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Use of Simulation for Optimizing Manoeuvres in Constantza Port

E. Barsan
Constantza Maritime University, Romania

ABSTRACT: Constantza Maritime University had won a two year research grant, financed by the Romanian Government through the National University Research Council, for optimization of the Constantza port fairway and assessment of maneuvering procedures for handling of very large ships. The actual port fairway could not ensure safe navigation for ships with a draught greater than 13 meters, and also in the container terminal area, the actual maximum depth is 11meters. In a port without tide, the unique solution is to deepen and enlarge the existing fairway. The aim of our paper is to present the working hypothesis and methodology, which we used for creating the ship handling simulator maneuvering scenarios for very large ships. Validation and assessment of these scenarios, in order to establish the optimum shape and dimensions of the redrawn fairway, were done in cooperation with Constantza port pilots and VTS operators.

1 INTRODUCTION

The Port of Constantza offers a lot of advantages, among which, the most important are:

- good connections with all modes of transport: railway, road, river, airway and pipelines and direct access to the Pan-European Corridor VII, through the Danube Black Sea Canal, providing a shorter and cheaper waterway transport towards Central Europe than the routes using the ports in Northern Europe;
- the new container terminal on Pier II South, increasing the container operating capacity and will be in future expansion;
- multi-purpose port with modern facilities and sufficient depth to accommodate the largest vessels passing through the Suez Canal;
- Ro-Ro and Ferry-boat terminals suitable for the development of short sea shipping serving the Black Sea and the Danube countries.

The total area covered by the Constantza Port is 36.26 sq Km, with 13.9 Km of breakwaters, 29 Km quay length and 132 berths. Depth at berths is between 7 and 16 meters, allowing operation of ships up to 150000 dwt (NCMPAC SA, 2004).

The Port of Constantza has two distinct areas, called Constantza North and Constantza South (figure 1). The Constantza North area is the old port, which underwent developments and expansions until 1980. The Constantza South area is the area built between 1980 and 1990, with new investments and facilities opened after 2000. In the Constantza South area, new infrastructure extensions and investments in port facilities are expected in the near future and until 2015.

2 CONSTANTZA PORT DEVELOPMENT STRATEGY

After ten years stagnation, a few major investments were made in the Constantza Port during the last 4 years, mainly in the South area. We will mention hear the new container terminal on Pier II S, grain terminal on Pier I S, and the Passenger terminal at berth no.0.

For the next year, Port of Constantza will face new developing challenges, in order to build new facilities: the barge terminal, Grain Terminal, LPG Terminal, completion of the North Breakwater, Waste Management facilities, International Business Centre. Locations of these new facilities were established in the Constantza South area.

In order to accomplish these goals, massive infrastructure works must be undertaken. Practically, an artificial island must be built in the middle part of the Constantza Port and in the southern part of the port, the new quays must be gained from the sea (figure 2).

The quays of the artificial island will accommodate deep draught vessels, having depths of 14.5-19.0 meters. In all the south area, depth of water will be increased, in order to allow access for bigger ships, including in the barge basin and barge canal, where de depth of water will be 7.0 meters.

