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Master's Thesis

Safety Assessment of Fishing Vessel Collisions

Graduate School of Chosun University

Department of Naval Architecture & Ocean Engineering

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어선의 충돌사고에서의 안전성 평가

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Contents

List of Figures

List of Tables

어선의 충돌사고에서의 안전성 평가

조비 앤써니
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초 록

해양사고에 있어서의 대부분은 인간의 실수에 기인함은 명백하며, 사회적이며 조직적인 배경과 같은 많은 근본적인 요소들은 선상에서의 인간의 행위에 영향을 미친다. 오랜 미해결 문제로 남아 있는 어선의 안전을 해결하기 위하여 많은 나라들은 상당한 시간과 자본을 투자하여 왔지만, 사고로 이어지게 하는 핵심쟁점에 있어서는 좀처럼 진전을 이루어 내지 못하였다. 어선의 안전에 관한 관리는 주로 개별 국가와 단체에서 관장하고 있으며, 그래서 안전을 증진하기 위한 노력들은 주로 이들 지역적인 기관들에 의하여 이루어졌다. 이번 논문을 통하여, 특히 우리는 문화와 조직적인 견지에서의 다양한 근본적인 요소들과 어선이 포함된 충돌사고에서 해양사고 사이에서의 관계를 규명하고자 시도하였다. 이번 작업은 generic error-modeling system(GEMS)와 Influence Network Methodology 같은 안전과 과실관리 모델을 이용하는 안전성 평가를 기초로 하고 있으며, 다양한 해양사고의 사례들을 분석하였고, 과실감소를 위한 권고사항들과 현행 법규들의 보다나은 실행을 논의하였다.

Safety Assessment of Fishing Vessel Collisions

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ABSTRACT

It is clear that majority of marine accidents are attributed to human error, and many underlying factors influence the human performance onboard ship, such as social and organizational background. Fishing vessel safety has been a long standing problem, many countries have spend considerable amount of time and energy dealing with this issue, but very little progress has been made on core issues leading to accidents. Control on fishing vessel safety is largely down to individual governments and organizations, so efforts to improve safety are to be made mainly by these regional bodies. Through this paper we have done an attempt to find out the relation between marine accidents, especially collision involving fishing vessels and various underlying factors such as culture and organizational aspects. The work is based on the safety and error management models used in safety assessment such as generic error-modeling system (GEMS) and Influence Network methodology. Various marine accident databases were analyzed and recommendations on error reduction and better implementation of current rules are discussed.

Chapter 1

Introduction

1.1 Background

Safety in marine industry has traditionally been poor compared to aviation, nuclear or chemical industries. Marine industry began to pay attention to safety issues and started to develop its own safety assessment methodologies during the early nineties. Most of these methodologies have their origin in safety assessment methodologies used in other industries. Nevertheless many problems still remain unresolved. This is mainly due to the fact that compared to other industries marine industry has a diverse array of areas to be tacked (for example different type of vessels) and each has its own safety problems.

One of the least safe area is fishing .Commercial fishing is among the most hazardous occupations in the world. In many countries it has the highest fatality rate of any occupation. It is reasonable to believe that the fatality rate in countries (especially developing and undeveloped countries), for which information is not available, will be higher than it is in those that do keep records. Thus, the International Labour Organization's [6] estimate of 24,000 fatalities worldwide, per year, may be considerably lower than the true figure. Fishing vessels have a high loss percentage in case of an accident compared to other ship types, which implies high fatalness and low safety standards followed in the industry [12]. Even though in some countries the number of fishing vessels being lost and fishermen being killed have reduced during recent years, as the size of the fishing fleet reduces, fatality rate remains high.

1.2 Motivation for the study

Risk and safety assessment is a hot topic in marine industry. Initiative to introduce safety based approach to marine industry started rather late, only during the early nineties of the last century. When we compare the safety record of marine industry with other industries such as chemical, aviation and nuclear industries, it is rather poor. As in most of the industries the main cause of accidents in marine industry is human error.

Human performance onboard ship is affected by a number of factors such as design and construction of equipments and systems and ship as a whole. But when we look into the larger picture we can see that social and organizational aspects have got a bigger role in preventing marine accidents. Especially for fishing vessels this aspect is very important as measures to improve safety have repeatedly failed.

Collision at sea is a major accident category and involvement of fishing vessels in marine collisions is very prominent .It is a very prominent issue in many countries and needs immediate attention. The issue needs special attention as new technologies such as Automatic Identification System (AIS), is been introduced onboard ships with little attention been given to the likely consequences on smaller vessels such as fishing vessels.

1.3 Scope of the Study

The main aim of this study is to shed light on the issue of ship-fishing vessel collisions. An effort is also made to compare the various safety assessment options currently available in marine industry for the application of fishing vessel safety. The issue of, ship-fishing vessel collisions is of particular importance, in the wake of introduction of Automatic Identification System (AIS) onboard most of the cargo ships. As a preliminary step, an analysis of the various accident databases is carried out and investigation reports on collisions involving cargo ships and fishing vessels are analysed. Influence Network methodology is used to model the Ship-Fishing Vessel accident scenario to focus on the relevant areas needing attention. The study may provide the starting point of a systematic FSA process. The analysis is mainly of qualitative nature and further investigations are needed in relevant areas.

The study has indicated that human and organisational factors are to be tackled if any significant improvement is to be made on fishing vessel safety. However, it has to be noted that whilst the study provides an initial diagnosis in this respect, it dose not provide a through analysis of the problems. Targeted human factors techniques should be applied to examine the factors identified as being critical.

