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Simulation Study Lock Complex IJmuiden

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Abstract

The port of Amsterdam is confronted with a limited capacity of the lock complex IJmuiden, giving access to the port of Amsterdam. Not only the capacity of this lock complex might limit the growth of the throughput of the port but also availability of only one big lock chamber reduces the attraction of the port.
This paper describes the estimation of the capacity of the approach to the port of Amsterdam, including the lock complex, using traffic flow simulation models. The paper deals with the following items:

- *Description of the traffic flow simulation model Approach Amsterdam The capacity of a port system can only be determined if the required* service level in terms of acceptable waiting times or turnaround times is provided. In most ports of the world, a lot of parameters controlling the ship traffic are stochastic of nature. This necessitates the development of probabilistic traffic flow simulation models to estimate waiting times due to occupation of channel sections and the lock complex. An outline will be given of the functioning of the traffic flow simulation model "Approach Amsterdam".
- *Management of the lock system*

As the lock system in the approach to the port of Amsterdam is the most dominant component in the turnaround times of the vessels. The description of functioning of this the lock complex constitutes the main part of the simulation model. As a consequence the lock will be described in detail.

1 Introduction

For a sound estimation of the capacity of the approach to the Port of Amsterdam in terms of number of ships that can be handled per year with an adequate service level and an adequate safety level, simple methods are not good enough.
An approach system with a complicated lock complex, a lot of different fleet types combined with a complex wet infra structure can only be schematized as a complex system.
To determine the capacity of such complex approach system traffic flow simulation models are an indispensable tool. For this reason the traffic flow simulation model "Approach Amsterdam" has been developed. The "process description method" is considered as an appropriate and efficient method. This method describes the behaviour of each live component and the interactions with other components. The model simulates the ship movements from arrival buoy to the different destinations.
In broad lines an overview of the configuration of the model is given in Figure 1.
The lock complex consists of 4 locks of which 3 are used for commercial traffic.

The dimensions of the locks and belonging vessel dimension limits are given are given in the in Table 1.

Table 1: Lock and belonging vessel dimension limits

Lock	Lock dimensions	Vessel dimensions
North Lock	Length = 400 m Width =47 m	length >180 m width >18 m draught >8 m
Middle Lock	Length= 200 m Width= 25 m	110m >length <180 m 17 m > width <18 m 5.8 m >draught <8 m
South Lock	Length=104 m Width= 18 m	length <110 m width <17 m draught <5.8 m

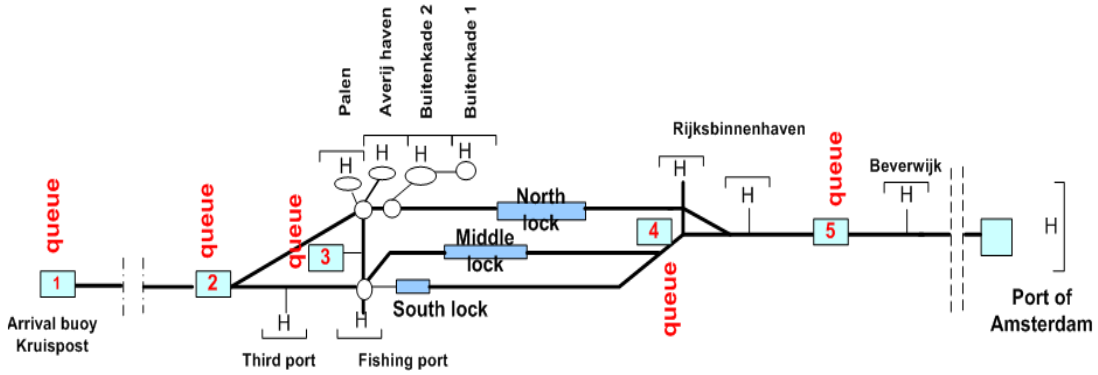


Figure 1: Configuration model Approach Amsterdam

Three main vessel categories are distinguished:

1. Vessels with destinations sea side of the the lock complex
2. Vessels passing the locks complex coming from:
   a. Outer buoy
   b. from locations land side of the lock complex:

Table 2 shows the sea vessels with destination Amsterdam.

