

# Emergency Management Systems to Accommodate Ships in Distress

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## ABSTRACT

As a future member of the European Union (EU), Croatia has decided to implement EU Directive 2002/59/EC of the European Parliament and of the Council binding all EU member states to define places of refuge for ships in need of assistance off their coasts, or to develop techniques for providing assistance to such ships. Consequently, the Ministry of the Sea, Tourism, Transport and Development of the Republic of Croatia has initiated a project for developing an effective Decision Support System (DSS) for defining the places of refuge for ships in distress at sea. Such a system would include a model based upon GIS and different operational research models, which would eventually result in establishing an integral DSS. Starting points for analysis are shipping corridors, and 380 potential locations for places of refuge designated in the official navigational pilot book. Multicriteria analysis, with GIS-generated input data, would be used to establish worthiness of a place of refuge for each ship category, taking into account kinds of accident. Tables of available intervention resources would be made, as well as analysis of their availability in respect of response time, and quantitative and qualitative sufficiency.

## Keywords

Emergency Management, GIS, Multicriteria Analysis, DSS

## INTRODUCTION

When defining its future development, the Republic of Croatia has decided on a gradual approach to joining the European Union. In this respect, it has assumed a commitment to harmonize its legal system with the legislation of the European Union. As a result, it is necessary that, among other things, working procedures of the Ministry of the Sea, Tourism, Transport and Development and its respective services be harmonized with the provisions of certain directives of the European Community relating to the safety of maritime traffic. Therefore, Directive 2002/59/EC<sup>1</sup> is binding on all member states of the European Community to establish (and communicate to the European Community) the places of refuge for ships in need of assistance off their coasts, or to develop techniques for providing assistance to such ships. Consequently, the Ministry of the Sea, Tourism, Transport and Development (MMTPR) has initiated the procedure of harmonizing its working procedures and the respective executive organization to meet the requirements provided for in the Directive. In this context, a study has been initiated aiming to:

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<sup>1</sup> Directive 2002/59/EC of the European Parliament and of the Council of 27 June 2002 establishing a Community vessel traffic monitoring and information system and repealing Council Directive 93/75/EEC

- examine the conditions of maritime traffic in the Adriatic, especially off its eastern coasts;
- show characteristics and assess the possibilities of action in case of maritime accidents or other emergencies or threats to the safety of ships or environment in the area within jurisdiction of the Republic of Croatia;
- develop working procedures for providing assistance to ships in distress in the area within jurisdiction of the Republic of Croatia;
- make preliminary selection of the places of refuge, in accordance with the experience and established working procedures in the European Community countries;
- create a DSS with GIS database of the relevant layers for the places of refuge.

First-year work on the project resulted in a study treating the issue of places of refuge (PoR) in a both scientific and professional manner. The study involves evaluation of natural, socio-economic and bio-ecological characteristics, maritime traffic situation and analysis of possible threats to the environment, and finally the principle of preliminary selection of places of refuge and their description. Relevant characteristics have been included in the GIS application called GIS ADRIA. An additional result achieved by this project is the drafting of the concept of a DSS for deciding on the requests for places of refuge, presented through the pilot project of three coastal counties. This concept is presented in this paper, and its development for a project approved by the Ministry of the Sea, Tourism, Transport and Development will significantly improve the decision-making processes in emergency situations at sea.

Two modules of DSS were conceived and built in the first stage of the project:

- GIS support with problem-oriented extensions, and over 30 thematic layers for subordinating characteristics of places of refuge
- MCA (Multicriteria analysis) for valuation of each potential shelter according to the relevant criteria with direct interface towards GIS application.

## **BUILDING DSS FOR DEFINING THE PLACES OF REFUGE**

The decision process is a generic process that can be applied on any kind of organized set of activities in order to meet objectives. Generally, there is no unique model of decision process, because it includes numerous variables, different levels of decisions (strategic, tactical, and operational), as well as different decision makers.

