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INTEGRATED MANAGEMENT SYSTEM FOR INTERVENTION IN MARITIME ACCIDENTS AND DISTRESS SITUATIONS ON THE BLACK SEA

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Abstract: *Saving of life at sea, represents, according to IMO conventions in the field (SOLAS), the number one priority for the whole maritime industry. To consolidate the safe port status for Romanian harbors at the Black Sea, it is extremely important to take measures to strengthen SAR intervention capabilities and marine depollution, in order to save human lives in danger at sea and the environment protection. An integrated system for management and intervention with specialized forces for maritime accidents and distress situations consists of intervention management center destined for coordination of monitoring activities and intervention, disposition points of forces and means of intervention, an analysis system and real time transmission of the level of pollutants concomitant with intervention to limit their effects and the integrated simulator for driving of watercraft to support the modeling and simulation of emergency situations. The implementation of the system is based on the development of new mathematical models necessary for the analysis and simulation of vessel's reaction, intervention means and equipment under the action of hydro-meteorological factors (wind and waves) for the highly vulnerable areas based on measurements and processing parameters involved in SAR and the dispersion of pollutants (oil and chemical).*
Keywords**:** *accidents, distress, management, SAR, depollution*

INTRODUCTION

Distress situations that took place in the last 25 years in Romania's Black Sea area resulted in over 60 human victims. From analysis of cases with human lives lost led to the conclusion that the ships sank in the vicinity of Constanta, Mangalia and Midia ports, due to bad hydro-meteorological conditions and the impossibility of destined intervention forces of saving lives due to their limitations.

Hydrocarbons, the major pollutants of the seas, are resistant to bacteria, persist for a long time in the affected regions, forming a surface film that prevents the diffusion of the oxygen in water, chlorophyll assimilation and organism's respiration being blocked. As a result phytoplankton photosynthesis which produces 70% of atmospheric oxygen is hindered. Staple food of marine life, algae and plankton cease to proliferate. Phenol and aromatic compounds have a toxic action upon aquatic living beings. Carcinogenic hydrocarbons concentrated in edible aquatic animal bodies, reach the human diet. So oil pollution affects not only the marine balance, but also human health.

Here are some major examples:

- On the 24 march 1989, Exxon Valdez tanker hit the Bligh reef from Prince William Strait, Alaska, resulting in the spill of over 40.000 m^3 oil. Exxon spent over 3.8 billion dollars to clean the affected area, damage compensation to 11,000 people and to pay fines.
- On 13 November 2002, Prestige tanker which was transporting 77.000 tons of oil near Galicia, Spain, broke in two leading to the spill of over 70 million litres of oil in the sea. The cleaning operation cost 12 billion dollars.
- On 20 April 2012 after the explosion of Deepwater Horizon drilling maritime platform in Gulf of Mexico (MACONDO incident) owned by British Petroleum company 11 people lost their lives, 17 people were seriously injured and other 98 easily injured. The damages were valued at about 36.9 billion dollars (CL Smith et all, 2010) to which is added a series of lawsuits due to compensation sought.

The necessity of developing and implementing this kind of a system appears as a need for reducing pollution risks of the economic agents based on the development of oil and gas drilling activities in the NW Black Sea area, taking into consideration the limited response capacity of Romania (according to EMSA analysis). As a result, the potential private companies willing to invest in the offshore industry will be forced to create their own structures capable of intervening to limit the effects of an eventual distress situation/maritime accident. Romanian government is in charge to coordinate, check and license economic agents involved in such activities [8, 15].

Given the importance of Romania's view in IMO regarding intervention capabilities as stated in the requirements [3, 4] and the consolidation of safe port status for Romanian harbors at the Black Sea, it is extremely important to take measures to strengthen SAR intervention capabilities and marine depollution [5], in order to save human lives in danger at sea and the environment protection.

