Some issues of safety assessment in the Ukraine

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Abstract

The safety of navigation and the marine environment is the core issue in the modern shipping industry which governs all the sides of its life, operation and development, but this issue preconditions the investigation of all sorts of dangers and threats as well as the degree of the ship's safety. The principal methodology of this process is **THE GUIDELINES FOR FORMAL SAFETY ASSESSMENT (FSA) FOR USE IN THE RULE-MAKING PROCESS** as adopted by **IMO (MSC/Circ. 1023 – MEPC/Circ. 392)** 5 April 2002 as amended by **IMO (MSC/Circ. 1180 – MEPC/Circ. 474**) 25 August 2005 and **IMO (MSC-MEPC.2/Circ.5.)** 16 October 2006. (2)

FSA is a structured and systematic methodology aimed at enhancing maritime safety including protection of life, health, the maritime environment and property by using risk and cost/benefit assessments, its principal objective being the formalization of all factors influencing the safety of the ship and the environment for their subsequent quantification.

The simplest mathematical expression of risk is the following R=PC, where R – risk, P – probability, C – consequence. Some authors give some other similar general expressions, but the most difficult and important problem in this respect is finding the independent variables -- the functions of which these expressions are -- which is of primary importance for their subsequent quantification. Some authors propose particular solutions for the identification of these independent variables and even give them quantitative values (3,8,10). In search of the solution for the above problems it is worthy to note that some authors attract the attention to the similarity of safety and the security issues (7). We also paid attention to this fact (4), especially to the identity of the mathematical expressions used for both problems.

Certainly, the independent variables of these functions will be absolutely different but the method of analysis used for the investigation of security is applicable for the investigation of the safety and vice versa.

The haphazard random element in the occurrence of accidents complicates the investigation of the causes of the disasters. Some authors (1,9) address sophisticated mathematics such as calculus of probability and game theory etc. to facilitate it.

1 Introduction

For better understanding of the analyzed papers it is necessary to review the principal terms and definitions used in them. To our mind the best definition of safety for our purpose is given by Ch. Kuo: "Safety is a perceived quality that determines to what extent the management, engineering and operation of a system is free of danger to life, property and the environment" (11).

One of the most important values requiring investigation for the provision of safety is risk. Ch. Kuo gives the following definition of risk: "It (risk) is likely outcome or probability of occurrence and the severity of consequences that are of interest"(11). One more definition is given by the other authors: "Risk was defined as a measure of the probability and severity of consequences of undesirable event". (6)

$R=PC$

Where R – risk; P – probability and C – consequences. Sometimes such characteristics as "frequency" and "hazard" are used in the definitions. Risk may be defined as "the combination of the frequency and the severity of the consequence" (2).

$R=FC$

Where F – frequency.

Or "A combination of the probability or frequency of occurrence of a defined hazard and the magnitude of the consequence of the occurrence" (ISO 8402; 1995).

Where

Consequence: The outcome of an accident.(2)

Frequency: The number of occurrences per unit time (e.g. per year).(2)

Hazard: A potential to threaten human life, health, property or the environment. (2)

In the security risk management the frequency is considered to be the product of two factors threat – (T) and vulnerability (V). (5)

$F=TV$

$R=TVC$

Where threat is defined as an event, process, or phenomenon which is able to break the stability and development. (9)

Vulnerability:

The magnitude of probability at which the existing protection measures will not be sufficient for the prevention at the undesirable event. (9)

After the Identification of hazards (step 1) the FSA manual proposes the fulfillment of risk analysis. (2)

The purpose of the risk analysis in step 2 is a detailed investigation of the causes and consequences of the more important scenarios identified in step1.

This can be achieved by the use of suitable techniques that model the risk. This allows attention to be focused upon high risk areas and to identify and evaluate the factors which influence the level of risk. (2)

Risk analysis is about developing an understanding of the risk. Risk analysis involves consideration of the sources of risk, their consequences and likelihood that those consequences may occur. That is, the risk is analyzed by combining consequences and their likelihood. The consequences and likelihood of each risk source determines the level of risk.