Table 2: Vessels from outerbuoy destination Amsterdam year 2005

Fleet	Ship type	Destination	Origin	Calls in 2005
1	Car carriers	Port of Amsterdam	sea	115
2	Supply vessels	Port of Velsen	sea	9
3	Bulk carriers	Port of Amsterdam	sea	529
4	Tankers	Port of Amsterdam	sea	1116
5	Container vessels	Port of Amsterdam	sea	43
6	General cargo	Port of Amsterdam	sea	2097
7	Cruise vessels	Port of Amsterdam	sea	91
8	Refrig. Cargo vessels	Port of Beverwijk	sea	119
9	Ro-ro vessels	Port of Amsterdam	sea	479
10	Dredgers	Port of Amsterdam	sea	387

2 Model description

The structure of this traffic flow simulation model consists of two parts:

a. The definition part
   In the definition part the structure of the model in terms of components, attributes of components and the interactions between the components are defined.
b. The dynamic part
   This part describes the behaviour of the components.

Table 3 shows the most important components with the modules.

Table 3: Components and modules of the model "Approach Amsterdam"

Component	Process description
Main	Initializes the structure of the model and reads input files
Generator (class)	Generates the ship traffic and assigns the attributes of the ship. Four generators are distinguished: 1. Vessels from outer buoy to destinations Port of Amsterdam 2. Vessels from outer buoy to lightening location and from there to the Port of Amsterdam 3. Vesels from outer buoy to destinations sea side of the lock complex 4. Vessels from amsterdam to destination sea side of the lock complex
Ship (class)	Describes the process of the component ship
Lockmaster (class)	Describes the process of the lock
Lock (class)	Data component describes the status of the lock
VTS (class)	Checks traffic situation for a requesting vessel
Tidal conditions	Determines the tidal conditions
Section Occupation	Reserves the channel section for an arriving vessel

2.1 Process of the generators

As shown in Table 3 four generator types are used to generate the ship traffic the traffic in this area.
When a ship has been generated the attributes are assigned.
The main attributes are listed below:

1. "Ship class" and "Lock class"
2. Length
3. Draught
4. Incoming and outgoing route
5. Ship speeds in the various port sections
6. Separation time with respect to other vessels
7. Service time (mooring, unloading, loading and demooring)
8. Tidal windows (if applicable)

The "Ship class" is mainly used to specify the traffic rules, for instance to determine whether it is allowed to overtake or to meet another ship in a certain channel section.
The "Lock class" is used to set the potential locks to be used for the vessel if the vessel passes the lock complex.

Ships with lock class 1 can only be locked by the North lock (because of the ships' dimensions), lock class 2 by the North and Middle lock while lock class 3 can be accomodated by by all locks.

2.2 Process of the ship

A ship is generated by the corresponding generator.
As an example the ship with destination Amsterdam is given (see Figure 1). The ship starts her process at the outer buoy. Six tracks are distinguished:
Track 1: from outerbuoy to queuing location lock
Track 2: from queuing location to assigned lock (sea side, queue 2 for ships >55000 dwt or queue 3 for ships < 55000 dwt)
Track 3 from lock to port
Track 4: from port to queuing location for lock
Track 5 from queuing location to assigned lock
Track 6 from lock to the outer buoy where the ship leaves the approach system.

A track can only be taken when the VTS has granted permission depending on the traffic situation and taking into account tidal windows.
The lock masters decide which lock will be assigned and when the lock is ready to receive the vessel.

2.3 Ship traffic rules and management of the lock system

Many ports in the world do not have strict appointed traffic rules as encounter and overtake possibilities in the different channel sections, traffic rules in turning and mooring basins, safety separation times between vessels and priorities. Nevertheless for safety reasons each port applies traffic rules. Therefore discussions with VTS-operators and the pilot organizations are the basis of the traffic rules applied in this capacity simulation study.
For the situation 2005 the model distinguishes 42 channel sections. Figure 2 shows the channel sections around the lock complex. For each channel section traffic rules have been formulated with respect to encounters overtaking and turning manoeuvres depending on ships classes.

