The environmental effects of projected container terminal to the safely manoeuvring

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ABSTRACT: This paper investigates vessel traffic risks that are exposed by a new port installation. A vessel traffic risk analysis was performed by the Ship Handling Simulator team for container terminal installation in Izmit Bay. The main purpose is to evaluate whether the container terminal project shall affect the proper operation of nearside Oil Refinery Terminal. Construction and revision of shore structures may form significant threats for masters in ports and narrow waterways. The Ship handling simulator of ITUMF presents the environmental objects' effects, vessel traffic and weather conditions. Furthermore, the Environmental Stress Model of Inoue (2000) may give an opportunity to analyse vessel traffic risks quantitatively by SHS.

1 INTRODUCTION

Merchant vessels reach to projected container terminal in Izmit Bay by a narrow strait (see Figure 1). Izmit Bay has over a hundred ports and terminals inside with an intensive maritime traffic. Many commercial vessels that berthing and unberthing expose a restricted and congested vessel traffic flow. The projected container terminal shall be located 18.8 miles after the Izmit Bay entrance. Petrochemical and oil refinery complex is also located 140 metres nearside the planned container terminal. A buoy mooring combination is used to handle vessel queue of oil refinery. In this respect, a conflict between the cross vessel traffic of two port establishment should be analysed quantitatively and take balance of judgement of terminals into serious consideration.

Three dimensional (3D) model of this geographic area is created by geographic position, oceanographical, meteorological and topographical structure, vessel traffic data of Petrochemical and oil refinery complex and planned container terminal. Vessel traffic and maneouvering stresses that caused by ports and effect safely maneouvering, are investigated by Environmental Stress Model (ES) due to simulation applications. Environmental Stress model is widely used tool to evaluate maneouvering results with a quantitatively way by an ability to determine indexes in order to standard limit conditions of ship handling operation. ES model was developed at "Inoue Laboratory" of Kobe University, Japan in 1995 and is revised continuously.

Current study of petrochemical and oil refinery terminal intensified to quantitative analysis of safely maneouvering restrictions by planned container terminal in this local area that limited by refinery establishment, due to investment projects of petrochemical and oil refinery terminal to supply national demand.

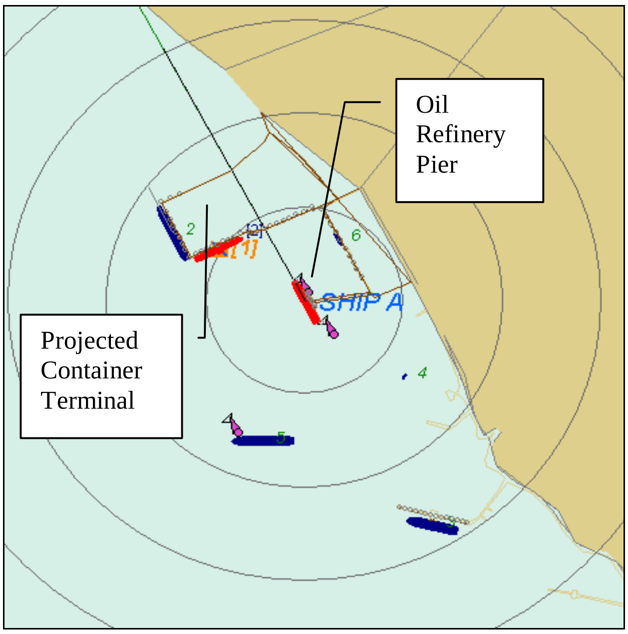

Fig. 1. Objective area of projected container terminal

The study is completed by the stages of:

I. Data introduction of environmental conditions that included by the terminal area to the simulation system interface.
II. Design of simulation scenarios due to port vessel traffic data.
III. Application of scenarios in different variable conditions of weather, sea, length of vessel etc by experienced pilots of Izmit Bay in Full Mission Bridge Simulators as a Real Time Simulation process.
IV. Output analysis on ES model that obtained from applications.
V. Risk evaluation of ES model results.