Risk assessment is often defined as the process of understanding what bad things can happen, how likely they are to happen, and how severe the effects may be.

2 The contribution of different authors to the specific problem of interest

Christopher Wiernicki, ABS President (3), brings into focus the predicted events for the near future which will greatly influence all the problems of shipping industry at all the levels, beginning from designing and construction of ship to their operation.

China's demand for oil and gas is now second only to that of the United States, yet its per capita consumption of energy is only a small fraction of its more developed trading partner. And India, with a population now exceeding one billion people, scarcely even registers as an energy consumer on a per capita basis. To meet the future expected demands of these two nations alone, both of which are on an accelerated pace of domestic economic growth, will provide an enormous challenge for the energy sector. Most of that exploration will take place within the marine environment. Some of those waters are relatively benign and some of them are decidedly hostile (such as the Kazakh portion of the Caspian and the northern waters of Russia).

Yet, the emerging global economic needs are relentlessly driving the next generation of Marine and Offshore Structures. These structures are growing to unprecedented size and complexity. It is likely that, before this year closes, the first order for a large compressed natural gas carrier will have been placed. In the last five years, LNG carriers have almost doubled in size from 135,000 to 250,000 cu meters for the latest orders. An entire new fleet of ice class tankers is taking shape in Asian shipyards, ready to transport the oil to market. Most of these projects are at or are pushing beyond the boundaries of existing knowledge.

The capital investments involved, the financial risks of downtime and the environmental risks of failure are now so great that safety can no longer be implied: It must be understood.

Prescriptive standards have served the industry well. Empirical knowledge will always form a bedrock upon which appropriate technical standards will be founded. But these techniques are no longer sufficient, by themselves, to offer

an acceptable level of confidence that the risks associated with a venture have been properly addressed.

The increased complexity and larger size of the ships being developed for operation in harsher and more remote environments are driving the adoption of safety equivalency standards, of unified standards and of risk-based approaches.

Current and proposed boundary pushing projects will challenge all of us to breakthrough our own technological barriers in order to protect and extend our safety frontier – the frontier where technology meets the immutable demands for the protection of life, property and the marine environment.

Perhaps, the single most important tool we have available to us as we confront this new frontier is risk assessment. Risk is defined as the product of the frequency with which an event is anticipated to occur and the consequence of the event's outcome. Risk assessment is the process of gathering data and synthesizing information to develop an understanding of the risk of a particular enterprise.

To gain an understanding of the risk of an operation, it is necessary to answer the following three questions:

- What can go wrong?
- How likely is it?
- What are the impacts?
- The risk assessment process consists of 4 basic steps:
- Hazard Identification
- Frequency Assessment
- Consequence Assessment
- Risk Evaluation

The challenge the Industry faces with these boundary pushing projects is how to properly evaluate a new design that falls outside of existing knowledge.

Risks can be quantified by risk indices that are developed from different combinations of frequencies and consequences. In general, there are four different types of risk tradeoffs based on the outcome of events and the group that is influenced by these outcomes.

These are:

- Risk Transfer
- Risk Offset
- Risk Transformation
- Risk Substitution

Depending on the frequency of occurrences, the resulting consequence and the risk tolerance of the company (or the industry or of society), these four types of risk tradeoffs form the foundation of the corporation's risk strategy.

The set of risk tradeoffs in which any increase in protection against one risk means a decrease in protection against another risk, for a given set of resources, traces out a Risk Protection Frontier.

The shape of the Risk Protection Frontier depends on the relationship between protecting against one risk and reducing protection against the other.

