Training for Environmental Risks in the Black Sea Basin

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ABSTRACT: The Potential Emergency Situations Simulator (PESS) for Constantza Maritime University (CMU) should provide training and practicing of the students or course attendants in choosing the best strategies in a given emergency situation, which is an informational high entropy, multi-tasking, fast changing environment. The simulator is used for the realistic modeling of a crisis situation and it is useful for both marine officers and emergency situation officials. The simulator will be used as an educational instrument enabling the interactive study of the different emergency situations. It has the aim of training students to efficiently react to emergency situations such as a leak from a ship/chemical plant, fire, poisonous gas emissions, or any other situations that could show a potential danger. The trainee must be provided with realistic information and the response of the model on the actions of the trainee must be in accordance with the real conditions and scientific based. It must be possible to accelerate the simulation speed without loss of information or functionalities. The input of the external weather conditions is a must, as well as the trainee-oriented graphic interface. It must be possible to change the chemical and physical properties and characteristics of the different polluting agents. The simulator is also used to evaluate the best strategies to be followed in an ongoing crisis. In order to fulfill this aim, the simulation must have the capability to receive data from various sensors, transducers and servers. The courses are designed to accommodate up to six course participants. Each course includes course material such as course manuals and other documents. The courses include hands-on experience with simulator operations and maintenance. To help the start up of the simulated emergency situations training at Constantza Maritime University, we have made a manual which includes some well-designed exercises with scenarios, initial conditions and relevant documentation. The exercise documentation includes the exercise objectives, exercise guidance, instructor guidance, expected results and all other information to make the exercise successful for an inexperienced instructor.

1 INTRODUCTION

1.1 *The importance of training on simulator*

Involving students in simulation training on PC in the higher education is a constant concern, especially in recent years, being also the best way to save resources-so insufficient. Training students in the field of potential incident and emergency situations could be made with good results using computer simulators.

Students can be trained in daytime / night scenarios, in any weather conditions and terrain, everything is done in a virtual environment as close to the real one, generated by computer and related programs, which include three-dimensional representations of land, objects and locations affected.

Computer assisted instruction allows analysis, programming and training of students, at managerial and operational level for different emergency situations without consuming extremely expensive resources and materials. Familiarizing students with unusual situations, also will permit them to act normally in a real intervention and combat in the future incidents.

Another software advantage is that the application automatically carry a useful tool for creating script carrying tactical exercise (technology based on GPS / GIS), for applications in the field of human resources and materials entrained land. Simulator automatically collect real time data of the position and state emergencies, automatically displays digital map of the terrain and dynamically generates real tactical situation on the ground units, register conducting maneuvers and actions while mechanized units involved in the exercise allows analysis of post-deployment training exercise. This system ensures: managing information about own and colateral resources, personnel and logistics, geographic data and maps, weather situation, radio visibility, preparation of plans, orders and reports, terrain analysis tools, messaging format, logic and computer security, communication possibilities through various media.

1.2 *Objectives*

1 development of pollution scenarios for students (6 workstations) using various types of virtual equipment, in order to limit pollution and recovery / annihilation pollutant;

2 discuss each solution obtained by the students, in order to identify possible errors;

3 the instructor can to assess the effectiveness of each student response to pollution, the assessment of the pollution on the coast, the flora and fauna but also by counting the total cost of equipment used in operations in response to pollution;

4 training on this simulator is recommended for practice management level exchange of documents between institutions / agencies that manage such crises.

2 RESEARCH METHODOLOGY

2.1 *Simulator users*

Many marine companies use this form of "E" training to act quickly and effectively in various pollution situations. In thus saving human and material resources and act towards a sustainable development of marine environment and human resource development in the "E" Era Higher Education. Regular users of this simulator are: Constantza Maritime University students, Faculty of Navigation, Environmental Engineering; Navy officers as recommended by IMO OPRC (Oil Pollution Preparedness, Response and Co-operation); Romanian Naval Authority, Maritime Coordination Centre; ARSVOM-Romanian Agency for Saving Life at Sea; Inspectorate for Emergency Situations Constantza Dobrogea.