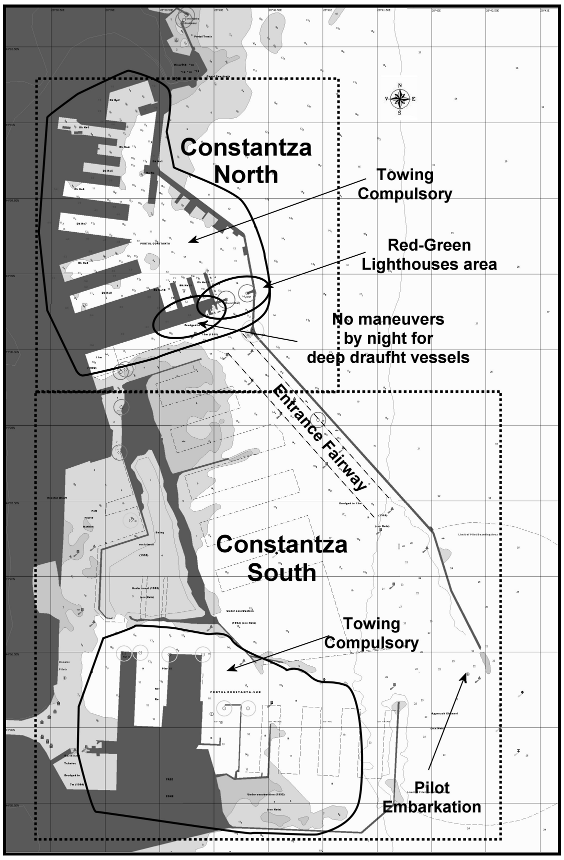

Fig. 1. Constantza Port operational areas and maneuvering reference points

As we can see in figure 2, the fairway will have 21.0 meters depth and a turning basin with 600 meters radius will be established abeam the 19 meters depth berths.

These were the circumstances that determined the Constantza Maritime University to propose to the Romanian government the OPTIMPORT research project. The proposal was accepted by the Ministry of Transport and the project is financed from the research funds of the Ministry of Education. The main goal of OPTIMPORT is to asses the feasibility of the planned fairways and quays configuration, in terms of safety for very large ships maneuvering actions. It was for the first time in Romania, when large scale, real time simulation was used for evaluation of the port engineering design.

In order to accomplish the working packages of OPTIMPORT project, Constantza Maritime University is using a Transas NT Pro-4000, class A, full mission ship handling simulator (FMSHS), and the maritime 3D and hydrological database special created for the Constantza Port area.

3 DESIGN OF SHIP HANDLING SCENARIOS

Use of FMSHS for design, evaluation and assessment of engineering port infrastructure projects is not a new issue. Starting from the 80ties, such researches were undertaken in different countries, and for different types of ports. These past experience, in terms of simulation procedures applied and results obtained could be used only as guidelines for new experiments, because there are not two ports where the basic ship handling conditions are the same (Webster, 1992). Any how, there are a few basic steps that must be accomplished before beginning the design of the new scenarios.

In order to draw up the deep draught ship handling scenarios for the optimization of the Constantza port access fairway, we have started from the existing rules and procedures related to.

In synthesis, the rules that imposed specific restriction for ship maneuvering are:

Pilotage is compulsory for al maritime ships, pilot embarkation point located 0.5 NM south of north breakwater head (see map in figure 1);

- port maneuvers of ships exceeding 16 m draught are forbidden by night in berths 80-82, when a tanker ship is moored alongside in berth no.79 (see map in figure 1);
- port maneuvers of tankers exceeding 11 m draught are forbidden by night in berths 69-78 (see map in figure 1);
- only one tanker could use the entrance fairway at one time;
- no ship must enter/leave Constantza North area, if the “Red-Green lighthouses” area is not clear
- ships entering the port must keep clear of the way of ships leaving the port;

– Constantza Port Control (VTS) could suspend maneuvers if wind exceeds 7 BFS or visibility is lower than 0.5 NM;

