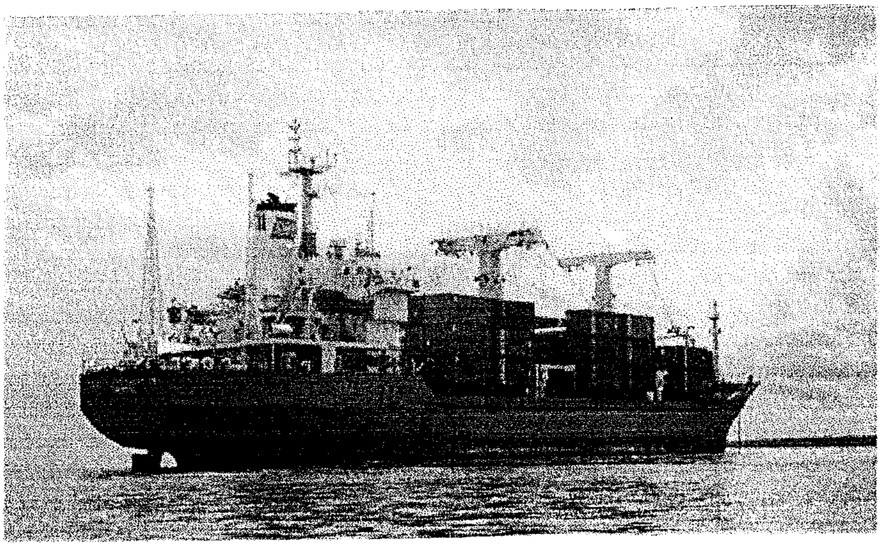
Optimisation of the depth of the navigation channel of the Musi river.

June 1, 1997

Rogier P. Brans



TU Delft
Technische Universiteit Delft

Faculteit der Civiele Techniek

Project description

This thesis is made for the graduation part of the educational program of Civil Engineering. It is part of a project in accordance with the co-operation between the Delft University of Technology (DUT) and the Institut Teknologi Sepuluh Nopember Surabaya (ITS).

Project title:	Optimisation of the depth of the navigation channel of the Musi river.
Discipline:	Hydraulic Engineering.
Purpose:	To find the depth for the Musi river shallow parts, in order to keep the waiting time for the vessels as short as possible.
Outputs:	Inventory of vessel movements in current situation. Model for vessel traffic simulation. Waiting costs for different vessel types for different river depths. Lowest sum of shipping costs and dredging costs, including river works, resulting in the optimum dredging depth for the Musi river.
Study location:	Musi river Palembang, South Sumatra, Indonesia
Project period:	October 1996 - December 1996: Surabaya, Indonesia January 1997 - April 1997: Delft, The Netherlands
Research methods:	Literature survey. Statistical analysis of vessel data. Numerical modelling of Musi river in DUFlow. Simulation model of vessel movements in PROSIM software. Consultation of advisors.

Organisation

Co-operating institutes:

Indonesia:	P.T. Pelabuhan Indonesia II, the harbour authority for Southern Sumatra and West Java.
Indonesia:	Institut Teknologi Sepuluh Nopember Surabaya (I.T.S.). -Fakultas Teknik Sipil dan Perencanaan, Jurasan teknik Sipil (F.T.S.P.-J.T.S.).
The Netherlands:	Delft University of Technology. -Faculty of Civil Engineering, Hydraulic and Geotechnical Engineering section. -Centre for International Co-operation and Appropriate Technology (C.I.C.A.T.).
Sub-commissioners:	Public port of Palembang, Boom Baru. Fertiliser Company, P.T. Pusri. Oil company, P.T. Pertamina.

Project team DUT:	Rogier P. Brans	Student
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	Ir. R. Groenveld	
	Ir. F. A. J. Waals	

Summary

In this report a prediction has been made for the influence of water depth in the Musi river on the shipping costs for vessels that call the harbour of Palembang. To this day shallow parts remain in the navigation channel. Due to these shallow parts vessels often have to postpone their entry of the Musi river until the tide provides enough depth. The vessels which call Palembang harbour have relatively low payloads, because they reduce the payload in order to have lower waiting times. A larger depth can also lead to a higher payload. From 11.3 the conclusions can be drawn that an increase of water depth will lead to shorter waiting times on the Musi river and possibly to an increase in payload, thus making less calls necessary. From chapter 12 the conclusions can be drawn that the optimum water depth for the Musi river is around LWS -6.5 m. For this depth the line for the fleet with 30% draught increase is favourable (Figure 49). This means that the optimum cost reduction can be attained for a draught increase in the order of 30% where possible. The reduction for the shipping costs is in the order of 30 billion Rupiah per year.

R. P. Brans

Delft, June 1, 1997

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1. Introduction

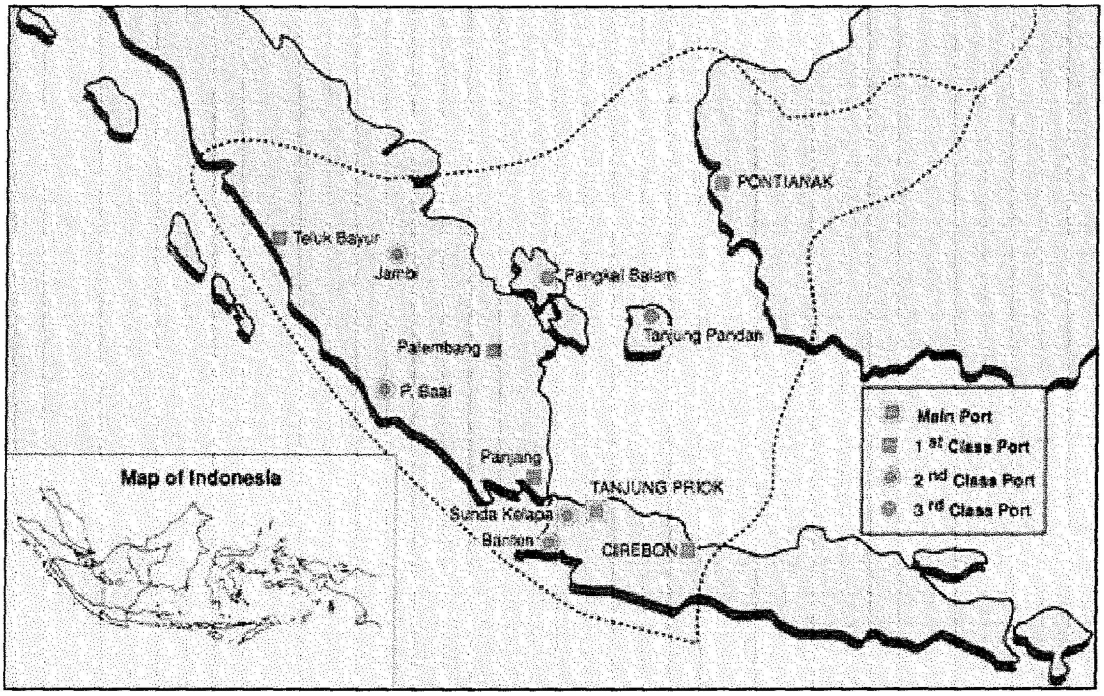

Figure 1 Indonesia

Palembang is the capital city of the province of South Sumatra, Indonesia. The port of Palembang is situated approximately 100 km up the Musi river[1] from the deep sea. A number of shoals in the river and a bar[2] at the entrance restrict the navigability of this river. Being a tidal river, navigation is also dependent on the incoming and outgoing tide. Nevertheless, there is fairly extensive development along both river banks, where various waterfront industrial facilities are equipped with loading/ unloading facilities.

[1] In *Bahasa Indonesia*, (the spoken language), the word *Musi* means tidal.

[2] A bar is a shallow part in the river.

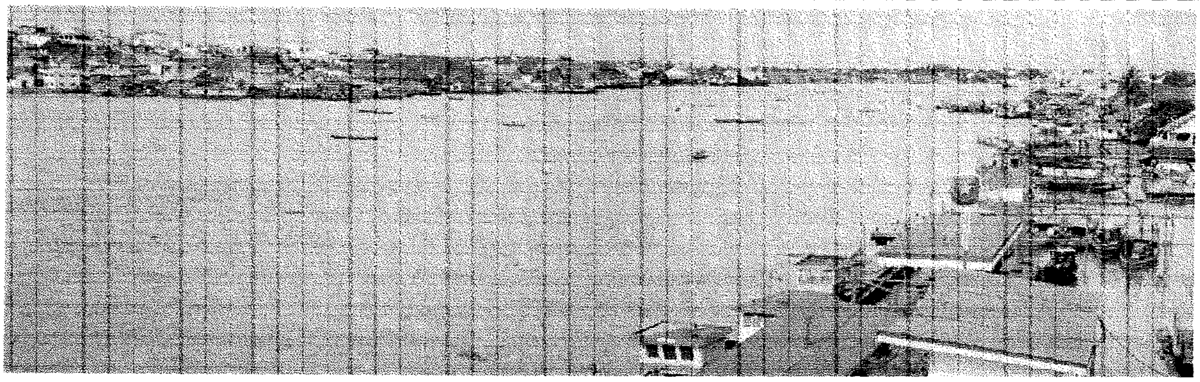

Figure 2 The city of Palembang along the Musi river banks

For the sake of the large vessels which call Palembang the Musi river is dredged annually. The pursued minimum water depth is LWS[3] -6,5 m. This depth is not maintained constantly [12]. To this day shallow parts remain, where the water depth is even less then LWS -6,5 m (Figure 32). Due to these shallow parts vessels often have to postpone their entry of the Musi river until the tide provides enough depth.

The vessels which call Palembang harbour have relatively low payloads, because they reduce the payload in order to have lower waiting times. A larger depth can also lead to a higher payload.

The Palembang port authorities want to study the feasibility of deepening the Musi river navigation channel.

The feasibility study consists of three parts:

a river study
a dredging study; and
a vessel traffic study.

This is the vessel traffic study in which the movements and dimensions of the vessels calling at Palembang have been analysed. A computer simulation model was used to simulate the behaviour of the vessels in a new environment with higher water depths. A comparison has been made between the shipping costs and the costs for dredging. The costs for dredging and

[3] LWS is an abbreviation for Low Water Spring. This is the lowest water level reached in the spring tide (see Figure 33)

shipping are related to the water depth. The lowest total costs are used as criteria to determine the optimum water depth, being the objective of this study.

2. Problem analysis

2.1 Occurring problems

The occurring problems can be summarised as follows:

- The river is too shallow, therefore:
    - shipping agents use small vessels and/or partially loaded vessels; or
    - vessels have to wait for high water to sail the Musi river

2.2 Problem definition

The following problem definition therefore was formulated:

- What is the optimum water depth of the navigation channel of the Musi river, based on a certain fleet composition.

2.3 Objectives of the study

The objectives of this study where formulated as follows:

- to estimate the reduction of shipping costs by increasing the nautical depth.

This will be achieved by using a simulation model for the current vessel traffic flow and to predict the response of the vessels on an increased nautical depth.

Using the results of a study by Haskoning [10] in which the costs for maintenance dredging, capital dredging and river works are estimated, a prediction for the optimum water depth for the Musi river will be made.

3. Present situation

3.1 The navigation channel of the Musi river

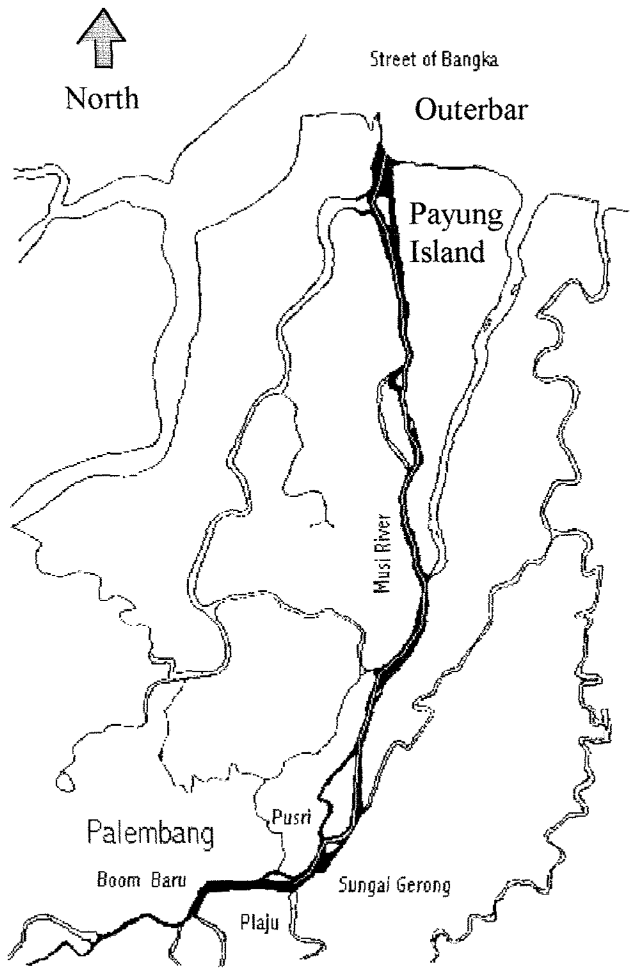

Figure 3 The Navigation channel of the Musi river

The navigation channel from the sea to Palembang has a length of approximately 100 km (Figure 3). The channel is used by vessels with draughts exceeding 4.5 m. Currently the minimum depth maintained for most of the navigation channel is LWS - 6.5 m. This depth is not maintained at all locations. In the navigation channel there are two bars that constrict today's shipping operations:

- the outer bar in the mouth of the Musi river; and
- the western channel around Payung Island.

Here the minimum depths are respectively LWS -4.9 m and LWS - 3.6 m [5]. As a result of these insufficient depths the larger vessels have to postpone their entry of the Musi river until they can sail from the sea to Palembang without having to stop in the river or vice versa.

The current minimum breadth of the navigation channel from the sea to Palembang is maintained at approximately 150 m all along the river [5], [16]. The largest vessels that currently sail to Palembang have a draught of 6 m, and a breadth of 30 m. For a two lane channel and these vessels a breadth of 150 m and a depth of approximately 6.6 m is recommended [2]. This means that the navigation channel is a two lane channel for most of the length.

3.2 A description of the Palembang port terminals

Loading and unloading of cargo at the port of Palembang is partly carried out at the public terminal and partly via the private terminals.

The following port terminals are operating in Palembang (Figure 4). In the second column the average number of ship calls to the terminal is given:

	vessels/month
• Boom Baru	60
• Pertamina	90
• Pusri	30
• Mariana	12
• P. Borang	4
• Kertapati	10
• P. Burung	3
• Selat Jaran	4

Table 1 Vessel calls per terminal

In order to get reliable statistical data, the terminals with only few vessel calls per month have been combined to one terminal. These vessels often call at several of the terminals in one visit as well, making it difficult to analyse the data. Most of these vessels also have small draughts and are therefore not of large influence to changes in the nautical depth in the simulation model of the river. These terminal do not pay for the maintenance of the river, they will therefore gain from a deepest possible water depth of the Musi river[4].

[4] The costs for the current maintenance of the river are paid by P.T. Pertamina (60%), P.T. Pusri (25%) and the Port of Palembang harbour authority (Boom Baru) (15%) [according to Pertamina harbour officials]

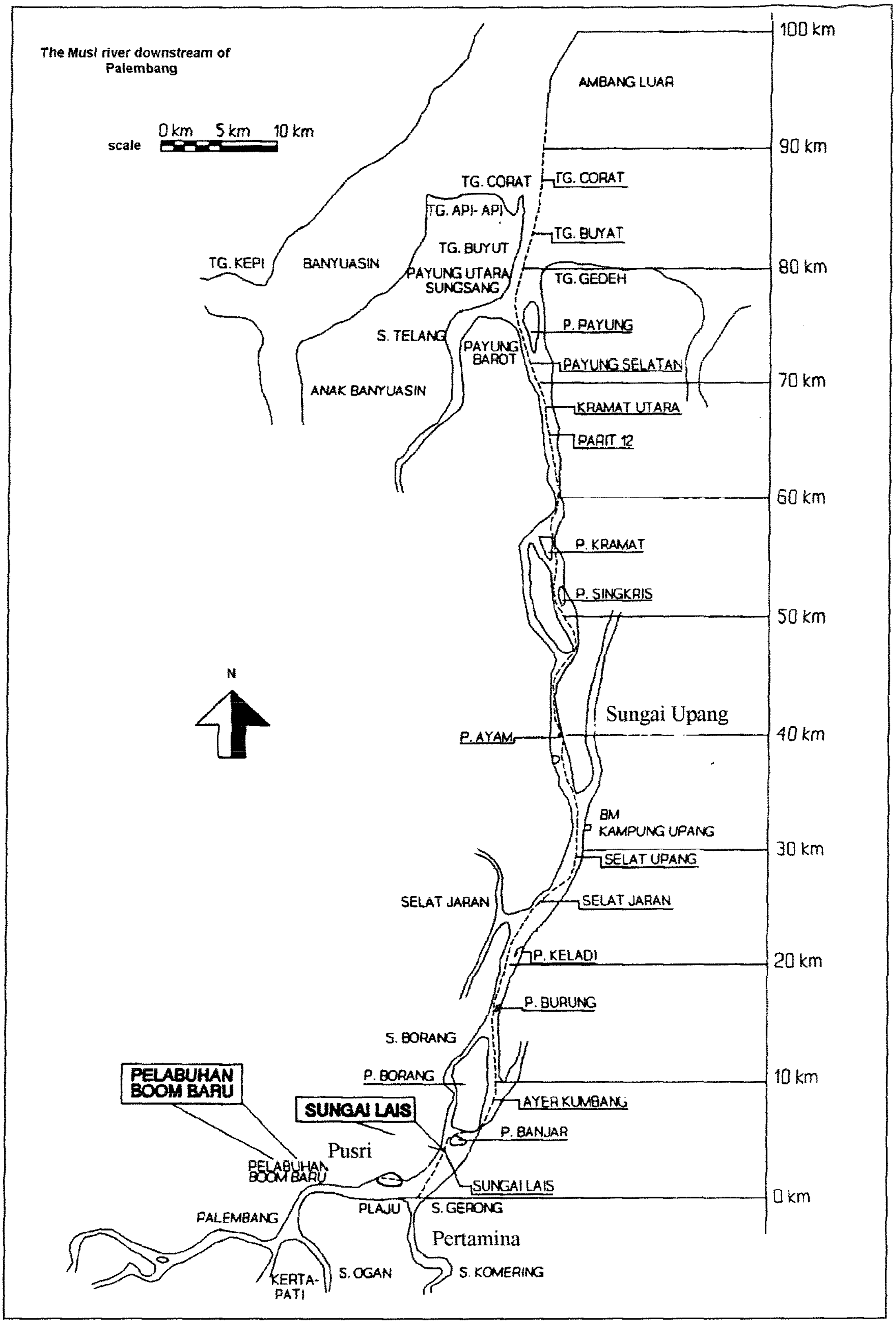

Figure 4 The Musi river

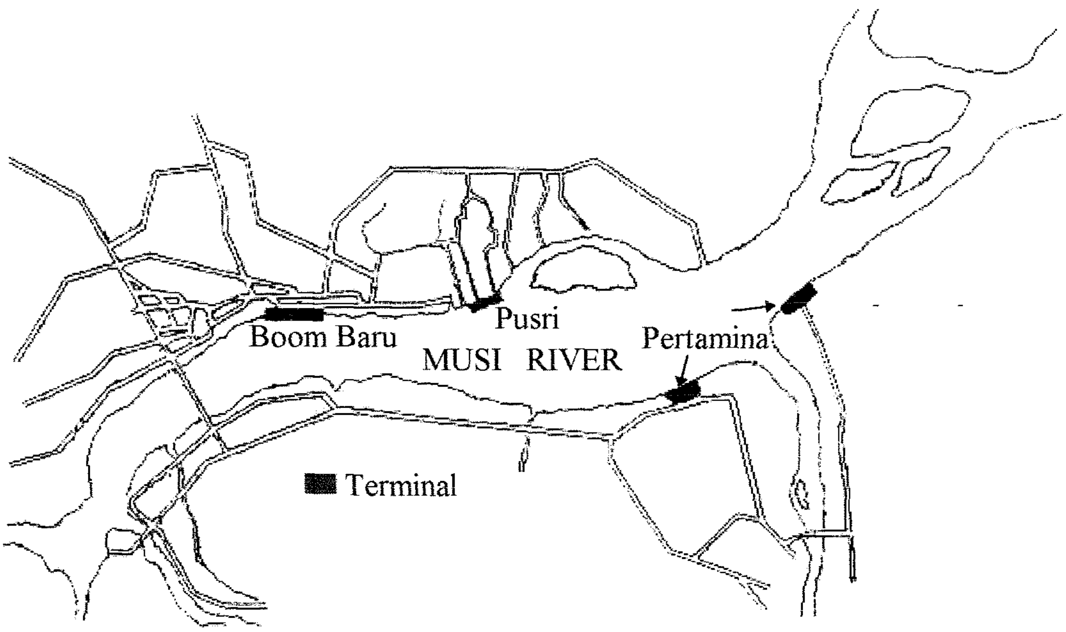

Figure 5 Port of Palembang

In the following paragraphs the characteristics of the terminals will be specified.

3.2.1 Boom Baru Terminal

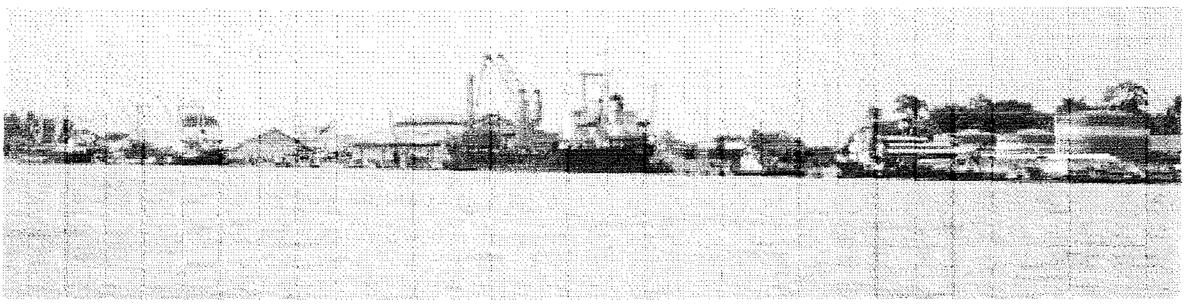

Figure 6 Boom Baru terminal

The Boom Baru Port is equipped with facilities to serve both ocean going and inter-island vessels. It supports general cargo and containers. And consists of the following wharves:

- Boom Baru public terminal. The public terminal consists of two quays for general cargo with lengths of 475 m respectively 265 m.
- Container wharf. The container wharf consists of one quay with a length of 280 m; and

- Mid-river mooring facilities for general cargo (dolphins).

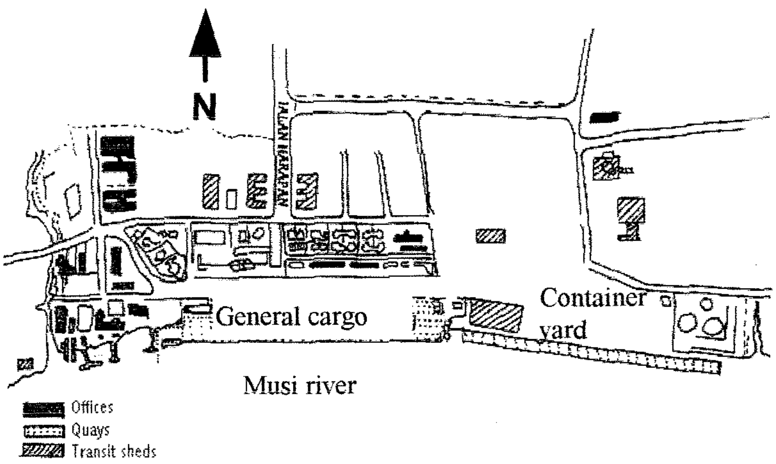

Figure 7 Boom Baru terminal map

For information about the vessel characteristics please refer to paragraph 7.2

3.2.2 P.T. Pertamina Terminal

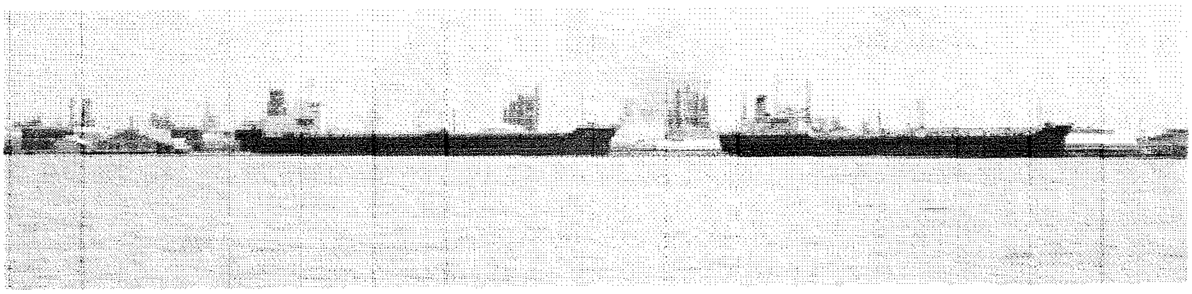

Figure 8 Pertamina terminal (Sungai Gerong)

The Pertamina terminal is part of an oil refinery, belonging to the national oil company P.T. Pertamina. It consists of the following oil jetties:

- Plaju (291 m quay length); and
- Sungai Gerong (301 m quay length).

For the maintenance and repair of their fleet, Pertamina operates a docking unit at Plaju. [28]

For information about the vessel characteristics please refer to paragraph 7.3 or [28]

3.2.3 P.T. Pusri Terminal

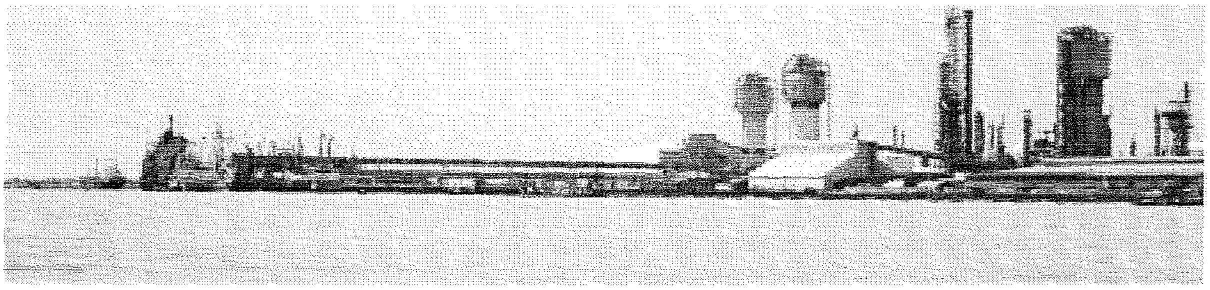

Figure 9 Pusri terminal

P.T. Pupuk Sriwidjaja. (P.T. Pusri) is the first fertiliser plant in Indonesia. The plant produces among others ammoniac (1,499,000 ton/year) and urea (2,280,000 ton/year) [29]. The plant uses the following quay:

- One quay with a length of 680 m and a capacity of 2,120,00 ton per year.

For information about the vessel characteristics please refer to paragraph 7.4 or [29]

3.2.4 Terminal 'Rest'

The other terminals have been joined to a fictive terminal:

- Kertapati (3 berths for Coal and cement, length 250 m, 50 m and 80 m)
- Mariana (1 quay for plywood)
- P. Burung (1 quay for plywood)
- P. Borang (1 quay for plywood)
- Selat Jaran (2 quays for plywood).

For information about the vessel characteristics please refer to 7.5

4. Methodology

4.1 Why a simulation model is used

The system that has to be analysed is very complex. Therefore it is inefficient to apply an analytical model for calculating the optimum water depth. A computer simulation model is a very effective tool to predict changes in the current situation. The software used for this simulation model is PROSIM. PROSIM is an advanced software system for combined discrete/continuous simulation using a personal computer. With this software system the situation in Palembang can be simulated. The model PALEMBANG was developed for that reason. With the right input parameters this model can simulate the current situation and predict the reactions of the system when some parameters are changed. In chapter 5 a description is given about PROSIM. In chapter 6 a description is given about the model PALEMBANG.

4.2 The input parameters for this simulation model

4.2.1 Vessel traffic data

The Surabaya Institute of Technology (ITS) has conducted a survey on vessel movements. Data of all incoming and leaving vessels have been collected. These vessel data were modified in order to use them for the PROSIM model PALEMBANG. A description of these data is given in chapter 7. The data were processed using *MS Excel* and fitted to functions with the help of the package *BestFit*.

4.2.2 Musi river data

The water levels in the Musi river are computed using DUFlow. DUFlow is a micro-computer package for the simulation of one-dimensional unsteady flow and water quality in open channel systems. It can be used, amongst others, for the calculation of water levels. Mutsaers [18] and Heukelom [11] have designed a model to predict the water levels in the Musi river. A description of the use and implementation of these data is given in chapter 8.

4.3 Verification and validation of the model

In chapter 9 the PROSIM model PALEMBANG is verified by tracing the movements of several vessels to and from their destination. The model is validated by calibrating the results for the waiting times for the current situation in the model with the results from the data.

4.4 Calculation of the shipping costs

A model is designed to predict the annual shipping costs, using the results of the PROSIM model. This model is described in chapter 10. In chapter 11 the results of the shipping costs for different water levels are described. Chapter 12 concludes with an estimation of the optimal depth.

5. PROSIM model development

5.1 Introduction

PROSIM is an advanced software system for combined discrete/continuous simulation using a personal computer. Simulation is used to study the dynamic behaviour of a system by means of experimentation with a model of that system. A model is a description of the "real life system" by leaving out all non relevant aspects. A model is used instead of the system itself because actual experimentation with the system is too expensive. The model is represented as a program for a digital computer [22]. The program that is used for this solution is called PALEMBANG[5]. This program will generate computer data. The data will show the behaviour of the model. If the model is valid the model generated data will be similar to data obtained from the system itself. The investigations carried out to discover whether a model is valid or not are called validation. Validation is achieved through calibration of the model, an iterative process of comparing the model to actual system behaviour and using the discrepancies to improve the model. When the model is validated, it can be used to predict the behaviour of the system in circumstances that are different from the current situation.

Because validation is a difficult process the model first has to be verified before validating it. Verification concerns a series of tests to check if the behaviour of the model is satisfactory. Verification refers to the questions:

- are the input parameters and logical structure of the model correctly represented; and
- is the model implemented correctly in computer code.

5.2 How to take samples from a distribution

Characteristics such as inter arrival times, service times and dimensions of vessels are set by chance. From a large number of observations a distribution can be made. The observations

[5] PALEMBANG is a program based on the program HARBORSIM, which is used to simulate complex port systems. The HARBORSIM program is extended with among others a stretched entrance channel and an extra anchorage.

are sorted in classes of a certain width. The number of observations in a class can be divided by the total number of observations, creating a probability density function (p.d.f.).

Class	Number	p.d.f.	c.d.f.
2	3	5	5
3	10	17	22
4	12	20	42
5	15	25	67
6	14	23	90
7	5	8	98
8	1	2	100

Table 2 Observations

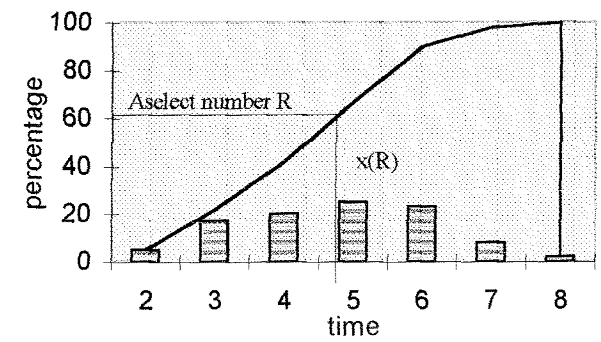

Figure 10 Cumulative distribution function

When the probability density function is cumulated a cumulative distribution function (c.d.f.) is created. Random numbers are defined as independent draws from the uniform distribution in the interval (0,1). Random numbers are a necessary basic ingredient in the simulation of almost all systems. PROSIM has a subroutine that can generate random numbers using the multiple congruency method. This method generates a cycle of pseudo random numbers based on the following algorithm:

$$\frac{1}{a} - \left(\frac{6c}{am}\right)\left(1 - \frac{c}{m}\right) \pm \frac{a}{m'} \qquad (4.1)$$

m : 2^{31}-1

a : 7^5

c : 0

Each integer from 1 to 2^{31}-2 appears just once somewhere in the cycle. Each number in the cycle can be obtained as a function of its predecessor. Therefore any number in the range 1 to 2^{31}-2 can be used as a starting point for a series of random numbers forming part of the cycle, without any chance of repetition. This starting number is called the seed of a random-stream. When a random number R is generated, x(R) is determined using the cumulative distribution function (Figure 10).

PROSIM can transform a random number, to among others the following distributions:

- Uniform; a lower bound and an upper bound need to be obtained.
- Normal; Normally distributed numbers are drawn from a standard noraml distribution table. If R is a random number obtained from this standard distribution, a drawing of the noraml distribution with mean M and deviation D is obtained from the formula: M+D*R.
- Exponential; The exponential distribution is mostly used to model a Poisson arrival process, because the inter arrival times of such a process are exponentially distributed. The only parameter that needs to be obtained is the mean of the distribution.
- Gammashape; The gamma distribution is defined over the interval $(0,\infty)$ and is usually specifeid by a factor k and a factor L. If k is an integer the sistribution is known as the Erlang-k distribution.
- Unknown; If the lower bound, the mean and the deviation of a random process are known, PROSIM tries to find a distribution function with a domain that is as small as possible according to the parameters.

6. Description of the PROSIM model Palembang

6.1 Introduction

PROSIM is using the process description method. The process description method describes the processes of al live components in the model. Live means that these components are executing activities. Characteristics are variables attached to a component to specify and describe the state of that component. Components with the same characteristics belong to the same class of components; for example the vessels [9].

6.2 Terms of reference for the simulation model

For the simulation model the following terms of reference apply:

- the simulation starts at the arrival of vessels at the outerbar. An arrival time is generated from a distribution function of inter arrival times
- processes at the terminals are not simulated, a service time is generated from a distribution function of service times
- the smallest vessels that are simulated have a dwt of 100 tons
- vessels smaller than approximately 6,000 dwt are not obstructed by low water levels, these vessels do not have to wait for the tide and can sail with their maximum payload
- each vessel is given a constant sailing time
- vessels call at only one terminal per visit
- the necessary keel clearance is fixed at 10% of the draught; and
- waiting times are never higher than five days.

6.3 The configuration of the simulation model

The configuration of the simulation model PALEMBANG is represented in Figure 11.

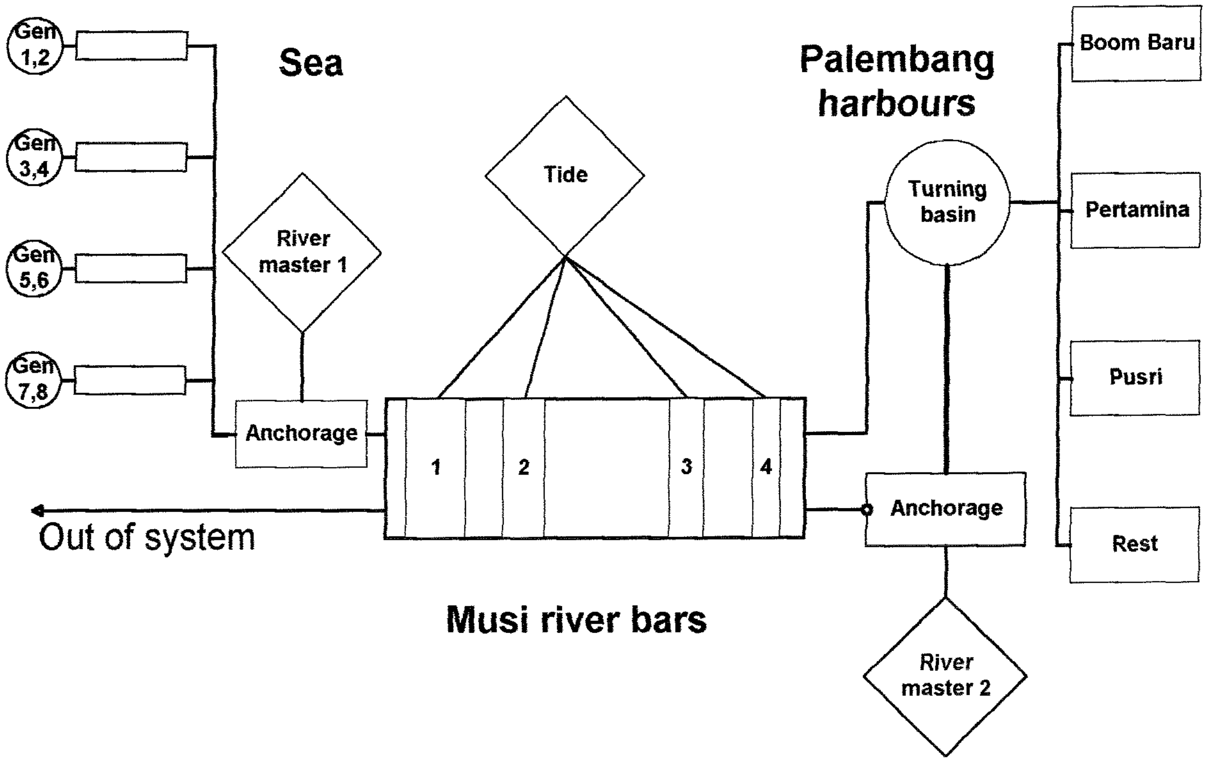

Figure 11 The configuration of the simulation model PALEMBANG

The model exists of a waterway with four bars. At the right end of the waterway the city of Palembang is located. On both sides of the waterway an anchorage is located. The waterway is divided in twelve sections. A description of the modules and input files and the belonging source text can be found in the appendices D through G.

6.4 The verbal model for the vessels

The vessel enters the system at the anchorage at the outerbar, to check the tidal conditions and the traffic situation. The check is carried out by the *river master for incoming vessels* (PRTRAFFCARRM). When permission has been granted the vessel will leave the anchorage queue and will enter the first section. When all the sections have been sailed the vessel will enter the turning basin. When the vessel is permitted to enter the port (the *harbour master for incoming vessels* (PR1HMASTER) checks the traffic situation) a berth will be allocated to that vessel by the *quaymaster* (QMASTERPR). When a berth is assigned and the traffic situation allows entrance, the ship leaves the anchorage queue and "enters" the quay queue of the terminal. When the vessel has been unloaded and loaded (equal to the service time of that vessel) the vessel will leave the berth and return to the turning basin. The *harbour master for outgoing vessels* (PR2HMASTER) checks the traffic situation in the harbour. When permission is granted the vessel will sail to the anchorage queue in the harbour. *River master 2* (PRTRAFFCDEP) checks when the ship is allowed to sail the Musi river again (Tidal conditions and traffic on the Musi river). When allowed, the ship will sail the Musi river and leaves the system.

7. Description of the schematization of the fleet types

As mentioned earlier (chapter 3.2) there are four different port terminals. For each port terminal a fleet type can be defined. In the computer model every fleet type is separated into two sub-fleets. The first sub-fleet consists of the small vessels (vessels with a dwt of less than for instance 6,500 tonnes[6]). The second sub-fleet consists of the rest of the vessels. This separation has been made to make it possible to adjust the encounter and overtaking possibilities: The larger vessels might not be able to encounter or overtake other large vessels in certain river sections[7]. The statistical information is gathered from a registration of vessel movements over a period of seven months from January 1996 until July 1996 [15].

This data was used to create cumulative distribution functions for the inter arrival times, the service times, the sailing times to and from Palembang, the waiting times at the outerbar and at the harbour and the dwt. Relations between the dwt and draught to and from Palembang and between the dwt and the overall length of the vessels were made. This was done in the period of October 1996 through January 1997 [3].

The quay length is based on information in [20], an information brochure distributed by the harbour authorities. The terminals consist of more than one quay. The service times are distributed exponentially. The following inputs are used in the simulation model.

7.1 Determining the inter arrival times and the service times

Cumulative distribution functions were made for the inter arrival time for the different fleet types. These functions can be plotted in a graph. Using the program *BestFit*[8] distribution functions can be fitted to the data. The goodness of fit can be analysed using the

[6] This separation has not been made at the same dwt value. The separation was made in an early stage of the programming. The only reason for the differences was an easier way to divide the fleet into two sub-fleets. It has no significant influence on the simulation results.

[7] In this simulation model the vessels do not overtake because they all sail with the same speed (7.7). In this model there are also no restrictions for encountering another vessel in the Musi river sections.

[8] *BestFit* is a program which can be used to fit functions on a data sample. The result of this fit can be analysed: how well does the input data fit a function. This can be done with the Kolmogorov-Smirnov test. This test compares the empirical distribution to the hypothesised distribution.

Kolmogorov-Smirnov statistics. *BestFit* then gives a ranking of the functions that best fit the input data. For the results of this statistical analysis please refer to Appendix H. The functions are plotted against an negative exponential distribution in the next chapters.

7.2 Boom Baru fleet

The Boom Baru fleet is divided into two sub-fleets. The characteristics for the fleet have the following values:

	whole fleet	dwt < 6,500	dwt > 6,500
Percentage	100%	76%	24%
Average inter arrival time (minutes)	816	927	6,800
Annual dwt	2,373,220	1,151,260	1,221,960

Table 3 Characteristics for Boom Baru

The sub-fleets call at the Boom Baru terminal, which has the following characteristics:

- quay length [20] 1,235 meters
- Average service time 2,800 minutes

The functions for the service time and inter arrival time are plotted on negative exponential distributions in Figure 12 and Figure 13. These negative exponential distributions are used in the PROSIM model:

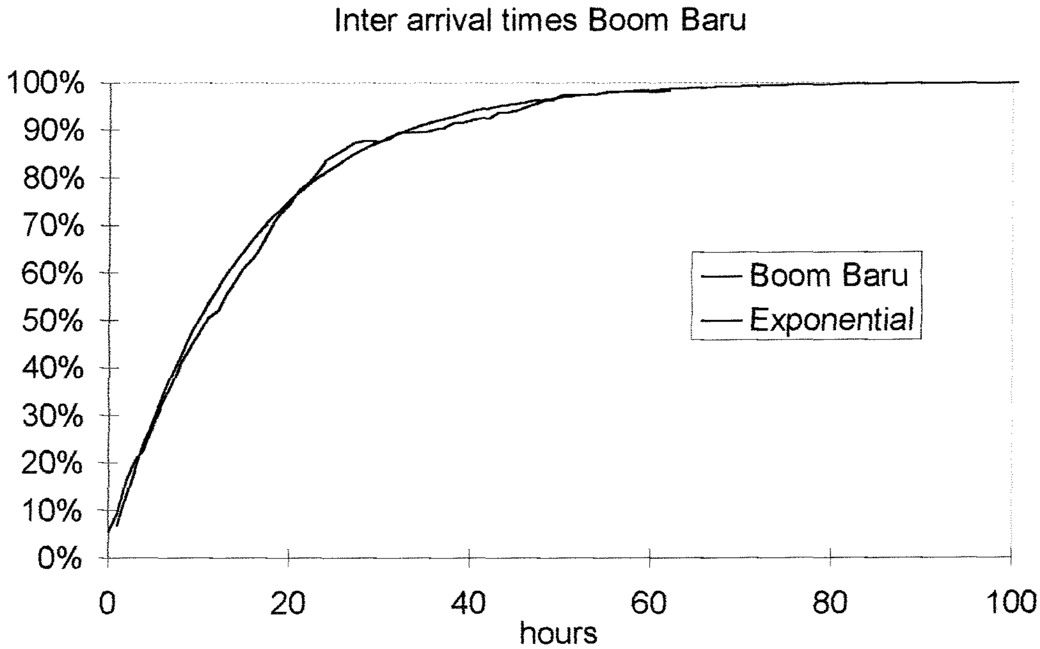

Figure 12 Inter arrival times Boom Baru

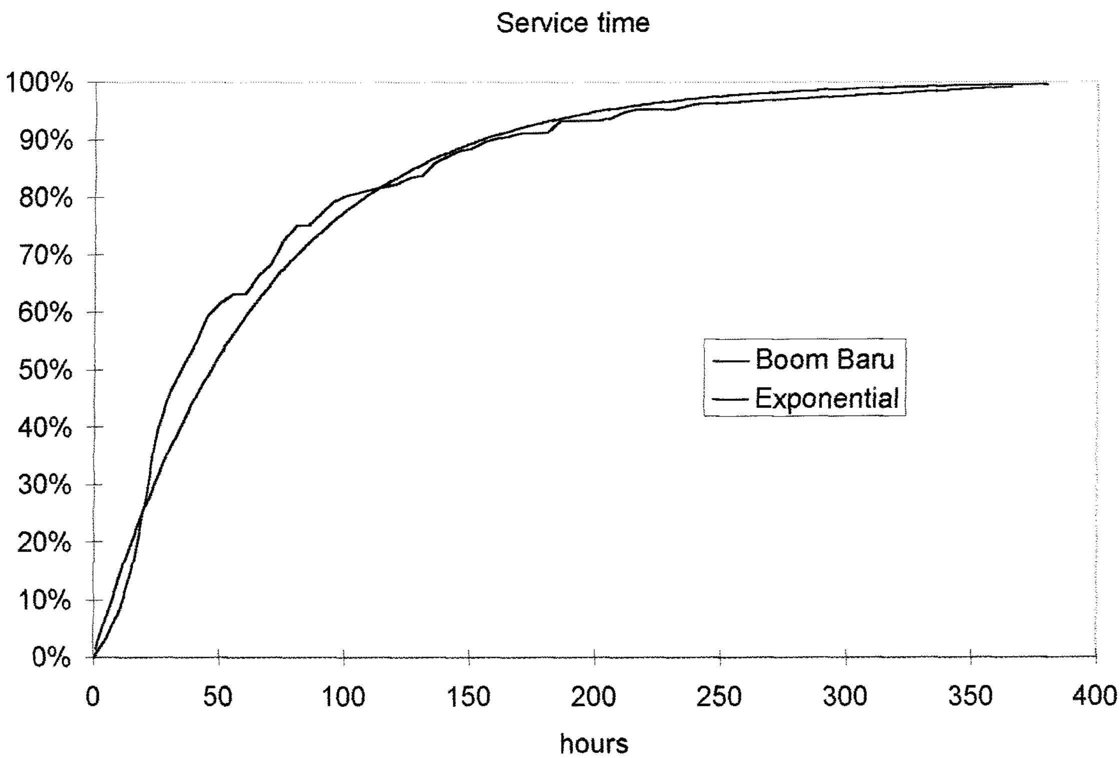

Figure 13 Service time Boom Baru

A cumulative distribution function for the dwt of Boom Baru vessels is necessary to assign the characteristics in PROSIM to the vessels. For the Boom Baru vessels the following cumulative distribution function was made (Figure 14):

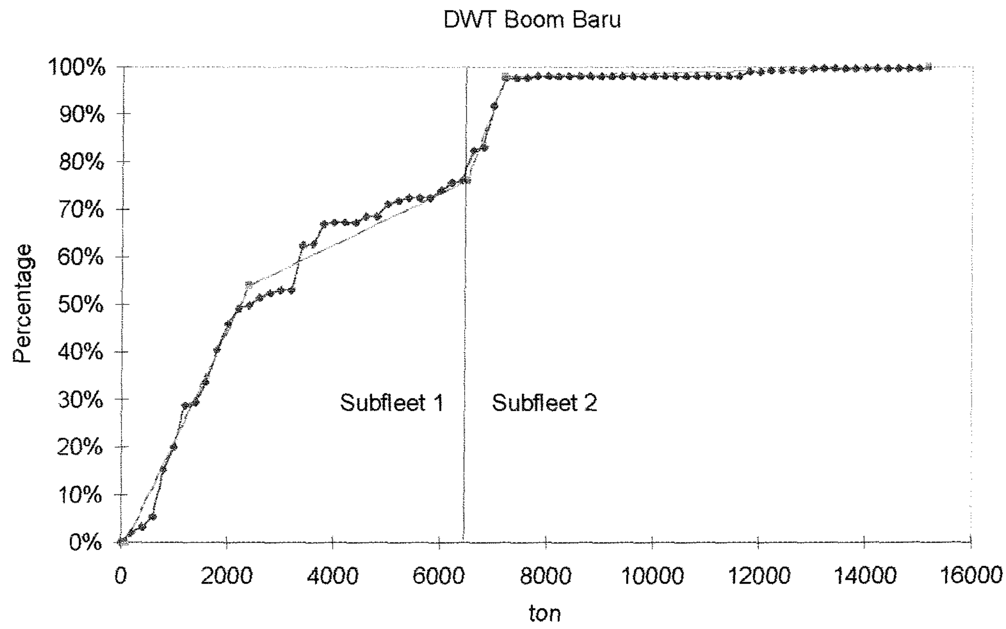

Figure 14 dwt Boom Baru vessels

In PROSIM this function was schematised in the following way for the two sub fleets:

Boom Baru 1	100-6,500 tons		Boom Baru 2	6,500-15,200 tons	
dwt	% total fleet	% sub fleet		% total fleet	% sub fleet
100	0%	0%	6,500	76%	0%
2,400	54%	71%	7,200	98%	92%
6,500	76%	100%	15,200	100%	100%

Table 4 dwt Boom Baru vessels

The percentage for the sub fleet was calculated by setting the highest percentage of a sub fleet at 100%. The rest is then related to this highest percentage. For example: for Boom Baru 1 the highest percentage is 76% (of the total fleet). This is set to 100% (percentage of this sub fleet), the second highest is then 54%/76%=71% (of this fleet).

