PARCEL TANKERS IN THE PORT OF ROTTERDAM

Research into the process of handling parcel tankers in port and creating commitment for shortening the port time in a multi-actor environment.
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Master Thesis
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Delft, July 2005

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I have learned a lot and had a great time. I would like to thank my supervisors for their assistance. Peter Jacobs for his endless patience, especially with explaining DSOL. Bastiaan van de Rakt for his help and continuous support. Alexander Verbraeck and Gerard Dijkema for their useful advices.

Furthermore, I would like to thank Ian Miller and Marco Melis for their support and advices. My time at INITI8 has been interesting and very enjoyable. At last, but definitely not least I would like to thank my family and friends, especially Dorine and Marijn, for their help and endless support.

Charlotte Woltman Elpers
Delft, July 2005
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## ABBREVIATIONS

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>BB</td>
<td>Board-Board</td>
</tr>
<tr>
<td>DSOL</td>
<td>Distributed Simulation Object Library</td>
</tr>
<tr>
<td>FCFS</td>
<td>First Come First Serve</td>
</tr>
<tr>
<td>GIS</td>
<td>Geographical Information System</td>
</tr>
<tr>
<td>GNP</td>
<td>Gross National Product</td>
</tr>
<tr>
<td>NAP</td>
<td>Nieuw Amsterdams Peil</td>
</tr>
<tr>
<td>NOR</td>
<td>Notice of Readiness</td>
</tr>
<tr>
<td>PoR</td>
<td>Port of Rotterdam</td>
</tr>
<tr>
<td>RPA</td>
<td>Rotterdam Port Authority</td>
</tr>
<tr>
<td>SWOT</td>
<td>Strengths, Weaknesses, Opportunities, Threats</td>
</tr>
<tr>
<td>USA</td>
<td>United States of America</td>
</tr>
</tbody>
</table>
DEFINITIONS

Actor  Actors represent individuals, organizations or other groups involved in the process.

Barge  Barges are responsible for inland transportation.

Coaster  Coasters, consisting of several compartments in which different kind of chemicals can be stored, are responsible for regional transportation of chemicals.

Parcel tanker  Parcel tankers, consisting of several compartments in which different kind of chemicals can be stored, provide intercontinental transport of chemicals overseas.

Production terminal  Production terminals are factories that have their own berths. Factories need products as input for the processes and the products of the factories have to be transported to the customers. This is partly done over water.

Rotation (plan)  The route the parcel tanker sails from the point it enters the port until it leaves the port is called the rotation of the parcel tanker. This route is listed in the rotation plan of the parcel tanker.

Shipper  Shippers are seller and/or buyer of goods.

Shipping agent  A shipping agent is responsible for the organisation of the transport. The agent makes the planning for the tankers.

Shipping company  Shipping companies are responsible for the transport of the cargo.

Stakeholder  An actor is a stakeholder when he has a preference in the direction in which the outcome of a problem or issue goes.

Surveyor  The surveyors inspect, test, verify and certify the goods that enter and leave the port. They do this on behalf of the shipper.

Transhipment terminal  The transhipment terminal stores cargo, and discharges and loads the vessels.
1 INTRODUCTION

First the motivation of this research is described in this chapter. The problem definition, goal and research questions are discussed in paragraph 1.2, after which the research approach is explained in paragraph 1.3. The description of the structure of this report is given at the end of this chapter.

1.1 MOTIVATION PROJECT

The port of Rotterdam is one of the most important ports of the world. A growth in tons transhipped in this port can be seen over the years. In 2004 the port transhipped 352 million tons compared to 328 million tons in 2003 [Port of Rotterdam, 2005]. Most of the transhipped goods are bulk goods like oil, chemicals, coal and ores [Port of Rotterdam, 2004]. This research focuses on the transhipment of chemicals in the port of Rotterdam.

Shippers, sellers or buyers of goods, give assignments to shipping companies to transport their chemicals from one point to another. Parcel tankers, consisting of several compartments in which different kind of chemicals can be stored, provide intercontinental transport overseas. The parcel tanker visits on average 4 terminals in port to tranship cargo [Janssen and Reinders, 2004; Hoevens, 2004] and during or after these terminal visits it also has board-board transhipment (BB transhipment) with coasters or barges. Coasters are responsible for regional transportation of chemicals, while barges are responsible for inland transportation.

The parcel tanker has a rotation plan in which the sequence of the terminals to visit and the BB transhipments for this parcel tanker are listed. The shipping agent of the shipping company the parcel tanker belongs to makes this rotation plan. The route the parcel tanker sails from the point it enters the port until it leaves the port is called the rotation of the parcel tanker.

A multi-actor environment can be found in port [Janssen and Reinders, 2004]; different autonomous and competitive parties, further called actors, are involved in handling parcel tankers. They are autonomous, because they are responsible for a specific part of handling parcel tankers and do not know from each other what the other actor does or decides. Furthermore, they are competitive, because they are commercial actors and want to make a maximum profit. This competitiveness is the reason that they do not want to share sensitive company information.

Every actor is responsible for a specific activity and has to be present at the parcel tanker at a certain moment in time to perform this activity. A broad list of the types of actors and their tasks involved in handling parcel tankers is given in appendix A. The main activities performed when the parcel tanker is in port, and the actors, who are responsible for this activity, are:

Table 1.1: Activities and responsible actors

<table>
<thead>
<tr>
<th>Activity</th>
<th>Actor/ actors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organising rotation parcel tanker in port</td>
<td>Shipping agent, Terminal planners</td>
</tr>
<tr>
<td>Moving from one terminal to another</td>
<td>Tug services, pilot services, rowers, traffic management of the Port of Rotterdam</td>
</tr>
<tr>
<td>Inspecting goods on specifications</td>
<td>Surveyors</td>
</tr>
<tr>
<td>(Dis)connecting hoses</td>
<td>Terminal operators</td>
</tr>
<tr>
<td>Transhipping goods to shore</td>
<td>Crew ship, terminal operators</td>
</tr>
<tr>
<td>Transhipping goods to barge/ coaster</td>
<td>Crew parcel tanker/ Crew barge or coaster</td>
</tr>
</tbody>
</table>

The activities of the parcel tanker at a terminal occur in a specific sequence and cannot be performed before the former activity is done [Janssen and Reinders, 2004]. The parcel tanker moors at the terminal, paperwork is filled in, hoses are connected, cargo has to be inspected if it is according to specifications, transhipment takes place and the parcel tanker unmoors. It often occurs that the parcel tanker has to wait for a certain actor to be present for performing a certain activity [Elpers, 2004]. This has also effect on other activities, because of the specific sequence in which the activities are performed. They have to be executed at another moment in time than planned.

The process of handling parcel tankers is complex and dynamic. It is complex, because of the large number of actors involved. The often changes in planning makes the process dynamic.

Parcel tankers spent approximately 35% of their time in port [Wijnolst, 1994]. A parcel tanker in port costs the shipping company money in two ways. First, the shipping company only gets paid for
transporting goods. The parcel tanker does not bring in money when it is in port for transshipping its goods. Second, parcel tankers in port cost money, the crew and insurance costs have to be paid, the depreciation of the ship. For big parcel tankers, these costs can amount to approximately 30.000 dollars per day [Bührmann, 2003]. It is therefore important for the shipping companies to spend as less time as possible in port [Elpers, 2004]. The average time parcel tankers spent in the port of Rotterdam per visit is approximately six days [Hoevens, 2004]. Currently, the shipping companies perceive the port time in the port of Rotterdam as too long [Elpers, 2004]. It is however not known if the port time is actually too long and could be shortened.

The port of Rotterdam is important to Dutch economy. They make up 6.2 billion euro direct value of the Gross National Product (GNP), 1.7% of the total GNP [Port of Rotterdam, 2005]. The income of the Port of Rotterdam1 (PoR) exists for the largest part of port tariffs. Port tariffs are paid for all transhipped cargo in the port, so for the income of the PoR it does not direct matter how long a parcel tanker stays in port [Bührmann, 2003]. However, on the long term companies can decide to use another port to transport their products to, if the port time increases. Furthermore, if the port time could be shortened, more cargo could be handled in the same time, which would lead to more income for the PoR.

A growth in transhipments of chemicals and the number of parcel tankers visiting the port of Rotterdam in the past years can be seen in appendix B [Janssen and Reinders, 2004]. One would say that the port becomes more attractive because of this growth, but looking at Hamburg and Antwerp, their overall transhipments together between 1999 and 2003 grew 26%, to 8% of Rotterdam [Schaberg, 2005]. So, Rotterdam does not become more attractive in comparison to Hamburg and Antwerp.

The perceived long port stay of parcel tankers in the port of Rotterdam can make its ‘product’ less attractive and can cause a reduction of the competitive positions of the actors. Shippers can decide to choose other ports, for instance the port of Antwerp to transship their products. Last years, a tendency can be seen of shippers and shipping companies that are using other ports in Hamburg-Le Havre Range. During Port Efficiency meetings of Odfjell2 in Bergen in 2002 and 2003, the conclusion was drawn that the efficiency in the port of Rotterdam in general is dropping [Hoevens, 2004]. Antwerp is a competitor on the Transatlantic Trade, last couple of years Rotterdam lost Huntsman3 and Celanese4 to Antwerp [Hoevens, 2004]. Stolt-Nielsen5 has fewer calls in the port and notices shippers moving to Antwerp [Elpers, 2004].

The port of Rotterdam is still the biggest port for chemicals in Europe at the moment, but on the long term its competitive position can be damaged. A shorter port time for parcel tankers in the port of Rotterdam could attract more parcel tankers to the port of Rotterdam. The shipping companies can save a lot of money if the port time is shorter and this is a big incentive for them to use a certain port. When more parcel tankers use the port of Rotterdam, it would increase the income out of port tariffs and a shorter port time could enlarge the competitive position of the port of Rotterdam and this would be good for the Dutch economy.

The problem of a perceived long port stay of parcel tankers in the port of Rotterdam has existed for many years and is becoming more and more urgent. Thus, it is not surprising that already some initiatives for shortening the port time have been taken. The most recent are ‘Portinfolink.Chemicals’ and ‘Chemical Tower’, of which ‘Portinfolink.Chemicals’ was already a project in which multiple actors were involved. Chemical Tower was only an idea. Both initiatives did not lead to shorter port times for parcel tankers, because of multiple reasons [Elpers, 2004]. Because there are so many initiatives taken, the actors lost trust in ever coming to a solution [Elpers, 2004].

1 with which the company is meant. In this report further called PoR, whereas the port itself is called port of Rotterdam.
2 Odfjell is a leading company in the global market of transporting chemicals and other speciality bulk liquids as well as providing related logistical services [Odfjell, 2005].
3 Huntsman is a global manufacturer and marketer of commodity and differentiated chemicals [Huntsman, 2004].
4 Celanese is an integrated global producer of value-added industrial chemicals [Celanese, 2004].
5 Stolt-Nielsen S.A. is one of the world’s leading providers of transportation services for bulk liquid chemicals, edible oils, acids, and other speciality liquids [Stolt-Nielsen, 2005].
This research is done in assignment of INITI8. INITI8 is a progressive, innovative company that focuses on resolving company-transgressing or inter-organisational bottlenecks in logistic processes and networks [INITI8, 2004]. INITI8 has a wide experience with projects in the port of Rotterdam. In 2003 they worked on the project APPROACH, in which a solution was found for the unreliable planning of the successive terminal visits of the container inland navigation in the port of Rotterdam [Connekt 2003]. The solution, also called APPROACH, is an application based on multi-agent technology. Every terminal operator\(^6\) and barge operator\(^7\) has its own software agent\(^8\) communicating and synchronizing its planning with software agents of other parties, while it stays between the boundaries set by the terminal or barge operator. Advantages of using this application are that it provides easy and fast communication and sensitive company information stays protected [Connekt, 2003].

