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Smart System to Coordination of the Available Response Resources in an Oil Spill Leakage

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ABSTRACT: A smart solution for assessing the consequences of pollution on the coast, on flora and fauna but also by accounting for the total costs of the equipment used in the response to pollution is a system for assessing, coordinating and simulating the risk situation with the help of a mathematical model implemented on a simulator. The mathematical model for the simulation of the event of pollution is the latest generation and take into account all the meteorological factors of the sea and air, as well as all the physico-chemical parameters of the substances involved (dispersion, surface tension). 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. In this paper we present the simulation of incident and the creation of response resources. The scenario incident is for KAPTAN M cruise ship that left the tourist port of TOMIS Constanta, Romania, having on board 20 passengers and a number of 15 crew members, and which collided with the oil ship EVIA Oil FIVE, having on board the quantity of 4200 MT crude oil. As a result of the collision, the passenger ship suffered a breach (water hole), on the starboard board, breach by which the ship began to ambarce sea water and in the car compartment a fire was produced. Containment and recovery of an oil spill during the exercise will be simulated through activation and control of response resources. The resources involved in the operations are divided into: platforms, equipment and personnel. The results of simulation is the list of response resources specified in the scenario together with their parameters, which can be exported into a text file. With this simulation tools you can efficiently appreciate the cost of resources in due time, avoiding material and human damage.

1 INTRODUCTION

1.1 *The purpose of simulation an pollution accident*

A smart solution for assessing the consequences of pollution on the coast, on flora and fauna but also by accounting for the total costs of the equipment used in the response to pollution is a system for assessing, coordinating and simulating the risk situation with the help of a mathematical model implemented on a simulator.

The purpose of simulating an accident/pollution exercise is to verify the viability of the "Cooperation plan on unitary intervention, in emergencies, for the search and rescue of human life at sea", the "National preparedness plan, response and Cooperation in the case of marine pollution with hydrocarbons "and the way of action and cooperation of competent authorities in the field.

1.2 *The objectives*

Main objectives:

1 the realistic modeling of a crisis situation to evaluation of the capacity to respond to the structures involved in organizing, conducting, managing and coordinating actions to search and save human life at sea, to provide support functions and assignments associated with them.
2 using the simulator as an interactive and efficient study tool for assessment of the capacity to respond to the structures involved in organising the conduct, management and coordination of response actions to marine pollution by hydrocarbons
3 the use of tools related to the intelligent system for determining the resources related to a pollution situation
4 verification of the viability of the crisis management documents, standards and operational procedures for action.

SAR Secondary Objectives:

1 Test response times for response to an event that requires search and rescue missions at sea.
2 Practice the mode of action of the staff during a search and rescue action at sea.
3 Training of staff in interinstitutional actions during participation in search and rescue actions at sea.
4 Practice of informational-decision flow from the cooperation plan on unitary intervention, in emergencies, for the search and rescue of human life at sea.
5 Verification of planned capabilities and real intervention times for the purpose of identifying vulnerabilities and how to eliminate them.
6 Checking the national fire-fighting capabilities of ships in danger at sea outside port areas.
7 Verification and testing of institutional/inter-institutional communication capabilities and between the participating forces and means.

Marine pollution secondary objectives consist of testing:

1 Application of the provisions of art. 10, para. (3) of H.G. No. 893/2006, which relates to the decision to grant the place of refuge to a ship involved in a marine pollution incident (according to the recommendation of the European Maritime Safety Agency).
2 Ability to reduce the effect of marine pollution by transferring cargo from a damaged tank to another vessel (minimum decision flow, ship identification and equipment available for such operations).
3 The capacity to take the water-oil mixture recovered from the sea by the specialised pickup/storage facilities.
4 The decontamination capacity of ships and equipment which have been involved in response to pollution.
5 Communication and informational-decision flow from the National plan for preparedness, response and cooperation in the case of marine pollution with hydrocarbons.
6 The degree of training of staff in working with the equipment for decontamination, for DOM and DOT.
7 Capacity/possibility of decontamination of equipment for limitation and recovery of the spilled product.
8 How to register and resolve complaints and requests made by persons/institutions affected by pollution.
9 Ability to reduce the effect of oil pollution at sea and ashore.
10 And verifying the capabilities of institutional/inter-institutional communication and between the forces and the participating means.

1.3 *Location of simulation*

Location:

– For search and rescue:
  A sea area: rectangle with sides of 7 x 5 mm, 10 mm away from the shore, between the coordinates:
  44 º 13 ' 50 ' ' N 028 º 47 ' 00 ' ' E
  44 º 18 ' 50 ' ' N 028 º 47 ' 00 ' ' E
  44 º 13 ' 50 ' ' N 028 º 58 ' 00 ' ' E
  44 º 18 ' 50 ' ' N 028 º 58 ' 00 ' ' E.
  A land area: Tomis Port and Port passenger Terminal Constanta.
– For marine Pollution:
  A sea area: rectangle with sides of 7 x 5 mm, 10 mm away from the shore, between the coordinates:
  44 º 13 ' 50 ' ' N 028 º 47 ' 00 ' ' E
  44 º 18 ' 50 ' ' N 028 º 47 ' 00 ' ' E
  44 º 13 ' 50 ' ' N 028 º 58 ' 00 ' ' E
  44 º 18 ' 50 ' ' N 028 º 58 ' 00 ' ' E.
  A land area: Operational: Năvodari Beach south of the South pier of the Midia port; Fictitious: Mamaia Beach.

