later *(in GIDS)* en zet ik in de opmerkingen dat 1 sleepboot van schip X af moet komen. De lodico moet dan de loods gaan bellen en vertellen wat ik in die melding gezet heb. Die 5 minuten later zetten is dus om de lodico een signaal te geven.

- De loods op de binnenkomer die 1 sleepboot bij Lage Licht zou krijgen en eentje die van een andere binnenkomer door moeten komen heeft zijn ETA LL met een half uur verlaat *(van 13:00 naar 13:30)*. De planner contact een andere sleepboot die net klaar is met een andere job en vraagt hoe laat deze sleepboot op het Lage Licht zou kunnen zijn. Deze sleepboot heeft een uurtje nodig en kan dan om 13:15 op het LL zijn. De sleepboot die door moet komen van de andere binnenkomer is dus niet meer nodig. *Sleep planner belt de lodico's om door te vragen of hij kan doorgeven aan loods X dat hij een andere boot heeft ingedeeld die om 13:15 op het Lage Licht kan zijn als tweede boot.*

- Met het HCC heb ik contact bij capaciteits problemen. En bij wind en mist geven wij aan dat we niet meer varen of niet meer voor vast maken maar alleen op de schouder.

- Als er echt iets onvoorziens gebeurd, dat krijg ik te horen of ik zie op de AIS als een sleepboot ergens te laat gaat komen, en ik heb de tijd ervoor dan bel ik de roeiers 'we zijn later bij de reis', zodat zij dan niet specifiek een extra ploegje optrommelen. Als het heel druk is dan schiet dat erbij in. De roeiers bellen zelf mij ook wel eens als ze zien dat wij een vertrekker 7e pet, binnnenkomer 7e pet en vertrekker 7e pet hebben. Als het heel rustig is doe je dat met verschillende boten, maar als het druk is maak je daar combinaties van. Dan bellen de roeiers om te checken of wij dat gaan combineren, want dan kunnen zij het ook combineren.

- *DO HCC belt de sleep planner door dat de Douane nog aan boord is bij een vertrekker dus dat die vertraagd is.* Ik ga dan nu die sleepboot even informeren. *Planner geeft via de telefoon door dat er wachttijd op het schip ligt. De kapitein antwoordt dat hij het al had doorgekregen van de loods. De planner antwoord dat hij hem nog niet gehoord had, dus dat hij vandaar even belde om te informeren.*

- Als een bericht aan een loods niet te veel haast heeft, heeft het de voorkeur om het bericht bij de lodico's neer te leggen. Dan is het van mijn bordje af.

- Als op een gegeven moment duidelijk wordt dat sleepboten te laat gaan komen dan ga ik dat eerst communiceren via GIDS. Dan maak ik hem 5 minuten later en dan zet ik er in de opmerking bij waar de sleepboot vandaan moet komen. Als er een schip om 14:15 gepland is en ik kom er om 13:45 achter dat het helemaal uit de hand loopt, dan is iedereen al onderweg. Dat in GIDS aanpassen heeft geen zin. Dan bel ik het HCC dat de sleepboten waarschijnlijk een half uurtje later zijn. Het heeft dus niet zozeer met de grote van de vertraging te maken, maar met het moment dat de vertraging opduikt. Als dat op tijd is *(voor vertrekkend is dat 1,5 uur of meer van te voren)* dan zet ik het in GIDS. Als het korter is dan dat dan bel ik in principe gewoon het HCC.

Tug planner and pilot

- Loods op binnenkomend schip belt de sleep planner om te checken of de sleepboten op tijd zijn. Hij weet dat hij de sleepboten moet krijgen van een vertrekker. Hij krijgt bevestigd dat de sleepboten al in het Beerkanaal zitten dus dat dat allemaal goed gaat komen. Loods checkt dus bij de planning of de sleepboten op tijd gaan zijn. Hij had ook zijn collega op de vertrekker kunnen bellen of op de AIS kunnen kijken, dan had hij ook genoeg geweten. Het ligt eraan hoe krap je plant of die loodsen je gaan bellen. Het is ook loods afhankelijk, vroeger werd alles doorgebeld. Dus de wat oudere loodsen die bellen eigenlijk gewoon altijd.

- We geven dus in principe mondeling aan als boten moeten komen van een ander schip. Aan het HCC. Die spreken dat dan weer door. Ik kan het ook nog wel in GIDS zetten. Als het echt spannend wordt zou ik het in GIDS zetten. Maar ik hou nu dat schip in de gaten en ik luister ook mee op de dienstverleners kanalen, dan hoor ik het dus gelijk als ze ergens willen gaan beginnen en er zit wachttijd op een schip. Als ik er dan achterkom dat er ergens wachttijd op zit zou ik in GIDS een opmerking erbij zetten 'loods je krijgt de boten van die vertrekker en daar zit wachttijd op'. Dan weet de loods op de binnenkomer dat hij eigenlijk even contact moet opnemen met zijn collega om af te stemmen hoe laat zijn boot vertrekt.

- Ik geef niet de tijd aan dat dat schip dan ook vertrekt, dat is ook niet bekend. Ik maak hem 5 minuten later in GIDS waardoor er een melding wordt verstuurd en dan gaat de loods op de binnenkomer contact opnemen met de loods op de vertrekker. Die vragen dan aan elkaar 'he hoe laat ga je beginnen en hoe laat denk je dat die boten klaar zijn'.

- Een verhaler wil opeens een derde sleepboot erbij. Dit betekent dat de planning een beetje aangepast moet worden. Het gevolg is dat een inkomer 1 sleepboot uit de haven krijgt en een tweede sleepboot die op het moment bezig met een inkomend schip *(dus inplaats van een tweede sleepboot die klaar lag in de haven).* Het binnenkomende schip krijgt in het nieuwe plan 1 sleepboot bij het Lage Licht en pakt de tweede dan wat later op. Mijn ervaring leert dat dat schip met 1 sleepboot achter gewoon door komt en dan het okee is als de tweede er dan wat later bij komt. Dan vertraag je dus eigenlijk niet, alleen doe je het even net wat anders dan gebruikelijk. Ik ga dat dan zometeen in GIDS zetten dat ze 1 boot uit de haven krijgen en dat de ander van schip X afkomt. En dan trekt die loods zijn plan wel. Hij gaat dan waarschijnlijk met de loods van schip X bellen zo van 'kan je er eentje wat eerder vrij geven'.

- Als sleepboten vertraging oplopen moeten ze dat via de VHF aan de planner doorgeven. De planner gaat dan bekijken wat dat betekent voor zijn planning. Waarschijnlijk betekent het namelijk dat de sleepboten dan niet op tijd komen bij hun volgende job. Kijk als ik die boten niet doorgepland heb dan maakt de wachttijd niet uit. Indien wel ga ik kijken of het impact op mijn planning heeft. Zo ja, dan ga ik kijken of ik mijn planning nog kan omgooien of ik ga het HCC of het Loodswezen informeren. Zo van 'he let op, daar zit wachttijd op, dus bij die volgende ben ik nu te laat'. Als het echt op de minuut aan komt bel ik direct de loods aan boord, maar anders dus het HCC.

- Als die loods het nou niks vindt wat ik net voorstel *(1 sleepboot wat later oppakken bij Lage Licht)*, dan past hij zijn ETA LL aan naar wat later.

Tug planner and tug captain

- Over de VHF roepen de sleepboten op als ze los zijn en geeft de planner ze een nieuwe opdracht. Bijvoorbeeld: 'Okee over een half uurtje bij het Lage Licht schip X voor haven X stuurboord landen samen met sleepboot X'.

- Sleepboten die in de haven liggen of rusten wordt mee gebeld. Sleepboten die varen kan over de VHF.

- *Planner wordt opgeroepen door een sleepboot in de haven dat ze klaar zijn met werkzaamheden. De planner geeft door dat schip X eraan komt, maar dat deze nog niet beloodst is dus dat hij zo nog wel even een belletje geeft.*

- *Sleepboot X roept via VHF dat ze klaar zijn. Planner antwoordt 'okee schip X komt eraan voor haven X. Schip zit nu op de maas oost en is 12:30 aan het Lage Licht.*

- Een sleepboot krijgt alleen het bericht op welke tijd een schip aan het Lage Licht is en waar het schip naartoe moet. Zowel de planners als de sleepboten weten dan waar ze het schip moeten tegenkomen. Alleen bij zo een uitzondering van net, als 1 van de sleepboten pas wat later aanhaakt dan ga ik daar wel over bellen. Want dat is eigenlijk een uitzondering.

- Alles van Europoort tot 5e PET is inprincipe op het Lage Licht vastmaken. Calandkanaal, 7e PET en britannie haven is een stukje verder vast maken. Er zijn dus een paar vaste plekken om sleepboten vast te maken. Dat is dus gewoon algemene kennis.

- Als ik de boot gekoppeld heb zet ik dat ook in het systeem en krijgt de sleepboot informatie te zien en kunnen ze de tijden in het systeem invullen. Als een sleepboot toevallig bezig is met details van een reis invullen dan zien ze de volgende reis ook wel in het systeem verschijnen, maar ze zitten verder niet de hele tijd op die laptop te kijken. Ik bel ze dus altijd als ze stilliggen en anders geef ik via het interne kanaal door waar ze naartoe moeten.

- Vertraging bij een vertrekker krijg ik door van de sleepboten die erbij liggen en ik luister mee op het dienstverleners kanaal waar ik het dan ook vaak al op hoor door de loods die communiceert met de sleepboten.

- Geen rechtstreeks contact met de terminal. Vertragingen van die kant komen dus altijd binnen via het kanaal dat wordt uitgeluisterd of via de sleepboot die er al bij ligt.

D.3. Terminal Resource planner

Interview conducted on 17-12-2019 at the planning department of the ECT Terminal with the resource planner.

Terminal planning process

- De planning is opgedeeld in de kade planning, de stuwage planning en de resource planner. De resource planner houdt de komende 8 uur in de gaten. De kade planning is gemaakt, die doen dat 3 maanden vooruit en naarmate het moment dichterbij komt blijven ze afstemmen. Als een boot te laat komt wordt het meestal ook eerst bij de kade planning neergelegd. De kade planning die zij maken, daar gaan wij als resource dan mee verder. De kade planning heeft met rederijen te maken, de resource planner heeft met agenten te maken.
- Resource planner houdt eigenlijk de gemaakte planning in de gaten. Hij maakt zelf geen planning meer. Hij spreekt de planning af met klanten en agenten. Op die manier zorgen we dat we wel altijd vervolg werk hebben. Ploegen die binnen zitten kosten veel geld.
- De resource planner houdt de tijdlijnen aan die de kade planners maken. Als er op een schip 4 kranen werken krijg je een grafische tijdlijn van waaruit wij kunnen bepalen hoe laat we het schip moeten bestellen. Het besluit wanneer een schip besteld wordt om te vertrekken is onder andere op basis van: hoeveel luiken moeten er nog of zijn er nog speciale containers waar andere tools voor nodig zijn. Er zijn wel een aantal computer tools die hierbij kunnen assisteren.

