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APPLICATION OF FORMAL SAFETY ASSESSMENT IN THE LEGAL ACTIVITY OF INTERNATIONAL MARITIME

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Abstract

Ensuring the safety of navigation requires searching and implementation new methods of operation by International Maritime Organization. Greater vessel dimensions, large quantities of dangerous goods transported by sea, require enforcing new regulations for waters of the increased risk of occurrence of a dangerous situation or collision. Identification of hazards allows predicting different scenarios of events and finally the diagnosis for risk assessment, its control and limitation.

Activity connected with the improvement safety of navigation should be unified and the same tools for such action are recommended to be applied worldwide.

The paper discusses the role of formal safety assessment as a tool used by the International Maritime Organization in the decision-making process. The applicability of this methodology in national and shipowners' regulations concerning the safety of navigation is presented in this article.

Keywords*: IMO, safety of navigation, risk assessment, FSA*

1. Introduction

Maritime Safety Committee of the International Maritime Organization during the 74 session in 2001 and the Marine Environment Protection Committee during the 47 sessions in 2002 approved the Guide for Formal Safety Assessment (Guidelines for Formal Safety Assessment-FSA). Its purpose was to use the process for creating regulations by the International Maritime Organization. In November 2012 and May 2013, the IMO Maritime Safety Committee together with the Marine Environment Protection Committee introduced changes to the document. The International Maritime Organization encourages the Member States and organizations participating in the work of the IMO to make these adjustments in their activities related to the creation of legal regulations. Formal Safety Assessment (FSA) is a method of enhancing maritime safety and the protection of life at sea, health and the marine environment, and property with risk analysis and study of the associated benefits. The method is a tool for the introduction of new regulations to improve maritime safety and protection of the environment. Their improvement and analysis in the context of rationalization, alike in terms of technical and formal-legal aspects should bring both the increase in safety and reduction of costs associated with shipping.

2. Components of the FSA

Formal Safety Assessment is a five-step process that covers all aspects of safety analysis and suggests adequate protective measures for marine areas. This process consists of the following steps:

- identification of hazards (risks),
- risk analysis,
- risk control options,

– cost benefit assessment,
– recommendations for decision-making and regulations.

Identification of potential hazards should be based on the following data: the type of vessel to be affected, the characteristics of the area (shallow waters, currents, tides), weather conditions, other vessels traffic. This process must include human element as one of the potential hazards. The analysis of possible accidents or events should result in creating of appropriate scenarios; identification of hazards should give the opportunity to build proper plan in a given situation. It is impossible to create exercises based only on legal regulations. Such scenarios for port approaches may be defined for example within Vessel Traffic Services. The method of risk identification should be a compromise of creative and analytical techniques. The creative technique is to ensure the continuity of the identification process and to assure that the process is not limited to the risks that occurred in the past. Identification must determine the cause and effects of the event and the associated risks. The identification process should involve experts from different branches, i.e. experts of the shipbuilding and ship operation, as well as ship management experts and specialists who identify hazards including human factor as one of them. The analytical technique ensures that the lessons learned from past events will be properly used. The identified risks and the associated event scenarios should be systematized and be given the right priorities depending on the possible risks.