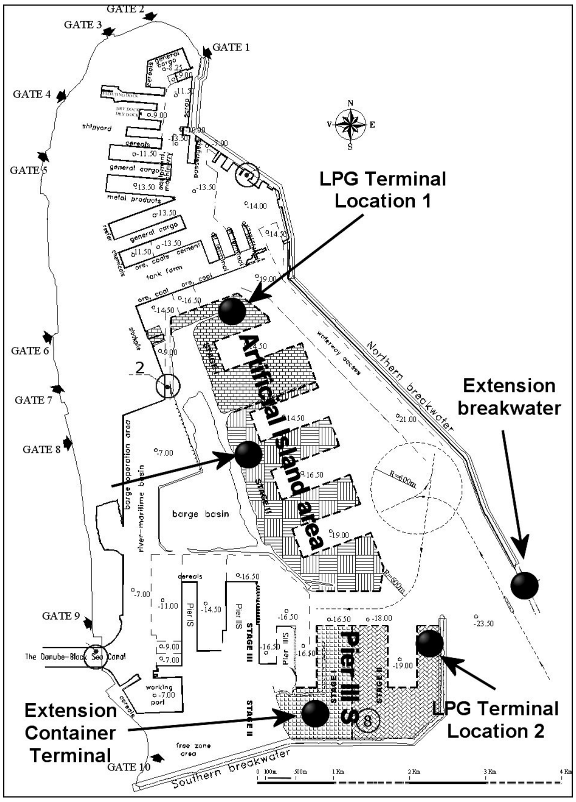

Fig. 2. Developments for Constantza Port for 2007-2013

– Towing is compulsory for all ships exceeding 1000 NRT, excepting ships with bow thrusters and/or two propellers. Towing is compulsory in all the port area, excepting the entrance fairway (see map in figure 1).

Number and power of tugs is related with ships length, as follows:

– length lower then 130 meters – 1 tug of at least 600 HP
– length between 131 and 150 meters – 2 tugs of at least 600 HP
– length between 151 and 200 meters – 2 tugs of at least 2000 HP
– length between 201 and 250 meters – 3 tugs (two of 2400 HP and one of 4800 HP)
– length greater then 250 meters – 4 tugs (two of 2400 HP and two of 4800 HP)

Power and number of tugs are very important elements that must be taken into consideration (TEWG, 2001) when we simulate maneuvers for full loaded bulk carriers (150000 DWT and above) and VLCCs (200000 DWT and above). Tugs must also be considered for simulated maneuvers of big containers ships and LPG ships with LOA over 250 meters.

In accordance with the port expansion projects, we will have to see in what conditions the turning basin with 600 meters radius is sufficient (USACE, 1987) for handling large ships in the deep draught berths area or Piers II and III.

Second major item for preliminary analysis refers to specific meteorological conditions of the Constantza maritime area. Here we have to deal with statistical multi-annual values, as an average per month for winds characteristics, but also with the direction, speed and duration of wind during severe storms.

The amount of work for hydro-meteorological conditions is lower than for other ports, because in Constantza Port there are no tides and water currents to be taken into consideration.

On the other hand, the Port of Constantza has a very low natural protection against the predominant northern winds, especially in the Constantza South area.

4 FAIRWAY ASSESSMENT AND OPTIMIZATION

Because the construction of the central quays on the artificial island (figure 2 – expansion zone no.4) will narrow very much the available safety maneuvering space on the west of the fairway, the team of instructors from the Navigation Simulation Complex of Constantza Maritime University divided the ship handling scenarios in two main categories: with or without the artificial island.

The first rows of simulations were done considering that the artificial island (project area no.4) will be not build. In these circumstances, we had take into account a fairway deepen at 21 meters and width extended from the actual 300 meters to 500 meters, in order to better respect the Rule of Thumb stating that the width of one-way channels should be between 4–5 times the maximum beam of ships expected to use (USACE, 2002). Also, for these simulations we considered the depths of water increased along the berths 79-82 to 19 meters, 16.5 meters along berths no.83 and 14.5 meters at berth no.84 (Delefortrie et al., 2004). For the same starting hypothesis, we assessed the proposed location no.2 for the LPG terminal at Pier III S.

We consider that construction of the quays on the artificial island area will decrease safety of navigation on the northern part of the entrance fairway and will amplify the bottle neck effect in the “Red-Green lighthouses” area (Barsan, 2006b). Even if this part of the extension project is considered by the Constantza port administration as stage 1, we think that we demonstrate that it will be better to reconsider construction of Pier III S-area no.5, also in stage 1.

The second row of scenarios that will be undertaken in the second part of year 2007 will consider the existence of the artificial island quays, but only in the stage 1 construction area, where the first option location for the LPG terminal has been planned. For these scenarios, the considered depth of the fairway will be also be 21 meters, same new depths at berths 79-84, but width of the fairway will be maintained at 300 meters.

