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RISK ESTIMATION OF SAR ACTION

ABSTRACT

The paper presents the influence of shipborne incidents on possible consequences. Non rescue ship during SAR action can come under risk. The presented hazard function in dependence on the vessel type, involved in SAR action, possible consequences for ships during the SAR action allow proposing the risk measure and matrix of vessel suitability during SAR action.

Keywords:
risk, hazard function, SAR.

INTRODUCTION

Together with other global industries, the maritime world is being forced by legislation and political pressure to reconsider its infrastructure, operations and processes. As a result, risk assessment is quickly becoming a central function of strategic management and corporate governance. In order to identify potential sources of harm in operational working environment, a structured approach is required to ensure that the activities are evaluated with respect to risk.

An accident will invariably result in harm to people, property or environment with the additional consequence of business loss [www.lr.org. Operational 2006]. Risk is a dynamic property of a system that requires a causal analysis of the system using models that represent abstractions of the actual system.

According to art. 60 § 1 the ship Master is obliged to help people in danger at sea, if this help rendering does not expose his ship and people on board to the serious danger. According to § 2. The ship owner is not responsible for the violation of the responsibility mentioned in § 1 by the ship Master [Act Maritime Code 201]. The United Nations Convention on the Law of the Sea (UNCLOS) imposes the obligation to render help [Daily of Acts art. 98, 2002].

Maritime transportation is connected with risk. The risk in dependence on the area of navigation — navigational conditions, environment, vessels equipment, reliability of devices and their technical working order as well as crew qualifications and real skills, can exist on different levels and can not ever be eliminated; the risk can only be reduced.

The rescue actions at sea are usually conducted in heavy sea conditions, hazardous for the survivors — in the water or inside life saving appliances. The stormy weather is also a potential threat for the ships 'under the way' [COLREG 1995] and the crews taking part in the search action. The environmental conditions can limit or even eliminate the contribution of a vessel or vessels in SAR action with respect to her technical and operational characteristics in heavy weather.

The six categories can be identified in the causal chain: basic causes, immediate causes, triggering incident, accidents, consequences and impacts. [Harrald 1995]:

1. Basic causes are root causes of an accident, such as inadequate recruitment, training or supervision, or poor preventative maintenance and/or inspection of critical systems.
2. Immediate causes are the direct causes of accidents; human error, such as incompetence or inattention, or component failure which lead to an incident.
3. Incidents are undesirable events related to control or system failures. Incidents are the events that trigger accidents. Incidents can be detected or corrected in time to prevent accidents; incidents can also be prevented from developing into accidents by the presence of redundant or back up system. Examples of incidents include propulsion failures, steering failures, electrical power failures, and human errors.
4. Accidents are occurrences that cause damage to vessels, facilities or personnel, such as pollution incidents, collisions, allisions, groundings, fires, explosions or foundering.
5. Consequences are the impacts of accidents on personnel, equipment and the environment; an example of consequences is persons in peril in the event of a grounded passenger vessel.
6. Impacts are the results of accident consequences on individuals, organizations, the environment and the system.

The hazards existed in ship operation classified in 6 categories of the casual chain are presented in figure 1.

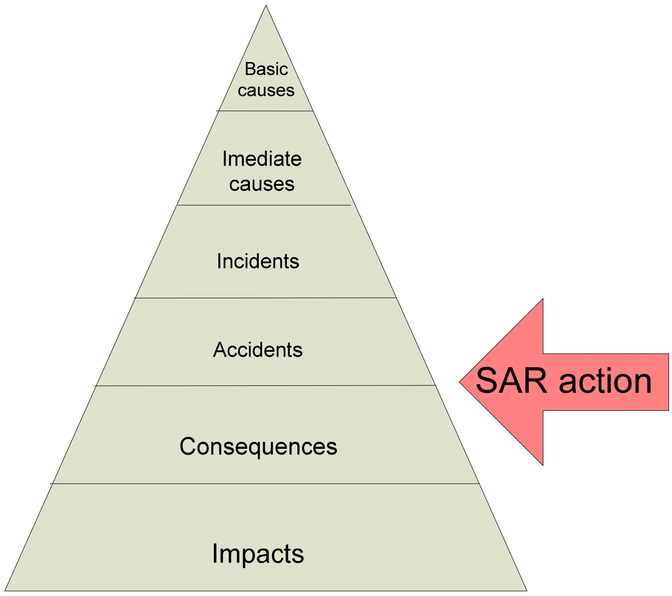

Fig. 1. The six categories in the causal chain, based on the data published by [Harrald 1995]