Based on IMO-A-849 Resolution, each member state is obliged to investigate the very serious events in the area of responsibility and to inform IMO General Secretary upon distress situations/maritime accidents and also taken measures to save human lives and goods.

At a national level, the Romanian Naval Authority (RNA) is the organism responsible with organizing and coordinating saving of life at sea activities through the SAR – Pollution service of the Maritime Coordination Centre (MRCC).

Table 1

The situation for means and forces of intervention in case of distress situation/maritime accident of ARSVOM

Intervention Units	Type	Technical Features			Action Time (min)
		Amplitude (Nm)	Maximum Speed (Nd)	Sea	
ALBATROS	SAR craft	50	9,5	2	15
HERCULES	Multi-functional tug	100	12,5	7	30
OPAL	SAR craft	50	30	3	10
TOPAZ	SAR craft	50	30	3	10
CRISTAL *	Intervation craft	50	14,5	2	15
SAFIR *	Intervation craft	50	14,5	2	15
RUBIN *	Intervation craft	50	14,5	2	15

The specialized technical body that ensures the search and rescue of life at sea and intervention in case of pollution activity is Romanian Agency of Safety of Life at Sea (RASLS). In the analysis of RASLS's endowment with intervention means in the case of distress situations/maritime accidents (Table 1) can be observed the impossibility of intervention timely for sea states higher than 4, the only vessel capable to intervene at a sea state up to 7 is the tug Hercules which can develop a maximum speed of 12,5 Kn.

According to the analysis by EMSA for 2013 (Table 2) Romania's preparedness and response capacity in intervention field of pollution is (criteria: response capabilities, specialized intervention equipments, specialized intervention vessels, specialized teams for response) *inexistent* or *very limited*.

Because the specialized technical organism (RASLS) has no rapid means of intervention that can act under special hydro meteorological conditions (helicopters, fast vessels, vessels that can intervene for pollution, drones) in case of distress situations/maritime accidents, these are contracted from the Minister of Defence, Minister of Internal Affairs, "Romanian Waters Agency" and economic agents which leads to the increase of the time of response and reduces the chances of a successful intervention [9].

Table 2

Inventory of EU Member States' Policies and Operational Response Capacities for Hazardous and Noxious Substances Marine Pollution 2013

Preparedness				Training and exercises
Ratification of the OPRC-HNS Protocol 2000	National Contingency Plan covers HNS	HNS Risk assessment conducted	Previous experience marine HNS incidents	
No	Yes	Yes	No	Yes

Response capacities					
Monitoring capability	Response capability	Specialised safety equipment	Specialised response vessels	Specialised response teams	Scientific support
Yes	Very limited	No	Very limited	No	Yes

At this time, concomitant with the increasing risk for distress situations/maritime accidents (concession for exploitation of oil resources from the NW Black Sea area, the increasing of tankers traffic to ensure raw matter and finished goods taking to/from Petro-Midia plant), the governmental structures responsible for SAR - pollution are underfinanced. The analysis of distress situations/maritime accidents in the last 20 years shows the necessity of implementing an integrated management and intervention system with specialized means in case of distress situation/maritime accident for own activities performed by economic agents that have high risk operations in the NW of the Black Sea area.

Configuration of the integrated management system

An integrated system for management and intervention with specialized forces for maritime accidents and distress situations consists of (*Figure 1*):

a. Inovative services and technologies – Integrated management system that contains:

- *Intervention management center* that will achieve the coordination of monitoring activities in case of distress situations/maritime accidents;
- *Disposition points for intervention* – will assure the achievement of response capabilities in case of distress situations/maritime accidents;

b. Experimental model – Analysis system and real time transmission of the level of pollutant from the means acting in the distress area to the decision center;

c. The developement mathematical models – of waves specific to the Black Sea, the transport of the pollutant particle diffusion and the dynamic response of naval structures, models that will be used for the optimization of intervention in case of distress situations/maritime accidents with the posibility of using them in other related fields (marine hydrography, mapping, oceanography, atlases for currents, marine geology, studies on coastal errosion, militaty fields – mine countermeasures);

d. The technical study will ensure the harmonization of national legislation in order to achieve successful tasks assumed by Romania through treaties and conventions governing SAR field and intervention in case of pollution.

