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IS INTERNATIONAL MARITIME ORGANISATION'S FORMAL SAFETY ASSESSMENT APPROACH LEADING TO A MORE SYSTEMATIC IMPROVEMENT OF SHIPPING EMERGENCY MANAGEMENT?

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Abstract:

Despite the technical progress achieved, the persistence with which maritime disasters recur is not acceptable. The recent shipping disasters of passenger vessels (Scandinavia Star, Estonia, etc.) and ecological disasters (Erika, etc.) have awoken the public opinion. The maritime community and industry are now converging to the same objectives of quality and safety under the auspices of the International Maritime Organisation (IMO), the United Nations Agency in charge of the commercial shipping regulation. The IMO and the whole maritime community are presently moving from a reactive to a proactive approach to safety and emergency response: reflecting the emerging recognition across the industry and its regulators of the risk management philosophy, efforts are undertaken to improve and effectively use risk based approaches in rule and decision making. This new approach developed within IMO is called Formal Safety Assessment (FSA) and includes the steps of hazard identification, risk analysis, evaluation of risk control options, cost/benefit analysis and recommendations for rule decision making.

This approach should eventually provide a more cost effective balance between prevention, protection and emergency measures accounting for technical and operational aspects. Of particular interest is the risk model established throughout FSA describing the distribution amongst the various causes, their interactions and the escalation barriers.

Both the change of approach in rule making and the global related perspectives are discussed as the backbone for an improved risk and disaster management in the maritime domain. The position of the regulatory framework in relation to emergency management will be examined. We will review the FSA approach and focus on its contribution to disaster management improvement. Finally, benefits and shortcomings will be highlighted.

Introduction

The importance of the risk management philosophy is progressing in the maritime industry and its regulator. One key feature of this philosophy is its "pro-activity". Peachey [1] defined the meaning of "Pro-active" as "planned action in anticipation of potential events or circumstances" and refined

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this meaning in the context of safety. This includes deciding upon a target risk level, identifying / implementing measures to achieve that risk level, and monitoring performance to ensure the target is achieved or exceeded.

Among all the safety approaches, two of them are especially emphasised as being "pro-active": the emergency management approach and the Formal Safety Assessment (FSA) approach. Although emergency management is a need for stakeholders close to the hazard and operational activities, FSA is the proactive approach with respect to regulation improvement. This approach, developed within the International Maritime Organisation (IMO), includes problem definition plus five steps: Step 1 - hazard identification, Step 2 - risk assessment, Step 3 - evaluation of risk control options, Step 4 - cost/benefit analysis and Step 5 - recommendations for rule decision making. FSA appears to be the backbone of the reactive to the proactive approach trend within the maritime community. Interim Guidelines for the Application of Formal Safety Assessment (FSA) to the IMO Rule-Making Process [2] – named hereafter the Interim Guidelines - were adopted by IMO technical committees in 1997. This paper will describe some of the key features of the crossed interactions and articulation between the risk assessment part (Step 1 to 3) of FSA and emergency management.

The first section of this paper will outline how the FSA approach enables to one capture and enhance operational issues, and especially emergency situations, with special attention on the modelling approach(es) used within FSA. This will be followed by a discussion of the FSA contribution to the improvement of emergency management and safety culture.

FSA capturing emergency issues

Preliminary remarks

IMO describes FSA [2] as "a rational and systematic process for assessing the risks associated with shipping activity and for evaluating the costs and benefits of IMO's options for reducing these risks." FSA should enable balance to be drawn between the various technical and operational issues, including the human element (and between safety and costs). The ability to address correctly these issues is highly dependant of the risk model and philosophy underlying FSA.