2 MATERIAL AND METHODS

2.1 *Scenario description*

On 20 June 2015, the hours..Commander Kaptan M transmitted by Channel 16 Call and distress message. Service officer of the SAR-pollution Service (centre for coordination of ANR/MRCC), received by VHF Ch. 16 Distress alert (cruise ship KAPTAN_M, C/S YP3082, MMSI 264163082, pavilion Romania, length 30 m, width 8 m, draught 2.70 m, with Loading capacity 30 passengers).

As a result of the collision, the passenger ship suffered a breach (water hole), on the starboard board, breach by which the ship began to ambarce sea water and in the car compartment a fire was produced.

After the collision, the oil vessel with IMO number 9358503 and MMSI 241344000, was released from the passenger ship, stopping at a distance of approx. Three millimeters from the crash site to the south direction.

Polluting vessel position: 044 º 16 ' 52 N and longitude 028 º 56 ' 00 E.

At hour .... The commander of the cruise ship announces the MRCC Service (Maritime Coordination Centre) of the Romanian Naval Authority (ANR) as the fire extends and cannot be controlled by the means of the board. Also, because of the sea water that penetrates through the water hole, the ship began to incline to starboard. Under these circumstances, the commander of the ship ordered the abandonment, requesting at the MRCC, assistance to save passengers and crew.

They prepared to abandon two lifeboats and also launched two lifeboats, one of 12 persons and one of 8 persons.

Both passengers and crew were instructionati to wear life jackets.

At hour ...... Officer MRCC, immediately after receiving all data from the incident, activates the co-operation Plan SAR 2013 and asks the ARSVOM to send urgently for SAR intervention, the units available.

On the basis of the information received from the MRCC, as well as the conclusions resulting from the discussions in the Technical secretariat of the CODM and analysis of the motion prediction of the crude oil stain, it is proposed to CODM the activation of DOT.

At houir ...., the Inspectorate for Emergencies "Dobrogea" of Constanta County, in its capacity as coordinator and ruler of land operations, alerts the DOT members for the preparation of forces and means for the purpose of intervention;

The Inspectorate for Emergencies "Dobrogea" of Constanta County, together with the water Bazinal Administration "Dobrogea-Litoral", assesses the situation and transmits a proposal for an intervention plan for response to pollution on land.

At hour ......, CODM transmits orders of intervention to the institutions/companies that will participate in the DOT actions. PNOC-T of the Water Bazinale Administration "Dobrogea-Litoral" and Emergency Inspectorate "Dobrogea" of Constanta County, as coordinator and ruler of land operations, the order to activate the division of Land operations;

The DOT coordinator transmits to the DOT members, the plan and the order of starting intrevenţiei of decontamination to dry.

At _hour ......, the crews of Constanta County Police Inspectorate and Constanta County gendarmes Inspectorate that secure the perimeter of the area by dividing the its and restricting access;

At _hour ......, the crews and equipment of the emergency inspectorate "Dobrogea" to the county of Constanta, the Bazinală administration of water "Dobrogea-

"SC Branic srl and SC Envirotech srl.

At _hour ......, the decontamination action of the coastal area affected by the oil product begins.

It is used as storage space at SC Rompetrol refining SA for liquid fraction and a storage space in Batalurile SC Envirotech SRL for solid fraction.

- The participating vessels shall be required to proceed to the decontamination zone of the ARSVOM,
- The participating institutions shall be required to provide written information on the completion of the decontamination operations (the date and time at which they are in the base position).

In the situation where there is a refuge for the tanker, there are steps to identify a tug to tow it in that place. Also, request that the recovered product be handed over to the CN plant APMC constant SA/Rompetrol refining, and the ships and equipment used to respond to pollution are decontaminated at ARSVOM.

At _hour ......, the coordinator of the Land Operations Division transmits to the Technical Secretariat of the CODM the proposal to terminate the decontamination actions.

CODM draws up the detailed report on the basis of reports received from the two divisions to start the procedure for the recovery of expenses and compensation of damages.

2.2 *Assumptions*

Input data for Simulator (weather conditions):

- Wind to the east at the speed of 5m/sec; After 30 hours from the start of the scenario the wind rises to 10m/sec,
- 17^0C air temperature,
- the water temperature of the 9^0C sea,
- the state of the sea 0.5 m,
- the density of the water 1026 kg/m^3.

3 SIMULATION DATA AND RESULTS

3.1 *Description of simulation scenarios*

The steps of accident were simulated on PISCES II simulator (Figure 1, Figure 2, Figure 3, ... Figure 16) (Panaitescu &oth.,2013).