In both cases, the turning basin location and dimension will be tested, mainly for handling of post-Panamax container ships without tugs, or with only one tug, in various wind conditions.

The scope of the OPTIMPORT project is to asses the safety of navigation and port maneuvering actions in the Constantza South area, along the routes labeled 1, 2 and 3 in figure 3. The following types of own ships were used during simulation:

- Large bulk carrier: LOA = 290 m, Breadth = 46 m, Draught = 17.1 m, 179658 DWT;
- VLCC full loaded: LOA = 261 m, Breadth = 48.3 m, Draught = 16.7 m, 210000 DWT;
- LPG: LOA = 183 m, Breadth = 22.6 m, Draught = 10.4 m;
- Post-Panamax Container ship – type 3: LOA = 277 m, Breadth = 40 m, Draught = 13 m, 58070 DWT;
- Post-Panamax Container ship – type 4: LOA = 347 m, Breadth = 42.2 m, Draught = 14 m, 104696 DWT.

Post-Panamax container ships, having draughts greater than 12 meters, could only be operated at Pier II S container terminal (simulation route no.3). In figure 4 is shown such a maneuver of a 277 meters long container ship, which has only bowthrusters. These kind of testing maneuvers were undertaken by CMU instructors' and the resulting trajectories were compared with real maneuvering trajectories of smaller container ships in Constantza South area, recorded by AIS receiver and electronic chart plotter.

Bulk carriers and VLCCs of such dimensions could be moored only in berth 79-82 (simulation route 1+2). We tested standard maneuvers with two pulling tugs and one tug in assistance. Such a maneuver, using three tugs is shown in figure 5, where an VLCC is departing berth 80 from the Constantza North area. For wind increasing over 4 BFT, we use three tugs (two pulling tugs and one pushing tug) for handling loaded bulk carriers along route 2 (figure 6). Very large bulk carriers could be unloaded only in berth # 81 and 82, after the dredging operations that will deepen water on this sector to 16.5 -19 meters.

One tug will be used for turning container ships at the end of route 3, in case post-Panamax container ships could not maneuver along route 3 without assistance. Starting with these basic conditions, we will amplify the risks (Hensen, 1999) increasing the force of wind from the most inconvenient, but most probable direction.

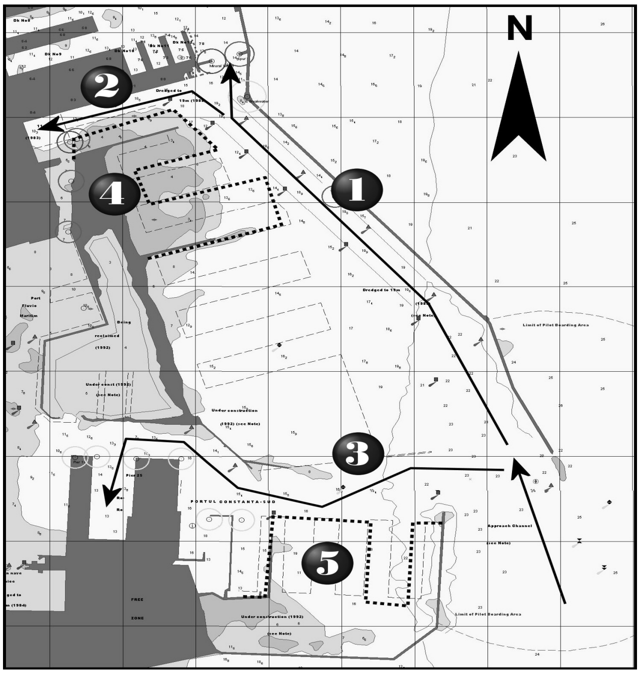

Fig. 3. Simulation routes and areas in OPTIMPORT project

Along route 2, we have to decide the optimum width of the new dragged fairway, in order to allow maneuvers of ships in berth 83 and/or 84 if large ships are moored alongside in berths 79-82 (Demirbilek , Sargent , 1999).

