APPLICATION OF BAYESIAN NETWORK TO ESTIMATE MERCHANT SHIP USABILITY FOR SAR ACTION

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Abstract

In Search and Rescue (SAR) operations on sea are use special ships with trained crew. In situation when the rescue ship is not available SAR action coordinator may use merchant ships that are in the accident area to help ship in danger. Merchant ship has not special equipment to search survivors and according to small number of crew, cargo on board and stability situation may be not suitable for SAR operation. Some weather conditions may be danger for this ship and there may be two ships in danger instead of one.

The action coordinator is responsible to choose good vessel. The paper will present elements that should be taken into consideration. Article will show usage of Bayesian network to estimate which ship is better for SAR action. This tool will help coordinator to make good decision. Paper specified elements of merchant ship usability for SAR action based on safety during action with algorithm of MSC decision according use of merchant ship. The paper also show example of calculations of hypothetic rescue action on the Mediterranean Sea using GeNIe program, which include probability of safety search pattern for ship, weather condition and other variables. Results show Mir Emad to be the least useful ship. The best result has tanker Excel, but during calculation didn't take into consideration type of the ship.

Keywords: *transport, sea transport, merchant ship, risk, SAR action*

1. Introduction

Under long-standing traditions of the sea every ship master helps other ship in danger on sea. Some years ago, when radio communication was the only way to inform others about our distress situation, only ships in close range was able to help. There was no other option and every seafarer tries to help.

Nowadays, when modern satellite communication and GMDSS system is fully operational more people know about danger situation and may help. On the strength of the International Convention on Maritime Search and Rescue [5] every sea countries have established special Search and Rescue organizations with specialized equipment and coordination centers. Based on SOLAS Convention [6] every ship sails in direction of ship in danger. SAR action is coordinated by SAR Mission Coordinator (SMC) in Maritime Rescue Coordination Centre (MRCC). SMC chooses which ships are the most suitable for action. Decision algorithm is presented in figure no 1.

SMC has to evaluate if merchant ship is good for SAR action. He has to estimate the risk inherent in any SAR action against the chances for success and the safety of SAR personnel and equipment. Later search plan is constructed and passed on to the ship. The captain has to check if ship will be safe during action one again. It takes time with is very valuable during SAR action.
The paper presents method of estimation merchant ship usability based on Bayesian network model.

2. Elements of merchant ship usability for SAR action

SMC should take into consideration some elements to choose the best available merchant ship.