The pollution's solutions are resolved with the PISCES II crisis management module of simulator, which includes an oil spill model and enables resource management for command centre personnel. Trainees learn how to handle oil spills according to the OPRC Convention (International Convention on Oil Pollution Preparedness, Response and Co-operation) requirements. The simulator also supports the *Preparedness for Response Exercise Program* (PREP) administered by the US Coast Guard (PISCES II_2-90, User manual). The oil spill model is affected by currents and wind. It simulates spreading, evaporation, dispersion, emulsification, viscosity variation and burning. The oil flow distribution is carefully calculated and is affected by vessels, recovery objects and other structures.
Realistic exercises can be created easily for both offshore and coastal scenarios.

Also, for our scenario, fast speedboat 150Cp A ONACVA S.R.L. arrives at the oil tanker and as a result of the diving intervention to shrink the water hole, after 3 hours the spill rate decreases from 80tone/hour to 40 tonnes/hour (Figure 1, Figure 2).

30 minutes after the start of the scenario (H0 30 min), the tug Perseus of PETROMAR S.A. travels to the ARSVOM headquarters where the inflatable anti-pollution dam (total length 3300 m for the sea) and 2 hydrocarbon recovery pumps (SKIMERE) with capacity of 130 MC/h each) (Figure 3, Figure 4).

Time H8 48 min stain is stopped at the barrier. It begins the recovery of oil, assisted by the ship of the tugboat HERCULES belonging to ARSVOM Constanta (Figure 5).

Continuing oil recovery from the Skimerele barrier to full capacity. At H19 22 min The oil stain exceeds the barrier at the northern end, due to the small recovery capacity of the skimmers. At H27 43min the escaped stain is 15 km from the shore, in quantity of 60 tonnes mixture (Figure 6).

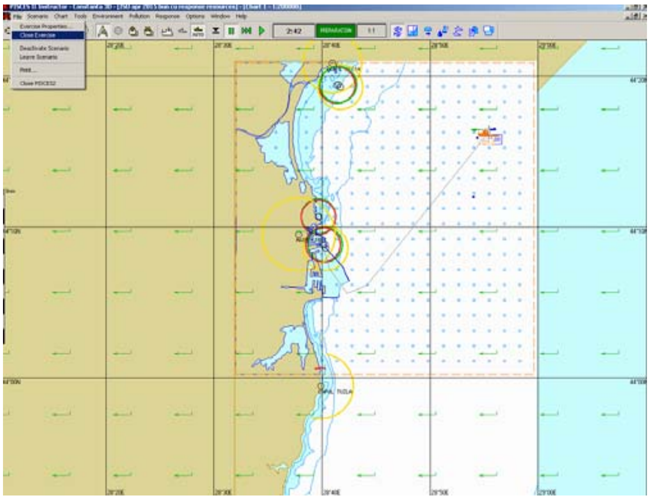

Figure 1. Fast speedboat 150Cp A ONACVA S.R.L arrives at the oil tanker

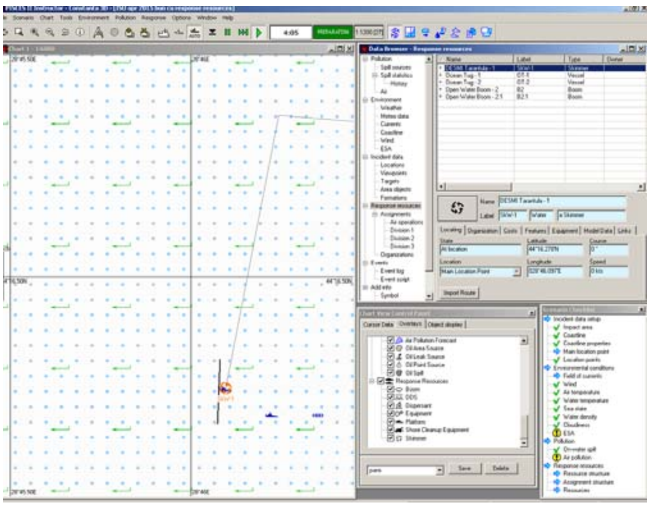

Figure 2. The the spill rate decreases.