Chapter 2

Risk and safety

2.1 Basic Principles [11]

Risk in the context of a specific situation, is the likely outcome or probability of occurrence and the severity of consequences. It would be helpful, therefore, to explain the relationship between consequence (C) and probability of occurrence (P) by considering an everyday situation in which a pedestrian selects the options for crossing various types of road. The specific decision in each case will be governed by his or her judgment on the chances of being run over and seriously injured or even killed. In Figure 2.1, a graph of C and P plotted for typical roads yields the following general trends:

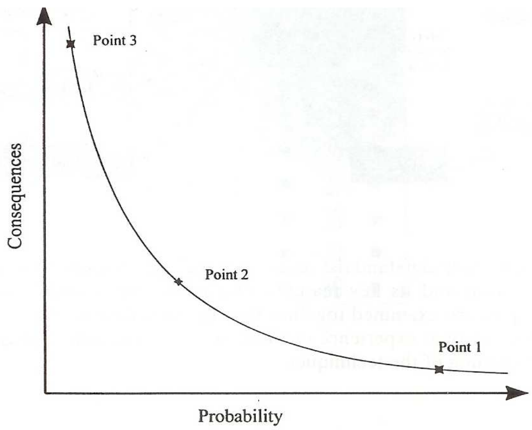


Figure 2.1 Consequences versus probability trend

For city centre roads: Vehicles travel fairly slowly because of traffic density and control measures such as lights, and this situation shows a low C and a high P, see Point 1.

For urban roads: Vehicles travel faster because of reduced traffic density and this situation shows a medium C and a medium P, see Point 2.

For motorways or expressways: Vehicles are travelling at high speed, and this situation shows a high C but a low P, see Point 3.

By fitting a curve to these points it can be seen that probability of occurrence tends to vary inversely with consequence. This means that few attempts will be made to cross an expressway because of the high danger of being knocked down and seriously injured, while more accidents will occur on city centre roads, but with less serious injuries. This can be stated in its simplest form as:

Consequence (C) varies inversely with Probability of occurrence (P)

In mathematical terms, $C \propto 1/P$ or $C = R/P$, where *R* is a coefficient which is called "risk". More usually the relation is written in the following form,

$R = C \times P$

It should be noted that both probability and consequence comprise a number of factors, and some of these are qualitative. For example, the probability value will be influenced by the behaviour of individuals (human factors), their views on how capable they are to deal with a situation (operational competence), the fact that the event takes place at a given point in time (time), and the attitude of individuals towards how the event should be treated (management). So a range of methods should be used to estimate the risk of a situation.

2.2 Definition of the Term ‘Safety’ [11]

The term "safety" is used in many different contexts and it is also interpreted in a variety of ways.The term "safety" is used in many different contexts and it is also interpreted in a variety of ways. Because of the broad nature of the concept and to enable attention to be focused on its enhancement, it is essential to have an agreed definition of the term "safety".

A definition of safety was proposed by Kuo, is as follows:

"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."

There are a number of words in this definition which may need clarification:

Quality: safety is not something absolute but an item which has to specified according to given circumstances and can be continuously enhanced over a period of time as a result of increased experience in m situations and advances in technology.

Perceived: Perception of safety depends on actual circumstances, and the judgment, competence and experience of those involved in the situation. For example, a householder's decision to fit a double-throw lock to the outside doors will stem from his or her perception of the chances of being burgle and how far this lock will increase the security of the house.

System: This term is used to represent any complete structure, such as a ship or semi submersible, or a component of a ship, installation, process or project.

Management: An arrangement devised for meeting a specific objective, which is implemented by the management of the organisation. Decisions by the management will affect and control the performance of the system.

Engineering: Many technical factors, including design and constructional methods, affect the system's performance.

Operation: The operational aspect is important because even the most carefully thought-out system could fail through incorrect operation. It is also virtually impossible to cater effectively in advance, via design, for the interaction of all possibilities. This is especially true in the case of a complex system such as a ship.

Danger: hazards, which have intolerable risk levels, are regarded as dangers.

Life: the concept of safety is rightly associated with the protection of human life. In practice, people are exposed to different types of danger in different activities and it would be virtually impossible to ensure absolute and complete safety in regard to all of them.

Property: the term "property" covers both the system of interest and other systems that may be endangered by it in any way.

Environment: marine failures and others as well, can affect the environment in a most significant way, e.g., the grounding of an oil tanker can result in the spillage of a significant amount of crude oil.

It is because safety involves all these factors that the subject has to be dealt with in a systematic way. In view of this, it is extremely difficult for risk to be represented properly by a “unique” numerical value derived mainly from engineering considerations, and yet risk is a key element in the judging of safety.

2.3 Risk Levels of Hazards [11]

The operation of a ship or offshore installation, or indeed any activity, will always involve hazards. Once these hazards are identified, it is important that risk assessment techniques should be employed to determine their importance in terms of risk level. Using the three regions of "intolerable", "tolerable" and "negligible" risk levels, it is possible to "place" each hazard in the appropriate region. This is illustrated in Figure 2.2.

Definitions of the three risk levels are as follows:

Intolerable Risk Level: The presence of the hazard in the system or situation cannot be justified and this is the intolerable region.

Tolerable Risk Level: The hazards in the system or situation may give rise to accidents, and if it is possible to reduce their risk levels cost-effectively then an effort should be made to do so. However, if the effort required far outweighs the benefits, these risk levels should not be reduced, and the hazards remain in the tolerable risk region.