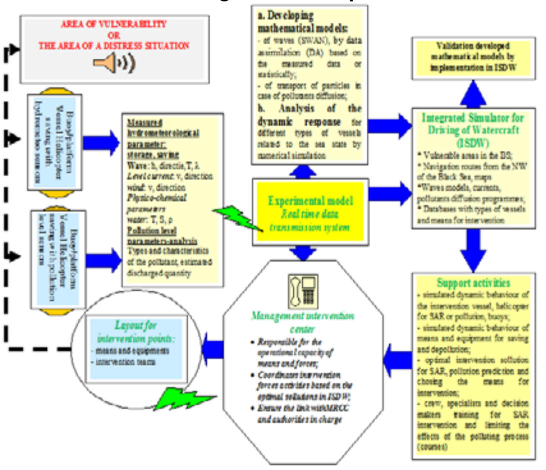

Figure 1 – The concept plan of the integrated management system

The areas of interest of maximum vulnerability will be determined after analyzing the vulnerabilities (risk factors) on the Romanian Black Sea coast with direct implications in distress situations/maritime accidents requiring SAR and depollution interventions. An important component in this stage is to analyze the wave regime, currents and sea level in the NW Black Sea area by processing quantitative and qualitative existing information in the field, in order to allow the best decision taking for the layout of the data acquisition buoy.

Modeling and simulation

Mathematical modeling of vessel's reaction/intervention means under the action of hydro meteorological parameters (wind, wave systems based on measurements in potential risk areas – *in situ*) in conditions of the NW Black Sea area by coupling to the wave model a new data assimilation module based on sequential techniques, represent not only a state of art (the actual models from the simulators in our country are based on unspecified Black Sea wave models – Pierson-Moskowitz, Phillips, ITTC spectrum, etc) but also a necessity in:

- testing specific intervention equipment (SAR and pollution) by modelling their behaviour depending on the sea state;
- crew training – by simulating the same configuration of intervention areas and vessel's reaction subjected to their action;
- testing by simulation the dispersion of pollutants (oil or chemicals) before deciding optimal intervention.

Transmission of real time information on pollutants involves two practical aspects:

- the introduction of analysis systems *in situ* onboard intervention vessels/buoys/platforms with sensors regarding essential information on the level of pollution (without the need to collect evidence and analyze it on shore) and hydro meteorological data in the area (with the help of automatic weather stations placed onboard vessels)
- transmission of analysis/hydro meteorological data to the ISDW, introduction of the pollutant dispersion in simulation software (GNOME, ADIOS-2, etc) which uses its physico-chemical characteristics, the environmental conditions and development in real time of technical and scientific solutions of which the best ones will destined to the situation's evaluation and intervention with means and equipments.

The buoy with meteorological - oceanographic sensors used for measuring hydro meteorological parameters and the level of pollutants and its installation in the area of interest will be made based on the analysis of factors with a determining role in the behavior of means and equipments to be used in the highly vulnerable areas previously established and pollutant dispersion. The buoy will establish the basis of the real time transmission system. This system will take measured information that will be used in the development of mathematical wave models and the transport of the pollutant particle diffusion.

Regarding the data assimilation procedure, the main goal is to take advantage of the observations available by introducing them into the modeling process, in such way that the model predictions are improved. As an example, Figure 2 presents the results of the SWAN simulations for a hypothetical oil release at the Gloria drilling platform. In the figure are illustrated the significant wave height fields, the wave and the wind vectors and also the position of the oil spill for three different time frames. For the situation considered (that corresponds to the environmental conditions from 11-13 March 2003) it is estimated that the oil spill will approach the near shore at Mangalia after 30 hours from the moment of the accident.