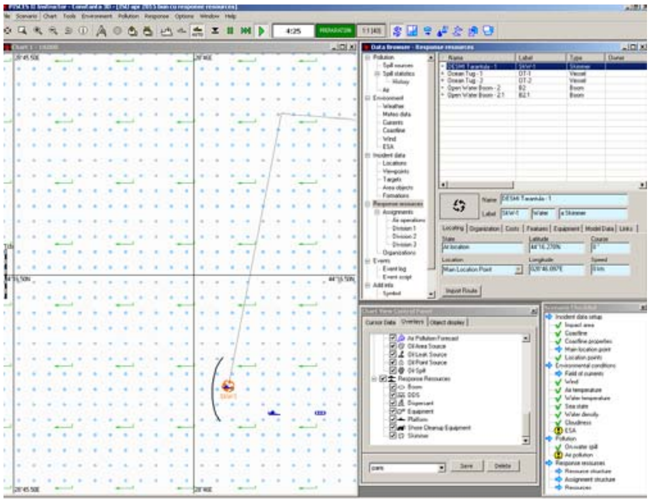

Figure 3. The instalation of the inflatable anti-pollution dam

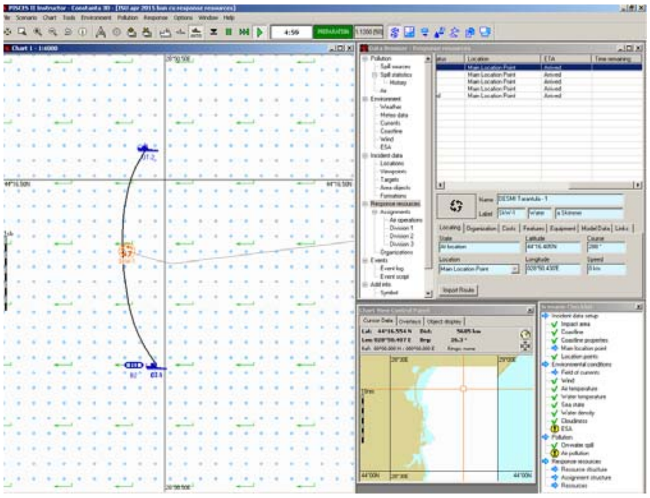

Figure 4. The responses of anti-pollution dam ‘s instalation

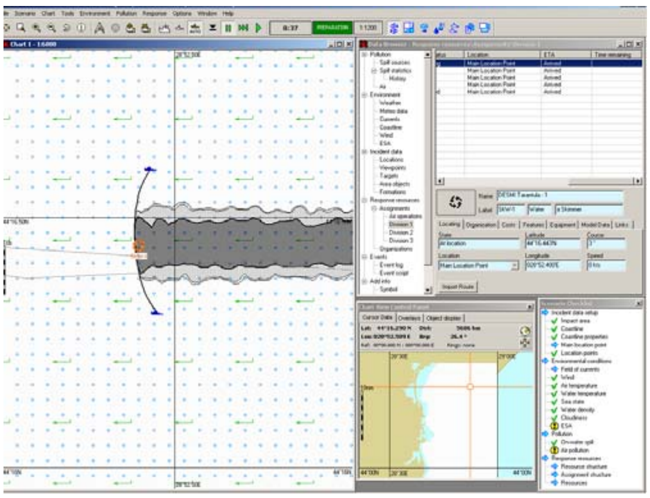

Figure 5. Stopping the stain on the barrier.

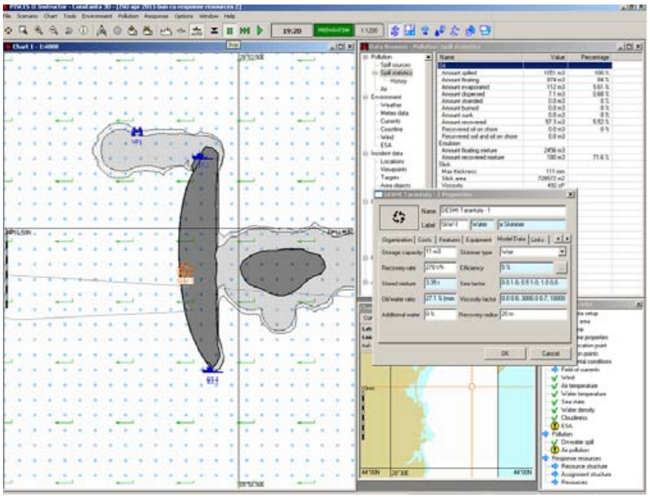

Figure 6. The oil stain exceeds the barrier .

Situation at H30 00min: The oil stain escaped from the barrier has 83.8 tonnes, max thickness 1.1 mm advancing to 13.6 km of shore (Figure 7);

Recovered with Skimmers 121 m^3, evaporated 163 m^3 , afloat 872 m^3, max 262 mm thickness at barrier surface 936000 m^2(Figure 7, Figure 8).

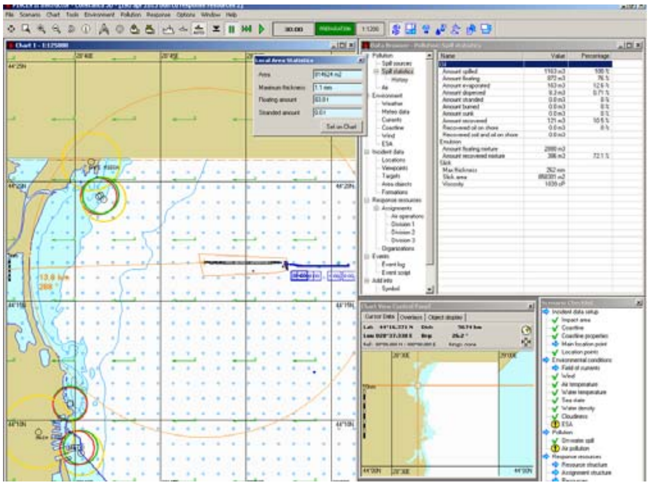

Figure 7. The situation at H30 00min.