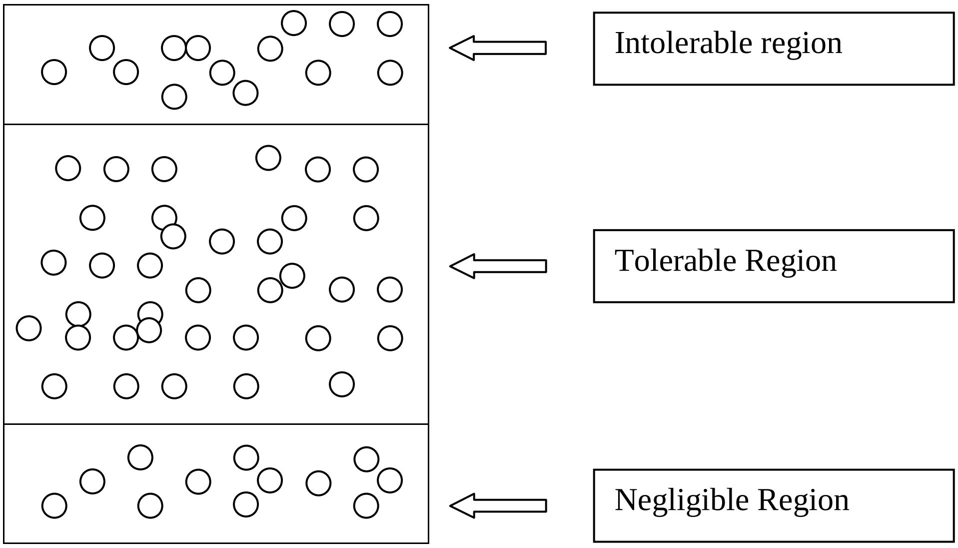


Figure 2.2 Risk regions of hazards

Negligible Risk Level: Certain hazards will exist in the system or situation but are most unlikely to lead to accidents and no effort should be expended on reducing their risk levels. These hazards are in the negligible risk region.

As can be seen, some hazards are in the region of negligible risk level, a certain number are in the region of tolerable risk level and some in the region of intolerable risk level. The ideal solution would be to shift all the hazards into the region of negligible risk level, but this would be impracticable in a complex system such as a ship. Instead the target must be to shift all the hazards within the intolerable risk level to the tolerable region. The particular position of any of these hazards within the tolerable region will depend on the following two factors:

• Care has been taken to ensure that the hazard is placed well away from the borderline between the intolerable and tolerable regions, because the risk assessment techniques used may not be capable of determining the risk levels to the required accuracy in these situations.

• It is cost-effective to reduce the risk level.

A risk matrix as explained in section 3.5.4.1 is very useful to represent the risk levels of the identified hazards. It helps to concentrate the focus on to the important issues.

Risk assessment, or determination of risk levels, may be carried out by qualitative and quantitative methods. The use of the former requires relevant knowledge and experience while the use of the latter requires numerical data as well. The most effective procedure for examining the risk levels of a system is one that combines the two approaches. The application of a qualitative method enables a better understanding of the system's safety to be gained at an early stage before numerical values are available. A quantitative approach will provide a numerical value of probability and consequences. However, it should be remembered that all numerical values require careful interpretation.

2.4 Comparison between Marine Industry and Other Industries

Compared to other industries such as aviation and nuclear industry the safety record of marine industry is much poorer. Initiatives to improve safety standards in marine industry are started only recently and much progress is to be made and much to be learned from other industries.

Most of the safety assessment methodologies are adapted to marine industry and has got their roots in other industries. Care must be given to such technologies before introducing to marine industry .For example compared to other industries very little relevant historical data is available in marine industry and methodologies should be capable of addressing inadequacies arising due to such situations. Outlook of safety problems is one of the most important aspects as attitudes of people is the driving force to achieve safety goals. This area needs particular attention in marine industry as the industry is in relatively early stages of implementing safety related rules and regulations.

Chapter 3

Safety Assessment Options

In general, there are several basic methods developed for ensuring safety of a system or ship.

(a) The prescriptive method

(b) The safety case approach

(c) Risk Based Decision Making (RBDM) approach

(d) Design for Safety, and

(e) Formal safety assessment (FSA).

In this chapter we will be discussing methodologies a,d,c and d in short and FSA in a rather detailed manner. We will compare these methodologies in short and will try to find out the most effective method to counter the problem of fishing vessel safety.

3.1 The prescriptive method [11]

The prescriptive method is based on the principle of enforcing certain safety features or rules and regulations by the government of a country or its representatives, or an international organization, on those who wish to provide products or services to the public or for their own use. The obeying parties are those who wish to provide products or services to the general public or for their own use.

3.1.1 Merits

The main advantages of this approach are as follows;

Reference standards: There is a set of reference standards to be met by everyone who wishes to build or operate a ship or marine vehicle in a given country or within a given area. *Incorporation of experience:* Many regulations have been derived from practical experience and they reflect the state of the art at a given point in time.

A straightforward concept: The approach is readily understood and application is relatively straightforward. It works well in noncomplex applications.

3.1.2 Drawbacks

Main drawbacks are;

Dealing with New Developments: The approach tends to provide “answers” before all the “questions” have been posed. The ship operator has to satisfy many rules and regulations before it has been ascertained whether some of the potential hazards, which may arise from factors not addressed by the detailed prescriptive requirement, are at a tolerable or negligible level.