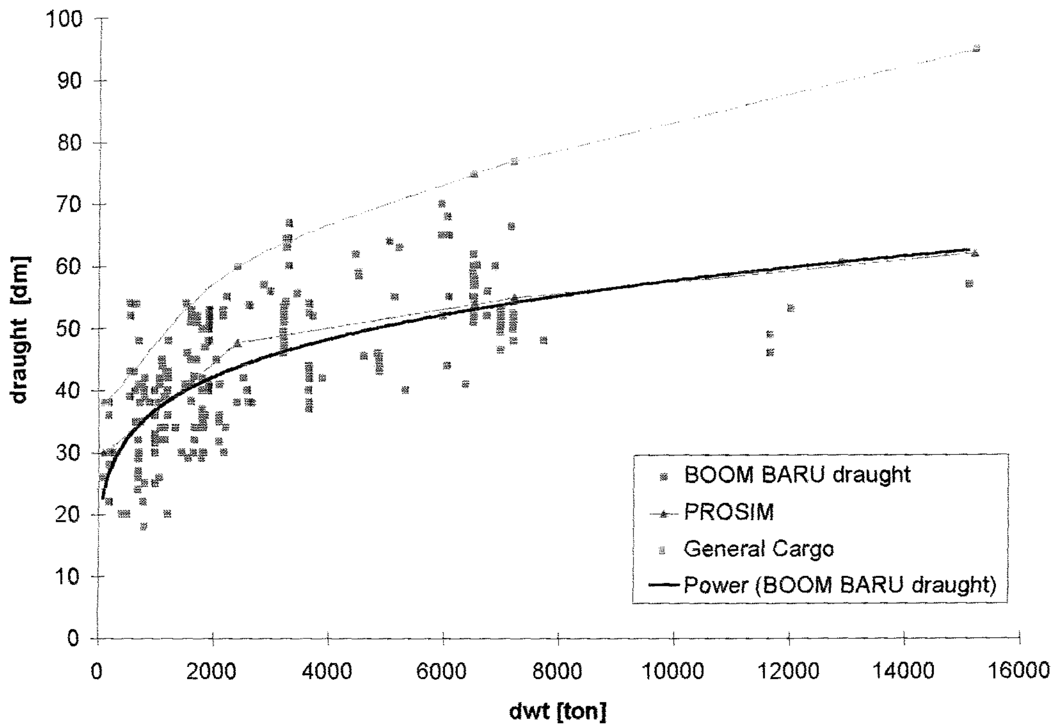

Figure 15 Draught for Boom Baru vessels

In Figure 15 the draught for vessels going to Palembang is plotted in their relation with the dwt of Boom Baru vessels. The function 'General Cargo' is plotted in the graph to show the difference between the actual draught for Boom Baru vessels and the average maximum draught of vessels of the same class [25]. It shows that Boom Baru vessels have lower draughts than usual. The polynomial function shows the average draught of the data for the Boom Baru vessels. The PROSIM function is the schematization used in the simulation model.

7.3 Pertamina fleet

The Pertamina fleet is divided into two sub-fleets. The characteristics for the fleet have the following values:

	whole fleet	dwt < 8,000	dwt > 8,000
Percentage	100%	60%	40%
Average inter arrival time (minutes)	510	729	1,700
Annual dwt	10,062,120	3,058,160	7,003,960

Table 5 Characteristics for Pertamina fleet

The sub-fleets call at the Pertamina terminal, which has the following characteristics:

- quay length [20] 1,200 meters
- Average service time 1,800 minutes

The functions for the service time and inter arrival time are plotted on negative exponential distributions in Figure 16 and Figure 17. These negative exponential distributions are used in the PROSIM model:

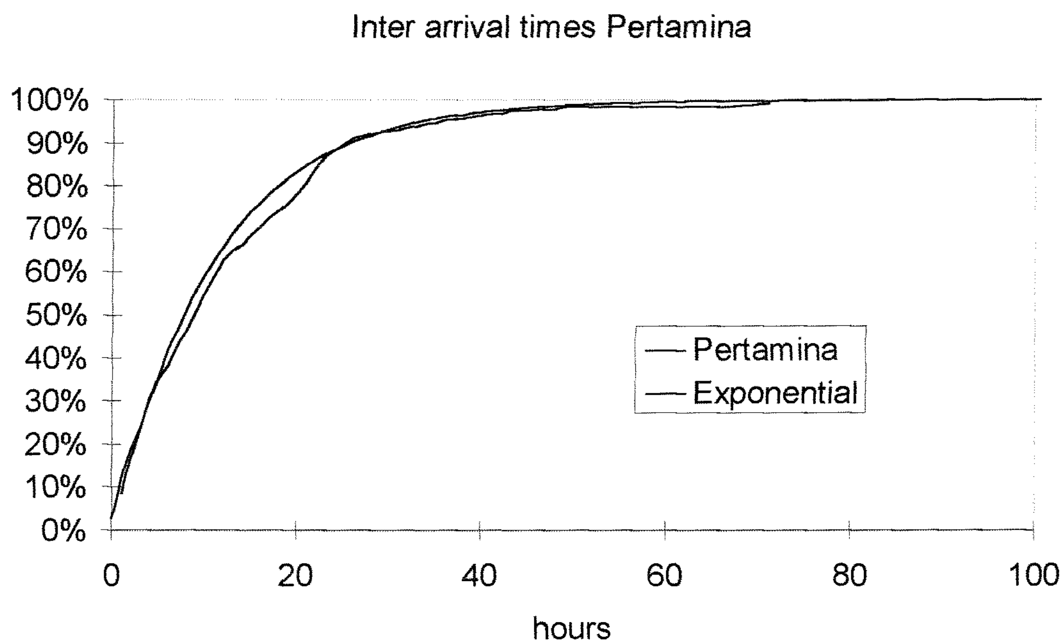

Figure 16 Inter arrival times Pertamina

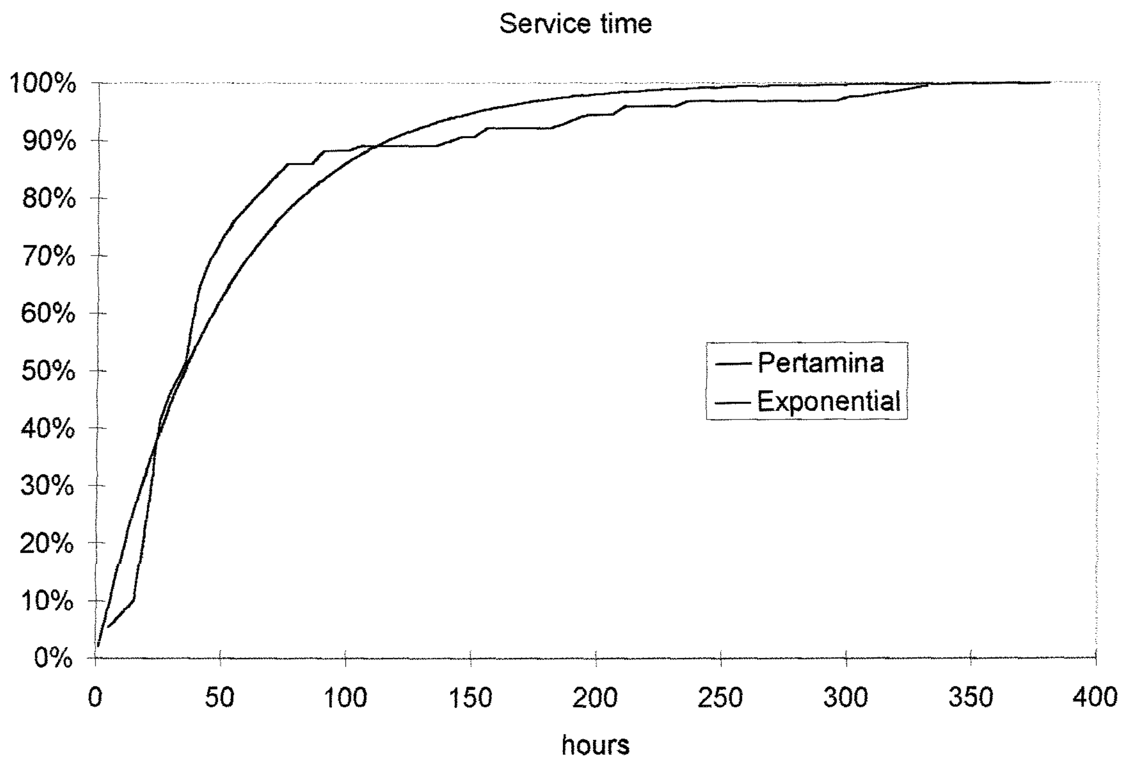

Figure 17 Service time Pertamina

A cumulative distribution function for the dwt of Pertamina vessels is necessary to assign the characteristics in PROSIM to the vessels. For the Pertamina vessels the following cumulative distribution function was made: (Figure 18)

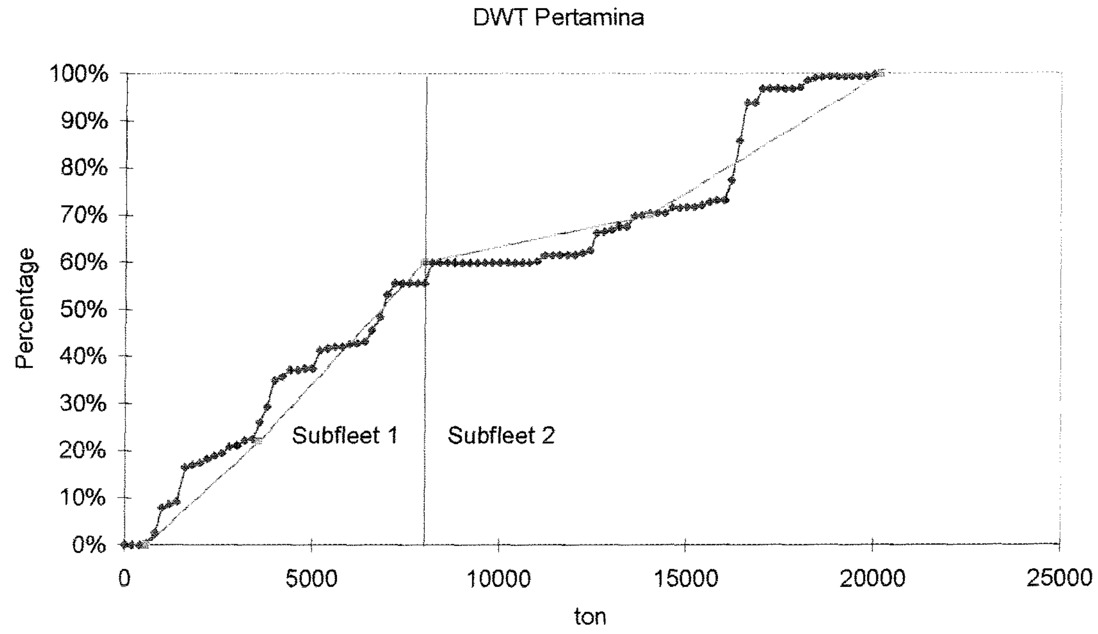

Figure 18 dwt Pertamina vessels

In PROSIM this function was schematised in the following way for the two sub fleets:

Pertamina 1	600-8,000 tons		Pertamina 2	8,000-20,200 tons	
dwt	% total fleet	% sub fleet		% total fleet	% sub fleet
600	0%	0%	8,000	60%	0%
3,600	22%	37%	14,000	70%	25%
8,000	60%	100%	20,200	100%	100%

Table 6 dwt Pertamina vessels

In Figure 19 the draught for Pertamina vessels going to Palembang is plotted in their relation with the dwt of Pertamina vessels. The function 'Tankers is plotted in the graph to show the difference between the actual draught for Pertamina vessels and the average maximum draught of vessels of the same class [25]. It shows that Pertamina vessels have lower draughts than usual. The polynomial function shows the average draught of the data for the Pertamina vessels. The PROSIM function is the schematization used in the simulation model.

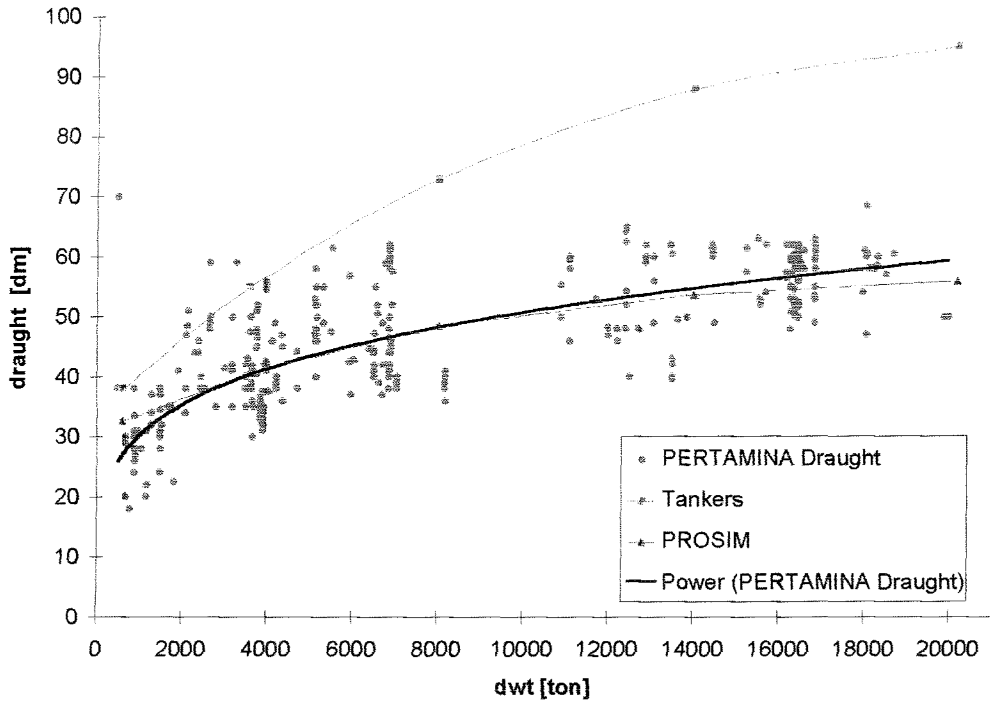

Figure 19 Draught for Pertamina vessels

7.4 Pusri fleet

The Pusri fleet is divided into two sub-fleets. The characteristics for the fleet have the following values:

	whole fleet	dwt < 8,000	dwt > 8,000
Percentage	100%	70%	30%
Average inter arrival time (minutes)	1,390	1,828	5,792
Annual dwt	1,905,133	758,403	1,146,730

Table 7 Characteristics for Pusri fleet

The sub-fleets call at the Pusri terminal, which has the following characteristics:

- quay length [20] 780 meters
- Average service time 2,900 minutes

The functions for the service time and inter arrival time are plotted on negative exponential distributions in Figure 20 and Figure 21. These negative exponential distributions are used in the PROSIM model:

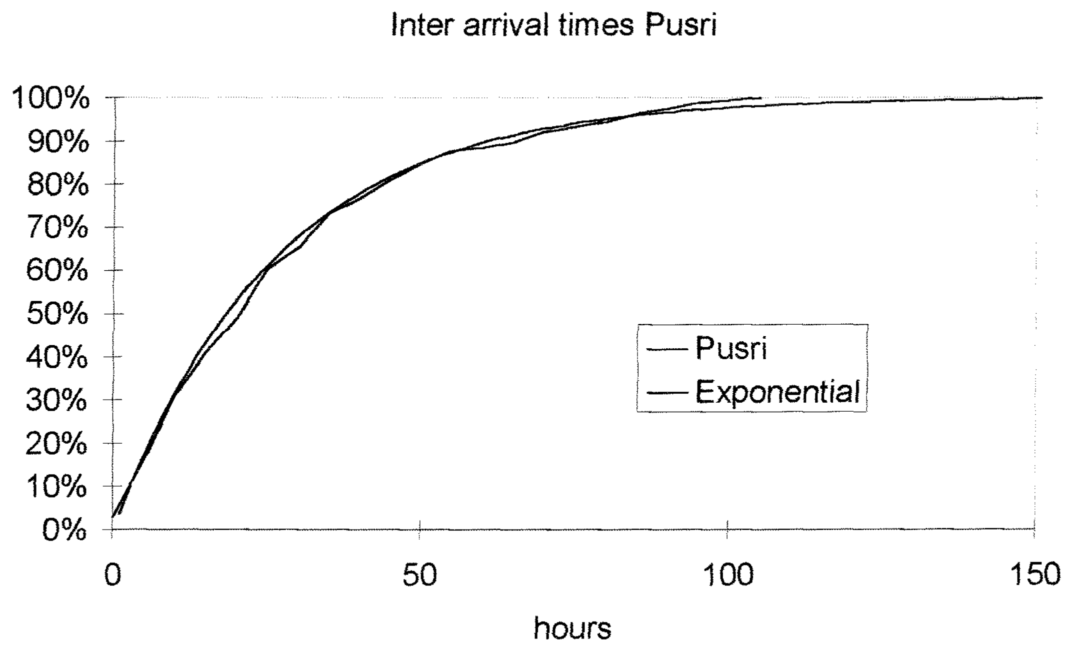

Figure 20 Inter arrival times Pusri

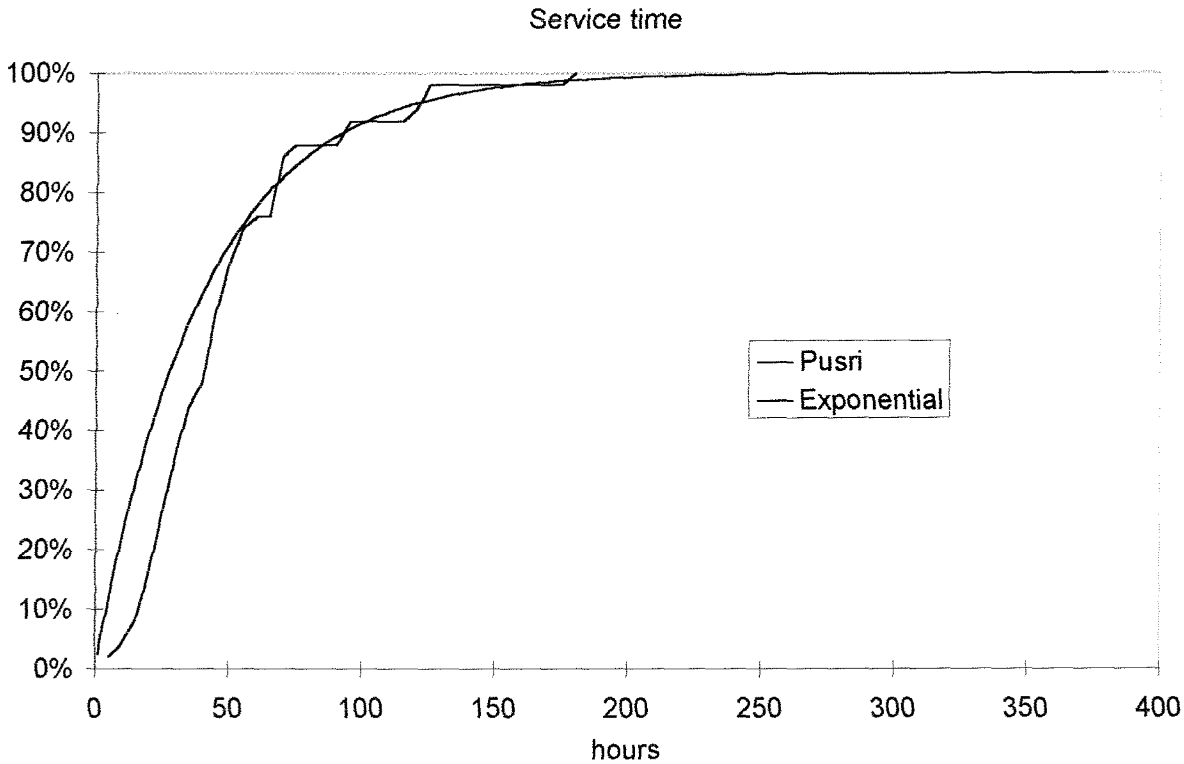

Figure 21 Service time Pusri

A cumulative distribution function for the dwt of Pusri vessels is necessary to assign the characteristics in PROSIM to the vessels. For the Pusri vessels the following cumulative distribution function was made: (Figure 22)

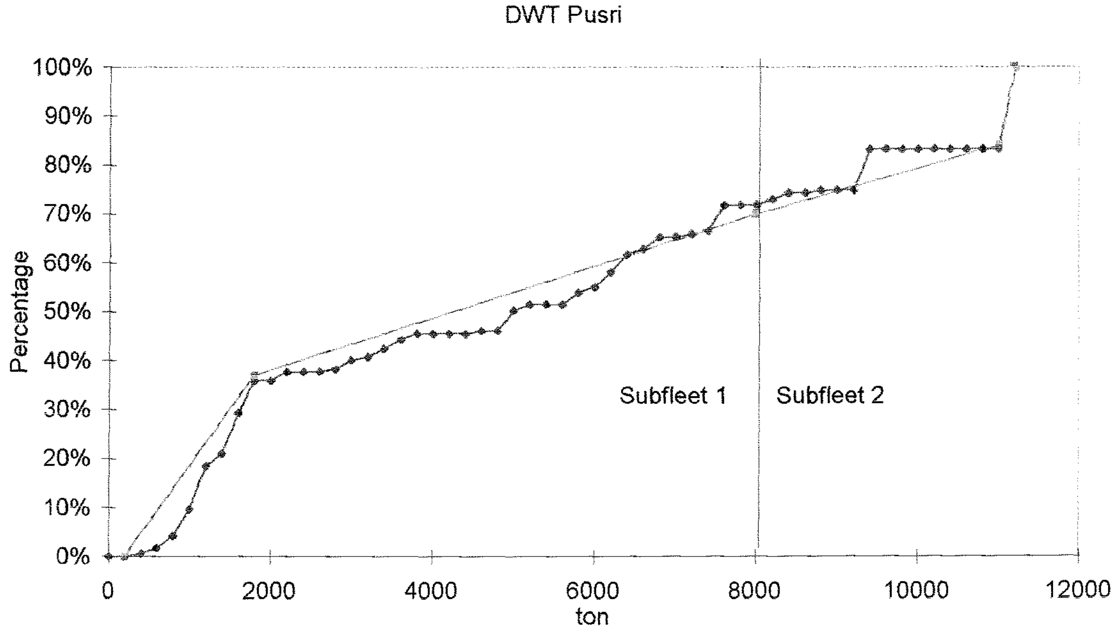

Figure 22 dwt Pusri vessels

In PROSIM this function was schematised in the following way for the two sub fleets:

Pusri 1	200-8,000 tons		Pusri 2	8,000-11,200 tons	
dwt	% total fleet	% sub fleet		% total fleet	% sub fleet
200	0%	0%	8,000	70%	0%
1,800	37%	53%	11,000	84%	47%
8,000	70%	100%	11,200	100%	100%

Table 8 dwt Pusri vessels

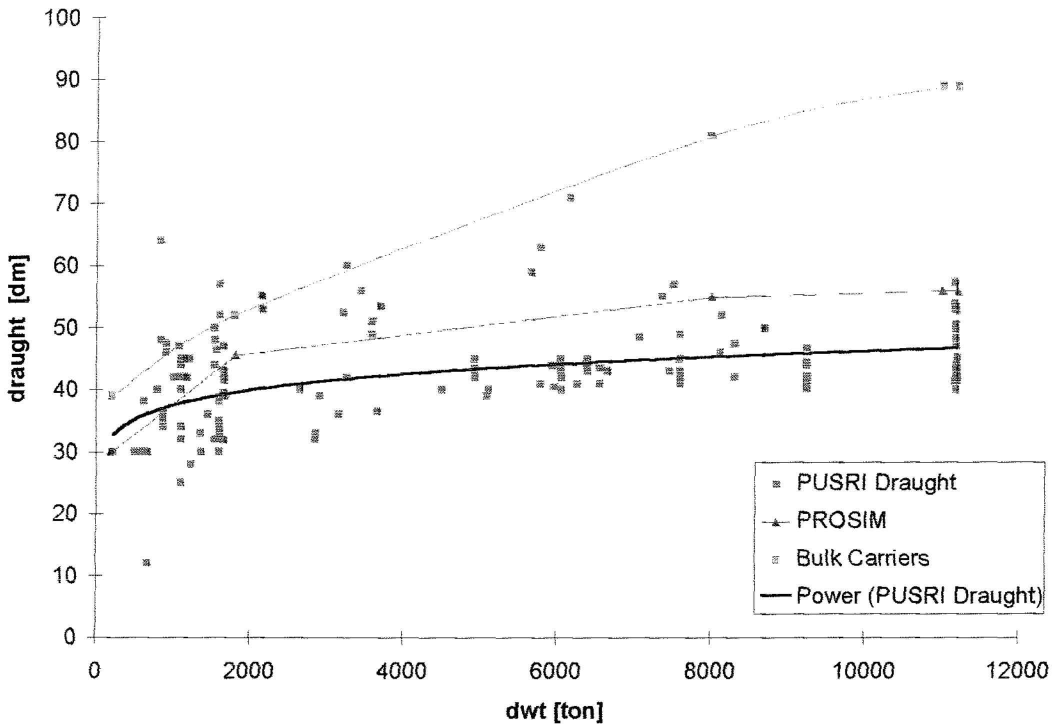

Figure 23 Draught for Pusri vessels

In Figure 23 the draught for vessels going to Palembang is plotted in their relation with the dwt of Pusri vessels. The function 'Bulk Carriers is plotted in the graph to show the difference between the actual draught for Pusri vessels and the average maximum draught of vessels of the same class [25]. It shows that Pusri vessels have lower draughts than usual. The polynomial function shows the average draught of the data for the Pusri vessels. The PROSIM function is the schematization used in the simulation model.

7.5 Rest of the vessels: Fleet Rest

In order to get reliable statistical data, the rest of the vessels have been combined to one fleet. These vessels often call at several of the terminals in one visit, making it difficult to analyse the data. Most of these vessels also have small draughts and are therefore not of large influence to changes in the nautical depth in the simulation model of the river. This fleet is called 'Fleet Rest'. The fleet is divided into two sub-fleets. The characteristics for the 'Fleet Rest' have the following values:

	whole fleet	dwt < 6,000	dwt > 6,000
Percentage	100%	52%	48%
Average inter arrival time (minutes)	1,408	1,696	8,282

Table 9 Characteristics for 'Fleet Rest'

The sub-fleets call at the "REST" terminal, which has the following characteristics:

- Quay length [20] 700 meters
- Average service time 3,100 minutes

The functions for the service time and inter arrival time are negative exponential distributions based on the average of the service time and inter arrival time of the Boom Baru, Pertamina and Pusri terminals. This was necessary because there was not enough information about the service time and inter arrival time of these vessels. A cumulative distribution function for the dwt of the rest of the vessels is necessary to assign the characteristics in PROSIM to the vessels. For the rest of the vessels the following cumulative distribution function was made: (Figure 24)

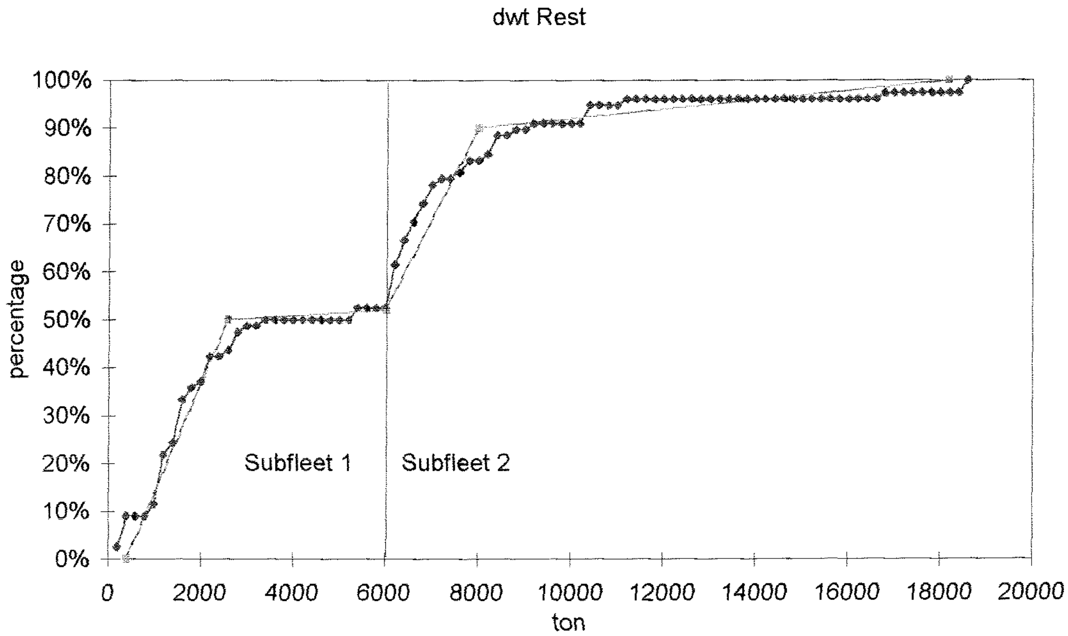

Figure 24 dwt Rest of the vessels

In PROSIM this function was schematised in the following way for the two sub fleets:

Rest 1		400-6,000 tons	Rest 2		6,000-18,200 tons
dwt	% total fleet	% sub fleet		% total fleet	% sub fleet
400	0%	0%	6500	52%	0%
2,600	50%	96%	7,200	90%	79%
6,000	52%	100%	15,200	100%	100%

Table 10 dwt Rest of the vessels

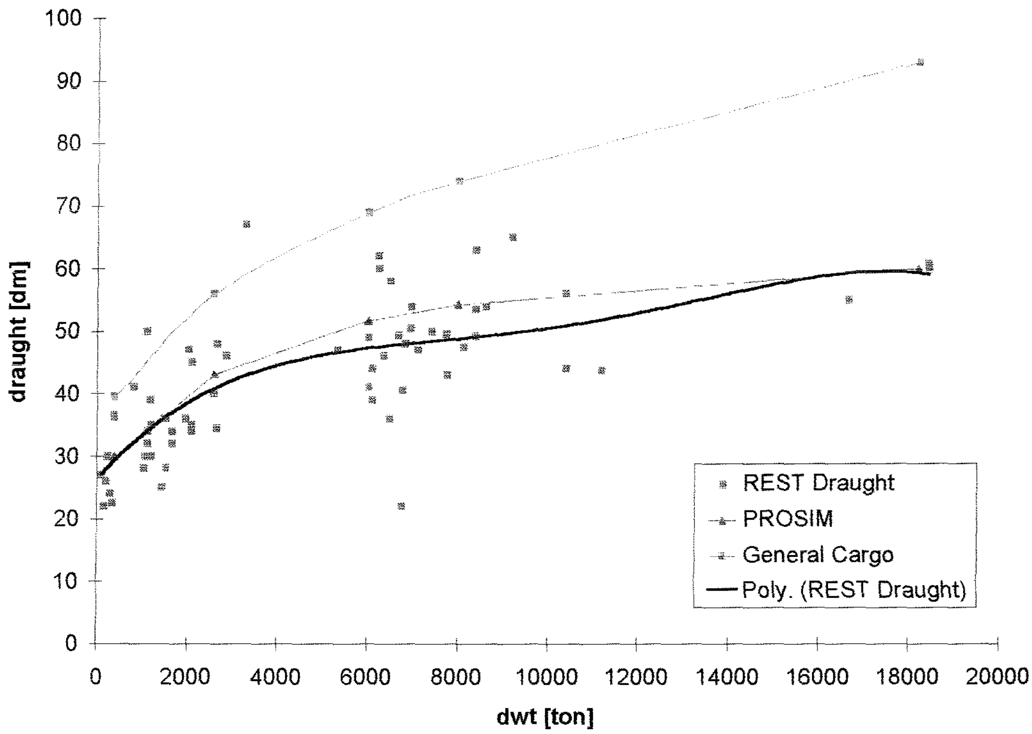

Figure 25 Draught for Rest vessels

In Figure 25 the draught for vessels going to Palembang is plotted in their relation with the dwt of the rest of the vessels. The function 'General Cargo' is plotted in the graph to show the difference between the actual draught for the 'Rest of the vessels' and the average maximum draught of vessels of the same class [25]. It shows that these vessels have lower draughts than usual. The polynomial function shows the average draught of the data for these vessels. The PROSIM function is the schematization used in the simulation model.

7.6 Length over all

The length over all (LOA) in relation to the dwt has also been deduced from the data. The data correspond with the lengths that are common for the vessels according to [25] (Figure 26).

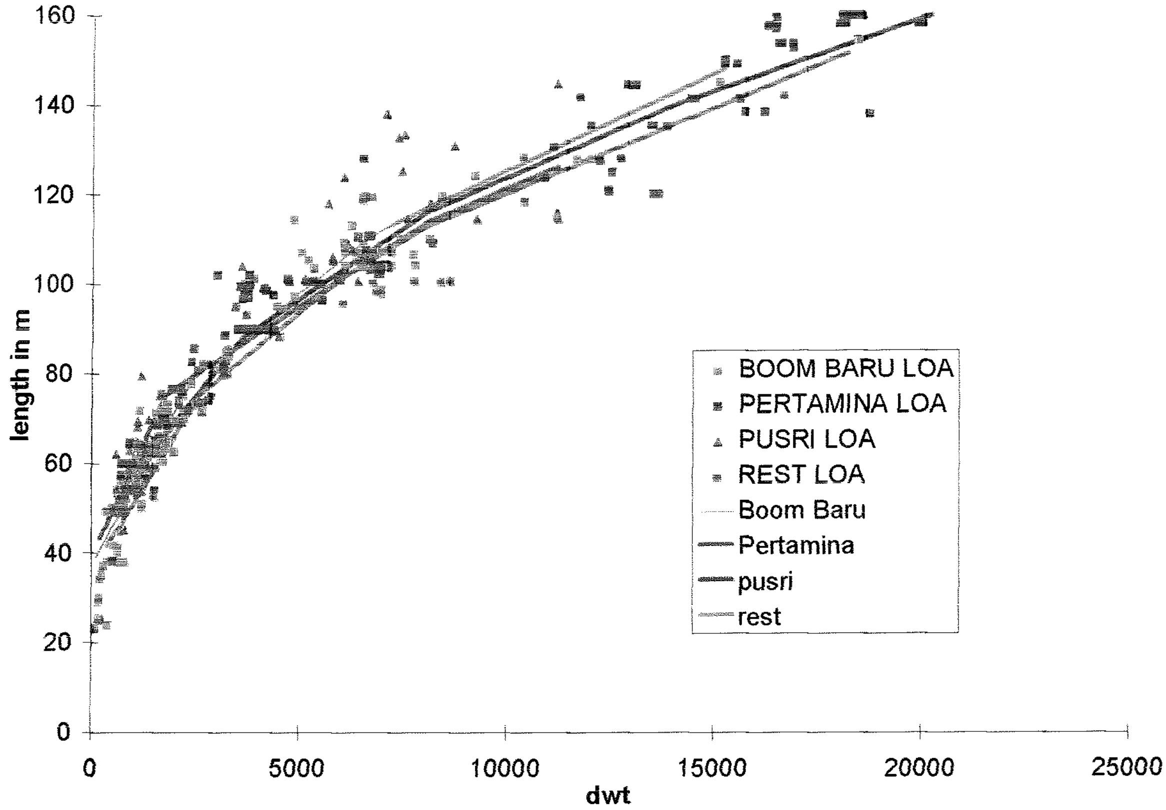

Figure 26 Length over all for all vessels

7.7 Sailing Times

The Musi river is divided in twelve sections (Figure 11) In the input files the sailing times per section are given per vessel. Per section the possibility to overtake or to encounter another vessel is given as well. For each ship type the sailing times for each section is given. The twelve sections of the Musi river are all assumed to be sailed in 30 minutes by all vessels. (The vessels consequently do not overtake other vessels in this simulation). This amounts to a total sailing time for the Musi river of 6 hours which is about average for all vessels [3, Appendix E].

8. Description of the schematization of the Musi river

8.1 The longitudinal profile of the Musi river

The longitudinal profile of the Musi river is composed from the navigation map [5], on which the depths are referred to local LWS. The depths have been taken for each kilometre from the Boom Baru terminal at Palembang to the mouth of the Musi river. These values have to be corrected by the average bottom slope ($1.8*10^{-5}$ [10]) in order to refer the bottom levels to one level.

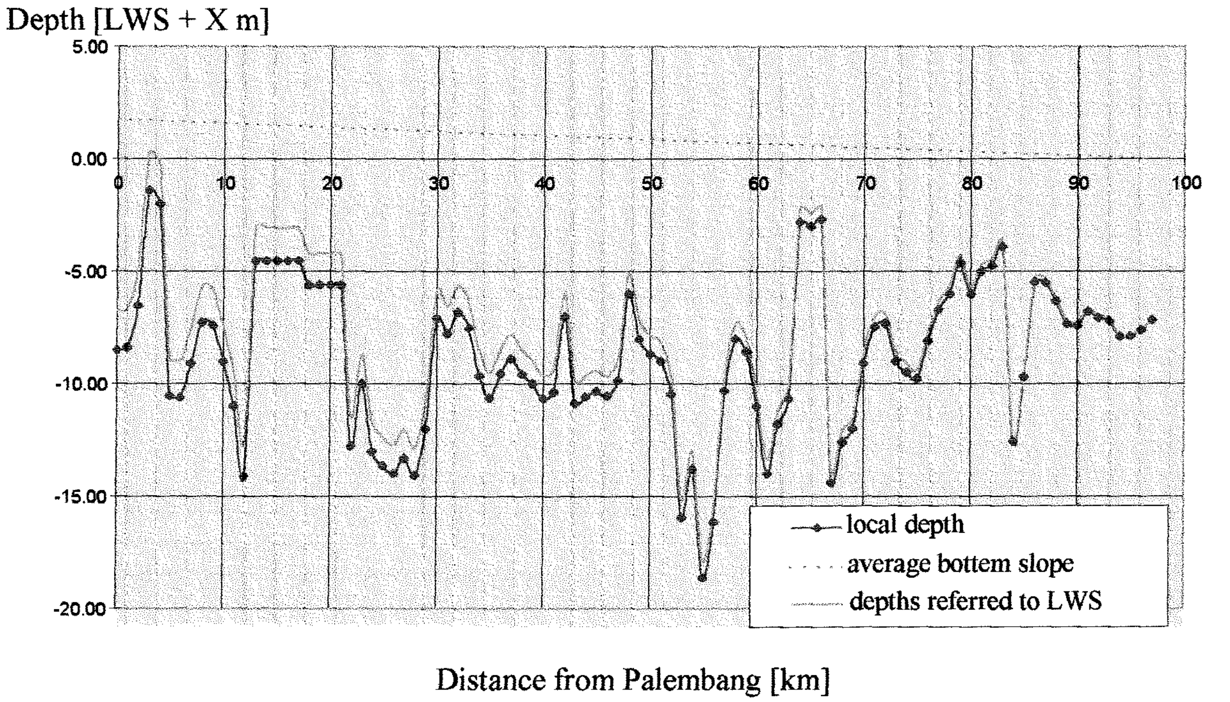

Figure 27 The longitudinal profile of the Musi river navigation channel

In Figure 27 the longitudinal profile of the navigation channel of the Musi river navigation channel is shown.

There is little information available on the longitudinal profile of the bifurcations and confluences of the Musi river. It is therefore assumed that they have straight bottom profiles from the location where they split of (bottom level can be read from the Musi river navigation map) to the point where they meet the Musi river again (bottom level can be read from the

8.2 Water levels

8.2.1 Introduction

The water level measurements were carried out according to the following principle. First at each location a local reference level was determined, the so called 'peilschaal'.

After that the measurements were taken and referred to this local 'peilschaal' (see Figure 28). The measurements were later adjusted with the average bottom slope ($1.8*10^{-5}$[10]) to obtain the water levels referred to LWS in the mouth of the Musi river (see Figure 29).

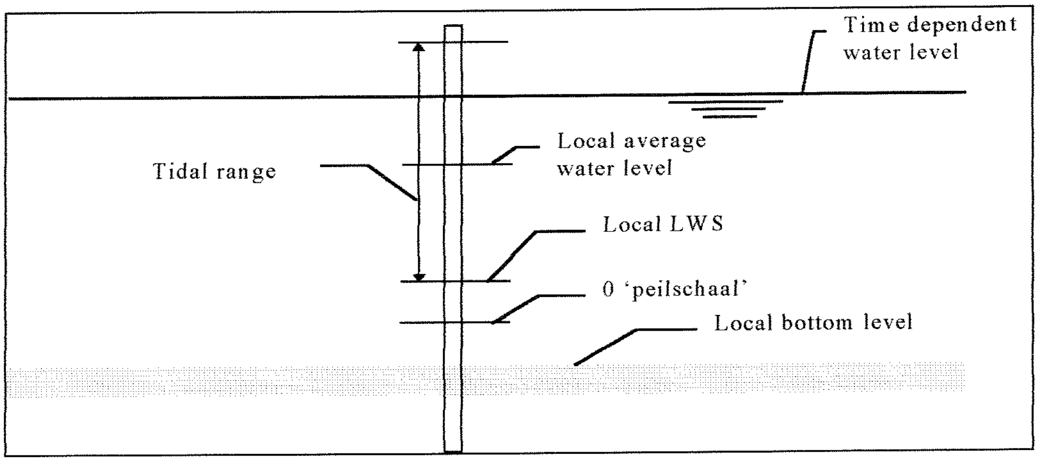

Figure 28 Illustration of water level measurement method

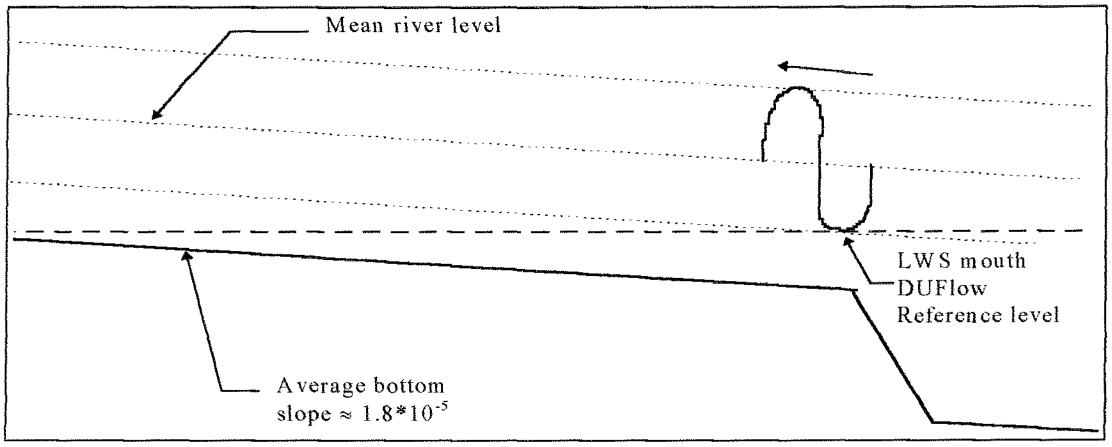

Figure 29 Correction of the local water level measurements with the average bottom slope

In the next paragraphs a separation is made between the maintenance depth and the tidal level.