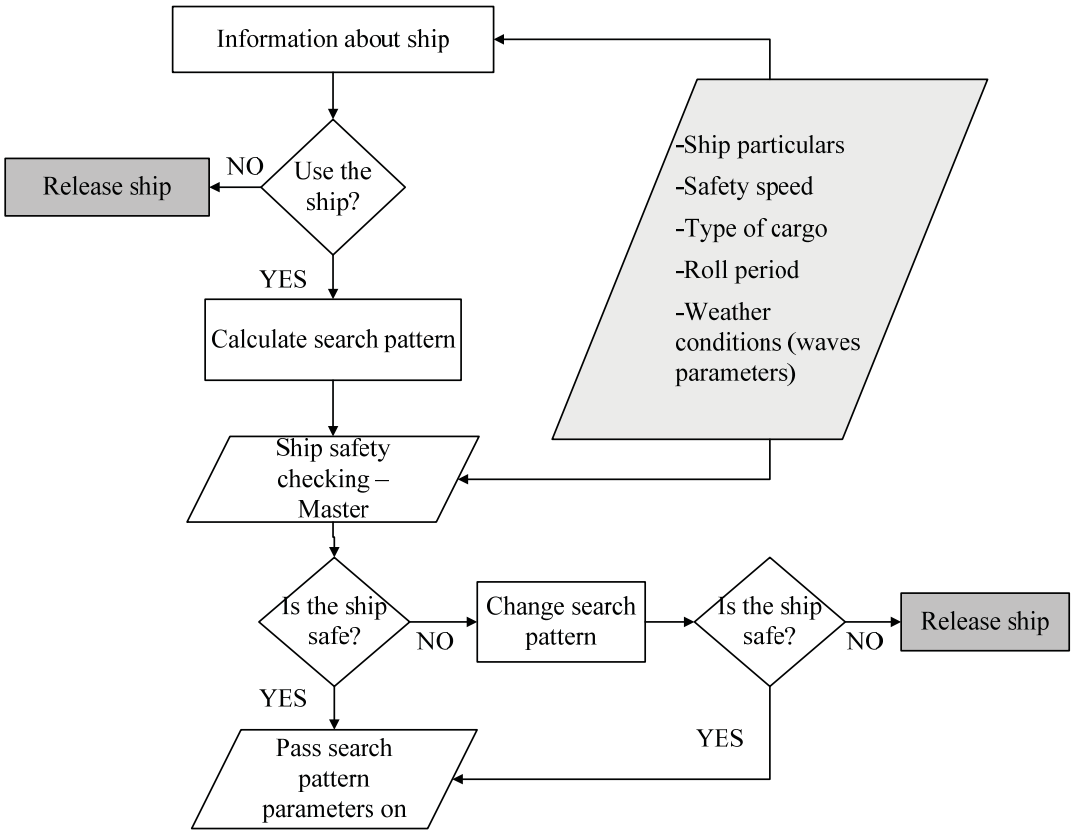

Fig. 1. Algorithm of MSC decision according use of merchant ship [1]

He should find answers for following questions:

- can the ship handle the weather conditions during sailing on ordered search pattern,
- what is the risk for cargo carried by the ship,
- what is the risk for marine environment in case of the ship damage or lose the cargo,
- is the ship equipped to detect search objects,
- has the ship got equipment to take up survivors on board.

The main problem is safety of the ship during SAR action. In normal navigation during storm weather, navigator changes course and speed to find way which will be the safest for ship. In SAR action rescue craft has to sail according special types of search patterns, for example expanding square search or parallel sweep. It requires ability of safety sailing on four correlated courses. The master of the ship decides if the vessel will be able to sail on ordered courses. SMC should foresee if the ship will be able to use one of search patterns otherwise he will waste time to prepare search plan which will be rejected by the master due to ship safety. For this purposes determine danger courses algorithm based on IMO guidance to the master for avoiding dangerous situations in adverse weather may be used. [7] Knowledge of main parameters of the ship and weather conditions allows calculating probability of finding safe search pattern.

The ship safety is strongly connected with safety of the cargo. Some cargos are more sensitive to heavy rolling than others. For example trucks carried by ro-ro vessel may move and cause list or even capsized of the ship. Deck cargos like containers or wood are lost during heavy weather very often. Cargos in bulk are more insensitive for rolling but on the other hand damage of the tanker may be very big danger for marine environment. So the type of the ship and carried cargo should be taken into consideration by SMC.

How the ship may help is the other aspect. We have two categories: search of the object and rescue survivors. Big vessels have technical equipment which is satisfactory for SAR action generally. The question is how many people will be using this equipment and may try to find the

object visually. Number of person on board is important information for SMC. The take up survivors from the water is more complicated on big ship. Special SAR crafts have rescue nets and designated zones to get survivors out of the water. Merchant ships have rescue boats on board but they are useless in heavy weather conditions very often. For example on car carrier rescue boat is located about 30 meters above sea. Launching of the boat is very dangerous for crew and later taking up is almost impossible. Ship cranes with nets may be used for get survivors out but a lot of modern vessels have not cranes, for example big container vessels. One again ship type is important information for SMC.

3. Bayesian network model

Bayesian networks are intuitive modeling tool which adds transparency and consistency to the modeling. They may be used in a wide range of applications within the maritime industry. In the past, Bayesian networks have been widely used for diagnosis in medicine and troubleshooting of various technical devices, but they may be used for inspection and repair planning for offshore structures, grounding risk analysis or preliminary ship design, etc. [2]

Based on elements presented above the Bayesian network for the ship usability for SAR action may be constructed. The model is presented in figure 2. The final calculation will help SMC to choose the best ship.