Problems of keeping Up-to-Date: The formulation of rules and regulations tends to lag quite far behind advances in technology, and it could sometimes be ineffective to apply the existing versions in new projects involving novel features.

Scope for innovative treatment: Prescriptive regimes tend to inhibit innovative solutions. Indeed the existence of regulations can deter designers from proposing novel solutions for client’s requirements.

Development of Responsibility: Once the requirements have been satisfied there is generally little incentive for operators to achieve anything beyond the minimum standard set.

The possibility of imbalance: Regulations are strongly influenced by practical events, and changes and increased stringency can be expected after a major disaster in the areas that are apparently relevant.

3.2 Safety case approach [11]

Safety case approach is based on the system principles and setting a safety goal to be achieved. A "Safety Case" is a written document prepared by the operator of an installation, onshore or offshore, to demonstrate that major potential hazards have been reduced to risk levels which are as low as reasonably practicable (ALARP), and that they will be effectively managed and controlled throughout the life cycle of the installation. The safety case is a "stand-alone" document which can be evaluated on its own but has cross-references to other supporting studies and calculations. The document has normally to be submitted to a regulating authority for approval and the amount of detail contained in it is a matter of agreement between the operator and the regulating authority.

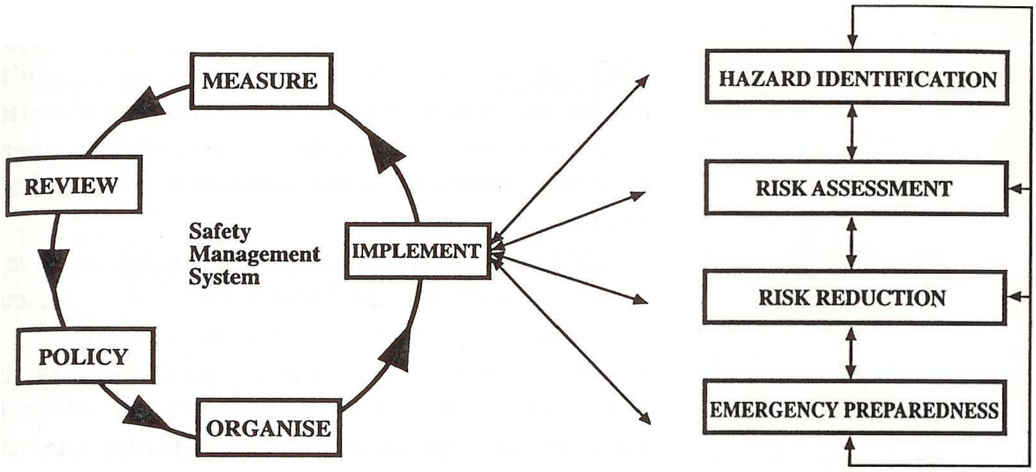


Figure 3.1 Safety case Concept

As can be seen from Figure 3.1, the central element is the Management System (SMS) which has five components, which are;

• Policy formulation.

• Organise resources and the communication of information.

• Implement the agreed policies and actions.

• Measure that the required standards are being met.

• Review performance and make relevant refinements.

The other four elements of the concept are:

Hazard Identification: Identify the likely hazards of the system. For a ship, typical examples would include collision and fire.

Risk Assessment: Evaluate the risk level of each hazard in order to determine whether it is in the intolerable, tolerable or negligible region.

Risk Reduction: Reduce the hazards with an intolerable risk level and, if it can be done cost effectively, lower also the hazards with a tolerable risk level.

Emergency Preparedness: Prepare for emergencies that could occur in the event of a potential hazard becoming a reality, even when all precautions against it have been taken.

3.3 Risk-based Decision Making (RBDM) [19]

RBDM is a process that organizes information about the possibility for one or more unwanted outcomes into a broad, orderly structure that helps decision makers make more informed management choices. It is again a system-oriented approach used by the United States Coast Guard [19]. The elements in RBDM are decision structure, risk assessment, risk management, impact assessment and risk communication, the last of which is quite unique and could be of great help for feedback.

3.3.1 Decision structure

Understanding and defining the decision that must be made is critical. This first component of risk-based decision making is often overlooked and deserves more discussion. The following are tasks that must be performed to accomplish this critical component. The basic elements of this step are;

• Recognizing that a decision needs to be made

Figure 3.2 RBDM process

• Determining who needs to be involved in the decision.

• Identifying the options available to the decision maker.

• Identifying the factors that will influence the decisions.

• Gathering information about the factors that influence stakeholders.

• Reaching agreed-upon decisions based on the information.

• Communicating and implementing decisions.

3.3.2 Risk assessment

Different types of risk are important factors in many types of decisions. Very simply, risk assessment is the process of understanding the following:

• What bad things can happen

• How likely they are to happen

• How severe the effects may be

Risk assessment can range from very simple, personal judgments by individuals to very complex assessments by expert teams using a broad set of tools and information, including historical loss data. The key to risk assessment is choosing the right approach to provide the needed information without overworking the problem.

3.3.3 Risk management

One goal in most decision-making processes is to lower risk as much as possible. Sometimes the risk will be acceptable; at other times, the risk must change to become acceptable. To reduce risk, action must be taken to manage it. These actions must provide more benefit than they cost. They must also be acceptable to stakeholders and not cause other significant risks.