2 METHOD

2.1 *Simulation Process*

Istanbul Technical University Maritime Faculty Japan Marine Science (JMS) Bridge Simulators have an ability to construct required geographic terrain by a single operator and simulate all geographic effects. Introduction of environmental data like depth, bank effect and berth equipments, meteorological and oceanographical effects are performed by an operator too. (see Table.1) For this purposes, interface software of JMS and 3D design software of Multigen Paradigm, Creator v2.0 are used for data entrance and 3D object rendering.

Table 1. Sea and weather condition at applications

Application No	Weather	Current	Wave
#1	SSW 2-3m/s	SW 0.2kt	SW 1m
#2	SSW 3.0m/s	SW 0.2kt	SW 1.4m
#3	SW 2.5m/s	SW 0.2kt	SW 1m
#4	SSW 2.5m/s	SW 0.2kt	SW 1m
#5	WSW 3m/s	SW 0.4kt	SW 1.4m
#6	SW 2-4m/s	SW 0.4kt	SW 1.4m
#7	SSW 2.5m/s	SW 0.2kt	SW 1m

Probable vessel traffic shall be generated on the simulation system that provides to analyse safely manoeuvering risks in a realistic environment. Operated vessels are 100.000 DWT Aframax Tanker, 37.000 DWT Handymax Bulker and 10.000 DWT Handysize Tanker. 5.000 GRT coaster is used inside the port. 4.000 TEU Panamax container ship is also berthed to the container terminal and mooring arrangement tests are performed to determine maximum handling weather conditions. Tug boats are taken into assistance due to scenario that have a variety of characteristics; 30 tons of bollard-pull and horse power in the range of 2500-4000.

2.2 *ITUMF Full Mission Bridge Simulator System (FMBS)*

ITUMF full mission bridge simulator has the latest generation equipments that can be found on a newbuild commercial vessel. FMBS provides the manoeuvering in a restricted narrow waters and operation of bridge consoles by actual equipment instruction with a real psychological circumstances. The system includes two independent cubicles; main bridge and secondary bridge that can be operated as dependent in a same scenario or independent in different scenarios.

Main bridge represents the core module of system. It has a 240 degrees view that is generated by 7 CRT projectors (wing to wing) and 360 degrees view can be provided by view point move as well. Bridge equipments that interconnected with computer based system include:

- Navigation console that formed by engine telegraph, bow & stern thrusters, water jet propeller, doppler log, steering gear, alarm panel, main engine alarm panel, emergency stops, internal communication, VHF phone, air horn and multi function monitor.
- Display panel that formed by engine revolution, speed gauge, rudder gauge, rate of turn gauge, wind speed & course monitor and ship’s clock.
- Steering console.
- Gyro repeater.
- Magnetic compass.
- Radar / ARPA.
- Electronic Chart(ECDIS).
- Multi Function Monitor(GPS, Echosounder, Doppler Log).

2.3 *Application of environmental stress model*

Maritime traffic simulation is a real time simulation that includes actions for collision avoidance with human factor in this study. Applying the environmental stress model to this simulation results, real environmental stress value (ES value) can be obtained. The concept of the real environmental stress value is introduced to show the real ship-handling difficulties imposed potentially on mariners of a ship manoeuvring at the port.

ES values are obtained by calculating the stress value, assuming that own ship navigations at a speed along a route depend on the mariner behaviour with making all collision avoidance actions against encountering ships. This is intended to avoid concealing information on stress levels that each encounter would naturally impose on the mariner by taking collision avoidance actions against other ships. The extent of such unacceptable real environmental stress value is considered to indicate the necessity for collision avoidance manoeuvres.

In the model, a situation giving the same SJ value, regardless of direction, was taken as the standard situation. The relationship between each stress ranking and the acceptable level was found through the ship-handling simulator experiments. The ES model, therefore, allows us to judge how great the stress value will be when it is no longer acceptable and to point out the disadvantages of the topographical and traffic situation in a waterway. The ES values over 750 are "unacceptable". (see Table 2.)