On the first stage, the team of instructors of the Navigation Simulation Complex of the Constantza Maritime University had run the planned simulations and performed the required maneuvers.

In stage 2 (starting from May 2007), the instructors will ask for technical assistance and consulting from the Constantza Port pilots. The bridge team that will undertake ship handling maneuvers during simulations will also include a certified pilot. The prime role of the real pilot is to give orders and coordinate tugs actions during maneuvers that involve two or three tugs. The tugs responses will be executed by the instructors, directly from the bridge, using the conning display maneuvering window, or from the instructors' exercise monitoring console.

On the last stage (stage 3 – starting from September 2007), we will perform a more complex simulation, in order to increase the realism of the simulation (Briggs et al., 2001). We will simultaneously use 3-4 own ships (OS), and 3-4 bridge teams. One OS will be the cargo ship (bulk, VLCC, container, etc.) and the rest of 2-3 OS will be the tugs that will handle the cargo ship. We will have a certified pilot on the bridge of the OS cargo ship, and a certified tug captain (from the Constantza Port Pilotage companies) on each of the tugs bridge teams. In accordance with our knowledge and from the survey of the existing technical literature it will be for the first time when simulation for optimization of waterways will consider also human reaction on the maneuvering tugboats. A lot of human resources will be implicated in these tests and coordination of teams could be difficult to manage if the people involved will not consider this work very seriously and as real as possible.

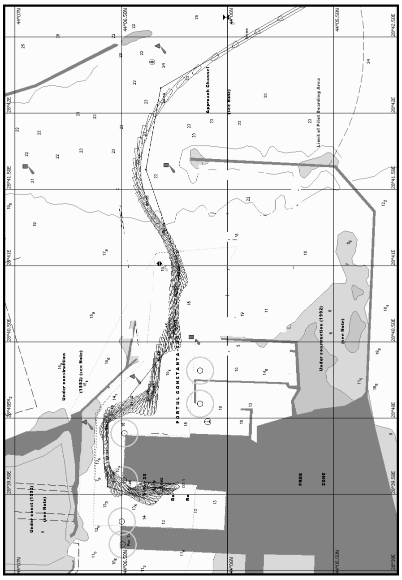

Fig. 4. Berthing maneuver on Pier IIS for Post-Panamax container ship (without tugs)

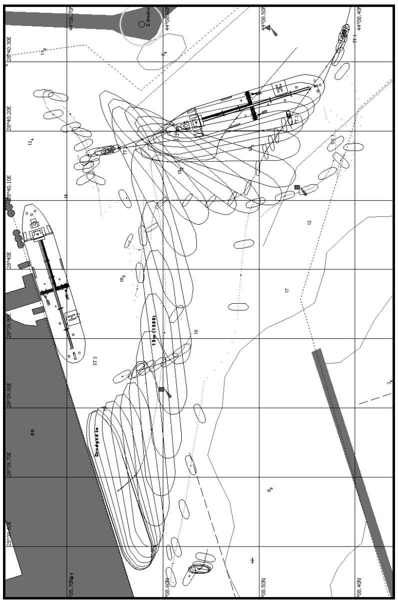

Fig. 5. VLCC departure maneuver from berth # 80, using three tugs

Finally, we think also about an extension of the OPTIMPORT project after year 2007, with new scenarios for testing the most favorable location of the LPG terminal. Because the Constantza Port Administration had not take a decision regarding the final location of this terminal (see figure 2), a set of simulations that will reveal the maneuvering characteristics of the two locations, will help the building place decision process.

5 CONCLUSIONS

Using the three phase simulation approach (instructors alone, instructors plus pilots, instructors plus pilots plus tug captains), we think that we will be able to make a very realistic assessment of the maneuvering capabilities and techniques that could be used in the new projected circumstances for the Constantza Port.