Terminal and vessel agent of outgoing vessel

- Op de resource planning zit je gewoon 8 uur vooruit te kijken. Bestellen moet 2 uur voordat het schip klaar is. Bestellen betekent aan de agent melden dat het schip kan vertrekken op een bepaalde tijd. Je moet dus een inschatting maken. Nog ongeveer 2 uur werk en dan kan hij weg. Dan gaat de agent de Havenmeester en iedereen informeren. Ook de slepers en loods bestellen. De resource planner geeft dus een seintje aan de agent wanneer hij inschat dat het schip over 2 uur klaar is. Je mag ook langer van te voren bestellen, maar 2 uur is de tijd die iedereen in de nautische omgeving nodig heeft om paraat te kunnen zijn.
- Hoe eerder je de bestelling aangeeft, hoe meer containers er nog geladen moeten worden. Als je een boot al besteld hebt dan zullen de kosten voor het wachten uiteindelijk naar de terminal toe gaan. Je wil hem krap en zuinig bestellen, maar je moet er dus ook rekening mee houden dat het wel eens een keertje anders loopt dan je hoopt. Het is eigenlijk het gunstigst om het schip pas 2 uur van te voren te bestellen. Het gebeurt meestal iets van 2,5 uur van te voren. Het is ook in het voordeel van de terminal als het schip snel weer vertrekt, want de boot die daarna ligt in de kade planning moet ook weer naar binnen.
- Het is dus eigenlijk een trade off tussen zo laat mogelijk bestellen, want dan de minste kans dat het schip nog niet klaar is, en strak plannen, omdat je wil dat het schip op tijd vertrekt. Daar moet je dus ergens tussen gaan zitten.
- Bestellen betekent dat de agent gebeld wordt. Telefoon blijft lastig, want heb ik het nou goed gezegd en heeft hij het wel goed ontvangen? Inmiddels is er ook een resource tool. Zodra het schip besteld wordt gaat er ook een mail naar de klant uit.
- Er wordt een tijdlijn per schip bijgehouden. In principe moeten de planners *(stuwage planners)* elke 3 a 4 uur een nieuwe update geven, want er verandert heel veel, bijvoorbeeld een kraan die sneller draait. Op de kade planning kan je zien met hoeveel kranen er gewerkt wordt. Tijdlijn geeft een overzicht van waar op het schip de kraan gaat werken en wanneer de laatste kraan dan uiteindelijk klaar is. Laatste kraan om 18:50 klaar. Dus voor 17:00 bestellen. Dan bel je de agent met 'he goeiedag ik wil graag schip X bestellen om 19:00'. En dan gaat hij verder actie ondernemen. Daarna vullen wij het dan weer in in onze resource monitor, klikken op 19:00 en dan gaat er ook een mailtje naar de agent toe.
- Agenten krijgen als het goed is elke dienst 2 keer een update via mail van hoe hun boot erbij staat. De tijdlijnen refreshen en dan stuur je een mail. Dat is niet allemaal handmatig, maar zit dus niet op een

platform ofzo. Er is een overzicht per schip van op welke tijden er een update naar de agent is gestuurd. De enige informatie die gegeven wordt is de op dat moment berekende ETD. Voor een klant wel van belang. Stel namelijk dat een boot van dezelfde maatschappij erachter vaart en jij hebt een boot op 's avonds 11 uur liggen, maar vervolgens kom je op het laatste moment van 'hij is om 17:00 al klaar'. Dan heb je een heel groot gat. Als de agent van te voren had geweten dat de boot al om 17:00 klaar was, hadden ze de boot die daar achter ligt misschien sneller laten varen. Dit werkt dus alleen als het schip wat er achter vaart van hun zelf is, maar gaat natuurlijk ook op als het schip van een andere reder/agent is. De kadeplanning die weet dat weer en communiceert met de klanten. Dit gaat 9 vd 10 keer buiten mijn 8 uur van de resource.

- Het gebeurt wel eens dat een schip vraagt om langer te kunnen blijven liggen, omdat ze aan het bunkeren zijn. Bunkeren is goedkoop in Rotterdam. Je belt dan de klant en zegt 'he ik wil die boot bestellen'. Dan gaat hij zeggen 'okee ik heb een probleem want we zijn nog aan het bunkeren'. Dan bestellen we hem wat later. De agent moet dat dus wel op tijd zeggen. Als de bunker wens gemeld word na de bestelling heeft hij een probleem.

Terminal and vessel agent of incoming vessel

- Taak van de resource is om met maatschappijen die gepland staan om aan de kade te komen af te stemmen 'he waar zijn je bootjes, waar liggen ze, hoe loopt de planning daar?' Ondertussen in de gaten houden of het schip dat er nu ligt ook op de geplande tijd kan vertrekken. Dus deels met de agent van het vertrekkende schip communcieren hoe laat die weg kan en wanneer diensten besteld moeten worden en met de agent die daarna op die plek moeten komen bespreek je de updates.
- De kade planning is gesplitst in 3 delen: barge, feeder, deepsea. Nu kijken we naar de real time planning. Dit grote schip verwachten ze van dat hij om 19:00 klaar is. De uitwissel tijd tussen grote boten is altijd 2 uur. Ze kunnen niet langs elkaar varen. 2 feeders *(iets kleinere boten)* moeten op de plek van het schip komen dat 19:00 weg gaat. Die worden om 20:00 aangeroepen. Een goede resource planner is bezig om de aankomende feeders alvast te bellen van 'he wij verwachten deze boot op 19:00 gereed, hoe zit jij met schip X? Zodra rond 17:00 het grote schip besteld wordt kan je gelijk de andere partij bellen 'om 19:00 is die boot besteld en wij zouden graag willen dat je om 20:00 voor de kant komt'.
- Voor inkomende reizen houdt de kade planning contact met de klanten en die krijgen allemaal vessel schedules binnen met updates waarin de klant aangeeft hoe laat ze hier zijn. De kade planning krijgt dat van de agent per mail. Als de kade planning de laatste update heeft ontvangen en hij staat erin, dan gaat de resource op een gegeven moment de agent bellen om te vragen 'he waar hang je uit'. Kade planning heeft wel in het systeem gezet hoe laat de boot aan loods station verwacht wordt. Aan de hand van vessel schedule dat ze binnen krijgen.
- Resource heeft dus ook een kort lijntje met de kade planning. Niet de hele tijd contact, maar je kan wel makkelijk vragen aan elkaar stellen. 'He is ie er echt zo laat of heb je nog wat anders gehoord'. Het kan bijvoorbeeld best dat een agent er belang bij heeft als een schip wat eerder binnen komt, dan is het voor hun ook weer van belang hoe laat de voorganger vertrekt. Eigenlijk dus de hele tijd met in en uitgaand aan het afstemmen wanneer iemand kan komen.
- Voor ons van belang dat de schepen ook op de juiste palen binnen komen. Terminal geeft paalnummers door aan de agent. De agent geeft dat dan door bij melding aan Havenmeester.
- Uitwisselaars zijn schepen die dicht op elkaar volgen. Zodra de uitgaander besteld word, gaat de ander binnenkomen. Vaak is de binnenkomer dan al iets eerder aanwezig en ligt hij buiten voor anker. Zodra wij de uitgaander bestellen 2/2,5 uur van te voren, en we hebben gezegd *(tegen de agent van de binnenkomer)* zet hem om uitwisselen, dan hoef ik de maatschappij van de binnenkomer niet meer zelf te bellen. Tegen de binnenkomer zeg je dan, zet hem maar op uitwisselen en dan vult de agent dat in in PCS. Zodra wij de uitgaander bestellen bij de klant, zal de agent van de uitgaander in PCS zetten dat de boot besteld is. Dan zal er denk ik een automatische link zijn dat de binnenkomer weet dat hij naar binnen kan. Soms bel ik nog wel eens. Het is wel een keer gebeurd dat we hebben gezegd zet maar op uitwisselen, maar dat het in de praktijk dus niet op uitwisselen stond. En ik kan dat dus niet controleren. In terminal systeem staat 'uitwisselen' maar je weet niet zeker of de agent dat goed ontvangen en doorgegeven heeft.

Resource planner and terminal employees

- Ik moet bij de superviser die op de terminal werkt informeren of er nog bijzonderheden aan boord van de boot zijn, want misschien zijn containers niet goed gestapeld.
- Verder vraag ik informatie van onze voorman *(leiding gevende op de terminal zelf)*, die dan weer contact heeft met z'n kranen en is misschien zelf aan boord geweest en met de matrans *(maken de containers vast)*. Dit gaat allemaal mondeling en intern, maar heeft wel invloed op mijn planning.
- Na bericht van de terminal vult de agent de paalnummers en stuurboord bakboord in in het PCS. Resource planner doet helemaal niks met PCS. Dus de agent vult info in in PCS die hij telefonisch en via mail van de terminal ontvangt. Maar of dat altijd door de agent weer geupdate wordt als wij een nieuwe mail sturen, dat weet ik niet.

Resource planner and Harbour Master

- Met de Havenmeester is alleen contact per mail of telefoon.
- Resource planner heeft alleen informatie van de agent en geeft info door aan de agent. De agent is dan weer in contact met de Havenmeester. Maar als de agent niet ingelicht wordt dat er geen loods beschikbaar is, dan gaat die agent ons ook niet bellen. Inmiddels wel iets meer contact met HCC.
- Bellen met HCC om te bespreken op welke palen welk schip moet komen. Dat is afgelopen jaar paar keer fout gegaan. Vandaar dat we nu mail naar de agent sturen en bellen met het HCC. Het HCC belt ons ook wel eens op om te vragen wat de palen zijn en of het schip stuur- of bakboord aan de kade komt. Als wij om welke reden dan ook die boot uiteindelijk een paal hoger willen hebben en we sturen de agent een mailtje, dan begrijp ik dat die mail niet altijd meer wordt gelezen. De agent vult de paalnummers in in PCS en ook dat gaat wel eens fout. Daarom dus nu ook af en toe een short cut tussen HCC en terminal.
- Als het schip afgeroepen is om 12:00 dan ga ik er vanuit dat ze om 12:00 naar binnen kunnen komen. Als een schip dan later komt heb ik bijvoorbeeld 1,5 uur 3 ploegen binnen zitten. Niet ideaal. Daar worden we ook niet altijd over ingelicht.
- Als er een groot schip binnenkomt en er ligt nog een groot schip aan de kade, dan komt de binnenkomer niet binnen. Zichtbaar dat de uitgaander nog niet besteld is. Er is geen contact moment tussen HCC en terminal om te checken of de kade vrij is. Het kan wel dat wij nog met een binnenvaart schip bezig zijn. Dan krijgen ze dat denk ik vaak door van de roeiers. Die zijn als eerste op de kade en zien dan het binnenschip nog liggen. Ze zullen ook wel een keer lastminute aan komen maar 9 vd 10 keer staan ze al te wachten als het schip binnenkomt. Vanuit daar krijgen we dan vaak een belletje 'he de X komt binnen maar binnenvaarder Y ligt nog voor de kant. Dan is het antwoord 'hij gaat zo weg'. In een half uur kunnen we nog best 10 containers op een binnenvaarder laden.
- Ik denk dat je verplicht bent om die informatie *(over een schip dat niet op de bestelde tijd klaar is met laden en lossen)* te delen met de agent. In principe moet je ook gewoon het HCC even bellen. Of dat altijd gebeurt, dat zal denk ik niet altijd. Wel sowieso de agent. Die gaat dan ook wel weer met het HCC contact opnemen. En buiten dat, wordt er hier heel vaak naar de roeiers gebeld. Wij weten dat de roeiers contact hebben met de loodsen, en loodsen hebben contact met HCC.

Resource planner and pilot

- Zo heel af en toe bellen de loodsen ons. Bijvoorbeeld: over 1,5 uur ben ik voor de kade, is hij vrij? Dan kan ik bijvoorbeeld zeggen dat we nog bezig zijn met een binnenkomer, maar als je in de buurt bent gaan we hem wegsturen. Schip wordt dan op de kaart in de gaten gehouden. We willen zoveel mogelijk containers doen, maar het moet natuurlijk wel voor iedereen veilig zijn om aan te meren.

D.4. Boatman planners

Interview conducted on 13-12-2019 at boatmen planning of the KRVE.

Figure D.2: Boatmen planning [conducted from https://www.youtube.com/watch?v=azTtDtDQgcU]

Boatmen planning process

- De haven is verdeelt over 4 reyons. De planning is verdeeld over 3 posten: Europoort, Botlek en Waalhaven. Op de Europoort post zit ook de planning voor de Maasvlakte. Op elke post zit een werkverdeler voor het reyon. Op de Europoort post dus ook een werkverdeler voor de Maasvlakte. Bij de Europoort post en Waalhaven post zit ook 1 planner voor het taxi vervoer van de loodsen (CP links). CP rechts zit alleen op de Waalhaven post. De CP rechts herverdeelt de mannen over de verschillende reyons wanneer nodig en belt anders mensen van huis.