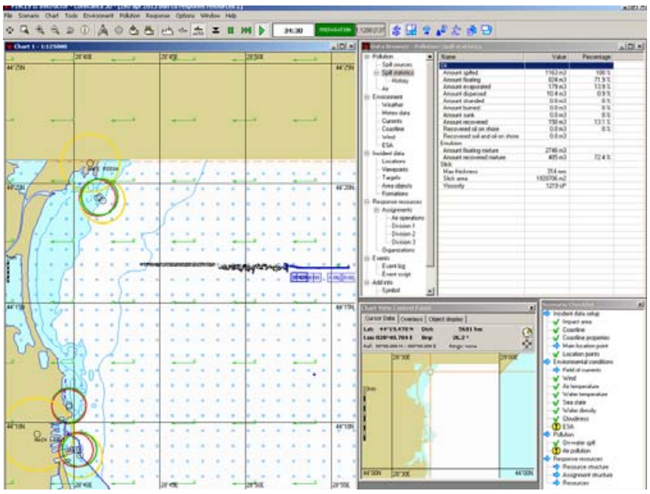

Figure 8. The intervention of skimmers at H30 00min

3.2 *The spill statistics of pollution*

The results of pollution are presented in the folowing figures (Figure 9, Figure 10):

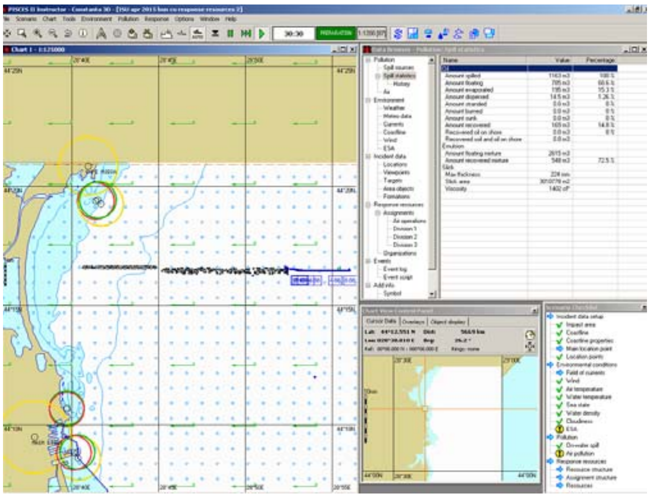

Figure 9. The spill statistics.

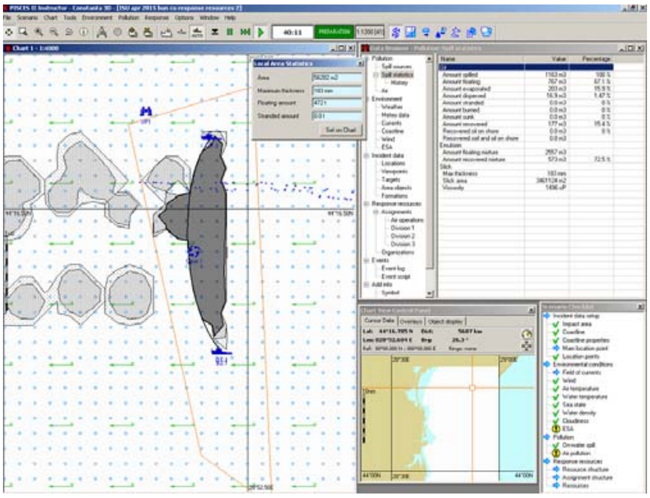

Figure 10. Local area statistics.

Situation at H40 5min: 220 to oil stain, max thickness 1.2 mm at 2.3 km from shore; recovered with Skimmers 177 m^3, evaporated 203 m^3 , afloat 766 m^3, max 262 mm thickness at barrier, 3 498 000 m^2 surface (Figure 11).

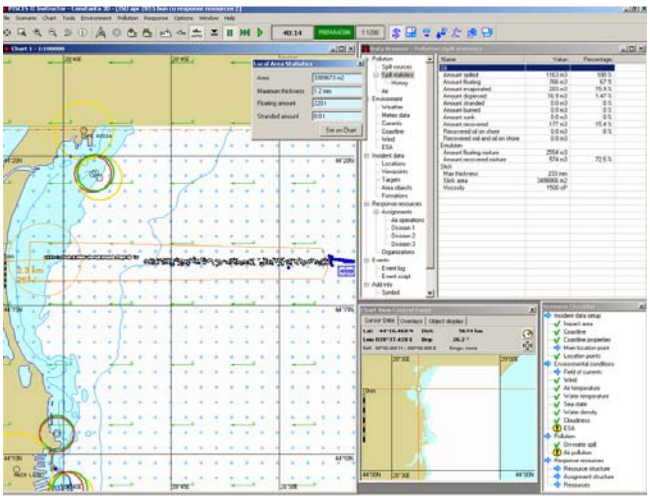

Figure 11. The intervention of skimmers at H40 5 min.