According to IMO [Casualty of Safe 1997]:

1. 'Very serious casualties' are casualties to ships which involve total loss of the ship, loss of life, or severe pollution, the definition of which, as agreed by the Marine Environment Protection Committee at its thirty-seventh session (MEPC 37/22, paragraph 5.8).
2. 'Serious casualties' are casualties to ships which do not qualify as 'very serious casualties' and which involve a fire, explosion, collision, grounding, contact, heavy weather damage, ice damage, hull cracking, or suspected hull defect, etc., resulting in:
   - immobilization of main engines, extensive accommodation damage, severe structural damage, such as penetration of the hull under water, etc., rendering the ship unfit to proceed, or
   - pollution (regardless of quantity); and/or
   - a breakdown necessitating towage or shore assistance.
3. 'Less serious casualties' are casualties to ships which do not qualify as 'very serious casualties' or 'serious casualties' and for the purpose of recording useful information also include 'marine incidents' which themselves include 'hazardous incidents' and 'near misses'.

Every sea accident is connected with hazard to people life and also with the considerable hazard to the sea environment. All the hazards are connected with several causes generating particular consequences or with the system components which condition or form a hazard [Smalko 2003].

There is a possibility of different consequences come into being for people, property and environment as the results of accident (fig. 2).

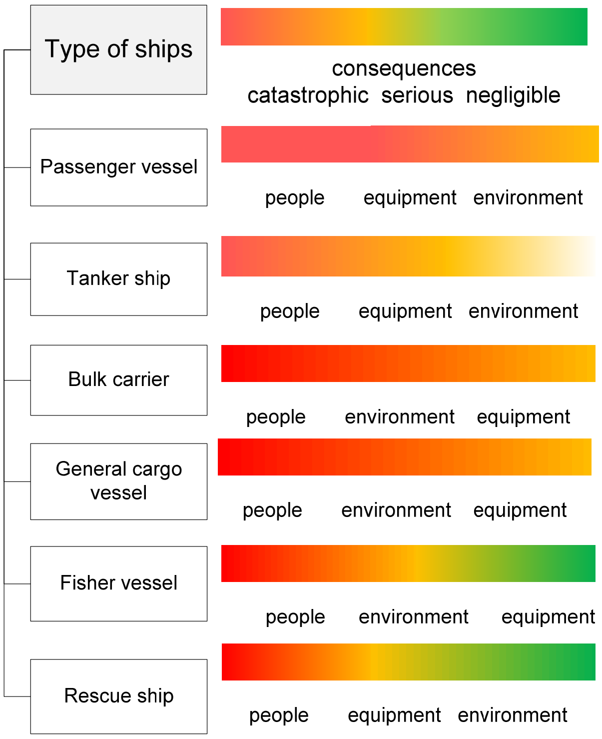

Fig. 2. Influence of shipborne incidents on possible consequences

RISK OF NON RESCUE SHIP IN SAR ACTION

Every ship during her voyage has to satisfy several safety criteria: i.a. stability, survivability, cargo lashing. Every Master is responsible for undertaking the appropriate action which aim at avoidance or reduction of hazardous situations during the navigation in heavy weather conditions [Dudziak 2008], [Acc.MSC.Circ.707, 2002]. The vessel's Master undertaking the action to participate in search action in stormy weather should consider safety of his ship, crew and cargo [Resolutions A168(ES.IV) 2006], [Code of Safe, 1997].