Any point on the Risk Protection Frontier represents a total risk distribution comprised of two components:

- Catastrophic risks (intolerable risk in FSA Manual terminology) and
- Operational risks (Tolerable risks, ALARP zone in FSA Manual terminology)

Beyond choosing among points along the Risk Protection Frontier, the question that we must continue to ask ourselves is – Can we do better and reduce overall risk?

The possibility of overall risk reduction can be achieved by moving the points to a higher Risk Protection Frontier through using "Risk Superior" moves.

Risk Superior moves are made possible by innovations in technology.

Risk Superior moves reduce overall risk rather than trading one kind of risk for another.

Risk Superior moves require a system solution that does not treat risks in isolation but acknowledges that risks cut across all boundaries.

In essence, safety must be redefined and quantified if we are to continue pushing both the physical and technical boundaries.

In considering operational safety, our efforts must be focused on how that question can be most effectively answered and to determine what information can be relayed to the operators to help them avoid previously identified operational hazards.

Technology breakthroughs such as dynamic loading analysis, probabilistic modeling, non linear structural response, composite materials, quantitative risk assessment and numerical simulations help us rationalize structure performance and safety requirements (3).

It is quite natural that those factors which influence the level of risk and the probability of an event and its consequences have a casual character. But there are such factors which may be determined and even quantified to a certain degree of approximation. For instance, factors such as region of navigation, ship design, age and the technical state of the ship certainly may influence the probability of an accident. Thus professor De Yi Gao (8), proposes as a very important criteria of risk assessment (Step 2 FSA Manual) the evaluation of two important risk components: the quality of the ship and its crew and the way of their quantification. The evaluation of the Quality Ship System may use the hierarchy analytical method of the management study by regarding the above six basic indexes as factors on the grade. Factors that can be logically estimated should not have the secondary index. As for the sixth index, a secondary index and even a tertiary one should be set in fix upon the quantified value. The index system is shown in table 1.

Table 1. The index system of the evaluation of the Quality Ship on the first grade

(Ship Safety Performance and Defect index System)

A1	Detention of the ship
A2	Violation of the safety rules
A3	Maritime accident
A4	Violation of the safety management regulation as individual
A5	The resort rate of the shipping company
A6	The accumulative integral of detects

The accumulative integral of defects (A6) can be further divided into the secondary and tertiary index according to the needs.

According the *To Rules on Safety Inspection, 1997*, 16 secondary indexes can be set. (See Table 2). Every secondary index may be followed by relevant tertiary index (C) in order to describe the meanings of the secondary index in details.

Table 2. The secondary indexes

A6	B61* W61	Ship's certificates and the relevant files end documents
	B62 * W62	Crew and equipment
	B63 * W63	Life-Saving Appliances
	B64 * W64	Fire fighting equipment
	B65 * W65	Presentations against accidents
	B66 * W66	Generic safety precautions
	B67 * W67	Alarm equipment
	B68 * W68	Stowage of goods and loading and unloading equipment
	B69 * W69	Load line
	B610 * W610	Mooring equipment
	B611 * W611	Propelling and auxiliary machinery
	B612 * W612	Navigation equipment
	B613 * W613	Radio equipment

	B614 W614	*	Anti-pollution equipment
	B615 W615	*	Loading and unloading equipment of liquid goods
	B616 W616	*	Relevant equipment of the post and manipulation ability of the crew

Table 3. The Tertiary indexes

B61	Ship's certificate and the relevant files and documents	C611 * W611	Nationality certificate
		C612 * W612	Copy of DOC
		C613 * W613	Ship's survey certificate
		C614 * W614	Certificate of minimum manning
		C615 * W615	Documents relating to the reliability and insurance of the oil pollution
		C616 * W616	Certificate of safe operation for high speed craft
		C617 * W617	Related documents, manual, instructions and materials
		C618 * W618	Inspection book of the cargo handing facilities
		C619 * W619	Ship endorsements
		C6110*W6110	Ship Log and legal records