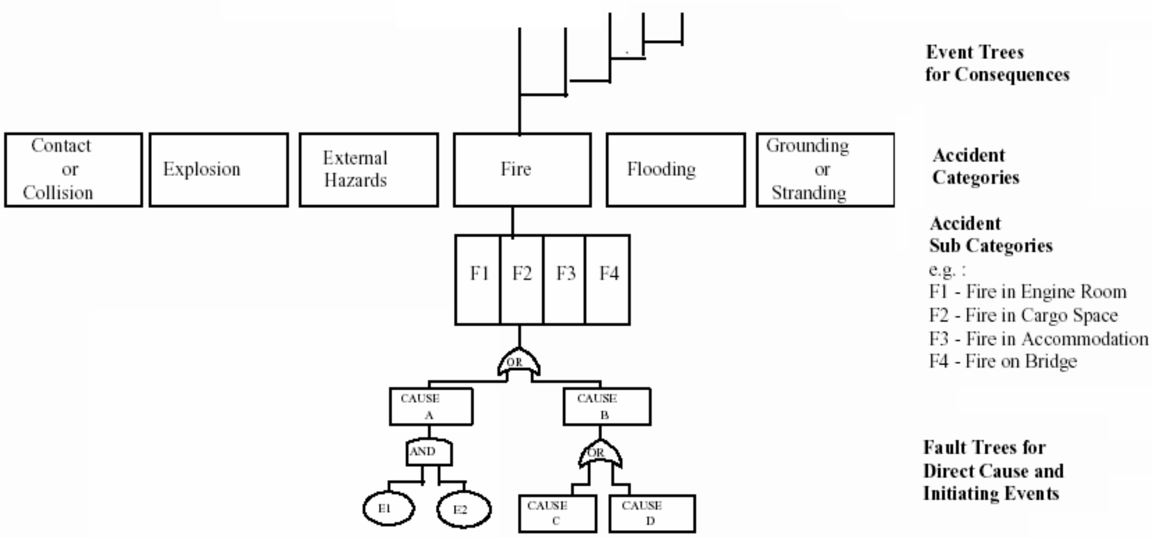
Boisson [3] has identified three approaches to explain accidents and enhance safety. The first approach, named the fatalistic approach, is an inheritance from the history of navigation itself. The accident is treated as the outcome of some act of God. Originally carried on by adventurers, the shipping trade uses expressions like "maritime perils", resulting from adventure, risk and good luck. The second approach, the deterministic one, that we would like to re-name the analytical one, rejects this idea of chance and fatalism but postulates that every event has a cause and that the same causes produce the same effect. This approach to safety has first focused on technical causes, then, as the causes of many accidents were identified as not purely technical but also strongly related to the operator, on human causes. The unsatisfactory nature of previous approaches has led to the emergence of new, total, global approaches mainly based on the theory of systems, recognising that beliefs, standards, values, objectives, data and models are of primary importance [4]. Describing the new approaches to regulation, Boisson classified FSA in the global approach trend to safety, and therefore recognises that FSA is able to deal with complex system issues. In particular the use of FSA should also enable one to assess the operational aspects, such as emergency situations, which are by nature unanticipated or infrequent in most systems.

Key aspects of FSA

The risk model

The risk model established throughout FSA step 2 is constituted by event trees and fault trees. In the Interim Guidelines the combination of these trees is referred to as the Risk Contribution Tree (RCT). See Figure 1. The goal of creating a Risk Contribution Tree is to provide an overview of where the main risk contributors are located in the risk model. Main risk contributors may exist as primary events in the fault trees of the risk model. They may also exist in the event trees of the risk model, as insufficient or missing escalation barriers.

Figure 2: Example of a Risk Contribution Tree [2]



Balance between prevention and protection

The FSA approach does not prioritise the measures to be applied in order to reduce risk, i.e. measures designed to reduce the probability of accidental events or measures designed to reduce the potential consequences of accidental events. Risk Control Measures, defined as a means of controlling a single element of risk, and subsequently Risk Control Options, defined as a combination of risk control measures, identified in FSA step 3, have a range of attributes. Category A attributes consider the two fundamental types of risk control that can be applied: preventive - preventive risk control is where the Risk Control Measure reduces the probability of the event; and, mitigating - mitigating risk control is where the Risk Control Measure reduces the severity of the outcome of the event or subsequent events. Thus, this dichotomy in the Interim Guidelines emphasises the balance between accident prevention and mitigation.