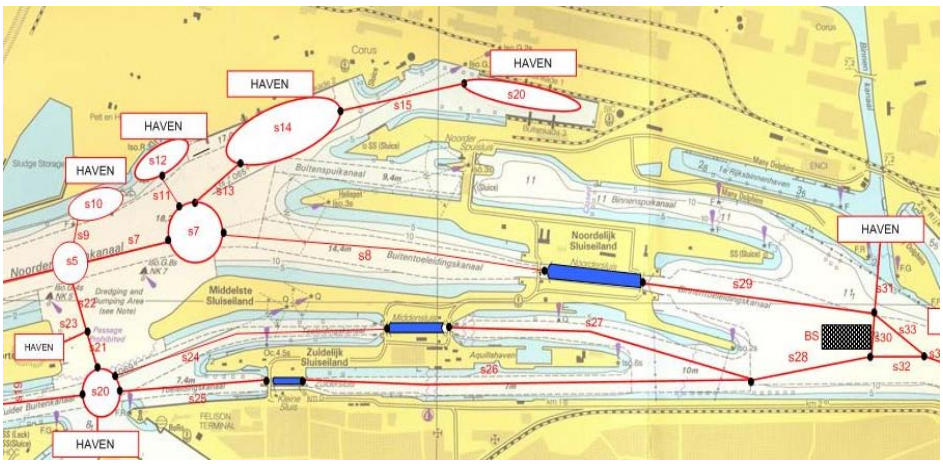


Figure 2: Lock complex with channel sections

When a ship is turning or manoeuvring in a manoeuvring area, indicated as a circle or ellipse (see Figure 2), no other ships are allowed in this area at the same time

In principle the assignment of a lock is based on the FIFO-discipline and the lock class of the ship. Figure 3 shows an example of lock assignment the figures give the order of arrival times. Depending on the status of the locks, ships will be selected for the next locking of the individual locks. Priority will be given to tidal bound vessels and Cruise vessels.

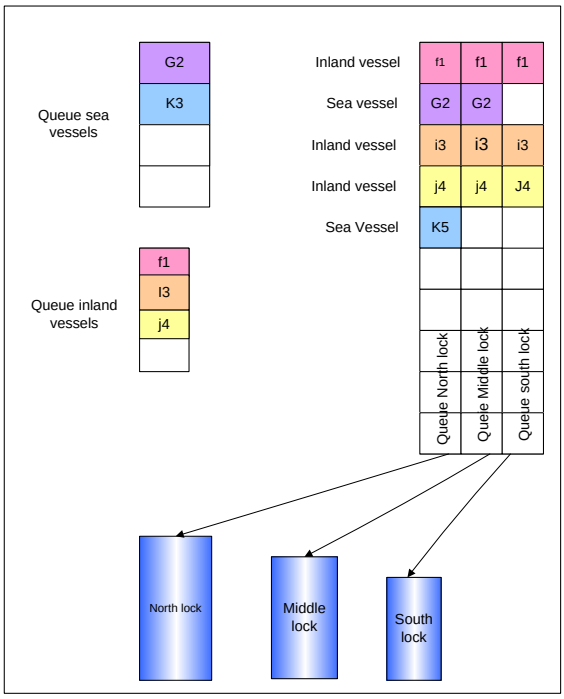


Figure 3: Lock assigning procedure for ships bound for Amsterdam

2.4 Process of the lockmasters

Each lock is provided with a lock master who decides on the lock management:

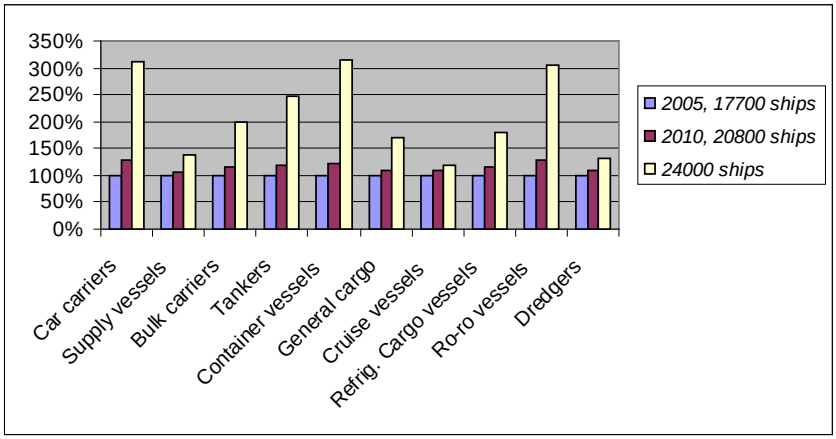
1. The ships to be locked in the next locking,
2. Locking without ships,
3. Waiting for a ship with a tidal window or an arriving vessel