Table 2. Stress Ranking and Acceptance Criteria

SJ	MARINERS' JUDGEMENT	ES value Σ(SJ)ᵢ	STRESS RANKING	ACCEPTANCE CRITERIA
0	Extremely safe	【0】	NEGLIGIBLE	ACCEPTABLE
1	Fairly safe			
2	Somewhat safe			
3	Neither safe or dangerous	【500】	MARGINAL	
4	Somewhat dangerous	【750】	CRITICAL	UNACCEPTABLE
5	Fairly dangerous	【900】	CATASTROPHIC	
6	Extremely dangerous	【1000】		

The results of a 7-times (approx. 9 hours totally) real time simulation were analysed. The level of stress imposed was assessed for the ship during manoeuvre at the objective area for assessment.

3 APPLICATION AND RESULTS

3.1 *Vessel Manoeuvering Simulator Applications*

Totally of seven real-time simulations have been performed. The scenarios consisted tankers and bulk carriers of 10,000, 37,000 and 100,000 DWT under various weather conditions with port and starboard side docking scenarios. The findings and comments of the pilots performing these simulations are given below.

Application #1: It consists of a starboard side docking tanker of 10,000 DWT under calm weather conditions. A "slapping" effect has been performed using the rudder and the engine to speed-up turning and good performance has been achieved. 2 tugs of 3,000 HP each have been used. The manoeuvering radius has been reduced due to the planned container terminal with the expected consequence of increased manoeuvering time. Except this negative result of increased manoeuvering time, the operation was completed successfully with minimum risk (see Figure 2).

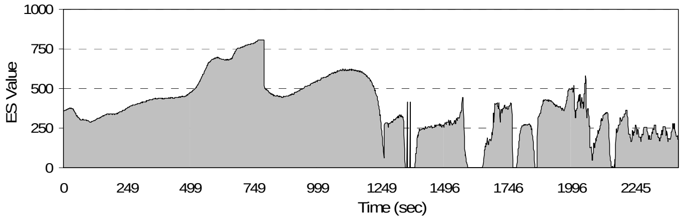

Fig. 2. ES value graphic for Application #1

Application #2: This consists of a starboard side docking tanker of 10,000 DWT under calm weather conditions. It has been observed that starboard side landing takes more time and effort than a port side landing. The operation took more time and required more attention due to a distance of only 300 meters between the port landfill and the ship's bow. The tugs have been used more to reduce the parallel vessel movement than to adjust the heading of the vessel (see Figure 3).

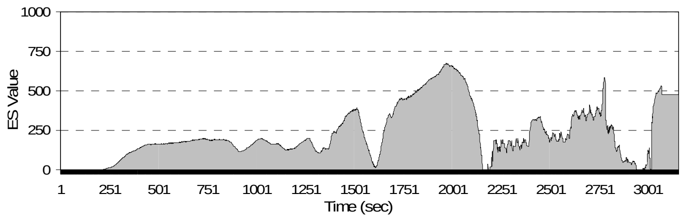

Fig. 3. ES value graphic for Application #2

Application #3: This consists of a port side docking tanker of 10,000 DWT under calm weather conditions. To better simulate the common real life conditions, an anchored LPG tanker has been placed at the east side of the manoeuvering zone. Manoeuvering has been performed mostly with the help of the pushing tugs. A fast forward motion towards the projected pier and the anchored LPG tanker has been avoided, causing an increased but acceptable manoeuvering time (see Figure 4).

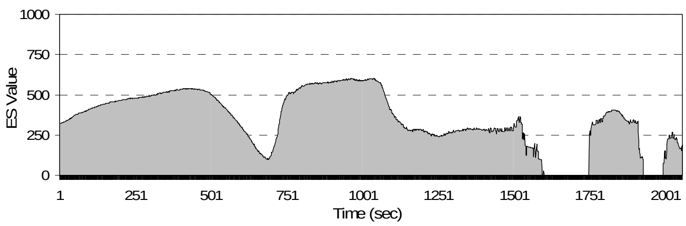

Fig. 4. ES value graphic for Application #3

Application #4: This consists of a port side docking tanker of 37,000 DWT under calm weather conditions. The obvious effect was getting too close to the ships docked alongside the planned pier on the landfill, increasing the manoeuvering risks. Non acceptable risky vessel speeds have been carefully avoided during manoeuvering. Manoeuvering area gets highly reduced under port side landing conditions because of the projected terminal (see Figure 5).

