RELIABILITY OF MERCHANT SHIP USED FOR SAR ACTION

NIEZAWODNOŚĆ STATKU HANDLOWEGO W AKCJI SAR

Andrzej Starosta
Gdynia Maritime University – Faculty of Navigation
Akademia Morska w Gdyni – Wydział Nawigacyjny
Aleja Jana Pawła II, 381-345 Gdynia, Poland
e-mails: (1) andrzej.starosta@wp.eu

Abstract: Paper presents elements that should be taken into consideration by SMC during chosen merchant ship for help in SAR action. Bayesian network was used to construct model of merchant ship reliability in SAR action. Preliminary assessment of ship usability uses basic information about ship from AIS or similar system. Other information to enhanced model are obtain from master by radio or from safety databases. The paper present analyses which elements are the most important. The aim of research is construct application which will inform SMC which ship in the distress area is the best for SAR action.

Keywords: reliability, merchant ship, SAR action

Streszczenie: Artykuł przedstawia informacje, jakie powinien rozważyć koordynator akcji SAR (SMC) podczas doboru jednostek handlowych do pomocy w akcji SAR. Do stworzenia modelu niezawodności statku w akcji SAR zostało użyte drzewo Bayesowski. Do wstępnej oceny wystarczą podsytowowe dane uzyskane np. z systemy AIS. Pozostałe informacje mogą być uzyskane później z innych źródeł. Artykuł zawiera analizę wpływu niektórych elementów na bezpieczeństwo statku. Celem badań jest stworzenie aplikacji, która w sposób automatyczny poinformuje SMC, które statki w pobliżu miejsca akcji będą najbardziej niezawodne podczas trwania akcji i zmieniających się warunków pogodowych.

Słowa kluczowe: niezawodność, statek handlowy, akcja SAR

Streszczenie: Artykuł przedstawia informacje, jakie powinien rozważyć koordynator akcji SAR (SMC) podczas doboru jednostek handlowych do pomocy w akcji SAR. Do stworzenia modelu niezawodności statku w akcji SAR zostało użyte drzewo Bayesowski. Do wstępnej oceny wystarczą podsytowowe dane uzyskane np. z systemy AIS. Pozostałe informacje mogą być uzyskane później z innych źródeł. Artykuł zawiera analizę wpływu niektórych elementów na bezpieczeństwo statku. Celem badań jest stworzenie aplikacji, która w sposób automatyczny poinformuje SMC, które statki w pobliżu miejsca akcji będą najbardziej niezawodne podczas trwania akcji i zmieniających się warunków pogodowych.

Słowa kluczowe: niezawodność, statek handlowy, akcja SAR
1. Introduction

During Search and Rescue (SAR) action merchant ship may be used to help people in distress. Master of the ship decides if his own vessel is able to assist and then acknowledge the alert to the ship in distress and to the Rescue Coordination Centre (RCC). SAR Mission Coordinator (SMC) has to decide which ship will be the best for SAR action. The SAR actions take place in adverse weather conditions and SMC’s wrong decision may cause that during action ship will abandon the search area due to his own safety. In the worst case the wrong decision may cause accident of ship which tried to help.

SMC may use merchant ships which answered for distress signal only. Based on reports from ships he chooses ship which is the most suitable. Other ships may be released. But nowadays MRCC has more information about others ships in area of accident, for example from AIS system or other e-navigations systems. Thank to those systems operator in MRCC has basic information about each ship. The paper presents elements that should be taken into consideration by the SMC during selecting of the ship.

2. Bayesian network model

Merchant ship that would be used for SAR action has to fulfill some safety requirements. To choose the best available merchant ship SMC should take into consideration those elements of ship which allow her to be useful during all time of SAR action, even if weather conditions will change for a worse. He should find answer for following questions:

- can the ship arrive to search area safely in short time;
- 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.

Based on those elements Bayesian network to estimate ship usability for SAR action was constructed. It is presented in figure 1. This model allows to prepare ranking of ship in the area of accident based on basic data form AIS system. (Starosta, 2009a; Starosta, 2009b)
3. Merchant ship reliability in SAR action

SMC has to choose ship which will be fit for use during all time of SAR action. The reliability of the required ship may be divide into:

- technical reliability;
- exploitation reliability, and
- SAR operational reliability.

Technical reliability means that during all SAR action main engine, hull structure and steering gear machine will not fail. Because ship are designed to sail in different weather condition, even very hard, the probability of fail is the same like in standard voyage. It depends on age of the ship mainly.

Exploitation reliability means that ship is able to sail in actual weather conditions in one direction. The main aim of the exploitation is to deliver the cargo in good condition as fast as possible. Due to heavy weather the master should change course or reduce speed of the ship to protect cargo and ship. In SAR action this means that the ship will be able arrive to action area on direct course.