Escalation barriers

The measures designed to reduce the potential consequences of accidental events are sometimes known as “ defence in depth” or “barriers”. Among the range of attributes related to Risk Control Measures (and subsequently Risk Control Options), identified in FSA step 3, Category B attributes relate to the type of action required:

- Engineering: Engineering risk control involves including safety features (either built in or added on) within a design.
- Inherent: Inherent risk control is where at the highest level in the design process, choices are made that restrict the level of potential risk.
- Procedural: Procedural risk control is where the operators are relied upon to control the risk by behaving in accordance with defined procedures.

Category B attributes consider risk control at the technical, operational and organisation levels to ensure that training, quality systems and other organisational issues are addressed.

Human element

The maritime community is now recognising that the human element is one of the most important contributory aspects to the causation and avoidance of accidents. The Interim Guidelines state that: "Human element issues…should be systematically treated within the FSA framework, associating them directly with the occurrence of accidents, underlying causes or influences. Appropriate techniques for incorporating human factors should be used."

The International Association of Classification Societies (IACS) has given consideration on how to properly incorporate the human element into the FSA process. They proposed the use of Human Reliability Analysis (HRA) as a tool to properly incorporate the human element into the FSA process [5] in 1999. This draft Guidance provides a framework to systematically treat human element issues within the FSA framework, associating them directly with the occurrence of accidents, underlying causes or influences.

Conclusion

One of the important strengths of the risk model is that it portrays an overall picture of risk, in which both prevention and mitigation measures are incorporated and balanced accounting for the human element. The risk modelling is made with the aid of event trees, which have the advantage that they give an easy-to-understand illustration of the potential accident sequences, and with fault trees aimed at detailing initiating event causes and barrier failures within the event tree. This approach has been successfully applied in various trial applications (Helicopter Landing area on cruise ship, High Speed Craft, Bulk carrier, etc.). However, even if the objective is to ensure safety accounting for technical and operational factors, and if the described approach could be satisfactory, the objective will now be to take a closer look at the philosophical trend of FSA.

<u>Trends in FSA</u>

The Interim Guidelines mandate the adoption of a balanced approach between technical and operational factors reflecting their contribution to the safety of the overall system. Operational and emergency issues receive increased attention as integral parts of FSA. At the same time we have evidence from the Guidelines development, current discussions within IMO [6] and trial applications that the appropriation of FSA, under cultural inheritance and tools « recognition », has been an analytical interpretation of FSA. In the next section, we will identify some « trends and shortcoming » features of FSA when dealing with complex systems.

Risk model

The RCT would focus primarily on the operational tasks and conditions necessary for a successful scenario, or in other words the events related directly to the emergency situation. However on the basis of some practical trial applications of FSA, it is recognised that the events addressed first in the RCT are technical and human (considered as a technical component) and that "latent" conditions, i.e. poor design, failure due to poor construction, wastage, or operational factors, are addressed at a very low level. Fault and event trees using 'corrections' to account for the contribution made by the environment are often incapable of displaying and linking different types of causal information. Kristiansen and Soma [7] have outlined the fact that much weight is put on the task aspect and too little on the context, and proposed an alternative barrier model of evacuation which takes the life cycle of the system as a starting point.

Human element

In order to address the human element, the HRA approach is proposed. Bedier, Hollnagel and Pariès [8] have pointed out that the HRA approach has won substantial support despite fundamental weaknesses. Moreover, human reliability is envisaged as a strict transposition of technical reliability, operator being considered similar to technical component and as the source of problems rather than solutions. According to Hughes and White [9], the identification of why humans err and not just how they failed will lead to improved mitigation measures for regulators and seafarers alike.

Problem definition

FSA effectively starts with the "problem definition" aiming at defining the boundaries of the assessment and the problems to be addressed. The proposition to name this step "Step 0" has been rejected by IMO FSA Correspondence Group members. The IACS FSA training course [10] concentrates on the five step process, proposing detailed training modules for each step but no dedicated module addresses the "problem definition" step. As a consequence and even if this "step" is of primary importance when dealing with the analysis of a complex system, it has been under-focused and FSA is accepted/and trained as a five step process.