INITI8 believes that the port stay of parcel tankers can be reduced by improving the planning of parcel tankers with the use of software agents and started the project 'ParcelTankerPlanning'. By using a distributed solution the sensitive information is protected and strategic behaviour of actors does not lead to advantages for these actors [Connekt 2003]. INITI8 does not yet have a wide knowledge of the processes among parcel tankers and does not know for sure if their planning system actually reduces the port time. Therefore, INITI8 also wants to get a better understanding of the process of handling parcel tankers, to know if their solution is suitable for this situation and if so, how the actors can be committed to their project.

INITI8, the PoR and the shipping companies can be seen as a stakeholder in this situation. INITI8 has preferences about the outcomes of this research. If it seems that a reliable planning contributes to a shorter port time, the planning system of INITI8 could be a solution for shortening the port time. This would lead to benefits for INITI8. The shipping companies and the PoR benefit from the shorter port time. The shipping companies can make more trading days and earn more money. The PoR can ensure and enlarge its competitive position if more parcel tankers use their port, a shorter port time attracts the shipping companies to use the port.

Furthermore, INITI8 is seen as problem owner in this research while they have the problem that they do not have insight in the handling of parcel tankers and therefore do not know if their planning system could be useful in this situation and how they can involve actors in their project. This research is aimed at solving their problem, creating insight in the current handling of parcel tankers and if their planning system could be a solution, committing actors to their project.

At the moment there is not a detailed picture of overall process of handling parcel tankers in the port of Rotterdam, because of the complex and dynamical environment. A multi-actor environment with autonomous, competitive actors can be found. The autonomy and the competitiveness is the reason that actors know in detail their part of the process, but do not have detailed insight in the overall process of handling parcel tankers. Shipping companies perceive the port time of parcel tankers as too long, but the lack of insight has as consequence that it is not known if the port time is actually too long and if it is too long, what the cause is. Furthermore, a lot of initiatives are already taken to shorten the port time, but these initiatives did not succeed. Actors lost trust in ever coming to a solution to shorten the port time.

### 1.2 PROBLEM DEFINITION, GOAL AND RESEARCH QUESTIONS

The shipping companies perceive the port time of parcel tankers as too long, but it is not been proven that this port time is actually too long. It could be that the port time cannot be shortened. However, for the problem definition, the goal and the research questions of this research is assumed that the port time can be shortened. This assumption is substantiated in chapter 2, paragraph 2.8.

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6 A terminal operator is the person responsible for the planning of the berths of the terminal. He assigns berths to ships.

7 A barge operator is the person responsible for the rotation of the barge in port.

8 Definition of software agent: an agent is a computer system that is situated in some environment, and that is capable of autonomous action in this environment in order to meet its design objectives [Wooldridge, 1995].
Problem definition
The competitive position of the port of Rotterdam in the chemical sector is losing strength; shippers and shipping companies are using alternative ports. Shortening the port time of parcel tankers in the port of Rotterdam could make the port more attractive for parcel tankers, but the way the port time could be shortened within the environment of autonomous, competitive actors is not known.

Goal
The goal of this research is to provide more insight in the process of handling parcel tankers in the port of Rotterdam and to create commitment of the actors for cooperation in further research to shorten the port stay of parcel tankers.

Main Research Question
Can more insight be created in what causes the long port time and can actors be committed to cooperate in a project to shorten the port stay, while taking into account the multi-actor environment with autonomous, competitive actors?

The main research question consists of five sub-research questions. These questions are:
1. Which actors influence the port time and/or benefit from a shorter port time for parcel tankers?
2. In what way is the rotation plan of a parcel tanker made and communicated with the actors?
3. Why do rotation plans change and how does the shipping agent communicate these changes with other actors?
4. Which performance indicators are used to measure the performance of the system?
5. What causes the long port stay of parcel tankers in the port of Rotterdam?

1.3 RESEARCH APPROACH
The goal of this research is to create more insight in the overall process and with help of this insight create commitment of the actors for further cooperation to shorten the port time. To create more insight in the handling of parcel tankers in the complex and dynamic multi-actor environment with autonomous and competitive actors, a simulation model in which this environment is reflected can be used in a workshop. By involving these actors in the process to come to a simulation model, by for example interviews with them and the validation of the simulation model, involvement and trust can be created in the simulation model and the outcomes. By making an ‘as-is’ model of the situation and play with certain steering variables, actors get feeling for what the effect of these steering variables are on the port time of parcel tankers and get insight in what the actual cause of the perceived long port time might be. This insight must give an incentive to start working on a solution, but this will not be enough. Not only in the simulation model the autonomous competitive environment has to be taken into account, also in the design of the workshop this is important to keep in mind. Otherwise, actors do not want to commit to cooperation in further research.

The methodology used in this research can be found in a diagram in figure 1.1. Two different lines are seen which together lead to the workshop, the simulation line and the design of the workshop line. The first line consists of steps to come to a simulation model and an analysis of the current situation with help of this model [Banks 1999]. This has the main purpose to create insight in the current situation of handling parcel tankers in the port of Rotterdam. The system boundaries are defined and the current situation is described in the conceptual model. The conceptual model is input for the specification phase to build the simulation model and the input- and output variables are defined. After the simulation model is verified and validated, an analysis of the current situation can be made. The second line consists of steps to come to the design of the workshop. To come to this design, first an actor analysis is done to investigate which actors should be invited to the workshop. After that content and process requirements are defined. Content requirements focus on what subjects have to be discussed in the workshop and are mainly based on the outcomes of the steps made to come to the diagnosis of the current situation. Process requirements are important for the way commitment can be created of the actors and are defined with help of the actor analyses and former initiatives. With these content and process requirements the programme of the workshop is determined. Between the two lines to come to the workshop interaction is seen. For example, the outcomes of the analysis of the current situation is input for the design of the workshop and the actor analysis can be
input for the selection of participants of the expert validation. The outcomes of the workshop give input for the conclusions and recommendations made as a result of this research.

Besides the simulation model and workshop explained in paragraph 1.3.1 and 1.3.2, the following methods are used within this research. Some methods are used in both the simulation line as in the design workshop line, but with different purposes:

(1) Literature research
A first idea comes from the processes among handling parcel tankers in the port of Rotterdam with help of literature research. Literature research is done on handling of parcel tankers and former initiatives. It gives input for the conceptualisation of the current situation and the process requirements for the workshop design.

(2) Interviews
The interviews are used to create commitment with this research and gather information. By involving the actors in the beginning of the process and give them the idea that the simulation model and the whole process is made with their help, commitment is created. Information is gathered on different subjects to give input in different steps taken in this research. Furthermore, information out of the interviews is used to get knowledge about (parts) of processes of handling parcel tankers that are not yet known and to verify the image that is formed based on the literature research. Interviews with different actors, responsible for different parts, are held. In this way the overall picture can be made for the input for the conceptualisation. Furthermore, information about former initiatives is gotten out of the interviews. This is input for defining process requirements in the design workshop.

(3) Field research
Besides interviews, some field research is done. A day is spent at a terminal to see which processes occur when a parcel tanker is moored and a day is spent with a surveyor to get some feeling what
surveying is all about. This is done to get a better view on the current situation and to give input for
the conceptualisation.

(4) Data analysis
Data analysis is used for analysis of the current process of handling parcel tankers in the
conceptualisation. During the research more data is gathered which can be used in the specification of
the simulation model. Data can come from former studies, databases of the PoR, port log analyses etc.

(5) Expert validation
An expert validation is done to validate the simulation model and to create trust in the simulation
model. People invited for this session have to be familiar with the overall process.

(6) Sensitivity analysis
A sensitivity analysis is used to investigate if no strange output is generated in the simulation model
and to define how sensitive the performance indicators are for certain variables.

(7) Pre-discussions with specific actors
To get acquainted with the comments in the workshop some pre-discussions with actors are made.
This is also done to create some commitment of these actors, so when they are at the workshop they
can try to convince other actors.

1.3.1 Simulation
To get more insight in the process of handling parcel tankers, while coping with the complex and
dynamic environment, simulation is used. Simulation can be defined as the process of designing a
model of a real system and conducting experiments with this model for the purpose either of
understanding the behaviour of the system or of evaluation various strategies (within the limits
imposed by a criterion or set of criteria) for the operation of the system [Shannon 1975].

Simulation fulfils different roles during this research, namely:
- **Diagnosis current situation:** an analysis has to be done to investigate the actual cause for the
  long port stay of parcel tankers in the port of Rotterdam. To be able to do this an ‘as-is’ model is
  built in which the reality is represented and determined performance indicators are used to
  measure the performance of the system. These performance indicators are determined in the
  specification phase. However, a first list can already be given. Typical measures of system
  performance of a queuing system (see paragraph 2.1) include server utilization, length of waiting
  lines, and delays of customers [Banks 1999]. Reflecting these on this situation, the following
  performance indicators can be defined.
  - Port time: the time a parcel tanker spends in port, from the moment it enters the port
    until it leaves the port again.
  - Waiting time for berths, operators, surveyors: waiting time has to be divided in three
categories; waiting time before a parcel tanker can moor at the berth, waiting time before the
  operator is present to do its job and waiting time before the surveyor is at
  berth for inspecting the goods.
  - Travel time; time it takes to sail to the different terminals the parcel tanker has to visit.
  - Occupancy rates of berths, terminal operators, surveyors; there are three resources that
    can be claimed by parcel tankers, namely the berths, operators and surveyors.
- **Communication purposes:** to create more insight with and for the actors, communication with the
  help of the simulation model is important. Not only to validate the model with assistance of
  experts, but also for discussing what actually happens during the rotation of a parcel tanker.

Requirements for the simulation model can be found in paragraph 2.1.

1.3.2 Workshop
To create commitment of the actors for cooperation in further research a workshop is organised. The
reason why the workshop is chosen is that the actors are present at the same time at the same place
and are stimulated to collaborate and discuss with each other. Together a better picture can be made
of the overall process with help of simulation and by collaborating and discussing, the actors can convince others of the (non)-existing of certain issues. The chance is higher that commitment can be created when actors are put in a room together than with individual meetings.

So, the workshop has as goal to create commitment of the participants for cooperation in further research. This is done by giving the actors insight in the overall process of handling parcel tankers with help of simulation. Besides providing insight in the process, it is also important take the environment of autonomous, competitive actors into account.