2.2 *Methodology applied*

The simulator is organized so that the instructor station can launch to all students pollution scenarios (6 workstations) and they can use various types of virtual equipment, chosen from a library, in order to limit pollution and recovery / annihilate the pollutant.

Simulator has a database for various types of response equipment (booms, dispersants, oil skimmers), the means of intervention (intervention marine division of the types of ships, air and land division), marine and terrestrial species of plants and animals .

Accidents that can be simulated are oil spills pollution at sea and spill of toxic / radioactive in air. The simulator is equipped with a module of crisis management that can be used in cases of forest fires, oil on water pollution, dangerous goods accidents, search and rescue operations or naval air accidents, acts of terrorism. This module serves to exercise managerial level exchange of documents between institutions / agencies that manage such crises.

2.3 *The mathematical model*

The process of product oil spreading on the water surface in the last 50 years several models have been proposed of which the most important are: Blokker's model (1964), Fay (1971), Hoult (1972), Mackay (1984), Johansen (1985), Elliot (1986), Shen Yapa (1988) Reed (1991).

Of all these models, Fay's model is considered as the most representative because it has been verified experimentally in the laboratory in 1971, which is why this process is presented.

Fay's model considers that the product spreading oil on the water surface is divided into three phases, corresponding to the four dominant forces (gravitational pressure, inertia, viscous friction and tension).

For the mathematical description of the process of spreading oil on the water surface are necessary the following assumptions:

– discharge of oil product on the water surface is instantaneous;

– the thickness of the oil film is small compared with the area so that the hydrostatic pressure distribution is uniform over the whole surface;

– during the spreading process, the movement of the product oil on the water surface is laminar;

– acceleration of particles centers of oil is low;

– effects of Coriolis forces are negligible;

– relative motion film of oil to current and wind is negligible;

– physico-chemical properties of oil product are time varying depending on atmospheric processes.

The fraction of oil floating above mean water is calculated by the relation :

$$\Delta = \frac{\rho_a - \rho_p}{\rho_a} << 1 \qquad (1)$$

where ρ_a and ρ_p is the density of water and oil product.

From equation (1) it follows that the thickness of the oil film above the mean water level, Δh, is much less than that of water below.

For example, at a temperature of 20 °C for the studied oil product $\rho_p = 888,77$ kg/m³ and $\rho_a = 1000$ kg/m³ the fraction of oil that floats above the average water level is $\Delta = 0,11$.

Immediately after the discharge of oil product the film is thick and the area is small. Therefore, the gravity pressure force (F_p) is greater than the surface tension force (F_{ts}) so that the gravity pressure is the main cause of the expansion of the oil film, according to the equation (Voicu, I., Fay, J.A., Hoult, D.).

$$\rho_p g \Delta h^2 l > \sigma l \quad \Rightarrow \quad h > \sqrt{\frac{\sigma}{\rho_p g \Delta}} . \tag{2}$$

At a temperature of 20 °C, for the fresh oil product whit density $\rho_p = 888,77$ kg/m3, $\Delta = 0,11$, the gravitational acceleration $g = 9,81$ m/s2 and the net spreading coefficient $\sigma = 24,19 \cdot 10^{-3}$ N/m, results that the thickness of the oil film is $h > 5,02 \cdot 10^{-3}$ m.

2.4 Training exercise on simulator

Simulator is also a powerful forecasting tool in a real accident situation: is coupled with a meteorological station of the Constantza Maritime University (CMU) of GSM LOGOTRONIC providing real time data on air parameters (speed/ wind direction, humidity, temperature and barometric pressure). Also is coupled with a submerged plant that belongs to CMU, mounted the marine central platform Petromar Oil Midia, which provides data for sea state in the location (direction/speed for marine currents, direction/amplitude of waves and water temperature) (figure 1).

Results. Typical class working method is: every student receive same scenario and same response resources (say: two tugs, two booms, 2-3 skimmers, etc.). Then we observe the ability to manage this resources in order to limit the spill effect (e.g. *Training exercise input data, Table 1*).

Table 1. Training exercise input data.