Moreover, within the problem definition is associated the concept of "generic model". As FSA results are intended to be used for rule development, they need to be valid for a variety of possible and typical designs or operations. Therefore, depending on the safety topic under consideration, a generic model, e.g. a system and its operation, under consideration is developed. The "generic model" concept should allow the use of FSA by attributing common features, characteristics and attributes to certain types of vessels operated under similar conditions. Once again this aspect is not emphasised and "generic model" has mostly been interpreted by "generic ship" and concerns concentrate too much on ship's hardware and not enough on operation. By limiting the "model" to the "ship" some important features are lost.

Risk Influence Diagram

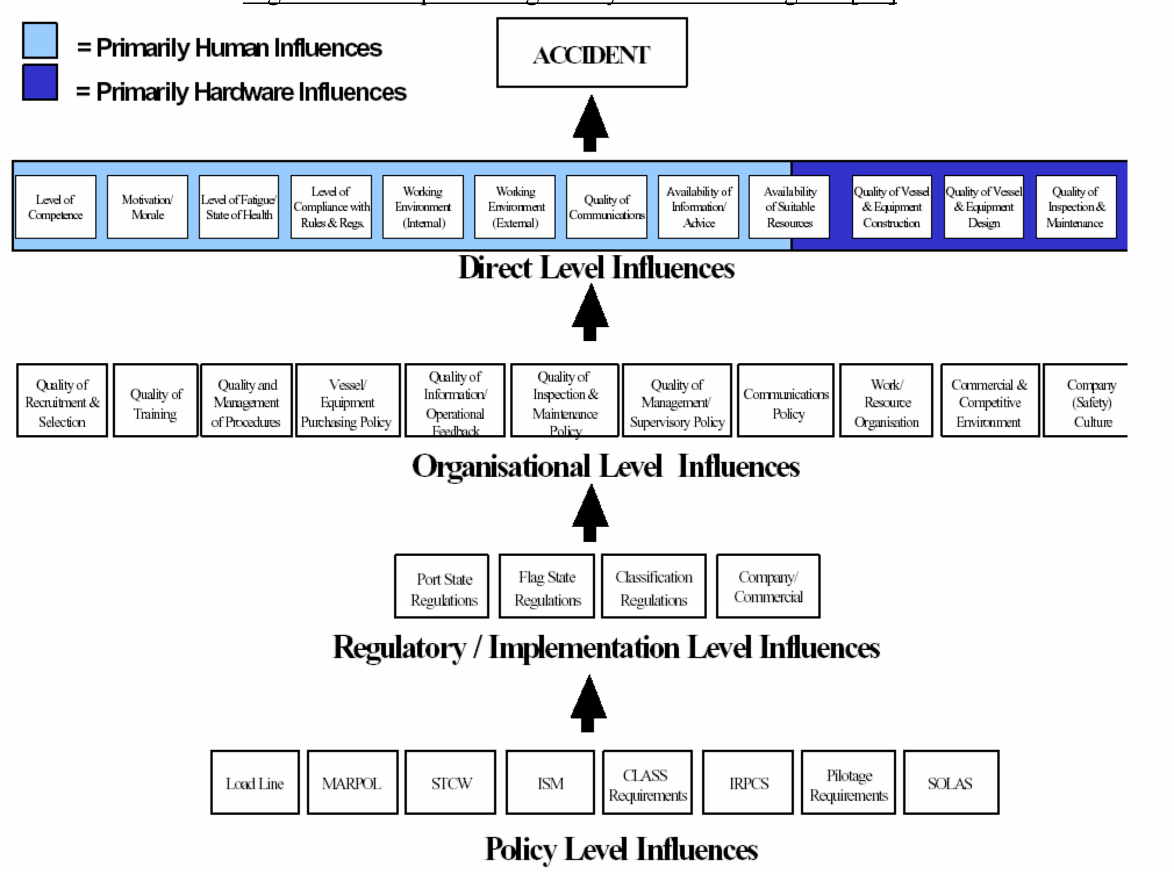
As a way of addressing some of the complex parameters, the Interim Guidelines make reference to the use of Regulatory Impact Diagrams (RID's). The RID is a method of modelling the network of influences on an event. These influences link failures at the operational level with their direct causes, and with the underlying influences. Basically, four levels of influences are addressed: a Direct Level (the direct causes of accidents, e.g. grounding, loss of hull integrity, etc.); an Organisational Level (the factors that influence the direct level); a Regulatory Level (the regulations and requirements that influence the shipping organisation); and a Policy Level (the Codes and Conventions and political structure that influences national regulators). See Figure 2. This tool can be an effective tool in the evaluation of Risk Control Measures and Risk Control Options, either by assisting in the identification of the type of regulations that may best influence safety, or in evaluating the effectiveness of proposed RCMs and RCOs. In 2001, the IMO FSA Correspondence Group [6] recommended to delete the Regulatory Impact Diagram from the Interim Guidelines.