- De reizen komen in ons eigen systeem binnen via HaMIS. Alle binnenkomers, vertrekkers en verhalers. Alle details van een schip en een reis zijn beschikbaar. HaMIS houdt alle meldingen bij die een schip maakt. MAI *(eigen systeem van de roeiers)* pikt daar de meldingen uit die van belang zijn voor de roeiers om te plannen. Bijvoorbeeld de melding dat een schip beloodst wil worden, dat een schip beloodst is, de ETA haven, de tijd dat het schip langs het Lage Licht komt en passage bevestigingen. Als er al roeiers op zijn ingedeeld door de planning zijn ook de mannummers te zien.

- Voor de Europoort schepen wordt de tijd dat de loods aan boord is gegaan op het scherm getoond en daarnaast de ETA haven die de loods heeft aangegeven. Voor andere schepen wordt de tijd dat hij het Lage Licht gepasseerd is getoond en de ETA haven die de loods heeft opgegeven. De reden voor dit verschil is dat de schepen die naar de Europoort gaan al snel na het Lage Licht op hun bestemming zijn.

- Binnenkomende schepen worden door de roeiers gepland op basis van passage punten waar het schip langs komt. Als het schip een passage lijn op ongeveer een half uur varen van bestemming passeert dan worden er roeiers op ingezet. Uitgaande reizen worden op bestelling gedaan en een half uur voor de bestelde ETD ingedeeld.

- Het kan voorkomen dat er 2 schepen in dezelfde haven tegelijk besteld zijn om weg te gaan. Hetzelfde roeiers team wordt dan ingedeeld om beide schepen te doen. De schepen kunnen toch niet allebei tegelijk de haven uit. De loodsen spreken dan onderling af wie eerst gaat. De keuze om eerst te gaan kan verschillende redenen hebben. Bijvoorbeeld 'jij hebt 3 sleepboten dus ga jij maar eerst want dan kunnen die sleepboten weer door'. De roeiers zitten op hetzelfde kanaal dus kunnen mee luisteren of advies geven. Als een binnenkomer en vertrekker tegelijk zijn, dan wordt meestal eerst de binnenkomer vastgelegd en dan de vertrekker los. Maar als een binnenkomer het vertrekkende schip al vrij snel passeert worden er gewoon meer roeiers naar de plek toegestuurd.

- Als de roeiers binnenkomen wordt hun bordje *(fysieke rij van houten naam bordjes)* naar beneden geschoven. Op die manier wordt bijgehouden wie al het langste op de post zit en als eerst volgende moet worden ingedeeld.

- GIDS wordt bij het maken van de roeiplanning weinig gebruikt. Als er een ETA of ETD in GIDS wordt geupdate komt dat wel door in ons systeem. Het heeft alleen niet zo veel effect, want de diensten worden toch pas 30 min van te voren ingepland.

Boatmen planners and tug planner

- Het komt wel eens voor dat de sleepdienst belt dat ze 30 min later dan gepland bij een schip zijn en dan kan de roeiplanning bepalen of de ingedeelde jongens nog ergens anders heen gestuurd kunnen worden. Als dat belletje niet gebeurd, dan komen de roeiers aan bij het vertrekkende schip en zien ze dat er geen sleepboten zijn. Of de planner heeft het al gezien op de HaMIS havenkaart. In dat geval bellen de roeiers de sleepdienst om te vragen wanneer ze komen. Dit is vooral van belang als er veel werk is.

Boatmen planners and boatmen

- Als het opeens druk is *(kun je zien aankomen door de meldingen in het systeem)* worden sommige dingen herpland, ook in samenwerking met de jongens buiten. Er wordt dan via de VHF gevraagd of ze denken ergens op tijd te kunnen zijn. De roeiers denken dan mee met de planners.

- De indeling wordt verteld via de VHF, maar de roeiers hebben ook een app waarop ze kunnen zien op welke reis ze zijn ingedeeld en op welke paalnummers het schip moet worden vastgelegd.

Boatmen planners and pilot

- Bij het plannen heb je altijd een plan B C D in je hoofd. Als die plannen op zijn, dan wordt het gokken. Als je verkeerd hebt gegokt, dan is het volgende plan om zelf een boot op te springen en het laatste plan om de loods te bellen dat de roeiers iets later zijn en dat hij even gas terug moet nemen.

- Als de loods vast staat in de file o.i.d. dan belt hij de roeiers dat hij een half uur later is voor de oppik. Dan weten de roeiers dus ook meteen dat het vertrekkende schip waarschijnlijk vertraagd is en dat ze daar pas wat later naar toe hoeven. De CP links *(taxi planner)* geeft het belletje dan door aan de CP rechts of de werkverdeler.

D.5. Harbour Master planning

The Harbour Master planning is executed by the Harbour Coordination Center. For incoming voyages, part of the process is executed by the VTS operator of Maas Approach.

Harbour Coordination Center

Interview conducted on 06-01-2020 at the Harbour Coordination Center. The interview transcript could not be included in the appendix.

Figure D.3: Harbour Coordination Center [conducted from schuttevaer.nl]

VTS Operator of Maas Approach

Interview conducted on 28-01-2020 at Vessel Traffic Center Hoek van Holland.

Port planning process of incoming voyages

- In de basis geeft een agent ons de informatie over hoe laat een schip dat binnenkomt aan het loods station kan zijn. De agent die bepaalt dat en wij hebben daar een aantal voorwaarden voor, zoals dat ligplaats vrij moet zijn.
- Als schepen met elkaar moeten uitwisselen zitten daar ook weer bepaalde voorwaarden aan verbonden. 9 van de 10 keer kun je gewoon zeggen tijd voor tijd. Als schip X om 10:00 vertrekt kan schip Y om 10:00 zijn loods oppikken.
- Het grijze gebied waar wij wel eens inzitten is dat we zien dat schip X moet uitwisselen met schip Y. Als schip Y dan in de lijst met vertrekkende schepen verschijnt, voeren wij vast binnenkomer X op. Je ziet dan meestal dat de agent een kwartiertje later ook de order *(instruction from the vessel agent)* aanpast.
- Kapiteins hebben de verplichting om om de zoveel uur een notice naar de agent te sturen. Die upgedate ETA moet de agent weer doorgeven aan het havenbedrijf en dat is eigenlijk de tijd die je hier nu ziet *(ETA Maas Center)*. De basis gegevens komen dus van de kapitein en de agent is degene die het aanlevert in de systemen van de Havenmeester.
- Eerst kijken we naar meldingen en dan op een gegeven moment maken de schepen operationeel contact. Dan krijgt Maas Aanloop te horen of de kapitein nog andere intenties heeft dan naar binnen gaan. Wij halen dan de ETA PS eruit en klikken aan dat het schip in operationeel contact is en vullen in wat de diepgang van het schip is. Op het moment dat wij hem operationeel contact geven gaat eigenlijk het hele circus in beweging. De agent krijgt daar een melding van. Dan weet de agent ook of het overeenkomt met de gegeven orders *(instructions from the vessel agent)*. Als een kapitein zelf gezegd heeft dat hij buiten wil blijven *(dus als het niet in de orders via Dirkzwager stond)* zetten wij er in de opmerking bij dat het bijvoorbeeld eerst buiten tanks gaat cleanen.
- Ongeveer 1 mijl ten zuiden van de Maas Center boei worden schepen beloodst. Sommige schepen worden eerder beloodst. De ETA MC blijft gewoon altijd staan. Het is eigenlijk gewoon een punt waarmee we dan berekenen hoe laat iemand aan het Lage Licht is. Tussen de MC boei en het Lage Licht is het ongeveer een uur varen. Wij kunnen in HaMIS zien of een schip loodsplichting is en er dus een loods besteld moet worden *(dus of er een ETA pilot station moet worden opgegeven in HaMIS)*.
- Als er in HaMIS staat dat het schip loodsplichtig is of als het schip een loods wil dan vullen we op basis van de opgegeven Maas Center tijd een ETA PS in. Die Maas Center tijd is dus gewoon een punt waar je naartoe of vanaf rekent. De pilot station kies je dan per schip. Voor LNG is dat bijvoorbeeld een uur voor MC. Eigenlijk worden alle schepen beloodst bij de MC boei, behalve LNG en geulers. Die worden voor de MC boei beloodst. De pilot stations waar uit gekozen kan worden zijn Maas Center, LNG of het rendez vous punt *(voor geulers)*.
- Maas Aanloop checkt voordat een schip wordt opgevoerd of de ligplaats vrij is of dat het schip op zijn ligplaats is besteld. Als blijkt dat het schip pas een uur later vertrekt dan dat het schip aan de kade kan zijn, dan veranderen we de ETA PS bijvoorbeeld naar een uur later. Daarnaast checken we de diepgang en of het een tijschip is. De tij afspraken staan in HaMIS vermeld en dan kijken we of de opgegeven tijd aan het loods station wel valt binnen zijn tijpoort. Het zou in theorie kunnen dat een schip roept en dat zijn tijpoort niet klopt met de opgegeven ETA MC en dat zijn ligplaats nog bezet is.
- Een schip mag pas het Pilot Maas gebied in als alle vinkjes van het HCC op groen staan. Zodra het schip in Pilot Maas gebied is gaat de teller lopen *(een loods kan dan worden afbesteld, als de loods voor PM gebied wordt gecanceld zitten er geen kosten aan verbonden)*. Voordat een schip onze sector dus uit vaart moet alles geregeld zijn.

VTS operator of Maas Approach and pilot planning

- Daarna gaan we bellen met de lodico's *(= pilot planners)* om te checken of zij wel een loods beschikbaar hebben. Dat doen we niet altijd. Daar hebben we allerlei voorwaarden voor. Dit belletje doen we bijvoorbeeld als een schip uit het anker gebied binnen wil komen met minder dan 3 uur notice of bij een bepaalde diepgang. Het gebeurt ook dat wij een ETA PS invullen en dat een kwartier later de agent zegt 'nee maar hij moet buiten blijven'. Dan moeten we ook even bellen dat het niet doorgaat, dus dat die loods weer ergens anders kan worden ingezet.

- Als een schip afwijkt van zijn opgegeven melding, maar het is meer dan 3 uur voor zijn ETA PS dan hoef ik de loods planners niet te bellen.

VTS operator of Maas Approach and HCC

- Als bij het melden blijkt dat de diepgang significant afwijkt van wat is opgegeven in de melding dan bel ik het HCC. Het HCC kan dan bijvoorbeeld de tijpoort opnieuw berekenen en koppelt dat terug naar Maas Aanloop indien nodig. Maas Aanloop vult dan vervolgens de geschikte ETA PS van het schip in. Het contact met het HCC loopt officieel via de DO VTS, die alles dan weer bespreekt met de DO HCC en Loodsdienstleider.
- Naast contact met de loods planners is er contact met de DO VTS via de telefoon of met de ADO's inkomend. Die laatste bellen we als we willen weten of een ligplaats op het nodige moment vrij is. Zij checken het dan met de terminal.
- Normaal moet er tussen 2 diepgaande schepen 45 min zitten. Het kan zijn dat er veel tegelijk binnen komen, waar we dan op moeten letten is dat als het op gaat stropen dat de veiligheid niet in het geding komt. De DO VTS bepaalt dan dat een bepaalde ETA PS verlaat moet worden. Wij zien dat natuurlijk ook wel aan komen dus zijn dan adviserend. Dan geef je dat aan bij de DO VTS.

VTS operator of Maas Approach and vessel captain

- Als een schip contact maakt checken wij nog een keer de opgegeven diepgang, de orders en de bestemming van het schip met de kapitein. De kapitein geeft de tijd door dat hij verwacht aan de MC boei te zijn. Vervolgens vult de VTS operator van Maas Aanloop de tijd ETA PS van het schip in *(in HaMIS)*.
- Nieuwe orders *(instructions from the vessel agent)* van de agent verschijnen met een pop-up in HaMIS *(als de agent gebruikt maakt van de Dirkzwager service)* en worden door de VTS operator van Maas Aanloop aan de kapitein van het schip medegedeeld.

VTS operator of Maas Approach and nautical planners

- De voormelding wordt gedaan door de agent in PCS. Dan zie je de schepen zonder operationeel contact. Zodra het schip in operationeel contact is dan zet je de actuele gegevens erin *(in HaMIS)*. De opgegeven diepgang door de kapitein en de werkelijke ETA pilot station. Zodra wij hem opvoeren gaat het door naar alle dienstverleners. De agent krijgt hiervan ook een terug koppeling.