The situation at H42 24min the oil stain ashore. Impact Zone 440 16, 63N 280 37, 33E (Figure 12).

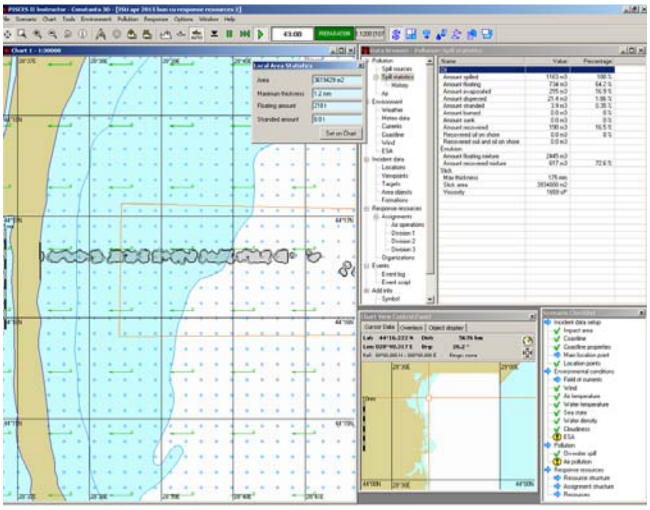

Figure 12. The intervention at H42 24min.

The situation at H44 00min: the length of the polluted shore 713 m, oil quantity 7. 8 m^3 (Figure 13).

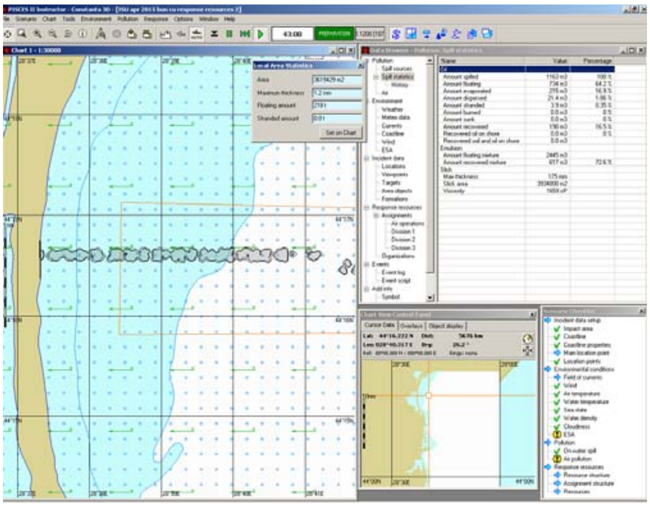

Figure 13. The intervention at H44 00min.

The situation at H47 00min: the length of the polluted shore 905 m, oil quantity 9. 8 m^3(Figure 14).

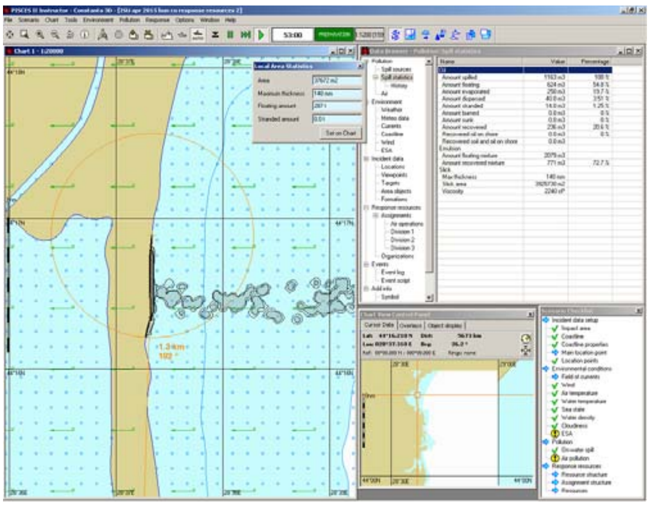

Figure 14. The intervention at H47 00min.

The situation at H56 30min: polluted shore length 1400, oil quantity on shore 16.2 m^3, recovered 252 m^3, evaporated 260 m^3, afloat 590 m^3(Figure 15).

The situation at H76 01min: polluted shore length 1500, oil quantity on shore 17.4 tonnes, recovered 338 m^3, at barrier 79 m^3, evaporated 295 m^3, floating near the shore 250 tonnes.