The way forward

Established techniques are employed at each step of the FSA process. These include, for example: brainstorming, hazard identification techniques, HRA techniques, and event and fault tree analysis. However, because the FSA process is intended to assess complex issues and to be used for shipping in general rather than for any particular ship, additional techniques are also expressed, including in particular:

- Development of a generic model to describe the functions and features which characterise the problem under consideration; and
- Modelling of the regulator's influence over the underlying causes of accidents.

Figure 3: Example of Regulatory Influence Diagram [11]



These are the systemic aspects of FSA that should enable rule development accounting for its environment. In the conduct of a marine FSA, the interpretation and appropriation, even if FSA has been characterised as global, have been traditional analytical ones. It leads us to characterise this FSA as a FSA first generation, the analytical generation. The principle of this simple FSA is to search for causes accounting for technical and human components, the objectives being to eliminate or contain these causes. However, through this analytical appropriation, the analyst will lose some aspects of the problems and will accomplish the opposite of what is intended- namely a narrow vision of the problem and to propose mis-elaborated measures. This is the area where a FSA second generation recognising the relevance of "systemic" tools becomes complimentary to the traditional approach. Increasing emphasis on the non-analytical part of FSA should lead to greater attention to the environment and to better emergency management.

FSA and challenges

It seems accepted that the value and effectiveness of a rule can be assessed only within its environment and the complex socio-technical context. Boisson [3] argued in favour of a total approach to the safety issue and that an accident must not be regarded as an isolated phenomenon, the causes of which are sought to act on them, but as a result, among other factors, of a complex system comprising individual passengers, seafarers, shipowners, ships and maritime craft, infrastructures, navigational aids and the environment.

For the discussion above, there is real will to account for operational and emergency aspects within the FSA framework. We have identified a trend in FSA appropriation and characterised a FSA first generation based on an analytical approach, the risk model being built on a decomposition in tasks and basic events directly related to the emergency situation. This enables potential hazards to be considered before a serious accident occurs and provides input such as hazard identification, risk models and barriers to a risk based emergency management taking into account human error.

Nevertheless it appears that the global aspects of FSA have been under focused and that there is a need to emphasise these aspects. A first step towards this FSA second generation could be to go beyond the operator and technical component itself to take into account the influence of the environment. This step is expected to be proved more realistic and more promising as regards insights on safety, hence as regards indications to enhance safety and improve emergency management.

The new framework should ensure that the systemic tools are taken into consideration and used where needed and appropriate in the FSA process in order to meet the need of both the regulator and the operator. If the structure is correct and well used the questions "is the ship the best candidate for risk reduction", and "maybe IMO/IACS is the best place to take action" should be raised. By taking this approach, FSA would be likely to design safer ships as well as to be an initiating step towards an improved compliance and safety culture through the maritime community.

FSA impact on emergency issues

<u>Introduction</u>

A characterising feature of disasters and crises is that they are unpredictable. In order to reduce the effects of disasters, people in the emergency management organisation have to be trained in those situations they can expect to encounter. However, for the emergency management organisation it is impossible to think of every possible situation or event in advance. It is therefore important that the entire organisation can adapt flexibly and efficiently. In this context, the UK's Maritime and Coastguard Agency makes a distinction between emergency and crisis management. Emergency management has been defined as a situation where decisions and actions are based on documented emergency procedures. Crisis management differs from emergency management in that decisions and actions do not necessarily have to be documented emergency procedures and there may not be a predefined response, or if there are defined emergency responses those responses may have conflicting requirements.