1.4 STRUCTURE REPORT

The steps to come to a simulation model and a diagnosis of the current situation can be found in chapter 2 to 4. The conceptualisation is presented in chapter 2. The specification is made in chapter 3 with help of the conceptual model made in the conceptualisation. The sensitivity analysis executed in chapter 4 is input for the diagnosis of the current situation of handling parcel tankers in the port of Rotterdam. The design of the workshop and the results of this workshop can be found in chapter 5. Finally, the conclusions and recommendations are given in chapter 6.
2 CONCEPTUALIZATION

The input for the conceptualisation consists of the literature study, data analysis and interviews with experts. Interviews with actors are held to confirm the image made in the literature study and the data analysis and to fill in the information gaps. The interviewed actors are asked about their part of the process in detail and the overall process of handling parcel tankers. More information about which persons are interviewed can be found in appendix C. The minutes of the interviews can be found in a separate report, see Elpers [2004]. The requirements of the simulation model can be found in paragraph 2.1. The chosen worldview process-interaction and the reason for this choice are explained in paragraph 2.2, after which the used system description is discussed in the next paragraph. The transportation of chemicals and the role of the port of Rotterdam are given in paragraph 2.4. The description of the ships, their assignments and the port is made in paragraph 2.5. The rotation, the port time and the rotation plan of the parcel tanker are described in paragraphs 2.6 and 2.7. The chapter ends with conclusions.

2.1 REQUIREMENTS SIMULATION MODEL

The handling of parcel tankers in the port of Rotterdam can be defined as a queuing system. Parcel tankers arrive in port, join a queue or multiple queues, are eventually served by specific actors, like a terminal or a surveyor, and finally leave the system. The key elements of queuing systems are customers and servers [Banks, 1999]. In this situation the ships are the customers and terminals and surveying companies serve the ships. This is a service based resource allocation system. The terminals allocate berths and terminal operators to serve the ships and the surveying companies allocate surveyors.

Queuing models could be modelled mathematically or with simulation. For relatively simple situations mathematical models would give a good representation and possibility to calculate the performance of the system. However, the situation with multiple ships, which have a large number of activities to perform and need different resources, is too complex to use mathematical models and simulation is required.

Systems can be categorized as discrete or continuous. With discrete event simulation, the simulation model specifies discrete time changes as a function of time. These time changes may either be continuous or discrete. With continuous simulation the model specifies continuous time changes as a function over time. Also in this case these time changes can be either continuous or discrete [Nance 1993]. The choice to use discrete, continuous or a combination of both depends on the characteristics of the system modelled and the goals of the research. The choice is made to use discrete event simulation in this case, because a queuing system is modelled. State change variables change only at discrete set of points in time; the number of parcel tankers in queue only changes when a parcel tanker is added to the queue or when it can be handled by the server, and leaves the queue.

Simulation has two roles in this research as defined in paragraph 1.3.1; it has to create insight in the current situation of handling parcel tankers and it is used for communication with and between actors. There are three subjects on which requirements for the simulation model can be based; usefulness, usability and usage [Keen and Sol, 2004]. The requirements for the simulation model in this situation are given per subject:

**Usefulness**

The simulation model is useful in this situation if it gives the actors insight in the overall process of handling parcel tankers in the port of Rotterdam. So, activities that influence the port stay of the parcel tanker have to be taken into account. The reason why the parcel tanker is in port is to transship cargo at one to multiple terminals. The length of the port stay of the parcel tanker depends on the number of terminals to visit and the time the parcel tanker spends at each terminal. The last depends on the time it takes to inspect and transship cargo. Other activities at berth, for instance bunkering and cleaning of tanks, are only done during the inspecting and transshipping of cargo. Furthermore, they are executed if there is enough time to perform these activities during the stay at the terminal. Otherwise these activities are postponed until there is enough time. These activities therefore do not influence the port stay of the parcel tanker and are not taken into account in the conceptual model.

The actors are not experienced with simulation. It is important that the model and its content are easy to understand. This is important as well as for the validation of the model, as for creating insight
in the overall process of handling parcel tankers in the workshop. By using animation the processes are visualized and easier to understand for the actors. The GIS (Geographical Information System) map of the port of Rotterdam can be used as environment where the actors can see ships move over water to the different animated terminals and buoys. Different frames can be used to show information during the simulation run, for example the rotation plan of a certain parcel tanker.

**Usability**

There are no specific requirements based on the usability of the simulation model, other than criteria mentioned in Tewoldeberhan [2002]. The simulation model is neither used by the actors, nor has to be simultaneously run at multiple locations. Actors are only observers during the validation session and the workshop.

**Usage**

Requirements for the usage of the simulation model are based on the use of the simulation model in the workshop and the possibility to use the simulation model for other purposes in the future. The simulation model is used in the workshop to create insight for the actors in the overall process. Based on this insight the participants in the workshop can decide to cooperate in further research with the simulation model. Thus, the simulation model has to give enough insight in the overall process and the performance of the system and has to be understandable for the participants in the workshop (see usability).

INITI8 thinks that their planning system could shorten the port time of parcel tankers. If this is the case, it could be that other purposes of the simulation model in the future are based on analysis of the effects of their planning system to synchronize the planning of the actors and in case of a possible implementation, as training tool.

To make the simulation model usable for these purposes, first the multi-actor network with autonomous competitive actors has to be reflected in the simulation model. If synchronization of planning must be created, the actors must be simulated as autonomous objects which can interact with each other. Every actor has its own planning technique and makes its own decisions. It has to be possible to build in these specific planning techniques and decision rules for every actor in the simulation model. Furthermore, actors do not want to share sensitive company information. Therefore, the information has to be kept within the actor and must not be available to other actors without permission.

If the simulation model is used as training tool, a distributed use of the simulation model has to be possible. The actors all must have their own computer where they can fill in their planning information and the results of the simulation run have to be available to all the actors.

To reflect the autonomy of the actors the worldview process-interaction is used in the simulation model (see paragraph 2.2). Furthermore, the competitiveness of the actors, which leads to non-sharing of sensitive information, is reflected in using an object-oriented language (see paragraph 2.2).

In the specification phase a simulation language has to be chosen that supports the worldview process-interaction and is an object-oriented language. Furthermore, the simulation language has to support a distributed use of the model.

### 2.2 PROCESS-INTERACTION

Process-interaction is chosen as worldview to describe the situation of handling parcel tankers in Rotterdam. An explanation of this worldview and the reason why it is used, is described in this paragraph.

To describe the dynamic structure of the system under investigation three different approaches can be defined, also called worldviews, formalisms or modelling constructs. To understand these worldviews first some definitions are important to give [Fishman, 1973], see figure 2.1:

- **Event**: an event signifies a change in state of an object.
- **Process**: a process is a sequence of events ordered in time.
- **Activity**: an activity is a collection of operations that transform the state of an object.
Three basic world-views for discrete event simulation can be identified [Fishman 1973, Nance 1981], namely:

- **Event scheduling (locality of time);** each event routine describes related actions that may all occur in a single instant. The modeller defines events in the model at which a change in state of the objects modelled occurs.

- **Activity scanning (locality of state);** each activity routine describes all actions that must occur because a particular model state is reached. The modeller can, in comparison with the event scheduling method, also define events that have to meet a certain condition. So some activities can begin when a certain condition is met.

- **Process interaction (locality of object);** each process routine describes the entire action sequence of a particular model.

For describing this particular problem the worldview process interaction is chosen. The process-interaction worldview provides locality of object. The simulation modeller thinks in terms of processes; a process is a life cycle of one object as it moves through a system, which consists of various events and activities (see figure 2.1). So in the case of a queuing system the model is defined in terms of objects and their life cycle as they move through the system, demanding resources and queuing for these resources. In the situation investigated in this research the parcel tanker has a certain rotation, process, in port. It visits terminals and has specific activities to perform at these terminals for which it needs certain resources. The activities have to occur in a certain sequence. For example, cargo cannot be discharged before a surveyor has inspected the cargo.

The parcel tankers needs three kinds of resources, namely berths, operators and surveyors. Resources have a certain capacity, which can be claimed (see figure 2.2). When an object wants to claim a certain capacity, it has to request this capacity from the resource. The resource decides if and when its capacity can be claimed. The autonomy of the resource is protected in this way.

```
+process() : void
+resume() : void
+suspend() : void
+hold (duration:double) : void
```

**Process**

```
-controlState:ControlState
```

**Resource**

```
-capacity : double
+requestCapacity (capacity:double) : void
+releaseCapacity (capacity:double) : void
+setCapacity (capacity:double) : void
```

Parcel tankers can claim the same resource at the same moment in time, which leads to waiting times. To resolve these conflicts between overlapping processes the process interaction approach uses ‘wait’ and ‘delay’ statements in both conditional and unconditional contexts [Fishman 1973]. The object, therefore, must have a control state with a reactivation point (see figure 2.2 and paragraph 3.1). This makes it possible to execute distinct processes at the same time.

If the parcel tanker has to wait it is suspended and resumed if it can claim the resource. So, parcel tankers move through the port, request berths and if they are at a berth, they request for operators and surveyors to respectively tranship and inspect cargo (see figure 2.3).
The actors within handling parcel tankers are besides autonomous, also competitive and do not want to share their sensitive company information. To reflect the protection of information in the simulation model, an object-oriented language can be used. Objects are ‘closed’ to the outside world because of encapsulation. The internal state of the object can only be accessed by ‘public’ methods. If actors are simulated as objects, and all objects have their own information, only by public methods another object can ask information from other objects. So, the information is kept within the objects.

In short, the worldview process-interaction is used to describe the system. Parcel tankers move through the port, demanding berths, operators and surveyors and queue for these resources. By requesting the resources and let the resources decide if and when its capacity can be claimed, the autonomy of the different actors is reflected in the simulation model. Furthermore, an object-oriented language is used to protect the competitiveness of the actors. Actors can only request information of other actors by using ‘public’ methods.

Based upon the chosen worldview process-interaction and the use of an object-oriented language the modelling technique to describe the handling of parcel tankers in the port of Rotterdam is selected in the next paragraph.

2.3 SYSTEM DESCRIPTION

For describing the system under investigation class diagrams and an actor-activity diagram are used. Class diagrams are used to describe the static structure of the process of handling parcel tankers. These class diagrams describe the types of objects used in handling parcel tankers in the port of Rotterdam and gives insight in the kind of relations between them. For each class its attributes and operations are also shown in the class diagram. By using class diagrams every object is described with its attributes and activities. Thereby information is kept within the object it belongs to and the autonomy of the actors is protected.

An actor-activity diagram is used to describe the dynamic structure of the handling of parcel tankers in the port of Rotterdam. The actor-activity diagram describes the activities the ships execute during their stay in port, the process of the ships. Furthermore, it points out which actor is responsible for performing the activity. In the actor-activity diagram the process-interaction worldview is represented, because it describes the sequence of the activities the ships perform, and indicate which actor is involved in each activity. In this way the autonomy of the actors is taken into account.

First, the transportation of chemicals in general and the role of the port of Rotterdam in this are described in the next paragraph. The activities of the ships in the port of Rotterdam are explained with help of class diagrams and an actor-activity diagram in paragraph 2.5 to 2.7.