3.3.4 Impact assessment

Impact assessment is the process of tracking the effectiveness of actions taken to manage risk. The goal is to verify that the organization is getting the benefits it hoped for as a result of implementing the actions. If the organization is not benefiting from the actions, it must accept current risks or return to the risk-based decision-making process to find better answers.

3.3.5 Risk communication

Risk communication is a two-way process that must take place during risk based decision making. At every step in the process, stakeholders do the following:

Provide guidance: Stakeholders identify the issues of importance to them. They present their views on how each step of the process should be performed, or at least provide comments on plans suggested by others.

Provide information: Some or all of the stakeholders may have key information needed in the decision-making process.

Provide buy-in: Stakeholders should agree on the work to be done in each phase of the risk-based decision-making process. They can then support the ultimate decisions.

3.4 Design for Safety [20]

It is a formalized methodology to allow safety assessment to become an integral part of the design process [20]. The Design for Safety methodology is an iterative process where a solution is sought that is safe, performance and cost-effective aiming at optimal solutions using a top-down approach. Input required is a ship design, which is developed using information modelling techniques.

Risk analysis is performed for the design concept and the resulting quantified risk level is controlled against the risk acceptance criteria. Risk reduction measures, or design features, are considered when a ship fails to meet risk acceptance criteria. There is a general distinction between risk reduction and mitigation means and both must be considered in order to develop an optimal design. On the basis of applying risk reduction measures 'new ship designs' are developed and the effects of the changes are again evaluated against risk acceptance criteria. Designs that are considered to be safe are put forward in the procedure and cost-benefit analysis of the risk reduction measures is performed.. The safe and cost-effective design solutions are thereafter assessed for their effect on other performance factors, such as seakeeping, cargo capacity, turnaround time, etc. The resulting solutions of this process are weighted and the best design is put forward in the design process for further development.

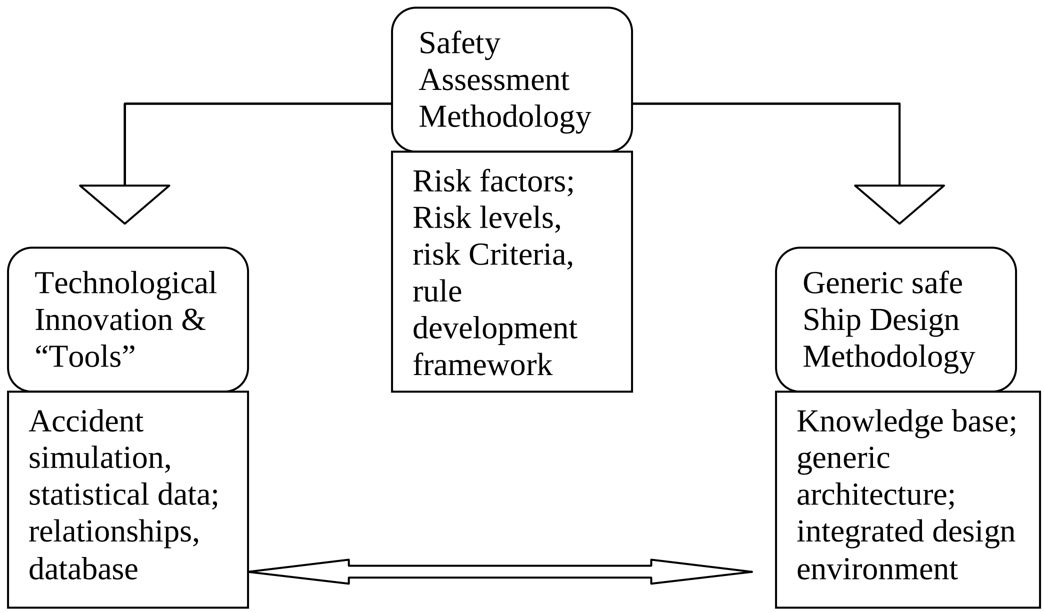


Figure 3.3 Design for safety Philosophy

The procedure has potential to accommodate multiple accident events, where the effects from the various event-driven design configurations are assessed. In such a scenario, event-driven design features may be conflicting necessitating the use of decision support models in order to derive the best overall design configuration.

3.5 Formal Safety Assessment [8]

By definition "Formal Safety Assessment (FSA) is a structured and systematic methodology, aimed at enhancing maritime safety, including protection of life, health, the marine environment and property, by using risk and cost benefit assessment". FSA can be used as a tool to help in the evaluation of new regulations for maritime safety and protection of marine environment or making a comparison between existing and possibly improved regulations, with a view to achieving a balance between the various technical and operational issues, including the human element, and between maritime safety or protection of marine environment and costs.