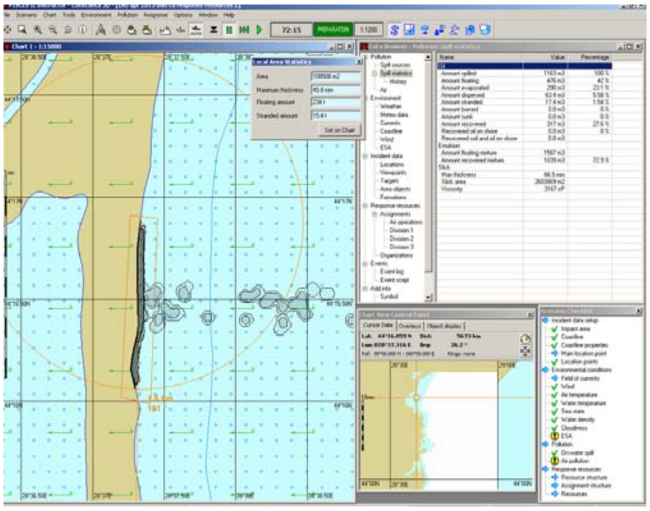

Figure 15. The intervention at H56 30min.

The situation at H78 00min: polluted shore length 1510, oil quantity on shore 17.4 m^3 , recovered 353 m^3, at the barrier still 59.2 tonnes, evaporated 297 m^3, floating near the shore 262 tonnes (Figure 16).

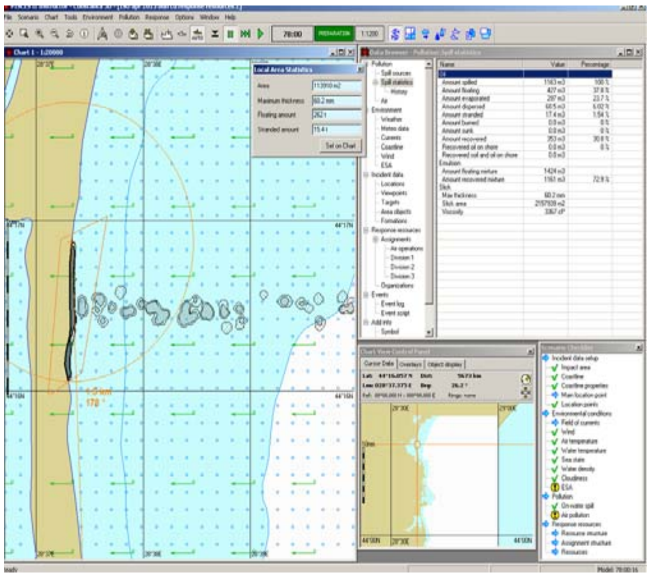

Figure 16. The intervention at H56 30min.

3.3 *Description of results simulation*

The summary of results are presented in Table 1 (Dumitrescu G.L&others, 2015) (Figure 17):

Table 1. The summary of results.

Equipments	Conditions	Deployment	Recovery	Average
1. Booms	3.182	3.182	3.112	3.159
2. Sweeping arms	3.411	3.612	4.000	3.674
3. Skimmers	3.112	3.783	3.672	3.522
4. Average	3.232	3.524	3.591	~ **3.45**

The results are presented in the scale from 0 to 4, where the semnification is: 0- the worst performance and 4-the best performance.

Figure 17. Response resources on simulator.

4 RESPONSE RESOURCES

4.1 *Description of response resources*

Smart system to coordination of the available response resources contains different categories of response resources, because the resources are divided into three types (Figure18): platforms, equipment, perssonel.

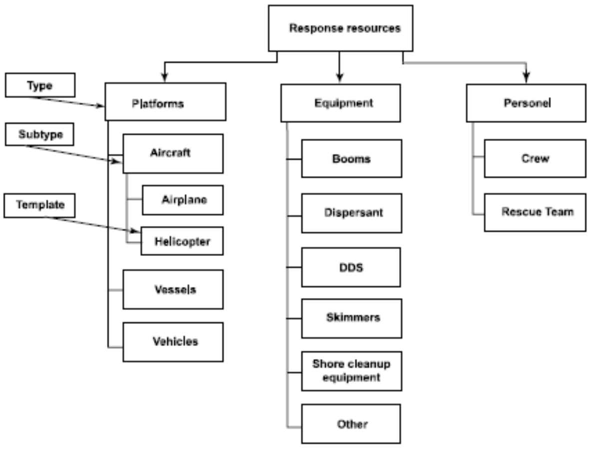

Figure 18. Smart system structure.

Each type contains one or more subtypes. Platforms do not affect operation of the slick mathematical model. Equipment directly influences the behaviour of the spill model. There are six subtype of equipment available in PISCES II:

– Booms;
– Oil skimmers;
– Dispersants;
– Dispersant application facilities;
– Shore cleanup equipment;
– Other facilities.

The booms, skimmers and dispersants take part not only in simulation of deployment and shutdown operations, but also in simulation of their interaction with the oil slick (Figure 19).