2.4 TRANSPORTATION OF CHEMICALS

The transportation of chemicals in general is described in this paragraph. First, the supply chain and the role of the port of Rotterdam is explained in paragraph 2.4.1. There are three kind of markets in transporting chemicals overseas, these three are given in paragraph 2.4.2. The products transshipped by parcel tankers to the port of Rotterdam can be found in paragraph 2.4.3.
2.4.1 Supply chain

Shippers give assignments to shipping companies to transport their chemicals from one point to another. The cargo is first transported to a terminal within a port, for instance Houston, where it is stored and eventually loaded into a ship (see figure 2.4). A ship carries the cargo to another port, for instance Rotterdam, where it discharges the cargo at the desired terminal or into another ship which carries the cargo to the desired terminal in the same or another port, for instance to Antwerp. When the cargo is transhipped to the terminal, trucks transport the cargo to its final destination (the customer). Worldwide there are terminals where chemicals can be transported to overseas (see appendix D). The ports where the most chemicals are transported to are Rotterdam, Houston, Singapore and also Antwerp, but in case of Antwerp the tonnage is much less in the other ports [Bührmann, 2003].

![Figure 2.4: Supply chain](image)

The part of the supply chain, on which this research is focused, is indicated with a red rectangle in figure 2.4. The problem investigated in this research is the perceived long port stay of parcel tankers in the port of Rotterdam. Thus, only the activities of the parcel tanker within the port of Rotterdam are taken into account; so the activities of a parcel tanker from entering the port until leaving it again. Furthermore, only processes at the seaside that affect the port stay of parcel tankers in port are interesting in this research. The transhipment to terminals and barges/coasters is important for the length of the port stay. If a parcel tanker cannot tranship its cargo because there is no capacity at the terminal available or the barge/coaster is not available, it has to wait. This can result in a longer port stay.

2.4.2 Markets

Three markets in the transportation of chemicals can be distinguished, namely deep sea, regional and inland markets. A certain type of vessel is used for each market. Intercontinental parcel tankers are used in the deep-sea market. The largest parcel tankers are mostly used for the transportation from for example USA and the Far East to Rotterdam and the smaller parcel tankers are used for transportation between for example Greece or Turkey and Rotterdam. Coasters are used within the regional market; they transport chemicals within Europe, for example from France to Rotterdam. In the inland market, barges are used which sail small distances, for example between Antwerp and Rotterdam. It often happens that cargo is transhipped from a parcel tanker to a coaster or barge for further transportation to another port or terminal within the same port to minimize the number of berths the parcel tanker has to visit to load or discharge all its cargo in the current port. This is called BB transhipment. Delays for parcel tankers are of much higher importance to shipping companies than delays of coasters and barges. The costs for parcel tankers to stay in port are 30.000 dollars per day, while coasters and barges cost respectively 6000 and 4000 dollars per day [Bührmann, 2003]. So parcel tankers in port cost much more money than other ships and therefore the focus of this research is on the deep-sea market, so on the intercontinental transport of chemicals with parcel tankers. However, coasters are taken into account for the claiming of berth capacity. Coasters use the same berths as parcel tankers do, while barges have their own berths at terminals. Barges are taken into account for the simulation of BB transhipment with parcel tankers. In reality, also coasters have BB transhipment with parcel tankers. For the process of the parcel tanker it does not matter which kind of ship has BB transhipment, because the delay of the barge and the handling time is the same as with the coaster.
2.4.3 Products

Besides chemicals, parcel tankers also transport edible oils. These oils are high quality products, and for this reason, they get the same treatment as chemicals. So, if in this report chemicals are mentioned, this also includes edible oils. Four main groups of products that are transhipped by parcel tankers to the port of Rotterdam can be defined. The four main groups and some examples of the most transported products per main group can be found in table 2.1. Some products need special kind of treatment and a special designed berth. This is not taken into account, because this is a negligible amount of products and therefore does not have a significant effect on the port time of parcel tankers in port.

Table 2.1: Main groups of products and some examples [Janssen and Reinders, 2004]

<table>
<thead>
<tr>
<th>Main group</th>
<th>Consist products such as:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organic chemicals</td>
<td>Methanol, Styrene, Ethanol, Xylem</td>
</tr>
<tr>
<td>Inorganic chemicals</td>
<td>Phosphorus acid, Sulphuric acid</td>
</tr>
<tr>
<td>Edible oils</td>
<td>Palm-oil, Soya bean oil, Sunflower oil, Talc</td>
</tr>
<tr>
<td>Other products</td>
<td>Lubricating oil, Molasses</td>
</tr>
</tbody>
</table>

Shippers are the ones who give assignments for transportation and transhipping products. This assigning is beyond the scope of this research. The parcel tankers enter the port with a list of assignments. The way these assignments are submitted is not relevant, because the focus is on the port time of parcel tankers. For the port time it is only relevant to know what the assignments are, so how much cargo has to be transhipped. The more cargo has to be transhipped, the more time it takes.

2.5 PORT OF ROTTERDAM

Before describing the rotation of the ships and their activities in the port of Rotterdam, first the objects ‘Ships’, their assignments and the port itself are described with help of class diagrams.

2.5.1 Ships

Three kinds of ships are occupied with the transportation of chemicals, as already mentioned in paragraph 2.4.2. The focus in this research is on parcel tankers, but coasters and barges are taken into account by respectively claiming the same berths as parcel tankers and BB transhipment.

Approximately 500 parcel tankers visit the port of Rotterdam each year [Elpers, 2004]. The parcel tankers are owned by shipping companies. There are five shipping companies who have the biggest part of the market of parcel tankers in the port of Rotterdam [Elpers, 2004], and some smaller shipping companies (see appendix E). The five biggest with the number of parcel tankers they have, are:
Table 2.2: Shipping companies

<table>
<thead>
<tr>
<th>Shipping Company</th>
<th>Number of tankers</th>
<th>DWT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stolt-Nielsen</td>
<td>64</td>
<td>1,879,334</td>
</tr>
<tr>
<td>Odfjell-Seachem</td>
<td>62</td>
<td>2,124,103</td>
</tr>
<tr>
<td>JO Tankers</td>
<td>30</td>
<td>794,927</td>
</tr>
<tr>
<td>Tokyo Marine</td>
<td>13</td>
<td>229,902</td>
</tr>
<tr>
<td>MISC</td>
<td>9</td>
<td>278,287</td>
</tr>
</tbody>
</table>

There is a difference in size between the shipping companies. Stolt-Nielsen and Odfjell are the biggest shipping companies, respectively approximately 100 and 130 parcel tankers of their company, have visited the port of Rotterdam last year [Elpers, 2004]. JO tankers is smaller than Stolt-Nielsen and Odfjell, but still has a relatively large part in the number of calls of parcel tankers in the port of Rotterdam. There are no numbers of the amount of calls of JO tankers known, but an estimation would be 60 to 70 parcel tankers per year [Elpers, 2004].

In the class diagram of the ships, a superclass 'Ship' can be found. The ship has a name, a type and a certain sailing speed. Every ship has a unique name and is a certain type of ship; parcel tanker, coaster or barge. The sailing speed in port depends on the type of ship. Barges can sail faster than sea ships, because they are smaller and manoeuvrable. The ship extends the class Process and implements the Resource Requester Interface and the Locatable Interface. The ship has a certain process or sequence of activities it performs during its stay in port and is able to request capacity of certain resources during its rotation. The process of the different ships can be found in paragraph 2.6.3. The locatable interface gives the ship a location in port.

The parcel tanker and coaster are sea ships and perform the same activities, but the coaster is smaller and has fewer assignments to execute. So, the parcel tanker and the coaster are both instances of the class 'SeaShip', but have different values for their attributes, for instance the number of assignments to execute. The parcel tanker and the coaster have a shipping agent to which they belong (see figure 2.6). Furthermore, parcel tankers have BB transhipment with barges.

The barge is used for BB transhipment and has another kind of process than the sea ship. When it enters the port, it gets the location of the parcel tanker and moves to the parcel tanker for BB transhipment. The barge does not have assignments to shore. The processes of the sea ship and the barge can be found in the actor-activity diagram in paragraph 2.6.3.
2.5.2 Assignments

The sea ships have one to multiple terminals to visit when they are in port, 'TerminalToVisit' in figure 2.7. The 'TerminalToVisit' has as attribute the terminal that it has to visit and a list with assignments to transship at this terminal. Furthermore, the parcel tankers and the barges have assignments for BB transhipment. 40 to 60% of all assignments the parcel tanker has in port, is BB transhipment. The 'BoardBoardTranshipment' and the 'AssignmentToShore' are both sub classes of the superclass 'Assignment', because they have similar attributes and operations (see figure 2.7). They both have a quantity to tranship and a kind of transhipment; discharge, load or BB transhipment. However, the assignment to shore has a terminal as location where the assignment takes place, while the board-board assignments is done at the location where the parcel tanker is at. This can either be a terminal or a buoy. The 'AssignmentToShore' further has an estimated time for executing this assignment, with which the planner of the terminal can make an estimation of the time the berth is occupied. The 'BoardBoardTranshipment' has a destination, which is the parcel tanker to do transhipment with and an ETA of the barge. This is the expected time of arrival of the barge in port. It can be that the barge is delayed and BB transhipment has to take place later in time.

![Class diagram assignments](image)

2.5.3 Port

The companies in the chemical sector of the port of Rotterdam are opened 365 days a year, 24 hours per day. When the sea ship visits the port of Rotterdam, it enters the port at Hoek van Holland (see red arrow, figure 2.8), visits one or multiple terminals to tranship cargo and leaves the port at Hoek van Holland again. The parcel tanker visits on average 4 terminals [Janssen and Reinders 2004; Hoevens 2004].

The classes belonging to the port can be found in figure 2.10. All classes with a location in port implement the Locatable Interface. The terminals visited by ships for transhipment of chemicals in the port of Rotterdam are mostly located in three areas; namely Eurooport, Botlek and Pernis (see figure 2.8). The Botlek and Pernis area are located next to each other. If a ship is in one of these two areas and has to get to the Eurooport area, it has to sail out of the port and then sail to Eurooport. This takes approximately 3.5 hours. The attributes of the 'Area' consist of its name and a sign if it is further located or if it has tide restrictions. Eurooport is further located and Pernis and Botlek both have tide restrictions.
There are two kinds of terminals, the transhipment terminal and the production terminal. The transhipment terminal leases storage capacity to shippers and takes care of the transhipment from the shore to the ship and vice versa. In the port of Rotterdam there are several factories that have their own berths, and therefore called production terminals. Factories need products as input for the processes and the end products of the factories have to be transported to the customers. This is partly done over water. The most terminals are located in the Botlek and Pernis area (see figure 2.8). Examples of terminals in the Botlek area are Vopak terminal Botlek (South) and Odfjell Terminal, examples of terminals in the Pernis area are Shell Pernis and Koole Tank Storage. In the Europoort area also terminals can be found, like Chemtrade Europoort. It depends on the shipping company and their assignments which terminals are visited. The transhipment terminals often visited are Odfjell terminal, Vopak terminal Vlaardingen, Koole tank storage and Vopak Terminal Botlek and the production terminals often visited are Shell and ExxonMobil. The terminals with their capacity can be found in appendix E. Terminals handle the parcel tankers according to the FCFS principle. For parcel tankers and coasters the point of tendering the Notice of Readiness (NOR) is taken as reference to determine which ship may moor at the berth. The two kinds of terminals have the same activities when handling ships at the terminal. Thus, the production and the transhipment terminal are seen as one type in the conceptualisation; the ‘Terminal’. The ‘Terminal’ has a name and terminal operators and terminal planners involved in handling parcel tankers (see paragraph 2.6.1). Furthermore, the terminal has a certain pump speed that determines, together with the amount to tranship, the time it takes before cargo is transhipped.
Before the cargo can be transhipped, it first has to be checked if its specifications are according to the satisfaction of the shipper. Furthermore, all tanks (shore tanks and parcel tanks) have to be inspected on cleanliness to prevent pollution. In the port of Rotterdam a couple of surveying companies are active which are responsible for these inspections. Three companies are big and five are smaller; the biggest are SGS, ITS Caleb Brett and Saybolt which employ together approximately 320 surveyors. The smaller companies employ together approximately 150 surveyors. If approved, the cargo can be transhipped. The ‘Surveyor’ class has one attribute, a name, and extends the Resource class (see figure 2.10). Surveyors have to be claimed by ships for the inspection of the cargo.