E

Data analysis of the recorded delays

The analyzed data includes data of the delays that are recorded by the Harbour Master of the Port of Rotterdam between October 2018 and October 2019. The available data consists of the following data files:

- Incoming and outgoing voyages: *voyage ID, vessel name, vessel number, vessel characteristics, nationality, berth of departure, previous port, vessel agent, cargo type, ATD, ETD*
- Incoming and outgoing voyages with pilot guidance: *voyage ID, vessel name, planned pilot boarding time, pilot boarding time, number of used tugs*
- Incoming and outgoing voyages with a recorded delay: *voyage ID, vessel name, ETD, ATD, delay time, delay cause, delay sub cause, additional remarks*

The different data sources are combined by linking the voyage ID's. Subsequently, the voyages that use one or multiple tugboats are filtered. This results in:

- Incoming and outgoing voyages with a recorded delay and pilot & tug assistance: *voyage ID, vessel name, ETD, ATD, delay time, delay cause, delay sub cause, additional remarks, planned pilot boarding time, pilot boarding time*

E.1. Incoming voyages

The total number of incoming voyages between October 2018 and October 2019 is **28484 sea-going voyages**.

The following diagrams provide insight into the share of incoming voyages that use pilot and tug services (Figure E.1), the share of incoming voyages with a recorded delay (Figure E.2) and the share of these delays that involve pilot or tug assistance (Figure E.3).

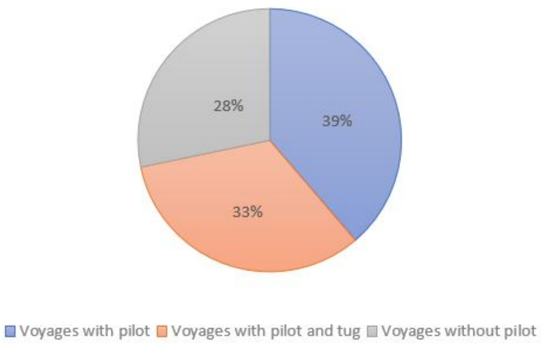


Figure E.1: Incoming voyages with pilot and tug assistance

Figure E.2: Incoming voyages with recorded delays

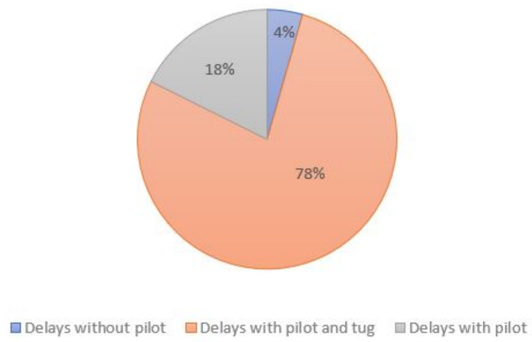


Figure E.3: Incoming delays with pilot and tug assistance

A total of **212** voyages of all voyages that use pilot and tug assistance is recorded as a delayed voyage:

- 19 of the 212 recorded delays are accounted to the pilots
- 37 of the 212 recorded delays show that the pilot boards the vessel more than half an hour later than planned.
- 131 of the 212 recorded delays are accounted to the tugboats.
- 1 of the 212 recorded delays is accounted to the boatmen
- 18 of the 212 recorded delays are accounted to an occupied berth.

Multiple causes and sub-cause categories are applied by the Harbour Master. The total overview of the applied causes and corresponding sub-causes is presented in Table E.1.

Delay cause categories	Sub-cause categories
Occupied berth	
Cargo services	○ Cargo ○ Other services
Nautical service providers	○ Pilot ○ Tugboats ○ Boatmen
Blockage	○ Incident ○ Object in maintenance ○ Object in failure ○ Other
Traffic	
Vessel services	○ Repairs ○ Technical failure ○ Other services

Table E.1: Delay cause categories and corresponding sub-causes that are applied by the Harbour Master for incoming voyages

In this thesis, the delay categories are restructured as presented in Table E.2.

Delay cause category *(in this thesis)*	Delay cause category *(recorded by the Harbour Master)*
Pilot	Nautical service providers > pilots
Tugboats	Nautical service providers > tugboats
Boatmen	Nautical service providers > boatmen
Berth not available	Occupied berth + cargo services
Congestion	Blockage + traffic
Technical failure at vessel	Vessel services

Table E.2: Delay cause categories used in this thesis for incoming voyages

Each of the delay categories is responsible for a percentage of the total number of recorded delays that use pilot and tug assistance and a percentage of the total delay time of all voyages that use pilot and tug assistance.

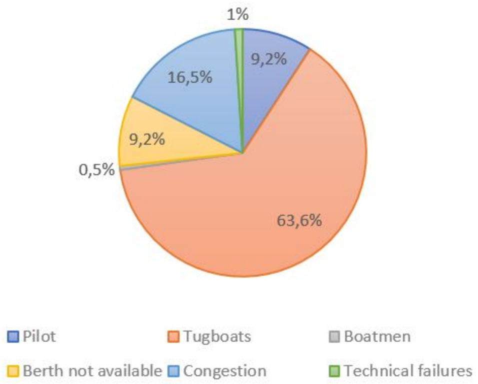


Figure E.4: Percentage of the recorded delays with pilot and tug assistance for incoming voyages

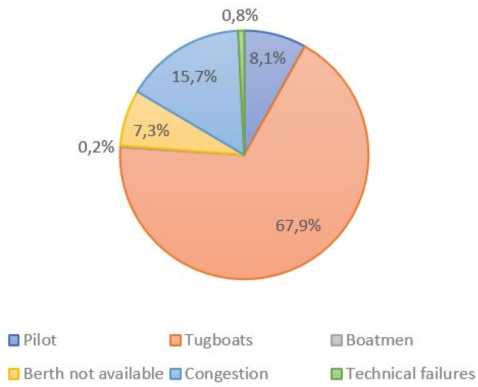


Figure E.5: Percentage of the total delay time of the recorded delays with pilot and tug assistance for incoming voyages

E.2. Outgoing voyages

The total number of incoming voyages between October 2018 and October 2019 is **28263 sea-going voyages**. The following diagrams provide insight into the share of outgoing voyages that uses pilot and tug services (Figure E.6), the share of outgoing voyages with a recorded delay (Figure E.7) and the share of these delays that involves pilot or tug assistance (Figure E.8).

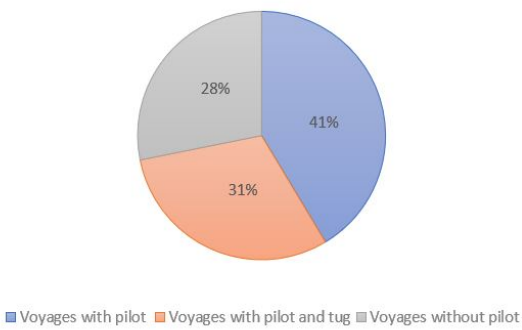


Figure E.6: Outgoing voyages with pilot and tug assistance

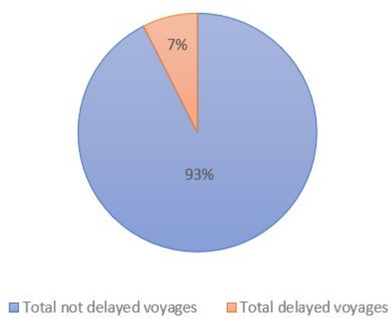


Figure E.7: Outgoing voyages with recorded delays

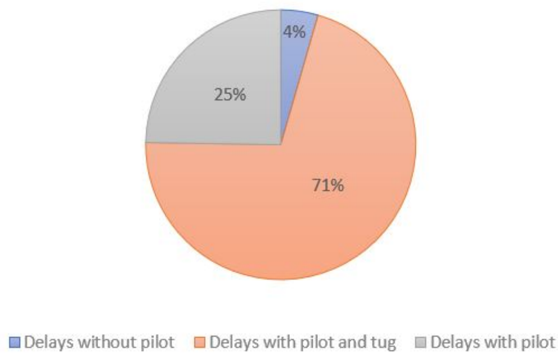


Figure E.8: Outgoing delays with pilot and tug assistance

A total of **1492** voyages of all voyages that use pilot and tug assistance is recorded as a delayed voyage:

- 101 of the 1492 recorded delays are accounted to the pilots.
- 32 of the 1492 recorded delays show that the pilot boards the vessel more than half an hour later than planned.
- 679 of the 1492 recorded delays are accounted to the tugboats.
- 1 of the 1492 recorded delays is accounted to the boatmen.
- 453 of the 1492 recorded delays are accounted to unfinished loading and unloading operations.

Multiple causes and sub-cause categories are applied by the Harbour Master. The total overview of the applied causes and corresponding sub-causes is presented in Table E.3.

Delay cause	Sub-cause
Vessel agent	○ Cancelled order ○ Documents ○ Draft survey ○ Cargo ○ Other services
Cargo services	○ Documents ○ Draft survey ○ Cargo ○ Cargo inspection ○ Lashing ○ Technical failure ○ Other
Harbour Master	○ HCC ○ Restrictions
Nautical service providers	○ Pilot ○ Tugboats ○ Boatmen
Blockage	○ Object in failure
Traffic	
Vessel services	○ Repairs ○ Technical failure ○ Bunker operations ○ Other services

Table E.3: Delay cause categories and corresponding sub-causes that are applied by the Harbour Master for outgoing voyages

In this thesis, the delay categories are restructured as presented in Table E.4.

Delay cause category *(in this thesis)*	Delay cause category *(recorded by the Harbour Master)*
Pilot	Nautical service providers > pilots
Tugboats	Nautical service providers > tugboats
Boatmen	Nautical service providers > boatmen
Terminal operations not finished	Cargo services
Vessel not ready for departure	Vessel services + vessel agent
Congestion	Blockage + traffic + Harbour Master

Table E.4: Delay cause categories used in this thesis for outgoing voyages

Each of the delay categories is responsible for a percentage of the total number of recorded delays that use pilot and tug assistance and a percentage of the total delay time of all voyages that use pilot and tug assistance.

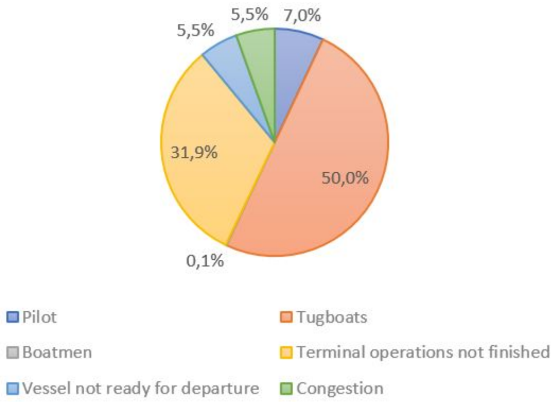


Figure E.9: Percentage of the recorded delays with pilot and tug assistance for outgoing voyages

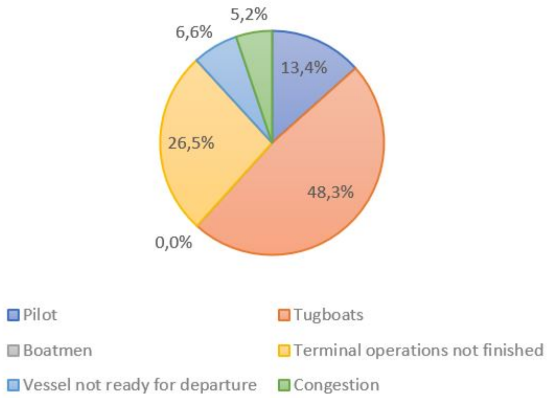


Figure E.10: Percentage of the total delay time of the recorded delays with pilot and tug assistance for outgoing voyages