A conclusion can be made from the characteristics of the above indexing system. That is, the valuation system of Quality Ship is a system made by the combination of the logical estimation grade (the first grade index A) and a series of hierarchy distributions (A6). The Quality Ship may be demonstrated by the following formula:

$QS = \Sigma Ai$

The accumulative integral of the defects (A6) may be demonstrated as follows:

$A6 = B61\ W61 + B62\ W62 + \ldots\ldots + B615\ W615 + A616\ W616$

$= B61\ (\Sigma Bi\ Wi,\ \Sigma Cj\ Wj)\ W1 + B62\ (\Sigma Bi\ Wi,\ \Sigma Cj\ Wj)\ W61 + \ldots\ldots + B615$
$(\Sigma Bi\ Wi,\ \Sigma Cj\ Wj\ )\ W615 + B616\ (\Sigma Bi\ Wi,\ \Sigma Cj\ Wj)\ W616$

Notes:

B61 ...B616   Stands for the secondary index of the accumulative integral of the defects.

Cj   Stands for the tertiary index

Wij   Stands for the secondary or tertiary or weight.

The statistics and analysis of previous and recent casualties, before and after the application of the ISM Code, reveals no improvement in the aspects of collisions and groundings problems.

"The rallying cry that most casualties were caused by human factors led to the natural corollary that about 75-96 percent of maritime casualties are caused, at least in part, by some form of human errors". (11) And the regulations and Codes are not always a proper remedy if that "part" of human errors was made at the designing level. In this respect the work of G.V. Egorov "Designing Inner Waterway ships on the basis of the Theory of Risk" is of an interest. His definition of risk is similar to those of other authors: "when considering risk it is necessary to observe its two sides: probability and damage (loss)". He tries to analyze the interconnection of theory of Risk and "Reliability theory". "In application to technical sciences risk and reliability are somewhat deferent approaches to the same side of the investigated object". "Risk may be expressed as the product of the reliability characteristic of a structure by the characteristic of the damage as a result of unreliability".

The author proposes the following expression of the risk of hull breakage used in the process of its designing

$R = PC = \Sigma Pi (\Sigma \alpha ik C k)$,

where R – risk, P – probability, C – consequences.

i – the category of the imminent danger (threat)

(i = 1 hull breakage during cargo operations, or repair

i = 2 hull breakage when grounding etc.)

k – expenses of the hull breakage consequences recovery

Pi - probability of the accident occurrence due to i – danger (threat)

Ck – cost of I – consequence

α ik – the weight coefficient of k – consequence of i – danger.

The author states that FSA gives ground for the correction of the existing set of standards and to create a new one for the construction and operation of ships taking into consideration the economic consequences of the shipping influence on the environment and the people. But he claims that FSA is not yet sufficient for the full cycle of standards creation for the control (monitoring) of the consequences of the measures undertaken for the risk management. He proposes to add one more step – risk monitoring.

3   Conclusion

FSA Guidelines is a complex document aimed at the improvement of safety at sea. The objective of this document is very well expressed in paragraph 3 of the preface:

"Application of FSA may be particularly relevant for proposals for regulatory measure which have far reaching implication in terms of costs to the maritime industry or the administrative or legislative burdens which may result.

This is achieved by providing a clear justification for proposed regulatory measures and allowing comparison of different options of such measures to be made. This is in line with the basic philosophy of FSA in that it can be used as a tool to facilitate a transparent decision-making process. In addition, it provides a means of being proactive, enabling potential hazards to be considered before a serious accident occurs" (2).

Many researchers were applying this methodology for their research. Some of them closely followed the FSA methodology "using it as a tool" in risk analysis and consideration of "potential hazards" in their particular cases, others were searching their own ways, but in any case their actions and recommendations may be analyzed "using the instrument of the FSA".

As nowadays most of the research for the shipping industry is produced in the maritime educational establishments, we believe that IAMU is suitable to serve as a centre for summarizing and evaluating all the contributions to the critical issues of safety provision made by different researchers.

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