The water depth on top of the bars is defined by the maintenance depth added by the tidal level (Figure 30).

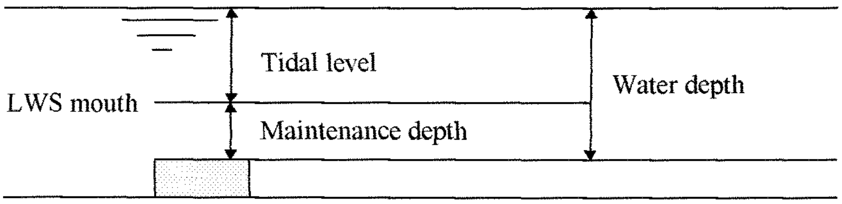

Figure 30 Definition water depth

The maintenance depth is varied in the model to simulate the influence of river works and dredging activities. In 8.2.2 the maintenance depth is described and in 8.2.3 the tidal level constitution is explained.

8.2.2 Maintenance depth of the bars in the Musi river

The locations of the bars are defined by the sailing times to the bars. As mentioned earlier (0), four bars are recognised.

The bars can be found at the following locations in Figure 31:

Ayer Kumbang

Sungai Upang

Pulau Ayam

Pulau Payung

The longitudinal profile is composed from the navigation map, on which the depths are referred to LWS in the river mouth (100 km from Palembang). The depths have been taken over for each kilometre from the Boom Baru terminal at Palembang to the mouth of the Musi river. In the PROSIM model only the relevant (shallow) points are represented.

In PROSIM a bar is represented by a single point. Two bars are too long to be schematised as points. Therefore these bars are schematised as two points (Figure 32). A vessel is not allowed between a begin and end point while the water depth is insufficient. Six bar points are thus defined in the model.

	Distance from Palembang	Depth [x. - LWS in the mouth]
Point 1	78 km	4.7 m
Point 2	82 km	3.6 m
Point 3	42 km	5.5 m
Point 4	32 km	5.2 m
Point 5	20 km	5.7 m
Point 6	8 km	5.4 m

Table 11 Location and depth of bar 'points'

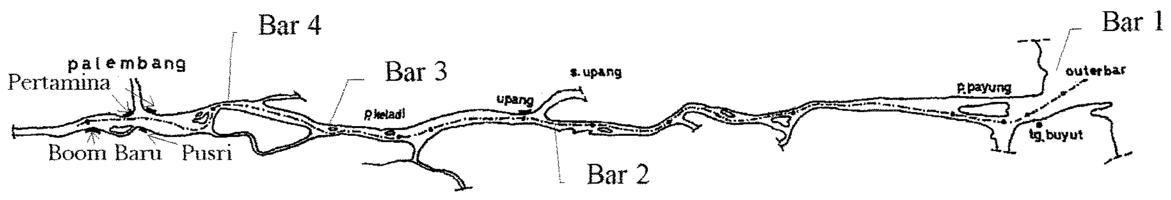

Figure 31 Location of bars in the Musi river

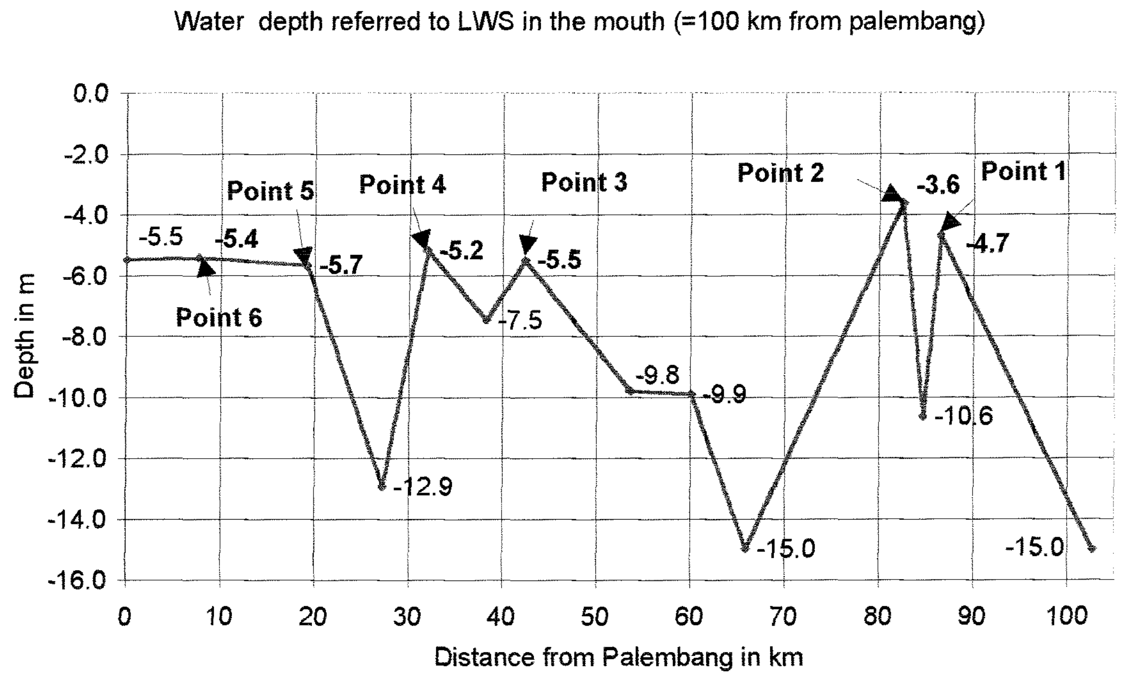

Figure 32 Schematised longitudinal water depth profile for Musi navigation channel

8.2.3 Tidal levels

The tidal influence is produced by the DUFlow model [18]. The tidal period at sea is approximately 24 hours (see Figure 33). The tidal amplitude is different for spring tide and neap tide. During spring tide, when the lowest water levels occur and therefore the most hindrance to the vessels, the tidal amplitude is approximately 1.9 m. The neap tide and the spring tide levels are computed for the relevant locations (the bars). The measurements were carried out covering one complete tidal cycle of fourteen days in which a tide will transform from spring tide to neap tide and back to spring tide. The neap tide is the period with small amplitudes and the spring tide is the period with higher amplitudes. Low Water Spring is the lowest water level for spring in a year and is represented by the zero level in the graph.

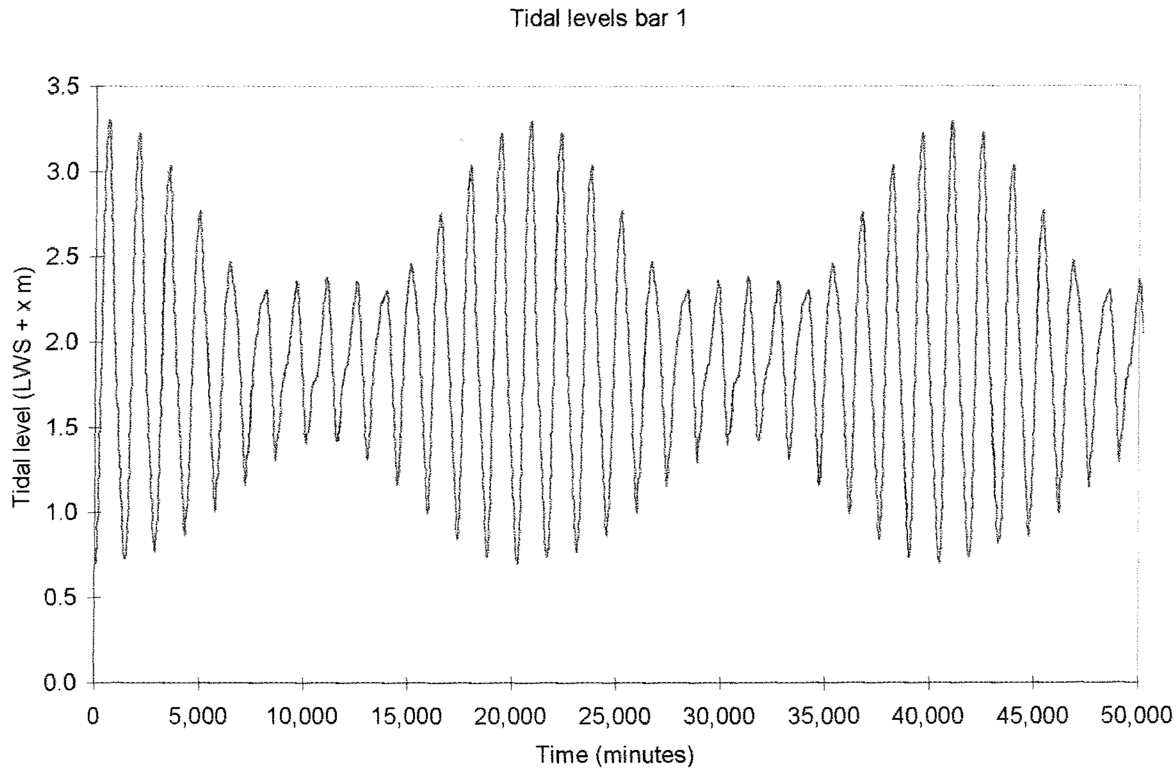

Figure 33 The tidal levels at bar 1

The levels have then been translated to the PROSIM model. The following graphs show the tidal levels in DUFlow and PROSIM for neap tide and spring tide for the first bar.

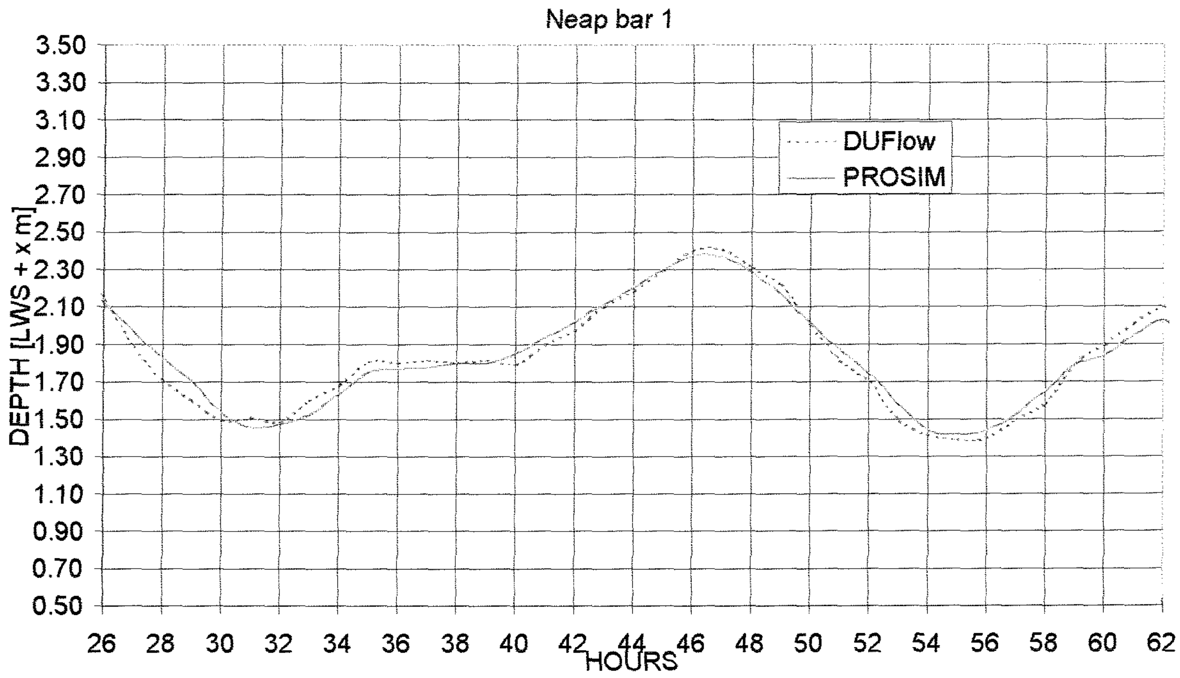

Figure 34 Neap tide bar 1

Figure 34 shows the similarity of the DUFlow results and the PROSIM output for the neap tide on bar 1.

There is a phase difference between water levels on the four bars. The phase difference between the tide at sea and the tide near Palembang is approximately 5 hours. This is clarified by the fact that a tidal wave on a river moves with a certain speed, in this case about 17 km/h. therefore the wave meets the different bars at different times. There is virtually no damping of the wave moving upstream, which can be explained by the small slope of the river bed. (1.8E-5) [10].

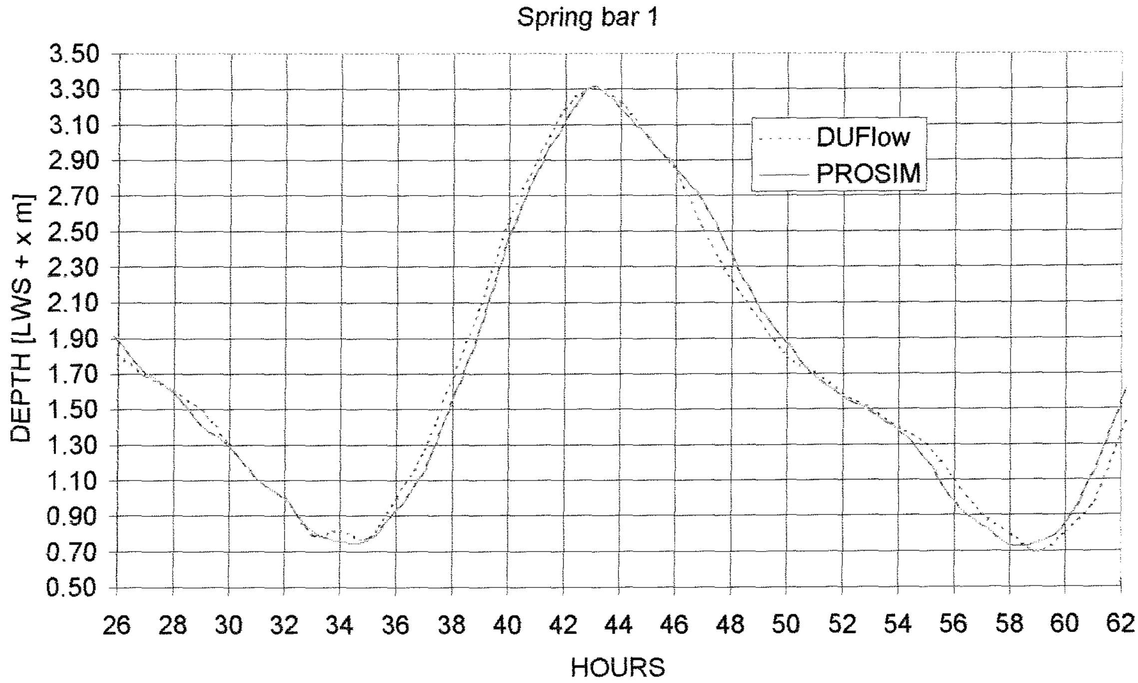

Figure 35 Spring tide bar 1

8.2.4 Influence of the maintenance depth on the tidal levels

In [11] simulations have been made for the change in the tidal levels due to higher water depths. The simulations have been carried out for LWS -5.5 m, LWS -6.5 m, LWS -7.0 m and LWS -7.5 m for the spring tide. The influence on the water depth is very small, which is illustrated in Figure 36 to Figure 38:

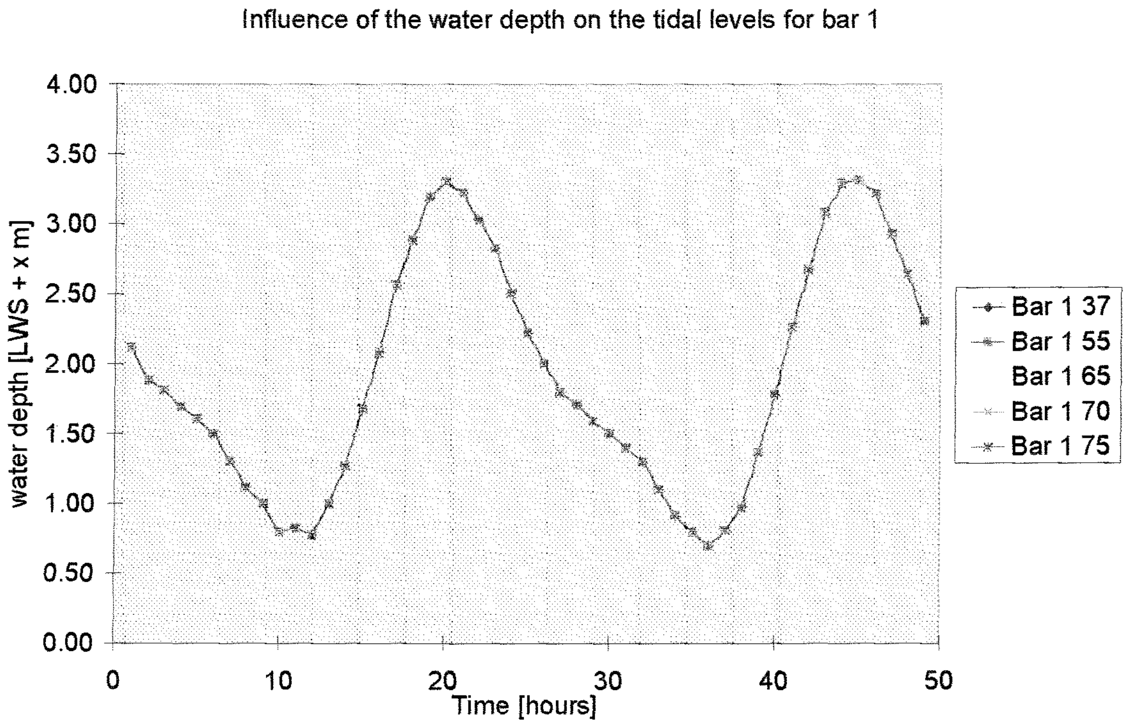

Figure 36 Influence of the water depth on the tidal levels for bar 1

For bar 1 the influence of the depth of the bars on the tidal levels is zero. This is explained by the fact that the bar is located close to the sea. The tidal level of bar 1 is governed for almost 100% by the tidal level of the sea.

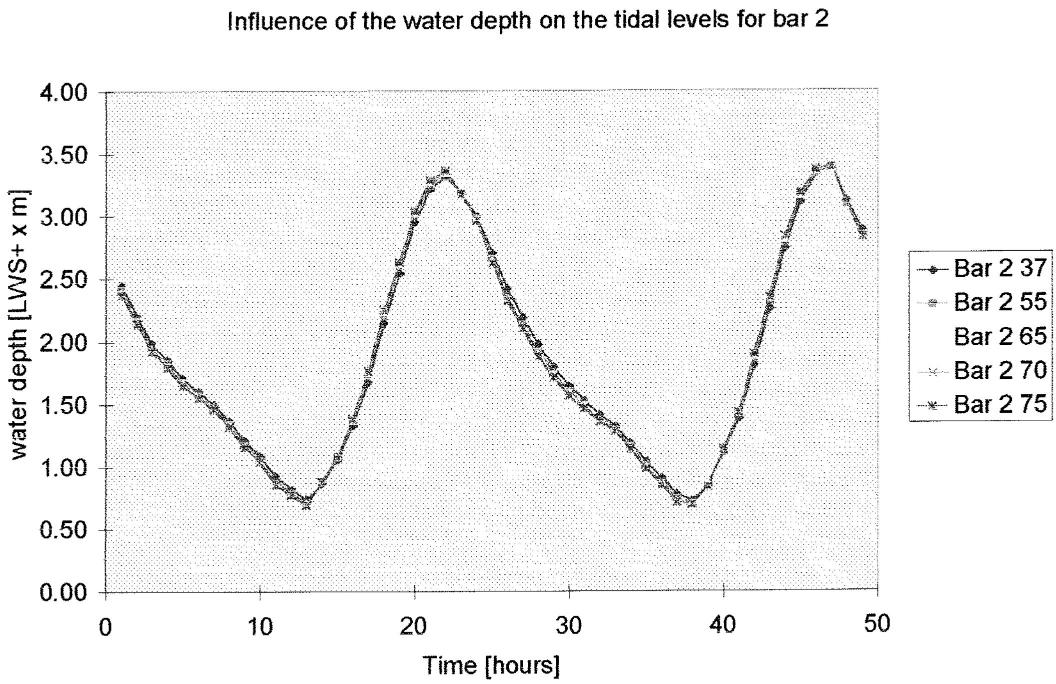

Figure 37 Influence of the water depth on the tidal levels for bar 2

For bar 2 the influence of the improved water depth on the bars is recognisable, but still very low. The maximum difference in the tidal levels is in the order of 1%. The maximum difference in the total water levels is less than 0.4%, which is negligible.

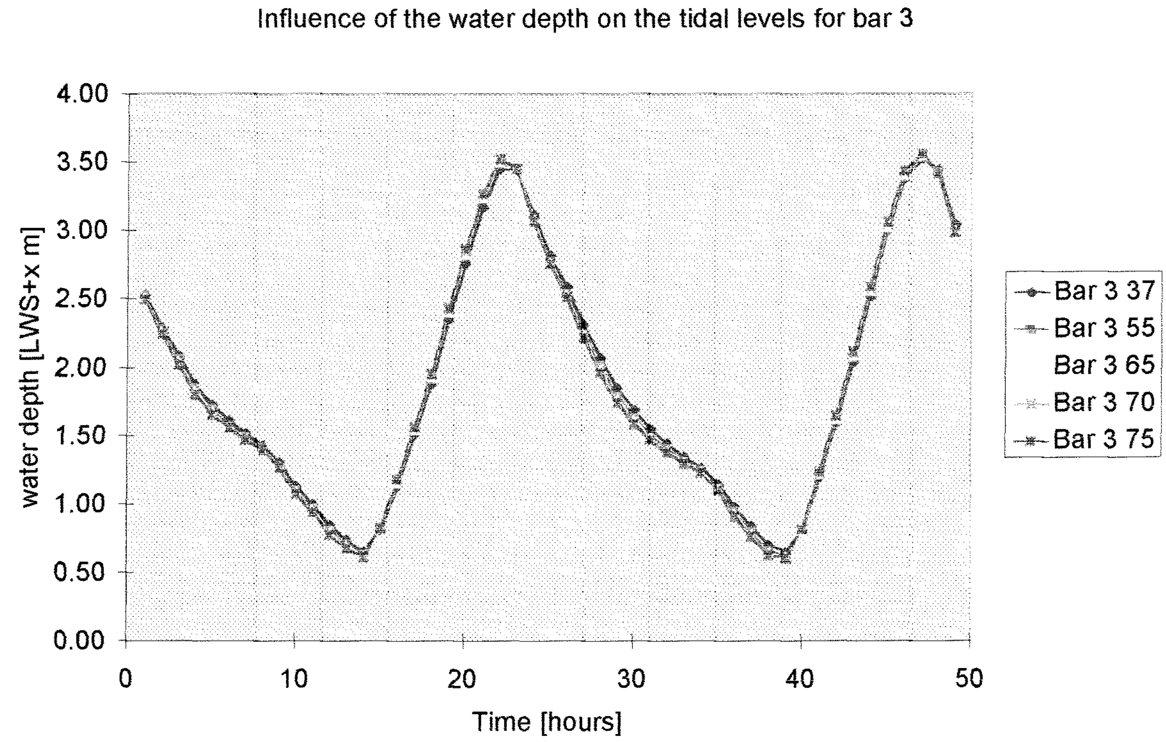

Figure 38 Influence of the water depth on the tidal levels for bar 3

For bar 3 the influence of the improved water depth on the bars is somewhat larger than for the previous bars, but still very low. The maximum difference in the tidal levels is in the order of 9 cm. The maximum difference in the total water levels is less than 0.4%, which is also neglected[9].

[9] In Mutsaers [18] it is stated that the difference between water levels in the real system and the DUFlow model are in the order of at least 25%.Neglect of a 0.4% difference is therefore justified.

9. Verification and validation of the PROSIM model Palembang

9.1 Verification

The inter arrival times have been verified by analysing the PROSIM results for a simulation run of 150,000 minutes. The comparison shows a satisfactory correlation. The inter arrival times are accurate up to a margin of 0.5% for the total amount of vessels.

Fleet	IAT (minutes)	vessels (150,000 min)	vessels in PROSIM
Boom Baru 1	1,074	140	149
Boom Baru 2	3,400	44	43
Pertamina 1	850	176	181
Pertamina 2	1,275	117	117
Pusri 1	1,986	76	75
Pusri 2	4,633	32	34
Rest 1	2,708	55	45
Rest 2	2,933	51	43
Total	216	691	687

Table 12 Verification of inter arrival times

The same has been done for the service times. The following table is the result thereof:

Fleet	Service time [days]	PROSIM [days]
Boom Baru 1	1.94	1.9
Boom Baru 2	1.94	1.95
Pertamina 1	1.25	1.2
Pertamina 2	1.25	1.2
Pusri 1	2.01	2
Pusri 2	2.01	2

Table 13 Verification of service times

The results are accurate in a 5% boundary.

The PROSIM package offers the possibility to trace the actions of a component in the system. This option can be used to verify if the model performs certain action correctly. In this paragraph the movements of a vessel has been traced from the generation of this vessel, to the point that the vessel leaves the system.

The vessel is the eleventh vessel to enter the system and is therefore called 'ship 11'. The vessel is created on 'date': 482.20852 (minutes). It is moved to the anchorage at the outerbar.

Time	Action	Action
482.20852	ship 11 is current now	ship 11 joined to anchoragem
	traffcarrm activated at 482.20852	ship 11 is passivated
	ship 11 is current now	ship 11 removed from anchoragem

The river master (traffcarrm) allows the vessel to immediately 'enter' the river. The river is divide in 12 sections which are all sailed in 30 minutes.

Time	Action	Action
	ship 11 joined to musiin 1	ship 11 suspended till 512.20852
512.20852	ship 11 is current now	ship 11 removed from musiin 1
	ship 11 joined to musiin 2	ship 11 suspended till 542.20852
542.20852	ship 11 is current now	ship 11 removed from musiin 2
	ship 11 joined to musiin 3	ship 11 suspended till 572.20852
572.20852	ship 11 is current now	ship 11 removed from musiin 3
	ship 11 joined to musiin 4	ship 11 suspended till 602.20852
602.20852	ship 11 is current now	ship 11 removed from musiin 4
	ship 11 joined to musiin 5	ship 11 suspended till 632.20852
632.20852	ship 11 is current now	ship 11 removed from musiin 5
	ship 11 joined to musiin 6	ship 11 suspended till 662.20852
662.20852	ship 11 is current now	ship 11 removed from musiin 6
	ship 11 joined to musiin 7	ship 11 suspended till 692.20852
692.20852	ship 11 is current now	ship 11 removed from musiin 7
	ship 11 joined to musiin 8	ship 11 suspended till 722.20852
722.20852	ship 11 is current now	ship 11 removed from musiin 8
	ship 11 joined to musiin 9	ship 11 suspended till 752.20852
752.20852	ship 11 is current now	ship 11 removed from musiin 9
	ship 11 joined to musiin 10	ship 11 suspended till 782.20852
782.20852	ship 11 is current now	ship 11 removed from musiin 10
	ship 11 joined to musiin 11	ship 11 suspended till 812.20852
812.20852	ship 11 is current now	ship 11 removed from musiin 11
	ship 11 joined to musiin 12	ship 11 suspended till 842.20852

When the Musi river sections have been sailed, the vessel enters the turning basin, where it waits until it can sail to the terminal

Time	Action	Action
842.20852	ship 11 is current now	ship 11 removed from musiin 12
	ship 11 joined to arrquay 1	ship 11 joined to quayq
	qmaster 1 activated at 842.20852	ship 11 is passivated
	ship 11 is current now	ship 11 removed from arrquay 1
	ship 11 removed from quayq	ship 11 joined to arrival
	hmaster1 activated at 842.20852	ship 11 is passivated

Permission is granted and the vessel sails to the quay. The track to the quay is divide in 5 sections which are sailed in 3, 3, 3, 30 respectively 30 minutes.

Time	Action	Action
887.20852	ship 11 is current now	ship 11 removed from arrival
	ship 11 joined to channel	ship 11 joined to channel in
	ship 11 suspended till 890.20852	
890.20852	ship 11 is current now	ship 11 suspended till 893.20852
893.20852	ship 11 is current now	ship 11 suspended till 896.20852
896.20852	ship 11 is current now	ship 11 suspended till 899.20852
899.20852	ship 11 is current now	ship 11 suspended till 902.20852
902.20852	ship 11 is current now	ship 11 suspended till 932.20852
932.20852	ship 11 is current now	ship 11 suspended till 962.20852

When the vessel arrives at the quay, it waits during the service time of the vessel.

Time	Action	Action
962.42857	ship 11 is current now	ship 11 removed from channel
	ship 11 removed from channelin	ship 11 joined to tquay 1
	termoper 1 activated at 962.42857	ship 11 is passivated
	ship 11 is current now	ship 11 suspended till 2318.92690

When the service time has passed, the vessel follows the same track back to the turning basin.

Time	Action	Action
2318.92690	ship 11 is current now	termoper 1 activated at 2318.92690
	ship1 is passivated	
2318.92690	ship 11 is current now	ship 11 removed from departure
	ship 11 joined to channel	ship 11 joined to channelout
	ship 11 suspended till 2348.92690	
2348.92690	ship 11 is current now	ship 11 suspended till 2378.92690
2378.92690	ship 11 is current now	ship 11 suspended till 2381.92690
2381.92690	ship 11 is current now	ship 11 suspended till 2384.92690
2384.92690	ship 11 is current now	ship 11 suspended till 2387.92690
2387.92690	ship 11 is current now	ship 11 suspended till 2390.92690
2390.92690	ship 11 is current now	ship 11 suspended till 2393.92690
2393.92690	ship 11 is current now	ship 11 removed from channelout
	ship 11 joined to anchoragep	traffcdep activated at 2393.93690
	ship 11 is passivated	

Then the vessel sails the 12 sections of the Musi river again, when permission is granted at date 3306.6790.

Time	Action	Action
3306.6790	ship 11 is current now	ship 11 removed from anchoragep
	ship 11 joined to musiout 1	ship 11 suspended till 3336.6790
3336.6790	ship 11 is current now	ship 11 removed from musiout 1
	ship 11 joined to musiout 2	ship 11 suspended till 3366.6790
3366.6790	ship 11 is current now	ship 11 removed from musiout 2
	ship 11 joined to musiout 3	ship 11 suspended till 3396.6790
3396.6790	ship 11 is current now	ship 11 removed from musiout 3
	ship 11 joined to musiout 4	ship 11 suspended till 3426.6790
3426.6790	ship 11 is current now	ship 11 removed from musiout 4
	ship 11 joined to musiout 5	ship 11 suspended till 3456.6790
3456.6790	ship 11 is current now	ship 11 removed from musiout 5
	ship 11 joined to musiout 6	ship 11 suspended till 3486.6790
3486.6790	ship 11 is current now	ship 11 removed from musiout 6
	ship 11 joined to musiout 7	ship 11 suspended till 3516.6790
3516.6790	ship 11 is current now	ship 11 removed from musiout 7
	ship 11 joined to musiout 8	ship 11 suspended till 3546.6790
3546.6790	ship 11 is current now	ship 11 removed from musiout 8
	ship 11 joined to musiout 9	ship 11 suspended till 3576.6790
3576.6790	ship 11 is current now	ship 11 removed from musiout 9
	ship 11 joined to musiout 10	ship 11 suspended till 3606.6790
3606.6790	ship 11 is current now	ship 11 removed from musiout 10
	ship 11 joined to musiout 11	ship 11 suspended till 3636.6790
3636.6790	ship 11 is current now	ship 11 removed from musiout 11
	ship 11 joined to musiout 12	ship 11 suspended till 3666.6790

After sailing all the sections, the vessel leaves the system.

Time	Action	Action
3336.6790	ship 11 is current now	ship 11 removed from musiout 12
	ship 11 is terminated	

The same method has been used to trace other components of the system. They all work conform their expectations.

9.2 Validation

The objective of the validation stage is to ensure that the simulation program is a proper representation of the system being studied, therefore this is a very important part of simulation modelling. But the difficulty arises, however, due to the fact that the model is never a complete representation of the real system, whereas the real system is never completely known. Therefore, it must be recognised that this objective of proving the simulation correct can only be approached, not achieved. Nevertheless, in simulation the goal is to have a model which represents the real system adequately for the purpose of the study for which it is used. Thus, a model is considered valid, if the difference between model generated data and data obtained from a real system is still within acceptable limits. For this purpose, the distributions of the waiting times per fleet is gathered to be used to test the model validity.

The waiting times in PROSIM have been compared with the cumulative distribution functions based on the VTS data [15]. The following four graphs illustrate the similarity. The resulting remaining differences can be put down to the following external factors:

- pilotage, the pilots are not always available, creating extra waiting times for the ships, which are not implemented in the model;
- vessels, the shipping agent knows the tidal levels and will react accordingly, by changing the load factor or by changing the arrival time. In the simulation model this possibility does not exist. The simulation has an artificial boundary for the waiting time of 1 day.
- draught, the function for the draughts is a schematization of the actual draught; and
- data, the data contains measurement errors.

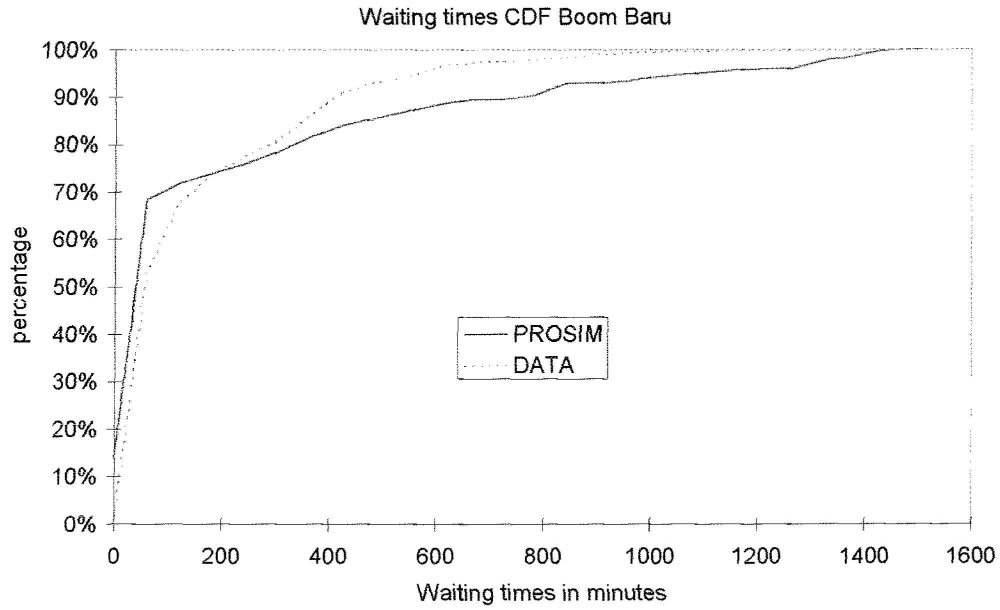

Figure 39 CDF's for the waiting time at outerbar for Boom Baru vessels

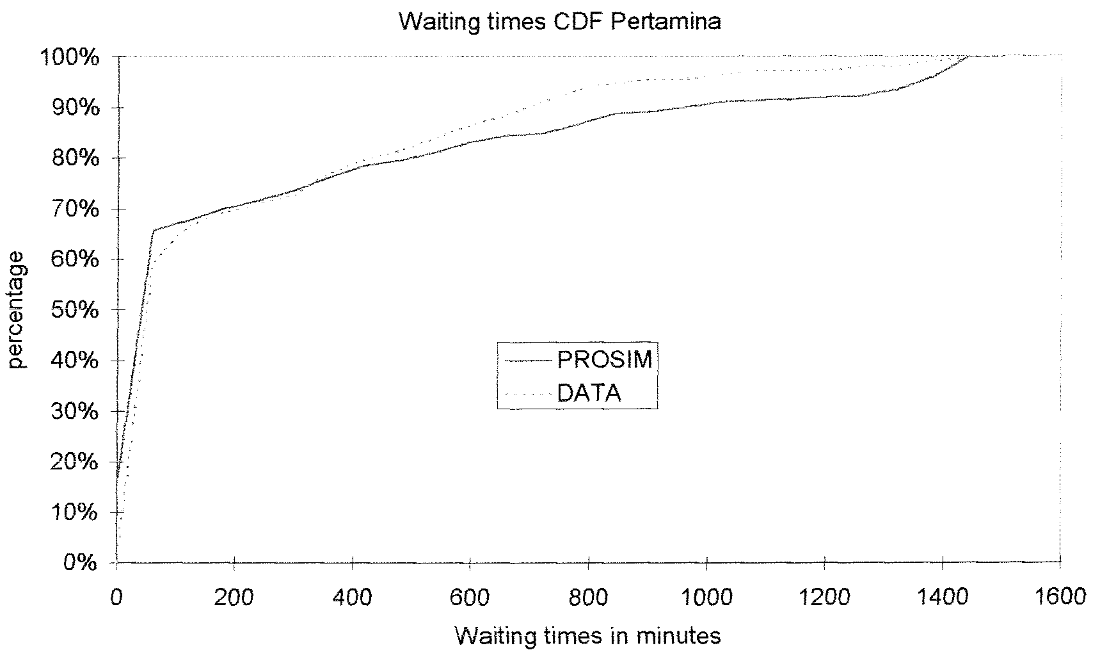

Figure 40 CDF's for the waiting time at outerbar for Pertamina vessels

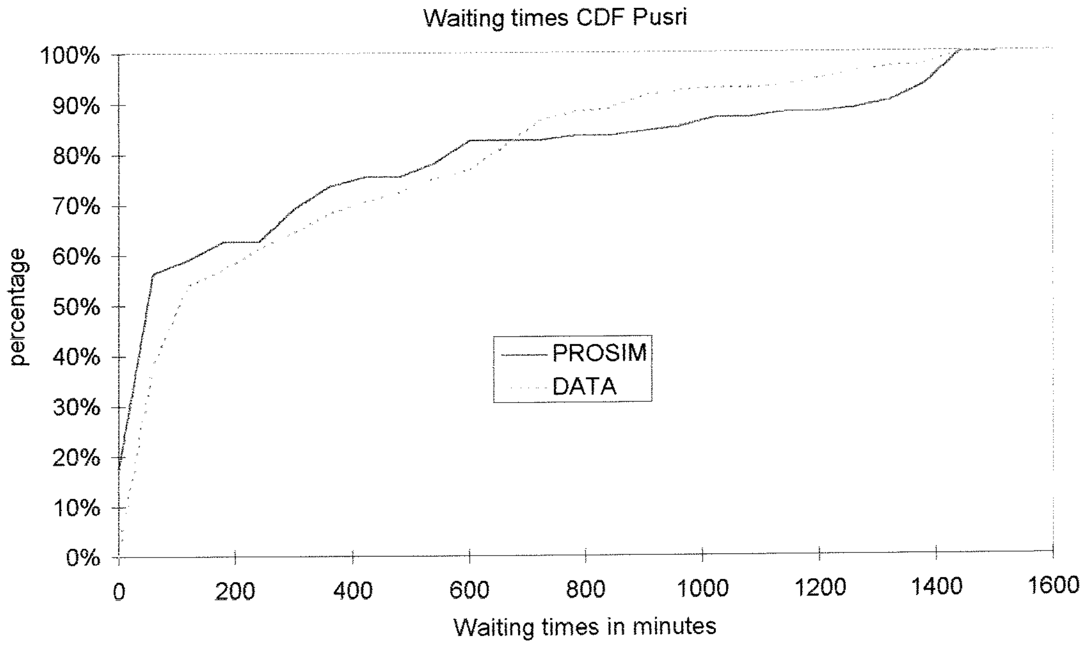

Figure 41 CDF's for the waiting time at outerbar for Pusri vessels

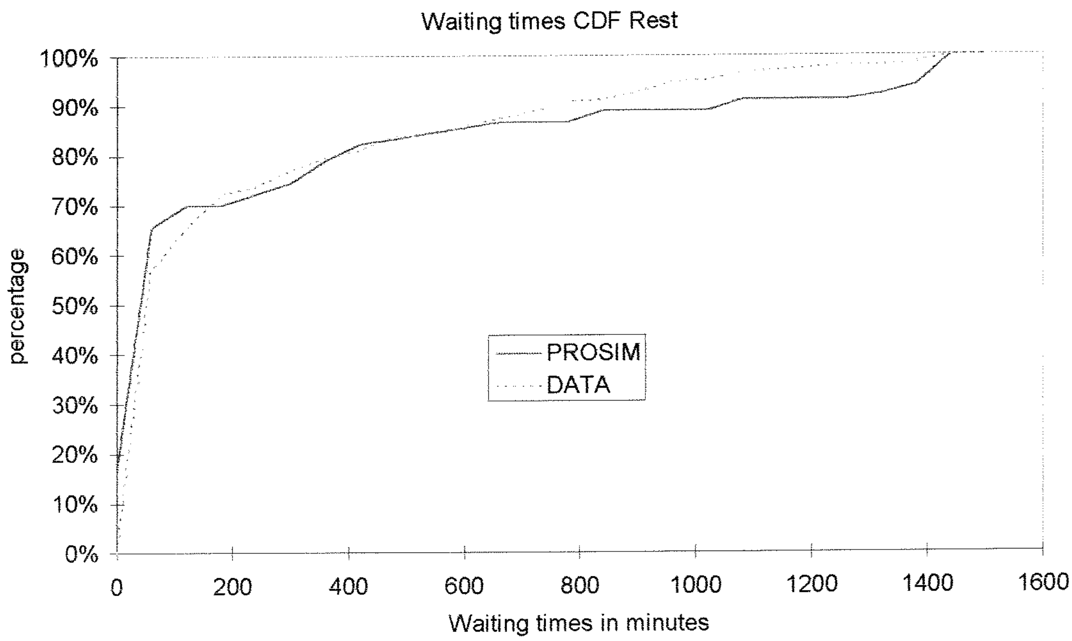

Figure 42 CDF's for the waiting time at outerbar for Rest of the vessels

10. Calculation of the shipping costs

10.1 Introduction

The cost of operating a ship depends on a combination of factors. First, the ship itself sets the broad framework of costs through its fuel consumption, the number of crew required to operate it and its physical condition, which dictates the requirement for repairs and maintenance. Secondly, running costs depend on the cost of bought-in items, particularly bunkers, wages paid to the crew and the level of repair costs, all of which are subject to general trends in world prices. Thirdly, the level of costs is influenced by the efficiency with which the owner manages the operation of the ship, including the administrative overhead.

These costs can be classified into four categories [23]:

- operating costs, which constitute the expenses involved in the day-to-day running of a ship - essentially those costs such as crew, stores and maintenance that will be incurred whatever trade the ship is engaged in;
- voyage costs, which are variable costs associated with a specific voyage and include such items as fuel, port charges and canal dues;
- capital costs, which cover interest and capital repayments and are determined by the way in which the ship has been financed; and
- cargo handling costs, which represent the expense of loading, stowing and discharging cargo. They are particularly important in the liner trades.

When an analysis is made for the influence of water depth improvements on the running costs for a ship, it can be seen that all the costs mentioned above except the operating costs are affected.

An increase in the water depth can lead to shorter waiting times and to an increase in the draught. An increase in the draught is accomplished by an increase in the cargo volume, which means that the same amount of cargo can be supplied by less round trips. While e.g. the buffer stock costs will rise [26], the total running costs will tend to be lower.

In the following paragraphs a model is presented in which only relevant factors are included. These are the factors that are influenced by the improvement of the water depth in the Musi river (see 10.4).

10.2 Shipping costs model for Palembang

In [24] a shipping model for Indonesia is presented in which shipping costs per route are expressed as a function of ship size and speed as major ship type parameters and further of operational or productivity parameters. The costs are expressed in Indonesia's currency; the Rupiah. 1,000 Rupiah equals approximately 0.75 Dutch Guilders or 0.40 US Dollars (May 1997).

$C_s = NRV_s(TS_sCS_s+TP_sCP_s)$ [millions Rupiah/day] (5.1)

C_s	: annual shipping costs	[millions Rupiah/year]
NRV_s	: number of round voyages per year	[voyage/year]
TS_s	: sailing time per round voyage	[days/voyage]
CS_s	: daily costs at sea	[millions Rupiah/day]
TP_s	: port time per round voyage	[days/voyage]
CP_s	: daily cost in port	[millions Rupiah/day]

The subscript s indicates that the variable is a function of ship size.