F

BPMN legend

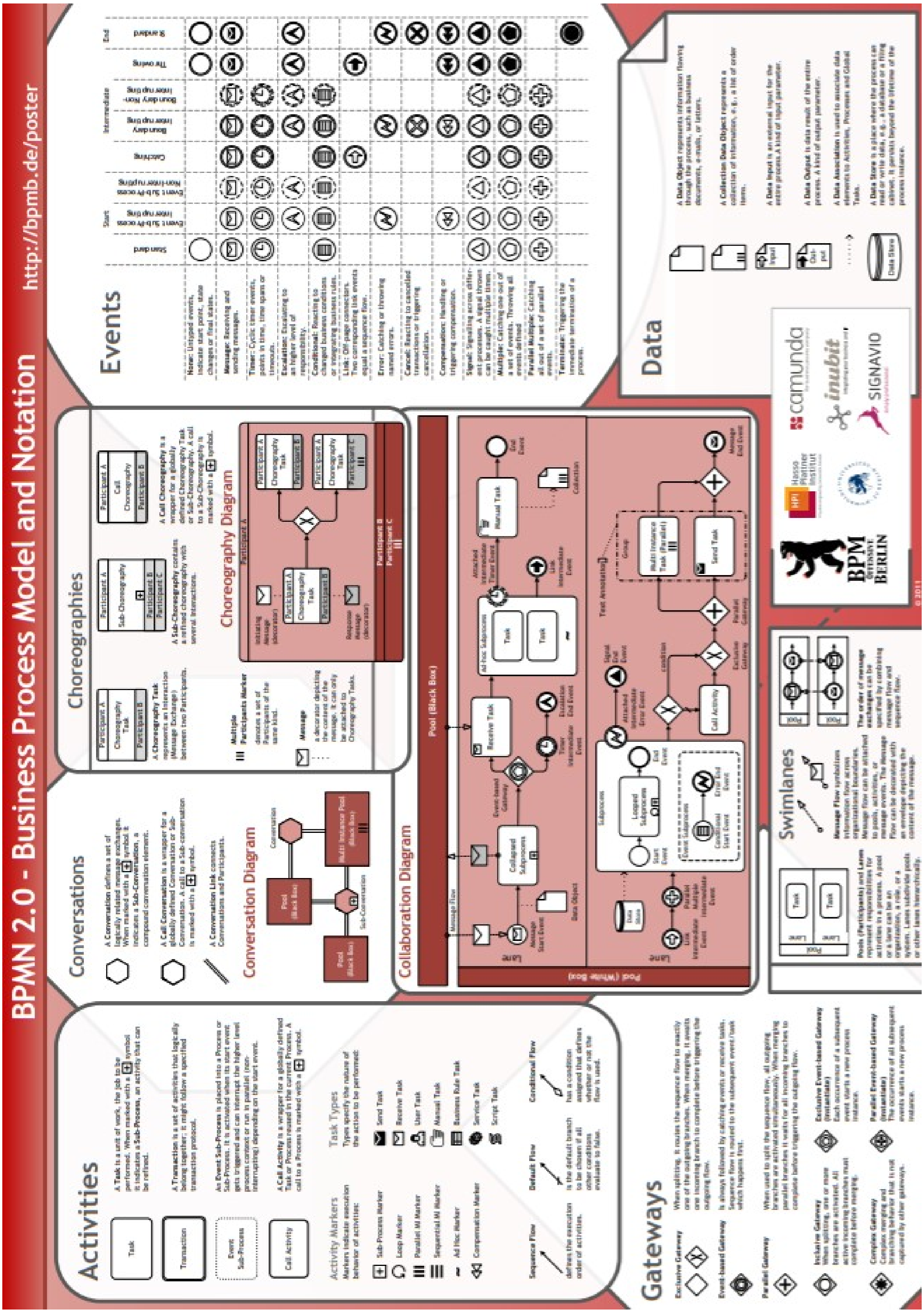


Figure F.1: Business Process Model and Notation 2.0 Legend

G

BPMN sub-processes

The sub-processes (indicated with a 'plus' sign in the BPMN conversation diagrams) are provided in this appendix. The diagram of a sub-conversation can only contain the participants who are linked to the sub-conversation within the 'parent' diagram. The details of a sub-conversation can be described in another conversation diagram. It is also possible to draw message flows directly into the conversation diagram (Allweyer, 2016). The left part of the presented figures in this appendix visualizes the conversation in the BPMN conversation 'parent' diagram, the right part of the figures presents the detailed sub-process.

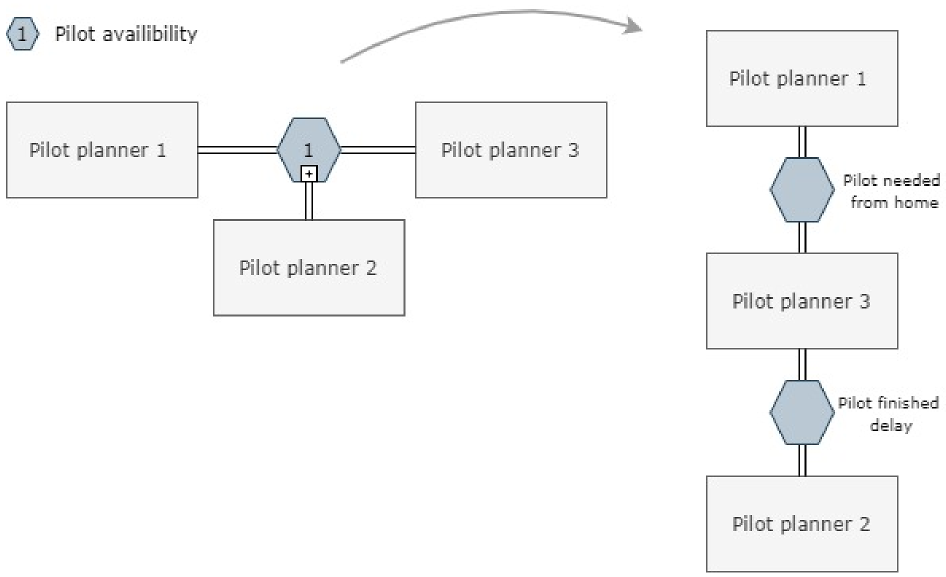


Figure G.1: BPMN conversation diagram sub-process 'pilot planning: conversation 1'

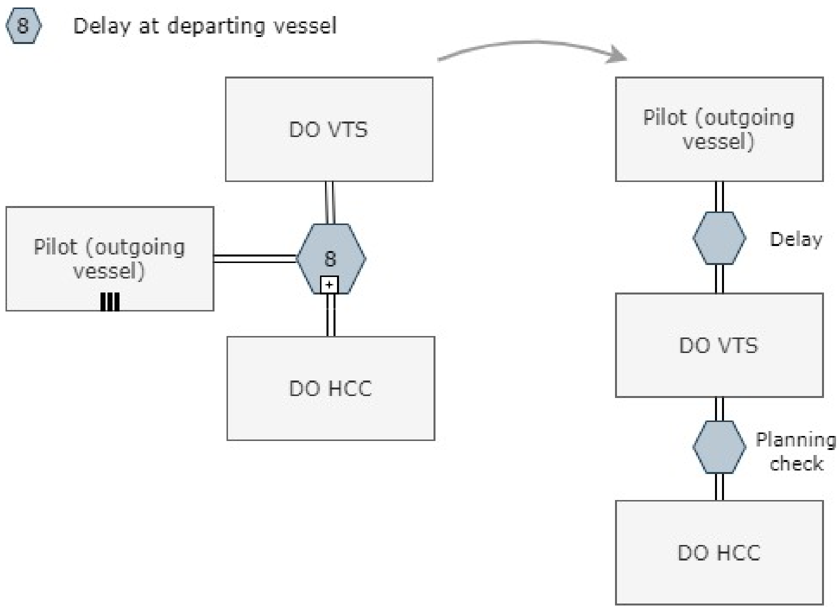


Figure G.2: BPMN conversation diagram sub-process 'HCC planning: conversation 8'

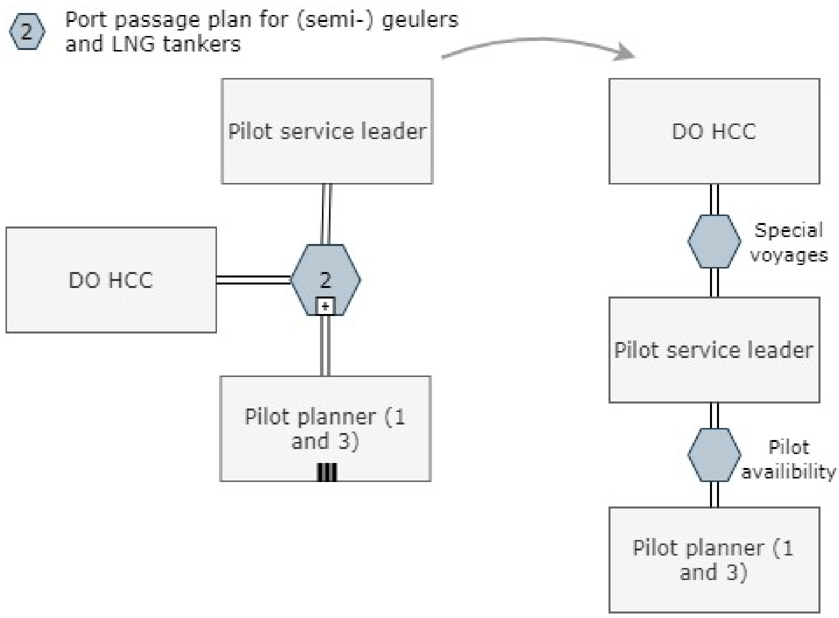


Figure G.3: BPMN conversation diagram sub-process 'HCC planning: conversation 2'

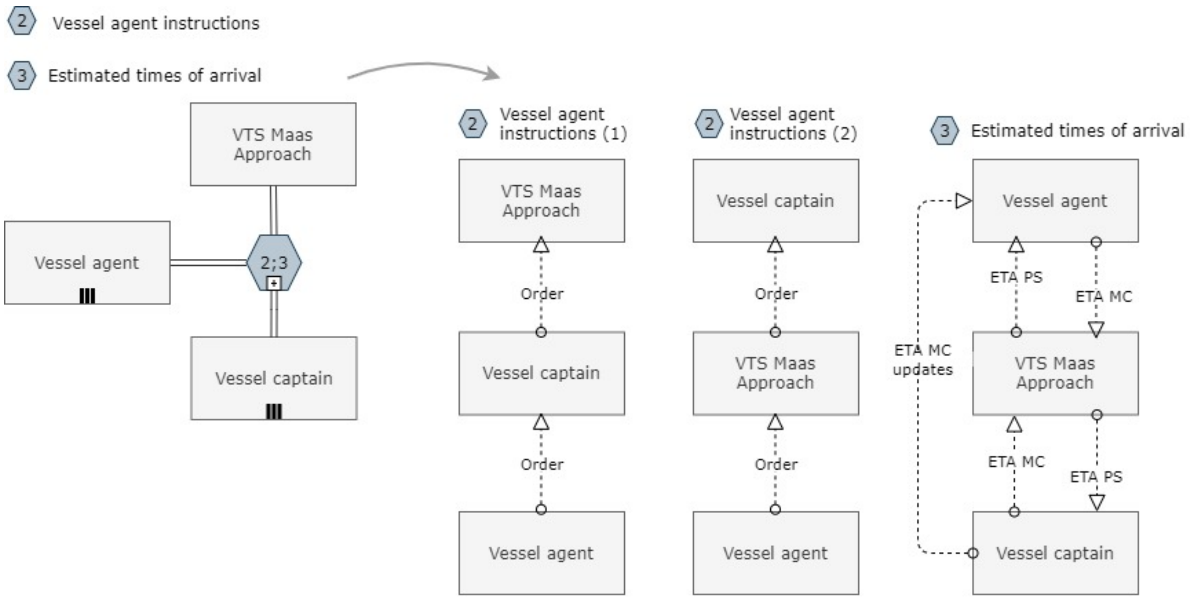


Figure G.4: BPMN conversation diagram sub-process 'VTS Maas Approach planning: conversation 2 & 3'