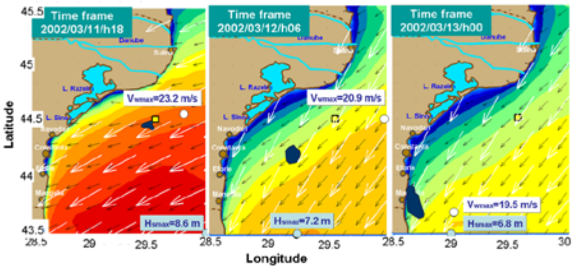

Figure 2 Simulation of an accident with oil release at Gloria drilling platform
(Rusu and Butunoiu, 2009) [17]

To evaluate the oil spills trajectory is considered and used a system similar with the General NOAA Operational Modeling Environment [1, 14], which predicts how wind, currents, and other processes might move and spread oil spilled on the water. GNOME is a system designed for the rapid assessment of pollutant trajectories on the water surface and can be easily coupled with the SWAN model [6]. As alternative methods, those implemented by Seabastiao and Guedes Soares (2006) can be also used [12].

In the coastal areas the near shore currents induced by wave are the fundamental factors in driving the pollution. Various models have been developed to achieve the assessment of these currents. A widely used prediction system for the assessment of near shore circulation is SHORECIRC [13]. A more simple and easy to implement system is NSSM [7]. In the present project, together with SHORECIRC, another alternative software package is proposed to be used, called ISSM – Interface for SWAN and SURF Models [11]. This system has a user-friendly interface for the rapid assessment of wave propagation and near shore circulation. It was tested and validated for NATO in 2005 by one of the team members involved in the present research proposal in various areas in the Italian near shore [2].

Regarding the means of intervention (vessels, platforms, dams, etc) response to different sea state conditions, these will be investigated through numerical simulation with HM. The maximum specific response accepted of the means of intervention (deduced using limiting sea keeping criteria) will be identified and added to the database. The wave prediction system will be coupled with HM through a MATLAB interface.

The main idea is to calculate the ship responses using the spectral wave model that provides HM wave input. The wave spectrum can be used especially for near shore operations by providing a measure of the ship response in specific conditions and over requested routes. Such a common model as the one presented by Lin & Thomas (2001) was proved to be of a particular importance in the coastal environment.

In the data manipulations, MATLAB interface will be used with capacities for data pre processing, control of the model simulations, input and output visualizations and post processing will be developed and associated with the Integrated Simulator for Driving of Watercraft – ISDW. This would allow a quick implementation of the models in any specific site, a better communication between the elements of the system and a comprehensive assessment of the models outputs. The final goal is that the PC based system interface to become an effective operational tool that could be used by personnel with limited resources for near shore wave assessments in the vulnerable areas of the NW Black Sea.

Validation of models

Validating new models developed and implementing them will be achieved in ISDW by comparing them with the existing models concomitant with the implementation of a software (MODEL WIZARD Spatial Database Modeling System) necessary to generate models of vessels/specific intervention equipments that will be used in later simulations. In ISDW support activities, that will be the basis for determining the disposition points for means and forces of intervention and the intervention management center, will take place, after the matrix analysis of the cumulative effects in case of a distress situation according to the area where it happened, modeling of the environmental parameters behavior and pollutants and also the prioritization of activities.

Achieving the optimum configuration for the information management center (IMC) and the disposition points of the means and intervention forces will consist of manning, provision with means and equipments, setting the structures of subordination / cooperation. Implementation of the experimental analysis and real time transmission of hydro meteorological information model and the level of pollutants will be completed by connecting the buoy to the disposition points and ISDW through the intervention management center.

The IMC will be responsible for the operational capacity of the forces and means, will coordinate intervention forces based on optimized solutions from the ISDW and will ensure the link with RNA's MRCC and the responsible authorities.