10.2.1 Load factor

The number of round trips needed to carry the annual cargo volume of the route concerned is:

$$NRV_s = \frac{F}{S}$$ [voyages/year] (5.2)

F	: annual dwt	[ton/year]
S	: average size of ship in dwt carrying capacity	[ton]

The values for the annual dwt (F) have been calculated using the PROSIM results for the present situation: The costs for the 'fleet Rest' have not been taken into account because this fleet is too diffuse.

	annual dwt (F) [ton/year]
Boom Baru	2,373,220
Pertamina	10,062,120
Pusri	1,905,133
Total	14,340,473

Table 14 Annual total dwt (F)

A higher water depth will make a higher load possible. Therefore simulation runs are carried out for two possible new loads. This is done by increasing the average draught with 10%, 20% and 30%.

Putting the case that the annual cargo volume remains constant after changes in the depth of the Musi river, F can be assumed to be constant in time. An increased load thus results in a lower NRV_s (formula 5.2).

It has been assumed that for an increase of draught with 10%, the load increases with approximately 20%.

To obtain a lower number of round trips in a year the average inter arrival time for the vessels is increased in PROSIM with 20% respectively 40% and 60%. Because the dwt of the vessels above 6000 dwt[10] is multiplied with the same factor, the total amount of cargo per year remains approximately constant.

10.2.2 Time spent at sea

Time spent at sea equals the round voyage distance divided by the ship's speed:

$$TS_s = \frac{D_t}{24\,V_s} + W_{t_{dest}} \qquad \text{[days/voyage]} \qquad (5.3)$$

[10] The smaller vessels do not change their load when the water depth is increased, because they already have sufficient keel clearance. Their load factor is not influenced by the water depth

D_t	: round trip distance	[km]
V_s	: service speed	[km/h]
W_{tdest}	: waiting time	[days]

Although the speed is related to the size of the ship, the speed is assumed to be constant. The vessels sail with an average speed of 10 knots[11]. Assuming that all voyages are between Singapore, West Indonesia and East Indonesia, the average round voyage distance[12] can be calculated using the data in Annex A.4 and A.5 of [24]:

$$Dt = 2\,\frac{\Sigma(Cd * Dd)}{Ct} \qquad [km] \qquad (5.4)$$

Dt	: average distance	[km]
Cd	: cargo flow to maritime district	[ton]
Dd	: distance to district	[km]
Ct	: total cargo flow	[ton]

The average distance is calculated in Table 1 of Appendix B The distance that results from this table is 1104 nautical miles[13].

TS_s is therefore equal to:

$$TS_s = \frac{1{,}104}{10*24} + W_{t_{dest}} = 4.60 + W_{t_{dest}} \qquad [days/voyage]\ (5.5)$$

It should be noted that equation (5.5) has the following limitations:

- The costs for time spent at sea are assumed the same as the waiting time at sea. The fuel costs for a waiting vessel are lower than for a sailing vessel. Therefore the costs for waiting are overestimated and should be reduced with a factor.

---

[11] 1 knot equals 1.85 km/h.

[12] A round trip is defined as a journey from a harbour of origin to the harbour of Palembang and a journey from the harbour of Palembang to a harbour of destination.

[13] 1 nautical mile equals 1.85 km.

- Table 1 of Appendix B is quoted from Veldman [24] and is valid for a regular liner system of vessels ranging from 200 dwt to 4,200 dwt. This table is therefore not valid for *all* vessels calling at Palembang, but only a first approximation. E.g. the Pertamina homepage on Internet [28] gives an average number of round trip days for *all* the Pertamina tanker vessels of 9.0 days for 1994/1995. It is not clear which definition for a round trip is used. Here a round trip is defined as a journey from a harbour of origin to the harbour of Palembang and a journey from the harbour of Palembang to a harbour of destination.
- The sailing speed is considered constant and the same for all vessels.
- The waiting time at the harbour of origin is not taken into account.

10.2.3 Time spent in port

Time spent in port per round trip is estimated at twice the average service time at the berth in Palembang. This is because two ports are called at, per round trip. The service time is assumed equal to the service time at the port of Palembang. Therefore:

$CP_s = 2\ St_{dest}$ [days/voyage] (5.6)

It should be noted that equation (5.7) has the following limitations:

- The effect of increased cargo volume on the service time is not taken into account.
- The costs for time spent in port are calculated for regular liners with a dwt between 200 and 4,200. These costs should be determined more accurately for the applicable terminals.
- The service time at the harbour of origin is estimated as being the same as the service time at the Palembang terminal.

The following average service times have been calculated:

Terminal	Service time [days]	$2*St_{dest}$ [days/voyage]
Boom Baru	1.94	3.89
Pertamina	1.25	2.50
Pusri	2.01	4.02
Rest	2.15	4.31

Table 15 Service times according to the VTS data

10.2.4 Cost elasticity factors

The costs CS_s (daily costs at sea) and CP_s (daily costs in port) can be related to ship size in the following way:

$CS_s = v_o\, S^{v1}$; and [millions Rupiah/day] (5.7)

$CP_s = w_o\, S^{w1}$ [millions Rupiah/day] (5.8)

Equation (5.7) is a good representation of the sailing costs per day. In Figure 43 equation (5.7) is compared with cost indications supplied by ITS and Pertamina. The equation matches reasonably with the costs indication.

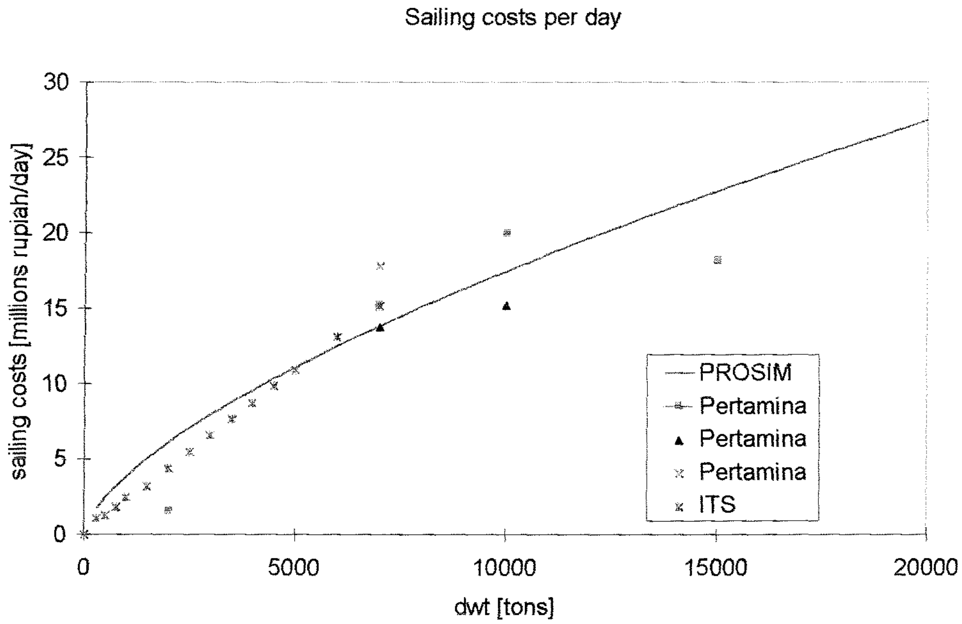

Figure 43 Sailing costs per day

There is no data available for the daily costs in port, therefore it is only assumed that equation (5.8) is also compliant

10.3 Conclusions for the shipping costs model

Substituting of equations (5.2) through (5.8) into (5.1) gives total shipping costs as a function of S and the destination:

$$C_{s,dest} = \frac{F}{S}\left(\left(4.60 + Wt_{dest}\right)v_0 S^{v1} + 2St_{dest} w_0 S^{w1}\right) \quad \text{[millions Rupiah]} \quad (5.9)$$

$C_{s,dest}$	: total annual shipping costs	[millions Rupiah]
F	: total annual dwt	[ton]
S	: ship size	[ton]
F/S	: number of trips	[-]
Wt_{dest}	: waiting time	[days/voyage]
St_{dest}	: service time	[days/voyage]
v_0, and w_0	: constants	[millions Rupiah/ton]
v_0, v_1, w_0 and w_1	: constants	[-]

From [24] comes an estimation for the constants v_0, v_1, w_0 and w_1. These are determined by analysing operational data for regular liners in Indonesia [24].

		RLS[14]. data	Correction	Palembang data
v_0	[millions Rupiah/ton]	0.0157	2.72	0.0427
w_0	[millions Rupiah/ton]	0.0285	2.72	0.0775
v_1	[-]	0.653	-	0.653
w_1	[-]	0.510	-	0.510

Table 16 Cost elasticities

Because the data is from 1983 v_0 and w_0 have been corrected for inflation with an average of 7.4% per year[15].

Total shipping costs for Palembang consequently consist of three components:

- the costs associated with the number of round trips in a year;
- the cost incurred at sea; and
- the costs of time spent in port for cargo handling.

[15] The inflation rate was calculated using the statistical tables of 27 provincial capital cities in Indonesia for 1986 until February 1997. [27]

Substituting Table 15 and Table 16 into (5.9) gives total shipping costs as a function of S,

$$C_{BoomBaru}(S, Wt_{dest}) = \frac{2{,}373{,}220}{S}\left(\left(4.60 + Wt_{dest}\right) * 0.0427 * S^{0.653} + 2 * 1.94 * 0.0775 * S^{0.510}\right)...(5.10)$$

$$C_{Pertamina}(S, Wt_{dest}) = \frac{10{,}062{,}120}{S}\left(\left(4.60 + Wt_{dest}\right) * 0.0427 * S^{0.653} + 2 * 1.25 * 0.0775 * S^{0.510}\right)...(5.11)$$

$$C_{Pusri}(S, Wt_{dest}) = \frac{1{,}905{,}133}{S}\left(\left(4.60 + Wt_{dest}\right) * 0.0427 * S^{0.653} + 2 * 2.01 * 0.0775 * S^{0.510}\right)...(5.12)$$

C_{dest}	: total annual shipping costs	[millions Rupiah]
S	: average ship size in dead weight tonnage	[ton]
Wt_{dest}	: average waiting time	[days/voyage]

and Wt_{dest} for each destination:

	S [dwt]	F/S[16]	Wt_{dest} [days/voyage]	C_{dest} [millions Rupiah]
$C_{boom\ Baru}$:	3,290	721	0.2430	41,511
$C_{pertamina}$:	8,741	1,151	0.3993	113,093
C_{Pusri} :	4,887	390	0.6106	31,003
Total		2,262		185,607

Table 17 Shipping costs for current situation

For the current situation the shipping costs amount to the following:

10.4 Limitations of the shipping costs model

As mentioned in chapter 10.1 the shipping model used here is a schematised representation of the real system. The model used here is fitted according to the available parameters only and can therefore not be seen as a complete model description for the shipping costs. It gives only an indication of the influence of the used parameters on the annual shipping costs. For a better representation the following parameters should be investigated more accurately:

[16] F/S : average annual number of vessels

- The costs for waiting at sea. In this model the costs for time spent at sea are assumed the same as the waiting time at sea. The fuel costs for a waiting vessel are lower than for a sailing vessel. Therefore the costs for waiting are overestimated and should be reduced with a factor.
- The sailing distance. Table 1 of Appendix B is quoted from Veldman [24] and is valid for a regular liner system of vessels ranging from 200 dwt to 4,200 dwt. This table is therefore not valid for *all* vessels calling at Palembang, but only a first approximation.
- Service time. The effect of increased cargo volume on the service time is not taken into account. This is done because the influence of this change on the annual costs is deemed small enough to neglect.
- The costs for time spent in port. The costs for time spent in port are calculated for regular liners with a dwt between 200 and 4,200. These costs should be determined more accurately for the applicable terminals.
- The waiting time at the harbour of origin is not taken into account.
- The service time at the harbour of origin is estimated as being the same as the service time at the Palembang terminal.
- The sailing speed is considered constant and the same for all vessels.

11. Vessel traffic simulation of alternatives

11.1 Introduction

The most important part of the simulation is to perform experiments of the model in order to obtain outputs at which the simulation modelling aimed for. The outputs are data of possible future situations.

The resulting alternatives have been compared, leading to a optimum depth for each fleet composition.

Fleet simulations were carried out for:

	Increase of draught			
Water depth	100%	110%	120%	130%
LWS - 3.6 m	⊙			
LWS - 4,0 m	⊙	⊙		
LWS - 4.5 m	⊙	⊙	⊙	
LWS - 5.0 m	⊙	⊙	⊙	⊙
LWS - 5.5 m	⊙	⊙	⊙	⊙
LWS - 6.0 m	⊙	⊙	⊙	⊙
LWS - 6.5 m	⊙	⊙	⊙	⊙
LWS - 7.0 m	⊙	⊙	⊙	⊙
LWS - 7.5 m	⊙	⊙	⊙	⊙

Table 18 Carried out fleet simulations

⊙ : Simulation for 150,000 minutes (100 days)

For the existing situation only the current fleet composition was simulated; it is clear (see Figure 45) that the annual shipping costs will be higher for a fleet simulation with higher draught vessels and therefore irrelevant. For the same reason not all the fleet compositions were simulations for the minimum water depth of LWS -4.0 m and LWS -4.5 m. The simulation speed decreases with lower water depths, because of the high waiting times. The simulations with high waiting times have been run for 100 days. To check the error made with this simulation time the simulation for LWS -7.5 m was also run for 0.5 year and 1.2 years. The difference between the simulation time of 100 days and the simulation time of 1.2 year is 1%.. The difference for the simulation time of 0.5 year and the simulation time of 1.2 year is 0.5%. It can therefore be assumed that the shipping costs comes to the solution in a 1% boundary.

Based on the accumulated facts a prediction for the shipping costs is made, using these three possible fleet compositions (In 10.2.1 it has been assumed that for an increase of draught with 10%, the load increases with approximately 20%).

	draught factor[17]	dwt load factor[17]
Existing fleet	1.0	1.0
fleet with 10% draught increase	1.1	1.2
fleet with 20% draught increase	1.2	1.4
fleet with 30% draught increase	1.3	1.6

Table 19 Factors for three possible fleet compositions

11.2 Fleet simulation for the existing situation

The simulation for the current situation has produced the following results for the annual cargo costs. The water depths are taken from Table 11. The calculations are based on the formulas in paragraph 10.3.

	Average total waiting time [days]	Total annual shipping costs [millions Rupiah]
Boom Baru	0.23430	41,511
Pertamina	0.3993	113,093
Pusri	0.6106	31,003
Total		185,607

Table 20 Annual shipping costs for LWS -3.6 m, existing fleet

[17] This factor is used only for vessels with a dwt higher than 6,000 ton.

The waiting times (sum of waiting time at the outerbar and the harbour) have been used to calibrate the model. The cumulative distribution functions for the waiting times have been compared with the cumulative distribution functions from the VTS data.

11.3 Fleet simulations for increased water depths

Simulation runs were made for increased water depths. The water depth was increased from LWS -3.6 m to 7.0 m for three different fleet compositions. Waiting times were calculated for the Boom Baru, Pertamina and Pusri vessels.

The water depth is in dm, the waiting times (sum of waiting time for the outerbar and harbour) are in days.

Boom Baru	36	40	45	50	55	60	65	70	75
Existing fleet	0.2430	0.1168	0.0254	0.0039	0.0004	0.0001	0.0001	0.0001	0.0001
Fleet with 10% draught increase		0.5955	0.1170	0.0397	0.0083	0.0001	0.0001	0.0001	0.0001
Fleet with 20% draught increase			0.7081	0.1578	0.0535	0.0119	0.0006	0.0001	0.0001
Fleet with 30% draught increase				1.0444	0.2096	0.0757	0.0244	0.0007	0.0001
Pertamina	36	40	45	50	55	60	65	70	75
Existing fleet	0.3993	0.1324	0.0264	0.0043	0.0001	0.0001	0.0001	0.0001	0.0001
Fleet with 10% draught increase		0.9382	0.1324	0.0380	0.0067	0.0002	0.0001	0.0001	0.0001
Fleet with 20% draught increase			0.7664	0.2236	0.0559	0.0119	0.0009	0.0001	0.0001
Fleet with 30% draught increase				1.3067	0.4646	0.0795	0.0248	0.0032	0.0001
Pusri	36	40	45	50	55	60	65	70	75
Existing fleet	0.6106	0.1778	0.0430	0.0123	0.0000	0.0000	0.0000	0.0000	0.0000
Fleet with 10% draught increase		1.2032	0.1950	0.0550	0.0087	0.0004	0.0001	0.0001	0.0001
Fleet with 20% draught increase			1.3520	0.4353	0.1019	0.0251	0.0035	0.0000	0.0000
Fleet with 30% draught increase				1.3118	0.8264	0.1370	0.0399	0.0067	0.0001

Table 21 Waiting times for increased water depth

The average waiting times were calculated by multiplying the waiting times with the percentage of the fleet for the total amount of vessels entering the system (the waiting times were divided by the inter arrival time of the fleet and multiplied by the average inter arrival time (256 minutes)).

$$\text{Total waiting time} = \left(\frac{\text{Waiting time}_{\text{Boom Baru}}}{816} + \frac{\text{Waiting time}_{\text{Pertamina}}}{510} + \frac{\text{Waiting time}_{\text{Pusri}}}{1390}\right) * \left(\frac{1}{\frac{1}{816} + \frac{1}{510} + \frac{1}{1390}}\right)$$

(5.13)

$$\text{Total waiting time} = \left(\frac{\text{Waiting time}_{\text{Boom Baru}}}{816} + \frac{\text{Waiting time}_{\text{Pertamina}}}{510} + \frac{\text{Waiting time}_{\text{Pusri}}}{1390}\right) * 256$$

(5.14)

.

Total	36	40	45	50	55	60	65	70	75
Existing fleet	0.3891	0.1358	0.0291	0.0057	0.0002	0.0001	0.0001	0.0001	0.0001
Fleet with 10% draught increase		0.8793	0.1391	0.0417	0.0076	0.0002	0.0001	0.0001	0.0001
Fleet with 20% draught increase			0.8558	0.2419	0.0636	0.0143	0.0013	0.0001	0.0001
Fleet with 30% draught increase				1.2252	0.4512	0.0889	0.0275	0.0030	0.0001

Table 22 Average waiting times for increased water depth

The waiting times can be plotted in a graph. It is clear that the waiting times decrease when the water depth increases. A larger draught leads to larger waiting times.

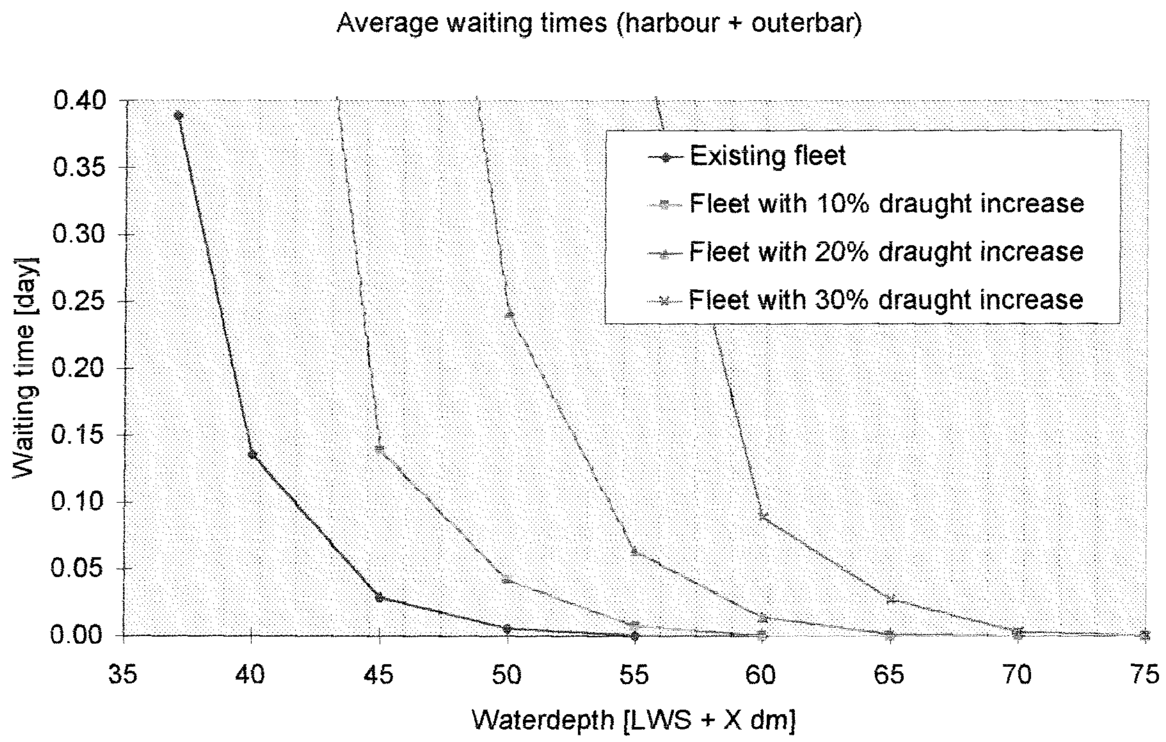

Figure 44 Average waiting times for four fleet compositions

Note that in the graph the sum of the waiting times for the outerbar and the waiting times at the harbour are drawn.

The annual shipping costs in millions Rupiah were determined using equations 5.10 -5.12 and the percentage of the amount of vessels of the sub-fleets.

Total Boom Baru	36	40	45	50	55	60	65	70	75
Existing fleet	41511	40763	39958	39778	39745	39742	39742	39742	39742
Fleet with 10% draught increase		43931	39456	38691	38409	38333	38333	38333	38333
Fleet with 20% draught increase			42813	38702	37731	37379	37282	37277	37277
Fleet with 30% draught increase				44907	37994	36879	36445	36249	36245
total Pertamina	37	40	45	50	55	60	65	70	75
Existing fleet	113093	105668	102965	102384	102271	102271	102271	102271	102271
Fleet with 10% draught increase		121545	100335	98046	97271	97110	97106	97106	97106
Fleet with 20% draught increase			111060	98821	94798	93759	93500	93479	93479
Fleet with 30% draught increase				117753	100622	92127	90893	90406	90336
total Pusri	36	40	45	50	55	60	65	70	75
Existing fleet	31003	28381	27636	27458	27377	27377	27377	27377	27377
Fleet with 10% draught increase		33665	27603	26825	26558	26508	26506	26506	26506
Fleet with 20% draught increase			32580	28032	26148	25721	25596	25576	25576
Fleet with 30% draught increase				31547	28730	25016	24491	24312	24278

Table 23 Annual shipping costs for increased water depth

The total annual shipping costs were calculated by adding the totals for Boom Baru, Pertamina and Pusri.

Total	36	40	45	50	55	60	65	70	75
Existing fleet	185607	174812	170559	169620	169393	169390	169390	169390	169390
Fleet with 10% draught increase		199141	167394	163562	162238	161951	161945	161945	161945
Fleet with 20% draught increase			186453	165555	158677	156859	156378	156332	156332
Fleet with 30% draught increase				194207	167346	154022	151829	150967	150859

Table 24 Total annual shipping costs

The total annual shipping costs can be plotted in a graph:

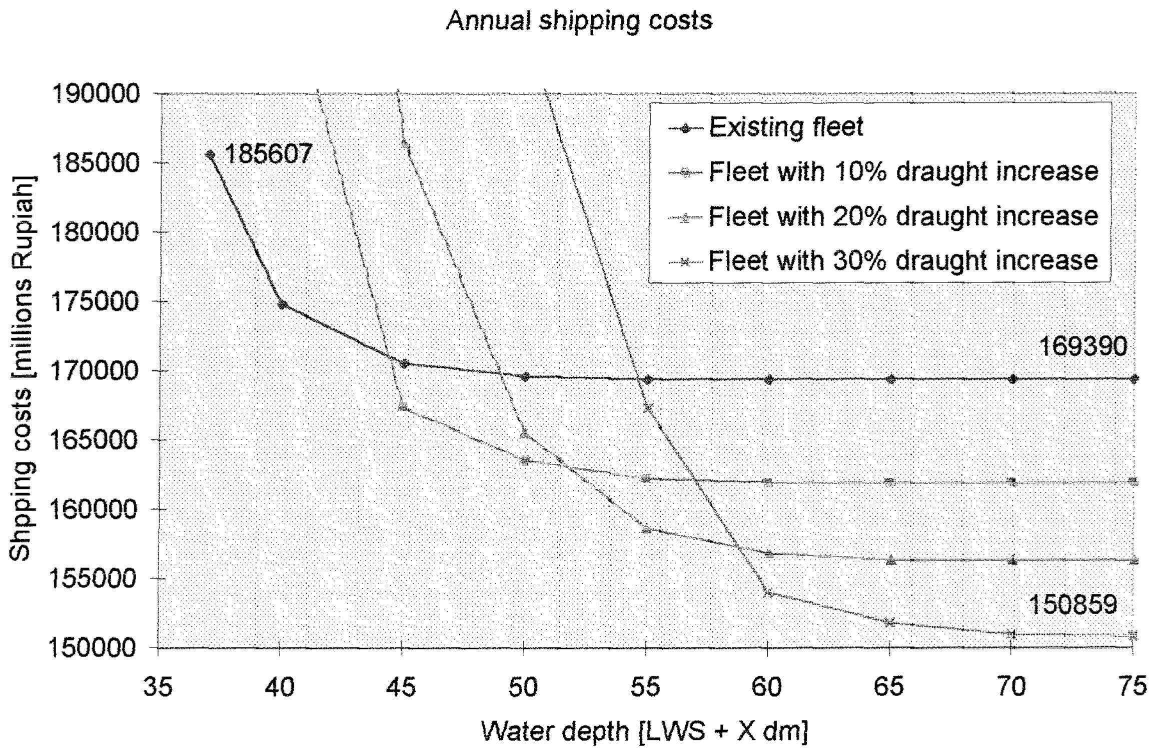

Figure 45 Annual shipping costs for four different fleet compositions

The graph (Figure 45) shows that for water depths up to approximately LWS -4.3 m the fleet with 10% draught increase is preferred and for LWS -5.2 m and up the fleet with 20% draught increase is favoured. The fleet with 30% draught increase is favoured from LWS -6.0 m and up.

11.4 Cost calculation for changes in the nautical depth

11.4.1 Introduction

In this chapter an estimation of the costs for changes in the nautical depth are made. This estimate is based on data obtained from various sources. These data do not always correspond, as is shown in the next paragraph. In Figure 48 an approximation has been made for the bandwidth of these uncertainties.

11.4.2 Data collection

In Haskoning [10]] the following graph is presented for the total amount of annually dredged material.

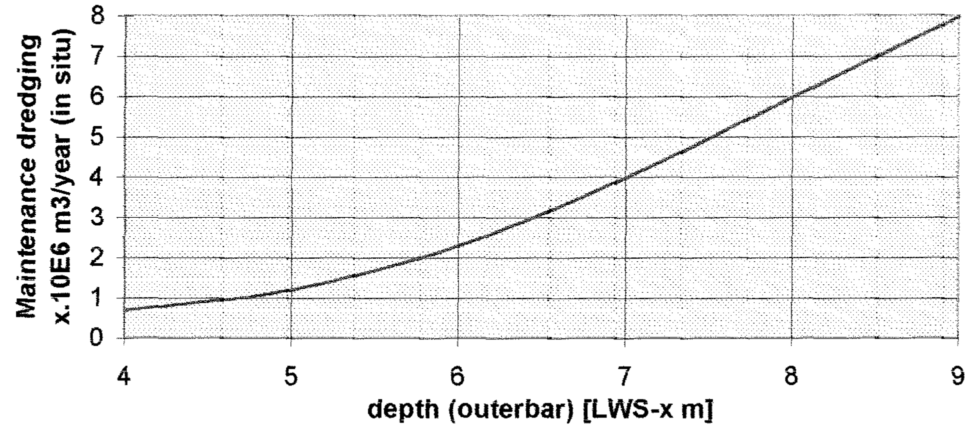

Figure 46 Required maintenance dredging

According to ITS [12] the volume of dredged material in 1995/1996 is in the order of 2,127,000 m^3 (in situ) . The total maintenance dredging costs are about 10 billion Rupiah per year [12]. Therefore the maintenance dredging costs are in the order of Rupiah 4,700.- per dredged m^3 (in situ). According to Figure 46 the dredging depth would consequently have been in the order of LWS -5.8 m.

In this study the depth of local LWS -3.6 m is assumed to be the significant dredging depth. This is according to the navigation map of the Musi river [5], Heukelom [12] and Mutsaers [18]. The volume of dredged material according to Figure 46 would be less than 1,000,000 m^3.

When the costs for river works, capital dredging and maintenance dredging are taken into account, the following graph can be drawn according to Haskoning [10] (Figure 47), with a correction for inflation with an average of 7.4% per year, according to CBS Indonesia[18] [27].

[18] The inflation rate was calculated using the statistical tables of 27 provincial capital cities in Indonesia for 1986 until February 1997.

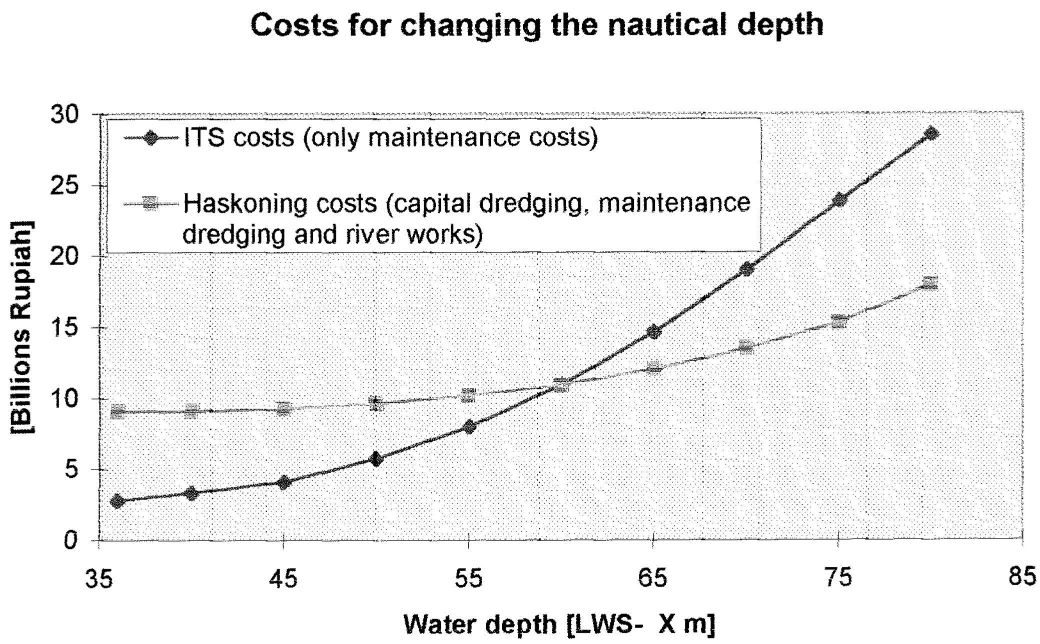

Figure 47 Costs for changing the nautical depth according to Haskoning and ITS

It is clear that the function for the costs for changing the nautical depth is not yet defined clearly. This function will be defined more clearly when the report by Heukelom [12] is available.

11.4.3 Accuracy of the costs for change of the nautical depth

To determine the boundaries of the optimum water depth region, two scenarios are proposed:

- a high estimation for the costs for change of the nautical depth (with 20% higher costs); and
- a low estimation for the costs for change of the nautical depth (with 20% lower costs).

These estimates are illustrated in the following graph (Figure 48):

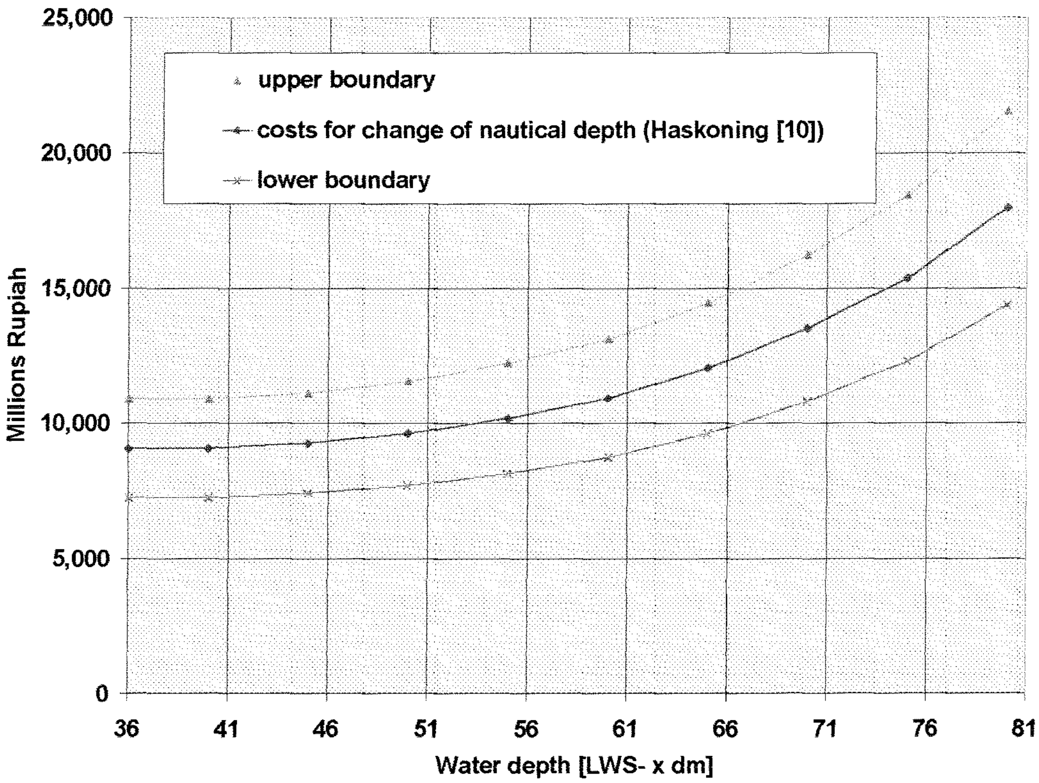

Figure 48 Approximation for costs for change of the nautical edpth

This graph is used in chapter 12.2.1 to make a first estimation for the optimum depth.

12. Estimation of the optimum depth for the Musi river

12.1 Introduction

The shipping costs can be outlined in a graph with the costs for change of the nautical depth. Here the costs for change of the nautical depth have been used according to (11.4). The two functions can be added up, leading to a U-shaped function.

12.2 The optimum water depth

Putting the case that the optimum fleet composition is used Figure 49 can be drawn. This graph is based on Figure 45. For each water depth the fleet composition with the lowest costs is illustrated. A line can be drawn through these lowest costs. In Figure 49 this is illustrated. The numbers next to the line represent the fleet with the lowest costs that the corresponding water depth.

The colours of the lines between these points represent the optimum fleet composition for the concerning water depth.

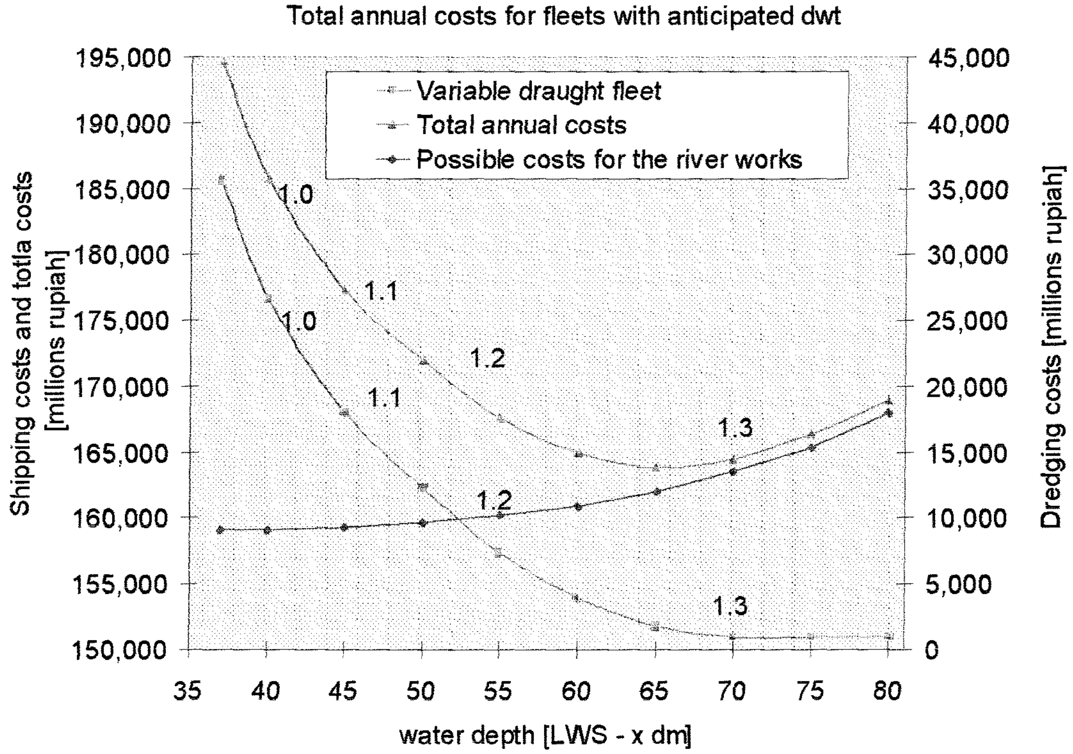

Figure 49 Total annual costs

Legend: (Figure 49)

1.0 : Existing fleet

1.1 : Fleet with 10% draught increase

1.2 : Fleet with 20% draught increase

1.3 : Fleet with 30% draught increase

From this graph the conclusion can be drawn that the optimum water depth for the Musi river is around LWS -6.5 m. For this depth the line for the fleet with 30% draught increase is favourable (Figure 49). This means that the optimum cost reduction can be attained for a increase of draught by 30%.

The reduction for the shipping costs is in the order of 30 billion Rupiah per year for an increase of the water depth from LWS -3.6 m to LWS -6.5 m.

12.2.1 Accuracy of the optimum depth

With Figure 49 and the graph from 11.4.3 (Figure 48), Figure 50 is composed. In this graph the influence of the uncertainty of the costs of changing the nautical depth are illustrated:

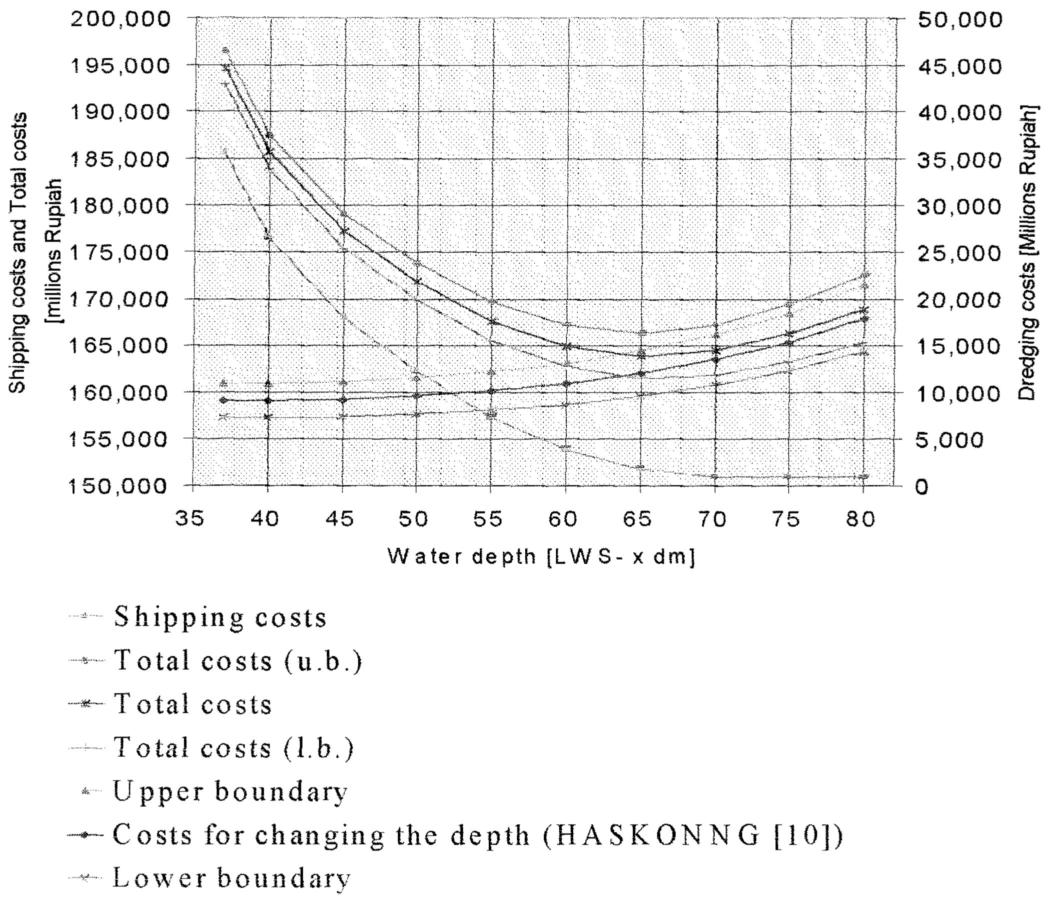

Figure 50 Annual costs for adjusted costs for change of the nautical depth

The optimum water depth remains at LWS - 6,5 m for all three possible alternative functions for the costs of changing the water depth. This is because the tangents of these three functions are almost equal.

12.2.2 Increase of vessel intensity

The vessel intensity can be defined as the number of vessels that call Palembang in year. On the basis of an optimum water depth of LWS -6.5 m simulations can be made for possible increases of intensity of the vessels.

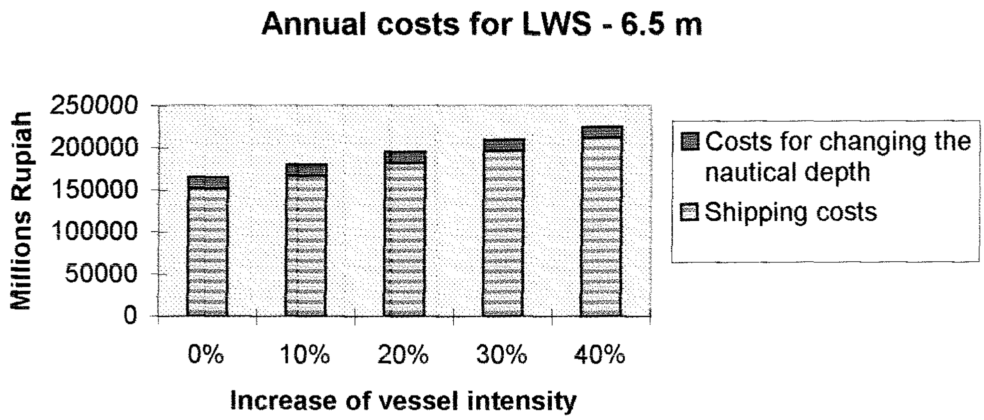

Figure 51 Annual costs for LWS - 6.5 m

From Figure 51 the conclusion can be drawn that an increase of 10% of the vessel intensity leads to a 10% increase in the shipping costs. The costs for changing the nautical depth remain constant. This can be explained by the fact that the maximum capacity of the river is not yet reached. The same holds for the increase of 20%, 30% and 40%.

An increase of intensity of 10% brings about a shift of the optimum water depth of about 0,05 m to the right. This means that an increase of intensity of 10% induces an increase of the optimum water depth with about 0.1% which is not significant.

12.2.3 Increase of the draught of outgoing vessels

Up to this point all simulations were carried out for fleets with identical incoming and outgoing draughts. This has been done because little is known about the draught of outgoing vessels. From the VTS data study rough comparisons between the average draught for incoming and outgoing vessels were made. From these calculations the impression rose that the outgoing vessels had an average 10-20% higher outgoing draught, depending on the terminal of destination. In this paragraph some simulations were carried out for these numbers. To make a good comparison, the draught of the incoming vessels were reduced with 5% respectively 10% and the outgoing vessels were increased with 5% respectively 10% to simulate the difference of 10% respectively 20% between in and outgoing vessels. The following relation was found.

Water depth	10% draught difference	20% draught difference
LWS - 3.6 m	Shipping costs+0.1%	Shipping costs+0.4%

Table 25 Shipping costs increase for different incoming and outgoing draughts

The shipping costs are therefore not sensitive for a small difference between the incoming and outgoing draughts.

13. Conclusions and recommendations

13.1 Conclusions

The following conclusions can be drawn:

- the current water depth in the Musi river is too low, the optimum water depth for a fleet with 30% higher draughts is around LWS - 6.5 m
- at LWS -6.5 m an increase of draught of 30% for vessels is recommended
- an increase of the vessel intensity leads to a equal increase in the shipping costs
- an increase of intensity of 10% does not change the optimum water level significantly.

13.2 Recommendations

The following recommendations are made:

- the costs for dredging and river works have to be determined more accurately
- the PROSIM could be extended with a simulation module for the harbours of destination In the current model vessels arrive at random, regardless of the tide. Therefore vessels often wait too long. In a extended model this problem can be solved by adjusting the time schedule or load factor in advance, considering the water level at the time of arrival
- the shipping cost model is still very rough. Parameters as fuel consumption and cost of cargo in transit have not been taken into account. Parameters as sailing time per round voyage have been estimated very roughly and should be determined more accurately
- For some parameters for the PROSIM model estimations had to be made. These parameters were not available. For a better representation of the reality, these parameters e.g. the draught of outgoing vessels should be determined more accurate

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Appendices

Appendix A: Cargo flow to Palembang

According to Pelabuhan II [20] the following number of vessels called at Palembang (Figure 1):

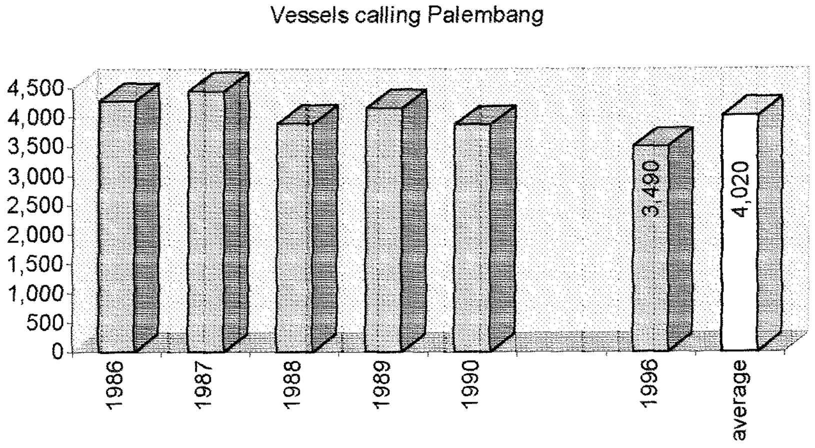

Figure 1 Vessels calling Palembang

In 1996 the total number of ship calls to Palembang was 3,490 [30]. The average number of ship calls to Palembang for 1986 -1990 and 1996 was 4,020. These numbers differ more than 40% from the measurements by ITS [15]. This difference can be due to the fact that vessels calling at more than one terminal are taken in account for only one call in the ITS measurements.