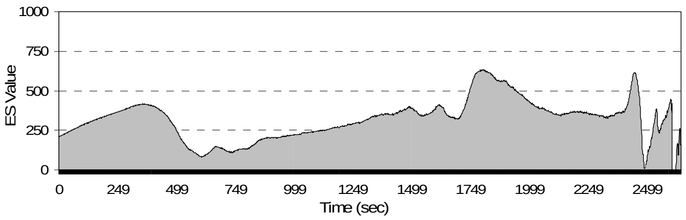

Fig. 5. ES value graphic for Application #4

Application #5: This consists of a port side docking bulk carrier of 100,000 DWT under calm weather conditions. The possible maximum landing speed has been used as a function of the container terminal location. The vessel's aft was observed to come too close to the ships docked alongside the terminal and the minimum docking time was observed to be 30 minutes (see Figure 6).

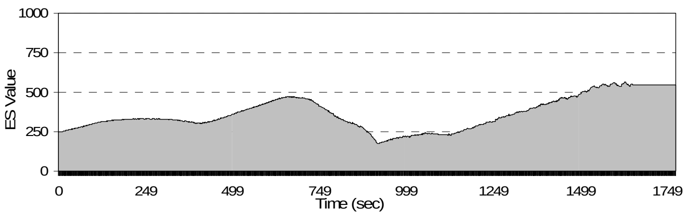

Fig. 6. ES value graphic for Application #5

Application #6: This consists of a starboard side docking tanker of 100,000 DWT under calm weather conditions. 3 tugs have been used. Docking time was observed to be 55 minutes and this should be considered as the longest estimated docking time in all simulations. The vessel speed has been greatly reduced during docking to decrease risks (see Figure 7).

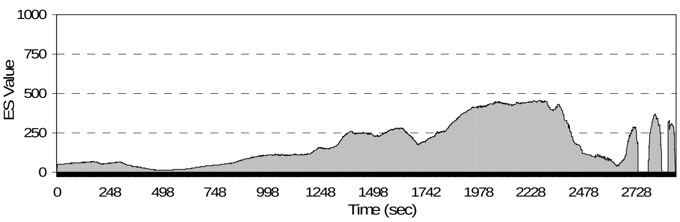

Fig. 7. ES Value graphic for Application #6

Application #7: This consists of a starboard side docking bulk carrier of 100,000 DWT under windy weather conditions. The turning radius was large and combined with the wind effects; this caused the vessel to drift on top of the pipeline marker buoys. This scenario clearly showed that at the presence of the wind and an anchored ship, starboard side docking is a high-risk operation (see Figure 8).