The intervention disposition points will be composed of teams, means and equipments of intervention that will act in real distress situations/maritime accidents based on the optimal solutions simulated in ISDW and transmitted through the intervention management center. The intervention forces, based on their own technical endowment, will transmit to the IMC the hydro meteorological parameters and the level of pollutants from the operating area.

Training of crews, specialists and decision makers to intervene in real-time SAR-pollution actions will be achieved based on the procedures developed and by organizing of courses.

Implementation of the integrated system will be made by organizing an exercise („generating" a distress situation – transmitting information - modeling environmental factors and ways of intervention – choosing the optimal SAR - pollution way to intervene – real intervention in the risk area – real time transmission of the level of pollutants concomitant to the intervention – balance and dissemination).

The analysis of vulnerabilities and parameters involved in the layout of forces and means of intervention, interpretation and modelling the hydrometeorological factors involved in SAR and pollutants diffusion.

Within this objective the realisation of base studies regarding risk factors involved in distress situations/maritime accidents on the Romanian shore will be pursued (identification, classification and mapping of their layout) and the analysis of current informations regarding the wave regime, currents and sea level in the NW of the Black Sea basin. An important point will be represented by the designation of area of interest with high vulnerability the case of a distress situation/maritime accident based on the matrix analysis of factors - estimated effects, mapping of their layout and choosing the area/areas of interest with a maximum potential.

Also, technical comparative studies regarding the equipments and means of intervention requirements in the areas with high vulnerability will be realised relative to the existing ones and presenting the ways to equip and also chosing the optimal way for the buoy and the mete-oceanographic equipments for measuring the hydrometeorological parameters (wind, wave currents, etc) and the level of pollutants in order to realise the experimental model for the real time transmission of data system in the mathematical models development.

CONCLUSION

Development of mathematical models for the analysis and simulation of hydro-meteorological factors behaviour afferent to highly vulnerable areas of the NW Black Sea that can influence SAR actions and pollutants diffusion (oil and chemical) based on measured and processed parameters.

Implementation of analysis and simulation models for the behaviour of hydrometeorological factors and pollutants in ISDW in order to obtain an optimal intervention in SAR, prediction for pollution with oil and chemicals and chosing the optimal way for real intervention, resulting in the identification of the disposition points for intervention and the management center.

The achievement of the information management center (IMC), points of disposition for means and forces of intervention and implementing the analysis and real time transmission of the level of pollutants system

Implementation of the integrated system at the Romanian shore, achievement of the technical study destined for actions at a legislative level in order to ensure the legal framework neccessary to implement this system in Romania's offshore industry and dissemination of results.

A major effect regarding the contribution to ensure maritime environment quality is that the integrated management and intervention system will be, according to the technical and quality standards, meeting EU requirements and recommendations established by the Directive EP-PE_TC1-COD(2011)0309 from 21.05.2013 regarding the amend of 2004/35/EC Directive on the safety of offshore operations in oil and gas exploitation by economic agents. In this manner, the integrated management and intervention system is related to the integrated protection of the following protected areas from the Black Sea in case of a maritime accident with the generation of a major pollution by an economic agent:

- ✓ ROSPA0076 Black Sea: Site of community importance, in accordance with the requirements of Birds Directive 79/409/CEE, directly designated as a special protected area – SPA by GD no. 1284/2007 regarding the declaring of protected bird areas as part of the European ecological network Nature 2000 in Romania – 147 242.9 ha;
- ✓ ROSCI0094 - Submarine sulphurous springs in Mangalia (362 ha);
- ✓ ROSCI0197 - Eforie Nord – Eforie Sud submerged beach (141 ha);
- ✓ ROSCI0273 – The maritime area from Tuzla cape (1.738 ha);
- ✓ ROSCI0237 – Submarine methane structures from Sfântu Gheorghe (6.122 ha): sites of Community importance in accordance with the requirements of the Habitats Directive 92/43/EEC, adopted by Decision 2009/92/EC
- ✓ ROSCI0269 - Vama Veche – 2 Mai: Site of Community Importance in accordance with the requirements of the Habitats Directive 92/43/EEC, adopted by Decision 2009/92/EC, which overlaps the Marine Reserve 2 Mai - Vama Veche) protected area of national importance - 5,272 ha;
- ✓ ROSCI0066 - Danube Delta Biosphere Reserve - the marine area: Site of Community Importance in accordance with the requirements of the Habitats Directive 92/43/EEC, adopted by Decision 2009/92/EC which overlaps with the marine area of the Danube Delta Biosphere Marine - protected natural area of national and international interest - 121.697 ha.