Against this background, the application of FSA for rule development is expected to lead to safer ships and to an improved safety and emergency culture. We will now discuss how beneficial FSA could be for an emergency culture development.

<u>From the reactive to the pro-active approach</u>

The shipping industry is regulated under the umbrella of the IMO. Present rules are of a prescriptive nature and have been historically established from principles of naval architecture, marine engineering and other scientific principles. Limitations of the current regulatory regime have been recently highlighted: the regulations are of a prescriptive hardware nature; they are often driven by recent accidents therefore being reactive rather than proactive, etc. Kristiansen and Soma [7] have pointed out that: "The maritime transport has exhausted the traditional approaches in safety work and that new ones must be sought". FSA puts risk concept at the very heart of regulations and at the very beginning of the ship life cycle. Even if a safety culture cannot be imposed by regulations, but demands strong involvement by company management, FSA by will also bring about a thorough change in the dominant culture of shipping which is moving from a reactive to a proactive approach.

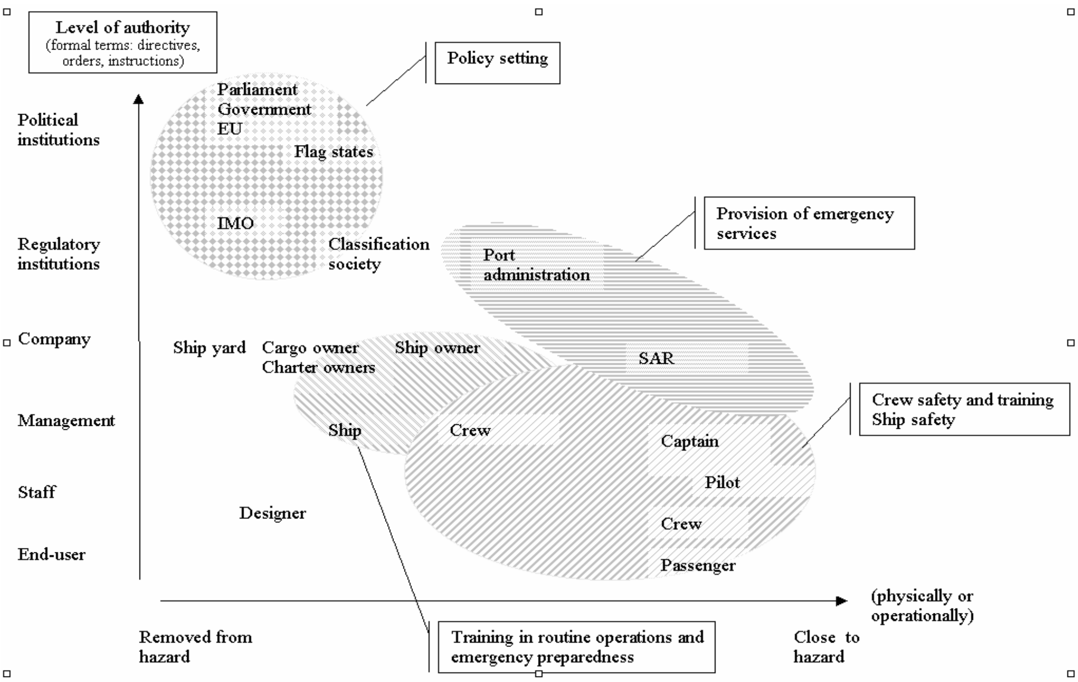
Stakeholder recognition

The use and need of crisis and emergency management approaches are widely spread within the maritime community. THEMES, an EU 5th FP Thematic Network for Safety Assessment of Waterborne Transport, recognises the importance of stakeholders. The starting point of this recognition is a description of stakeholder needs in respect to knowledge and information (and the extent to which these needs are shared with or common to other stakeholders), comparing needs with information availability, and analysing stakeholder interactions. An important deliverable [12] from the work so far has identified potential stakeholders and their related needs and decisions. The following have been identified as having emergency needs/decisions:

- Training in routine operations and emergency preparedness; and ISM compliance: Ship owners, Ship managers,
- Provision of emergency services: Port authorities, Bridge/Lock Controllers (inland navigation), Regional (waterway) authorities, Search and Rescue (SAR) organisations
- Crew safety and training; and ship safety: Pilot, Crew, Ship managers and owners

The next stage will categorise stakeholders according to their level of authority and degree of hazard exposure. A typology of decision domains, its implication on safety assessment and the interaction between decision domains and safety assessment approaches are foreseen. The results will especially indicate interaction between regulatory decisions and safety assessment approaches and the emergency management. See Figure 3.