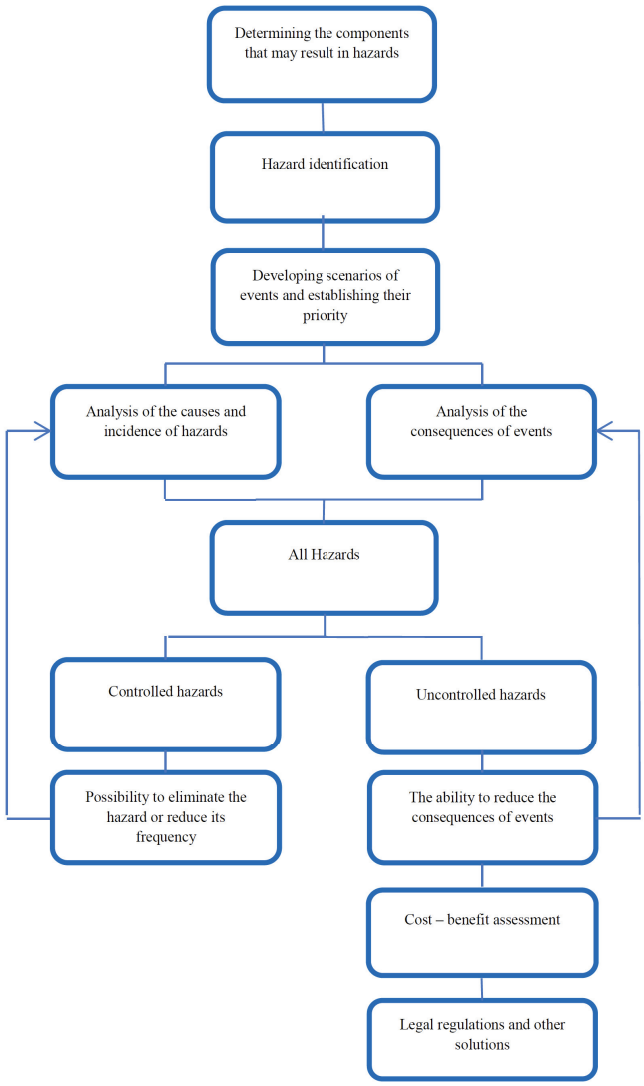

Fig. 1. Methodology applied in Formal Safety Assessment and in the involvement of human factor (HRA) in this process [6]

Factors that should be taken into account when identifying risks are the following:

a) vessels (type, size, draft, condition),
b) transported cargo (bulk, containers, dangerous goods, gas, liquid, etc.),
c) possible accidents categories (e.g. collision, grounding, fire, etc.),
d) hydrometeorology (occurrence of bad weather conditions),
e) the characteristics of the sea area (navigable waters, risk of grounding),
f) human element (the consequences of making a mistake by a crewmember).

The purpose of risk analysis is a detailed study of accidents and events and their consequences. It is necessary to predict possible consequences for integrated hazards and to use available risk modelling techniques for such cases. This allows to draw attention to high-risk areas and to identify factors, which affect the level of risk. Different types of risks (relating to people, to the environment or to property) should be selected as a problem to be solved. Three main categories of risk can be distinguished as a result of risk analysis.

The pattern below illustrates the existence of individual risk.

$$IR_{\text{for person Y}} = F_{\text{for understanding the event}} * P_{\text{for person Y}} * E_{\text{for person Y,}}$$

where:
F = frequency,
P = probability of an accident occurrence,
E = minimal risk exposure.

Another category is the social risk that is a medium risk in terms of the number of fatalities. An example of social risk is to expose a whole group of persons (e.g. crew, port workers or the general public) to the risk of accidents. Social risk occurs when there is risk of death and this is expressed in specific patterns and in potential risk of loss of life (Potential Loss of Life -PLL).

There are many methods for risk analysis. If some data for their assessment are missing, the estimation method or set of expert techniques should be used.

The result of the risk analysis should be the following:

- identification of areas of relative risk,
- explanation of risk models.

3. FSA Methodology

As mentioned above, the methodology includes five consecutive interdependent activities to the final stage of the formulation of specific recommendations or to issue the necessary legal acts:

A. Identification of Hazards

When catalog of hazards is created, it is important to employ creativity and analytical approach. A distinctive creative method is HAZOP study (Hazard and Operability Studies -risks and possible actions) [5]. This technique is used for progressive risk analysis covering the whole and operational period starting from the identification of hazards ending on preventive measures. This makes it possible to exclude the possible hazard during its identification. Experts from various fields of science (such as ships' construction and operation) in other stages of formation of the system take into account the potential errors of devices, while searching for the reasons and consequences of their occurrence [5].

Another technique using a creative method is WIA (What If Analysis) that is being used by experts during consultations [5]. Experts in the analysis consider issues such as errors involving the improper use of equipment, measurement mistakes, equipment failures, malfunctions. Technical instructions, manuals or explanations by professionals [5] are used by these experts.

The analytical method is a technique that allows developing a catalog of hazards. This system is mainly based on the most efficient use of the experience gained with the use of an object that is formal regulation subject of safety assessment. It is about the analysis of events, the norms and forced regulations in some area. Statistical research into separate instances of hazards, accidents

and harmful substances is used for this kind of action.

The analytical method makes use of FMEA Analysis (Failure Made and Effect Analysis – analysis of the causes and effects of failure). This method allows detailed analysis of a selected component of the system. The impact of failure of an element on the operation of the device is analysed. For this purpose, all security and mitigating measures are taken into consideration as well as the consequences of compensatory failures. This helps to find opportunities to minimize or eliminate the impacts of failure. FMEA allows also defining reason for the whole system failure [5].

