Study on the navigation capacity of the approach channel of Tianjin Port: Part 2

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Because of the complexity of port systems, especially due to the effects of many random factors involved such as the arrival time of ships etc., an effective method to evaluate the approach channel navigation capacity of a port is currently unavailable. This paper introduces a simulating model of complete port systems that includes the relevant factors such as ship, channel, berth and handling operation. By using this model, a study has been performed on the demand for the channel navigation capacity by Tianjin Port at various development stages.

Establishment of the simulation model

The simulation model was established in two steps. In the first step, computing techniques are used to convert the mathematic models of the subsystems and the system logic relations into a conceptual model of an integral system. Special simulation language GPSS/H and Proof Animation software, which are the products of Wolverine Software Corporation of USA, was then used to convert the conceptual model into the simulation model so that it could be run on the computer. Figure 1 shows the brief flowchart of the simulation model.

The model was validated by comparing the simulated results of Tianjin Port for the year 2004 with the actual statistics data.

In order to study whether the channel will still be able to meet the demand of the port, further development of the simulation was performed for the following three cases:

Case 1: Tianjin Port operation in 2010
Case 2: Tianjin Port operation in 2020
Case 3: Tianjin Port operation beyond 2020

Simulation results

The calculation results of the Case 1 study shows that in the year of 2010, the average density of ships navigating through the approach channel of Tianjin Port will be 142.8 ships a day. Within the time of the year, the idle time of the channel (no ships in the channel) is only about 4.08 per cent of the total time of the year. There will be on average 6.81 ships at a time in the channel, and there will be at maximum 19 ships in the channel at a time. The distribution of number of ships in the channel is shown in Figure 2.

The ship wait time for channel availability when entering or leaving the port is 1.71 h/ship on average. The frequencies of waiting times are shown in Table 1 (see overleaf).

Table 1 shows that among the 26,060 ships that navigate through the channel in one year, about 81.63 per cent of the total number of ships will wait for less than 2 hours for channel availability (including 34.65 per cent of ships that do not need to wait for the channel). Whereas the number of ships that have to wait for more than 11 hours only accounts for 3.06 per cent of the total number of ships. The calculation results show that about 6.58 per cent of channel wait time is caused by the insufficient width of the channel for two-way navigation, about 84.43 per cent of the channel wait time is caused by over density of ships (including the effect of ships turning in the main channel), about 3.50 per cent of channel wait time is due to waiting for favourable tidal levels, and about 3.45 per cent of the channel wait time caused by some ships passing the converging point of the North Branch Channel and the Main Channel.

The calculation result for Case 2 show that in the year of 2020, the approach channel of Tianjin Port will be comparatively

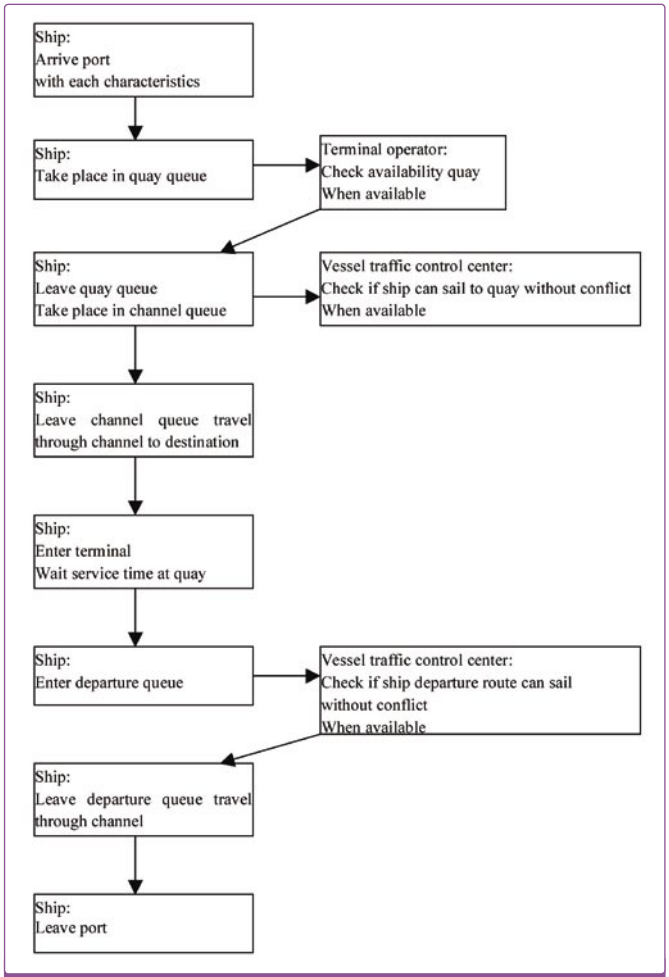

Figure 1. Brief flowchart of the simulation model.