These vessels had the following grt[1] according to [20] (Figure 2):

[1] grt is an abbreviation for gross register tonnage: the total volume of all permanently enclosed space above and below decks, with certain exceptions, such as the wheelhouse, chart room, radio room and other specific space above deck [25].

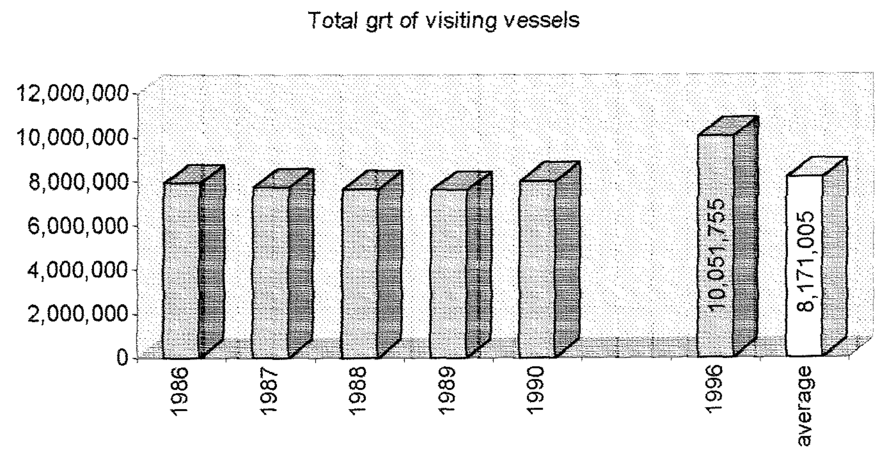

Figure 2 Total grt of visiting vessels

The average grt of visiting vessels for 1986 -1990 and 1996 was 8,171,005 ton/year.

The total grt amounted to the following annual cargo flow to and from Palembang (Figure 3) [20]:

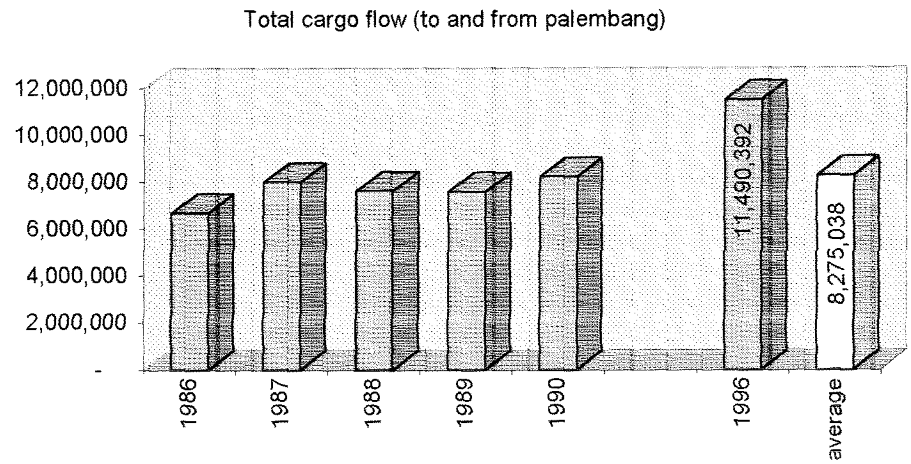

Figure 3 Total cargo flow (to and from Palembang)

The average cargo flow for 1986 - 1990 and 1996 was 8,275,038 ton/year. The conclusion can be drawn that although the total number of vessels has decreased, the total grt and cargo flow has increased. Therefore the vessel dimensions (grt per vessel) have increased. when this development continues, the vessel draught will continue to increase. The optimal water depth for the navigation channel will increase accordingly.

Appendix B: Calculation of average distance between maritime districts

The following table (Table 1) was used to calculate the average distance between maritime districts.

The first column gives the name of the district;

The second column gives the cargo flow in '000 tonnes from Palembang to this district (1983);

The third column gives the cargo flow in '000 tonnes to Palembang from this district (1983)

The fourth column gives the distance between Palembang and this district in Nautical miles.

In column five and the cargo flows are multiplied by the distance.

In the last row the columns are averaged, leading to an average distance of 550 nautical miles per call. A round voyage therefore is 2 * 550 = 1100 nautical miles. This is equal to 2045 km.

Maritime district	from Palembang	to Palembang	Distance in nautical miles			
Belawan	2	13	634	1268	8242	
Sumatra Barat	2	12	837	1674	10044	
Jambi	2	0	270	540	0	
Sumatra Selatan 2	5	0	188	940	0	
Lampung	8	0	390	3120	0	
D.K.I Jaya 1	1	1	345	345	345	
Jawa Tengah 1	11	0	493	5423	0	
Surabaya	6	37	638	3828	23606	
Jawa Timur	32	11	638	20416	7018	
Ujung Pandang	0	15	344	0	5160	
Sulawesi Selatan	0	1	1012	0	1012	
Sulawesi Tenggara	0	2	1078	0	2156	
Pontianak	1	0	1432	1432	0	
Bali	16	0	879	14064	0	
Singapura	30	12	261	7830	3132	
West Malaysia	2	3	450	900	1350	average
Total	118	107	9889	524	580	**550**

Table 1 average distance between maritime districts

This table is quoted from Veldman [24] and is valid for a regular liner system of vessels ranging from 200 dwt to 4,200 dwt. This table is therefore not valid for *all* vessels calling at Palembang, but only a first approximation.

Appendix C: Statistical analysis of the vessel data compilation

Introduction

ITS has conducted a survey on vessel movements for the period of seven months starting January 1996. Data of all incoming and leaving vessels have been collected. In this paragraph a description is given of the statistical analysis of the vessel data compilation

The VTS data [15] is composed of the following information base:

1. Vessel number
2. Name of the vessel
3. DWT
4. GRT
5. LOA
6. Arrival
    - 6.1 Draught bow
    - 6.2 Draught stern
    - 6.3 Date of arrival
    - 6.4 time of arrival
    - 6.5 time of departure of pilot (from pilotage station)
    - 6.6 time of arrival of pilot (vessel)
    - 6.7 time of completion of pilotage
    - 6.8 Sort of payload
7. Departure
    - 7.1 Draught bow
    - 7.2 Draught stern
    - 7.3 Date of departure
    - 7.4 time of departure
    - 7.5 time of departure of pilot (from pilotage station)

7.6 time of arrival of pilot (vessel)

7.7 time of completion of pilotage

7.8 Sort of payload

8. Origin
9. Destination
10. Mooring

10.1 Origin

10.2 Destination

These data needed to be modified in order to use them for the PROSIM model. The following steps were taken.

Preliminary actions

1. The data were classified into four sections. Distinctions were made between the following vessels:
   - Boom Baru
   - Pertamina
   - Pusri
   - Rest
2. The date and time were changed into serial number, as used by the spreadsheet program '*Excel 7.0*'. This made it possible to subtract the times, necessary to create periods of service time, inter arrival time and waiting times (at the harbour and at the outerbar). In [3, Appendix A] an example of this process is given.
3. Every vessel occupies several rows in the spreadsheet. Only one set of times per vessel is wanted. Therefore a filter was used to select only the first row of times in case of arrival and the last row in case of departure. In a few occasions also vessels were selected that did not sail from the outerbar directly to Palembang, but made a call in between. This was made visible by looking at the sailing times, which were too short. These vessels were excluded from the CDF for the sailing time. The data were not excluded from the inter arrival time and the waiting time.
4. It was not possible to extract the service time in the harbour from the data presented, because of the irregular registration. Therefore it was necessary to type in the original

data again, from the paperwork, in a more organised manner. Because this is extensive work, it was not done for all the months available.

5. The same problem arises with the waiting time at the harbour. This was even more difficult, because many descriptions were used to record the information. The vessels often not wait at one location. Many unrelated data were recorded, making it necessary to type in this data again as well. This is also not done for all the available data. It has to be noted that probably some of the vessels wait for the tide at the quay. This depends of the occupancy of the quay. This implies that the service time and waiting time at the harbour are sometimes mixed.
6. The sailing time (departure) also had to be typed in again.
7. The serial numbers were organised and changed into times again. [3, Appendix A]

Vessel dimensions

For the dimensions of the vessels the following procedure was used.

1. For each vessel the matching dwt, loa and draught (arriving) were extracted. The draught arriving is the highest of the draught bow and draught stern. [3, Appendix A]
2. It was not possible to determine the draught (departure) for the belonging vessel due to irregular registration. For the outgoing and arriving vessels the same draught has been assigned. (Rough calculations have been made to estimate the difference between the draught of outgoing and incoming vessels. This difference is in the order of 10% to 20% higher average draughts for outgoing vessels. Simulations have been made for these numbers with the following outcome:

Water depth [LWS -x. m]	original configuration	10% increase outgoing vessels
3.6	183,703	189,898
5.5	169,601	169,782

For higher water depth the difference is even less.)

Distribution functions

Tables were created for each terminal.

1. For each vessel the following attributes are tabulated: Number of vessel, dwt, loa, draught (arriving), inter arrival time, waiting time at the outerbar, sailing time to

Palembang, sailing time from Palembang, waiting time at the harbour and service time [3, Appendix A].

2. Cumulative distribution functions were made for the inter arrival time, the waiting times, the service time and the sailing times [3, Appendix C].
3. Empirical distribution functions were made for the dwt [3, Appendix C].
4. Loa and Draught were plotted against the dwt [3, Appendix D].

With the program *'BestFit'* it was possible to fit the inter arrival time and the service time to a *Erlang -1* distribution [3, Appendix E]. These negative exponential distributions and the average sailing time are used in the PROSIM model. The cumulative distribution functions for the waiting time (at the outerbar) were used to calibrate the model.

Appendix D: Calculation of shipping costs from waiting times

In this appendix the annual shipping costs as calculated in the PROSIM model Palembang are given. First the waiting times are given, followed by the shipping costs based on these waiting times, (as well as on the service times and the dwt of the vessel).

1. In the first column the fleet description is given:

Boom Baru 1	: Boom Baru fleet 1. Sub fleet with dwt <6.500
Boom Baru 2	: Boom Baru fleet 2. Sub fleet with dwt >6.500
Boom Baru total	: Total Boom Baru fleet. Waiting times for Boom Baru total = 0.76*Boom Baru 1+0.24*Boom Baru 2
Pertamina 1	: Pertamina fleet 1. Sub fleet with dwt <6.500
Pertamina 2	: Pertamina fleet 2. Sub fleet with dwt >6.500
Pertamina total	: Total Pertamina fleet. Waiting times for Pertamina total = 0.6*Pertamina 1+0.4*Pertamina 2
Pusri 1	: Pusri fleet 1. Sub fleet with dwt <6.500
Pusri 2	: Pusri fleet 2. Sub fleet with dwt >6.500
Pusri total	: Total Pusri fleet. Waiting times for Pusri total = 0.7*Pusri 1+0.3*Pusri 2
Total	: All fleets cumulated.
Total waiting time	: (Boom Baru/816+Pertamina/510+Pusri/1390)*253
Total costs	: Boom Baru total +Pertamina total + Pusri total

2. In the first table the waiting times (in days) for 6 different water depth (in LWS - dm) are given.

3. In the second table the shipping costs (in millions Rupiah) for 6 different water depth (in LWS -dm) are given.

Waiting times

Boom Baru 1	37	40	45	50	55	60	65	70	75
Existing fleet	0.0539	0.0368	0.0093	0.0006	0.0001	0.0001	0.0001	0.0001	0.0001
Fleet with 10% draught increase		0.0759	0.0182	0.0042	0.0006	0.0001	0.0001	0.0001	0.0001
Fleet with 20% draught increase			0.0181	0.0187	0.0068	0.0011	0.0001	0.0001	0.0001
Fleet with 30% draught increase				0.0165	0.0135	0.0039	0.0025	0.0001	0.0001

Boom Baru 2	37	40	45	50	55	60	65	70	75
Existing fleet	0.8418	0.3702	0.0763	0.0142	0.0015	0.0001	0.0001	0.0001	0.0001
Fleet with 10% draught increase		2.2408	0.4298	0.1523	0.0328	0.0001	0.0001	0.0001	0.0001
Fleet with 20% draught increase			2.893	0.5984	0.2012	0.046	0.0023	0.0002	0.0002
Fleet with 30% draught increase				4.2993	0.8306	0.3032	0.0939	0.0024	0.0001

Total Boom Baru	37	40	45	50	55	60	65	70	75
Existing fleet	0.2430	0.1168	0.0254	0.0039	0.0004	0.0001	0.0001	0.0001	0.0001
Fleet with 10% draught increase		0.5955	0.1170	0.0397	0.0083	0.0001	0.0001	0.0001	0.0001
Fleet with 20% draught increase			0.7081	0.1578	0.0535	0.0119	0.0006	0.0001	0.0001
Fleet with 30% draught increase				1.0444	0.2096	0.0757	0.0244	0.0007	0.0001

Pertamina 1	37	40	45	50	55	60	65	70	75
Existing fleet	0.02	0.0088	0.0002	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Fleet with 10% draught increase		0.0367	0.0074	0.0003	0.0001	0.0001	0.0001	0.0001	0.0001
Fleet with 20% draught increase			0.049	0.016	0.0001	0.0001	0.0001	0.0001	0.0001
Fleet with 30% draught increase				0.062	0.0122	0.0001	0.0001	0.0001	0.0001

Pertamina 2	37	40	45	50	55	60	65	70	75
Existing fleet	0.9683	0.3177	0.0656	0.0107	0.0001	0.0001	0.0001	0.0001	0.0001
Fleet with 10% draught increase		2.2904	0.3199	0.0945	0.0166	0.0004	0	0	0
Fleet with 20% draught increase			1.8424	0.5349	0.1397	0.0297	0.0022	0	0
Fleet with 30% draught increase				3.1738	1.1431	0.1987	0.0619	0.0078	0

total Pertamina	37	40	45	50	55	60	65	70	75
Existing fleet	0.3993	0.1324	0.0264	0.0043	0.0001	0.0001	0.0001	0.0001	0.0001
Fleet with 10% draught increase		0.9382	0.1324	0.0380	0.0067	0.0002	0.0001	0.0001	0.0001
Fleet with 20% draught increase				0.2236	0.0559	0.0119	0.0009	0.0001	0.0001
Fleet with 30% draught increase				1.3067	0.4646	0.0795	0.0248	0.0032	0.0001

Pusri 1	37	40	45	50	55	60	65	70	75
Existing fleet	0.1333	0.0681	0.0101	0.0001	0	0	0	0	0
Fleet with 10% draught increase		0.1694	0.0503	0.0101	0.001	0.0001	0.0001	0.0001	0.0001
Fleet with 20% draught increase			0.2806	0.0394	0.0132	0.0012	0	0	0
Fleet with 30% draught increase				0.346	0.0962	0.0162	0.0058	0.0018	0

Pusri 2	37	40	45	50	55	60	65	70	75
Existing fleet	1.7244	0.4336	0.1199	0.0407	0.0001	0.0001	0.0001	0.0001	0.0001
Fleet with 10% draught increase		3.6155	0.5326	0.1596	0.0265	0.0011	0.0001	0.0001	0.0001
Fleet with 20% draught increase			3.8518	1.3591	0.3087	0.0808	0.0115	0.0001	0.0001
Fleet with 30% draught increase				3.5652	2.5303	0.4188	0.1194	0.0181	0.0002

total Pusri	37	40	45	50	55	60	65	70	75
Existing fleet	0.6106	0.1778	0.0430	0.0123	0.0000	0.0000	0.0000	0.0000	0.0000
Fleet with 10% draught increase		1.2032	0.1950	0.0550	0.0087	0.0004	0.0001	0.0001	0.0001
Fleet with 20% draught increase			1.3520	0.4353	0.1019	0.0251	0.0035	0.0000	0.0000
Fleet with 30% draught increase				1.3118	0.8264	0.1370	0.0399	0.0067	0.0001

total	37	40	45	50	55	60	65	70	75
Existing fleet	0.3891	0.1358	0.0291	0.0057	0.0002	0.0001	0.0001	0.0001	0.0001
Fleet with 10% draught increase		0.8793	0.1391	0.0417	0.0076	0.0002	0.0001	0.0001	0.0001
Fleet with 20% draught increase			0.8558	0.2419	0.0636	0.0143	0.0013	0.0001	0.0001
Fleet with 30% draught increase				1.2252	0.4512	0.0889	0.0275	0.0030	0.0001

Shipping costs

Boom Baru 1	37	40	45	50	55	60	65	70	75
Existing fleet	23964	23865	23770	23740	23738	23738	23738	23738	23738
Fleet with 10% draught increase		24024	23401	23353	23341	23339	23339	23339	23339
Fleet with 20% draught increase			23299	23477	23437	23417	23414	23414	23414
Fleet with 30% draught increase				23454	23424	23391	23386	23378	23378

Boom Baru 2	37	40	45	50	55	60	65	70	75
Existing fleet	17547	16898	16188	16038	16007	16004	16004	16004	16004
Fleet with 10% draught increase		19907	16055	15338	15068	14994	14994	14994	14994
Fleet with 20% draught increase			19514	15225	14294	13962	13868	13863	13863
Fleet with 30% draught increase				21453	14570	13488	13059	12871	12867

Total Boom Baru	37	40	45	50	55	60	65	70	75
Existing fleet	41511	40763	39958	39778	39745	39742	39742	39742	39742
Fleet with 10% draught increase	0	43931	39456	38691	38409	38333	38333	38333	38333
Fleet with 20% draught increase	0	0	42813	38702	37731	37379	37282	37277	37277
Fleet with 30% draught increase	0	0	0	44907	37994	36879	36445	36249	36245

Pertamina 1	37	40	45	50	55	60	65	70	75
Existing fleet	43269	42132	42070	42069	42069	42069	42069	42069	42069
Fleet with 10% draught increase		43143	40835	40785	40784	40784	40784	40784	40784
Fleet with 20% draught increase			41317	40136	40028	40027	40027	40027	40027
Fleet with 30% draught increase				39801	39430	39350	39349	39349	39349

Pertamina 2	37	40	45	50	55	60	65	70	75
Existing fleet	69824	63536	60895	60315	60202	60202	60202	60202	60202
Fleet with 10% draught increase		78402	59500	57261	56487	56326	56322	56322	56322
Fleet with 20% draught increase			69743	58685	54770	53732	53473	53452	53452
Fleet with 30% draught increase				77952	61192	52777	51544	51057	50987

total Pertamina	37	40	45	50	55	60	65	70	75
Existing fleet	113093	105668	102965	102384	102271	102271	102271	102271	102271
Fleet with 10% draught increase	0	121545	100335	98046	97271	97110	97106	97106	97106
Fleet with 20% draught increase	0	0	111060	98821	94798	93759	93500	93479	93479
Fleet with 30% draught increase	0	0	0	117753	100622	92127	90893	90406	90336

Pusri 1	37	40	45	50	55	60	65	70	75
Existing fleet	14757	14824	14700	14679	14679	14679	14679	14679	14679
Fleet with 10% draught increase		15252	14607	14523	14504	14501	14501	14501	14501
Fleet with 20% draught increase			15225	14292	14237	14212	14209	14209	14209
Fleet with 30% draught increase				15308	13806	13643	13622	13613	13610

Pusri 2	37	40	45	50	55	60	65	70	75
Existing fleet	16246	13557	12936	12779	12698	12698	12698	12698	12698
Fleet with 10% draught increase		18413	12996	12302	12054	12007	12005	12005	12005
Fleet with 20% draught increase			17355	13740	11911	11509	11387	11367	11367
Fleet with 30% draught increase				16239	14924	11373	10869	10699	10668

total Pusri	37	40	45	50	55	60	65	70	75
Existing fleet	31003	28381	27636	27458	27377	27377	27377	27377	27377
Fleet with 10% draught increase		33665	27603	26825	26558	26508	26506	26506	26506
Fleet with 20% draught increase			32580	28032	26148	25721	25596	25576	25576
Fleet with 30% draught increase				31547	28730	25016	24491	24312	24278

total (excel)	37	40	45	50	55	60	65	70	75
Existing fleet	185607	174812	170559	169620	169393	169390	169390	169390	169390
Fleet with 10% draught increase		199141	167394	163562	162238	161951	161945	161945	161945
Fleet with 20% draught increase				165555	158677	156859	156378	156332	156332
Fleet with 30% draught increase				194207	167346	154022	151829	150967	150859

Appendix E: Description of the PROSIM Modules for the Palembang model

The following flow chart (Figure 4) was made to express the relations between the modules and the macros used in the model. The Palembang model consists of two parts: The definition section, in which the configuration is shown and the dynamic section, which shows the dynamic behaviour of the living components.

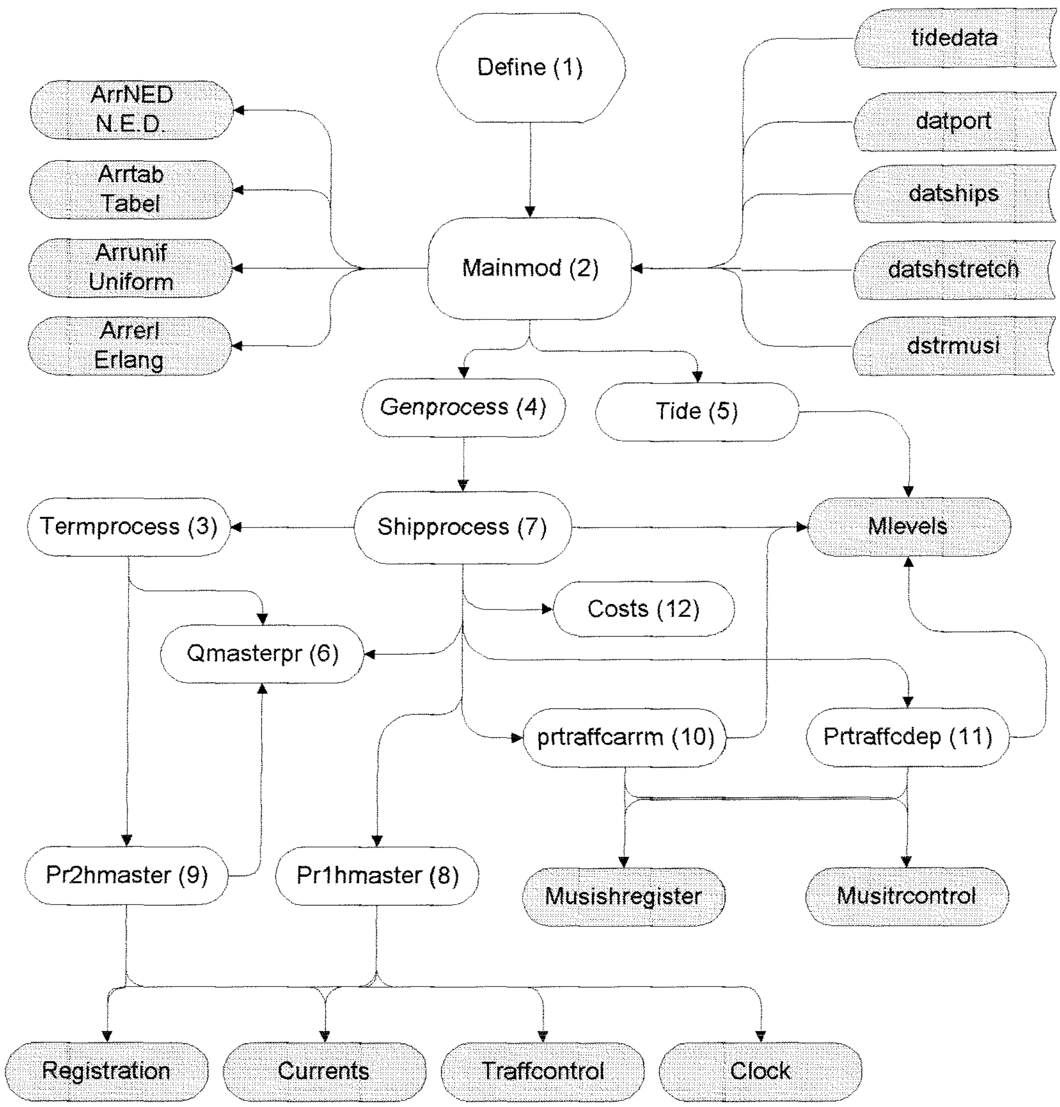

Figure 4 Flow chart of PALEMBANG model

The white coloured element represent modules, the grey element with rounded edges represent macros. The input files are represented by grey elements with a dent in the right side.

The model consists of the following twelve modules (see also Figure 4):

par.	#	Module	Description	activates	activated by
5.5.1	1	Define	Definition	2	user
5.5.2	2	Mainmod	Run control	4,5	1
5.5.3	3	Termprocess	Terminal process	6,9	7
5.5.4	4	Genprocess	Generator	7	2
5.5.5	5	Tide	Tide process		2
5.5.6	6	Qmasterpr	Quay process		3,7,9
5.5.7	7	Shipprocess	Ship process	3,6,8,10,11,12	4
5.5.8	8	Pr1hmaster	Traffic conditions and tide for incoming vessels (harbour)		7
5.5.9	9	Pr2hmaster	Traffic conditions and tide for outgoing vessels (harbour)	6	3
5.5.10	10	Prtraffcarrm	Traffic conditions and tide for incoming vessels (Musi river)		7
5.5.11	11	Prtraffcdep	Traffic conditions and tide for outgoing vessels (Musi river)		7
5.5.12	12	Costs	Annual costs calculator		7

Table 2 Modules in the PROSIM model PALEMBANG

The following macros are in use by the program (see also Figure 4)

Macro	Description	activated by module
Mlevels	Water levels on the bars	5,7,10,11
Musitrcontrol	Traffic control (Musi)	10,11
Musishregister	Registration incoming and leaving vessels (Musi)	10,11
Registration	Registration incoming and leaving vessels (harbour)	8,9
Currents	Calculation of currents (all current are zero)	8,9
Traffcontrol	Traffic control (harbour)	8,9
Clock	Determination of the tidal time (not in use)	8,9
Arrned	Generation of the inter arrival time from a NED distribution.	2
Arrtab	Generation of the inter arrival time from a table	2
Arrunif	Generation of the inter arrival time from a uniform distribution	2
Arrerl	Generation of the inter arrival time from a Erlang distribution	2

Table 3 Macros in the PROSIM model Palembang

DEFINE

The definition section, shows the structure of the model in terms of components and attributes. Moreover queues, tables, input streams (input files), output streams (output files) and random streams are defined.

Lines 1 to 15:

Definition of the components, classes, queues, streams and tables.

Lines 15 to 33:

Definition of the attributes of the component MAIN

Lines 34 to 46:

Definition of the attributes of the components PR1HMASTER (Harbour master1), PR2HMASTER and QMASTERPR (quay master).

Lines 47 to 65:

Definition of the attributes for the class GENERATOR

Lines 66 to 84:

Definition of the attributes for the class SHIP

Lines 85 to 108:

Definition of the attributes for the components TERMPROCESS (Terminal Processor), PRTRAFFCARRM (traffic Controller Arrival Musi), PRTRAFFCDEP (Traffic Controller Departure) and TIDALREC (Tidal recorder (not in use))

Lines 108 to 112:

Definition of the attributes for the component COSTS:

Lines 113 to 115:

Definition of the figure files.

MAINMOD

Directs the initiation of the simulation, the run control and the termination of the simulation.

Lines 1 to 9:

Initialisation. General inputs are read.

Lines 10 to 91:

Vessel generators are created for each ship type. Inputs are read, distributions are reshaped for the arrival times and empirical continuous distributions for the vessel data are created. For each dwt the following data are tabulated: Draught, Length, Costs and Delay time (The time each vessel has to stay behind another vessel).

Lines 92 to 185:

Configuration of sailing times and service time. GENPROCESS is activated.

Lines 187 to 192:

Delay time (The time each vessel has to stay behind another vessel) for the Musi river is configured.

Lines 192 to 237:

Terminals are generated. Inputs for quay-length are read., distributions are reshaped for the service times at the terminal. These service times are not in use. Service times are defined for each ship type in lines 92 to 185.

Line 238 to 243:

Traffic control is initialised.

Lines 244 to 275:

Inputs for the tide are read and TIDE is activated.

TERMPROCESS

Terminal Processor. Controls the processes at the terminal. Checks for a vessel if enough quay length is available to join the quay. The service time of the vessel is stored.

Lines 1 to 10

The last vessel in the quay is activated

Lines 11 to 14

The length of the vessel is added to the free quay length and the vessel is removed from the quay. QMASTERPR is activated.

Lines 15 to 20

The vessel is moved to the departure queue and PR2HMASTER is activated.

GENPROCESS

The generator of particular fleets.

Lines 1 to 9:

After a waiting period, drawn from a distribution function, a ship is generated and values of attributes are assigned.

Lines 10 to 15:

Type, terminal to be called, dwt, draught, length and costs are assigned.

Lines 16 to 18:

If the dwt of a vessel is larger than 6.000 tonnes, the dwt and the draught to and from Palembang are multiplied with factors to simulate the fleet compositions for the existing situation (1.0 and 1.0 respectively), the composition with 10%

draught increase (1.2 and 1.1 respectively)), the composition with 20% draught increase (1.4 and 1.2 respectively) or the composition with 30% draught increase (1.6 and 1.3 respectively).

Lines 19 to 22:

Sailing times, separation times in the approach channel are assigned.

Lines 23 to 54:

The route to and through the port and the related sailing times in the different sections of this route are assigned.

Line 55 to 60:

The service time parameters are assigned to the ship type.

Line 61:

SHIPPROCESS is activated and the GENERATOR repeats the process.

TIDE

The level is on the bars and shoals is simulated in this module.

Lines 1 to 12

For every bar the Macro MLEVELS is activated and the levels on the bars are calculated and stored for the current time.

QMASTERPR

Quay Master Processor. Checks the availability of quay length of a terminal. This is done for the ship under consideration. If so, the necessary quay length is reserved and the SHIP is activated.

Lines 1 to 14

The first ship in the queue is activated if the free quay length is higher than the length of the vessel.

SHIPPROCESS

This module describes the process of the vessels.

Lines 1 to 20:

The SHIP starts her process from the label SHSTART, the ship enters the queue ANCHORAGEMUSI and activates the PRTRAFFCARRM. The PRTRAFFCARRM checks the criteria for entrance. Next the waiting time of the SHIP is determined. This waiting time is stored, the ship leaves the ANCHORAGEMUSI and enters the MUSIIN. It then sails all the sections of the Musi river.

Lines 21 to 24:

After staying in all the sections for the assigned time the SHIP enters the queue ARRQUAY for the terminal that was assigned to the vessel

Lines 25 to 116:

QMASTERPR is activated. The QMASTER checks if there is free quay length. PR1HMASTER is activated. The PR1HMASTER checks the criteria for entering the harbour. After entering the TERMPROCESS is activated. The vessel is moved to the quay when enough space is available.

Line 117:

The vessel waits the assigned service time.

Lines 118 to 119:

The SHIP leaves the quay, TERMPROCESS is activated to register the new quay length.

Lines 120 to 202:

The SHIP is moved to the ANCHORAGEPALEMB where the PR2HMASTER checks the criteria for exiting the Musi river. The waiting time is stored and COST is activated. The SHIP then exits the Musi river and is removed from the system.

PR1HMASTER

Harbour master 1. Controls incoming ship traffic. For the first ship in the queue two checks are carried out: 1. Ship traffic conditions and 2. The tidal conditions.

Lines 1 to 14

The harbour master checks if the currents are not too high (The currents are always zero in this model and therefore never too high!)

Lines 14 to 51

Macro TRAFFCONTROL is activated. It is checked if the vessel can sail the stretches without interfering with other vessels where not allowed..

PR2HMASTER

Harbour master 2. Controls leaving ship traffic. For the first ship in the queue two checks are carried out: 1. Ship traffic conditions and 2. The tidal conditions.

Lines 1 to 14

The harbour master checks if the currents are not too high

Lines 14 to 51

Macro TRAFFCONTROL is activated. It is checked if the vessel can sail the stretches without interfering with other vessels where not allowed..

PRTRAFFCARRM

Process of traffic control on the Musi river. (Arriving vessels)

Lines 1 to 20

For every vessel the level on the bars is checked. Using the macro MLEVELS the draught is compared with the level on the bars on the moment of arrival at that bar. The vessel can continue when the water level is higher than the draught of that vessel.

Lines 21 to 40

Macro MUSITRCONTROL is activated. It is checked if the vessel can sail the stretches without interfering with other vessels where not allowed.

Lines 41 to 55

The next vessel is checked, if any.

PRTRAFFCDEP

Process of traffic control on the Musi river. (Departing vessels)

Lines 1 to 20

For every vessel the level on the bars is checked. Using the macro MLEVELS the draught is compared with the level on the bars on the moment of arrival at that bar. The vessel can continue when the water level is higher than the draught of that vessel.

Lines 21 to 40

Macro MUSITRCONTROL is activated. It is checked if the vessel can sail the stretches without interfering with other vessels where not allowed.

Lines 41 to 55

The next vessel is checked, if any.

COSTS

In this module the annual shipping costs are calculated, as well as the average dwt, the average service time, the number of vessels to each terminal and the average waiting times of each fleet type.

Lines 1 to 8:

The total waiting time for a ship is determined by adding the waiting time at the outerbar to the waiting time at the harbour. The total waiting time in minutes is converted into days.

Lines 8 to 12:

For the regarding terminal the costs are calculated. First the total waiting time, total dwt and total service time are determined

Lines 13 to 15:

Average waiting time, average dwt and average service time are calculated. For the regarding terminal.

Line 16:

The costs for the regarding terminal are calculated using equation 5.11 through 5.13.

Line 17:

The costs of these six terminals are multiplied by the fraction of the fleet the terminal constitutes and is added to the total shipping cost per year.

Lines 18 to 24:

From the point that the simulation has run for e.g. 150,000 minutes (104 days) the attributes of the vessels are stored.

Line 25:

From the point that the simulation has run for e.g. 150,000 minutes (104 days) the total costs are stored

The annual shipping costs will reach a stationary state after a period of approximately 50,000 minutes. This can be presented in a graph (for instance Figure 5). The actual simulations are run for at least 150,000 minutes (104 days).

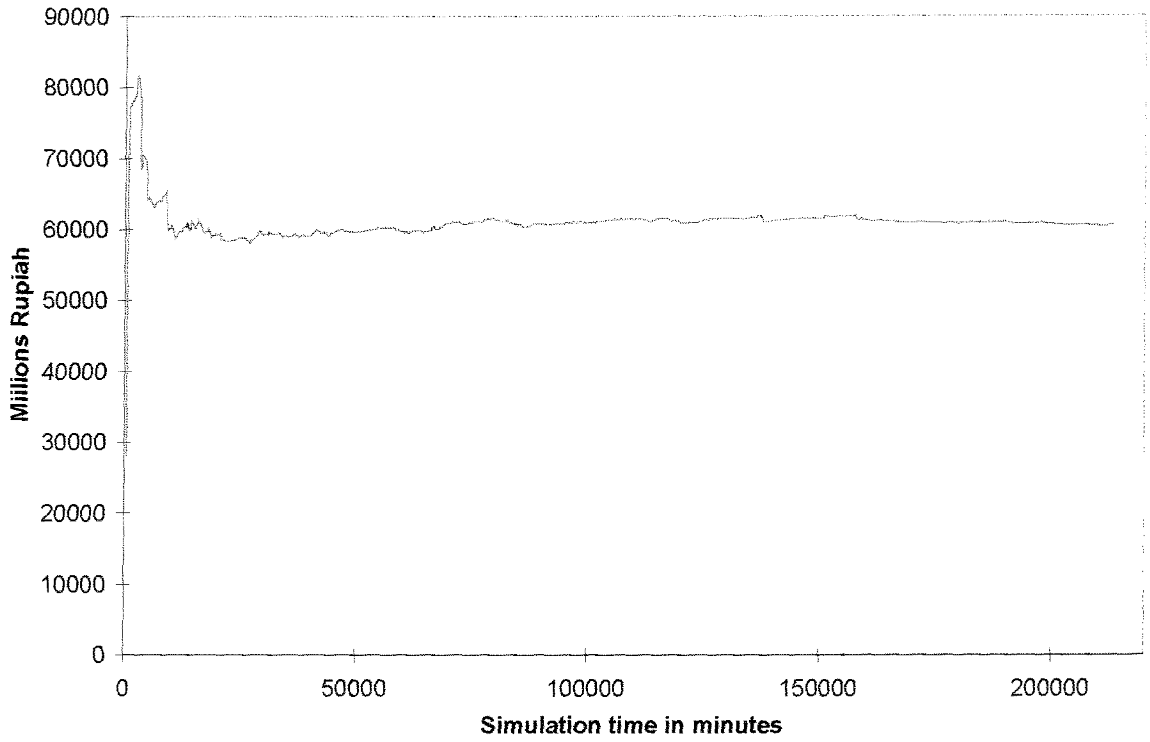

Figure 5 Annual total shipping costs in time for a fictitious situation

The source text of the input files is presented in appendix D: The input files for the model PALEMBANG.

Appendix E: The source text of the modules in the PROSIM model Palembang

MOD DEFINE

```
@ DEFINITION SECTION
component         :HMASTER1 HMASTER2 TIDALC TRAFFCARRM TRAFFCDEPP
                   COSTMAN
class             : SHIP GENERATOR TERMOPER QMASTER TIDALREC
queue             : ARRIVAL DEPARTURE CHANNEL TQUAY[8] TERMDEPQ[8]
queue             :ARRQUAY[8] QUAYQ CHANNELIN CHANNELOUT
                   ANCHORAGEPALEMB
queue             : ANCHORAGEMUSI MUSIIN[12] MUSIOUT[12]
inputstream       : DATSHIPS DATPORT DATSHSTRETCH TIDEDATA DSTRMUSI
randomstream      : RDWT[8] RINTARR[8] RSERVT[8] GRSERVT[8] RDCOMM
outputstream      : ARRVT1 ARRVT2 DEPARTT
outputstream      : TCOST ATR1 ATR2 ATR3 ATR4 ATR5 ATR6
table(11)         : TTABSERV[8] GARRTAB[8]
table(20)         : GTABDRI[8] GTABDRO[8] GDWTDIST[8] GTABLENGTH[8]
                   GTABCOMMIN[8] GTABCOMMOUT[8] GTABCPH[8]


attributes of main:
reference to GENERATOR  : GEN[8]
reference to TERMOPER   : TERMOP[8]
integer           : I J K L TOTGEN TOTOPER ENC OVERT TOTNBSHG
real              : CTIME TIDALCYCL KEELCL CPH
real              : T1 T2 S_CU DT DT_LAST CNT[26] CST[26] CURRENTT
real              : A B T_AF_LW R_CU N T_AF_N C1 C2 CURRENT
real              : H1 H2 WNT[6,26]WST[6,26] @was [3,26]
real              : LEVTIME LEVBAR[6] DEPTH[6]   @was [3]
integer           : TPCURVE TCURVES @ POINTS TIDAL CURVE, NUMBER CURVES
integer           : TRTEST ARI ARO ONFO[20,4] INFO[20,4] NBSTRCOM
integer           : MARIS MAROS MINFOS[20,4] MONFOS[20,4]
integer           : TRVRS NBBARS NBSTRMUSI MTRTEST
real              : INCTRI[15,55,2] OUTTRI[15,55,2]  SHIPTIMES[55,2]
real              : MINCTRIS[15,12,2] MOUTTRIS[5,12,2] MSHIPTIMES[12,2]
logical           : OVERTAKE[12,55,12] ENCOUNTER[12,55,12] INCLEAN OUTCLEAN
logical           : MOVERTAKE[12,12,12] MENCOUNTER[12,12,12] MINCLEAN
                   MOUTCLEAN
logical           : TRVERS
real              : V0 W0 V1 W1 TONYEAR[8] SAILTIME[8] FACDWT FACDRAUGHT

attributes of HMASTER1:
reference to SHIP :HM1SHIP
real              : DELAYT1

attributes of HMASTER2:
reference to SHIP :HM2SHIP
real              : DELAYT2

attributes of QMASTER:
```

```
reference to SHIP:QMSHIP
integer        :QMTERMN

attributes of GENERATOR:
character(15) : GENTYPE GENIADIS GENSLDIS GSERVT
integer      : FLN GTERMN GENPRIOR TOTCLASSES
integer      : GNBSTR GNBMSTR GSTRCOM GDEST GSTRETCH[13] GMSTRETCH[12]
real         : GDRI GDRO GLENGTH GCOMMIN GCOMMOUT
real         : GSTI[13] GSTO[13] GCURRENTT GCTWLIN[6] GCTWLOUT[6] @[6] was 3
real         : GMSTI[12] GMSTO[12]
real         : ARRPAR1 ARRPAR2 ARRPAR3
real         : GSERVPAR1 GSERVPAR2 GSERVPAR3 GSERVICET GDOWNPERC
real         : DELAYTI DELAYTO
real         : LOADIN LOADOUT
real         : GENSINT GENSOUTT BTIDALWI ETIDALWI BTIDALWO ETIDALWO
real         : FLDWTDIST[20,2]
real         : GARRTB INTARRT
macro         : GINTARR
macro         : GSERVTIME
reference to TIDALREC:GTWR


attributes of SHIP:
character(15)       : TYPESHIP POS SHDIRECTION SHDESTINATION
real                : SHSAILINT SHSAILOUTT SHSERVT SLENGTH SHPRIOR
real                : SHDELTI SHDELTO SDWT DRAUGHTIN DRAUGHTOUT SCPH
real                : ADQUAYT ARRQUAYT WTOB WTHB
real                : SCOMMIN SCOMMOUT STARTWAIT
real                : SHWINDBI SHWINDEI SHWINDBO SHWINDEO
real                : SHSTI[13] SHSTO[13]
real                : SHMSTI[12] SHMSTO[12]
real                : SHCURRENTT SHCTWLIN[6] SHCTWLOUT[6] @was [3]
integer              : SHTERMN PRIORITY NBSTRETCHES STRCOM DESTINATION
integer              : SHIPTYPE TRNB STRETCH[13] SHPOS SHPOSO NUMBERSH
integer              : SHSPOS
integer              : SHMSTRETCH[12]
integer              : SHNBMSTR
logical             : SHTEST1 SHTEST2 SHTEST3 DELAYT
logical             : SHTESTM[6] SHTRTEST     @was [3]
reference to TERMOPER :SHTERMOP

attributes of TERMOPER:
character(15)                : TERMTYPE TSERVT
logical                      : AVAILTERMQ
integer                      : TNUMBER MAXDEPQ  AVTQ
real                         : SERVPAR1 SERVPAR2 SERVPAR3
real                         : TERMQUAYL FRQUAYL TTBSERV SERVICETT QUAYMH
reference to SHIP            : TSHIP
reference to QMASTER         :QUAYMASTER
macro                        :TERMSERVT

attributes of TRAFFCARRM:
reference to SHIP: TCMSHIP
real           : TCMDELAY

attributes of TRAFFCDEPP:
reference to SHIP: TCPSHIP
real           : TCPDELAY

```

```
attributes of TIDALREC:
real              :TIDOPENPER TIDCLOSEDPER TIDTOOP
integer           :TIDCOLN1 TIDCOLN2 TIDSHIPTYPE
character(5)      : STATE

attributes of COSTMAN:
real              : WAITTIME TOTALCOST
real              : AVWT[8] TOTWT[8] CUMUCOST[8] TOTSERVT[8]
real              : TOTSDWT[8] TOTSHIP[8] AVSDWT[8] AVSERVT[8]

figure     :CHPOS[20] TB1[20] TB2[20] TB3[20] TB4[20] TB5[20] TB6[20]
           TBMB1[20] TBMB2[20] TBMB3[20] TBMB4[20] TBMB5[20] TBMB6[20]
           MB1[20] MB2[20] MB3[20] MB4[20] MB5[20] MB6[20] BD1 BD2 BD3 BD4
           ANCHORAGE SHIPWAITT SHIPTURNT DEPART
figure     :TBMB1O[20] TBMB2O[20] TBMB3O[20] TBMB4O[20] TBMB5O[20]
           TBMB6O[20] CHPOSO[20] CHANNELF TIDALW[12]
           CHANNELOUTF CHANNELINF
figure     :FMUSIIN[12] FMUSIOUT[12] FANCHMUSI FANCHPALEMB
```