Entry data of pollutants	Values		
	5 hours	4 hours	30 min
Crude oil	10 mt/h	3 mt/h	-
Discharge rate	200 mt/h		
Direction/	290⁰ (E-NE)	180⁰ (S)	170⁰ (S-SE)
speed of currents	0.29 m/s	0.19 m/s	0.39 m/s
Direction/	200⁰	270⁰	-
Wind speed	10 m/s	13 m/s	-
Sea water temp	15⁰ C	15⁰ C	15⁰ C
Waves H = 0.2 m downwind			
Visibility	5	5	5
Sea water density	1015 kg/m³	1015 kg/m³	1015 kg/m³

Each of the obtained solutions during the exercises of training can be discussed with all students (using videoprojector), in order to identify any mistakes. Finally instructor can assess the effectiveness of each student response to pollution (1).

All data obtained are shown graphically in real-time virtual - 3D visualization of oil spill and response resources (figure 2 and figure 3) (2,3).

Conducting a parallel between real and virtual resources for a complete training exercice, considering 138 kg=1baril and ~93 $/baril~311.55 lei/baril (e.g.in month July 2012), we can present below the folowing values for this comparative study (Table 2):

Table 2. Virtual-real values for a pollution incident.

Output data	Values	
	real	virtual
pollutant discharged	200 t	0 t
costs resources	~100 000 Euro	10000Euro
technical resources (tugs, booms, etc.)	~15 000 Euro	0 Euro

Figure 1. Central platform Petromar Oil Midia
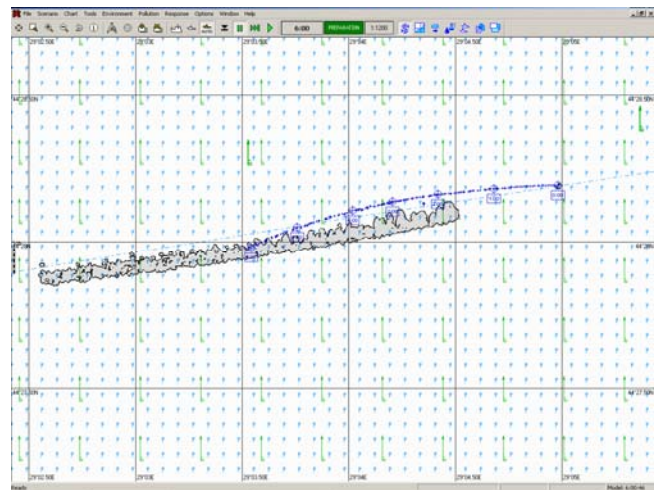

Figure 2. Situation after 9 hours from the event (2)
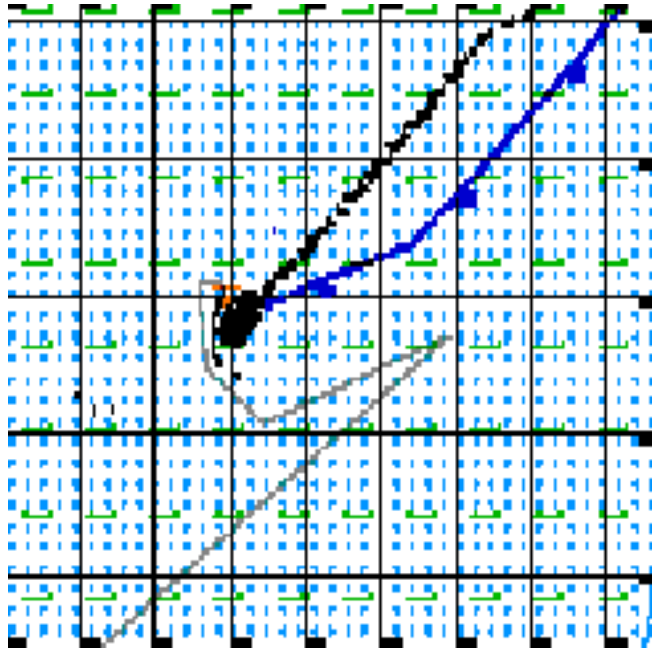
Figure 3. 3D Visualization (3)