Once a catalog of hazards has been created and their scenarios developed, it is necessary to select those that are least likely to occur. Each scenario requires an estimate of its frequency and the impact of its occurrence. On the basis of these data, classification of hazards is created. The table of hazards is used for such classification.

B. Risk Analysis

Risk analysis is the next step in the technique used by the FSA. Its main task is a detailed assessment of risk resulting from hazards identified in the first phase and the identification of factors affecting its level. For this purpose event, trees and fault trees are used.

Event tree is a graph used to analyse logical consequences of the accident, unintentional actions or failures. It is used to illustrate the probability of an accident in connection with a certain action to be taken in order to stop the development of the danger. Value of possibility of occurrence of a specific effect is the ratio of elements of probability of failure or success leading to it.

This diagram showing the logical relationship between events that occur individually or in combination with other events causing a higher level of the tree is called a failure (fault tree). They are used for representation of the probability of occurrence of an event, which is at the top of the chart. Building of tree unreliability uses top-down action, systematically searching for events and reasons for even lower levels. Detailed principle of operation of reliability tree and relationship between events are described in document IMO -MEPC.2 / CIR.12, 2013.

C. Risk Control Options

The next step of FSA technique is to find the most effective methods of reducing risk. Risk control option (RCO Risk Control Options) must meet the following requirements:

- devote particular caution to areas that are most exposed to risk and require special attention.
- create potential risk control measures RCM (Risk Control Measures)
- estimate the effectiveness of potential risk control measures by reducing the risk degree,
- using the results obtained at the second stage.
- forming legal solutions on the basis of risk control measures.

At the second step of synthesis, issues that involve the greatest risk of exposure require close monitoring.

The following elements should be taken into account:

- the degree of risk – making the synthesis of the frequency of occurrence and taking into account the results that may arise thereof, those cases where the degree of risk is unacceptable should be focused on,
- the possibility of probability – diagnosis of issues related to the most probable occurrence of risks. The synthesis of possibility of the event occurrence does not take into consideration the consequences that the event brings about,
- the severity of the consequences – identify the areas that involve the most dangerous consequences. Regardless of the probability of occurrence,
- the reality – define the least probability of occurrence or the lowest severity.

Risk degree adjusting is performed using the risk control measures. It is based on the following issues:

- limiting the number of accidents and incidents, by streamlining procedures and organization of

work, perfecting the construction, modernization of education, etc...,
- moderating consequences of events so they will not result in an accident,
- exclusion of situations leading to failure,
- moderating consequences of accidents.

New risk management methods are created for the issues for which the current methodology is insufficient. Properties applicable in the cause and effect analysis and those pointing out the moment of RCM implementation are useful here to minimize the risk of occurrences.

There are three types of risk control measures:
- The RCM action:
  - preventive measures – reducing the chance / probability of events,
  - neutralizing agents – mitigating the extent and events.
- Characteristics related to the scope of RCM action:
  - technological measures – the ingredients for enhanced security, placed in the scheme during designing phase,
  - switch off measures – reduce the risk by eliminating the components potentially contributing to occurrence of accidents,
  - the coordination measures – reducing risk by proceeding in accordance with the guidelines and procedures in force.
- RCM attributes:
  - de-concentrated measures – operation of all components of the entire system,
  - focused measures – operation of the individual components of the system,
  - passive measures – automatic operation,
  - active measures – acting after switching on the system,
  - separate measures – do not affect the operation of other risk control measures
  - dependent on human activities measures:
    - using human factor – the risk control is dependent on the activity of a person,
    - where a human error does not affect the occurrence of an accident,
    - employing a critical human factor – risk control is dependent on human activities, where human error has an impact on the occurrence of an accident,
  - quantitative and qualitative measures – indicating whether the risk control measures are based on quantitative or qualitative risk assessment,
  - the existing measures – built on existing solutions and their development,
  - new measures – to create new risk management measures.

In order to synthesize the risk control measures, properties are added. Closed list of risk control measures is formed and then follows their qualification in functional risk control options. RCM can be connected through many different techniques to create the least complicated useful options. There are two methods of RCM connection:
- general method – the risk is controlled by preventing the possibility of initiating events. This leads to inhibition of the sequence of events that lead to occurrence of accidents,
- special method – the risk is controlled by the accidents and the prospect of the occurrence and progression of other dangerous events.

D. The balance of benefits and costs

Binder connecting analysis with the proceedings of the IMO decision-making can be found in the last two steps of the FSA methodology. This correlation makes it possible for effectively use development, to increase the efficiency and clarity of the regulation of international maritime law.