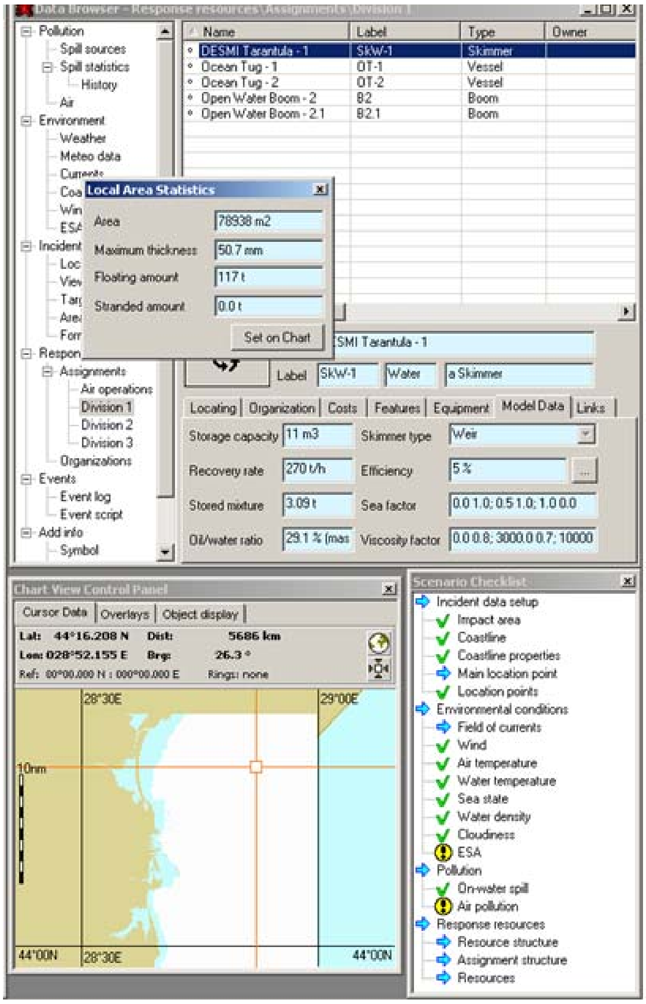

Figure 19. Response of booms and skimmers

4.2 *The calculus of response resources*

Efficiency of booms and skimmers is calculated automatically depending on environment conditions and oil slick properties (F.V. Panaitescu, M. Panaitescu, I.Voicu & I.I. Panaitescu, 2014).

All resources created in the scenario have the *"Free"* status. It can order a resource with this status to come on scene using the *ORDER* command or immediately involve it in the operation by the *EMPLOY* command.

The simulator makes it possible to calculate the cost of applying both the individual resources and the whole operation for the current time. It can view the cost of using each resource in the properties window of the object in question by going to the *"Total cost"* field of the *"Costs"*(Figure 20):

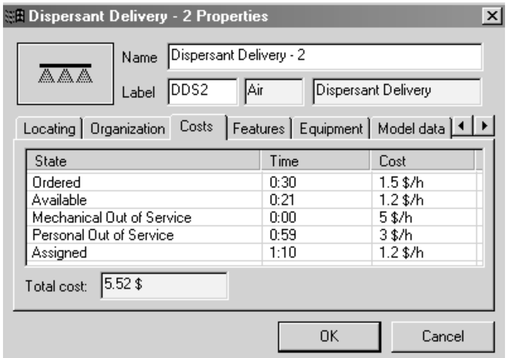

Figure 20. Costs of the resources.

Calculation of the resource application costs is based on duration of its application, being performed by the program automatically. The data on the whole operation cost can be exported to an Excel file.

To obtain data on expenses it can choose a type of the financial report in the "Report" list (Table 2).

Table 2. The report's types

Type of report	Description
By assignments	The cost of resources is calculated for each Organization
By organizations	The cost calculation of resource is performed for these conditions: "Ordered", "Available", "Assigned" and "Out of service"
By resources	The cost of resources is calculated for each resource
All reports	Global report includes: - the operational report; -the report of each organization.

4.3 *The reasons for which it is considered a smart system*

The reasons are:

- Simulation software gives us the prediction of the time development of the oil stain (surface and), its road and position according to weather conditions.
- Also gives us variants of the optimum location of resources (booms and Skimmers) for oil collection, taking into account the speed of movement of ships (the time required to reach the location position), the time required for the deployment time for booms and skimmers (booms deployment dependencies on boom lenght).
- These variants are provided with the help of "smart" tools in the "crisis management" mode of decision makers to establish an efficient, fast and correct solution.
- All fast and efficient operating information is the results of using tools to calculate resources belonging to an intelligent system of resource coordination for the polluters accident (smart system to coordination of the Available response resources)

5 CONCLUSIONS

Preparation of a scenario is complex process which requires frequent returns to the previously made saving points and new replays of the scenario. In the scenario modelling, information on the spill state is saved every five minutes of model time. The spill statistics history display interval can be increased.

By using the tools for this intelligent operating system in the event of hydrocarbon pollution, it was followed the achievement of strict and objective steps to make effective decisions, namely:

- Simulation with specialized software (Pisces II0
- Determination of the results of the simulation
- Assessment of resources related to the simulated situation
- Setting the costs of these resources with specialized software
- making effective, fast and real-time operational decisions.

The results of simulation is the list of response resources specified in the scenario together with their parameters, which can be exported into a text file. With this simulation tools you can efficiently appreciate the cost of resources in due time, avoiding material and human damage.

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