Generally, use of that knowledge and experience in the development of a Decision Support System (DSS) for emergency management system in case of maritime accidents logically leads to the implementation of a system that will support all decision levels (Mladineo, N., Knezic, S., Jajac, N.; 2005). The organization of that system is generally hierarchic; at each level decisions are made in accordance with the political competences. Decision character is different at some levels and depends on the system organization; decision range at lower levels is in accordance with previously made strategic decisions. The DSS helps to structure and organize such a large quantity of information related to the emergency management system in case of maritime accidents, especially spatial data, in order to make it available to decision makers in a comprehensible and user-friendly way. A systematic approach throughout the DSS provides very simple and comprehensible integrated information regarding the technological changes and in accordance with different emergency policies and management methods.

Conceptualized DSS for tactical and operational level is divided in a number of segments (modules) that will be additionally built in the further phases. The basic module is GIS (Geographical Information System), for all levels of DSS, that comprise information sub-systems about spatial and other data and serves the other modules with data and information. The GIS module is divided into several thematic layers with basic information about places of refuges, climatological and maritime characteristics, hydrographic characteristics, ecological and biological characteristics, existing navigable waterways, maritime limits, boundaries of counties and cities, limits of territorial sea, continental shelf, military zones, topographic data, location emergency services, etc. (Mladineo, N., Knezic, S., 2005).

DSS is based on a combination of GIS analysis and a multicriteria method in order to enable effective emergency management, namely it would be used to establish *worthiness* of a place of refuge for each ship category, taking into account different kinds of accidents. GIS is outlined as a powerful tool for the generation of aggregated information used in multicriteria analysis, as is the link between hierarchic decision levels in the proposed DSS.

### CONCEPT OF DSS FOR PLACES OF REFUGE

Figure 1 shows the conceptual scheme of DSS for the strategic level, namely DSS that support functions of Croatia's Maritime Rescue Coordination Centre and supporting organizations of MMTPR, which are focused on support to the activities connected to:

- Segment A: planning and preparing for interventions at sea;
- Segment B: response;
- Segment C: relief and remediation planning.

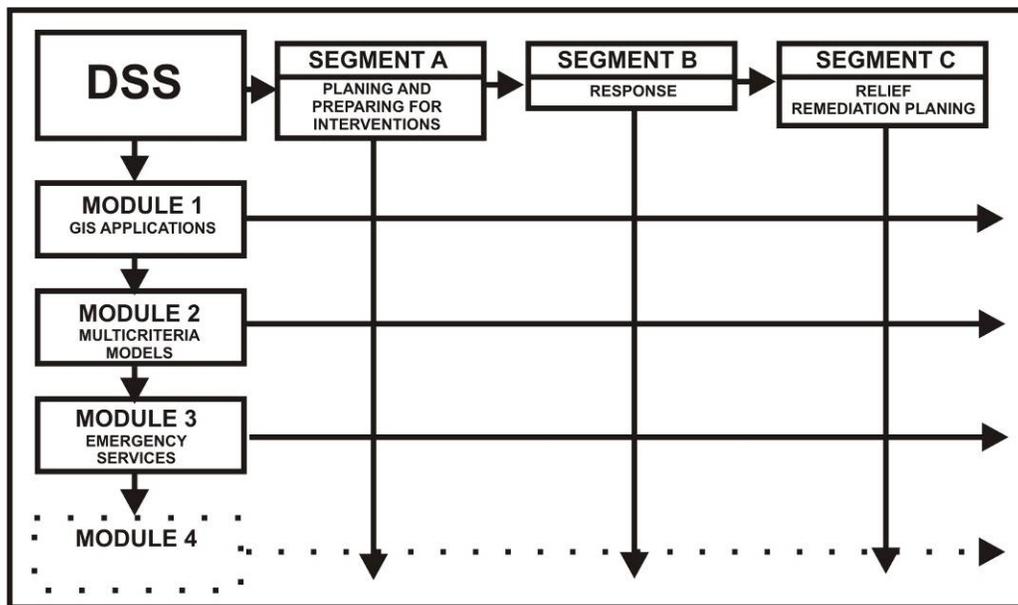


Figure 1. Basic DSS concept

The function of Module 2 (multicriteria models) is the evaluation of the suitability of each of the 380 potential locations for places of refuge (PoR) designated in the official navigational pilot book for each category of vessel and each type of maritime accident. For the suitability valuation of each PoR, relevant criteria are defined as well as their ranges and weights that define the importance of criteria. There are a total of 14 criteria for assessing each potential place of refuge (Table 1).