MOD MAINMOD

```
@ PROCESS OF MAIN
TRVRS←read from DATPORT
TRVERS←true if TRVRS=1
TRVERS←false if TRVRS=0
@ INTIALISATION GENERATORS TERMINALS
TOTNBSHG←0
TIDALCYCL←read from DATPORT
reshape RDCOMM as sampled from distribution uniform with parameters     lb(0.8) ub(1.2)
seed of RDCOMM←read from DATSHIPS

@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@
@ GENERATION OF SHIP GENERATORS @
@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@
NBBARS←read from TIDEDATA
TOTGEN←read from DATSHIPS
KEELCL←read from DATSHIPS
V0←read from DATSHIPS
W0←read from DATSHIPS
V1←read from DATSHIPS
W1←read from DATSHIPS
FACDWT←read from DATSHIPS
FACDRAUGHT←read from DATSHIPS
for k←1 to TOTGEN
 this GENERATOR←new GENERATOR
 GENTYPE←chread from DATSHIPS
 FLN←read from DATSHIPS
 GTERMN←read from DATSHIPS
 GDEST←read from DATSHSTRETCH
 TOTCLASSES←read from DATSHIPS
 TONYEAR[I]←read from DATSHIPS      @toegevoegd
 SAILTIME[I]←read from DATSHIPS     @toegevoegd
 GENSINT←read from DATSHSTRETCH
 GENSOUTT←read from DATSHSTRETCH
 BTIDALW←read from DATSHIPS
 ETIDALW←read from DATSHIPS
```

```
BTIDALWO←read from DATSHIPS
ETIDALWO←read from DATSHIPS
GENPRIOR←read from DATSHIPS
DELAYTI←read from DATSHIPS
DELAYTO←read from DATSHIPS
LOADIN←read from DATSHIPS        @toegevoegd
LOADOUT←read from DATSHIPS       @toegevoegd
for J←1 to TOTCLASSES
  FLDWTDIST[J,1]←read from DATSHIPS
  FLDWTDIST[J,2]←read from DATSHIPS
  tabulate FLDWTDIST[J,1] in GDWTDIST[I] at FLDWTDIST[J,2]
  GDRI←read from DATSHIPS
  GDRO←read from DATSHIPS
  GDRI←GDRI*KEELCL*LOADIN
  GDRO←GDRO*KEELCL*LOADOUT     @ keel clearance, load degree
  GLENGTH←read from DATSHIPS
  CPH←read from DATSHIPS      @COSTS PER HOUR
  GCOMMIN←read from DATSHIPS
  GCOMMOUT←read from DATSHIPS
  tabulate GDRI     in GTABDRI[I]     at FLDWTDIST[J,1]
  tabulate GDRO     in GTABDRO[I]     at FLDWTDIST[J,1]
  tabulate GLENGTH  in GTABLENGTH[I]  at FLDWTDIST[J,1]
  tabulate CPH      in GTABCPH[I]     at FLDWTDIST[J,1]
  tabulate GCOMMIN  in GTABCOMMIN[I]  at FLDWTDIST[J,1]
  tabulate GCOMMOUT in GTABCOMMOUT[I] at FLDWTDIST[J,1]
end

seed of RDWT[I]← read from DATSHIPS
reshape RDWT[I] as sampled from distribution uniform with parameters lb(0) ub(100)
GENIADIS←chread from DATSHIPS
ARRPAR1←read from DATSHIPS
ARRPAR2←read from DATSHIPS
ARRPAR2←ARRPAR2*FACDWT
ARRPAR3←read from DATSHIPS
if GENIADIS="UNIFORM"
  GINTARR←ARRUNIF
  reshape RINTARR[I] as sampled from distribution uniform with parameters lb(ARRPAR1)
  ub(ARRPAR2)
end
if GENIADIS="ERLDIS"
  GINTARR←ARRERL
  reshape RINTARR[I] as sampled from distribution gammashape with parameters lb
  (ARRPAR1) mean(ARRPAR2) deviation(ARRPAR3)
  end
if GENIADIS="NED"
  GINTARR←ARRNED
  reshape RINTARR[I] as sampled from distribution exponential   with parameters
 mean(ARRPAR2)
  end
if GENIADIS="TABLEDIS"
   for J←1 to 11
   GARRTB← read from DATSHIPS
   tabulate GARRTB in GARRTAB[I] at J
   end
  GINTARR←ARRTAB
  reshape RINTARR[I] as sampled from distribution uniform with parameters    lb(1) ub(11)
  end
```

```
seed of RINTARR[I]← read from DATSHIPS
@ PORT CONFIGURATION SAILING TIMES
GNBSTR←read from DATSHSTRETCH
GSTRCOM←read from DATSHSTRETCH
for J←1 to GNBSTR
 GSTRETCH[J]←read from DATSHSTRETCH
end
for J←1 to GNBSTR
 GSTI[J]←read from DATSHSTRETCH
end
for J←1 to GNBSTR
 GSTO[J]←read from DATSHSTRETCH
end
GCURRENTT←read from DATSHSTRETCH
for K←1 to TOTGEN
 for J←1 to GNBSTR
 ENC←read from DATSHSTRETCH
 L←GSTRETCH[J]
 ENCOUNTER[I,L,K]←true if ENC=0
 ENCOUNTER[I,L,K]←false if ENC=1
 end
end
for K←1 to TOTGEN
 for J←1 to GNBSTR
 OVERT←read from DATSHSTRETCH
 L←GSTRETCH[J]
 OVERTAKE[I,L,K]←true if OVERT=0
 OVERTAKE[I,L,K]←false if OVERT=1
 end
end
GSERVT←chread from DATSHIPS
GSERVPAR1←read from DATSHIPS
GSERVPAR2←read from DATSHIPS
GSERVPAR3←read from DATSHIPS
GDOWNPERC←read from DATSHIPS
if GSERVT="UNIFORM"
   GSERVTIME←TSERVUNIF
reshape GRSERVT[I] as sampled from distribution uniform  with parameters
lb(GSERVPAR1) ub(GSERVPAR2)
end
if GSERVT="NED"
   GSERVTIME←TSERVUNIF
reshape GRSERVT[I] as sampled from distribution exponential  with parameter
mean(GSERVPAR2)
end
@ MUSI CONFIGURATION SAILING TIMES
for J← to NBBARS
  GCTWLIN[J]←read from DSTRMUSI
end
for J←1 to NBBARS
 GCTWLOUT[J]←read from DSTRMUSI
end
```

```
GNBMSTR←read from DSTRMUSI   @ NUMBER STRETCHES MUSI RIVER @
for J←1 to GNBMSTR
 GMSTRETCH[J]←read from DSTRMUSI
end
for J←1 to GNBMSTR
 GMSTI[J]←read from DSTRMUSI
end
for J←1 to GNBMSTR
 GMSTO[J]←read from  DSTRMUSI
end


for K←1 to TOTGEN
 for J←1 to GNBMSTR
 ENC←read from DSTRMUSI
 L←GMSTRETCH[J]
 MENCOUNTER[I,L,K]←true if ENC=0
 MENCOUNTER[I,L,K]←false if ENC=1
 end
end
for K←1 to TOTGEN
 for J←1 to GNBMSTR
 OVERT←read from DSTRMUSI
 L←GMSTRETCH[J]
 MOVERTAKE[I,L,K]←true if OVERT=0
 MOVERTAKE[I,L,K]←false if OVERT=1
 end
end

seed of GRSERVT[I]←read from DATSHIPS
GEN[I]← this GENERATOR
GTWR←new TIDALREC
TIDOPENPER of GTWR←ETIDALWI-BTIDALWI
TIDCLOSEDPER of GTWR←abs((TIDALCYCL-ETIDALWI)+BTIDALWI)
TIDTOOP of GTWR←BTIDALWI
TIDCOLN1 of GTWR←read from DATSHIPS
TIDCOLN2 of GTWR←read from DATSHIPS
TIDSHIPTYPE of GTWR←FLN
@ ACTIVATE GTWR FROM STARTTIDR IN TIDALWINDOWREC
activate GEN[I] from GENSTART in GENPROCESS
end

@@@@@@@@@@@@@@@@@@@@@
@ CONTROL MUSIRIVER
@@@@@@@@@@@@@@@@@@@@@

TCMDELAY←read from DSTRMUSI
TCPDELAY←read from DSTRMUSI

@@@@@@@@@@@@@@@@@@@@@@@@@@@@@
@ GENERATION OF TERMINALS                    @
@@@@@@@@@@@@@@@@@@@@@@@@@@@@@

TOTOPER←read from DATPORT
for I←1 to TOTOPER
 this TERMOPER←new TERMOPER
```

```
QUAYMASTER←new QMASTER
TERMTYPE←chread from DATPORT
TNUMBER←read from DATPORT
QMTERMN of QUAYMASTER←TNUMBER
AVTQ←read from DATPORT
AVAILTERMQ←0.5<AVTQ
MAXDEPQ←read from DATPORT
TERMQUAYL←read from DATPORT
FRQUAYL←TERMQUAYL
QUAYMH←0
TSERVT←chread from DATPORT
SERVPAR1←read from DATPORT
SERVPAR2←read from DATPORT
SERVPAR3←read from DATPORT
if TSERVT="UNIFORM"
  TERMSERVT←TSERVUNIF
  reshape RSERVT[I] as sampled from distribution uniform with parameter
 lb(SERVPAR1) ub(SERVPAR2)
end
if TSERVT="NED"
  TERMSERVT←TSERVNED
  reshape RSERVT[I] as sampled from distribution exponential with parameter
 mean(SERVPAR1)
end
if TSERVT="ERLANG"
  TERMSERVT←TSERVERL
  reshape RSERVT[I] as sampled from distribution gammashape   with parameters
 lb(SERVPAR1) mean(SERVPAR2) deviation(SERVPAR3)
  end
if TSERVT="TABELDIS"
    for J←1 to 11
    TTBSERV←read from DATPORT
    tabulate TTBSERV in TTABSERV[I] at J
    end
  TERMSERVT←TSERVTAB
  reshape RSERVT[I] as sampled from distribution uniform   with parameters
 lb(10) ub(11)
  end
seed of RSERVT[I]← read from DATPORT
TERMOP[I]←this TERMOPER
end

@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@
@ INTIALIZING TRAFFIC CONTROL
@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@
ARO←0
ARI←0

@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@
@ INITIALIZING OF TIDAL CONDITIONS
@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@


for I←1 to NBBARS
 DEPTH[I]←read from TIDEDATA
end
WRITE DEPTH[2];FACDRAUGHT TO ATR1  WITH IMAGE xxx.xxx^-  xxx. xxx
```

```
WRITE DEPTH[2];FACDRAUGHT TO ATR2  WITH IMAGE xxx.xxx^- xxx. xxx
WRITE DEPTH[2];FACDRAUGHT TO ATR3  WITH IMAGE xxx.xxx^- xxx. xxx
WRITE DEPTH[2];FACDRAUGHT TO ATR4  WITH IMAGE xxx.xxx^- xxx. xxx
WRITE DEPTH[2];FACDRAUGHT TO ATR5  WITH IMAGE xxx.xxx^- xxx. xxx
WRITE DEPTH[2];FACDRAUGHT TO ATR6  WITH IMAGE xxx.xxx^- xxx. xxx
WRITE DEPTH[2];FACDRAUGHT TO TCOST WITH IMAGE xxx.xxx^- xxx. xxx
T1←read from TIDEDATA
T2←read from TIDEDATA
S_CU←read from TIDEDATA
DT←read from TIDEDATA
DT_LAST←read from TIDEDATA
TPCURVE←read from TIDEDATA
TCURVES←read from TIDEDATA
for I←1 to TPCURVE
 CNT[I]←read from TIDEDATA
end
for I←1 to TPCURVE
 CST[I]←read from TIDEDATA
end
for I←1 to NBBARS
  for J←1 to TPCURVE
    WNT[I,J]←read from TIDEDATA
  end
  for J←1 to TPCURVE
    WST[I,J]←read from TIDEDATA
  end
end
activate TIDALC from TSTART in TIDE
passivate
```

MOD TERMPROCESS

```
@ PROCESS OF THE TERMINAL OPERATOR
TERMCONTR:
TSHIP←last SHIP in TQUAY[TNUMBER]
QUAYMH←QUAYMH+SHSERVT of TSHIP*SLENGTH of TSHIP
@store quaymh/now*termquayl as "OCCTERM1"  if tnumber=1
@store shservt of tship as "STpal" if tnumber=1
reactivate  TSHIP
passivate
TERMDEP:
if AVAILTERMQ & (length of TERMDEPQ[TNUMBER]+1)≤ MAXDEPQ
    remove TSHIP from TQUAY[TNUMBER]
    join TSHIP to TERMDEPQ[TNUMBER]
    FRQUAYL←FRQUAYL+ SLENGTH of TSHIP
    activate QUAYMASTER of SHTERMOP of TSHIP from QUAYCONTR in QMASTERPR
ADQUAYT of TSHIP←0
end
move DEPART to length of DEPARTURE
join TSHIP to DEPARTURE
activate HMASTER2 from DEPCONTR in PR2HMASTER if HMASTER2 is not active
passivate
```

MOD GENPROCESS

```
@ PROCESS OF THE GENERATORS
GENSTART:
call GINTARR
wait INTARRT
this SHIP← new SHIP
TOTNBSHG←TOTNBSHG+1
TOTNBSHG←1 if TOTNBSHG>20
NUMBERSH←TOTNBSHG
TYPESHIP←GENTYPE
SHTERMN←GTERMN
SDWT       ←value of GDWTDIST[GTERMN] at(RDWT[GTERMN])
DRAUGHTIN  ←value of GTABDRI[GTERMN] at(SDWT)
DRAUGHTOUT ←value of GTABDRO[GTERMN] at(SDWT)
if SDWT>6000
 SDWT←SDWT*FACDWT
 DRAUGHTIN←DRAUGHTIN*FACDRAUGHT
 DRAUGHTOUT←DRAUGHTOUT*FACDRAUGHT
end
SLENGTH    ←value of GTABLENGTH[GTERMN] at(SDWT)
SCPH       ←value of GTABCPH[GTERMN] at(SDWT)
SCOMMIN    ←(value of GTABCOMMIN[GTERMN] at(SDWT))*RDCOMM
SCOMMOUT   ←(value of GTABCOMMOUT[GTERMN] at(SDWT))*RDCOMM
SHSAILINT←GENSINT
SHSAILOUTT←GENSOUTT
SHPRIOR←GENPRIOR
SHWINDBI←BTIDALWI
SHWINDEI←ETIDALWI
SHWINDBO←BTIDALWO
SHWINDEO←ETIDALWO
SHDELTI←DELAYTI
SHDELTO←DELAYTO
SHTERMOP←TERMOP[SHTERMN]
NBSTRETCHES←GNBSTR
STRCOM←GSTRCOM
TRNB←GSTRCOM
ARRQUAYT←0
for I←1 to GNBSTR
  STRETCH[I]←GSTRETCH[I]
  SHSTI[I]←GSTI[I]
  SHSTO[I]←GSTO[I]
end
for I←1 to NBBARS
  SHCTWLIN[I]←GCTWLIN[I]
  SHCTWLOUT[I]←GCTWLOUT[I]
end
for I←1 to GNBMSTR
  SHMSTRETCH[I]←GMSTRETCH[I]
  SHMSTI[I]←GMSTI[I]
  SHMSTO[I]←GMSTO[I]
end
SHNBMSTR←GNBMSTR
SHCURRENTT←GCURRENTT
DESTINATION←GDEST
```

```
SHIPTYPE←FLN
call GSERVTIME
SHSERVT←(GSERVICET*GDOWNPERC)
@store draughtin as "DRAbb" if shiptype=1
@store slength as "LOAbb" if shiptype=1
@store scph as "CPHrest" if shiptype=4
@store sdwt as "DWTbb" if shiptype=1
activate this SHIP from SHSTART in SHIPPROCESS
repeat from GENSTART
```

MOD SHIPPROCESS

```
@ PROCESS OF THE DIFFERENT SHIPTYPES
SHSTART:
enter ANCHORAGEMUSI
move FANCHMUSI to length of ANCHORAGEMUSI
STARTWAIT←now
activate TRAFFCARRM from STMUSIARR in PRTRAFFCARRM if TRAFFCARRM is not active
passivate
store now-arrivaltime as "WTOBBB1" if SHTERMN=1
store now-arrivaltime as "WTOBBB2" if SHTERMN=2
store now-arrivaltime as "WTOBPT1" if SHTERMN=3
store now-arrivaltime as "WTOBPT2" if SHTERMN=4
store now-arrivaltime as "WTOBPU1" if SHTERMN=5
store now-arrivaltime as "WTOBPU2" if SHTERMN=6
store now-arrivaltime as "WTOBRE1" if SHTERMN=7
store now-arrivaltime as "WTOBRE2" if SHTERMN=8
WTOB←(now-arrivaltime)
leave ANCHORAGEMUSI
move FANCHMUSI to length of ANCHORAGEMUSI
for SHSPOS←1 to SHNBMSTR
  enter MUSIIN[SHMSTRETCH[SHSPOS]]
  move FMUSIIN[SHMSTRETCH[SHSPOS]] to length of MUSIIN[SHMSTRETCH[SHSPOS]]
  work SHMSTI[SHMSTRETCH[SHSPOS]]
  leave MUSIIN[SHMSTRETCH[SHSPOS]]
  move FMUSIIN[SHMSTRETCH[SHSPOS]] to length of MUSIIN[SHMSTRETCH[SHSPOS]]
end
enter ARRQUAY[SHTERMN]
enter QUAYQ
ARRQUAYT←now
move ANCHORAGE to length of ARRIVAL+length of QUAYQ
activate QUAYMASTER of SHTERMOP from QUAYCONTR in QMASTERPR
passivate
leave ARRQUAY[SHTERMN]
leave QUAYQ
enter ARRIVAL
activate HMASTER1 from ARRCONTR in PR1HMASTER if HMASTER1 is not active
passivate
move SHIPWAITT to now-arrivaltime if (SHIPTYPE=1) | (SHIPTYPE=2)
store now-ARRQUAYT as "WARRSHT_1" if SHIPTYPE=1
leave ARRIVAL
move ANCHORAGE to length of ARRIVAL + length of QUAYQ
enter CHANNEL
enter CHANNELIN
move CHANNELF to length of CHANNEL
move CHANNELINF to length of CHANNELIN
```

```
for SHPOS←1 to (STRCOM-1)
move CHPOS[NUMBERSH] to SHPOS
work SHSTI[SHPOS]
end
move CHPOS[NUMBERSH] to sink
if TRNB=5
move TB1[NUMBERSH] to 1
work SHSTI[STRCOM]
move TB1[NUMBERSH] to sink
end
if TRNB=7
move TB2[NUMBERSH] to 1
work SHSTI[STRCOM]
move TB2[NUMBERSH] to sink
end
if TRNB=9
move TB3[NUMBERSH] to 1
work SHSTI[STRCOM]
move TB3[NUMBERSH] to sink
end
if TRNB=11
move TB4[NUMBERSH] to 1
work SHSTI[STRCOM]
move TB4[NUMBERSH] to sink
end
if SHIPTYPE=1
move TBMB1[NUMBERSH] to 1
work SHSTI[STRCOM+1]
move TBMB1[NUMBERSH] to sink
move MB1[NUMBERSH] to 1
work SHSTI[STRCOM+2]
move MB1[NUMBERSH] to sink
end
if SHIPTYPE=2
move TBMB2[NUMBERSH] to 1
work SHSTI[STRCOM+1]
move TBMB2[NUMBERSH] to sink
move MB2[NUMBERSH] to 1
work SHSTI[STRCOM+2]
move MB2[NUMBERSH] to sink
end
if SHIPTYPE=3
move TBMB3[NUMBERSH] to 1
work SHSTI[STRCOM+1]
move TBMB3[NUMBERSH] to sink
move MB3[NUMBERSH] to 1
work SHSTI[STRCOM+2]
move MB3[NUMBERSH] to sink
end
if SHIPTYPE=4
move TBMB4[NUMBERSH] to 1
work SHSTI[STRCOM+1]
move TBMB4[NUMBERSH] to sink
```

```
move MB4[NUMBERSH] to 1
work SHSTI[STRCOM+2]
move MB4[NUMBERSH] to sink
end

if SHIPTYPE=5
move TBMB5[NUMBERSH] to 1
work SHSTI[STRCOM+1]
move TBMB5[NUMBERSH] to sink
move MB5[NUMBERSH] to 1
work SHSTI[STRCOM+2]
move MB5[NUMBERSH] to sink
end

if SHIPTYPE=6
move TBMB6[NUMBERSH] to 1
work SHSTI[STRCOM+1]
move TBMB6[NUMBERSH] to sink
move MB6[NUMBERSH] to 1
work SHSTI[STRCOM+2]
move MB6[NUMBERSH] to sink
end

leave CHANNEL
leave CHANNELIN
move CHANNELINF to length of CHANNELIN
move CHANNELF to length of CHANNEL
CTIME←now
enter TQUAY[SHTERMN]
ARRQUAYT←now
activate SHTERMOP from TERMCONTR in TERMPROCESS
passivate
move BD1 to length of TQUAY[SHTERMN] if SHTERMN=1
move BD2 to length of TQUAY[SHTERMN] if SHTERMN=2
move BD3 to length of TQUAY[SHTERMN] if SHTERMN=3
move BD4 to length of TQUAY[SHTERMN] if SHTERMN=4

work SHSERVT
TSHIP of SHTERMOP←this SHIP
activate SHTERMOP from TERMDEP in TERMPROCESS
passivate
LEAVEHAR:
@store now-queuetime in departure as "WDEPSHT_1" if shiptype=1
leave DEPARTURE
move DEPART to length of DEPARTURE
move BD1 to length of TQUAY[SHTERMN] if SHTERMN=1
move BD2 to length of TQUAY[SHTERMN] if SHTERMN=2
move BD3 to length of TQUAY[SHTERMN] if SHTERMN=3
move BD4 to length of TQUAY[SHTERMN] if SHTERMN=4

@write arrquayt;slength;draughtin;scommin;scommout;shprior;adquayt to arrvt1 with image
   xxxxxxxxx^- xxxxxxx^-x xxx. xxx^- xx xxx^- xxx xx^- xx^- xxxxx xxxx  i f  shtem=2
enter CHANNEL
enter CHANNELOUT
move CHANNELF to length of CHANNEL
move CHANNELOUTF to length of CHANNELOUT

if SHIPTYPE=1
```

```
move MB1[NUMBERSH] to 1
work SHSTO[STRCOM+2]
move MB1[NUMBERSH] to sink
move TBMB1O[NUMBERSH] to 1
work SHSTO[STRCOM+1]
move TBMB1O[NUMBERSH] to sink
end
if SHIPTYPE=2
move MB2[NUMBERSH] to 1
work SHSTO[STRCOM+2]
move MB2[NUMBERSH] to sink
move TBMB2O[NUMBERSH] to 1
work SHSTO[STRCOM+1]
move TBMB2O[NUMBERSH] to sink
end
if SHIPTYPE=3
move MB3[NUMBERSH] to 1
work SHSTO[STRCOM+2]
move MB3[NUMBERSH] to sink
move TBMB3O[NUMBERSH] to 1
work SHSTO[STRCOM+1]
move TBMB3O[NUMBERSH] to sink
end
if SHIPTYPE=4
move MB4[NUMBERSH] to 1
work SHSTO[STRCOM+2]
move MB4[NUMBERSH] to sink
move TBMB4O[NUMBERSH] to 1
work SHSTO[STRCOM+1]
move TBMB4O[NUMBERSH] to sink
end
if SHIPTYPE=5
move MB5[NUMBERSH] to 1
work SHSTO[STRCOM+2]
move MB5[NUMBERSH] to sink
move TBMB5O[NUMBERSH] to 1
work SHSTO[STRCOM+1]
move TBMB5O[NUMBERSH] to sink
end
if SHIPTYPE=6
move MB6[NUMBERSH] to 1
work SHSTO[STRCOM+2]
move MB6[NUMBERSH] to sink
move TBMB6O[NUMBERSH] to 1
work SHSTO[STRCOM+1]
move TBMB6O[NUMBERSH] to sink
end
 for SHPOSO←1 to STRCOM
 SHPOS←(STRCOM+1)-SHPOSO
```

```
 move CHPOSO[NUMBERSH] to 12-SHPOS
 work SHSTO[SHPOS]
 end
 move CHPOSO[NUMBERSH] to sink
move SHIPTURNT to now-arrivaltime if (SHIPTYPE=1) | (SHIPTYPE=2)

leave CHANNEL
leave CHANNELOUT
move CHANNELOUTF to length of CHANNELOUT
move CHANNELF to length of CHANNEL
enter ANCHORAGEPALEMB
STARTWAIT←now
activate TRAFFCDEPP from STPALDEP in PRTRAFFCDEPP if TRAFFCDEPP is not active
move FANCHPALEMB to length of ANCHORAGEPALEMB
passivate
store now-queuetime in ANCHORAGEPALEMB as "WTPLBB2" if SHIPTYPE=2
store now-queuetime in ANCHORAGEPALEMB as "WTPLPT2" if SHIPTYPE=4
store now-queuetime in ANCHORAGEPALEMB as "WTPLPU2" if SHIPTYPE=6
store now-queuetime in ANCHORAGEPALEMB as "WTPLRE2" if SHIPTYPE=8
WTHB←now-queuetime in ANCHORAGEPALEMB
activate COSTMAN from STARTCOST in COSTS
leave ANCHORAGEPALEMB
move FANCHPALEMB to length of ANCHORAGEPALEMB
for SHSPOS←1 to SHNBMSTR
  enter MUSIOUT[SHMSTRETCH[SHSPOS]]
  move FMUSIOUT[SHMSTRETCH[SHSPOS]] to length of MUSIOUT[SHMSTRETCH[SHSPOS]]
  work SHMSTO[SHMSTRETCH[SHSPOS]]
  leave MUSIOUT[SHMSTRETCH[SHSPOS]]
  move FMUSIOUT[SHMSTRETCH[SHSPOS]] to length of MUSIOUT[SHMSTRETCH[SHSPOS]]
end
terminate
```

MOD PR1HMASTER

```
@ PROCESS OF THE HARBOUR MASTER1
ARRCONTR:
INCLEAN←FALSE
OUTCLEAN←FALSE
HM1SHIP←FIRST SHIP IN ARRIVAL
AGAIN:
THIS SHIP←HM1SHIP
SHTEST1←FALSE
SHTEST2←FALSE
SHTEST3←true    @veranderd op 25/2/97

CURRENTT←SHCURRENTT+NOW
CALL CURRENTS
SHTEST1←true @ IF CURRENT<1.35 veranderd op 20/3/97

FOR I←1 TO 52
 FOR J←1 TO 2
 SHIPTIMES[I,J]←0
 END
END

```

```
SHIPTIMES[STRETCH[1],2]←NOW+SHSTI[1]
SHIPTIMES[STRETCH[1],1]←NOW
FOR I←2 TO NBSTRETCHES
 SHIPTIMES[STRETCH[I],1]←SHIPTIMES[STRETCH[I-1],2]
 SHIPTIMES[STRETCH[I],2]←SHIPTIMES[STRETCH[I-1],2]+SHSTI[I]
END
POS←"ARRIVAL"
INCLEAN←TRUE
CALL TRAFFCONTROL
SHTEST2←true  if TRTEST>0

@ CALL CLOCK
@ SHTEST3←TRUE IF (CTIME>SHWINDBI)&(CTIME<SHWINDEI)

IF SHTEST2 & SHTEST1
 REACTIVATE HM1SHIP
 CALL REGISTRATION
 DELAYT1←SHDELTI
 WAIT DELAYT1
 HM1SHIP←FIRST SHIP IN ARRIVAL
 PASSIVATE IF HM1SHIP IS NONE
 REPEAT FROM AGAIN
END
HM1SHIP← SUCC OF HM1SHIP IN ARRIVAL
IF HM1SHIP IS NONE
 PASSIVATE IF LENGTH OF ARRIVAL=0
 WAIT 15
 REPEAT FROM ARRCONTR
END
repeat from AGAIN
```

MOD PR2HMASTER

```
@ PROCESS OF HMASTER2

DEPCONTR:
HM2SHIP←FIRST SHIP IN DEPARTURE
REP:
THIS SHIP←HM2SHIP
SHTEST2←FALSE
SHTEST3←true   @veranderd op 25/2/97

FOR I←1 TO 52
 FOR J←1 TO 2
  SHIPTIMES[I,J]←0
 END
END

J←NBSTRETCHES
SHIPTIMES[STRETCH[J],2]←NOW
SHIPTIMES[STRETCH[J],1]←NOW+SHSTO[J]
FOR I←1 TO NBSTRETCHES-1
 J←NBSTRETCHES-I
 SHIPTIMES[STRETCH[J],2]←SHIPTIMES[STRETCH[J+1],1]
 SHIPTIMES[STRETCH[J],1]←SHIPTIMES[STRETCH[J],2]+SHSTO[J]
END
```

```
POS←"DEPARTURE"
OUTCLEAN←TRUE
CALL TRAFFCONTROL
SHTEST2←true  if TRTEST>0

@ call clock
SHTEST3←true  @ if (ctime>shwindbo ) & (ctime<shwindeo)

IF SHTEST2  & SHTEST3
  REMOVE HM2SHIP FROM TERMDEPQ[SHTERMN] IF HM2SHIP BELONGS TO TERMDEPQ[SHTERMN]
  @ WRITE NOW TO DEPARTT WITH IMAGE xxxxxxxxx IF SHTERMN=1
  IF HM2SHIP BELONGS TO TQUAY[SHTERMN]
  ADQUAYT←(NOW-QUEUETIME OF HM2SHIP IN TQUAY[SHTERMN])-SHSERVT
  REMOVE HM2SHIP FROM TQUAY[SHTERMN]
  FRQUAYL OF SHTERMOP←FRQUAYL OF SHTERMOP + SLENGTH
  ACTIVATE QUAYMASTER OF SHTERMOP FROM QUAYCONTR IN QMASTERPR
  END
  CALL REGISTRATION
  REACTIVATE HM2SHIP
  DELAYT2← SHDELTO
  HM2SHIP←SUCC OF HM2SHIP IN DEPARTURE
  WAIT DELAYT2
  IF HM2SHIP IS NONE
    PASSIVATE IF LENGTH OF DEPARTURE=0
    REPEAT FROM DEPCONTR
  END
  REPEAT FROM REP
END
HM2SHIP←SUCC OF HM2SHIP IN DEPARTURE
IF HM2SHIP IS NONE
  PASSIVATE IF LENGTH OF DEPARTURE=0
  WAIT 15
  REPEAT FROM DEPCONTR
END
REPEAT FROM REP
```

MAC ARRERL

```
@ GENERATION OF THE INTER ARRIVAL TIME
INTARRT←RINTARR[GTERMN]
RETURN
```

MAC ARRTAB

```
@ GENERATION OF THE INTER ARRIVALTIME FROM A TABLE
INTARRT← VALUE OF GARRTAB[FLN] AT(RINTARR[GTERMN])
RETURN
```

MAC TSERVERL

```
@ GENERATION OF A SERVICE TIME FROM AN ERLANG DISTRIBUTION
SERVICETT←RSERVT[TNUMBER]
RETURN
```

MAC TSERVTAB

```
@GENERATION OF A SERVICE TIME FROM A TABLE DISTRIBUTION
SERVICETT←VALUE OF TTABSERV[TNUMBER] AT(RSERVT[TNUMBER])
RETURN
```

MAC CLOCK

```
@ DETERMINATION OF THE "TIDAL TIME"
CTIME←NOW- TIDALCYCL*FLOOR(NOW/TIDALCYCL)
RETURN
```

MAC TRAFFCONTROL

```

@ CONTROL TRAFFIC INCOMING TEST SHIP / INCOMINGTRAFFIC
@ REDUCTION DATA INCOMING SHIPS

REDUCINT  :
IF (ARI>4) & INCLEAN
 IF INCTRI[1,INFO[1,2],2]<NOW-0.25
  FOR I←2 TO ARI
   FOR J←1 TO 91
     FOR K←1 TO 2
      INCTRI[I-1,J,K]←INCTRI[I,J,K]
     END
    END
    FOR J←1 TO 4
     INFO[I-1,J]←INFO[I,J]
    END
  END
  FOR I←1 TO 91
    FOR J←1 TO 2
    INCTRI[ARI,I,J]←0
    END
  END
  FOR I←1 TO 4
    INFO[ARI,I]←0
  END
  ARI←ARI-1
  END
  GOTO REDUCINT IF INCTRI[1,INFO[1,2],2]<NOW-0.25
END
INCLEAN←FALSE

 @ REDUCTION DATA LEAVING SHIPS

REDUCOUTTR:
IF (ARO>4) & OUTCLEAN
 IF OUTTRI[1,1,1]<NOW-0.25
  FOR I←2 TO ARO
   FOR J←1 TO 91
    FOR K←1 TO 2
     OUTTRI[I-1,J,K]←OUTTRI[I,J,K]
```

```
    END
   END
   FOR J←1 TO 4
    ONFO[I-1,J]←ONFO[I,J]
   END
  END
 FOR I←1 TO 91
   FOR J←1 TO 2
   OUTTRI[ARO,I,J]←0
   END
 END
 FOR I←1 TO 4
   ONFO[ARO,1]←0
 END
 ARO←ARO-1
 END
 GOTO REDUCOUTTR IF OUTTRI[1,1,1]<NOW-0.25
END
OUTCLEAN←FALSE
TRTEST←1
FOR I←1 TO ARI
 @ DETERMINATION POINTS COMMON STRETCH
 NBSTRCOM←STRCOM     IF INFO[I,4]>STRCOM
 NBSTRCOM←INFO[I,4] IF INFO[I,4]<_ STRCOM
 @ CONTROL TRAFFIC INCOMMING TEST SHIP / INCOMMINGTRAFFIC
 @ CONTROL TRAFFIC COMMON STRETCH
  IF POS="ARRIVAL"
   FOR J<- 1 TO NBSTRCOM
    IF OVERTAKE[INFO[I,3],J,SHIPTYPE]
       TRTEST←-1 IF ((SHIPTIMES[J,1]-INCTRI[I,J,1])*(SHIPTIMES[J,2]-INCTRI[I,J,2]))<0
       TRTEST←-1 IF (ABS(SHIPTIMES[J,1]-INCTRI[I,J,1]))<15
       TRTEST←-1 IF (ABS(SHIPTIMES[J,2]-INCTRI[I,J,2]))<15
    END
   END
   GOTO ENDTRT IF TRTEST<0
   @ CONTROL TURNING BASINS
   J←TRNB
    IF OVERTAKE[INFO[I,3],J,SHIPTYPE]
    TRTEST←-1 IF (SHIPTIMES[J,1]<INCTRI[I,J,2]) & (SHIPTIMES[J,2]> INCTRI[I,J,1])
    J←INFO[I,1]
    TRTEST←-1 IF (SHIPTIMES[J,1]<INCTRI[I,J,2]) & (SHIPTIMES[J,2]>INCTRI[I,J,1])
    GOTO ENDTRT IF TRTEST<0
   END
   @ CONTROL MOORINGBASIN AND LAST STRETCH
   IF INFO[I,2]=DESTINATION
    J←DESTINATION-40
    IF OVERTAKE[INFO[I,3],J,SHIPTYPE]
     TRTEST←-1 IF ((SHIPTIMES[J,1]-INCTRI[I,J,1])*(SHIPTIMES[J,2]- INCTRI[I,J,2]))<0
      TRTEST←-1 IF (ABS(SHIPTIMES[J,1]-INCTRI[I,J,1]))<15
      TRTEST←-1 IF (ABS(SHIPTIMES[J,2]-INCTRI[I,J,2]))<15
    END
    GOTO ENDTRT IF TRTEST<0
```

```
   J←DESTINATION
   IF OVERTAKE[INFO[I,3],J,SHIPTYPE]
   TRTEST←-1 IF (SHIPTIMES[J,1]<INCTRI[I,J,2]) & (SHIPTIMES[J,2]>INCTRI[I,J,1])
    TRTEST←-1 IF (ABS(SHIPTIMES[J,2]-INCTRI[I,J,2]))<15
    END
   END
   GOTO ENDTRT IF TRTEST<0
  END

  @ CONTROL LEAVING TEST SHIP / INCOMING TRAFFIC
  IF POS="DEPARTURE"
   @ CONTROL STRECH COMMON
   FOR J←1 TO NBSTRCOM
    IF ENCOUNTER[INFO[I,3],J,SHIPTYPE]
     TRTEST←-1 IF ((SHIPTIMES[J,1]-INCTRI[I,J,1])*(SHIPTIMES[J,2]-INCTRI[I,J,2] ))<0
      TRTEST←-1 IF (ABS(SHIPTIMES[J,1]-INCTRI[I,J,1]))<15
      TRTEST←-1 IF (ABS(SHIPTIMES[J,2]-INCTRI[I,J,2]))<15
    END
   END
   GOTO ENDTRT IF TRTEST<0
   @ CONTROL TURNING BASIN PERFORMEND IN CONTROL STRETCH COMMON
   @ CONTROL  MOORING BASIN AND LAST STRETCH
   IF INFO[I,2]=DESTINATION
    J←DESTINATION-40
    IF ENCOUNTER[INFO[I,3],J,SHIPTYPE]
     TRTEST←-1 IF ((SHIPTIMES[J,1]-INCTRI[I,J,1])*(SHIPTIMES[J,2]-INCTRI[I,J,2]))<0
      TRTEST←-1 IF (ABS(SHIPTIMES[J,1]-INCTRI[I,J,1]))<15
      TRTEST←-1 IF (ABS(SHIPTIMES[J,2]-INCTRI[I,J,2]))<15
    END
    J←DESTINATION
    IF ENCOUNTER[INFO[I,3],J,SHIPTYPE]
     TRTEST←-1 IF ((SHIPTIMES[J,1]-INCTRI[I,J,1])*(SHIPTIMES[J,2]-INCTRI[I,J,2]))<0
      TRTEST←-1 IF (ABS(SHIPTIMES[J,1]-INCTRI[I,J,1]))<15
      TRTEST←-1 IF (ABS(SHIPTIMES[J,2]-INCTRI[I,J,2]))<15
     END
   END
   GOTO ENDTRT IF TRTEST<0
  END
END

@ CONTROL TRAFFIC TEST SHIP / LEAVING TRAFFIC

FOR I<- 1 TO ARO
 @ DETERMINATION POINTS COMMON STRETCH
 NBSTRCOM<- STRCOM     IF ONFO[I,4]>STRCOM
 NBSTRCOM<- ONFO[I,4]  IF ONFO[I,4]<STRCOM
 NBSTRCOM<- ONFO[I,4]  IF ONFO[I,4]=STRCOM

 @ CONTROL TRAFFIC INCOMMING TEST SHIP / LEAVING TRAFFIC
 @ CONTROL TRAFFIC COMMON STRETCH
 IF POS="ARRIVAL"
  FOR J<- 1 TO NBSTRCOM
   IF ENCOUNTER[ONFO[I,3],J,SHIPTYPE]
    TRTEST<- -1 IF ((SHIPTIMES[J,1]-OUTTRI[I,J,1])*(SHIPTIMES[J,2]-OUTTRI[I,J,2]))<0
      TRTEST<- -1 IF (ABS(SHIPTIMES[J,1]-OUTTRI[I,J,1]))<15
      TRTEST<- -1 IF (ABS(SHIPTIMES[J,2]-OUTTRI[I,J,2]))<15
    END
   END
```

```
   GOTO ENDTRT IF TRTEST<0
   @ CONTROL TRAFFIC TURNING BASIN PERFORMEND IN STRETCH COMMON
   @ CONTROL MOORING BASIN AND LAST STRETCH
   IF DESTINATION=ONFO[I,2]
    J←DESTINATION-40
    IF ENCOUNTER[ONFO[I,3],J,SHIPTYPE]
    TRTEST←-1 IF ((SHIPTIMES[J,1]-OUTTRI[I,J,1])*(SHIPTIMES[J,2]-OUTTRI[I,J,2]))<0
      TRTEST←-1 IF (ABS(SHIPTIMES[J,1]-OUTTRI[I,J,1]))<15
      TRTEST←-1 IF (ABS(SHIPTIMES[J,2]-OUTTRI[I,J,2]))<15
    END
    J←DESTINATION
    IF ENCOUNTER[ONFO[I,3],J,SHIPTYPE]
    TRTEST←-1 IF ((SHIPTIMES[J,1]-OUTTRI[I,J,1])*(SHIPTIMES[J,2]-OUTTRI[I,J,2]))<0
    TRTEST←-1 IF (ABS(SHIPTIMES[J,1]-OUTTRI[I,J,1]))<15
    TRTEST←-1 IF (ABS(SHIPTIMES[J,2]-OUTTRI[I,J,2]))<15
    END
   END
   GOTO ENDTRT IF TRTEST<0
  END
@ CONTROL LEAVING TEST SHIP / LEAVING TRAFFIC
IF POS="DEPARTURE"
   FOR J←1 TO NBSTRCOM
    IF OVERTAKE[ONFO[I,3],J,SHIPTYPE]
    TRTEST←-1 IF ((SHIPTIMES[J,1]-OUTTRI[I,J,1])*(SHIPTIMES[J,2]-OUTTRI[I,J,2]))<0
      TRTEST←-1 IF (ABS(SHIPTIMES[J,1]-OUTTRI[I,J,1]))<15
      TRTEST←-1 IF (ABS(SHIPTIMES[J,2]-OUTTRI[I,J,2]))<15
    END
   END
   GOTO ENDTRT IF TRTEST<0
   @ CONTROL TURNING BASIN IS NOT NECESSARY
   @ CONTROL MOORING BASIN AND LAST STRETCH
   IF DESTINATION=ONFO[I,2]
    J←DESTINATION-40
    IF OVERTAKE[ONFO[I,3],J,SHIPTYPE]
    TRTEST←-1 IF ((SHIPTIMES[J,1]-OUTTRI[I,J,1])*(SHIPTIMES[J,2]-OUTTRI[I,J,2]))<0
      TRTEST←-1 IF (ABS(SHIPTIMES[J,1]-OUTTRI[I,J,1]))<15
      TRTEST←-1 IF (ABS(SHIPTIMES[J,2]-OUTTRI[I,J,2]))<15
    END
    J←DESTINATION
    IF OVERTAKE[ONFO[I,3],J,SHIPTYPE]
    TRTEST←-1 IF SHIPTIMES[J,2]<OUTTRI[I,J,1]
    END
   END
   GOTO ENDTRT IF TRTEST<0
  END
 END
 ENDTRT:
 return
```

MAC REGISTRATION

```
@ REGISTRATION INCOMING AND LEAVING SHIP TRAFFIC
IF POS="ARRIVAL"
 ARI←ARI+1
 FOR I←1 TO NBSTRETCHES
  FOR J←1 TO 2
```

```
  INCTRI[ARI,STRETCH[I],J]<- SHIPTIMES[STRETCH[I],J]
 END
END

@ IF TRVERS
@ WRITE "INCOMING SHIP" WITH IMAGE xxxxxxxxxxxxxxxx
@ WRITE "NBSHIP";"SHIPTYPE" WITH IMAGE xxxxxxxxx^- xxxxxxxxx
@ WRITE  ARI;SHIPTYPE WITH IMAGE        xxxxxx^- xxxxxx
@WRITE 1;2;3;4;5;6;7;8;9;10;11 WITH IMAGE xxxxx^- xxxxx^-x xxxx^-xx xxx^-xxx xx^-
xxxxx^- xxxxx^-x xxxx^-xx xxx^-xxx xx^-xxxx x
@ WRITE
INCTRI[ARI,1,1];INCTRI[ARI,2,1];INCTRI[ARI,3,1];INCTRI[ARI,4,1];INCTRI[ARI,5,1];INCTRI[
ARI,6,1];INCTRI[ARI,7,1];INCTRI[ARI,8,1];INCTRI[ARI,9,1];
NCTRI[ARI,10,1];INCTRI[ARI,11,1] WITH IMAGE xxxxx^- xxxxx^-x xxxx^-xx xxx^-xxx xx^-
xxxxx^- xxxxx^-x xxxx^-xx xxx^-xxx xx^-xxxx x
@ WRITE "TBM";"STM";"ENDM" WITH IMAGE xxxxx^- xxxxx^-x xxxx
@ L←STRETCH[NBSTRETCHES]
@ K←STRETCH[NBSTRETCHES-1]
@ WRITE INCTRI[ARI,K,1];INCTRI[ARI,L,1];INCTRI[ARI,L,2] WITH IMAGE xxxxx^- xxxxx^-
xxxxx
@  END

INFO[ARI,1]←TRNB
INFO[ARI,2]←DESTINATION
INFO[ARI,3]←SHIPTYPE
INFO[ARI,4]←STRCOM
END

IF POS="DEPARTURE"
ARO←ARO+1
FOR I←1 TO NBSTRETCHES
 FOR J←1 TO 2
  OUTTRI[ARO,STRETCH[I],J]←SHIPTIMES[STRETCH[I],J]
 END
END
@ IF TRVERS
@ WRITE "LEAVING SHIP" WITH IMAGE xxxxxxxxxxxxxxxx
@ WRITE "NBSHIP";"SHIPTYPE" WITH IMAGE xxxxxxxxx^- xxxxxxxxx
@ WRITE  ARI;SHIPTYPE WITH IMAGE        xxxxxx^- xxxxxx
@ WRITE 1;2;3;4;5;6;7;8;9;10;11 WITH IMAGE xxxxx^- xxxxx^-x xxxx^-xx xxx^-xxx xx^-
xxxxx^- xxxxx^-x xxxx^-xx xxx^-xxx xx^-xxxx x
@ WRITE OUTTRI[ARO,1,1];OUTTRI[ARO,2,1];OUTTRI[ARO,3,1];OUTTRI[ARO,4,1];
UTTRI[ARO,5,1];OUTTRI[ARO,6,1];OUTTRI[ARO,7,1];OUTTRI[ARO,8,1];
UTTRI[ARO,9,1];OUTTRI[ARO,10,1];OUTTRI[ARO,11,1] WITH IMAGE xxxxx^- xxxxx^-
xxxxx^- xxxxx^-x xxxx^-xx xxx^-xxx xx^-xxxx x^-xxxxx ^-xxxxx^ -xxxxx
@ WRITE "TBM";"STM";"ENDM" WITH IMAGE xxxxx^- xxxxx^-x xxxx
@ L←STRETCH[NBSTRETCHES]
@ K←STRETCH[NBSTRETCHES-1]
@ WRITE OUTTRI[ARO,K,1];OUTTRI[ARO,L,1];OUTTRI[ARO,L,2] WITH IMAGE xxxxx^-
xxxxx^- xxxxx
@ END

ONFO[ARO,1]←TRNB
ONFO[ARO,2]←DESTINATION
ONFO[ARO,3]←SHIPTYPE
ONFO[ARO,4]←STRCOM
END
RETURN
```