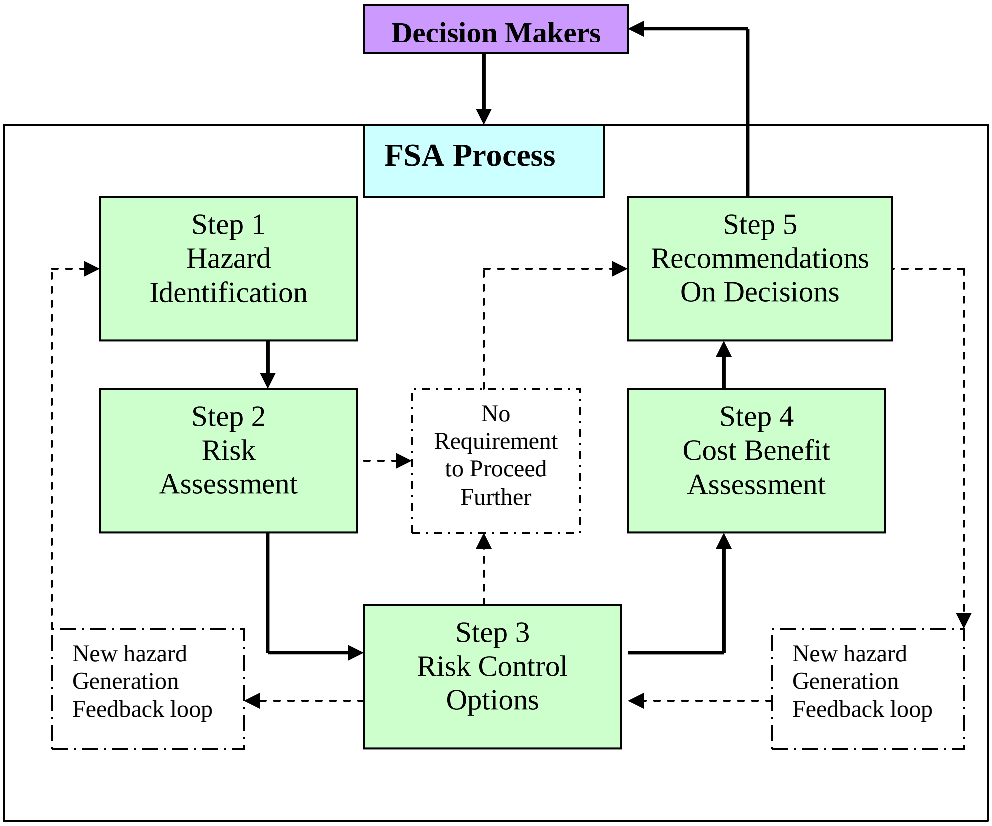


Figure 3.4 FSA Methodology [8]

FSA should comprise the following steps

(1) Identification of hazards;

(2) Risk analysis;

(3) Risk control options;

(4) Cost benefit assessment; and

(5) Recommendations for decision-making.

Figure 3.4 is a flow chart of the FSA methodology. The process begins with the decision makers defining the problem to be assessed along with any relevant boundary conditions or constraints. These are presented to the group who will carry out the FSA and provide results to the decision makers for use in their resolutions. In cases where decision makers require additional work to be conducted, they would revise the problem statement or boundary conditions or constraints, and resubmit this to the group and repeat the process as necessary. Within the FSA methodology, step 5 interacts with each of the other steps in arriving at decision-making recommendations. The group carrying out the FSA process should comprise suitably qualified and experienced people to reflect the range of influences and the nature of the "event" being addressed.

If applied properly FSA can considerably improve the safety status of the marine industry by providing valuable information to decision makers. Especially, fishing industry has long been lacking systematic approach to deal with safety problems. Therefore, FSA could well provide the desired safety results for, the most hazardous industry in the world. In the following sections, the so-called pre-requisites for the application of FSA will be briefly reviewed before entering main steps of the process.

3.5.1 Screening approach

There should be a screening approach before the application of FSA in accordance with the nature and significance of the problem. A rough application is necessary for the relevant ship type or hazard category, in order to include all aspects of the problem under consideration. Whenever there are uncertainties, e.g. in respect of data or expert judgment, the significance of these uncertainties should be assessed.

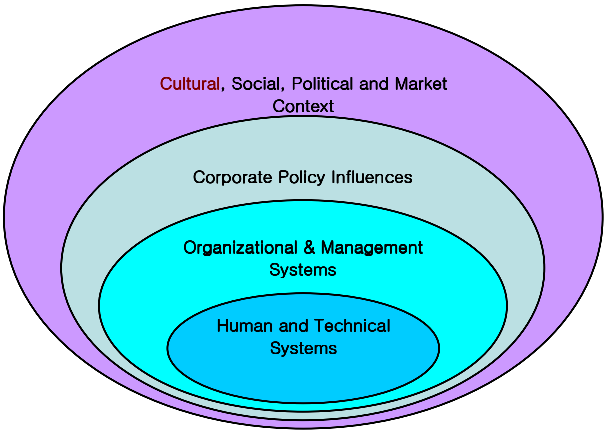
3.5.2 Information and data

The availability of suitable data necessary for each step of the FSA process is very important. This aspect is of particular importance to marine industry as it lacks systematic and accurate data. When data are not available, expert judgment, physical models, simulations and analytical models may be used to achieve valuable results. Data concerning incident reports, near misses and operational failures may be very important for the purposes of making more balanced, proactive and cost-effective legislation. A judgment on the value of data should be carried out in order to identify uncertainties and limitations, and to assess the degree of reliance, which should be placed on the available data.

3.5.3 Incorporation of the human element

Human element is the most important aspect in causation or prevention of maritime accidents. Various studies have proved that around 80% of marine accidents are attributed to this aspect

Human element issues as shown in Figure 3.5 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 in order to get the desired results.



. **Figure 3.5 Nested systems of Influences [8]**

3.5.4 Evaluating regulatory influence

It is important to identify the network of influences linking the regulatory regime to the occurrence of the event. It is a very important aspect as new risks may arise due to the risk control options (RCOs) or decisions and a thorough evaluation of the new RCOs should be carried out. Construction of Influence Diagrams [8] may help to a great extend in this regard.