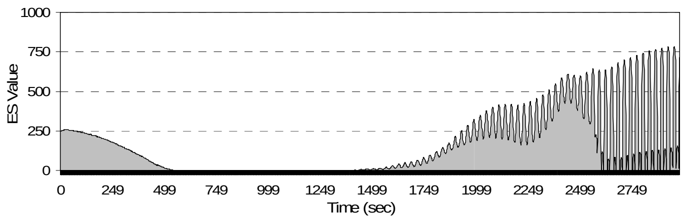

Fig. 8. ES Value graphic for Application #7

3.2 *Investigation of Simulator Application Results*

3.2.1 *Risk Analysis in order to Manoeuvering Diffuculties*

1. Projected container terminal restricts the manoeuvering area of tankers that berthing and unberthing to refinery piers and also other assistance like tugs.
2. Manoeuvering duration is determined maximum 55 minutes and minimum 30 minutes by simulation experiences.
3. In terms of diffuculty and manoeuvering duration, starboard berthing is found less feasible than port berthing.
4. Applications were carried out with taking care of ship speed that expected not to excess higher risk. The case formed to keep risks at minimum.
5. In port berthing, nearmiss risks are found to be existed by the vessels that berthed on east piers of container terminal. Therefore, manoeuverings are advised to be carried out in a special care on higher beaford forces.
6. Mooring safety of a full loaded 4000 TEU container vessel is tested on 5 m/sec. south and northeast winds. In order to mooring tests, container vessel remains on safe berth at south winds, but she loses position and takes free movement at northeast winds. The vessel cuts the bow line at 77 minutes after the beginning of scenario and takes a dangerous case for any vessels nearside region that containing refinery terminal installations. However, if necessary measures are taken into pilotage and mooring policy, that minimizes remaining risks (see Table 3.)

Table 3. Drifting records of container vessel on berth

Weather / Time	3 - 4 . (5 m/s) NE Wind		
	Bow cm/s	Mid kt	Aft cm/s
30 sn	Ø	Ø	Ø
60 sn	18 ►	Ø	◄ 6
90 sn	27 ►	0,1 ↓	3 ►
120 sn	46 ►	Ø	4 ►
150 sn	69 ►	Ø	7 ►
180 sn	83 ►	Ø	9 ►
210 sn	110 ►	0,1 ↑	2 ►
240 sn	122 ►	Ø	17 ►
270 sn	120 ►	0,1 ↑	54 ►
300 sn	122 ►	0,1 ↑	58 ►
330 sn			

3.2.2 *Risk Analysis for Manoeuvers in Harbour*

Risk analysis is carried out by introduction of quantitative results of simulations to ES model. The model results give some forecoming evaluations about risks that refinery installations are effected by projected container terminal manoeuvers. Environmental stresses that exposed by vessel traffic and risk measures are investigated below.

1. As pointed out on Figure 9, ES values are determined as 82% negligible, 17,4% marginal and 0.6% critical levels.
2. In spite of 82% negligible risk level, 17,4% marginal risk that means a dangerous situation may be occurred in any time, observed due to restrictions of maneouvering area. A good manner and experienced assistance should be provided for mentioned refinery terminal by masters and marine pilots. Otherwise, marginal levels can reach to unpreventable realizations.

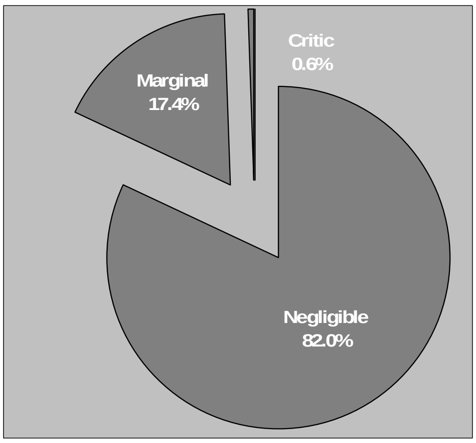

Fig. 9. Risk Distribution of ES Model

3. 0.6% critical levels must be reduced in any case for safety of navigation and berthing. 0.6% ratio of critical levels may not be accepted as preventable and it is seriously taken into project plan to remove.

4 CONCLUSION

A container terminal installation on a shore structure brings some additional risks in this port region. Quantitative analysis of the risks that caused by the maritime traffic is a considerable tool to measure safety and determine safety policy of the local area. Furthermore, separation of negligible or critical risks is a useful and vital opportunity for masters and pilots. Research exposed that concerned refinery terminal manoeuvers reached to 0.6% critical ratio. Critical ratio introduces risks that must be reduced mostly and it may cause an accident. 0.6% critical ratio is lower as an ordinary level that may be observed in any berth-pier combinations. Absence of catastrophic ratio indicates that there is no need to revise project.

Quantitative analysis of maritime traffic risks is an important part of emergency case plans in a waterway region. It is expected to apply for the all ports of Turkiye as well.

5 ACKNOWLEDGEMENT

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