MOD QMASTERPR

```
@ PROCESS OF THE QUAY MASTER
QUAYCONTR:
QMSHIP←FIRST SHIP IN ARRQUAY[QMTERMN]
NEXTSH:
PASSIVATE IF QMSHIP IS NONE
THIS SHIP←QMSHIP
SHTEST1←FALSE
SHTEST1←TRUE IF FRQUAYL OF SHTERMOP>SLENGTH
IF SHTEST1=TRUE
  REACTIVATE QMSHIP
  FRQUAYL OF SHTERMOP←FRQUAYL OF SHTERMOP-SLENGTH
END
QMSHIP←SUCC OF QMSHIP IN ARRQUAY[QMTERMN]
REPEAT FROM NEXTSH
```

MAC ARRNED

```
INTARRT←RINTARR[GTERMN]
RETURN
```

MOD TIDALWINDOWREC

```
STARTTIDR:
MOVE TIDALW[TIDSHIPTYPE] TO 1
STATE←"CLOSED"
WAIT TIDTOOP
STARTTID:
MOVE TIDALW[TIDSHIPTYPE] TO COLOUR TIDCOLN1
STATE←"OPEN"
WAIT TIDOPENPER
MOVE TIDALW[TIDSHIPTYPE] TO COLOUR TIDCOLN2
STATE←"CLOSED"
WAIT TIDCLOSEDPER
REPEAT FROM STARTTID
```

MAC TSERVNED

```
@ GENERATION OF SERVICETIME FROM AN NED DISTRIBUTION
GSERVICET←GRSERVT[TNUMBER]
RETURN
```

MAC TSERVUNIF

```
@ GENERATION OF A SERVICE TIME FROM AN UNIFORM DISTRIBUTION
GSERVICET←GRSERVT[FLN]
RETURN
```

MAC CURRENTS

```
STARTTIDE:
A← CURRENTT - T1*FLOOR(CURRENTT/T1)
B←FLOOR(A/T2)
T_AF_LW←A-B*T2
R_CU←B+S_CU
R_CU←R_CU-28 IF R_CU>27
N←FLOOR(T_AF_LW/DT)
T_AF_N←T_AF_LW-N*DT
C1←CNT[N+1]+(CST[N+1]-CNT[N+1])/2
C1←C1+(CST[N+1]-CNT[N+1])*(COS(2*ARCCOS(~1)*R_CU/28))/2
C2←CNT[N+2]+(CST[N+2]-CNT[N+2])/2
C2←C2+(CST[N+2]-CNT[N+2])*(COS(2*ARCCOS(~1)*R_CU/28))/2
CURRENT←C1+(T_AF_N/DT_LAST)*(C2-C1) IF N=16
CURRENT←C1+(T_AF_N/DT)*(C2-C1) IF N<16
```

MAC ARRUNIF

```
@ GENERATION OF THE INTER ARRIVAL TIME
INTARRT←RINTARR[FLN]
RETURN
```

MOD TIDE

```
tstart:
levtime←now
for i←1 to nbbars
call mlevels
 store levbar[i] as "LEVBAR1n" if i=1
 store levbar[i] as "LEVBAR1s" if i=2
 store levbar[i] as "LEVBAR2n" if i=3
 store levbar[i] as "LEVBAR2s" if i=4
 store levbar[i] as "LEVBAR3 " if i=5
 store levbar[i] as "LEVBAR4 " if i=6
end
wait 60
repeat from tstart
```

MOD PRTRAFFCARRM

```
@ PROCESS OF TRAFFIC CONTROL VESSELS ARRIVAL MUSI RIVER
STMUSIARR:
MINCLEAN←true
MOUTCLEAN←true
TCMSHIP←first SHIP in ANCHORAGEMUSI
TCMAGAIN:
this SHIP←TCMSHIP
```

```
for I←1 to 3
 SHTESTM[I]←false
end
SHTRTEST←false

for I←1 to NBBARS
LEVTIME←now +SHCTWLIN[I]
call MLEVELS
SHTESTM[I]←true if ((DRAUGHTIN<(LEVBAR[I]/10)) | ((STARTWAIT+1440)<ct))
end                              @aangepast 26/3/97

if (SHTESTM[1]) & (SHTESTM[2]) & (SHTESTM[3])
 for I←1 to 12
   for J←1 to 2
   MSHIPTIMES[I,J]←0
   end
 end

 MSHIPTIMES[SHMSTRETCH[1],1]←now
 MSHIPTIMES[SHMSTRETCH[1],2]←now +SHMSTI[SHMSTRETCH[1]]
 for I←2 to SHNBMSTR
   J←SHMSTRETCH[I]
   MSHIPTIMES[SHMSTRETCH[I],1]←MSHIPTIMES[SHMSTRETCH[I-1],2]
   MSHIPTIMES[SHMSTRETCH[I],2]←MSHIPTIMES[SHMSTRETCH[I],1]+ SHMSTI[SHMSTRETCH[I]]
 end

 SHDIRECTION←"INCOMING"
 call MUSITRCONTROL
 SHTRTEST←true if MTRTEST>0
end

if (SHTRTEST)
  reactivate TCMSHIP
  call MUSISHREGISTER
  wait TCMDELAY
  TCMSHIP←first SHIP in ANCHORAGEMUSI
  passivate if TCMSHIP is none
  repeat from TCMAGAIN
end

TCMSHIP←succ of TCMSHIP in ANCHORAGEMUSI
if TCMSHIP is none
  passivate if length of ANCHORAGEMUSI=0
  wait 0.25
  repeat from STMUSIARR
end
repeat from TCMAGAIN
```

MOD PRTRAFFCDEPP

```
@ PROCESS OF TRAFFIC CONTROL VESSELS DEPARTURE PALEMBANG

STPALDEP:
MINCLEAN←true
MOUTCLEAN←true
```

```
TCPSHIP←first SHIP in ANCHORAGEPALEMB
TCPAGAIN:
this SHIP←TCPSHIP
for I←1 to NBBARS
  SHTESTM[I]←false
end
SHTRTEST←false
for I←1 to NBBARS
  LEVTIME←now + SHCTWLOUT[I]
call MLEVELS
SHTESTM[I]←true if ((DRAUGHTOUT<(LEVBAR[I]/10)) | ((STARTWAIT+1440)<ct))
end
if SHTESTM[1] & SHTESTM[2] & SHTESTM[3]
 for I←1 to 12
   for J←1 to 2
   MSHIPTIMES[I,J]←0
   end
 end
 MSHIPTIMES[SHMSTRETCH[1],2]←now
 MSHIPTIMES[SHMSTRETCH[1],1]←now +SHMSTO[SHMSTRETCH[1]]
 for I←2 to SHNBMSTR
   MSHIPTIMES[SHMSTRETCH[I],2]←MSHIPTIMES[SHMSTRETCH[I-1],1]
   MSHIPTIMES[SHMSTRETCH[I],1]←MSHIPTIMES[SHMSTRETCH[I],2] +
   SHMSTO[SHMSTRETCH[I]]
 end
 SHDIRECTION←"LEAVING"
 call MUSITRCONTROL
 SHTRTEST←true if MTRTEST>0
end
if SHTRTEST
  reactivate TCPSHIP
  call MUSISHREGISTER
  wait TCPDELAY
  TCPSHIP←first SHIP in ANCHORAGEPALEMB
  passivate if TCPSHIP is none
  repeat from TCPAGAIN
end
TCPSHIP←succ of TCPSHIP in ANCHORAGEPALEMB
if TCPSHIP is none
  passivate if length of ANCHORAGEPALEMB=0
  wait 0.25
  repeat from STPALDEP
end
repeat from TCPAGAIN
```

MAC MUSITRCONTROL

```
@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@
@ CONTROL TRAFFIC INCOMING TEST SHIP / INCOMINGTRAFFIC
@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@

@ REDUCTION DATA INCOMING SHIPS

REDUCINT  :
IF (MARIS>4) & MINCLEAN
 IF MINCTRIS[1,MINFOS[1,2],2]<NOW-0.25
   FOR I←2 TO MARIS
    FOR J←1 TO 10
     FOR K←1 TO 2
      MINCTRIS[I-1,J,K]←MINCTRIS[I,J,K]
     END
    END
    FOR J←1 TO 4
     MINFOS[I-1,J]←MINFOS[I,J]
    END
   END
  FOR I←1 TO 10
    FOR J←1 TO 2
    MINCTRIS[MARIS,I,J]←0
    END
  END
  FOR I←1 TO 4
    MINFOS[MARIS,I]←0
  END
  MARIS←MARIS-1
  END
  GOTO REDUCINT IF MINCTRIS[1,MINFOS[1,2],2]<NOW-0.25
END
MINCLEAN←FALSE

 @ REDUCTION DATA LEAVING SHIPS

REDUCOUTTR:
IF (MAROS>4) & MOUTCLEAN
 IF MOUTTRIS[1,MONFOS[1,2],1]<NOW-0.25
  FOR I←2 TO MAROS
   FOR J←1 TO 10
    FOR K←1 TO 2
     MOUTTRIS[I-1,J,K]←MOUTTRIS[I,J,K]
    END
   END
   FOR J←1 TO 4
   MONFOS[I-1,J]←MONFOS[I,J]
   END
  END
 FOR I←1 TO 10
```

```
  FOR J←1 TO 2
  MOUTTRIS[MAROS,I,J]←0
  END
 END
 FOR I←1 TO 4
  MONFOS[MAROS,1]←0
 END
 MAROS←MAROS-1
 END
 GOTO REDUCOUTTR IF MOUTTRIS[1,MONFOS[1,2],1]<NOW-0.25
END
MOUTCLEAN←FALSE

@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@
@ CONTROL TRAFFIC TEST SHIP WITH INCOMING TRAFFIC
@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@

MTRTEST←1
FOR I←1 TO MARIS

@@@@ CONTROL TRAFFIC INCOMING TEST SHIP / INCOMING registered TRAFFIC

 IF SHDIRECTION="INCOMING"
  FOR J←1 TO NBSTRMUSI
   IF MOVERTAKE[MINFOS[I,3],J,SHIPTYPE]
    MTRTEST←~1 IF ((MSHIPTIMES[J,1]-MINCTRIS[I,J,1])*(MSHIPTIMES[J,2] - MINCTRIS[I,J,2]))<0
    MTRTEST←~1 IF (ABS(MSHIPTIMES[J,1]-MINCTRIS[I,J,1]))<0.25
    MTRTEST←~1 IF (ABS(MSHIPTIMES[J,2]-MINCTRIS[I,J,2]))<0.25
   END
  END
 END


 @@@@ CONTROL LEAVING TEST SHIP / INCOMING registered TRAFFIC

 IF SHDIRECTION="LEAVING "
  FOR J<- 1 TO NBSTRMUSI
  IF MENCOUNTER[MINFOS[I,3],J,SHIPTYPE]=TRUE
   MTRTEST<- -1 IF ((MSHIPTIMES[J,1]-MINCTRIS[I,J,1])*(MSHIPTIMES[J,2] - MINCTRIS[I,J,2]))<0
   MTRTEST<- -1 IF (ABS(MSHIPTIMES[J,1]-MINCTRIS[I,J,1]))<0.25
   MTRTEST<- -1 IF (ABS(MSHIPTIMES[J,2]-MINCTRIS[I,J,2]))<0.25
  END
  END
 END
END

@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@
@ CONTROL TRAFFIC TEST SHIP / LEAVING TRAFFIC
@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@

FOR I←1 TO MAROS

@ CONTROL TRAFFIC INCOMING TEST SHIP / LEAVING TRAFFIC

```

```
IF SHDIRECTION="INCOMING"
 FOR J←1 TO NBSTRMUSI
  IF MENCOUNTER[MONFOS[I,3],J,SHIPTYPE]
     MTRTEST←-1 IF ((MSHIPTIMES[J,1]-MOUTTRIS[I,J,1])*(MSHIPTIMES[J,2]-
   MOUTTRIS[I,J,2]))<0
     MTRTEST←-1 IF (ABS(MSHIPTIMES[J,1]-MOUTTRIS[I,J,1]))<0.25
     MTRTEST←-1 IF (ABS(MSHIPTIMES[J,2]-MOUTTRIS[I,J,2]))<0.25
  END
 END
END


@@@@ CONTROL LEAVING TEST SHIP / LEAVING TRAFFIC

 IF SHDIRECTION="LEAVING"
  FOR J←I TO NBSTRMUSI
   IF MOVERTAKE[MONFOS[I,3],J,SHIPTYPE]
     MTRTEST←-1 IF ((MSHIPTIMES[J,1]-MOUTTRIS[I,J,1])*(MSHIPTIMES[J,2]-
    MOUTTRIS[I,J,2]))<0
     MTRTEST←-1 IF (ABS(MSHIPTIMES[J,1]-MOUTTRIS[I,J,1]))<0.25
     MTRTEST←-1 IF (ABS(MSHIPTIMES[J,2]-MOUTTRIS[I,J,2]))<0.25
    END
   END
  END
END
ENDTRT:
return
```

MAC MUSISHREGISTER

```
@ REGISTRATION INCOMMING AND LEAVING SHIP TRAFFIC

IF SHDIRECTION="INCOMING"
 MARIS←MARIS+1
 FOR I←1 TO 8
  FOR J←1 TO 2
   MINCTRIS[MARIS,I,J]←MSHIPTIMES[I,J]
  END
 END


 MINFOS[MARIS,1]←DESTINATION
 MINFOS[MARIS,2]←SHMSTRETCH[SHNBMSTR]
 MINFOS[MARIS,3]←SHIPTYPE
END

IF SHDIRECTION="LEAVING"
 MAROS←MAROS+1
 FOR I←1 TO 8
  FOR J←1 TO 2
   MOUTTRIS[MAROS,I,J]←MSHIPTIMES[I,J]
  END
 END

 MONFOS[MAROS,1]←DESTINATION
```

```
MONFOS[MAROS,2]←SHMSTRETCH[SHNBMSTR]
MONFOS[MAROS,3]←SHIPTYPE
END
RETURN
```

MAC MLEVELS

```

starttide:
a ← levtime - t1*floor(levtime/t1)
b←floor(a/t2)
t_af_lw←a-b*t2
r_cu←b+s_cu
r_cu←r_cu-tcurves if r_cu>tcurves-1
n←floor(t_af_lw/dt)
t_af_n←t_af_lw-n*dt
h1←wnt[i,n+1]+(wst[i,n+1]-wnt[i,n+1])/2
h1←h1+(wst[i,n+1]-wnt[i,n+1])*(cos(2*arccos(~1)*r_cu/tcurves))/2

h2←wnt[l,n+2]+(wst[l,n+2]-wnt[l,n+2])/2
h2←h2+(wst[i,n+2]-wnt[i,n+2])*(cos(2*arccos(~1)*r_cu/tcurves))/2
levbar[i]←depth[i]+h1+(t_af_n/dt_last)*(h2-h1) if n=tpcurve-2

levbar[i]←depth[i]+h1+(t_af_n/dt)*(h2-h1) if n<(tpcurve-2)
```

MOD COSTS

```
@ PROCESS OF COST CALCULATIONS
startcost:
avwt[shtermn]←0
avsdwt[shtermn]←0
avservt[shtermn]←0
waittime←0
totalcost←0
waittime←(wtob+wthb)/1440
totwt[shtermn]←totwt[shtermn]+waittime
totsdwt[shtermn]←totsdwt[shtermn]+sdwt
totship[shtermn]←totship[shtermn]+1
totservt[shtermn]←totservt[shtermn]+(shservt/1440)
avwt[shtermn]←totwt[shtermn]/totship[shtermn]
avsdwt[shtermn]←totsdwt[shtermn]/totship[shtermn]
avservt[shtermn]←totservt[shtermn]/totship[shtermn]
cumucost[shtermn]←(tonyear[shiptype]/avsdwt[shtermn])*(((sailtime[shiptype]+
   avwt[shtermn])*v0*avsdwt[shtermn]^v1)+(2*w0*avservt[shtermn]*avsdwt[shtermn]^w1))
totalcost←.88*cumucost[1])+(0.12*cumucost[2])+(0.70*cumucost[3])
   +(0.30*cumucost[4])+(0.76*cumucost[5])+(0.24*cumucost[6])
if now≥100000
 write avwt[shtermn];avsdwt[shtermn];avservt[shtermn];cumucost[shtermn]
   to atr1 with image xx.xxxxx^- xxxxx^-x x xxx^- xx xxxxx i f ster m=1
 write avwt[shtermn];avsdwt[shtermn];avservt[shtermn];cumucost[shtermn] to atr2
   with image xx.xxxxx^- xxxxx^-x x xxx^- xx xxxxx i f ster m=2
 write avwt[shtermn];avsdwt[shtermn];avservt[shtermn];cumucost[shtermn] to atr3
   with image xx.xxxxx^- xxxxx^-x x xxx^- xx xxxxx i f ster m=3
```

```
write avwt[shtermn];avsdwt[shtermn];avservt[shtermn];cumucost[shtermn] to atr4
  with image xx.xxxxx^- xxxxx^-x x xxx^- xx xxxxx if shtermn=4
write avwt[shtermn];avsdwt[shtermn];avservt[shtermn];cumucost[shtermn] to atr5 with image
  xx.xxxxx^- xxxxx^-x x xxx^- xx xxxxx if shtermn=5
write avwt[shtermn];avsdwt[shtermn];avservt[shtermn];cumucost[shtermn] to atr6 with image
  xx.xxxxx^- xxxxx^-x x xxx^- xx xxxxx if shtermn=6
write totalcost to tcost with image xxxxxxx if shtermn=1 @ tbv reductie
end
sdwt←0
shservt←0
passivate
```

Appendix G: Description of the PROSIM Input files

The following input files are used by the program PALEMBANG: The data is read by module MAINMOD.

Filename	Input stream	Description
TIDESPAL	TIDEDATA	Data about the tide
PORTPAL	DATPORT	Data about the terminals
SHIPPAL	DATSHIPS	Data about the vessels calling at Palembang
SHSTRPAL	DATSHSTRETCH	Information about sailing times and routes of the different fleets as well as the traffic rules in the sections of the wet infrastructure of the harbour
SHSTRMUS	DSTRMUSI	Information about sailing times and routes of the different fleets as well as the traffic rules in the sections of the wet infrastructure of the Musi river

Table 4 Input files

The source text of the input files can be found in Appendix D. In the next few paragraphs a short description of these files is given.

Input file TIDESPAL

This file contains data about the tidal conditions and the depth (- LWS) of the bars

Line1: 6	Number of bars
Lines 2 to 12:	Depth of the bars for 8 different situations.
Lines 13 to 14:	Parameters for the function for the tide
Lines 15 to 18:	Information about the currents. (All currents are zero).
Lines 19 to 35:	Water levels on each bar (point) for neap tide and spring tide. With these numbers the function for the tide is calculated.

Input file PORTPAL

This file contains data about: the tidal conditions and the terminals in the port.

Line 4: 1444	Length of the tidal cycle in minutes
Line 5: 8	The total number of terminals
Line 7:Boom Baru 1	Gives the name of the terminal, here the Boom Baru general cargo terminal.
Line 8: 1	Terminal number
Lines 9 to 10:	Not used
Line 11: 680	Total quay length of this terminal
Line 12: NED	The service time distribution is described by an Negative Exponential Distribution (Erlang - 1) function.
Line 13:4200 0 0:	Parameters to characterise the service time distribution function of the terminal
Line 14: 1349575:	Seed of the random stream for the service time distribution function of the terminal
Lines 15 to 23:	Characterise terminal Boom Baru 2
Lines 24 to 32:	Characterise terminal Pertamina 1
Lines 33 to 41:	Characterise terminal Pertamina 2
Lines 42 to 50:	Characterise terminal Pusri 1
Lines 51 to 59:	Characterise terminal Pusri 2
Lines 60 to 68:	Characterise terminal Rest 1
Lines 69 to 77:	Characterise terminal Rest 2

Input file SHIPPAL

This file contains data about the ships calling the port.

Line 3: 8	Total number of generators
Line 4: 1.1	Keel clearance of the vessels
Lines 5 to 8:	Parameters for calculating the shipping costs
Lines 9 to 14:	Parameters for simulating fleets with changed dwt, inter arrival time and draught.
Lines 15 to 49:	Provide the data for Boom Baru 1 vessels (Boom Baru vessels with dwt up to 6,500 dwt.
Line 15: 1 1	Fleet number and terminal number

Line 16: 3	Total number of classes of the fleet
Line 17: 1151260	Total amount of cargo in tons per year for Boom Baru 1 vessels
Line 18: 4.6	Sailing time per round voyage in days
Line 19 to 21:	Not in use
Line 22: 10 10	Minimum separation (in hours) relative to the nest incoming and leaving vessel.
Line 23 to 24:	Not in use
Line 25: 100 0	Dwt value (100) of the cumulative distribution function corresponding with the percentage (0)
Line 26: 3.0 3.0	Draught of the incoming and the outgoing vessel, here corresponding with a 100 dwt of the fleet.
Line 27: 39.2	The length of the incoming and the outgoing vessel, here corresponding with a 100 dwt of the fleet.
Line 28 to 29:	Not in use
Lines 30 to 34:	Attributes for the dwt value (2,400) with the percentage 76
Lines 35 to 39:	Attributes for the dwt value (6,500) with the percentage 100
Line 40: 475000	Seed of the random stream used to determine the dwt of this vessel type
Line 41: NED	The inter arrival time distribution is described by an Negative Exponential Distribution (Erlang - 1) function.
Line 42: 0 927 0	Parameters to characterise the inter arrival time distribution function of the terminal.
Line 43: 96451	Seed of the random stream used to determine the inter arrival time of this vessel type
Line 44: NED	The service time distribution is described by an Negative Exponential Distribution (Erlang - 1) function.
Line 45: 1	Not in use
Line 46: 0 2800 0:	Parameters to characterise the service time distribution function of the terminal
Line 47: 1 2	Not in use
Lines 48 to 82:	Provide the data of the Boom Baru 2 vessels

Lines 83 to 117:	Provide the data of the Pertamina 1 vessels
Lines 118 to 152:	Provide the data of the Pertamina 2 vessels
Lines 153 to 187:	Provide the data of the Pusri 1 vessels
Lines 222 to 256:	Provide the data of the Pusri 2 vessels
Lines 257 to 291:	Provide the data of the Rest 1 vessels
Lines 292 to 326:	Provide the data of the Rest 2 vessels

Input file SHSTRPAL

This file provides information about sailing times and routes of the different fleets as well as the traffic rules in the sections of the wet infrastructure of the harbour:

Line2: 52	Destination number of the Boom Baru fleet 1
Line 3to 4: 48	Sailing time from the entering point of the harbour sections to the quay.
Line 5: 7	Number of sailing sections to be taken
Line 6: 5	Number of sections to be taken on the main approach track of the harbour.
Line 7 to 10:	Numbers of the sections to be taken by the vessel and the sailing time for each section.
Lines 11 to 28:	Information about possibilities to encounter or take over any other vessel in each section.
Line 29 to 147:	Provide data about the route of the other vessel types

Input file SHSTRMUS

This file provides information about sailing times and routes of the different fleets as well as the traffic rules in the sections of the wet infrastructure of the Musi river

Line 2: 29 68 15 155 299 310	Sailing times to the bars from the sea
Line 3:50 61 205 245 292 331	Sailing times to the bars from the harbour
Line 4: 12	Number of sections in the Musi river
Line 5: 1 2 3 4 ... 12	Section numbers
Lines 6 to 7:	Sailing times per sections for in and outgoing vessels.

Lines 8 to 27:	Information about possibilities to encounter or take over any other vessel in each section.
Line 28 to 182:	Provide data about the route of the other vessel types

Appendix G: The Input files for the model PALEMBANG

Tidespal

```
1          @simulation run: 1=existing,2=10%,3=20%,4=30%@
6          @ NBBARS @
@ DEPTH BARS BELOW LWS IN DM (1-6)@
47 36 55 52 57 54
@47 40 55 52 57 54 @
@47 45 55 52 57 54 @
@50 50 55 52 57 54 @
@55 55 55 55 57 55 @
@60 60 60 60 60 60 @
@65 65 65 65 65 65 @
@70 70 70 70 70 70 @
@75 75 75 75 75 75 @
@80 80 80 80 80 80 @
20216 1444 0 60 4   @ NEAP-SPRING-NEAP,LW-LW, START CURVE, DT, DT-LAST @
26 14          @ TPCURVE (POINTS TIDAL CURVE), (TCURVES) TIDAL CURVES @
@ CURRENTS NEAP TIDE @
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
@ CURRENTS SPRING TIDE @
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0

@ WATERLEVELS NEAP TIDE BAR 1 north@
14.6 14.5 15.0 15.5 17.1 17.9 17.5 18.0 18.0 18.0 19.0 19.7 20.7 21.6 22.5 23.5 24.0 23.4 22.4
21.0 19.4 18.1 16.9 14.9 14.0 14.1
@ WATERLEVELS SPRING TIDE BAR 1 north@
 7.0  7.1  8.2 11.3 15.3 19.3 24.3 28.2 31.1 32.1 33.0 32.8 29.8 26.8 23.8 20.9 18.9 16.9 15.9
13.9 12.9 10.9  9.9  7.9  7.3  7.4
@ WATERLEVELS NEAP TIDE BAR 1 south@
14.6 14.5 15.0 15.5 17.1 17.9 17.5 18.0 18.0 18.0 19.0 19.7 20.7 21.6 22.5 23.5 24.0 23.4 22.4
21.0 19.4 18.1 16.9 14.9 14.0 14.1
@ WATERLEVELS SPRING TIDE BAR 1 south@
 7.0  7.1  8.2 11.3 15.3 19.3 24.3 28.2 31.1 32.1 33.0 32.8 29.8 26.8 23.8 20.9 18.9 16.9 15.9
13.9 12.9 10.9  9.9  7.9  7.3  7.4

@ WATERLEVELS NEAP TIDE BAR 2  north@
14.8 14.3 14.0 15.0 16.0 17.1 18.4 19.0 19.0 18.8 18.0 17.9 18.5 19.7 20.5 22.1 24.0 25.0 24.7
23.9 21.5 19.9 17.9 15.9 15.0 13.7
@ WATERLEVELS SPRING TIDE BAR 2 north@
 8.9  7.9  7.0  7.1  8.1 10.2 13.3 17.3 21.3 26.3 30.1 32.1 34.0 33.9 31.9 29.8 26.7 22.8 19.9 17.9
15.9 14.9 12.9 11.9  9.2  8.3
@ WATERLEVELS NEAP TIDE BAR 2 south@
14.8 14.3 14.0 15.0 16.0 17.1 18.4 19.0 19.0 18.8 18.0 17.9 18.5 19.7 20.5 22.1 24.0 25.0 24.7
23.9 21.5 19.9 17.9 15.9 15.0 13.7
@ WATERLEVELS SPRING TIDE BAR 2 south@
 8.9  7.9  7.0  7.1  8.1 10.2 13.3 17.3 21.3 26.3 30.1 32.1 34.0 33.9 31.9 29.8 26.7 22.8 19.9 17.9
15.9 14.9 12.9 11.9  9.2  8.3

@ WATERLEVELS NEAP TIDE BAR 3 @
```

```
15.8 13.9 13.5 14.3 15.0 16.2 17.2 18.6 20.0 19.5 18.5 17.5 17.0 17.5 18.5 20.1 22.6 25.1 26.0
24.4 22.5 20.9 18.9 16.9 15.3 13.8
@ WATERLEVELS SPRING TIDE BAR 3 @
 9.9  7.9  6.9  6.1  7.1  8.2 11.3 15.3 19.3 24.3 28.3 32.1 34.1 34.9 33.9 31.7 27.7 23.8 20.9 18.9
16.9 15.9 13.9 12.9 10.2  8.2
@ WATERLEVELS NEAP TIDE BAR 4 @
15.8 13.9 13.5 14.3 15.0 16.2 17.2 18.6 20.0 19.5 18.5 17.5 17.0 17.5 18.5 20.1 22.6 25.1 26.0
24.4 22.5 20.9 18.9 16.9 15.3 13.8
@ WATERLEVELS SPRING TIDE BAR 4 @
 9.9  7.9  6.9  6.1  7.1  8.2 11.3 15.3 19.3 24.3 28.3 32.1 34.1 34.9 33.9 31.7 27.7 23.8 20.9 18.9
16.9 15.9 13.9 12.9 10.2  8.2
```

Portpal

```
@ TRACE VERSION YES OR NO @
0                          @ 1=YES 0=NO @
@ DATA OF THE TERMINAL OPERATOR MODEL HARBDEM @
1444                       @ TIDALCYCL @
8                          @ TOTOPER @

"BoomBaru1"                @ TERMTYPE @
1                          @ TNUMBER @
0                          @ AVTQ @
0                          @ MAXDEPQ @
680                        @ TERMQUAYL @
"NED"                      @ TSERVT @
2800  0  0                 @ SERVPAR1 SERVPAR2 SERVPAR3 @
1349575

"BoomBaru2"                @ TERMTYPE @
2                          @ TNUMBER @
0                          @ AVTQ @
0                          @ MAXDEPQ @
390                        @ TERMQUAYL @
"NED"                      @ TSERVT @
2800  0  0                 @ SERVPAR1 SERVPAR2 SERVPAR3 @
134955

"Pertamina1"               @ TERMTYPE @
3                          @ TNUMBER @
0                          @ AVTQ @
0                          @ MAXDEPQ @
450                        @ TERMQUAYL @
"NED"                      @ TSERVT @
1800 0  0                  @ SERVPAR1 SERVPAR2 SERVPAR3 @
1349576

"Pertamina2"               @ TERMTYPE @
4                          @ TNUMBER @
0                          @ AVTQ @
0                          @ MAXDEPQ @
500                        @ TERMQUAYL @
"NED"                      @ TSERVT @
1800 0  0                  @ SERVPAR1 SERVPAR2 SERVPAR3 @
134956

"Pusri1"                   @ TERMTYPE @
5                          @ TNUMBER @
```

```
0                        @ AVTQ @
0                        @ MAXDEPQ @
390                       @ TERMQUAYL  @
"NED"                      @ TSERVT @
2900  0   0                @ SERVPAR1 SERVPAR2 SERVPAR3 @
7365485

"Pusri2"                   @ TERMTYPE @
6                        @ TNUMBER @
0                        @ AVTQ @
0                        @ MAXDEPQ @
390                       @ TERMQUAYL  @
"NED"                      @ TSERVT @
2900  0   0                @ SERVPAR1 SERVPAR2 SERVPAR3 @
736545

"Rest1"                    @ TERMTYPE @
7                        @ TNUMBER @
0                        @ AVTQ @
0                        @ MAXDEPQ @
375                       @ TERMQUAYL @
"NED"                      @ TSERVT @
3100  0   0                @ SERVPAR1 SERVPAR2 SERVPAR3 @
143789

"Rest2"                    @ TERMTYPE @
8                        @ TNUMBER @
0                        @ AVTQ @
0                        @ MAXDEPQ @
325                       @ TERMQUAYL @
"NED"                      @ TSERVT @
3100  0   0                @ SERVPAR1 SERVPAR2 SERVPAR3 @
14379
```

Shippal

```
@ DATA SHIPS MODEL Palembang  04/03/97 @
35785910                 @ SEED OF RDCOMM @
8                    @ TOTGEN @
1.1                  @ KEEL CLEARANCE @
0.0427                 @ V0 @
0.0775                 @ W0 @
0.653                 @ V1 @
0.510                 @ W1 @
1.0                  @ Fleet factor for dwt and inter arrival time@
1.0                  @ Fleet factor for draught @

"Boom Baru1"              @ GENTYPE @
1 1                  @ FLN GTERMN  fleetnumber terminal number@
3                    @ TOTCLASSES @
1151260                 @ TONNES PER YEAR @
4.6                  @ SAILING TIME PER ROUND VOYAGE IN DAYS @
0   1500               @ BTIDALWI ETIDALWI @
0   1500               @ BTIDALWO ETIDALWO @
1                    @ GENPRIOR @
10  10                 @ DELAYTI DELAYTO @
1                    @ LOAD FACTOR IN @
1                    @ LOAD FACTOR OUT @
```

```
100  0              @ FLDWTDIST[J,1] FLDWTDIST[J,2] @
3.0 3.0             @ GDRI GDRO @
39.2                @ GLENGTH @
22000               @ COSTS PER HOUR: CPH @
0  0                @ GCOMMIN GCOMMOUT (not in use)@
2400  71            @ FLDWTDIST[J,1] FLDWTDIST[J,2] @
4.77 4.77           @ GDRI GDRO @
78.5                @ GLENGTH @
188000              @ COSTS PER HOUR: CPH @
0  0                @ GCOMMIN GCOMMOUT @
6500  100           @ FLDWTDIST[J,1] FLDWTDIST[J,2] @
5.4 5.4             @ GDRI GDRO @
109.5               @ GLENGTH @
475000              @ COSTS PER HOUR: CPH @
0  0                @ GCOMMIN GCOMMOUT @
4534837             @ SEED OF RDWT[I] @
"NED"               @ GENIADIS @
0 1074 0            @ ARRPAR1 ARRPAR 2 ARRPAR 3@
96451               @ SEED OF RINTARR[I] @
"NED"               @ GSERVT @
0 2800 0            @ GSERVPAR1 GSERVPAR2 GSERVPAR3 @
1                   @ GDOWNPERC @
124456              @ SEED GSERVT @
1 2                 @ COLN1 COLN2 @

"Boom Baru2"        @ GENTYPE @
2 2                 @ FLN GTERMN  fleetnumber terminal number@
3                   @ TOTCLASSES @
1221960             @ TONNES PER YEAR @
4.6                 @ SAILING TIME PER ROUND VOYAGE IN DAYS @
0   1500            @ BTIDALWI ETIDALWI @
0   1500            @ BTIDALWO ETIDALWO @
1                   @ GENPRIOR @
10  10              @ DELAYTI DELAYTO @
1                   @ LOAD FACTOR IN @
1                   @ LOAD FACTOR OUT @
6500  0             @ FLDWTDIST[J,1] FLDWTDIST[J,2] @
5.4 5.4             @ GDRI GDRO @
109.5               @ GLENGTH @
475000              @ COSTS PER HOUR: CPH @
0  0                @ GCOMMIN GCOMMOUT @
7200   92           @ FLDWTDIST[J,1] FLDWTDIST[J,2] @
5.5 5.5             @ GDRI GDRO @
113.3               @ GLENGTH @
506000              @ COSTS PER HOUR: CPH @
0  0                @ GCOMMIN GCOMMOUT @
15200  100          @ FLDWTDIST[J,1] FLDWTDIST[J,2] @
6.21 6.21           @ GDRI GDRO @
148                 @ GLENGTH @
655000              @ COSTS PER HOUR: CPH @
0  0                @ GCOMMIN GCOMMOUT @
4534837             @ SEED OF RDWT[I] @
"NED"               @ GENIADIS @
0 3400 0            @ ARRPAR1 ARRPAR 2 ARRPAR 3@
96451               @ SEED OF RINTARR[I] @
"NED"               @ GSERVT @
0 2800 0            @ GSERVPAR1 GSERVPAR2 GSERVPAR3 @
1                   @ GDOWNPERC @
223456              @ SEED GSERVT @
```

```
1 2                @ COLN1 COLN2 @

"Pertamina1"       @ GENTYPE @
3 3                @ FLN GTERMN @
3                  @ TOTCLASSES @
3058160            @ TONNES PER YEAR @
4.6                @ SAILING TIME PER ROUND VOYAGE IN DAYS @
0  1500            @ BTIDALWI ETIDALWI @
0  1500            @ BTIDALWO ETIDALWO @
1                  @ GENPRIOR @
2 2                @ DELAYTI DELAYTO @
1.0                @ LOAD FACTOR IN @
1.0                @ LOAD FACTOR OUT @
600 0              @ FLDWTDIST[J,1] FLDWTDIST[J,2] @
3.26 3.26          @ GDRI GDRO @
52.9               @ GLENGTH @
44000              @ COSTS PER HOUR: CPH @
0  0               @ GCOMMIN GCOMMOUT @
3600 37            @ FLDWTDIST[J,1] FLDWTDIST[J,2] @
4.07 4.07          @ GDRI GDRO @
88                 @ GLENGTH @
360000             @ COSTS PER HOUR: CPH @
0  0               @ GCOMMIN GCOMMOUT @
8000 100           @ FLDWTDIST[J,1] FLDWTDIST[J,2] @
4.85 4.85          @ GDRI GDRO @
116                @ GLENGTH @
628000             @ COSTS PER HOUR: CPH @
0  0               @ GCOMMIN GCOMMOUT @
4534837            @ SEED OF RDWT[I] @
"NED"              @ GENIADIS @
0 850 0            @ ARRPAR1 ARRPAR2 ARRPAR3 @
123222             @ SEED OF RINTARR[I] @
"NED"              @ GSERVT @
0 1800 0           @ GSERVPAR1 GSERVPAR2 GSERVPAR3 @
1                  @ GDOWNPERC @
123157             @ SEED GSERVT @
1 2                @ COLN1 COLN2 @

"Pertamina2"       @ GENTYPE @
4 4                @ FLN GTERMN @
3                  @ TOTCLASSES @
7003960            @ TONNES PER YEAR @
4.6                @ SAILING TIME PER ROUND VOYAGE IN DAYS @
0  1500            @ BTIDALWI ETIDALWI @
0  1500            @ BTIDALWO ETIDALWO @
1                  @ GENPRIOR @
2 2                @ DELAYTI DELAYTO @
1                  @ LOAD FACTOR IN @
1                  @ LOAD FACTOR OUT @
8000    0          @ FLDWTDIST[J,1] FLDWTDIST[J,2] @
4.85 4.85          @ GDRI GDRO @
116                @ GLENGTH @
628000             @ COSTS PER HOUR: CPH @
0  0               @ GCOMMIN GCOMMOUT @
14000   25         @ FLDWTDIST[J,1] FLDWTDIST[J,2] @
5.37 5.37          @ GDRI GDRO @
140                @ GLENGTH @
741000             @ COSTS PER HOUR: CPH @
0  0               @ GCOMMIN GCOMMOUT @
```

```
20200  100          @ FLDWTDIST[J,1] FLDWTDIST[J,2] @
5.60 5.60           @ GDRI GDRO @
160                 @ GLENGTH @
788000              @ COSTS PER HOUR: CPH @
0  0                @ GCOMMIN GCOMMOUT @
4534837             @ SEED OF RDWT[I] @
"NED"               @ GENIADIS @
0 1275 0            @ ARRPAR1 ARRPAR2 ARRPAR3 @
123222              @ SEED OF RINTARR[I] @
"NED"               @ GSERVT @
0 1800 0            @ GSERVPAR1 GSERVPAR2 GSERVPAR3 @
1                   @ GDOWNPERC @
23457               @ SEED GSERVT @
1 2                 @ COLN1 COLN2 @

"Pusri1"            @ GENTYPE @
5 5                 @ FLN GTERMN @
3                   @ TOTCLASSES @
758403              @ TONNES PER YEAR @
4.6                 @ SAILING TIME PER ROUND VOYAGE IN DAYS @
0  1500             @ BTIDALWI ETIDALWI @
0  1500             @ BTIDALWO ETIDALWO @
1                   @ GENPRIOR @
10  10              @ DELAYTI DELAYTO @
1.0                 @ LOAD FACTOR IN @
1.0                 @ LOAD FACTOR OUT @
200 0               @ FLDWTDIST[J,1] FLDWTDIST[J,2] @
3.0 3.0             @ GDRI GDRO @
43.3                @ GLENGTH @
22000               @ COSTS PER HOUR: CPH @
0  0                @ GCOMMIN GCOMMOUT @
1800 53             @ FLDWTDIST[J,1] FLDWTDIST[J,2] @
4.56 4.56           @ GDRI GDRO @
75.5                @ GLENGTH @
165000              @ COSTS PER HOUR: CPH @
0  0                @ GCOMMIN GCOMMOUT @
8000 100            @ FLDWTDIST[J,1] FLDWTDIST[J,2] @
5.50 5.50           @ GDRI GDRO @
113.6               @ GLENGTH @
582000              @ COSTS PER HOUR: CPH @
0  0                @ GCOMMIN GCOMMOUT @
4527896             @ SEED OF RDWT[I] @
"NED"               @ GENIADIS @
0 1986 0            @ ARRPAR1 ARRPAR2 ARRPAR3 @
0893743             @ SEED OF RINTARR[I] @
"NED"               @ GSERVT @
0 2900 0            @ GSERVPAR1 GSERVPAR2 GSERVPAR3  @
1                   @ GDOWNPERC @
123428              @ SEED GSERVT @
1 2                 @ COLN1 COLN2 @

"Pusri2"            @ GENTYPE @
6 6                 @ FLN GTERMN @
3                   @ TOTCLASSES @
1146730             @ TONNES PER YEAR @
4.6                 @ SAILING TIME PER ROUND VOYAGE IN DAYS @
0  1500             @ BTIDALWI ETIDALWI @
0  1500             @ BTIDALWO ETIDALWO @
1                   @ GENPRIOR @
```

```
10 10          @ DELAYTI DELAYTO @
1.0            @ LOAD FACTOR IN @
1.0            @ LOAD FACTOR OUT @
8000 0         @ FLDWTDIST[J,1] FLDWTDIST[J,2] @
5.50 5.50      @ GDRI GDRO @
113.6          @ GLENGTH @
582000         @ COSTS PER HOUR: CPH @
0  0           @ GCOMMIN GCOMMOUT @
11000 47       @ FLDWTDIST[J,1] FLDWTDIST[J,2] @
5.60 5.60      @ GDRI GDRO @
125.4          @ GLENGTH @
681000         @ COSTS PER HOUR: CPH @
0 0            @ GCOMMIN GCOMMOUT @
11200 100      @ FLDWTDIST[J,1] FLDWTDIST[J,2] @
5.60 5.60      @ GDRI GDRO @
126            @ GLENGTH @
698000         @ COSTS PER HOUR: CPH @
0 0            @ GCOMMIN GCOMMOUT @
4527896        @ SEED OF RDWT[I] @
"NED"          @ GENIADIS @
0 4633 0       @ ARRPAR1 ARRPAR2 ARRPAR3 @
0893743        @ SEED OF RINTARR[I] @
"NED"          @ GSERVT @
0 2900 0       @ GSERVPAR1 GSERVPAR2 GSERVPAR3  @
1              @ GDOWNPERC @
1358           @ SEED GSERVT @
1 2            @ COLN1 COLN2 @

"Rest1"        @ GENTYPE @
7 7            @ FLN GTERMN @
3              @ TOTCLASSES @
1000000        @ TONNES PER YEAR @
4.6            @ SAILING TIME PER ROUND VOYAGE IN DAYS @
0   1500       @ BTIDALWI ETIDALWI @
0   1500       @ BTIDALWO ETIDALWO @
1              @ GENPRIOR @
10  10         @ DELAYTI DELAYTO @
1.0            @ LOAD FACTOR IN  @
1.0            @ LOAD FACTOR OUT @
400 0          @ FLDWTDIST[J,1] FLDWTDIST[J,2] @
3.0 3.0        @ GDRI GDRO @
41.7           @ GLENGTH @
0              @ COSTS PER HOUR: CPH @
0  0           @ GCOMMIN GCOMMOUT @
2600 96        @ FLDWTDIST[J,1] FLDWTDIST[J,2] @
4.31 4.31      @ GDRI GDRO @
75.5           @ GLENGTH @
0              @ COSTS PER HOUR: CPH @
0  0           @ GCOMMIN GCOMMOUT @
6000 100       @ FLDWTDIST[J,1] FLDWTDIST[J,2] @
5.17 5.17      @ GDRI GDRO @
101.5          @ GLENGTH @
0              @ COSTS PER HOUR: CPH @
0  0           @ GCOMMIN GCOMMOUT @
09746445       @ SEED OF RDWT[I] @
"NED"          @ GENIADIS @
0 2708 0       @ ARRPAR1 ARRPAR2 ARRPAR3 @
786334344      @ SEED OF RINTARR[I] @
"NED"          @ GSERVT @
```

```
0 3100 0            @ GSERVPAR1 GSERVPAR2 GSERVPAR3   @
1.00               @ GDOWNPERC @
123458              @ SEED GSERVT @
1 2                @ COLN1 COLN2 @

"Rest2"             @ GENTYPE @
8 8                @ FLN GTERMN @
3                  @ TOTCLASSES @
1000000              @ TONNES PER YEAR @
4.6                @ SAILING TIME PER ROUND VOYAGE IN DAYS @
0  1500             @ BTIDALWI ETIDALWI @
0  1500             @ BTIDALWO ETIDALWO @
1                  @ GENPRIOR @
10  10              @ DELAYTI DELAYTO @
1.0                @ LOAD FACTOR IN  @
1.0                @ LOAD FACTOR OUT @
6000 0              @ FLDWTDIST[J,1] FLDWTDIST[J,2] @
5.17 5.17           @ GDRI GDRO @
101.5               @ GLENGTH @
0                  @ COSTS PER HOUR: CPH @
0  0               @ GCOMMIN GCOMMOUT @
8000 79             @ FLDWTDIST[J,1] FLDWTDIST[J,2] @
5.43 5.43           @ GDRI GDRO @
112.8               @ GLENGTH @
0                  @ COSTS PER HOUR: CPH @
0 0                @ GCOMMIN GCOMMOUT @
18200 100            @ FLDWTDIST[J,1] FLDWTDIST[J,2] @
6.0 6.0             @ GDRI GDRO @
151.8               @ GLENGTH @
0                  @ COSTS PER HOUR: CPH @
0  0               @ GCOMMIN GCOMMOUT @
09746445             @ SEED OF RDWT[I] @
"NED"               @ GENIADIS @
0 2933 0            @ ARRPAR1 ARRPAR2 ARRPAR3 @
786334344            @ SEED OF RINTARR[I] @
"NED"               @ GSERVT @
0 3100 0            @ GSERVPAR1 GSERVPAR2 GSERVPAR3   @
1.00               @ GDOWNPERC @
12348               @ SEED GSERVT @
1 2                @ COLN1 COLN2 @
```