Criterion No.	Criterion Description	Criterion Weight
C1	Swing room	9
C2	Navigational approach	8
C3	Bottom keeping	8
C4	Grounding suitability	7
C5	Booming ability	9
C6	Wind protected (preferential)	10
C7	Accessibility by road, train, and/or air	8
C8	Socio-economic acceptability	10
C9	Oil spill shoreline sensitivity	9
C10	Ecological sensitivity	10
C11	Repair facilities	6
C12	Tug response time	8
C13	Dispersants response time	8
C14	Tank barge response time	8

Table 1. Criteria for Multicriteria Analysis

A mathematical programme of MCA adapted to the criteria values and connected to ADRIA GIS database performs selection or ranking of a certain number of places of refuge within a pre-defined radius around the position of a ship sending a request (Figures 2 and 5). Figure 3 shows a schematic procedure (Mladineo et al. 2003), which contains GIS analysis as a first step, with evaluation of relevant criteria presented as thematic layers. For criteria that cannot be spatially presented using GIS analysis, specific numerical values, as the input for multicriteria analysis, are evaluated by expert teams.

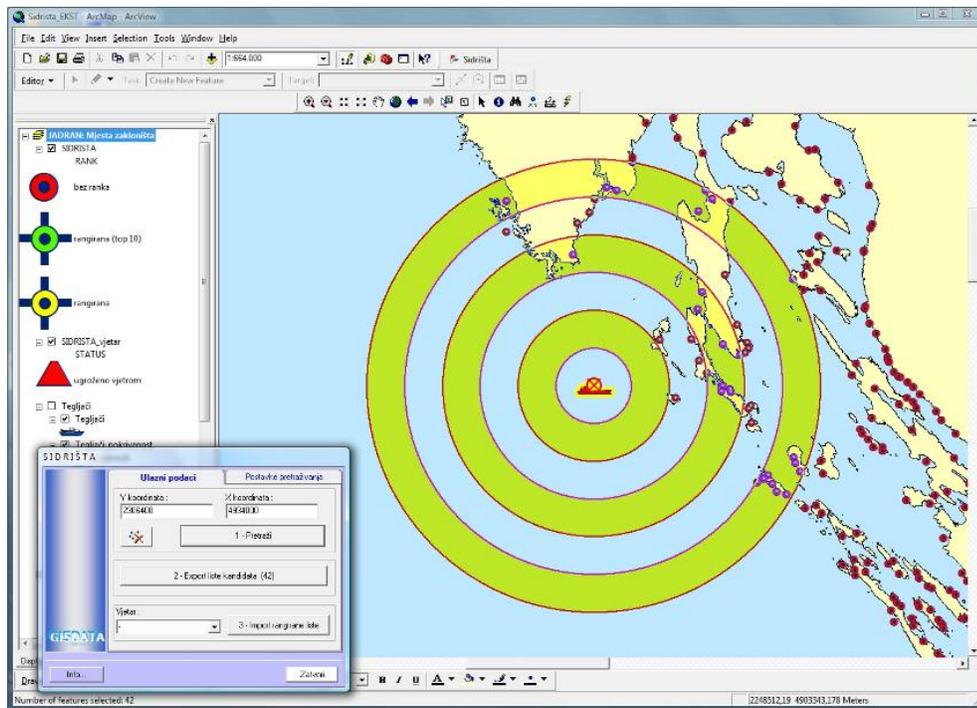
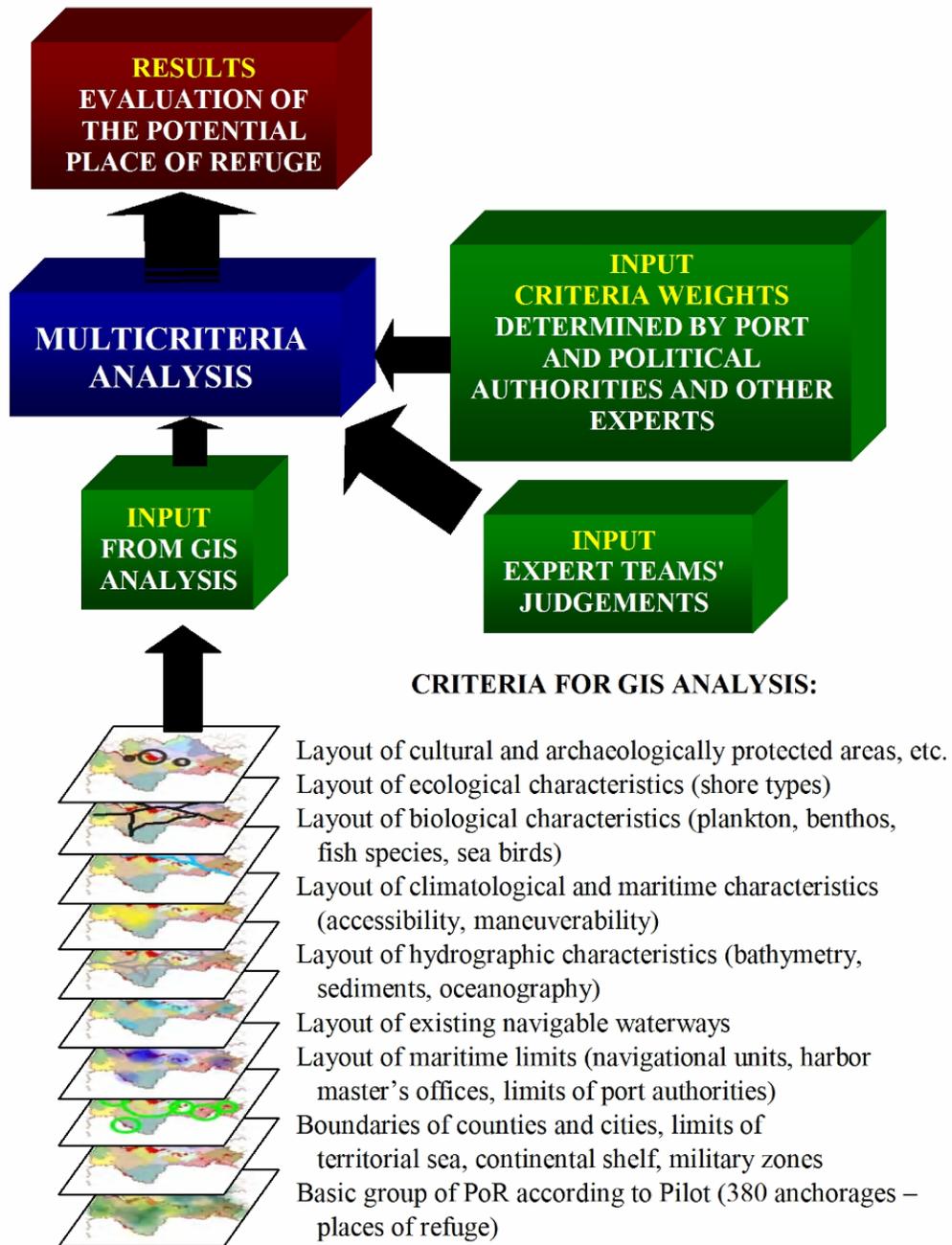


Figure 2. GIS + additional extension - Searching potential places of refuge according to defined radius



**Figure 3. Layout of the methodological procedure to define places of refuge for ships**

To facilitate and automate the process of decision making in an emergency, and consequently reduce the possibility of subjective error, the expert team develops “designated scenarios”, as shown in Table 2, in which criteria weights are changed to adapt the decision-making process to the characteristics of an incident, e.g., ship damage.