This is the most complicated part of the model as for an efficient lock management the lockmaster has to deal with many situations.

3 Simulation results

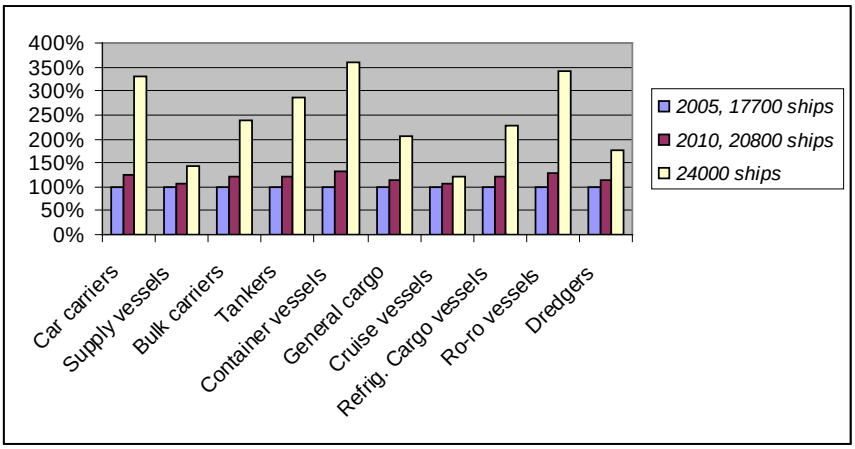
Figure 4 and Figure 5 show the simulation results of the transit times, from outer buoy to the Port of Amsterdam and reverse. The figures are given in percentage of transit times in 2005.

Figure 4: Transit times from outer buoy to port of Amsterdam, incoming vessels



Three situations are simulated 2005 with a traffic volume 17700 ships, 2010 with a traffic volume of 20800 ships and a situation with 24000 ships. The increase of the transit times in 2010 is still modest, but when dealing with 24000 vessels per annum the increase for deep drafted vessels goes up to 300% which not acceptable. So it is concluded that additional lock facilities are required when traffic volumes between 20800 and 24000 vessels are using the approach to Amsterdam.

Figure 5: Transit time from Port of Amsterdam to outerbuoy, outgoing vessels



4 Conclusions

1. Capacity models satisfy quite well the demands.
   The accuracy strongly depends on the input data as the arrival pattern, the service time and applied traffic rules. In most ports of the world, traffic rules will always bring about higher ship waiting times specially when dealing with high traffic intensities.
2. The traffic management of the lock complex with respect to the different fleet types strongly influences the transit times and waiting times of the vessels. Therefore a careful formulation of the lock procedures is required.
3. Additional lock facilities are required when traffic volumes between 20800 and 24000 vessels are using the approach to Amsterdam.(zie boven)

5 References

DE GANS, O, 2005, Personal Prosim Manual 2005, Prosim bv"., *Zoetermeer*, The Netherlands, p 1-96

GROENVELD, R (2000), Service systems in ports and inland waterways, *Delft University of Technology, Faculty of Civil Engineering and Geosciences*, Delft, The Netherlands p 1- 76

GROENVELD, R., HOEK, C.V.A. (2000): A simulation tool to assess nautical safety in port approaches, *Seminar of the Permanent Commission for Development and Co-operation of PIANC*, Buenos Aires, Argentina, CD p 1-24

GROENVELD, R., ONASSIS, I., VAN WIJHE (2002), H.J., Safety and capacity wet infrastructure Puerto America Venezuela, *Book of abstracts PIANC-AIPCN congress*, Sydney, Australia, CD S7B P102, p 1-14