3.5.5 Problem definition

The purpose of problem definition is to carefully define the problem under analysis in relation to the regulations under review or to be developed. The definition of the problem should be consistent with operational experience and current requirements, by taking into account all relevant aspects. Those which may be considered relevant when addressing ships are:

• 1 ship category (e.g. type, length or gross tonnage range, new or existing, type of cargo);

• 2 ship systems or functions (e.g. layout, subdivision, type of propulsion);

• 3 ship operation (e.g. operations in port and/or during navigation);

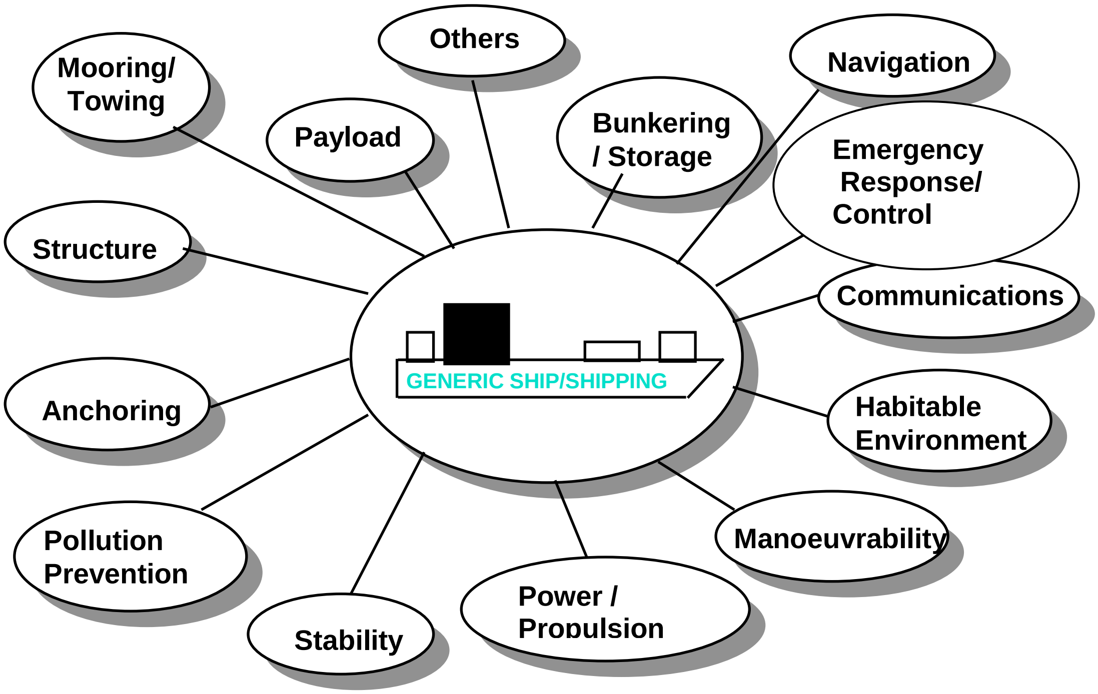


Figure 3.6 Generic Ship Functions [8]

• 4 external influences on the ship (e.g. Vessel Traffic System, weather forecasts, reporting, routing);

• 5 accident category (e.g. collision, explosion, fire); and

• 6 risks associated with consequences such as injuries and/or fatalities to passengers and crew, environmental impact, damage to the ship or port facilities, or commercial impact.

A ‘Generic Model’ should be generated considering the various functions of the generic ship type under consideration; these functions include carriage of payload, communication, emergency response, maneuverability, etc. Alternatively, where the problem relates to a type of hazard, for instance fire, the functions include prevention, detection, alarm, containment, escape, suppression, etc. The functions and systems should be broken down to an appropriate level of detail. Aspects on the interaction of functions and systems, and the extent of their variability should be addressed.

The output of the problem definition comprises:

•1 problem definition and setting of boundaries

•2 development of generic model

3.5.6 FSA STEP 1 - Identification of Hazards

The purpose of step 1 is to identify a prioritized list of hazards and associated scenarios specific to the problem under review. This aim is achieved by the use of standard techniques to identify hazards and by screening these hazards using a combination of available data and expert judgment. Hazard identification is generally done using a combination of creative and analytical techniques. It typically consists of structured group reviews (HAZID meetings and Brainstorming secessions) aiming at identifying the causes and effects of accidents and relevant hazards.

A rough analysis of possible causes and outcomes of each accident category should be made by using established techniques (Fault Tree Analysis, Event Tree Analysis, Failure Mode and Effects Analysis (FMEA), Hazard and Operability Studies (HAZOP), What if Analysis etc.), which is to be chosen according to the problem under concern.

3.5.6.1 Risk Screening

Identified hazards and their associated scenarios relevant to the problem being considered, should be ranked to prioritise them and to discard scenarios judged to be of minor significance. The frequency and consequence of the scenario outcome requires assessing. Ranking is undertaken using available data, supported by judgement, on the frequency of different outcomes of scenarios.

A risk matrix can be used to screen the identified hazards during the initial stages of a risk assessment. A generic risk matrix as shown in Figure 3.7.It has got three specific regions. The region of high risk is represented in the upper right corner of the risk matrix and is often indicated with red colour. Hazards in this region should be treated with adequate care and every effort should be done to bring those to low risk regions, at least to ALARP.