Scenario No.	Scenario Description
Scenario 1	General criteria weights - places of refuge with no specific purpose
Scenario 2	Ship category (large) - no risk of oil spill
Scenario 3	Ship category (large) - risk of sinking and oil spill
Scenario 4	Ship category (large) - risk of fire and many casualties
Scenario 5	Ship category (large) passenger - evacuation and care of many casualties needed
Scenario 6	Ship category (smaller) - no risk of oil spill
Scenario 7	Ship category (smaller) - risk of sinking and oil spill
Scenario 8	Ship category (smaller) - fire risk
Scenario 9	Ship category (smaller) passenger - evacuation and care of casualties needed
Scenario 10	.....

Table 2. Example of designated scenarios

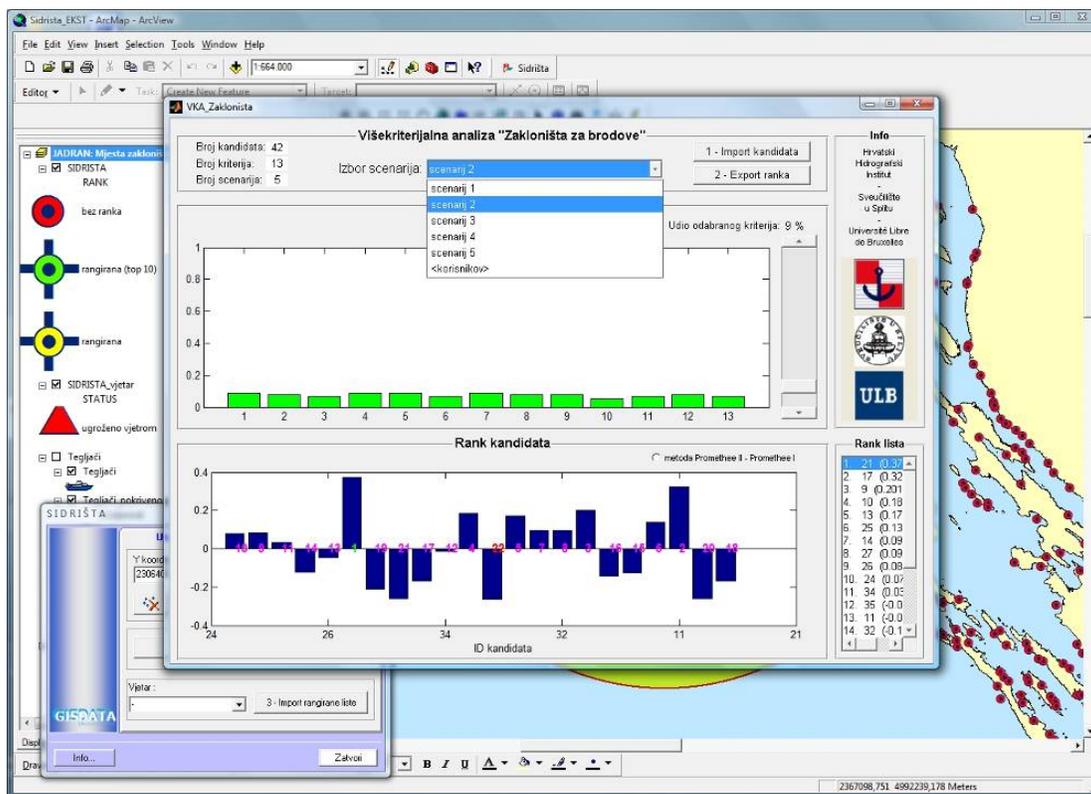
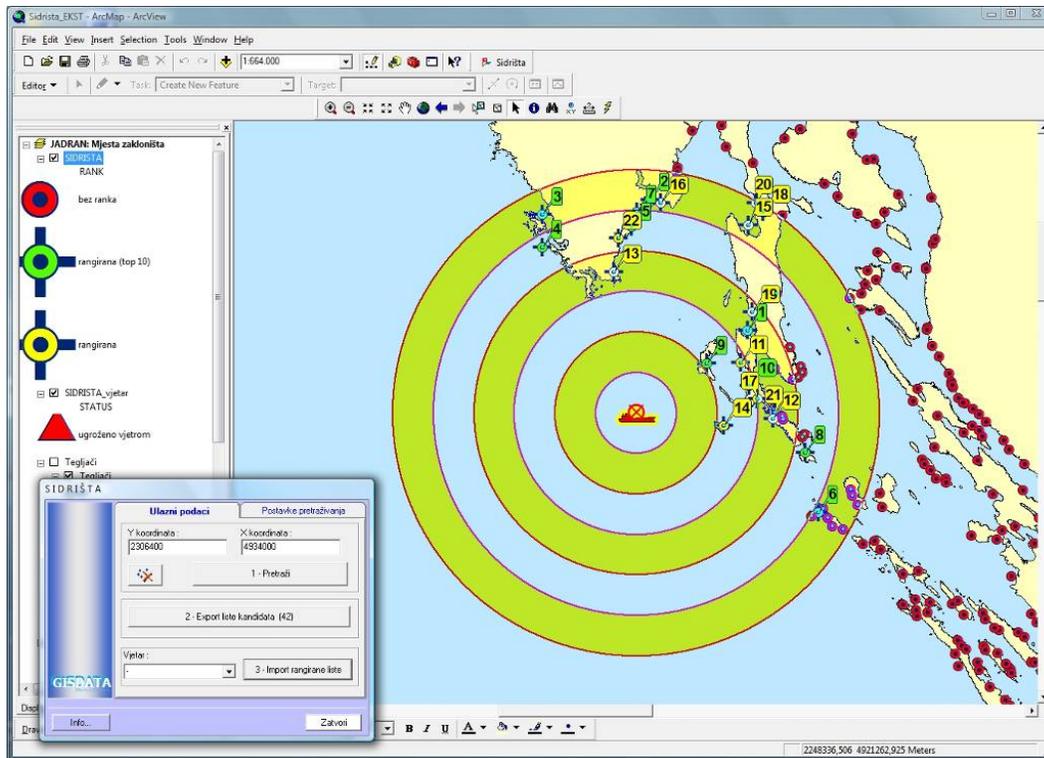