The most important for SMC is SAR operational reliability. It is hard to estimate because if the ship is fit for continue SAR action or not depends on the master. According to the Convention for the Unification of Certain Rules of Law Relating to Assistance and Salvage at Sea, signed at Brussels in 1910, master is bound to render assistance to everybody who found at sea
in danger of being lost, so far as he can do so without serious danger to his vessel and crew. He makes decision based on his own experience. Master has also different kind of owner instructions and international guides. One of them is approved by the Maritime Safety Committee in 2007 Revised Guidance to The Master for Avoiding Dangerous Situations in Adverse Weather and Sea Conditions.

Thanks to the Guidance the master may check if actual course is danger for his ship. The best way to avoid danger situation is change the ship speed or/and alter course. Unfortunately during SAR action the master should realize prepared search plan. 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 no only on one like in normal navigation. Theoretically the master should inform SMC that his ship is not safe on this course so the ship is unfit for SAR action.

Based on the guidance the algorithm to determine danger courses was prepared (figure 2). The algorithm allows to estimate probability to find safe search pattern for ship in actual or forecast weather conditions. If we know the weather forecast we may calculate ship reliability during SAR action.

Fig. 2 Algorithm to determine danger courses
4. Example of calculation

Some ship particulars are more important for calculating ship reliability based on the algorithm. In this section the influence of ship length and ship metacentric height (GM) is shown. Let’s assumed three different size ships to analyze:

- Small ship – Length Over All (LOA) 80 m, breadth (B) 14 m, draft 5 m, metacentric height (GM) 0,65 m and speed (V) 9 knots;
- Medium ship – LOA=140 m, B=22 m, draft=7 m, GM=0,7 m, V=14 kn;
- Big ship - LOA=250 m, B=44 m, draft=12 m, GM=1,2 m, V=12 kn.

4.1. Length of the ship

According to the guidance reduction of intact stability phenomena is directly connected with the length of the ship. The intact stability can be decreased substantially according to changes of the submerged hull form, when a ship is riding on the wave crest. The amount of stability reduction is nearly proportional to the wave height. This situation is dangerous in following and quartering seas, because the duration of riding on the wave becomes longer. Therefore the guidance states that the phenomena is danger when the angle of encounter is in the range $135^\circ<\alpha<225^\circ$.

The wide range of danger courses cause that there is no chance to find safety search pattern for ship, because always at least one course will be in danger zone, and the captain may retreat from action. In heavy storm big number of ship may have this problem (figure 3).

![Fig. 3 Danger of reduction of intact stability due to wave length](image-url)
4.2. Influence of GM inaccuracy

Metacentric height is only one data that is not transmitted by AIS system. SMC has to assume this data based on his experience or he has to contact with master to obtain actual information. But even GM obtained from master report may include inaccuracy due to improper calculation or unknown masses on the ship.

In below figures the influence of inaccuracy in GM changes probability of unsafe search pattern $P(Z)$, it means that one of courses will be danger.

Fig. 4 Probability of unsafe search pattern for small ship

Fig. 5 Probability of unsafe search pattern for medium ship
Reliability of merchant ship used for SAR action
Niezawodność statku handlowego w akcji SAR

Fig. 6 Probability of unsafe search pattern for big ship

5. Conclusions

For SMC the most important is SAR operational reliability of the chosen ship. One of the most important elements of the reliability is ship safety during SAR action. The master may retreat ship from SAR action due to own ship safety in any time. To estimate SAR operational reliability weather forecast connected with presented algorithm may be used. The reduction of intact stability phenomena is the most problematical elements of the algorithm, because when it occurs finding of safe search pattern for the ship is impossible in lot of case. The future discussion if this phenomena should be taken into consideration without connection with others phenomena should be continued.

The inaccuracy in used GM is very problematical too. Small difference in GM may give big change in P(Z). It is hard to predict how P(Z) will change because it depends on ship particulars, actual wave length and geometrical configuration of danger courses zones.

Generally big ships are better for SAR action, what is presented in figure 7, but in some situation small ships may be safer too. Future study will be done to prepare better model to estimate SAR operational reliability. The connection of this model with e-navigation systems will give SMC very good decision support tool and improve SAR action reliability.
Fig. 7 Probability of unsafe search pattern for assumed GM

References

1. Burciu Z., Bezpieczeństwo w transporcie morskim. Tom I Poszukiwanie i ratowanie życia na morzu w ujęciu systemowy, Monograph – working version
2. Dz.U.38.101.672 KONWENCJA o ujednolnieniu niektórych przepisów dotyczących niesienia pomocy i ratownictwa morskiego, podpisana w Brukseli dnia 23 września 1910 r.
5. MSC.1/Circ. 1228 Revised guidance to the master for avoiding dangerous situations in adverse weather and sea conditions
6. Starosta A., Application of Bayesian network to estimate merchant ship usability for SAR action, Journal of KONES vol. 13 no. 3,