The conditions following from the safety analysis which should be considered by the SAR action coordinator in case of the requisition of merchant vessel are as follows:

— ship stability parameters: *GM*, natural rolling period;
— type of cargo and lashing (required strength of lashings);
— ship manoeuvrability;
— maximum (available) safe speed in particular weather conditions;
— minimum (available) safe speed necessary to keep the course stability;
— possibility of navigation on the head waves — possible slamming and dynamical loads;
— possibility of navigation in the following seas — loss of stability, surfriding, broaching;
— possibility of navigation on the transverse courses to the wave direction;
— synchronous rolling and parametric rolling, resonance;
— number of the observers on watch, conducting simultaneously the optical observation;
— means of electronic observation availability;
— possibilities of picking up survivors, rescue boats, lifeboats, operational skills of rescuers, experience of rescuers;
— possibilities of taking the survivors on board.

The sweep width is dependent i.a. on the visibility range. For example not every vessel can be involved in expanding square search It depends on the possible expositions and manoeuvring characteristics. For example the tactical diameter for VLCC can be over 0.5 Nm, which eliminates this vessel form the search when the maximum sweep width is less then 0,5 Nm. Picking up survivors in the life raft on board some vessels is difficult or even impossible as for example for car carriers.

The unfavoured circumstances to proceed the rescue task are identified as expositions [Smalko 2003/5], causing the hazard to for the rescuing people and vessel. Their reasons are the internal forcing factors (for example — ship loading condition) as well as the external forcing factors (environmental, atmospheric).

In case of a possible threat to the vessel the SAR action coordinator should check the possibilities of the search pattern position change with respect to the wind direction. If this will not position the vessel in the sector of safe navigation then the search pattern should be changed.

Positioning of the search pattern with respect to the wind direction (wave direction) is the most important element ensuring safety of the merchant vessel working as a search unit. The Master of the search unit has the right to not agree with a certain search pattern.

RISK ESTIMATION IN SAR ACTION

The resultant risk is a stochastic term, therefore the risk estimation in SAR action means the calculations with a certain probability of and certain confidence level.

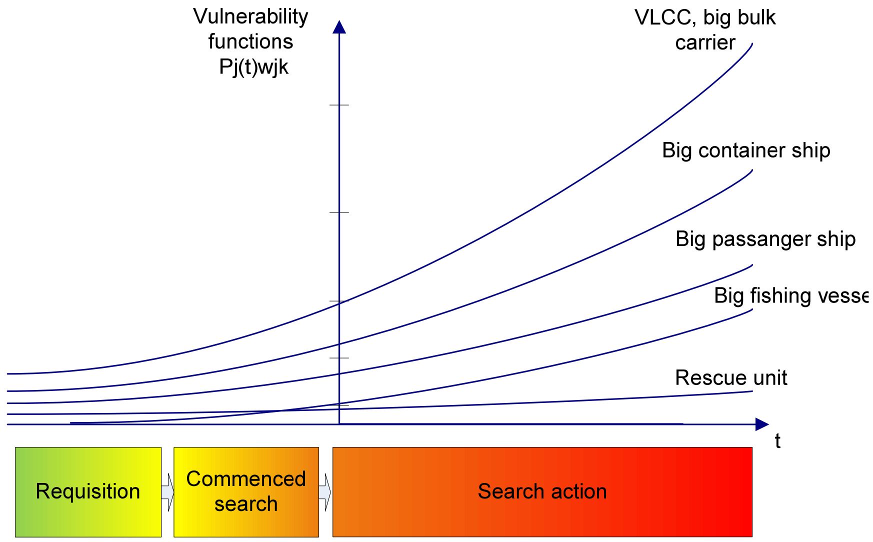

Fig. 3. Hazard function in dependence on the vessel type taking part in SAR action — based on the experts opinions