There are different port entry points for the ships. Parcel tankers and coasters come from sea (see red arrow in figure 2.8) and barges enter the port via two inland entries, along the bottom and along the top of the port (see the black crosses in figure 2.8). The ‘PointOfEntry’ class has one attribute, the name of the point of entry.

Tide restrictions at certain locations in port cause ships to be unable to get to the terminal at every moment in time. The tide restrictions are taken into account, because it influences the decision of the shipping agent which terminal to choose next (see paragraph 2.7). The ‘Tide’ class has as attribute the water level and this level is updated every half hour.

Buoys are placed in the port where ships can moor if they have to wait, for instance on a berth to be available. The ‘Buoy’ class has the name of the buoy as attribute.
2.6 ROTATION PARCEL TANKER

This paragraph and paragraphs 2.7 and 2.8 are confidential. For more information contact INITI8 at info@initi8.nl.
3 SPECIFICATION

The choice for the simulation language used can be found in paragraph 3.1. Reductions made to the conceptual diagram to reduce the complexity are explained in paragraph 3.2. The input and output parameters of the simulation model are defined in paragraph 3.3. Animation build into the model is described and the treatment of the model is determined. The simulation model is finally verified and validated in paragraph 3.5.

3.1 SIMULATION LANGUAGE

The simulation language has to be an object-oriented language and has to support the process-interaction formalism (see paragraph 2.2). DSOL is a distributed web based simulation package, which is developed at the TU Delft. DSOL stands for Distributed Simulation Object Library and is a simulator implemented in Java [Jacobs et al., 2002]. As the name implies, distributed use of the simulation model is possible. DSOL is java-based which is an object-oriented language. The process-interaction formalism is supported in DSOL [Jacobs and Verbreeck, 2004]. A process class is specified which has a “control state” in which it stores its reactivation point in its sequence of activities. The process class is abstract, which means that the ship classes have to implement the abstract process method and in this method the sequence of activities of the ships can be specified (see paragraph 2.2).

3.2 SIMULATION MODEL

The conceptual model is made in the conceptualisation in chapter 2. To reduce complexity, this model is simplified where possible. The simplified conceptual model can be used to build the simulation model in DSOL. The following simplifications can be made:

- The ships have a certain number of assignments to fulfil when they are in port. These assignments consist of transhipping cargo out or into the tanks of the ships. The format and the number of these tanks are not simulated. Assumed is that they carry a certain number of cargos with different quantities corresponding to the assignments they have.
- If a ship has to wait, it waits at a buoy. In reality a buoy has only capacity for one ship and there are multiple buoys in port. However, these buoys are located near each other. The difference in distances to get to these buoys is not significant. Thus is assumed that there are two buoys with unlimited capacity, one in the Europort area and one in the Botlek area. It depends on which terminals the parcel tanker has to wait at which buoy it stays. No buoys can be found in the Pernis area, in reality. This is why no buoy is located in the Pernis area.
- Terminals seldom visited by the ships are not taken into account. There are terminals which do not have chemicals as their core business and are seldom visited by parcel tankers, approximately once per month. For simulating the visiting of terminals and the port time of parcel tankers, these visits are not relevant and have not a significant effect on the port time. These terminals are therefore not simulated.
- Only tide restrictions in the Eerste Petroleumhaven and the Derde Petroleumhaven are taken into account. These restrictions cause shipping agents to decide to go to another terminal. These tide restrictions only count for ships longer than 180 m, so only for parcel tankers. Other tide restrictions are assumed to not cause delays for the ships.
- A surveyor has to drive approximately 20 minutes before it is from the laboratory to the terminal. When the surveyor is assigned to a parcel tanker for inspecting the cargo, he or she is almost always already in port. The planning department of the surveying companies tries to assign surveyors, which are already in the neighbourhood, and at busy terminals often surveyors are stationed. Thus, it can be assumed that the travelling time for surveyors to get to the ship is very short to nothing and this time is not taken into account in the simulation model. However, when the surveyor has to bring the sample to the laboratory for analysis, he drives himself to the laboratory. Before the sample is analysed the cargo cannot be transhipped. So in this case, the driving time of 20 minutes is relevant and taken into account.

3.3 IN- AND OUTPUT VARIABLES

This paragraph is confidential. For more information contact INITI8 at info@initi8.nl.
3.4 ANIMATION

The purpose of the simulation model is to provide insight in the overall process of handling parcel tankers in the port of Rotterdam. Therefore, visualisation of the activities of a parcel tanker in port is required. Animation gives observers, who are not experienced with simulation, more understandable insight in what actually happens. DSOL supports 2D animation and based on the Java3D library it is not difficult to add 3D animation [Jacobs and Verbraeck, 2004]. 2D animation is used in this case, because it is sufficient to show the processes of a parcel tanker 2D and the GIS map of the port of Rotterdam is 2D and could otherwise not be used.

The following items in the simulation model are animated:

- A GIS map of the port of Rotterdam is used to animate the port (see figure 3.1).
- Three kind of ships are animated; parcel tankers as red rectangles, coasters as green rectangles and barges as black rectangles (see figure 3.2).
- Terminals are simulated with different locations where parcel tankers and coasters can moor.
- Barges lay by parcel tankers for BB transhipment.
- Tides are animated; the water levels in the harbours where tide restrictions occur, are indicated with a number which indicates the water level to NAP (Nieuw Amsterdams Peil).
- Rotation plans of different parcel tankers can be selected in a frame. The terminals which have to be visited and the current terminal can be seen in the frame.
- From every terminal the current occupied berths, available berths and the length of the waiting queue can be found in a frame.

![Figure 3.1: Overview animation](image-url)
3.5 TREATMENT

The treatment of the simulation model has to be defined to represent the performance of the system correctly. The warm-up period, the period after which the performance of the system is measured, and the run length have to be defined. Furthermore, the number of replications to make conclusions with a certain confidence level has to be calculated.

Warm-up period
No ships are in port when starting the simulation model, which is never the case in reality. This means that no capacity of certain resources, like berths, is claimed. The first ships that enter the port will not have any problems claiming resources, because there are no other ships claiming them. The port time of these first parcel tankers is unrealistic. The statistics of these ships must not be taken into account. Therefore, a warm-up period has to be defined. To define this, the model is run six months. The period before the point where the graph of the port time stabilizes is the warm-up period (see appendix J). It is difficult to detect this point, because of the peaks in port times of the ships. To be sure, a warm-up period of 500 hours is used in the simulation model.

Run length
The run length of a simulation model is the amount of simulated time used to measure the performance of the system without taking the warm-up period in account. There are no general methods to determine the run length of a simulation model. However, there is a rule of thumb which contains that the run length is three times the longest cycle time in the simulation model. In the graph in appendix J one can see that the longest port time of a parcel tanker is 340 hours (approximately 14 days). In the interviews with shipping agents, this number of days was also indicated for extreme cases. The simulation model has to run 1520 hours; 3 times 340 is 1020 and adding the 500 hours warm-up period makes 1520.
Number of replications
Different outcomes can occur in every run when using other seed values, because of the distributions used in the simulation model. Thus, multiple runs with different seed values have to be done to get results of the simulation model with a certain confidence level. To determine the number of replications the average port time of 10 replications is used. With 10 replications the average port time is 152 hours, with a lower and upper boundary of respectively 134 and 171 hours (appendix K). The corresponding half value h is 18.54. The number of necessary replications \( n' \) to obtain a certain confidence \( h' \) can now be determined based on the 10 replications mentioned above and the calculated h with help of the following formula: 

\[
n' = \left\lfloor \frac{n(h/h')^2}{2} \right\rfloor
\]

A certain confidence \( h' \) of 10 would be desired, because better confidence is not feasible while too many replications have to be run. With a confidence of 10 the number of replications is still feasible and the results of the model give a good representation of reality. This leads to \( n' = \left\lfloor 10 \left( \frac{18.54}{10} \right)^2 \right\rfloor = \left\lfloor 34.4 \right\rfloor = 35 \) replications run for measuring the performance of this system.

3.6 VERIFICATION AND VALIDATION
The verification and validation of the model are described in this paragraph. The methodology of the verification and the validation is explained in paragraph 3.6.1 and the results of the verification and the validation are summarized in paragraph 3.6.2. For the validation a session is held with a couple of experts. This session also has the purpose to create trust in the model and the process of this research. In the expert validation, animation of the activities in the simulation is important. The experts get a quicker insight in the processes modelled and this increases the speed and quality of the validation session.

3.6.1 Methodology
In the verification of the simulation model a check is done if the translation from the conceptual model to the simulation model is made correctly. The purpose of the validation session is to check if the model resembles reality. Besides the quantitative analysis, does the model behave as supposed to when changing an input parameter, also a qualitative check is done. The qualitative check is done with help of 'experts', in this case the shipping agents of the three largest shipping companies (Odfjell, Stolt Nielsen en JO Tankers) in the port of Rotterdam. The shipping agents have the most knowledge about the whole process and can therefore give the best input for the validation of the model. In the validation session first the estimated values used in the simulation model are discussed, which are the following:

- Duration surveying
- Pump speed
- Quantity of cargo
- Distribution visited terminals
- Number of terminals to visit per parcel tanker
- Number of assignments (in total + per terminal)
- Arrivals parcel tanker in port, the number of ships that arrive and the arrival pattern
- Chance that barges and coaster are not available

After the estimated values are discussed three parcel tankers are followed in the simulation model. They are given another colour, so they can be followed easily during their rotation in the port of Rotterdam. The overall process from making the rotation plan for these parcel tankers to sailing in port and visiting terminals until they leave the port again is followed and discussed. After that, the output of the model per parcel tanker and for all parcel tankers is discussed. For discussing the output of the model the performance indicators as given in paragraph 3.3.2 are used. The experts indicate if the output is according to reality and if not, what has to be changed so that it is.

3.6.2 Results verification & validation
The sensitivity of the steering variables surveyors, terminal operators and berths on the port time is investigated in the sensitivity analysis in chapter 4. In this way, a check is done if the simulation model generates no strange unexpected output and variables, for which the port time is sensitive, are defined. The minutes of the validation session can be found in a separate report (Elpers, 2004). The results and only the changes, which have to be made, are described shortly in this paragraph:
Some remarks are given on the estimations:

- Pump speed of 350 m³/hour is a bit high, assumed is that the pump speed lays between 250 and 400 m³/hour.
- The chance that barges are not present at the moment of BB transhipment is approximately 60%.
- There are too many parcel tankers arriving in port. The experts estimate with help of own experience with their ships that approximately 550 parcel tankers enter the port of Rotterdam per year. The number of coasters is correct.