Records of simulations are compared, not only regarding the tracks of the ships, but also the overall maneuvering time, for defining and selecting the best maneuvering procedures (Barsan, 2006a). The same maneuver is performed in different weather conditions, changes being made mainly to wind force and directions. For the more difficult maneuvers, the same scenario will be run through the three stages, at least with unfavorable wind direction force 3, force 5 and force 7. This means that we will have at least 9 simulations for the same basic situation.

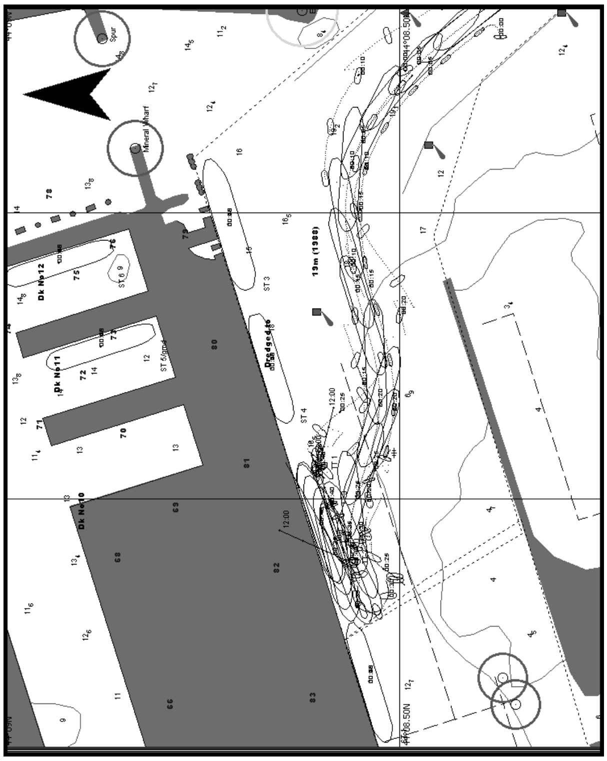

Fig. 6. Berthing maneuver of 200000 dwt bulk carrier, using three tugs

This research methodology will increase the general cost of the OPTIMPORT project, but we expect to have voluntary collaboration from the Constantza Port pilots and tugs captains. At the end of the project, in exchange for the consulting done by the pilots, we will organize a series of short simulation training courses, free of charge, courses that will meet the requirements of paragraph 5.5 of the IMO Resolution A.960(23)/2003 regarding Recommendations on training and certification for maritime pilots other than deep-sea pilots. These courses will include simulation in the featured depth conditions and with the very large ships that will berth at the new cargo terminals.

In the project risk management procedures we will also estimated costs of the dredging works required for deepening and enlarging the entrance fairway at the dimensions specified above. If these costs are too high, and the advantages offered for increasing the safety of navigation and ship handling are not relevant, we will undertake a new series of simulations working with the actual 300 meters width of the fairway, and the new 21 meters depth. Maintaining the actual with of the fairway will amplify the existing traffic problems and also the already identified risks, related to the use of the actual fairway as a two way passage available for large ships. In accordance with actual piloting procedures, when a large oil tanker is entering or leaving the port, all other traffic in the fairway area is closed. Same restriction applies for loaded bulk carriers entering the port. For crude oil and bulk cargo, Constantza port is a discharging port, so we have to handle deep draught loaded vessels only for arrival. Because oil and bulk terminals are located in the southern part of the port North Area, these vessels had to transit the entire entrance fairway, blocking the passage for the two way traffic flow.

The actual budget of OPTIMPORT does not allow design of a new 3D database model for the Constantza Port, with the featured new quays locations in areas 4 and 5 (figure 2). The simulations that will be run in order to test the implications of the new berths will aim only at the passage and maneuvering of ships in and near the fairway and near the new quays, without effective berthing maneuvers.

We intend to keep the simulator instructors' community informed about our findings and to share the experience that we will gain in the next year, regarding the use of simulation for testing deep water fairway design and optimization of port maneuvering procedures.

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