Figure 4: Stakeholders and needs/decisions domains *(adapted from [13])*



Emergency preparedness improvement

As part of the safety culture encouraged by IMO, FSA could be used to develop new transparent, either prescriptive or performance based, regulations, which will directly impact both the ship safety level and the emergency preparedness.

FSA, in addition to providing a systematic method of developing risk based regulation, could serve as a starting point to the safety management system. IMO has stated the following objectives for the International Management Code for the Safe Operation of Ships and for Pollution Prevention (International Safety Management Code): "provide for safe practices in ship operation and a safe working environment; establish safeguards against all identified risks; and continuously improve the safety management skill of personnel ashore and aboard, including preparing for emergencies related both to safety and environmental protection".

FSA could serve as a safety management tool in the activities necessary to meet the objectives by supporting decision making regarding where safety investments are located best, e.g. in technical or operational modifications, or crew training to improve response in contingency. In other words, FSA could help targeting of emergency management resources and ensure that risks are correctly examined. Finally, since risk based regulation is often associated with performance, it may be a good opportunity to help the operators implement policies favouring personnel motivation and responsibility.

Safety culture improvement

The concept of culture appeared in literature on organisations in the 1980s. Culture has been described as a 'peeled onion' with a succession of different levels, starting from a centre consisting of core values and going to an outer layer with values, beliefs, norms and artefact. Moreover, Reason and al. have suggested the characteristics of an "advanced" safety culture [14]: Informed – managers know what is really going on and the workforce is willing to report their own errors and near misses. This relies greatly on trust. Wary – members of the organisation are ready for the unexpected. Just – there is a 'no blame' culture but with a clear line between the acceptable and unacceptable. Flexible – the organisation operates according to the needs of the current situation. Learning – it is willing to adapt and implement necessary reforms.

One means of "engineering" a safety culture can be via increased communication about the concept of risk. This requires an increased recognition of safety assessment methods to support decisions. FSA, by strengthening regulatory decision making, will allow the regulatory bodies to lead by example in promoting a safety culture. Encouraging risk concept/philosophy in this way will enable more effective practical application and is expected to contribute to an effective global cultural change in shipping safety, moving to a safety culture instead of a compliance culture.

Conclusions

The FSA approach combines risk and cost/benefit assessments, and is aimed at providing a rational and systematic risk-based approach balancing technical and operational issues to maritime safety regulation. This paper has discussed interaction between the FSA approach and emergency management. Within FSA, several aspects have been identified as improving the understanding of emergency operations. First, the risk model (RCT, a combination of event and fault trees) aims at providing an overview of where the main risk contributors are located in the risk model. Second, this risk model specifies that the main risk contributors may exist as primary events in the fault trees or as insufficient or missing escalation barriers in the event trees. Third, the potential measures to reduce risk can either be preventive, i.e. reducing the probability of an event, or mitigating, i.e. reducing the severity of the outcome. Fourth, the measures could address technical, operational, human and organisational aspects. Finally, the human element must be addressed.

However, we have pointed out that the appropriation of this approach to safety assessment and management has been an analytical one, and we have characterised this "1st FSA generation". Nevertheless, acknowledging the complex character of maritime safety and the fact that the 1st FSA generation is now mature, global and systemic tools should emerge. Such tools should be correctly incorporated, such as during the problem definition and the risk control option step, in order to account for complex features when developing new rules.

Moreover, FSA is expected to contribute significantly to the diffusion of a safety culture throughout the maritime community by making the regulations more transparent, developing a proactive approach towards safety rather than a reactive approach, increasing the understanding of user needs, focusing on areas of higher risks, explicating why and for what rules have been created, acknowledging that maritime safety is a complex issue, and leading by example.

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