Shstrmusi

```
@ Boombaru fleet1@
29 68 115 155 299 310 @gctwlin(nbars 1-6) sailing times to bars from sea@
50 61 205 245 292 331 @gctwlout(nbars 6-1) sail times to bars from palembang@
12            @number of sections@
 1  2  3  4  5  6  7  8  9  10  11  12  @ GNBMSTR(J) @
30  30  30  30  30  30  30  30  30  30  30  30  @ GMSTI(J) @
30  30  30  30  30  30  30  30  30  30  30  30  @ GMSTO(J) @

@1  2  3  4  5  6  7  8  9 10 11 12 @
 1  1  1  1  1  1  1  1  1  1  1  1  @ 1MENCOUNTER(RSHIP,STRETCH,TSHIP) @
 1  1  1  1  1  1  1  1  1  1  1  1  @ 2MENCOUNTER(RSHIP,STRETCH,TSHIP)  @
 1  1  1  1  1  1  1  1  1  1  1  1  @ 3MENCOUNTER(RSHIP,STRETCH,TSHIP)  @
 1  1  1  1  1  1  1  1  1  1  1  1  @ 4MENCOUNTER(RSHIP,STRETCH,TSHIP)  @
 1  1  1  1  1  1  1  1  1  1  1  1  @ 5MENCOUNTER(RSHIP,STRETCH,TSHIP)  @
 1  1  1  1  1  1  1  1  1  1  1  1  @ 6MENCOUNTER(RSHIP,STRETCH,TSHIP)  @
```

```
 1 1 1 1 1 1 1 1 1 1 1 1 @ 7MENCOUNTER(RSHIP,STRETCH,TSHIP) @
 1 1 1 1 1 1 1 1 1 1 1 1 @ 8MENCOUNTER(RSHIP,STRETCH,TSHIP) @

 1 1 1 1 1 1 1 1 1 1 1 1 @ 1MOVERTAKE(RSHIP,STRETCH,TSHIP) @
 1 1 1 1 1 1 1 1 1 1 1 1 @ 2MOVERTAKE(RSHIP,STRETCH,TSHIP) @
 1 1 1 1 1 1 1 1 1 1 1 1 @ 3MOVERTAKE(RSHIP,STRETCH,TSHIP) @
 1 1 1 1 1 1 1 1 1 1 1 1 @ 4MOVERTAKE(RSHIP,STRETCH,TSHIP) @
 1 1 1 1 1 1 1 1 1 1 1 1 @ 5MOVERTAKE(RSHIP,STRETCH,TSHIP) @
 1 1 1 1 1 1 1 1 1 1 1 1 @ 6MOVERTAKE(RSHIP,STRETCH,TSHIP) @
 1 1 1 1 1 1 1 1 1 1 1 1 @ 7MOVERTAKE(RSHIP,STRETCH,TSHIP) @
 1 1 1 1 1 1 1 1 1 1 1 1 @ 8MOVERTAKE(RSHIP,STRETCH,TSHIP) @

@ Boombaru fleet2@
29 68 115 155 299 310 @gctwlin(nbars 1-6) sailing times to bars from sea@
50 61 205 245 292 331 @gctwlout(nbars 6-1) sail times to bars from palembang@
12              @number of sections@
 1  2  3  4  5  6  7  8  9 10 11 12 @ GNBMSTR(J) @
30 30 30 30 30 30 30 30 30 30 30 30 @ GMSTI(J) @
30 30 30 30 30 30 30 30 30 30 30 30 @ GMSTO(J) @

@1 2 3 4 5 6 7 8 9 10 11 12 @
 1 1 1 1 1 1 1 1 1 1 1 1 @ 1MENCOUNTER(RSHIP,STRETCH,TSHIP) @
 1 1 1 1 1 1 1 1 1 1 1 1 @ 2MENCOUNTER(RSHIP,STRETCH,TSHIP) @
 1 1 1 1 1 1 1 1 1 1 1 1 @ 3MENCOUNTER(RSHIP,STRETCH,TSHIP) @
 1 1 1 1 1 1 1 1 1 1 1 1 @ 4MENCOUNTER(RSHIP,STRETCH,TSHIP) @
 1 1 1 1 1 1 1 1 1 1 1 1 @ 5MENCOUNTER(RSHIP,STRETCH,TSHIP) @
 1 1 1 1 1 1 1 1 1 1 1 1 @ 6MENCOUNTER(RSHIP,STRETCH,TSHIP) @
 1 1 1 1 1 1 1 1 1 1 1 1 @ 7MENCOUNTER(RSHIP,STRETCH,TSHIP) @
 1 1 1 1 1 1 1 1 1 1 1 1 @ 8MENCOUNTER(RSHIP,STRETCH,TSHIP) @

 1 1 1 1 1 1 1 1 1 1 1 1 @ 1MOVERTAKE(RSHIP,STRETCH,TSHIP) @
 1 1 1 1 1 1 1 1 1 1 1 1 @ 2MOVERTAKE(RSHIP,STRETCH,TSHIP) @
 1 1 1 1 1 1 1 1 1 1 1 1 @ 3MOVERTAKE(RSHIP,STRETCH,TSHIP) @
 1 1 1 1 1 1 1 1 1 1 1 1 @ 4MOVERTAKE(RSHIP,STRETCH,TSHIP) @
 1 1 1 1 1 1 1 1 1 1 1 1 @ 5MOVERTAKE(RSHIP,STRETCH,TSHIP) @
 1 1 1 1 1 1 1 1 1 1 1 1 @ 6MOVERTAKE(RSHIP,STRETCH,TSHIP) @
 1 1 1 1 1 1 1 1 1 1 1 1 @ 7MOVERTAKE(RSHIP,STRETCH,TSHIP) @
 1 1 1 1 1 1 1 1 1 1 1 1 @ 8MOVERTAKE(RSHIP,STRETCH,TSHIP) @

@ Pertamina fleet1@
60 90 230 250 290 350 @gctwlin(nbars 1-6) sailing times to bars from sea@
10 60 110 130 270 300 @gctwlout(nbars 6-1) sail times to bars from palembang@
12
 1  2  3  4  5  6  7  8  9 10 11 12 @ GMSTRETCH(I) @
30 30 30 30 30 30 30 30 30 30 30 30 @ GMSTI(I) @
30 30 30 30 30 30 30 30 30 30 30 30 @ GMSTO(I) @

@1 2 3 4 5 6 7 8 9 10 11 12 @
 1 1 1 1 1 1 1 1 1 1 1 1 @ 1MENCOUNTER(RSHIP,STRETCH,TSHIP) @
 1 1 1 1 1 1 1 1 1 1 1 1 @ 2MENCOUNTER(RSHIP,STRETCH,TSHIP) @
 1 1 1 1 1 1 1 1 1 1 1 1 @ 3MENCOUNTER(RSHIP,STRETCH,TSHIP) @
 1 1 1 1 1 1 1 1 1 1 1 1 @ 4MENCOUNTER(RSHIP,STRETCH,TSHIP) @
 1 1 1 1 1 1 1 1 1 1 1 1 @ 5MENCOUNTER(RSHIP,STRETCH,TSHIP) @
 1 1 1 1 1 1 1 1 1 1 1 1 @ 6MENCOUNTER(RSHIP,STRETCH,TSHIP) @
 1 1 1 1 1 1 1 1 1 1 1 1 @ 7MENCOUNTER(RSHIP,STRETCH,TSHIP) @
 1 1 1 1 1 1 1 1 1 1 1 1 @ 8MENCOUNTER(RSHIP,STRETCH,TSHIP) @

 1 1 1 1 1 1 1 1 1 1 1 1 @ 1MOVERTAKE(RSHIP,STRETCH,TSHIP) @
 1 1 1 1 1 1 1 1 1 1 1 1 @ 2MOVERTAKE(RSHIP,STRETCH,TSHIP) @
```

```
 1 1 1 1 1 1 1 1 1 1 1 1 @ 3MOVERTAKE(RSHIP,STRETCH,TSHIP) @
 1 1 1 1 1 1 1 1 1 1 1 1 @ 4MOVERTAKE(RSHIP,STRETCH,TSHIP) @
 1 1 1 1 1 1 1 1 1 1 1 1 @ 5MOVERTAKE(RSHIP,STRETCH,TSHIP) @
 1 1 1 1 1 1 1 1 1 1 1 1 @ 6MOVERTAKE(RSHIP,STRETCH,TSHIP) @
 1 1 1 1 1 1 1 1 1 1 1 1 @ 7MOVERTAKE(RSHIP,STRETCH,TSHIP) @
 1 1 1 1 1 1 1 1 1 1 1 1 @ 8MOVERTAKE(RSHIP,STRETCH,TSHIP) @

@ Pertamina fleet2@
60 90 230 250 290 350 @gctwlin(nbars 1-6) sailing times to bars from sea@
10 60 110 130 270 300 @gctwlout(nbars 6-1) sail times to bars from palembang@
12
 1  2  3  4  5  6  7  8  9 10 11 12 @ GMSTRETCH(I) @
30 30 30 30 30 30 30 30 30 30 30 30 @ GMSTI(I) @
30 30 30 30 30 30 30 30 30 30 30 30 @ GMSTO(I) @

@1 2 3 4 5 6 7 8 9 10 11 12 @
 1 1 1 1 1 1 1 1 1 1 1 1 @ 1MENCOUNTER(RSHIP,STRETCH,TSHIP) @
 1 1 1 1 1 1 1 1 1 1 1 1 @ 2MENCOUNTER(RSHIP,STRETCH,TSHIP) @
 1 1 1 1 1 1 1 1 1 1 1 1 @ 3MENCOUNTER(RSHIP,STRETCH,TSHIP) @
 1 1 1 1 1 1 1 1 1 1 1 1 @ 4MENCOUNTER(RSHIP,STRETCH,TSHIP) @
 1 1 1 1 1 1 1 1 1 1 1 1 @ 5MENCOUNTER(RSHIP,STRETCH,TSHIP) @
 1 1 1 1 1 1 1 1 1 1 1 1 @ 6MENCOUNTER(RSHIP,STRETCH,TSHIP) @
 1 1 1 1 1 1 1 1 1 1 1 1 @ 7MENCOUNTER(RSHIP,STRETCH,TSHIP) @
 1 1 1 1 1 1 1 1 1 1 1 1 @ 8MENCOUNTER(RSHIP,STRETCH,TSHIP) @

 1 1 1 1 1 1 1 1 1 1 1 1 @ 1MOVERTAKE(RSHIP,STRETCH,TSHIP) @
 1 1 1 1 1 1 1 1 1 1 1 1 @ 2MOVERTAKE(RSHIP,STRETCH,TSHIP) @
 1 1 1 1 1 1 1 1 1 1 1 1 @ 3MOVERTAKE(RSHIP,STRETCH,TSHIP) @
 1 1 1 1 1 1 1 1 1 1 1 1 @ 4MOVERTAKE(RSHIP,STRETCH,TSHIP) @
 1 1 1 1 1 1 1 1 1 1 1 1 @ 5MOVERTAKE(RSHIP,STRETCH,TSHIP) @
 1 1 1 1 1 1 1 1 1 1 1 1 @ 6MOVERTAKE(RSHIP,STRETCH,TSHIP) @
 1 1 1 1 1 1 1 1 1 1 1 1 @ 7MOVERTAKE(RSHIP,STRETCH,TSHIP) @
 1 1 1 1 1 1 1 1 1 1 1 1 @ 8MOVERTAKE(RSHIP,STRETCH,TSHIP) @

@ Pusri fleet1@
60 90 230 250 290 350 @gctwlin(nbars 1-6) sailing times to bars from sea@
10 60 110 130 270 300 @gctwlout(nbars 6-1) sail times to bars from palembang@
12
 1  2  3  4  5  6  7  8  9 10 11 12 @ GMSTRETCH(I) @
30 30 30 30 30 30 30 30 30 30 30 30 @ GMSTI(I) @
30 30 30 30 30 30 30 30 30 30 30 30 @ GMSTO(I) @

@1 2 3 4 5 6 7 8 9 10 11 12 @
 1 1 1 1 1 1 1 1 1 1 1 1 @ 1MENCOUNTER(RSHIP,STRETCH,TSHIP) @
 1 1 1 1 1 1 1 1 1 1 1 1 @ 2MENCOUNTER(RSHIP,STRETCH,TSHIP) @
 1 1 1 1 1 1 1 1 1 1 1 1 @ 3MENCOUNTER(RSHIP,STRETCH,TSHIP) @
 1 1 1 1 1 1 1 1 1 1 1 1 @ 4MENCOUNTER(RSHIP,STRETCH,TSHIP) @
 1 1 1 1 1 1 1 1 1 1 1 1 @ 5MENCOUNTER(RSHIP,STRETCH,TSHIP) @
 1 1 1 1 1 1 1 1 1 1 1 1 @ 6MENCOUNTER(RSHIP,STRETCH,TSHIP) @
 1 1 1 1 1 1 1 1 1 1 1 1 @ 7MENCOUNTER(RSHIP,STRETCH,TSHIP) @
 1 1 1 1 1 1 1 1 1 1 1 1 @ 8MENCOUNTER(RSHIP,STRETCH,TSHIP) @

 1 1 1 1 1 1 1 1 1 1 1 1 @ 1MOVERTAKE(RSHIP,STRETCH,TSHIP) @
 1 1 1 1 1 1 1 1 1 1 1 1 @ 2MOVERTAKE(RSHIP,STRETCH,TSHIP) @
 1 1 1 1 1 1 1 1 1 1 1 1 @ 3MOVERTAKE(RSHIP,STRETCH,TSHIP) @
 1 1 1 1 1 1 1 1 1 1 1 1 @ 4MOVERTAKE(RSHIP,STRETCH,TSHIP) @
 1 1 1 1 1 1 1 1 1 1 1 1 @ 5MOVERTAKE(RSHIP,STRETCH,TSHIP) @
 1 1 1 1 1 1 1 1 1 1 1 1 @ 6MOVERTAKE(RSHIP,STRETCH,TSHIP) @
 1 1 1 1 1 1 1 1 1 1 1 1 @ 7MOVERTAKE(RSHIP,STRETCH,TSHIP) @
```

1 1 1 1 1 1 1 1 1 1 1 1 @ 8MOVERTAKE(RSHIP,STRETCH,TSHIP) @

@ Pusri fleet2@
60 90 230 250 290 350 @gctwlin(nbars 1-6) sailing times to bars from sea@
10 60 110 130 270 300 @gctwlout(nbars 6-1) sail times to bars from palembang@
12
1 2 3 4 5 6 7 8 9 10 11 12 @ GMSTRETCH(I) @
30 30 30 30 30 30 30 30 30 30 30 30 @ GMSTI(I) @
30 30 30 30 30 30 30 30 30 30 30 30 @ GMSTO(I) @

@1 2 3 4 5 6 7 8 9 10 11 12 @
1 1 1 1 1 1 1 1 1 1 1 1 @ 1MENCOUNTER(RSHIP,STRETCH,TSHIP) @
1 1 1 1 1 1 1 1 1 1 1 1 @ 2MENCOUNTER(RSHIP,STRETCH,TSHIP) @
1 1 1 1 1 1 1 1 1 1 1 1 @ 3MENCOUNTER(RSHIP,STRETCH,TSHIP) @
1 1 1 1 1 1 1 1 1 1 1 1 @ 4MENCOUNTER(RSHIP,STRETCH,TSHIP) @
1 1 1 1 1 1 1 1 1 1 1 1 @ 5MENCOUNTER(RSHIP,STRETCH,TSHIP) @
1 1 1 1 1 1 1 1 1 1 1 1 @ 6MENCOUNTER(RSHIP,STRETCH,TSHIP) @
1 1 1 1 1 1 1 1 1 1 1 1 @ 7MENCOUNTER(RSHIP,STRETCH,TSHIP) @
1 1 1 1 1 1 1 1 1 1 1 1 @ 8MENCOUNTER(RSHIP,STRETCH,TSHIP) @

1 1 1 1 1 1 1 1 1 1 1 1 @ 1MOVERTAKE(RSHIP,STRETCH,TSHIP) @
1 1 1 1 1 1 1 1 1 1 1 1 @ 2MOVERTAKE(RSHIP,STRETCH,TSHIP) @
1 1 1 1 1 1 1 1 1 1 1 1 @ 3MOVERTAKE(RSHIP,STRETCH,TSHIP) @
1 1 1 1 1 1 1 1 1 1 1 1 @ 4MOVERTAKE(RSHIP,STRETCH,TSHIP) @
1 1 1 1 1 1 1 1 1 1 1 1 @ 5MOVERTAKE(RSHIP,STRETCH,TSHIP) @
1 1 1 1 1 1 1 1 1 1 1 1 @ 6MOVERTAKE(RSHIP,STRETCH,TSHIP) @
1 1 1 1 1 1 1 1 1 1 1 1 @ 7MOVERTAKE(RSHIP,STRETCH,TSHIP) @
1 1 1 1 1 1 1 1 1 1 1 1 @ 8MOVERTAKE(RSHIP,STRETCH,TSHIP) @

@ Rest fleet1@
60 90 230 250 290 350 @gctwlin(nbars 1-6) sailing times to bars from sea@
10 60 110 130 270 300 @gctwlout(nbars 6-1) sail times to bars from palembang@
12
1 2 3 4 5 6 7 8 9 10 11 12 @ GMSTRETCH(I) @
30 30 30 30 30 30 30 30 30 30 30 30 @ GMSTI(I) @
30 30 30 30 30 30 30 30 30 30 30 30 @ GMSTO(I) @

@1 2 3 4 5 6 7 8 9 10 11 12 @
1 1 1 1 1 1 1 1 1 1 1 1 @ 1MENCOUNTER(RSHIP,STRETCH,TSHIP) @
1 1 1 1 1 1 1 1 1 1 1 1 @ 2MENCOUNTER(RSHIP,STRETCH,TSHIP) @
1 1 1 1 1 1 1 1 1 1 1 1 @ 3MENCOUNTER(RSHIP,STRETCH,TSHIP) @
1 1 1 1 1 1 1 1 1 1 1 1 @ 4MENCOUNTER(RSHIP,STRETCH,TSHIP) @
1 1 1 1 1 1 1 1 1 1 1 1 @ 5MENCOUNTER(RSHIP,STRETCH,TSHIP) @
1 1 1 1 1 1 1 1 1 1 1 1 @ 6MENCOUNTER(RSHIP,STRETCH,TSHIP) @
1 1 1 1 1 1 1 1 1 1 1 1 @ 7MENCOUNTER(RSHIP,STRETCH,TSHIP) @
1 1 1 1 1 1 1 1 1 1 1 1 @ 8MENCOUNTER(RSHIP,STRETCH,TSHIP) @

1 1 1 1 1 1 1 1 1 1 1 1 @ 1MOVERTAKE(RSHIP,STRETCH,TSHIP) @
1 1 1 1 1 1 1 1 1 1 1 1 @ 2MOVERTAKE(RSHIP,STRETCH,TSHIP) @
1 1 1 1 1 1 1 1 1 1 1 1 @ 3MOVERTAKE(RSHIP,STRETCH,TSHIP) @
1 1 1 1 1 1 1 1 1 1 1 1 @ 4MOVERTAKE(RSHIP,STRETCH,TSHIP) @
1 1 1 1 1 1 1 1 1 1 1 1 @ 5MOVERTAKE(RSHIP,STRETCH,TSHIP) @
1 1 1 1 1 1 1 1 1 1 1 1 @ 6MOVERTAKE(RSHIP,STRETCH,TSHIP) @
1 1 1 1 1 1 1 1 1 1 1 1 @ 7MOVERTAKE(RSHIP,STRETCH,TSHIP) @
1 1 1 1 1 1 1 1 1 1 1 1 @ 8MOVERTAKE(RSHIP,STRETCH,TSHIP) @

@ Rest fleet2@
60 90 230 250 290 350 @gctwlin(nbars 1-6) sailing times to bars from sea@
10 60 110 130 270 300 @gctwlout(nbars 6-1) sail times to bars from palembang@

```
12
 1  2  3  4  5  6  7  8  9 10 11 12 @ GMSTRETCH(I) @
30 30 30 30 30 30 30 30 30 30 30 30 @ GMSTI(I) @
30 30 30 30 30 30 30 30 30 30 30 30 @ GMSTO(I) @

@1 2 3 4 5 6 7 8 9 10 11 12 @
 1 1 1 1 1 1 1 1 1 1 1 1 @ 1MENCOUNTER(RSHIP,STRETCH,TSHIP) @
 1 1 1 1 1 1 1 1 1 1 1 1 @ 2MENCOUNTER(RSHIP,STRETCH,TSHIP) @
 1 1 1 1 1 1 1 1 1 1 1 1 @ 3MENCOUNTER(RSHIP,STRETCH,TSHIP) @
 1 1 1 1 1 1 1 1 1 1 1 1 @ 4MENCOUNTER(RSHIP,STRETCH,TSHIP) @
 1 1 1 1 1 1 1 1 1 1 1 1 @ 5MENCOUNTER(RSHIP,STRETCH,TSHIP) @
 1 1 1 1 1 1 1 1 1 1 1 1 @ 6MENCOUNTER(RSHIP,STRETCH,TSHIP) @
 1 1 1 1 1 1 1 1 1 1 1 1 @ 7MENCOUNTER(RSHIP,STRETCH,TSHIP) @
 1 1 1 1 1 1 1 1 1 1 1 1 @ 8MENCOUNTER(RSHIP,STRETCH,TSHIP) @

 1 1 1 1 1 1 1 1 1 1 1 1 @ 1MOVERTAKE(RSHIP,STRETCH,TSHIP) @
 1 1 1 1 1 1 1 1 1 1 1 1 @ 2MOVERTAKE(RSHIP,STRETCH,TSHIP) @
 1 1 1 1 1 1 1 1 1 1 1 1 @ 3MOVERTAKE(RSHIP,STRETCH,TSHIP) @
 1 1 1 1 1 1 1 1 1 1 1 1 @ 4MOVERTAKE(RSHIP,STRETCH,TSHIP) @
 1 1 1 1 1 1 1 1 1 1 1 1 @ 5MOVERTAKE(RSHIP,STRETCH,TSHIP) @
 1 1 1 1 1 1 1 1 1 1 1 1 @ 6MOVERTAKE(RSHIP,STRETCH,TSHIP) @
 1 1 1 1 1 1 1 1 1 1 1 1 @ 7MOVERTAKE(RSHIP,STRETCH,TSHIP) @
 1 1 1 1 1 1 1 1 1 1 1 1 @ 8MOVERTAKE(RSHIP,STRETCH,TSHIP) @

5                      @ TCMDELAY @
5                      @ TCPDELAY @
```

Shstrpal

```
@ Boombaru fleet1 @
52                     @ GDEST  destination number@
48                     @ GENSINT sailing time from IN to quay@
48                     @ GENSOUT sailing time from quay to out@
7                      @ GNBSTR number of sections to be taken@
5                      @ GSTRCOM n.o.s. on main approach track@
1  2  3  4  5 12 52       @ GSTRETCH(I) @
3  3  3  3  3 30 30       @ GSTI(I) @
3  3  3  3  3 30 30       @ GSTO(I) @

1  1  1  1  1 1  0       @ ENCOUNTER(RSHIP,STRETCH,TSHIP) @
1  1  1  1  1 0  0       @ ENCOUNTER(RSHIP,STRETCH,TSHIP) @
1  1  1  1  1 1  0       @ ENCOUNTER(RSHIP,STRETCH,TSHIP) @
1  1  1  1  1 1  0       @ ENCOUNTER(RSHIP,STRETCH,TSHIP) @
1  1  1  1  1 1  0       @ ENCOUNTER(RSHIP,STRETCH,TSHIP) @
1  1  1  1  1 1  0       @ ENCOUNTER(RSHIP,STRETCH,TSHIP) @
1  1  1  1  1 1  0       @ ENCOUNTER(RSHIP,STRETCH,TSHIP) @
1  1  1  1  1 1  0       @ ENCOUNTER(RSHIP,STRETCH,TSHIP) @
40
1  1  1  1  1 1  0       @ OVERTAKE(RSHIP,STRETCH,TSHIP) @
1  1  1  1  1 0  0       @ OVERTAKE(RSHIP,STRETCH,TSHIP) @
1  1  1  1  1 1  0       @ OVERTAKE(RSHIP,STRETCH,TSHIP) @
1  1  1  1  1 1  0       @ OVERTAKE(RSHIP,STRETCH,TSHIP) @
1  1  1  1  1 1  0       @ OVERTAKE(RSHIP,STRETCH,TSHIP) @
1  1  1  1  1 1  0       @ OVERTAKE(RSHIP,STRETCH,TSHIP) @
1  1  1  1  1 1  0       @ OVERTAKE(RSHIP,STRETCH,TSHIP) @
1  1  1  1  1 1  0       @ OVERTAKE(RSHIP,STRETCH,TSHIP) @

@ Boombaru fleet2 @
```

```
52                          @ GDEST  destination number@
48                          @ GENSINT sailing time from IN to quay@
48                          @ GENSOUT sailing time from quay to out@
7                           @ GNBSTR number of sections to be taken@
5                           @ GSTRCOM n.o.s. on main approach track@
1  2  3  4  5  12  52          @ GSTRETCH(I) @
3  3  3  3  3  30  30          @ GSTI(I) @
3  3  3  3  3  30  30          @ GSTO(I) @

1  1  1  1  1  1  0          @ ENCOUNTER(RSHIP,STRETCH,TSHIP) @
1  1  1  1  1  0  0          @ ENCOUNTER(RSHIP,STRETCH,TSHIP) @
1  1  1  1  1  1  0          @ ENCOUNTER(RSHIP,STRETCH,TSHIP) @
1  1  1  1  1  1  0          @ ENCOUNTER(RSHIP,STRETCH,TSHIP) @
1  1  1  1  1  1  0          @ ENCOUNTER(RSHIP,STRETCH,TSHIP) @
1  1  1  1  1  1  0          @ ENCOUNTER(RSHIP,STRETCH,TSHIP) @
1  1  1  1  1  1  0          @ ENCOUNTER(RSHIP,STRETCH,TSHIP) @
1  1  1  1  1  1  0          @ ENCOUNTER(RSHIP,STRETCH,TSHIP) @
40
1  1  1  1  1  1  0          @ OVERTAKE(RSHIP,STRETCH,TSHIP) @
1  1  1  1  1  0  0          @ OVERTAKE(RSHIP,STRETCH,TSHIP) @
1  1  1  1  1  1  0          @ OVERTAKE(RSHIP,STRETCH,TSHIP) @
1  1  1  1  1  1  0          @ OVERTAKE(RSHIP,STRETCH,TSHIP) @
1  1  1  1  1  1  0          @ OVERTAKE(RSHIP,STRETCH,TSHIP) @
1  1  1  1  1  1  0          @ OVERTAKE(RSHIP,STRETCH,TSHIP) @
1  1  1  1  1  1  0          @ OVERTAKE(RSHIP,STRETCH,TSHIP) @
1  1  1  1  1  1  0          @ OVERTAKE(RSHIP,STRETCH,TSHIP) @

@ Pertamina fleet1 @

53                          @ GDEST @
48                          @ GENSINT  @
48                          @ GENSOUT @
7                           @ GNBSTR @
5                           @ GSTRCOM @
1  2  3  4  5  13  53          @ GSTRETCH(I) @
3  3  3  3  3   3  30          @ GSTI(I) @
3  3  3  3  3   3  30          @ GSTO(I) @
40
1  1  1  1  1  1  0          @ ENCOUNTER(RSHIP,STRETCH,TSHIP) @
1  1  1  1  1  1  0          @ ENCOUNTER(RSHIP,STRETCH,TSHIP)  @
1  1  1  1  1  1  0          @ ENCOUNTER(RSHIP,STRETCH,TSHIP)  @
1  1  1  1  1  0  0          @ ENCOUNTER(RSHIP,STRETCH,TSHIP)  @
1  1  1  1  1  1  0          @ ENCOUNTER(RSHIP,STRETCH,TSHIP)  @
1  1  1  1  1  1  0          @ ENCOUNTER(RSHIP,STRETCH,TSHIP)  @
1  1  1  1  1  1  0          @ ENCOUNTER(RSHIP,STRETCH,TSHIP)  @
1  1  1  1  1  1  0          @ ENCOUNTER(RSHIP,STRETCH,TSHIP)  @

1  1  1  1  1  1  0          @ OVERTAKE(RSHIP,STRETCH,TSHIP) @
1  1  1  1  1  1  0          @ OVERTAKE(RSHIP,STRETCH,TSHIP) @
1  1  1  1  1  1  0          @ OVERTAKE(RSHIP,STRETCH,TSHIP) @
1  1  1  1  1  0  0          @ OVERTAKE(RSHIP,STRETCH,TSHIP) @
1  1  1  1  1  1  0          @ OVERTAKE(RSHIP,STRETCH,TSHIP) @
1  1  1  1  1  1  0          @ OVERTAKE(RSHIP,STRETCH,TSHIP) @
1  1  1  1  1  1  0          @ OVERTAKE(RSHIP,STRETCH,TSHIP) @
1  1  1  1  1  1  0          @ OVERTAKE(RSHIP,STRETCH,TSHIP) @

@ Pertamina fleet2 @

53                          @ GDEST @
```

```
48                      @ GENSINT  @
48                      @ GENSOUT @
7                       @ GNBSTR @
5                       @ GSTRCOM @
1  2  3  4  5 13  53       @ GSTRETCH(I) @
3  3  3  3  3  3  30       @ GSTI(I) @
3  3  3  3  3  3  30       @ GSTO(I) @
40
1  1  1  1  1 1  0        @ ENCOUNTER(RSHIP,STRETCH,TSHIP) @
1  1  1  1  1 1  0        @ ENCOUNTER(RSHIP,STRETCH,TSHIP)  @
1  1  1  1  1 1  0        @ ENCOUNTER(RSHIP,STRETCH,TSHIP)  @
1  1  1  1  1 0  0        @ ENCOUNTER(RSHIP,STRETCH,TSHIP)  @
1  1  1  1  1 1  0        @ ENCOUNTER(RSHIP,STRETCH,TSHIP)  @
1  1  1  1  1 1  0        @ ENCOUNTER(RSHIP,STRETCH,TSHIP)  @
1  1  1  1  1 1  0        @ ENCOUNTER(RSHIP,STRETCH,TSHIP)  @
1  1  1  1  1 1  0        @ ENCOUNTER(RSHIP,STRETCH,TSHIP)  @

1  1  1  1  1 1  0        @ OVERTAKE(RSHIP,STRETCH,TSHIP) @
1  1  1  1  1 1  0        @ OVERTAKE(RSHIP,STRETCH,TSHIP) @
1  1  1  1  1 1  0        @ OVERTAKE(RSHIP,STRETCH,TSHIP) @
1  1  1  1  1 0  0        @ OVERTAKE(RSHIP,STRETCH,TSHIP) @
1  1  1  1  1 1  0        @ OVERTAKE(RSHIP,STRETCH,TSHIP) @
1  1  1  1  1 1  0        @ OVERTAKE(RSHIP,STRETCH,TSHIP) @
1  1  1  1  1 1  0        @ OVERTAKE(RSHIP,STRETCH,TSHIP) @
1  1  1  1  1 1  0        @ OVERTAKE(RSHIP,STRETCH,TSHIP) @

@ Pusri fleet1 @
54                      @ GDEST @
48                      @ GENSINT  @
48                      @ GENSOUT @
7                       @ GNBSTR @
5                       @ GSTRCOM @
1  2  3  4  5 14  54       @ GSTRETCH(I) @
3  3  3  3  3 15  30       @ GSTI(I) @
3  3  3  3  3 15  30       @ GSTO(I) @
40
1  1  1  1  1 1  0        @ ENCOUNTER(RSHIP,STRETCH,TSHIP)  @
1  1  1  1  1 1  0        @ ENCOUNTER(RSHIP,STRETCH,TSHIP)  @
1  1  1  1  1 1  0        @ ENCOUNTER(RSHIP,STRETCH,TSHIP)  @
1  1  1  1  1 1  0        @ ENCOUNTER(RSHIP,STRETCH,TSHIP)  @
1  1  1  1  1 1  0        @ ENCOUNTER(RSHIP,STRETCH,TSHIP) @
1  1  1  1  1 1  0        @ ENCOUNTER(RSHIP,STRETCH,TSHIP)  @
1  1  1  1  1 1  0        @ ENCOUNTER(RSHIP,STRETCH,TSHIP)  @
1  1  1  1  1 1  0        @ ENCOUNTER(RSHIP,STRETCH,TSHIP)  @

1  1  1  1  1 1  0        @ OVERTAKE(RSHIP,STRETCH,TSHIP) @
1  1  1  1  1 1  0        @ OVERTAKE(RSHIP,STRETCH,TSHIP) @
1  1  1  1  1 1  0        @ OVERTAKE(RSHIP,STRETCH,TSHIP) @
1  1  1  1  1 1  0        @ OVERTAKE(RSHIP,STRETCH,TSHIP) @
1  1  1  1  1 1  0        @ OVERTAKE(RSHIP,STRETCH,TSHIP) @
1  1  1  1  1 1  0        @ OVERTAKE(RSHIP,STRETCH,TSHIP) @
1  1  1  1  1 1  0        @ OVERTAKE(RSHIP,STRETCH,TSHIP) @
1  1  1  1  1 1  0        @ OVERTAKE(RSHIP,STRETCH,TSHIP) @

@ Pusri fleet2 @
54                      @ GDEST @
48                      @ GENSINT  @
48                      @ GENSOUT @
7                       @ GNBSTR @
```

```
5                          @ GSTRCOM @
1  2  3  4  5  14  54        @ GSTRETCH(I) @
3  3  3  3  3  15  30        @ GSTI(I) @
3  3  3  3  3  15  30        @ GSTO(I) @
40
1  1  1  1  1  1  0        @ ENCOUNTER(RSHIP,STRETCH,TSHIP)  @
1  1  1  1  1  1  0        @ ENCOUNTER(RSHIP,STRETCH,TSHIP)  @
1  1  1  1  1  1  0        @ ENCOUNTER(RSHIP,STRETCH,TSHIP)  @
1  1  1  1  1  1  0        @ ENCOUNTER(RSHIP,STRETCH,TSHIP)  @
1  1  1  1  1  1  0        @ ENCOUNTER(RSHIP,STRETCH,TSHIP) @
1  1  1  1  1  0  0        @ ENCOUNTER(RSHIP,STRETCH,TSHIP)  @
1  1  1  1  1  1  0        @ ENCOUNTER(RSHIP,STRETCH,TSHIP)  @
1  1  1  1  1  1  0        @ ENCOUNTER(RSHIP,STRETCH,TSHIP)  @

1  1  1  1  1  1  0        @ OVERTAKE(RSHIP,STRETCH,TSHIP) @
1  1  1  1  1  1  0        @ OVERTAKE(RSHIP,STRETCH,TSHIP) @
1  1  1  1  1  1  0        @ OVERTAKE(RSHIP,STRETCH,TSHIP) @
1  1  1  1  1  1  0        @ OVERTAKE(RSHIP,STRETCH,TSHIP) @
1  1  1  1  1  1  0        @ OVERTAKE(RSHIP,STRETCH,TSHIP) @
1  1  1  1  1  0  0        @ OVERTAKE(RSHIP,STRETCH,TSHIP) @
1  1  1  1  1  1  0        @ OVERTAKE(RSHIP,STRETCH,TSHIP) @
1  1  1  1  1  1  0        @ OVERTAKE(RSHIP,STRETCH,TSHIP) @

@ Rest fleet1 @
55                          @ GDEST @
48                          @ GENSINT  @
48                          @ GENSOUT @
7                          @ GNBSTR @
5                          @ GSTRCOM @
1  2  3  4  5  15  55        @ GSTRETCH(I) @
3  3  3  3  3  30  30        @ GSTI(I) @
3  3  3  3  3  30  30        @ GSTO(I) @
40
1  1  1  1  1  1  0        @ ENCOUNTER(RSHIP,STRETCH,TSHIP) @
1  1  1  1  1  1  0        @ ENCOUNTER(RSHIP,STRETCH,TSHIP)  @
1  1  1  1  1  1  0        @ ENCOUNTER(RSHIP,STRETCH,TSHIP)  @
1  1  1  1  1  1  0        @ ENCOUNTER(RSHIP,STRETCH,TSHIP)  @
1  1  1  1  1  1  0        @ ENCOUNTER(RSHIP,STRETCH,TSHIP)  @
1  1  1  1  1  1  0        @ ENCOUNTER(RSHIP,STRETCH,TSHIP)  @
1  1  1  1  1  1  0        @ ENCOUNTER(RSHIP,STRETCH,TSHIP)  @
1  1  1  1  1  1  0        @ ENCOUNTER(RSHIP,STRETCH,TSHIP)  @

1  1  1  1  1  1  0        @ OVERTAKE(RSHIP,STRETCH,TSHIP) @
1  1  1  1  1  1  0        @ OVERTAKE(RSHIP,STRETCH,TSHIP) @
1  1  1  1  1  1  0        @ OVERTAKE(RSHIP,STRETCH,TSHIP) @
1  1  1  1  1  1  0        @ OVERTAKE(RSHIP,STRETCH,TSHIP) @
1  1  1  1  1  1  0        @ OVERTAKE(RSHIP,STRETCH,TSHIP) @
1  1  1  1  1  1  0        @ OVERTAKE(RSHIP,STRETCH,TSHIP) @
1  1  1  1  1  1  0        @ OVERTAKE(RSHIP,STRETCH,TSHIP) @
1  1  1  1  1  1  0        @ OVERTAKE(RSHIP,STRETCH,TSHIP) @

@ Rest fleet2 @
55                          @ GDEST @
48                          @ GENSINT  @
48                          @ GENSOUT @
7                          @ GNBSTR @
5                          @ GSTRCOM @
1  2  3  4  5  15  55        @ GSTRETCH(I) @
3  3  3  3  3  30  30        @ GSTI(I) @
```

```
3  3  3  3  3 30 30        @ GSTO(I) @
40
1  1  1  1  1  1  1       @ ENCOUNTER(RSHIP,STRETCH,TSHIP) @
1  1  1  1  1  1  1       @ ENCOUNTER(RSHIP,STRETCH,TSHIP)  @
1  1  1  1  1  1  1       @ ENCOUNTER(RSHIP,STRETCH,TSHIP)  @
1  1  1  1  1  1  1       @ ENCOUNTER(RSHIP,STRETCH,TSHIP)  @
1  1  1  1  1  1  1       @ ENCOUNTER(RSHIP,STRETCH,TSHIP)  @
1  1  1  1  1  1  1       @ ENCOUNTER(RSHIP,STRETCH,TSHIP)  @
1  1  1  1  1  1  1       @ ENCOUNTER(RSHIP,STRETCH,TSHIP)  @
1  1  1  1  1  1  1       @ ENCOUNTER(RSHIP,STRETCH,TSHIP)  @

1  1  1  1  1  1  1       @ OVERTAKE(RSHIP,STRETCH,TSHIP) @
1  1  1  1  1  1  1       @ OVERTAKE(RSHIP,STRETCH,TSHIP) @
1  1  1  1  1  1  1       @ OVERTAKE(RSHIP,STRETCH,TSHIP) @
1  1  1  1  1  1  1       @ OVERTAKE(RSHIP,STRETCH,TSHIP) @
1  1  1  1  1  1  1       @ OVERTAKE(RSHIP,STRETCH,TSHIP) @
1  1  1  1  1  1  1       @ OVERTAKE(RSHIP,STRETCH,TSHIP) @
1  1  1  1  1  1  1       @ OVERTAKE(RSHIP,STRETCH,TSHIP) @
1  1  1  1  1  1  1       @ OVERTAKE(RSHIP,STRETCH,TSHIP) @
```

Appendix H: The statistical analysis of the service time and inter arrival time distributions using *BestFit*

The goal of *BestFit* is to find the distribution that best fits the input data. For a given distribution, *BestFit* varies the parameters of the function in order to optimise the goodness-of-fit.

The first step in interpreting the results is to consider what the Kolmogorov-Smirnov value means; namely, how well the input data fits a certain distribution function. A lower value indicates a better fit. The exponential distribution, which has been used in the PROSIM model, is always a reasonably good fit. (A reasonably good fit is defined here as a fit with a K-S test value of less than 0.5. This value is based on the visual comparison of the exponential distribution with the input data.)

Another means of interpreting the results is visually assessing how well the fit distribution agrees with the input data. These results are printed in chapter 7.2 and further.

Best Fit Results Boom Baru service time:

Function	K-S Test	Rank
Weibull(0.63,20.84)	0.138433	1.0
Lognormal2(1.73,3.39)	0.237152	2.0
Lognormal(1.75e+3,5.44e+5)	0.237152	3.0
Expon(34.42)	**0.291178**	**4.0**
Erlang(1.00,34.42)	0.29135	5.0
Logistic(34.42,56.09)	0.36197	6.0
Normal(34.42,1.02e+2)	0.386057	7.0
Erf(6.91e-3)	0.519947	8.0
Chisq(34.00)	0.694777	9.0
Triang(0.00,0.00,7.42e+2)	0.792793	10.0

Pareto(1.00,0.00)	0.947531	11.0
Beta(1.00e-2,2.01) * 7.42e+2	2.660746	12.0
Gamma(0.11,3.05e+2)	7.5545	13.0

Best Fit Results Boom Baru inter arrival time:

Function	*K-S Test*	*Rank*
Lognormal(72.51,1.22e+2)	0.06243	1.0
Weibull(0.89,65.22)	0.089744	2.0
Expon(69.67)	**0.112588**	**3.0**
Erlang(1.00,69.67)	0.113003	4.0
Lognormal2(3.99,1.17)	0.149269	5.0
Logistic(69.67,56.56)	0.228374	6.0
Beta(0.34,1.04) * 7.43e+2 + 0.80	0.248001	7.0
Normal(69.67,1.03e+2)	0.266404	8.0
Gamma(0.66,1.40e+2)	0.476948	9.0
Erf(6.69e-3)	0.522992	10.0
Triang(-4.63e+2,-2.81e+2,7.44e+2)	0.554014	11.0
Chisq(69.00)	0.581847	12.0
Pareto(1.00,0.80)	0.82213	13.0

Best Fit Results Pertamina service time:

Function	*K-S Test*	*Rank*
Weibull(0.66,8.60)	0.140805	1.0
Lognormal(78.63,9.31e+2)	0.249475	2.0
Expon(12.89)	**0.24969**	**3.0**
Lognormal2(1.97,2.37)	0.269446	4.0
Logistic(12.89,18.00)	0.364543	5.0
Normal(12.89,32.86)	0.364599	6.0
Erlang(1.00,24.37)	0.465877	7.0
Chisq(12.00)	0.48433	8.0

Erf(2.15e-2)	0.519947	9.0
Triang(0.00,0.00,2.16e+2)	0.743235	10.0
Beta(0.37,8.01) * 2.16e+2	0.817687	11.0
Pareto(1.00,0.00)	0.978495	12.0
Gamma(0.18,74.01)	4.899984	13.0

Best Fit Results Pertamina inter arrival time:

Function	*K-S Test*	*Rank*
Lognormal2(3.43,0.71)	0.084685	1.0
Lognormal(39.64,31.98)	0.084685	2.0
Triang(3.17,17.63,97.88)	0.131028	3.0
Beta(3.39,6.78) * 94.71 + 3.17	0.15409	4.0
Weibull(1.16,41.59)	0.187383	5.0
Gamma(1.16,34.16)	0.205306	6.0
Erlang(1.00,39.80)	0.236515	7.0
Expon(39.80)	**0.237106**	**8.0**
Logistic(26.58,15.94)	0.249052	9.0
Chisq(34.00)	0.281512	10.0
Normal(23.89,26.42)	0.304152	11.0
Erf(1.92e-2)	0.60262	12.0
Pareto(3.07,3.17)	0.925388	13.0

Best Fit Results Pusri service time:

Function	*K-S Test*	*Rank*
Weibull(0.84,31.62)	0.060309	1.0
Expon(35.55)	**0.091757**	**2.0**
Lognormal(4.72e+2,1.80e+4)	0.21834	3.0
Lognormal2(2.52,2.70)	0.21834	4.0
Logistic(35.55,36.25)	0.272783	5.0
Normal(35.55,66.19)	0.311146	6.0

Erlang(1.00,76.42)	0.347083	7.0
Beta(2.77,35.90) * 6.12e+2	0.401808	8.0
Chisq(35.00)	0.489813	9.0
Erf(1.01e-2)	0.519947	10.0
Triang(0.00,0.00,6.12e+2)	0.679838	11.0
Pareto(1.01,0.00)	0.97076	12.0
Gamma(0.29,1.23e+2)	2.704445	13.0

Best Fit Results Pusri inter arrival time:

Function	*K-S Test*	*Rank*
Lognormal2(3.69,0.69)	0.089532	1.0
Lognormal(50.71,39.60)	0.089532	2.0
Gamma(2.07,24.00)	0.089906	3.0
Erlang(2.00,24.79)	0.095895	4.0
Weibull(1.56,55.38)	0.107287	5.0
Beta(1.37,3.67) * 1.84e+2 + 3.90	0.164039	6.0
Normal(49.57,34.49)	0.169462	7.0
Logistic(49.57,18.89)	0.178939	8.0
Expon(49.57)	**0.232244**	**9.0**
Triang(-7.73,20.77,1.88e+2)	0.280848	10.0
Chisq(49.00)	0.332552	11.0
Erf(1.42e-2)	0.586182	12.0
Pareto(2.24,3.90)	0.895905	13.0