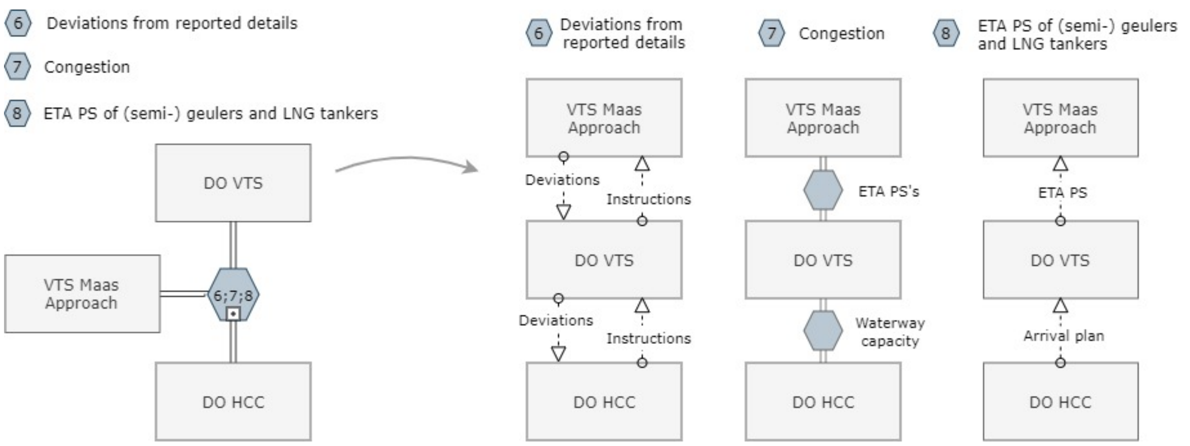


Figure G.5: BPMN conversation diagram sub-process 'VTS Maas Approach planning: conversation 6,7 & 8'

H

Portmap

In this appendix, maps are provided that clarify the following locations:

- The VTS sectors of the Port of Rotterdam (figure E.1 and figure E.2)
- The pilot stations for boarding and disembarking (figure E.3)
- The Lage Licht and Pistoolhaven (figure E.4)

In figure E.1, the VTS sectors at the 'sea-side' of the Port of Rotterdam are shown. Each of the sectors uses its own VHF-channel for communication between the VTS operator and the vessels. Furthermore, the anchorage areas are indicated. Also, the MC buoy in the Pilot Maas sector is presented. This is the pilot station that is used as the 'regular' pilot boarding and disembarking location. In figure E.2, all VTS sectors of the Port of Rotterdam are shown (except sector Maas Approach).

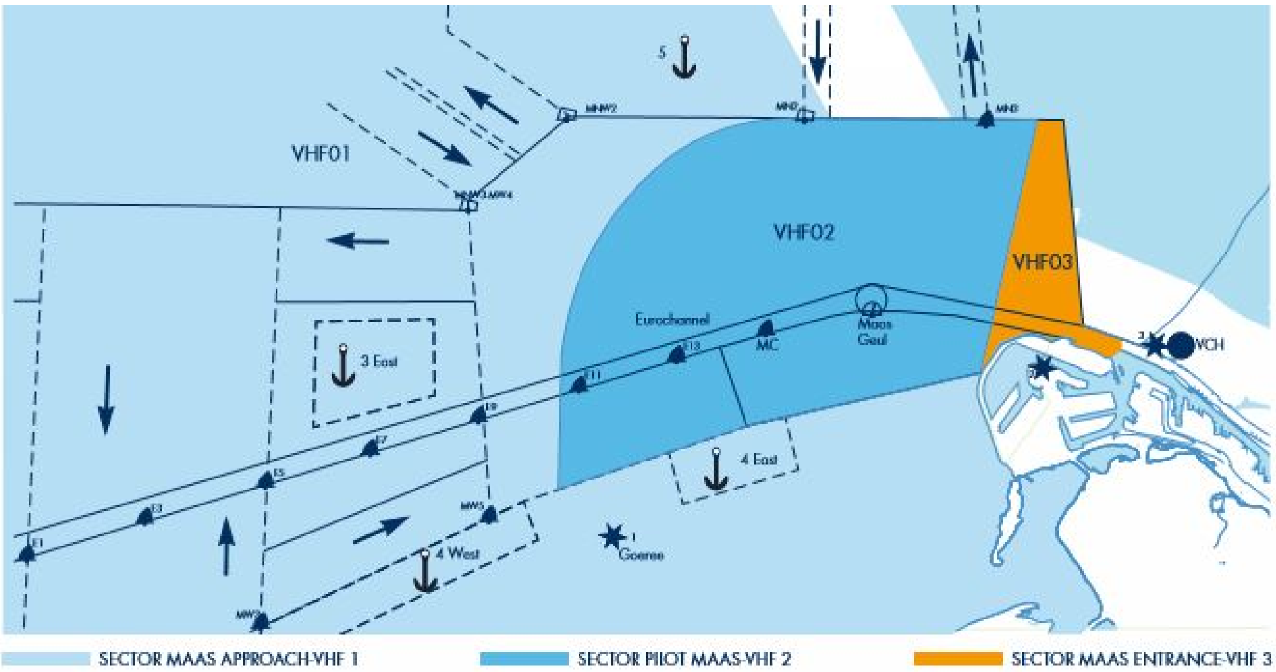


Figure H.1: VTS sectors of the Port of Rotterdam: Maas Approach, Pilot Maas and Maas Entrance [conducted from portofrotterdam.com]

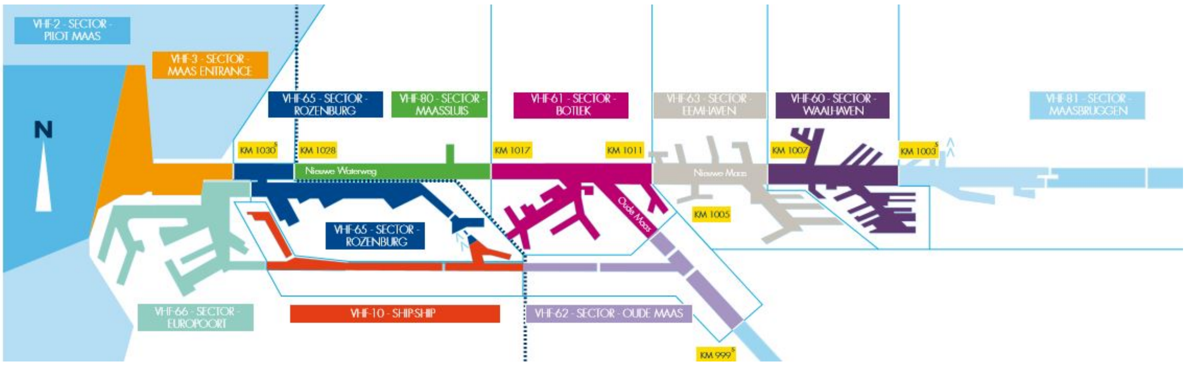


Figure H.2: VTS sectors of the Port of Rotterdam [conducted from portofrotterdam.com]

In figure E.3, the different pilot stations that are used for the Port of Rotterdam are shown. The 'regular pilotage point' is located close to the MC buoy. Vessels of exceptional size or with hazardous cargo use a different pilot station. LNG tankers that are larger than 180 meters receive a pilot at the LNG pilot station. Vessels that are bounded by length and draught to use the 'Geul' are piloted by helicopter at the Rendezvous pilot station.

Figure H.3: Pilot stations Port of Rotterdam [conducted from rijnmond.loodswezen.nl]

In figure E.4, the location of the Lage Licht and the Pistoolhaven are depicted. The Lage Licht can be seen as the entrance of the Port of Rotterdam and is used as a reference point by the pilot. When boarding a vessel, the pilot estimates the ETA at the Lage Licht. This ETA is then shared with the other nautical service providers. The Pistoolhaven is the location from where pilots are transported to the pilot stations at sea by a pilot tender. It takes about 1 hour to transport a pilot from the Pistoolhaven to the MC pilot station (see 'regular pilotage point' in figure E.3).

Figure H.4: Location of the Lage Licht and Pistoolhaven [conducted from google.maps.com]

I

Expert survey

With expert input from Hans Aarts and Raymond Seignette (Harbour Master Department of the Port of Rotterdam), root cause diagrams of the delays that are recorded by the Harbour Master are conducted (see chapter 9). A survey document containing these root cause diagrams is shared with experts of the Harbour Coordination Center, the Vessel Traffic Services of the Port of Rotterdam, the policy department of the Harbour Master, the pilot organization and the tug company. The experts were asked to score the root causes that they consider to occur relatively more or less frequent by filling in the following type of figure:

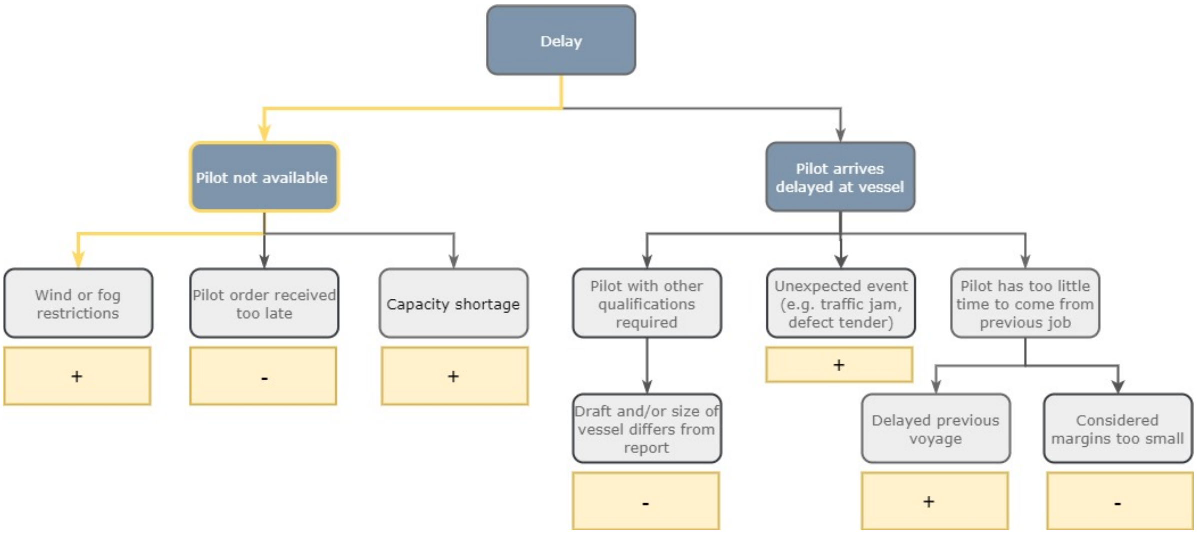


Figure I.1: Example of figure filled in by the experts about the frequency of the root causes

Branches that are scored with a plus sign are considered to occur frequent, while branches scored with a minus sign are considered to occur less frequent. The survey document contained a diagram of delays accounted to pilots, tugboats, an occupied berth, terminal operations, vessel not ready for departure and congestion (see the applied delay categories in Appendix E). Instructions on how to complete the document were provided to the experts. The instructions included the definition of a delay for an incoming and outgoing voyage. Furthermore, it is assumed that the capacity of the fairway and the nautical services is fixed and can not be increased. Also, it was enhanced that the branches should be scored 'relatively' to the other branches within the same diagram.