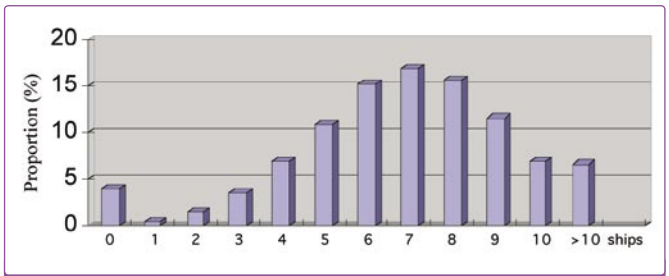

Figure 2. Distribution of number of ships in the channel.

TABLE 1. DISTRIBUTION OF CHANNEL WAIT TIME

Ship's waiting time for availability of channel (hours)	Frequency (%)
0	34.65
0< t ≤1	38.04
1< t ≤2	8.94
2< t ≤3	4.04
3< t ≤4	2.64
4< t ≤5	1.97
5< t ≤6	1.53
6< t ≤7	1.44
7< t ≤8	1.28
8< t ≤9	0.93
9< t ≤10	0.85
10< t ≤11	0.62
t >11	3.06

busy, with average density of 175.5 ships at the channel daily. Within the time of the year, the idle time of the channel (no ships in the channel) is only about 4.06 per cent. There will be on average 8.27 ships at a time in the channel, and there will be at maximum 20 ships in the channel at a time.

The average time for a ship to wait for the channel is 3.28 hours. Among the 32,033 ships that navigate through the channel in one year, there will be about 70.123 per cent of the total number of the ships that will wait for less than 2 hours. Whereas the number of ships that have to wait for more than 11 hours only accounts for 7.99 per cent of the total number of ships.

The calculation results show that about 8.82 per cent of the channel wait time is caused by the insufficient width of the channel for two-way navigation, about 85.22 per cent of the channel wait time is caused by over density of ships (including the effect of ships turning in the main channel), about 1.96 per cent of the channel wait time is due to waiting for favourable tidal level, and about 1.96 per cent of the channel wait time is caused by some ships passing the converging point of the North Branch Channel and the Main Channel.

The calculation for Case 3 (Tianjin Port future conditions) shows that due to over density of ships and an excessively long waiting time for the channel, the berth performance capacity will be greatly wasted and part of the berths will suffer too high utilisation rate to receive the planned number of ships (it mainly means two cases: 1) The berth is already allocated but is idle because the designated ship is queuing to enter the port and cannot arrive at the berth at the right time; 2) The ship at berth has completed its handling operations but cannot leave the berth at the right time due to congested channel, causing the berth to lay idle). The calculation results show that within a year, there will be about 5,000 ships that cannot enter the port for handling operation. Therefore, their values cannot be entered into the comparison. From the results of the ships that will be able to enter the port and complete the handling operation, it is derived that the average waiting time for the channel availability will be as long as 7.72 hours per ship.

Result analysis and conclusion

Through analysis on the results of the above calculations, the following conclusions can be made: In the year of 2010, the number of arrival ships and their tonnage classes will be increased to certain extent compared with the present. However, the channel width and depth will also be improved for most of the ships, the average ship's waiting time for channel will be only 1.71 hours/ship. For the Port of Tianjin, the upgrade of the navigation channel to 250,000 dwt class not only means the possibility of receiving large sized ships up to 250,000 dwt class, but also is of great interest because it will reduce the total time of the ships at port, hence increasing the economic benefits of the port operator, the cargo owner and the shipping company.

In the year of 2020, the Port of Tianjin will be more developed then in 2010. The fleet of arrival ships will increase not only in number but also in tonnage classes. The simulation results show that although the channel will still be able to ensure the fulfilment of the target throughput, a great waste of as much as 2521.06 ship-days will be caused as a result of waiting for the availability of the channel for such a large fleet. This is very uneconomic and especially so when the port becomes even more developed into the period beyond 2020; the above mentioned channel conditions will be unable to ensure the fulfilment of the target throughput. Therefore it is suggested that feasibility study should be performed for the determination of the size, location and direction for the second navigation channel.

According to the Tianjin port planning, there are will about 50 container berths located at the two sides of the Northern Branch Channel, and a huge number ships will call at these berths. The statistics of arrival container ships at Tianjin Port show that small sized ships (≤30,000 dwt) will remain the majority in the fleet in terms of quantity. Thus, the authors suggest that the new channel should be designated especially for those berths and need not be dredged too deep, as it will be mainly oriented to diverging the small ships from the Main Channel, meanwhile reducing the chance for ships to cross the converging point between the Northern Branch Channel and the Main Channel.

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References available upon request.

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