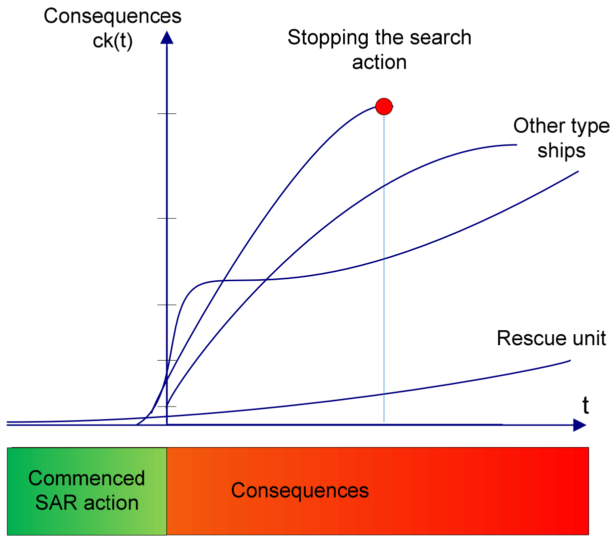

Fig. 4. Possible consequences for ships during the SAR action

Risk (R) is the function of hazard probability (P) and hazard consequences (S):

$$R = f(P, S). \tag{1}$$

Probability (P) is a function of frequency (O) of similar events, exposition (E) which is the time of exposure and possibility of harm (A) of a particular weight (S) reduction. The risk can be presented in the following form [Burciu 2007/1, 2007/2]:

$$R = f(O; E; A; S). \tag{2}$$

The applied theory of risk refers to a body of techniques to model and measure the risk associated with a set of N rescue ships in search action. The approach consists of the modeling of the distribution of total searched area over a fixed period of time using the collective model of risk theory.

Let the random variable S represent the aggregate area amount over a fixed period of time, random variable N represent the number of rescue ships over that period, and random variable S_k represent the amount of searched area for *k-th* ship. Then, we have the random sum:

$$S = \sum_{k=1}^{N} S_k \ , \tag{3}$$

where we assume that S_1, S_2, … are mutually independent random variables, each independent from N. The task consists in evaluating numerically the cdf of S, given by

$$F_S(x) = \sum_m P\left[S < x \middle| N = m\right] P\left[N = m\right] = \sum_m F_{S_k}{}^{\bullet_k n}\left[x\right] P\left[N = m\right], \tag{4}$$

where $$F_{S_m}(x) = P\left[S_k < x\right]$$

is the common cumulative distribution function of S_k and

$$F_{S_k}{}^{\bullet_k n}\left[x\right] = P\left[\sum_{k=1}^{N} S_k < x\right] \tag{5}$$

is the n-fold convolution of $F_{Sk}(.)$.

In this case the reasonable solution is the adoption of weighting factors reflecting the negative consequences of the particular types of hazards, dependent on the type of the rescue unit and the character of her exploitation, which influence the quantity of the search area (fig. 5). The proposed risk measure is expressed by the following formula:

$$R[t] = \sum_{j} P_j(t) \sum_{k=1}^{N(t)} w_{jk} \cdot c_k(t), \tag{6}$$

where: $R[t]$ — risk measure for the search units taking part in SAR action;
$P_j(t)$ — probability of the j-hazard;
$N(t)$ — number of search units in time t;
w_{jk} — weighting factor reflecting the negative consequences of j-hazard for k-type of vessel influencing the success of SAR action;
$c_k(t)$ — consequences of k-type of vessel.