These input variables are adjusted and used in the simulation model.

While the simulation model was running and the three parcel tankers were followed, the following remarks were made:

- The experts indicated that the way shipping agents choose the next terminal for a parcel tanker is purely based on minimizing waiting times. Also when a terminal in another (further located) area is the only one that is free, the parcel tanker will sail to the other area to visit the free berth. The process of choosing the next terminal to visit has to be adjusted in the simulation model.
- The experts did not miss activities in the simulation model, like bunkering and inspections of customs. They confirmed that these activities did not contribute to a long port time. So, all relevant activities are represented in the simulation model.

The results per followed parcel tanker and of all simulated parcel tankers are discussed:

- In the results per parcel tanker and the overall results, the experts noticed that the waiting time for operators is much lower than in reality would be. In the results it is average 15 minutes to an hour, while in reality the experts speak of 2 to 3 hours. The reason for this is that in the simulation model the operators are only claimed during the (dis)connection of hoses. In reality, the operators are present during the stay of the parcel tanker at berth for safety reasons. This is changed in the simulation model.
- The waiting time for berths is relatively long; approximately one and half days in the simulation model. In reality this is approximately 1 day on the total port time. The reason for this is the decision process of the shipping agent when choosing the next terminal. The choosing process in the simulation model was based on areas, while it actually has to be based on minimizing waiting times. This could not be changed during the validation session and therefore, this is done afterwards and new results are sent to the experts per e-mail.
- The average port time of 6.3 days could be a little lower, approximately 6 days and the largest part has to be time spend at berth. Approximately 70% of the time in port is spent at berth, in the current results this is now approximately 50%. This is probably because of the high waiting times for berths. The parcel tankers spend less time at berth because of the low waiting for operators time, which leads to less BB transhipments possible when the parcel tanker is at berth. This is the cause that more transhipment has to be done at buoys, so a higher BB transhipment time is the result.

The agreed adjustments are made in the simulation model and the new output of the simulation model can be found in paragraph 4.1 and is e-mailed to the participants. The participants indicated that these new results are conform reality.

In the sensitivity analysis experiments are done with the number of surveyors, operators and berths, separately and combined. The outcomes of the sensitivity analysis are described in paragraph 4.2. The outcomes are shortly mentioned in this paragraph; the port time is sensitive for the surveyors and operators in the case that decreasing the number of these resources leads to a higher port time. However, the port time is not sensitive for increasing the number of surveyors, operators and berths. Also combined experiments are done with the variables. In these experiments the port time does decrease more than in the experiments with the variables separately, but still waiting times occur. Concluded can be that the port time is sensitive for decreasing the capacity of resources, but not for increasing the capacity of the resources surveyors, operators and berths. By increasing the capacity of the resources, still waiting times for these resources occur.
3.7 CONCLUSIONS SPECIFICATION

The conceptual model made in the conceptualisation phase is simplified and translated to a simulation model. The simulation language used is DSOL; it supports the process interaction formalism and is java-based, which is an object-oriented language. The input-variables are defined with help of an analysis of data gathered during the research of different actors. The performance indicators used to measure the performance of the system are defined. To create more and faster insight in the simulated activities for non-simulation experienced people, 2D animation is added to the simulation model. This also makes the validation of the simulation more easy and of higher quality. The visualization includes animation of the port, tides, terminals and ships moving between the terminals. Rotation plans of ships and waiting queues for berths per terminal can be seen. The treatment of the simulation model is determined; the model runs for approximately 9 weeks with a warm-up period of approximately 2 weeks. The model is verified and validated with an expert-validation and a sensitivity analysis. After adjustments are made to the model, the experts indicate that the model is conform reality. Out of the sensitivity analysis can be concluded that the port time is sensitive for decreasing the capacity of resources, but not for increasing the capacity of the resources surveyors, operators and berths. Now a valid ‘as-is’ model of handling parcel tankers in the port of Rotterdam is available for analysis of the current situation.
4 ANALYSIS CURRENT SITUATION

This chapter is confidential. For more information contact INITI8 at info@initi8.nl.
5 WORKSHOP

The design of the workshop has to meet a couple of content requirements (what has to be presented) and a couple of process requirements (in which way has this to be presented). These requirements can be found in paragraphs 5.3 and 5.4. They come from an actor analysis (see paragraph 5.2), former initiatives and pre-discussions and steps taken to come to the simulation model and analysis of current situation.

5.1 GOAL WORKSHOP

By organising a workshop the actors are present at the same time at the same place and are stimulated to collaborate and discuss with each other. Together a better picture can be made of the overall process with help of the simulation model and by collaborating and discussing, the actors can convince others of the (non)-existing of certain issues.

The goal of the workshop is to create commitment of the actors for cooperation in further research with the simulation model. The actors get insight in the overall process of handling parcel tankers with help of the simulation model and in the cause for the long port time. Simultaneously all actors present validate the simulation model, because in the expert validation only a selected group has validated the model. Besides creating insight in handling parcel tankers in the workshop, it is also important to do this while keeping the multi-actor environment with autonomous, competitive actors in mind. Thus, there are not only content requirements for the design of the workshop, but also process requirements defined. To come to the design for this workshop, first an actor analysis is done in which is analysed which relevant actors have to be invited to the workshop. The content requirements to the design of the workshop can be formulated based on the steps taken to come to the simulation model and the analysis of the current situation. The actor analysis also creates input for the process requirements. The different interests of these actors have to be taken into account. Former initiatives are taken to reduce the port time with the same actors present at the workshop. To get some feeling for their environment, experiences in former initiatives are gathered with help of interviews with the actors. These experiences are input for the process requirements.

The desired result of the workshop is commitment for cooperation in further research. To come to this commitment, also during the research this commitment has to be created. During the interviews involvement in the research is created (see figure 5.1). The actors must have the feeling that they make a significant contribution to the making and the design of the simulation model. During the expert validation, trust has to be created in the simulation model and the analysis of the current situation done with the simulation model. In pre-discussions already some commitment can be created with the actors who are approached for these discussions. In the workshop, commitment of all actors for further research has to be created.

Figure 5.1: Timeline creating commitment

5.2 ACTOR ANALYSIS

For the workshop it is important to invite actors who benefit direct from a shorter port time, they are willing to take initiatives for shortening the port time. Besides these actors, it is also important to invite actors that can influence the port time. The implementation of a solution that shortens the port time is highly dependable of the cooperation in the solution of these actors. In the conceptualisation a selection is made of actors who’s tasks are relevant to take into account in the conceptual model. These actors influence the port time. However, there can be actors that are not taken into account in the conceptual model, but still benefit from a shorter port time. This is the reason that in the beginning of the actor analysis, no actors are omitted. Furthermore, in the conceptualisation the production and transhipment terminal are represented as a single actor because they perform the same tasks. In the actor analysis, they are approached separately, because they have different interests. To get gain more insight in the benefits for the actors from a shorter port time, an analysis
is made, based on the tasks and interests of all actors involved in handling parcel tankers. First all actors are described with their individual tasks and interests, then is indicated which actors benefit from a shorter port time and which actors are able to influence the port time and the reason why. Finally, the actors who are invited for the workshop are listed. The information used in this actor analysis is based on literature study and interviews with actors [Eipers, 2004].

5.2.1 Actors with their tasks and interests

The following actors with their tasks and interests are involved with the handling of parcel tankers in the port of Rotterdam. The tasks of the different actors have already been described in the second chapter, but to clarify their interests, their tasks are shortly defined in this paragraph:

Port of Rotterdam
As manager of the port, the PoR leases sites to businesses and bears responsibility for the efficient and safe handling of shipping traffic. The PoR also takes care of the infrastructure of waterways, roads, quays and other facilities for users of the port area [port of Rotterdam, 2004]. The PoR is in two ways involved in handling parcel tankers, by the department of dangerous goods and by traffic management:

Department of dangerous goods
The task of the Department of dangerous goods is focused on maintaining the defined safety- and environmental protection level of activities with dangerous goods in the port and optimising the conditions for these activities [R. de Koning and A. Timmermans, 2002]. The main tasks/responsibilities/activities are:
- Processing and judging announcements of transport of dangerous goods
- Giving permissions
- Performing inspections and surveys

Traffic management
Traffic management is responsible for the efficient and safe handling of shipping traffic in the port. The traffic management process is performed within the department of the Rotterdam Port Authority (RPA) [R. de Koning and A. Timmermans, 2002]. Traffic management coordinates and authorizes the movement of vessels through the port.

The interests of the PoR are (1) to strengthen the port and the industrial complex in Rotterdam and (2) to look after a safe, efficient, comprehensive and clean port. [port of Rotterdam, 2004].

Figure 5.2: Picture vessel of PoR

Shipper
A shipper is the owner of cargo; he sells and/or buys goods. He gives orders to transport, tranship, store and analyse cargo. The shipper wants (1) to make a maximum profit by the shipping of goods and (2) to achieve maximal customer service at the lowest possible cost.

Shipping Company
The shipping company is hired by the shipper to transport the cargo from one point to another. The goal of the shipping company is (1) to make a maximum profit by transporting as much as possible loads and (2) to obtain an optimal use of the transport capacity at the lowest possible cost.
Shipping Agent
The shipping agent works for the shipping company and is often part of the shipping company. The shipping agent is responsible for the organisation of handling parcel tankers in the port. The shipping agent makes the rotation plan for the parcel tanker and communicates with the other parties like the terminal and the surveying company. The shipping agent wants to optimise the handling of parcel tankers in the port to minimize the port time of parcel tankers as much as possible.

Transhipment Terminal
The transhipment terminal leases storage capacity to shippers and takes care of the transhipment from the shore to the ship and vice versa. The transhipment terminal wants to achieve a maximum profit by (1) leasing as much as possible storage capacity and (2) transferring cargo at the lowest possible cost.

Production Terminal
Besides the transhipment terminal, there is also a production terminal. In the port of Rotterdam there are several factories that have their own berths. Factories need products as input for the processes and the products of the factories have to be transported to the customers. This is partly done over water. These factories also use storage capacity of transhipment terminals and can therefore partly also been seen as shipper. The production terminal wants to make a maximum profit by (1) selling as much as possible products and (2) producing at the lowest possible cost.

Surveying Company
The surveying company analyses the quantity & quality of cargo and inspects the cleanliness of tanks (shore and parcel tanks). If the analysis or inspection has been approved, it gives certificates (Certification of Analysis or Certification of Cleanliness). The surveying company does this on behalf of the shipper and is assigned by him. It is possible that two surveyors of different companies are present, one of the buyer and one of the seller of the cargo. The surveying company wants to make a maximum profit by (1) executing as much surveys as possible surveys and (2) surveying at the lowest possible cost. The surveying company wants (3) to execute surveys without extra delaying the logistical process.