The attached instructions of the document were as follows (in Dutch):

Questionnaire afstudeerproject Kim Molkenboer
Datum: 24-02-2020

- Het doel van deze questionnaire is om inzicht te krijgen in welke oorzaken voor een vertraging relatief vaak en welke relatief minder vaak voorkomen.
- Op de volgende pagina's worden meerdere diagrammen met oorzaken voor opgetreden vertragingen getoond. Elke rij in de diagram presenteert de aangenomen oorzaken van de gebeurtenis in de rij erboven.
- Bij het maken van de diagrammen zijn een aantal aannames gedaan:
  - Een **vertraging voor een inkomende reis** is een afwijking van de opgegeven ETA Pilot Station van het schip of een vertraging die optreedt tussen aankomst bij de Pilot Station en aankomst bij de ligplaats.
  - Een **vertraging voor een uitgaande reis** is een afwijking van de opgegeven ETD (bij bestelling).
  - De huidige capaciteit van de vaarweg en de nautische services staat vast en kan niet worden vergroot.
- Vul voor elke diagram in het gele vakje in of u van mening bent dat de aangegeven oorzaak relatief vaak voorkomt (+) of relatief minder vaak voorkomt (-) **ten opzichte van de andere oorzaken in dezelfde diagram**. Hierbij moet de gehele 'route' naar de oorzaak in de laagste rij in overweging worden genomen. Een voorbeeld is te zien op de volgende pagina. (***Let op: de eventuele impact van een vertraging is bij het invullen van deze questionnaire niet van belang)***.
- U mag iets als 'relatief vaak voorkomend' beschouwen als u van mening bent dat de specifieke oorzaak vaker voorkomt dan andere oorzaken die **in dezelfde diagram** genoemd worden. Hetzelfde principe geldt voor 'relatief minder vaak voorkomend'.
- Veel van de genoemde oorzaken leiden pas tot een vertraging als de beschikbare capaciteit in het geding komt. Bij het invullen van de questionnaire moet hier rekening mee worden gehouden. Dus: hoe vaak leidt de genoemde oorzaak inderdaad tot het genoemde gevolg.

Figure I.2: Instructions of the distributed questionnaire

Although the frequency of the recorded delays is known from data (see Appendix E), it is chosen to not distinguish between delays that are recorded more or less frequent, because the root causes are extremely interrelated. Consequently, the experts are asked to score the root causes relatively within their own recorded delay cause category. This means that it could be that a root cause of a delay accounted to the pilots that is mainly scored with a 'plus' sign, actually occurs less frequent than a root cause of a delay accounted to tugboats that is mainly scored with a 'minus' sign. However, this method assures that the delays that are considered to occur most frequent are included in the analysis.

Feedback on the survey is received from 10 experts. The feedback is processed into the table presented in Table I.1. A question mark is placed if the expert left the root cause blank. The results presented in Table I.1 are used to identify the delays that are considered to occur frequent within the nautical chain. A root cause and its connected branch are included as 'frequent' if 8 or more experts assigned a 'plus sign' to the root cause branch.

	Resp 1	Resp 2	Resp 3	Resp 4	Resp 5	Resp 6	Resp 7	Resp 8	Resp 9	Resp 10
Delay incoming voyage (pilots)										
Wind or fog restrictions	-	-	+	+	+	?	-	+	-	-
Pilot order received too late	-	+	-	-	-	?	-	+	-	-
Capacity shortage	+	+	+	+	+	?	+	+	+	+
Considered margins too small	-	-	-	-	-	?	-	-	+	-
Delayed previous voyage	-	+	+	-	+	?	-	-	+	-
Unexpect event	+	-	-	-	-	?	-	-	-	+
Draft and/or size differs from report	-	-	-	-	-	?	-	-	-	-
Delay incoming voyage (tugs)										
Fog restrictions	-	-	+	-	-	-	-	+	-	-
Capacity shortage	+	+	+	+	+	+	+	+	+	+
Unexpected events	-	-	-	-	-	-	-	-	-	-
Considered margins too small	+	-	-	+	-	-	+	+	+	+
Delayed previous voyage	+	+	+	-	+	+	+	+	+	+
Pilot orders extra tug	-	-	+	+	+	-	-	+	+	+
Delay incoming voyage (occupied berth)										
Delayed sea-going vessel occupies berth	+	+	+	+	+	+	+	?	+	+
Unexpected events	-	-	-	+	-	-	-	?	-	-
Barge occupies berth	+	+	+	-	+	+	+	?	+	+
Delay outgoing voyage (pilot)										
Wind or fog restrictions	-	-	+	+	-	?	-	+	-	-
Pilot order received too late	-	-	-	-	+	?	-	-	+	-
Capacity shortage	+	+	+	+	+	?	+	+	+	+
Draft and/or size differs from report	-	-	-	-	-	?	-	-	-	-
Unexpect event	-	+	-	-	-	?	-	-	-	+
Considered margins too small	+	-	-	-	-	?	-	-	-	+
Delayed previous voyage	+	-	-	+	+	?	-	-	+	+
Delay outgoing voyage (tugs)										
Capacity shortage	+	+	+	+	+	+	+	+	+	+
Fog restrictions	-	-	-	-	-	-	-	-	-	-
Tug order received too late	+	-	-	-	+	-	-	-	-	-
Delayed previous voyage	+	+	+	+	+	+	-	+	+	+
Considered margins too small	+	+	-	-	-	-	+	+	-	+
Unexpected external events	-	-	-	-	-	-	-	-	-	-
Pilot orders extra tug	+	-	+	+	+	-	-	+	+	+
Delay outgoing voyage (terminal operations)										
Technical problems	-	+	+	+	-	?	-	+	+	?
Waiting for loading from shipper	-	?	-	-	+	?	-	-	-	?
Loading takes longer than expected	+	+	+	+	?	?	+	+	+	?
Lashing activities not finished	-	?	+	-	+	?	-	+	-	?
Delay outgoing voyage (vessel not ready)										
Bunker activities	+	+	+	+	+	+	+	+	?	+
Inspection activities	-	?	-	-	-	-	-	-	?	-
Problems with the documents	+	+	+	-	-	-	+	+	?	+
Technical failures	+	?	+	+	-	-	-	+	?	+
Delay (congestion)										
Weather circumstances	+	?	+	+	+	-	-	+	+	+
Peak demand	+	?	+	+	+	+	+	+	+	+
Object in failure	-	?	-	-	-	-	-	+	-	-
Passage of large vessels	+	?	+	+	+	+	+	+	+	+
Object (temporarily) blocking fairway	-	?	-	-	-	-	-	-	-	-
Technical problems at vessel	-	?	-	-	-	-	-	-	-	-
Logistical problems	+	?	+	-	-	+	-	+	-	+

Table I.1: Expert input on the relative frequency of delay causes

J Results

This appendix provides a table of the information sharing links that are used for each of the identified frequent delay situations. The 'conversation ID' refers to the BPMN conversation diagram (e.g. pilot planning or pilot operational) and the number of the specific conversation in the BPMN conversation diagram.

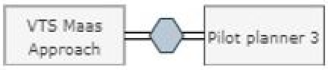
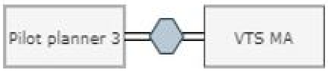
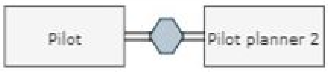
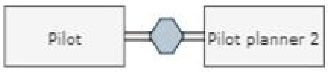
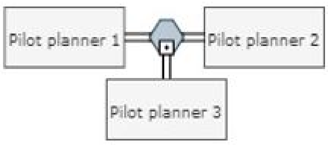
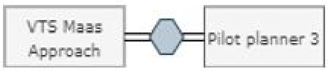
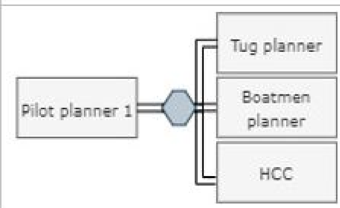
Communication partners	Shared information	Conversation ID
Initial notification of the delay		
	○ Arrivals within 3 hours before ETD ○ The registered ETA PS is shared with the pilot planner via the HaMIS system	Pilot planning 12 VTS MA 5
	By listening to the communication on the VHF channel of MA, the pilot planner can notice that a vessel makes operational contact and if a pilot is required	Pilot planning 14
	Update when pilot is finished	Pilot planning 2
	Updates on occurring delays which cause that the pilot is finished later than expected	Pilot planning 4
	The pilot availability and the need for calling pilots from home	Pilot planning 1
Sharing the delay		
	Request for delaying an ETA PS of an incoming voyage	Pilot planning 12
	Proposal for a new ETD of an outgoing voyage via GIDS	Pilot planning 10

Table J.1: Information sharing links related to a delay caused by a **pilot capacity shortage**

Communication partners	Shared information	Conversation ID
Initial notification of the delay		
Pilot Service Leader – Tug planner	Estimated numbers of tugs to use via GIDS	Tug planning 1
Tug planner – Pilot planner	Request to fill in the estimated number of tugs to use when this has not been done yet	Tug planning 5
VTS Maas Appraoch – Tug planner	The registered ETA PS of a vessel is shared with the tug planner via the HaMIS system	VTS MA 5
Tug planner – Pilot	The number of final ordered tugs is shared by the pilot with the tug planner via GIDS. The pilot also shared the planned ETA LL. This is the time the tugboats should meet the vessel.	Tug planning 12
Tug captain – Tug planner	The tug captain updates the tug planner on the current situation	Tug op. A3 Tug op. A6
Sharing the delay		
Tug planner – DO HCC	Request for delaying an ETA PS of an incoming voyage	Tug planning 3 HCC planning 7
Pilot Service Leader – Pilot planners	Update on current tug capacity (if known at the HCC)	Pilot planning 9
Pilot planner 1 – Tug planner	Check tug availability for outgoing vessel if the approval of the tug company takes longer than the scheduled 30 minutes	Pilot planning 13
Tug planner – Pilot planner 1, Boatmen planner, HCC	Proposal for a new ETD of an outgoing voyage via GIDS	Tug planning 13

Table J.2: Information sharing links related to a delay caused by a **tug capacity shortage**

Communication partners	Shared information	Conversation ID
Initial notification of the delay		
Tug captain – Tug planner	○ Any delays that occur at a departing vessel are shared with the tug planner ○ The tug captain contacts the tug planner if the tug captain doubts to be on time for the assigned job	Tug planner 8 Tug op. A3 Tug op. A4 Tug op. A5
Tug captain – Pilot	Pilot updates the tug captain on occurring delays	Tug op. B4
Tug planner – NSP's (on the job)	From listening to the nautical VHF channel, the tug planner can extract information on the real-time operations and any delays that occur at the current jobs	Tug planner 14
Tug captain – NSP's	○ The tug captain can follow the communication between pilots and tugs of other vessels via the VHF to signal an occurring delay ○ The tug captain can follow the communication between pilots of other vessels via the VHF to signal the made decisions and a probable occurring delay	Tug op. E1 Tug op. E2
Tug planner – Pilot Service Leader	The tug planner can update the Pilot Service Leader in case specific tugboats are planned from another vessel	Tug planning 2
Tug planner – Pilot	The tug planner shares information about the assigned tugs and if they have to arrive from another vessel with the pilot of a vessel	Tug planning 15
DO VTS – Pilot	A delay at a departing vessel is communicated from the boarded pilot to the DO VTS	VTS op. G2 Pilot op. H2
Sharing the delay		
Tug planner – Pilot planner 2	Any updates on delays regarding assigned tugboats are shared with the pilot planning so that they can communicate the delay with their pilot	Pilot planning 3 Tug planning 6
Pilot – Pilot planner 2	Update on a delayed tug arrival (from the pilot to the pilot planners or vice versa)	Pilot op. G4
Tug planner – Pilot	○ The tug planner directly contacts the pilot on board of an incoming vessel to inform the pilot on a delayed tug arrival if the message is more urgent ○ The tug planner shares a notification via GIDS to inform the pilot on a delayed tug arrival ○ In case the pilot does not see the tugboats on the AIS, the pilot calls the tug planner for information	Tug planning 7 Pilot op. C2 Pilot op. C3 Pilot op. C4
Tug planner – Boatmen planner	The tug planner shares a delayed tug arrival with the boatmen planners	Tug planning 11 Boatmen planning 7
VTS PM – Pilot	Update on delayed tugboats for incoming voyage	Pilot op. D1
Tug captain – Pilot	○ The tug captain updates the pilot on a delayed tug arrival via VHF channel (in case of a departing vessel, the receive this message as well) ○ Possibilities for earlier tug release	Pilot op. B5 Pilot op. B6 Tug op. B5
Boatmen – Pilot	For a departing voyage, the pilot updates the boatmen on the current situation	Boatmen op. B5
DO VTS – VTS operator	Update on delayed tug arrival for incoming vessel	VTS op. A2
VTS operator – Pilot	If the VTS operator is informed on a delayed arrival of tugboats for an incoming vessel in his sector, the VTS operator updates the pilot to reduce the vessel speed	VTS op. C3