One of the last steps of the FSA methodology is the balance of costs and benefits. It is designed to demonstrate the specific profits that may arise due to a potential risk control measures (RCO). Costs of implementation of each option, which were put into effect, are presented and summarized.

Cost and benefit can comprise the following steps:

- considering the risks assessed at the second stage, both in terms of frequency and consequently to determine the case base considered in terms of the level of risk in a given situations,
- organization of RCO in such a way as to facilitate the understanding of the costs and advantages of the RCO,
- estimation of relevant costs and benefits for each RCO,
- estimation and comparison of the cost-effectiveness of each option in terms of cost per unit of risk reduction by dividing the net cost by reducing the risk by means of the options,
- RCO classification in terms of costs and benefits in order to facilitate the decision-making of recommendations (for example, to search those that are not profitable and unrealistic).

Costs should be expressed in terms of life cycle costs and may include initiation, implementation, training, inspection, certification, liquidation, etc. Benefits can include decrease in fatalities, injuries, accidents, environmental damage and waste, the exemption of obligations of third parties and increase in average life of ships.

Costs and benefits assessment can be carried out using various methods and techniques. Such process should be conducted for general situation and also for those parties who are most involved.

Generally, the concerned party can be defined for example as a person, organization, company, the coastal State, flag State, that is directly or indirectly affected by the accident or the cost-effectiveness of the proposed new regulation. Different parties with similar objectives can be grouped to apply together the FSA methods and to identify recommendations decision.

There are several indicators that express the profitability in relation to the safety of life, such as the gross cost to prevent misfortune (CAF gross) and the net cost to prevent misfortune (CAF net). Other indices based on damage and affecting property and the environment can be used to assess the costs and benefits associated with such matters. Comparison of cost-effectiveness of RCO can be made by calculating these indicators.

Criteria for assessing environmental risk can be used for the evaluation of the RCO, focusing on the prevention of oil spills from ships.

Sensitivity and uncertainty analysis should be included in cost-benefit analysis and cost-effectiveness and the results should be reported.

The final step of evaluation of costs and benefits includes:

- the costs and benefits for each RCO identified in step 3 from the perspective,
- the costs and benefits to parties most affected by the said problem,
- profitability expressed by means of appropriate indicators.

The last step in the FSA procedure involves the creation of the recommendations for decision-making. Its main task is to identify the recommendations to be presented to the relevant decision makers under the control and verifiable manner. Recommendations should be based on the comparison and ranking of all hazards and their causes.

The recommendations should be presented in a form that is clear to all parties, regardless of their experience in applying risk and cost-benefit assessment and related techniques. Transfer of the results of the FSA process should be timely and provide open access to relevant documents and provide an opportunity and a mechanism to add comments.

There are several criteria for risk acceptance, yet none has been widely accepted. However, it is desirable that new legislation or amendments to existing regulations were explicit in order to establish consistent criteria for risk assessment and for those used as part of the FSA proposed by the organization and national governments.

The output of the last step of formal safety assessment includes:

- comparison of alternative solutions with regard to potential risk and cost reduction in areas where the legislation or regulations should be revised or developed,
- feedback to review the results achieved in the previous steps,
- RCO recommendation associated with the use of RCO, for example the use of the type (s) of

vessels and the date of their building and / or systems to be installed on board.

E. Recommendations for decision-making

FSA in the last step of its methodology assumes the introduction of amendments to legislation. Recommendations should be based on a catalog of hazards and their causes, the costs and benefits of risk control options, the implementation of which would increase the degree of risk to the expected level. These projects should be written in such a way that neither the research teams nor any individuals are affected by the legal wording.

4. Conclusion

The increase in safety of navigation is an ongoing process and requires the use of better available methods. This process involves IMO, Maritime Administration of different states and ship owners. Introduction of Formal Safety Assessment allows for the assessment of safety in a systematic way. Hazard identification is complex and if it is performed thoroughly, all factors that could create a hazard will be taken into account. If the risks are known, they can be assessed and their gradation can be determined from negligible to most dangerous. The scenarios of events allow for action that is more effective when a defined event occurs. The list of hazards enables actions to eliminate them where possible. Many elements of the formal safety assessment can be used in assessing the safety of ships. It is performed by the owner and the master of the ship. This method can be particularly helpful in assessing the safety of a ship carrying dangerous goods (large gas carriers, oil tankers, etc.). To improve the safety of navigation it is important to use formal safety assessment. This methodology helps to eliminate the hazards, avoid them or take actions minimizing their consequences by implementing appropriate regulations.

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