Economic objectives with high risk potential at the Black Sea (Midia Navodari Petro-chemical plant, port areas with high traffic: Constanţa, Mangalia, Midia, Sulina, maritime platforms, etc.) will obtain a lower risk level of performed activities, attracting strategic investors which based on the EU legislation will be obliged to use safety services offered by local agents.

REFERENCES

1. Beegle-Krause, C. J., 2001. General NOAA oil modelling environment (GNOME): A new spill model. IOSC 2001 proceedings, Volume 2, 856-871, Mira Digital Publishing, Inc. St. Louis, Missouri.
2. Conley, D.C. and Rusu, E., 2006: Tests of wave shoaling and surf models in a partially enclosed basin, Maritime Transportation and Exploitation of Ocean and Coastal Resources, Francis & Taylor publications, London, ISBN 13: 978-0-415-39036-1, Vol II, pp. 1015-1021.
3. 1974 International Convention for the Safety of Life at Sea, London 1st November (SOLAS 74).
4. 1979 International Convention for the Safety of Life at Sea Hamburg 9-27 April.
5. 1978 International Convention for the Prevention of Pollution from Ships, 1973, as amended by the 1978 Protocol (MARPOL 73/78).
6. Deng, Z., Yu, T., Shi, S., Jin, J., Jiang, X., Kang, L., Zhang, F., Wang, W., 2013: Numerical study of the oil spill trajectory in Bohai Sea, China, Marine Geodesy, in press.
7. Mettlach, T. R., Earle, M. D., Hsu, Y. L., 2002: Software Design Document for the Navy Standard Surf Model, Version 3.2, Naval Research Laboratory, Stennis Space Center, Mississippi, 187p.
8. POSITION OF THE EUROPEAN PARLIAMENT adopted at first reading on 21 May 2013 with a view to the adoption of Directive 2013/.../EU of the European Parliament and of the Council on safety of offshore oil and gas operations and amending Directive 2004/35/ECB.
9. Pricop, M., Chiţac, V. and others - Mixed Road And Naval System for Swift Intervention at Floods, Ovidius University annals, INGINERIE MECANICĂ, Vol X Nr. 1, 2008, ISSN 1223-7221
10. Rusu, E. and Butunoiu, D. 2009: Wave modeling in the proximity of Constanta harbor, Proceedings of the 13th International Congress of Maritime Transportation and Exploitation of Ocean and Coastal Resources - IMAM2009, Istanbul, Turkey, Vol. 2, 633-640.
11. Rusu, E., Conley, D.C. and Coelho, E.F., 2008: A Hybrid Framework for Predicting Waves and Longshore Currents, Journal of Marine Systems, Elsevier, Journal of Marine Systems 69 (2008), pp. 59–73.
12. Sebastiao, P., Guedes Soares, C., 2006. Uncertainty in predictions of oil spill trajectories in a coastal zone, Journal of Marine Systems 63, pp. 257–269.
13. Svendsen I. A., Haas, K. and Zhao, Q., 2002: Quasi-3D Nearshore Circulation Model SHORECIRC, version 2.0, Center for Applied Coastal Research, University of Delaware, Newark, DE 19716 U.S.A.
14. http://response.restoration.noaa.gov/oil-and-chemical-spills/oil-spills/response-tools/gnome.html
15. http://www.emsa.europa.eu