Table J.3: Information sharing links related to a delay caused by a **delayed tug arrival due to the delay of another vessel**

Communication partners	Shared information	Conversation ID
Initial notification of the delay		
Pilot – Resource planner	The pilot might contact the resource planner to check if the berth is available	Ter. planning 12
Boatmen – Pilot	○ The boatmen notice that a barge is occupying the quay and inform the pilot on board of the incoming vessel ○ The pilot might request the boatmen at the quay to check the berth availability	Pilot op. I4 Boatmen op. B7
Boatmen – Terminal employees	The boatmen at the quay inform at the terminal employees what actions are taken to clear the berth	Boatmen op. F2
VTS operator – Pilot	If the VTS operator notices that a barge is occupying the berth of an incoming vessel, the VTS operator informs the pilot via the VHF and suggests to reduce speed	Pilot op. A5 VTS op. C5
Sharing the delay		
Pilot – Pilot planner 2	The pilot updates the pilot planners on the occurring delay	Pilot op. G4 Pilot planning 4
Tug captain – Pilot	○ The pilot updates the tug captain on the current situation ○ If it appears that the barge will not leave on time, the pilot takes back gas and if needed informs the tugboats that the vessel must wait at the channel	Tug op. B4 Tug op. B6
Tug captain – Tug planner	The tug captain updates the tug planner on the current situation	Tug op. A3 Tug op. A6
Boatmen – Boatmen planner	The boatmen inform the boatmen planner on the occurring delay	Boatmen op. A4
DO VTS – VTS operator	The VTS operator and DO VTS update each other as soon as it is noticed that a barge occupies the berth of an incoming vessel	VTS op. A3

Table J.4: Information sharing links related to a delay caused by a **berth that is occupied by a barge**

Communication partners	Shared information	Conversation ID
Initial notification of the delay		
DO VTS – VTS operator	A delay at a departing vessel that is communicated with the DO VTS is shared with the VTS operator of the sector	VTS op. A1
VTS operator – Pilot	A delay at a departing vessel is communicated from the boarded pilot to the VTS operator of the sector	VTS op. C2
DO VTS – Pilot	A delay at a departing vessel is communicated from the boarded pilot to the DO VTS	VTS op. G2 Pilot op. H2
VTS MA – ADO incoming	If it is not clear if the vessel at the destined berth of an incoming vessel leaves on time, the VTS operator of Maas Approach contacts the ADO's responsible for incoming voyages	VTS MA 1
Pilot – Pilot	The pilot of an outgoing vessel updates the pilot of an incoming vessel to inform the incoming pilot on the delayed departure and occupied berth	Pilot op. E2
Sharing the delay		
Pilot – Pilot planner 2	The pilot updates the pilot planners on the occurring delay	Pilot op. G4 Pilot planning 4
Tug captain – Pilot	o The pilot updates the tug captain on the current situation o If it appears that the barge will not leave on time, the pilot takes back gas and if needed informs the tugboats that the vessel must wait at the channel	Tug op. B4 Tug op. B6
Tug captain – Tug planner	The tug captain updates the tug planner on the current situation	Tug op. A3 Tug op. A6
DO VTS – VTS operator	The DO VTS calls the VTS operator of the sector in which an incoming vessel for a destined berth with a delayed departing vessel is sailing. The DO VTS requests the VTS operator to inform the incoming vessel to reduce its speed	HCC planning 9 VTS op. A4 VTS op. B2
VTS operator – Pilot	The VTS operators informs the pilot on the occupied berth and suggests speed reduction. If the vessel is in the MA sector, not the pilot but vessel captain is informed.	VTS op. C4 VTS op. F1 Pilot op. A7
Pilot – Pilot	The pilot of an incoming vessel is in contact with the pilot of an outgoing vessel to discuss the details on the delay and maneuvering possibilities	Pilot op. E2
DO HCC – Pilot Service Leader	If the situation of an occupied berth is known at the HCC (via the DO VTS) and a pilot already boarded the incoming vessel, the Pilot Service Leader is updated on the situation as well.	HCC planning 10
Pilot Service Leader – Pilot	If the Pilot Service Leader is updated on an occupied berth of an incoming vessel that already has a pilot on board, the Pilot Service Leader calls the pilot of an incoming vessel to slow down	Pilot op. K1

Table J.5: Information sharing links related to a delay caused by a **berth that is occupied by a sea-going vessel**

Communication partners	Shared information	Conversation ID
Initial notification of the delay		
Pilot – Bridge crew	A delay regarding terminal operations is shared from the bridge crew to the pilot when the pilot boards the vessel	Pilot op. F4
Boatmen – Pilot	○ The pilot can ask the boatmen at the quay to gather additional details on the occurring terminal delay ○ The boatmen share any information they have on the terminal operations	Pilot op. I3 Boatmen op. B6
Boatmen – Terminal employees	The boatmen ask the terminal employees at the quay for additional information on the (un)loading operations	Boatmen op. F1
Sharing the delay		
Pilot – Pilot planner 2	The pilot updates the pilot planners on the occurring delay	Pilot op. G4 Pilot planning 4
DO VTS – Pilot	A delay at a departing vessel is communicated from the boarded pilot to the DO VTS	VTS op. G2 Pilot op. H2
Tug captain – Pilot	The pilot updates the tug captain on the current situation	Tug op. B4
Boatmen – Pilot	The pilot updates the boatmen on the current situation	Boatmen op. B5
Tug captain – Tug planner	The tug captain updates the tug planner on the current situation	Tug op. A3
VTS operator – Pilot	A delay at a departing vessel is communicated from the boarded pilot to the VTS operator of the sector	VTS op. C2
DO VTS – VTS operator	A delay at a departing vessel that is communicated with the DO VTS is shared with the VTS operator of the sector	VTS op. A1
Boatmen – Boatmen planner	The boatmen inform the boatmen planner on the occurring delay	Boatmen op. A4

Table J.6: Information sharing links related to a delay caused by **unfinished terminal operations due to unfinished (un)loading activities**

Communication partners	Shared information	Conversation ID
Initial notification of the delay		
Pilot ↔ Bridge crew	A delay is shared from the bridge crew to the pilot when the pilot boards the vessel	Pilot op. F4
Sharing the delay		
Pilot ↔ Pilot planner 2	The pilot updates the pilot planners on the occurring delay	Pilot op. G4 Pilot planning 4
DO VTS ↔ Pilot	A delay at a departing vessel is communicated from the boarded pilot to the DO VTS	VTS op. G2 Pilot op. H2
Tug captain ↔ Pilot	The pilot updates the tug captain on the current situation	Tug op. B4
Boatmen ↔ Pilot	The pilot updates the boatmen on the current situation	Boatmen op. B5
Tug captain ↔ Tug planner	The tug captain updates the tug planner on the current situation	Tug op. A3
VTS operator ↔ Pilot	A delay at a departing vessel is communicated from the boarded pilot to the VTS operator of the sector	VTS op. C2
DO VTS ↔ VTS operator	A delay at a departing vessel that is communicated with the DO VTS is shared with the VTS operator of the sector	VTS op. A1
Boatmen ↔ Boatmen planner	The boatmen inform the boatmen planner on the occurring delay	Boatmen op. A4

Table J.7: Information sharing links related to a delay caused by a **vessel that is not ready for departure due to unfinished bunker activities**

Communication partners	Shared information	Conversation ID
Initial notification of the delay		
Tug captain ↔ Pilot, Pilot	The communication between the pilots on the VHF channel informs the tugboats on the current traffic situations	Tug op. E2
DO VTS ↔ VTS operator	Traffic situations in the sector that require attention are discussed between the DO VTS and VTS operator of a sector	HCC planning 6
Sharing the delay		
DO VTS ↔ Pilot	The DO VTS can decide to refuse to provide a departing vessel operational clearance	HCC planning 1
DO VTS ↔ DO HCC	The DO HCC and DO VTS together discuss traffic situations to align the macro- with the micro planning	HCC planning 5
VTS operator ↔ Pilot	o The VTS operator updates the pilot on the current traffic situation o If a pilot made agreements with a pilot colleague via phone contact, the pilot updates the VTS operator o If needed, the VTS operator can advise the pilot to wait at the quay based on the current traffic situation	Pilot op. A2 Pilot op. A3 VTS op. C3
Pilot ↔ Pilot	Pilots discuss the traffic situation and the consequences together via phone or VHF channel	Pilot op. E1
DO VTS ↔ VTS operator	o If the DO VTS refuses operational clearance, the DO VTS informs the VTS operator of the sector o The VTS operator and DO VTS share situations in the sector that require extra attention	VTS op. A2 HCC planning 6
DO VTS ↔ VTS MA	When the DO HCC, DO VTS or VTS MA notice a congested traffic situation it is discussed at the HCC. If needed, the VTS MA is asked to delay the ETA PS of certain vessels by the DO VTS	VTS MA 7
Boatmen ↔ Pilot	The pilot updates the boatmen on the current situation	Boatmen op. B5
Tug captain ↔ Pilot	The pilot updates the tug captain on the current situation	Tug op. B4
Pilot ↔ Pilot planner 2	The pilot updates the pilot planners on the occurring delay	Pilot op. G4 Pilot planning 4
Tug captain ↔ Tug planner	The tug captain updates the tug planner on the current situation	Tug op. A3
Boatmen ↔ Boatmen planner	The boatmen inform the boatmen planner on the occurring delay	Boatmen op. A4

Table J.8: Information sharing links related to a delay caused by **congestion at the fairway due to peak demand**

Communication partners	Shared information	Conversation ID
Initial notification of the delay		
DO VTS – Pilot	A delay at a departing vessel is communicated from the boarded pilot to the DO VTS	VTS op. G2 Pilot op. H2
Tug captain – Pilot / Pilot / Other NSP's	o The tug captain can notify congested situations via communication on a delay between the pilot and nautical service providers of another vessel o The communication between the pilots on the VHF channel informs the tugboats on the current traffic situation and the planned actions	Tug op. E1 Tug op. E2
VTS operator – Pilot	A delay at a departing vessel is communicated from the boarded pilot to the VTS operator of the sector	VTS op. C2
DO VTS – VTS operator	A delay at a departing vessel that is communicated with the DO VTS is shared with the VTS operator of the sector	VTS op. A1
Sharing the delay		
DO VTS – Pilot	The DO VTS can decide to refuse to provide a departing vessel operational clearance	HCC planning 1
DO VTS – DO HCC	The DO HCC and DO VTS together discuss traffic situations to align the macro- with the micro planning	HCC planning 5
VTS operator – Pilot	o The VTS operator updates the pilot on the current traffic situation o If a pilot made agreements with a pilot colleague via phone contact, the pilot updates the VTS operator o If needed, the VTS operator can advise the pilot to wait at the quay based on the current traffic situation	Pilot op. A2 Pilot op. A3 VTS op. C3
Pilot – Pilot	Pilots discuss the traffic situation and the consequences together via phone or VHF channel.	Pilot op. E1
DO VTS – VTS operator	o If the DO VTS refuses operational clearance, the DO VTS informs the VTS operator of the sector o The VTS operator and DO VTS share situations in the sector that require extra attention	VTS op. A2 HCC planning 6
DO VTS – VTS MA	When the DO HCC, DO VTS or VTS MA notice a congested traffic situation it is discussed at the HCC. If needed, the VTS MA is asked to delay the ETA PS of certain vessels	VTS MA 7
Boatmen – Pilot	The pilot updates the boatmen on the current situation	Boatmen op. B5
Tug captain – Pilot	The pilot updates the tug captain on the current situation	Tug op. B4
Pilot – Pilot planner 2	The pilot updates the pilot planners on the occurring delay	Pilot op. G4 Pilot planning 4
Tug captain – Tug planner	The tug captain updates the tug planner on the current situation	Tug op. A3
Boatmen – Boatmen planner	The boatmen inform the boatmen planner on the occurring delay	Boatmen op. A4

Table J.9: Information sharing links related to a delay caused by **congestion at the fairway due to the passage of large vessels**