Captain and Crew
The captain has the overall responsibility on the ship and he or the steersman has contact with the shipping agent about the rotation of the parcel tanker in port. Together with the crew he is responsible for (1) a fast, safe and reliable transport over water and (2) a fast, safe and reliable handling of the parcel tanker in port.

Customs
Customs inspects the import and export of goods in the port of Rotterdam. Customs wants (1) to inspect the goods as thorough as possible and (2) to execute the inspections without extra delaying the logistical process.

Tug Service
Tug services are responsible for the tugging of the parcel tanker from one point to another and are ordered by the shipping agent. Tug services want (1) to tug as much vessels as possible at the lowest possible cost and (2) to obtain an optimal usage of tugs.

Pilot Service
Pilot services, which are also ordered by the shipping agent, guide the vessel through the port. Parcel tankers are obligated to have a pilot on board during sailing in the port, because of the dangerous goods they transport. Pilot services want (1) to pilot as much vessels as possible at the lowest possible cost. and (2) to safely navigate the vessels in the port of Rotterdam.

Rowers
Rowers are mainly responsible for the (un)tying of the vessel to the berth and are also ordered by the shipping agent. Rowers are an association and do not have the goal to make profit. Rowers want to do their work as good as possible.
**Bunkering Service**
The bunkering service is responsible for the bunkering of the tankers. The bunkering service is ordered by the shipping agent. The bunkering service wants to achieve a maximum profit at the lowest possible cost.

**Ship Chandler**
The ship chandler supplies the vessels with different kind of things, from food to engine parts. They want to make a maximum profit at the lowest possible cost.

**Nautical Information Services**
Nautical Information Services offer information to users of the port. The kind of information depends on the company or service. The information can consist of weekly charts, yearbooks or daily overviews of arrival times. Nautical Information Services want to provide a clear communication of necessary and correct information.

**Emergency Services**
Different kinds of services, such as the fire department, are present in the port to secure the safety in the port. They want (1) a safe as possible port and if a disaster occurs (2) as less as possible consequences.

**Insurance Company**
An insurance company takes care of the insurance of ships and cargo. The insurance company wants (1) to sell as much as possible insurances and (2) to receive as less as possible claims.

### 5.2.2 Relevant actors
A list is made with all actors and their tasks and benefits in the former paragraph. With help of this information, it can be indicated which actors benefit from a shorter port time and which actors are able to influence the port time. A ‘yes’ is given in columns ‘benefit port time’ and ‘influence port time’ of table 5.1 when the actor is benefiting from or influencing the port time and a ‘no’ when the actor is not. An explanation for the different choices is made in the following paragraph.

#### Table 5.1: Benefits and influences of actors

<table>
<thead>
<tr>
<th>Actor</th>
<th>Benefit port time</th>
<th>Influence port time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Port of Rotterdam (PoR)</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Department of dangerous goods</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Traffic management</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Shipper</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Shipping Company</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Shipping Agent</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Transhipment Terminal</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Production Terminal</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Surveying Company</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Captain and Crew</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Customs</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Tug Service</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Pilot Service</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Rowers</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Bunkering Service</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Ship Chandler</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Nautical Information Services</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Emergency Services</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Insurance Company</td>
<td>No</td>
<td>No</td>
</tr>
</tbody>
</table>

In the conceptualisation is already indicated which actors are taken into account in the conceptual model and are able to influence the port time and why. The reason why certain actors benefit from a shorter port time is indicated below.

The PoR benefits from a shorter port time, because a shorter port time will attract more shipping companies and shippers to the port of Rotterdam. This will ensure the competitive position of the port and strengthen it on the long term. The department of dangerous goods and traffic management are...
both services of the PoR, but do not benefit of a shorter port time. They only want a safe and efficient handling of parcel tankers, it does not concern them when port time takes longer. Shippers benefit from a shorter port time, demurrage claims will be reduced and on the long term it can happen that increased ship-efficiency may lower the freight rates. Shipping companies and their shipping agents benefit the most of a shorter port time. More trading days can be made (ship can transport more) which leads to more profit. More reliable estimates concerning the time spend in port can be made, resulting in a higher service level towards the clients. And last, the amount of money spend on demurrage will be reduced as well (the time and money which the shipping company loses during the determined grace period). The transhipment terminal does not see the direct benefit from a shorter port time for parcel tankers, they only want to have their berths occupied, but it does not matter which ship is at the berth. On the long term however, more business could be attracted from competing ports because of the shorter port time. Production terminals have other interests than transhipment terminals, but neither benefit from a shorter port time. On the long term, it could be that when arrivals at their terminals are more reliable, less safety storage has to be kept, which can lead to cost reduction. The surveying company, bunkering service, ship chandler and tug & pilot services also do not directly benefit from a shorter port time for ships, they are only concerned with the duration of their own activities. The faster they can perform their activities, the more activities can be done, the more money the companies can earn. On the long term however, when the port becomes more attractive, more customers can create more earnings. Captain and crew do not benefit themselves from a shorter port time, it could be however that they receive a bonus for a faster rotation, but this has not been confirmed. Customs do not benefit from a shorter port time, they are an independent actor in this process. Rowers are an association, and do not have the goal to make a profit. Thus, they do not benefit from a shorter port time. Nautical information services, emergency services and insurance company do not benefit from a shorter port time. Nautical information services only want to give clear information, emergency services are only interested in a safe port and an insurance company wants as less as possible claims.

5.2.3 Participants workshop
This paragraph is confidential. For more information contact INITI8 at info@initi8.nl.

5.3 CONTENT DESIGN REQUIREMENTS
Out of the steps taken to come to a simulation model and a diagnosis of the current situation (see chapter 2 to 4), content design requirements can be defined. In the conceptualisation the actors have given information in interviews about their activities to build the simulation model. They are therefore involved in the process. The simulation model is now build, but the actors do not yet know what the overall process contains and which variables have effect on the port time. So, the content of the workshop has to be focused on giving them this insight. An analysis of the current situation has to be made with the participants. To create this insight, first a parcel tanker has to be followed in the simulation model, so the actors can see the different activities and simultaneously can validate the simulation model. With validating the model, trust is created by the actors in the simulation model and the outcomes of the simulation model. A couple of actors previously validated the model, so no mayor adjustments are expected. The way to come to a diagnosis of the current situation, by first doing a sensitivity analysis, is also input for the workshop. By doing this together with the participants, they get more feeling what affects the port stay of parcel tankers. The diagnosis of the current situation made in this research (see paragraph 4.3) is then discussed with the participants to check if actors do think this could be actually the cause for a long port time. Summarized, the following content requirements have to be taken into account in the design of the workshop:

(1) Validation of simulation model; the simulation model is already validated with some experts, but now all actors can validate the model and get trust in the model. This is important if experiments are done with the participants. They must have trust in the outcomes of these experiments. Furthermore, for further analysis it is important to know if adjustments have to be made.

(2) Insight in overall process of handling parcel tankers; the simulation model gives insight in the overall process of handling parcel tankers. Every actor knows a part of the process in detail, but does not have a detailed picture of the whole process. The change in steering variables can be tested to get feeling for what effect it has on the port stay of a parcel tanker. The same is done as in the sensitivity analysis in paragraph 4.2.
(3) **Diagnosis current situation:** the actual cause of long port time according to the analysis of the current situation in paragraph 4.3 is presented to check with the actors if they think this could be the cause. And if not, why this is not the cause.

### 5.4 PROCESS DESIGN REQUIREMENTS

Not only the content of the workshop is important, also the process (the way this is presented/discussed) is important, because of the multi-actor network with different interests. These actors all have to commit to further research and creating insight in the process of handling parcel tankers does not only do this. Also the way in which this insight is created is important. Thus, process requirements to the design of the workshop are defined with help of the actor analysis, former initiative and pre-discussions with some participants. In the actor analysis (see paragraph 5.2) was described that not all actors influence the port time, do benefit from a shorter port time. It is important that there are prospects on interests for all actors. By evaluating former initiatives taken to shorten the port stay of parcel tankers (see paragraph 5.4.1) feeling is created how to cope with the environment of actors. Furthermore, pre-discussions with two participants are kept, to get feeling for the reactions of participants on the content of the workshop. These reactions can contribute to the process requirements defined in paragraph 5.4.3.

#### 5.4.1 Former initiatives

To get some more understanding of the multi-actor environment of handling parcel tankers in the port of Rotterdam, former initiatives to shorten the port time in this environment are evaluated. The input for this is received from interviews with the same actors as were involved in these initiatives. Out of this analysis, process requirements for the design of the workshop can be defined. The most recent initiatives to shorten the port stay of parcel tankers in the port of Rotterdam are Portinfolink.Chemicals and Chemical Tower; the later was more an idea than a project. Unfortunately, these initiatives did not have the desired effect and have been cancelled. First a short explanation of the initiative is given, after which the initiative is evaluated and process requirements are defined.

In 2001, the PoR started a project with the goal to reduce the port stay of parcel tankers, Portinfolink.Chemicals. The way parcel tankers were planned and the lack of synchronization of the planning with other actors was seen as the cause for a long port time. A notice board on internet would be used to exchange operational planning information between the actors to improve the planning of parcel tankers [Holland Consulting Group 2001]. The exchange of this information is normally done per telephone or fax, but now the different actors have to fill the information in on the internet notice board. The idea is that if operational changes occur, and are filled in, other actors can see where there are problems or changes and can anticipate on the situation. The actors involved in this project did see the advantage of a more reliable planning, but this project still did not succeed, the actors gave some operational reasons and some reasons concerning the process used in this project:

- The handling of parcel tankers in the port of Rotterdam goes on 365 days a year and 24 hours per day. This means there always has to be someone to keep the information up-to-date, also out of the office hours. In the current time, companies are not very enthusiastic to hire more personnel; actually you can see a tendency toward reducing the number of personnel. So, the desired capacity to keep the information up-to-date is not always available.
- Operational changes occur very often. In that case, the shipping agent has more urgency to solve the problem than to fill in the changes on the notice board.
- The confidentiality of certain information on the notice board is protected, but there are situations in which the information cannot be protected and the information can provoke strategic behaviour. For example, the 'First Come First Serve' principle is used by terminals. If a shipping agent knows that another parcel tanker wants to claim the same berth, he will try to get its ship to be sooner at a certain terminal.
- A lot of (different kind of) actors were involved in the project Portinfolink.Chemicals. However, there is a difference between transhipment terminals and production terminals. These two different kind of terminals have different interests. Only the transhipment terminals were involved in the project, but for the success of the project also the cooperation of the production terminal is important.
The terminals do not see a clear benefit (see actor analysis, paragraph 5.2) for using the notice board, but their information is important for the success of the notice board. If they do not keep information up-to-date, the notice board has less added value for other actors.

The actors had the idea that a decision to use the internet board was already made without them and the project was organised to get more insight in how the notice board should be build.

Chemical tower was a project that has not been developed as far as PortInfolink.Chemicals, so less information is available. Actually, it was more an idea, which has been proposed to the shipping companies, but has not been further analysed. The idea was that the shipping agents would send all their planning information to one point (the tower) and the tower would then give advice about the rotation of the parcel tankers. However, the goal of this is to optimise the whole process of handling parcel tankers, but the shipping companies are only interested in their part. They want their parcel tankers to stay in port as short as possible and do not want to be put to a disadvantage to serve the whole system. Furthermore, the shipping agents did not want to let other actors do their work and they did not want to hand in their sensitive company information. The autonomy and the competitiveness of the multi-actor environment in handling parcel tankers can be detected in these objections.