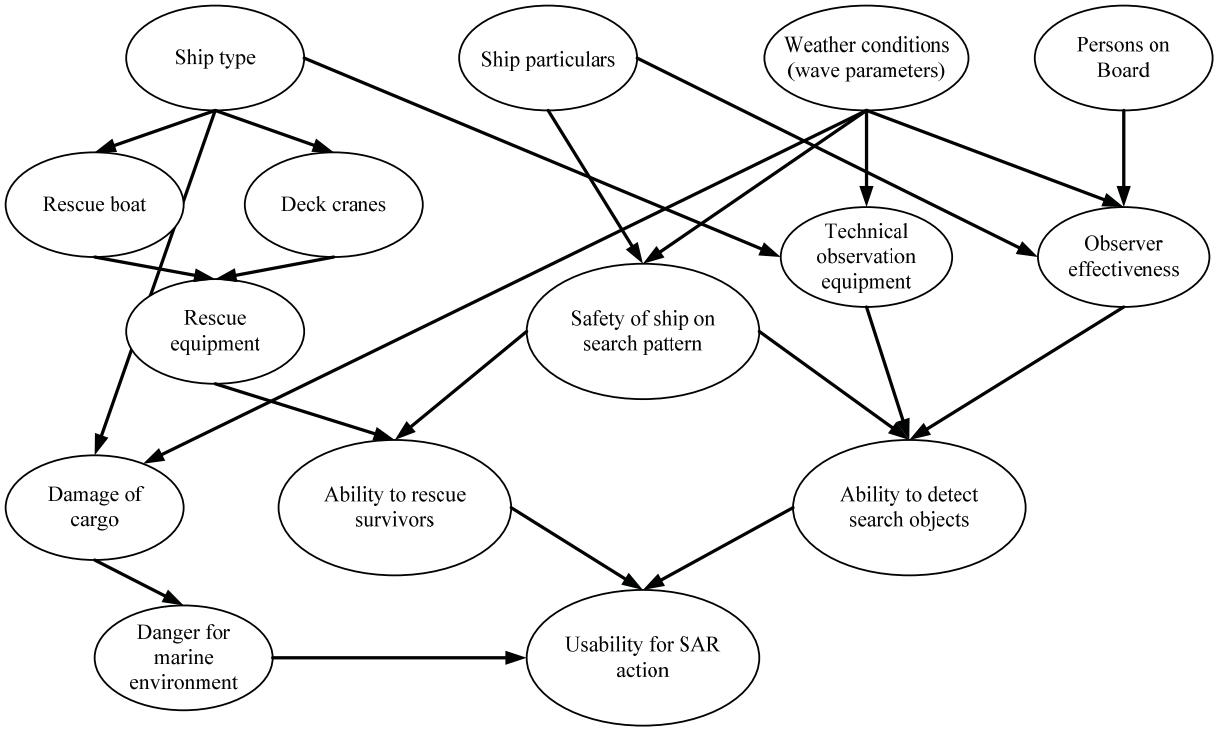

Fig. 2. Ship usability for SAR action - The Bayesian network

4. Example of calculations

Let's assume hypothetic rescue action on the Mediterranean Sea. Actual positions of ships are presented in Figure 3. Four ships reported to MRCC that they received distress signal and are sailing into direction of ship in distress (marked as X in the figure): EXCEL – LNG tanker with membrane tanks, MAERSK KALMER – container vessel; MEREMAD and INGA H general cargo vessels. Assumed weather conditions: length of wave about 100 meters, period of wave (Tw) about 8 seconds and height of wave (Hw) about 5 meters.

For each ship probability of safety search pattern was calculated. It was used in simplified.