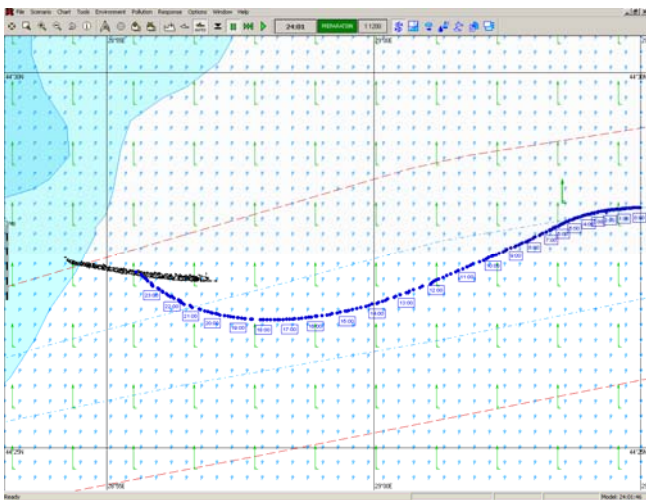Figure 6. Technical resources no 5 boom ready to water h 6:49

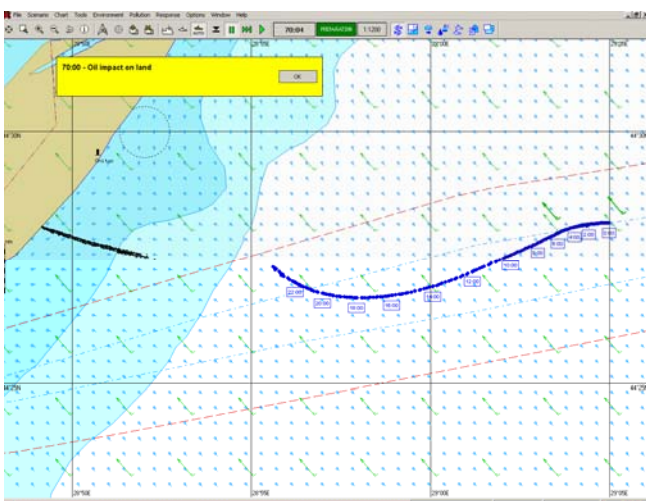Figure 4. Oil shore impact - 24 hours from the event (3)

Figure 5. Oil impact on land at 70 hours from the event (3)

3   CONCLUSIONS

The simulator for emergency situations was designed to evaluate the preparedness to respond effectively to oil spills, in accordance with the requirements of the Oil Pollution Act   of 1990 (OPA 90).

The simulator is developed specifically to support the Preparedness for Response Exercise Program (PREP) with the goal of providing an improved training environment for response managers.

The training on emergency simulator provides the exercise participants with interactive information environment based on the mathematical modeling of an oil spill interacting with surroundings and combat facilities (figure 4, 5, 6).

We drafted a system which also includes information-collecting facilities for the assessment of the participants' performance.

The emergency simulator help us to operating modes corresponding to these stages (Forecast, Conduct and Debrief) are used for reproducing the "reality" of the exercise, automation of the instructor's activities and recording of the exercise key events.

We created sets of scenarios (2) to test the responsiveness of the students in real time and effectively.

Software also permits the student skill evaluation:

We establish a cost per hour for each resource, and we receive the total cost for entire operation, for each student.

Effective training simulator consists of lowering real time response, saving human and material resources, low cost price (Table 2) of company staff training costs.

Major impact produced on the environment from accidental spillage of petroleum products on the

208

surface of the Black Sea water has led to the need for better monitoring of pollution and reducing the time to intervention for the organization and conduct remediation operations. Therefore, modeling of the pollution is becoming a very important and useful operation required for all institutions involved in remediation operations.

The PISCES II simulator is a powerful tool for forecasting the simple fact that enables the simulation of a large number of scenarios (emergency) are discharged various types of petroleum products in different environmental conditions.

Also it can deliver in a short time optimal solutions for maneuvering by teams formed to limit pollution and recovery of spilled oil on the surface of the sea.

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