In case of PortInfolink.Chemicals the main response was that it took too much time to keep the system up to date, not all actors saw benefits in it for them and actors did not want to share sensitive company information. Furthermore, the actors involved in the project did not had the idea people were listening to their objections. Thus, it is first important to collaborate with the actors and let them have the feeling that they take decisions. By doing this, they are in charge and have the feeling they can leave the process at any time they want. This causes often actors to stay in the process. Second, for all actors, benefits have to be seen to come to the workshop in the first place, and after that they must see benefits in it for them to cooperate in further research. Otherwise, actors certainly leave the process. The actors are autonomous, commercials parties, they are not dependable of other actors and do not want to join a project if they cannot see profit in it.

In case of Chemical Tower the main objection was that the actors did not want to hand in their information to a central party. This is because they do not want other actors to have insight in their information nor another party doing their work in which they are good at. Their core values were affected. It is thus important to protect their core values, otherwise actors do not want to cooperate. Summarized, out of former initiatives the following process requirements are defined: collaboration with parties; let them make the decisions, prospect on benefits for all parties to join the workshop and further research and protecting the core values of the actors.

5.4.2 Process design requirements

Out of the actor analysis, the former initiatives and pre-discussions the following process design requirements are determined. To create commitment for further cooperation, the participants have to be involved in the workshop, collaboration with the participants is important and they must have the idea that they are making the decisions. The role of the leader of the workshop must be the one of a facilitator. Also the core values have to be protected. The actors all have their own activities for which they are responsible, and no actor has to be pointed out as the bad guy and the cause for the problem. To get the actors committed to further analysis, it is important to let them understand that they commit to the process of further research and not to the result of this research, so no decision is made for a certain solution. Otherwise they will not commit. Summarized, the following process requirements to cope with the environment of actors are:

1) **Prospect on benefits for all participants**; the participants must have the idea that there is something in it for them. Otherwise they will not attend the workshop and during the workshop they will not cooperate with other (competitive) actors. Especially for the terminals and the surveying companies their benefits have to be shown.

2) **Collaboration**; the participants have to be involved in the workshop. They must have the idea that they are the ones who are doing the research and they take the decisions. The result is not yet fixed.

3) **Protect core values**; the core values of the participants have to be protected. No actor has to be pointed out as the actor who does not do its job correctly and causes the long port time.
(4) Commitment to process; the participants must not have the feeling that they have to commit themselves to a given solution, for now it is important that they commit to the process of further analysis.

5.5 PROGRAMME WORKSHOP

With help of the content and process requirements the programme for the workshop can be made. The steps taken in the workshop are described in paragraph 5.5.1. In pre-discussions with certain actors already an image is formed of the reaction of the participants in the workshop. These pre-discussions are described in paragraph 5.5.2.

5.5.1 Steps taken in workshop

In the workshop different steps have to be taken to create insight in the current situation while taking into account the environment of competitive, autonomous actors. Finally, commitment has to be created for cooperation in further research. So combining the content and process requirements out of paragraphs 5.3 and 5.4, leads to the following steps taken in the workshop (see figure 5.3):

Figure 5.3: Steps taken in workshop

1. Explain purpose and prospects on benefits
   The workshop starts with a welcome word, in which the motivation for this research is told. Furthermore, the steps that have been taken together with the participants to come to a simulation model, and finally this workshop where the results of the analysis of the current situation are discussed with the participants, are explained. The purpose of the workshop, to create more insight in the overall process of handling parcel tankers with help of the simulation model and to answer the question how the simulation model can be used in further research, is described. Important is also to indicate what the prospect for benefits of the actors is.

2. Show overall process and validate simulation model
The overall process of handling parcel tankers is presented and discussed with help of the simulation model. Diagrams of the processes, made in the conceptualisation, can be used for supporting the simulation model. By following a specific parcel tanker and the activities it has from entering the port until leaving it again, the participants get a good overview of the processes and simultaneously can validate the model. Indicated is that the model is already validated with some of the participants. By validating the model one more time with all actors, trust is created in the model and with that trust in the outcomes of the experiments with steering variables in the next step.

Figure 5.4: Picture presentation workshop

(3) *Experiment with steering variables in model*
Together with the participants experiments are listed. Out of the interviews with the participants steering variables are defined. The chance is high that the same variables are mentioned. The number of surveyors and operators are certain to be supposed by the actors. It is important in this step to not mention names of certain actors, especially when talking about for example at which terminal berths have to be added. These experiments are run in the simulation model and the outcomes can be discussed. With the simulation model all performance indicators can easily be presented and the actors get a good view of the effect these variables have on the port stay and other performance indicators.

(4) *Explain and discuss diagnosis current situation*
The diagnosis of the current situation is given as explained in paragraph 4.3. Asked is if the actors can believe this when they just had more insight in the overall process and the effects of increasing the steering variables. There is no discussion about the feasibility of a solution to solve this problem planned in this part of the workshop. Referred is to the presentation INITI8 will held at the end of the workshop in which INITI8 explains the project APPROACH in the container inland navigation.

(5) *Discuss potential further research*
The question is asked how the simulation model can be used in further research. This is to get a discussion going about further research. It is important to make clear that the participants do not commit themselves to the result of a certain solution, but only to further research. In the future cooperation between the actors can contribute to extending the model and performing more analyses.
5.5.2 Pre-discussions
There is a lot of interaction with the participants in the workshop. There is a relatively high chance of surprises; participants can act differently than expected. Pre-discussions could be important, because a better estimation can be made from reactions and sensitivities of the participants. Not only input for the workshop can be gathered, already some commitment for further cooperation can be created, which would help during the workshop and to convince the other actors of committing to the project. Thus, pre-discussions are planned with two actors, which also were involved in the expert validation of the simulation model. The advantage of this is that there is no time spent on explaining the model and creating trust for the outcomes of the simulation model. Within these pre-discussions the results of the analyses were shortly explained and their response on this was asked. The actors did not expect the increasing of certain resources to have little effect on the port time. It is thus necessary to thoroughly explain the reasons why this does not have a big effect. The diagnosis of the current situation was, after explaining the effect of the steering variables on the port time, easier to understand for the actors and they could imagine this to be the case. The actors were also asked how they thought other actors would react. In case of delays, actors are blaming others to be responsible. It is important to not choose side for a certain actor. For example, if in the workshop would be said that surveyors do not cause a longer port time at all, these surveyors would use that in discussions with for example the shipping companies who is to blame for a certain delay. The shipping companies do not desire this and during the workshop shipping companies could leave the process because of this.

5.6 RESULTS WORKSHOP
The workshop is held on the 14th of April in the building of the PoR. Ten persons of different types of actors were invited to the workshop (see paragraph 5.2.3). Eight persons were able to join the workshop and all different kinds of actors were present: shipping companies (shipping agents), transhipment and production terminals, surveying companies and the PoR. First the level of commitment of the actors for cooperation in further research is described in paragraph 5.6.1. The degree, in which the roles of the simulation model in the workshop are fulfilled, is explained in paragraph 5.6.2.

5.6.1 Commitment actors
Almost all invited persons from all different kind of actors were present at the workshop and the ones who were not could not be because of other obligations. This indicates that the actors are aware of possible benefits for them and see a sense of urgency to shorten the port time of parcel tankers. There is commitment created for further research with the simulation model. The actors have indicated that they are willing to give more information and data. The simulation model will be further extended with help of this data and an analysis is done on the effect of a more reliable planning on the port time of parcel tankers. The actors also will be present at the next meeting, organised by INITI8, where results of the analysis are discussed. At that meeting a decision will be made by the participants if they want to continue with the solution of INITI8 and what the possible next steps are.
5.6.2 Simulation model

Already requirements were defined for the simulation model to make it useful for the workshop in paragraph 2.1. These requirements are used as basis to evaluate the simulation model in this paragraph. The simulation model is used in the workshop as communication instrument to create insight in the current situation of handling parcel tankers for the actors. To make it possible to communicate with the participants the processes simulated in the model should be understandable and recognizable by the participants who are not experienced with simulation. To achieve this, the GIS map of the port of Rotterdam is used as environment where the actors can see ships move over water to the different animated terminals and buoys. Sometimes it was necessary to support the simulation model with diagrams, especially when explaining activities at berth. Therefore, the processes at berth could be better visualised and this has to be taken into account when the simulation model is extended. Furthermore, not all waiting queues are simulated, for example the waiting queues for surveyors are not animated. This would also give more insight in the process and is necessary to add to the simulation model.

With the simulation model the overall process of parcel tankers in the port of Rotterdam was explained and discussed. During this discussion it became clear that actors do not have insight in the overall process, because of some questions asked. In the expert validation of the simulation model and in the workshop the participants indicated to not miss activities relevant for the port stay of parcel tankers in the simulation model. Thus, the simulation model is valid.

A multi-actor network with autonomous, competitive actors, which do not want to share sensitive company information with each other can be found in the situation of handling parcel tankers. To create commitment of the actors for further research, it is important that they can find their kind of environment in the simulation model and see the possibilities for their own decision-making. So they have to be aware that it is possible with the simulation model to see the effect of for example other planning techniques on their performance and the performance of the overall process. The world-view process-interaction is chosen to reflect the autonomy in the simulation model and an object-oriented language is used to protect the information sharing between actors. The question is if the requirement of keeping the autonomy and competitiveness of actors protected is met by the simulation model. It is difficult to say, because during the workshop the actors could only see the simulated processes and did not have insight in the way the simulation model was built. What can be said is that the actors all committed to further research with help of this simulation model. This is an indication that the actors experienced the simulation model as reflecting the current situation correctly which also includes their kind of environment. They had the feeling that their values of autonomy and competitiveness were taken into account in the workshop and the simulation model. The simulation model would be useful in further research. It is, however, important for the continuation of the commitment that actors also
in the future have the feeling their autonomy and competitiveness stays protected, something which has to be constantly monitored. Furthermore, with the simulation model experiments were done so the actors could get acquainted with the effects certain variables have on the port time of parcel tankers. Participants gave input for different experiments. As expected, increasing the number of surveyors, terminal operators and berths were mentioned. To not delay the workshop too much, an indication was given by the facilitator with which percentage the number of the different resources could be increased and which combinations of these variables could be made. In this way, the simulation model also gave insight in the current situation and the effects of increasing the capacity of the resources. After the experiments were done and more insight was created, the analysis of the current situation was explained to the actors. The actors did believe the unreliable planning could be the cause for the long port time, which is an indication that the analysis could be correct.

In short, the simulation model is valid and gives insight in the overall process of handling parcel tankers. It reflects the autonomy and the non-sharing of information between actors involved in this environment. However, not all activities that need to be visualised are animated, like the activities at berth and not all waiting queues are animated. If the simulation model is used in further meetings, the animation of the simulation model has to be extended.

5.7 SWOT ANALYSIS
This paragraph is confidential. For more information contact INITI8 at info@initi8.nl.
6 CONCLUSIONS AND RECOMMENDATIONS

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