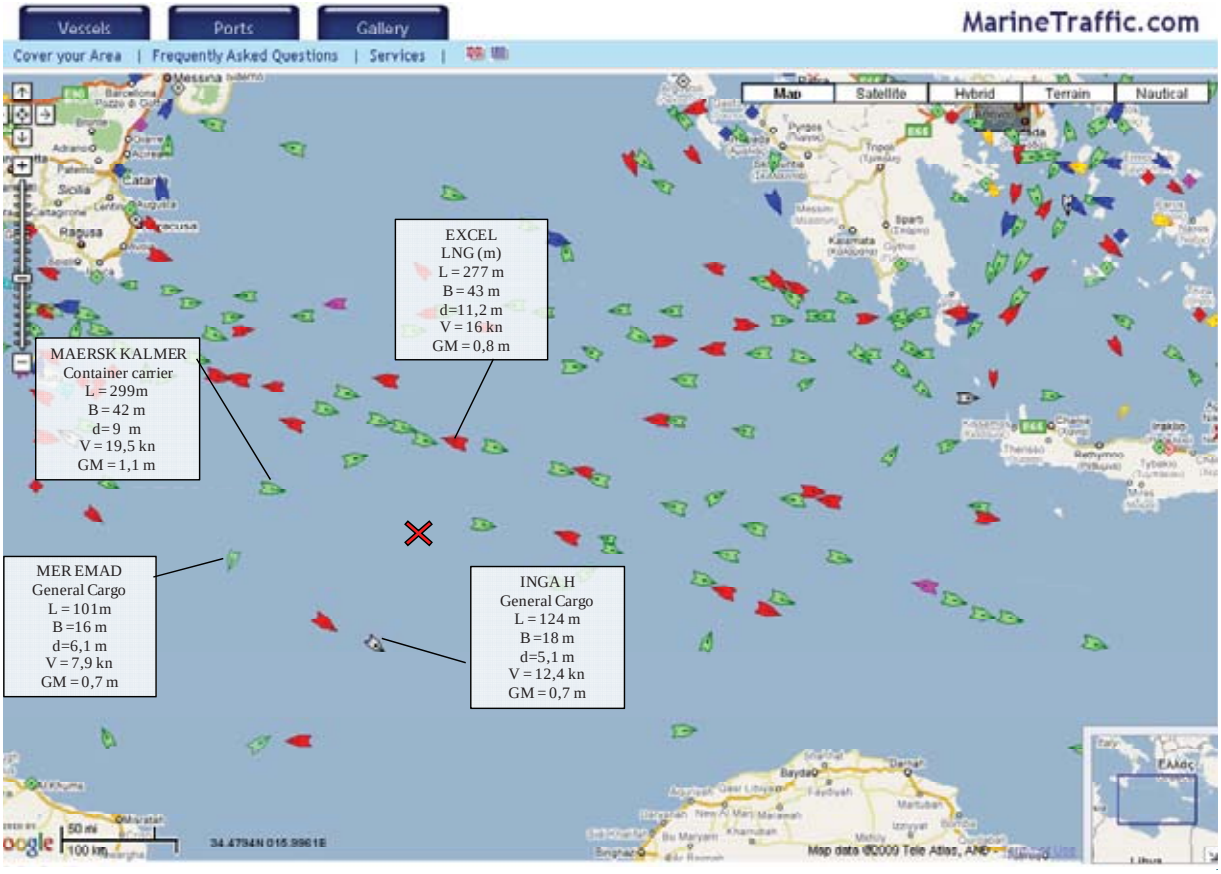

Fig. 3 Ships on the Mediterranean Sea [8]

Bayesian network (Fig.4). In calculation was assumed that all ships have the same ability in searching object and rescuing survivors. During calculation GeNIe program was used [3].

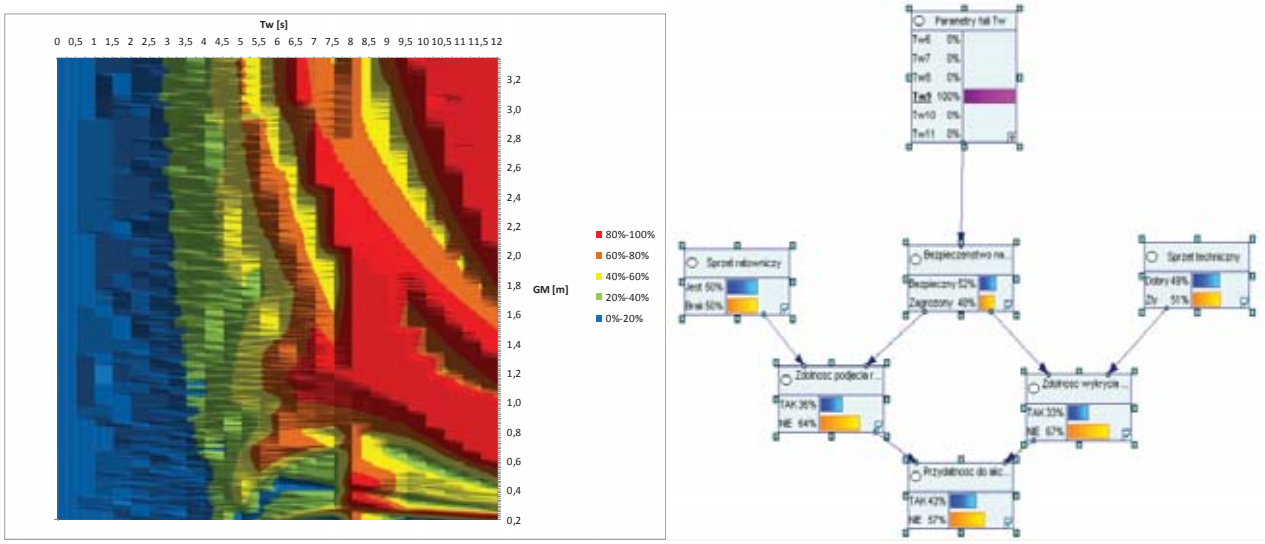

Fig. 4. Graph of safe search pattern probability and calculation for INGA H

Calculations were made for actual wave parameters and for worse weather. As a result Mir Emad is the least useful and should be released, because in case of weather deteriorated she may need assistant or will have to leave action. The best result has tanker Excel, but during calculation didn't take into consideration type of the ship.

Tab. 1. Usability of ships in SAR action

Wave parameters	INGA H	MEARSK KALMER	EXCEL	MIR EMAD
Tw=8s Hw=5m	32%	46%	56%	31%
Tw=9s Hw=5,5m	43%	28%	53%	18%

5. Conclusions

Automation of calculation will help SMC to take proper decision in short time. Obtaining information about ship from captain may be replaced by data from AIS system and some statistical information. It will help to eliminate the worst ships and allowed SMC to ask masters of more usable ships who didn't decided to proceed to the scene of a distress to reconsider the decision. There are a lot of works to develop and improve the model of Bayesian network of usability ship for SAR action.

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[8] *www.marinetraffic.com.*