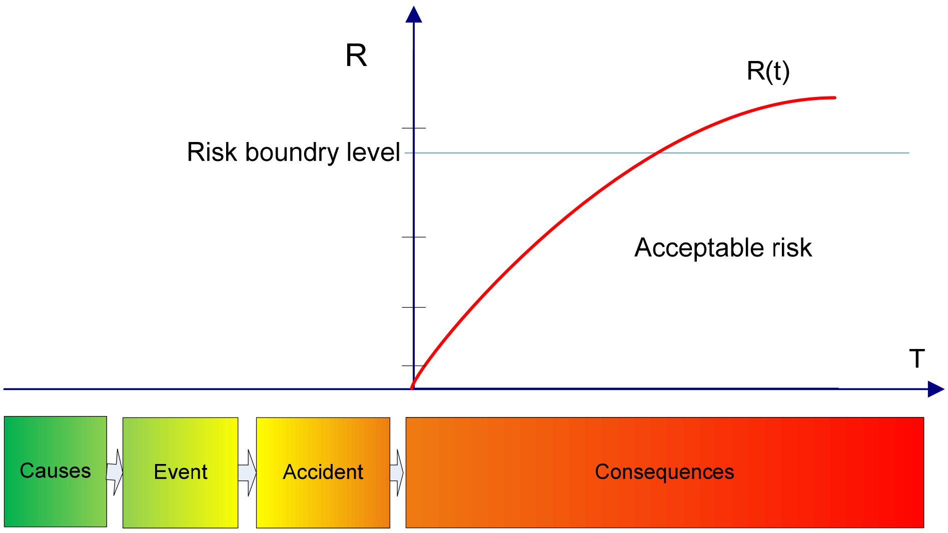

Fig. 5. Example of risk function

The safety of a vessel taking part in SAR action can be estimated on the basis of ship safety matrix presented in figure 6, however the mutability of operational parameters within the same type of vessel in dependence on propulsion and steering equipment should be considered.

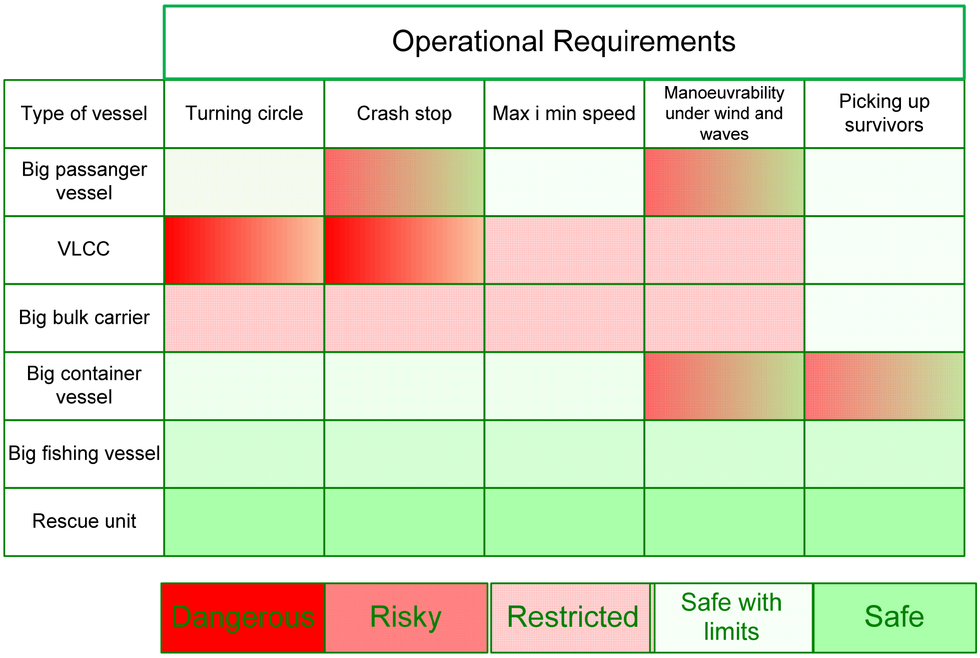

Fig. 6. Matrix of vessel suitability during SAR action

CONCLUDING REMARKS

The paper presents problems connected with safety of waterborne search units taking part in SAR action. One of the most important problems is the estimation of the operational hazard in SAR action with respect to search units hazards. The estimation of the hazards is especially important for the SAR action coordinator during the process of making decision on non-rescue vessels requisition, with drawing the search unit from the search action and interruption of search.

The models presented in the paper allow for the determination of the time dependent risk function, for the particular units and the whole action. This requires to comply with the environmental conditions — on line and predicted in the estimation of probability distributions $P_j(t)$ and technical and operational parameters of the particular units necessary for the estimation of weighting factors w_{jk} as well as consequences functions $c_k(t)$.

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