Figure 4. MCA Software Support - Display of change of criterion weight scenario according to characteristics of incident (oil spill, fire, etc.)

The presented DSS, based on GIS in conjunction with multicriteria analysis, is found to be a powerful tool for spatial decision-making. Figure 5 show calculated rank of potential places of refuge using MCA.



**Figure 5. GIS + additional extension: Display of calculated rank of potential places of refuge using MCA**

The conceptualized DSS is divided in a number of segments (modules); some of them will be additionally built in later phases. Using GIS and other GIS-based tools the scope of the emergency services action is visualized. For example, it is possible to visualize a tug response time from the nearest location (Figure 6). This figure shows a color ramp where every color represents 3 nautical miles. This is used for a quick estimation of response time, taking into account that an average speed of tug is approximately 12 nautical miles per hour. At the same time, the characteristics of the tug, such as its dimensions, speed, pulling power, available counter-fire equipment, equipment for oil spill relief, etc., could be easily retrieved from the data base and displayed on the screen.

While developing the DSS it has been important to think about introduction of dynamic aspects of the system, such as wind which is very important during maritime accidents because it influences emergency management actions. Figure 7 shows how DSS also supports a dynamic approach. For example, it is possible to input data about present wind (the tabbed window in the lower left corner of the screen) and eliminate places of refuge which are exposed to the wind (red triangle which points to PoRs that are not suitable concerning wind characteristics).



## CONCLUSION

Supporting complex and sensitive decision-making processes such as selection of places of refuge for ships in distress cannot be achieved without using DSS principles of connection of appropriate methods and data. International regulations and guidelines for defining places of refuge for ships were a good starting point for considering such methodological approach and solution concept. The Decision Support System presented in this paper is a unique system for the safety of navigation at sea conceptualized as a conjunction of operational models and GIS spatial functions. Applied to the pilot counties it seems to function well. However, the system depends upon availability of relevant thematic layers (system parameters) in GIS, which calls for the defining, collecting and editing of data in a suitable format to be the basis for necessary analyses. This paper proposes the basic concept of the DSS which helps to establish efficient emergency management using GIS and its spatial analysis tools. After the analysis it should clear where the sea territories that cannot be reached in reasonable time are situated, and what emergency management strategy has to be undertaken.

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