The second region is at the mid part of the risk matrix and is often described as As Low As Reasonably Practicable (ALARP) .It would be useful to consider the meaning of the term 'reasonably practicable'. Since risk reduction involves both the effort needed and the risk level' reduction achieved, the term implies that an attempt may be made to achieve a balance between the two. Effort can be measured by means of the cost involved or the time spent, or a combination of the two. "Reasonably" demands that the appropriate effort is expended to achieve a given reduction of risk. "Practicability" really holds the key, in that-regardless of cost, time or effort-if a risk reduction method is not practical it will be unsuitable. So hazards in ALARP region are addressed based on their cost effectiveness.

The third and final region of a generic risk matrix is the low or negligible risk region .Hazards in this region should be left alone.

The frequency and consequence categories used in the risk matrix have to be clearly defined. The combination of a frequency and a consequence category represents a risk level.

The output from step 1 comprises:

• 1 a list of hazards and their associated scenarios prioritized by risk level; and

• 2 a description of causes and effects.

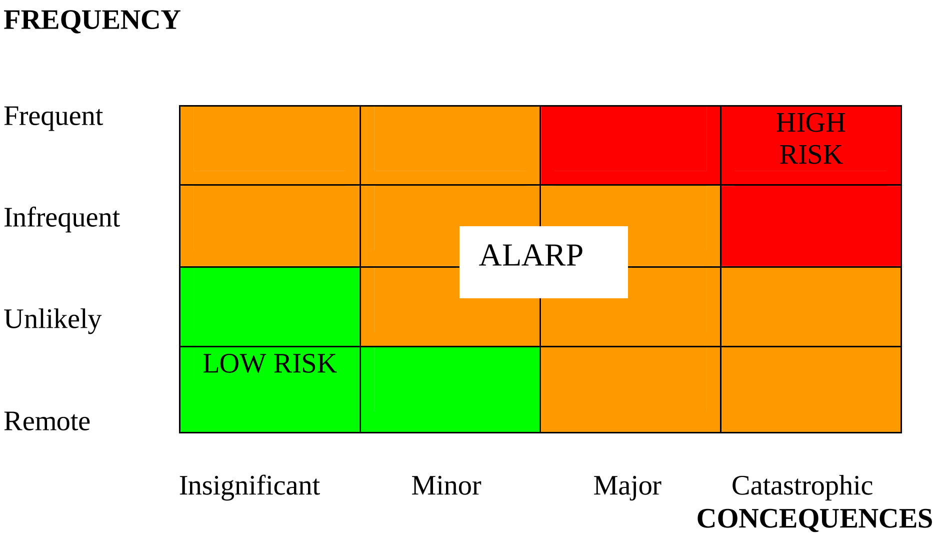


Figure 3.7 Example of Risk Matrix

3.5.7 FSA STEP 2 – Risk Analysis

The purpose of Risk analysis in step 2 is a detailed investigation of the causes and consequences of the more important scenarios identified in step 1. This is achieved by the use of suitable techniques that model the risk. Different types of risk (i.e. risks to people, the environment or property) should be addressed as appropriate to the problem under consideration.

There many methods used for risk assessment .The construction and quantification of fault trees and event trees are standard risk assessment techniques that can be used to build a risk model. An example of a conceptual risk model is the Risk Contribution Tree (RCT) as shown in Figure 3.9 .Whilst the example makes use of fault and event tree techniques, other established methods could also be used if deemed appropriate.

Relation between risks and relevant areas of influence are modelled using a method called ‘influence diagram’ .It can relate failures with direct causes and underlying organisational and regulatory influences and allows the most significant influences to be identified as shown in Figure 3.8.This diagram is then evaluated to find out the most significant influences which are then represented as probabilities.

The output from step 2 comprises identification of the high risk areas needing to be addressed.

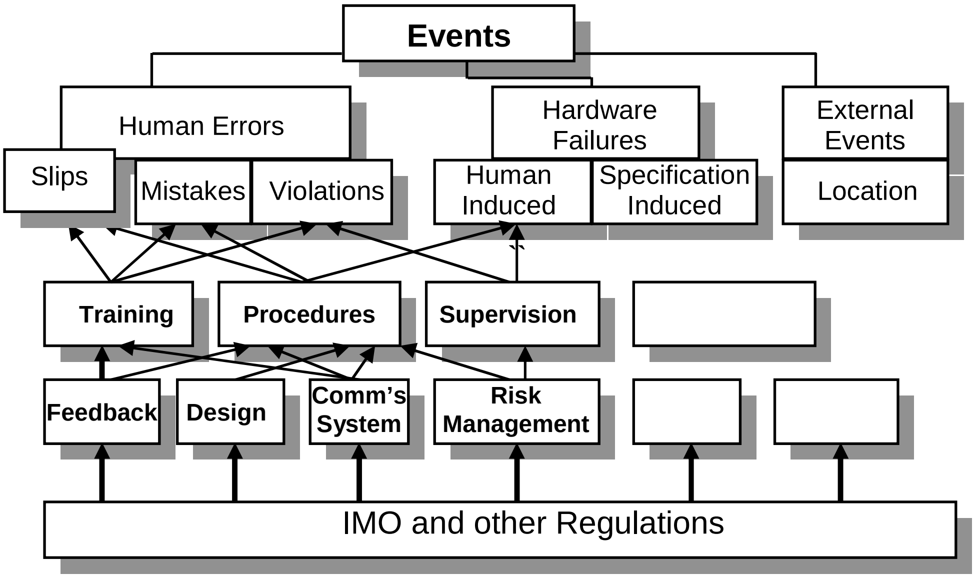


Figure 3.8 Influence Diagram

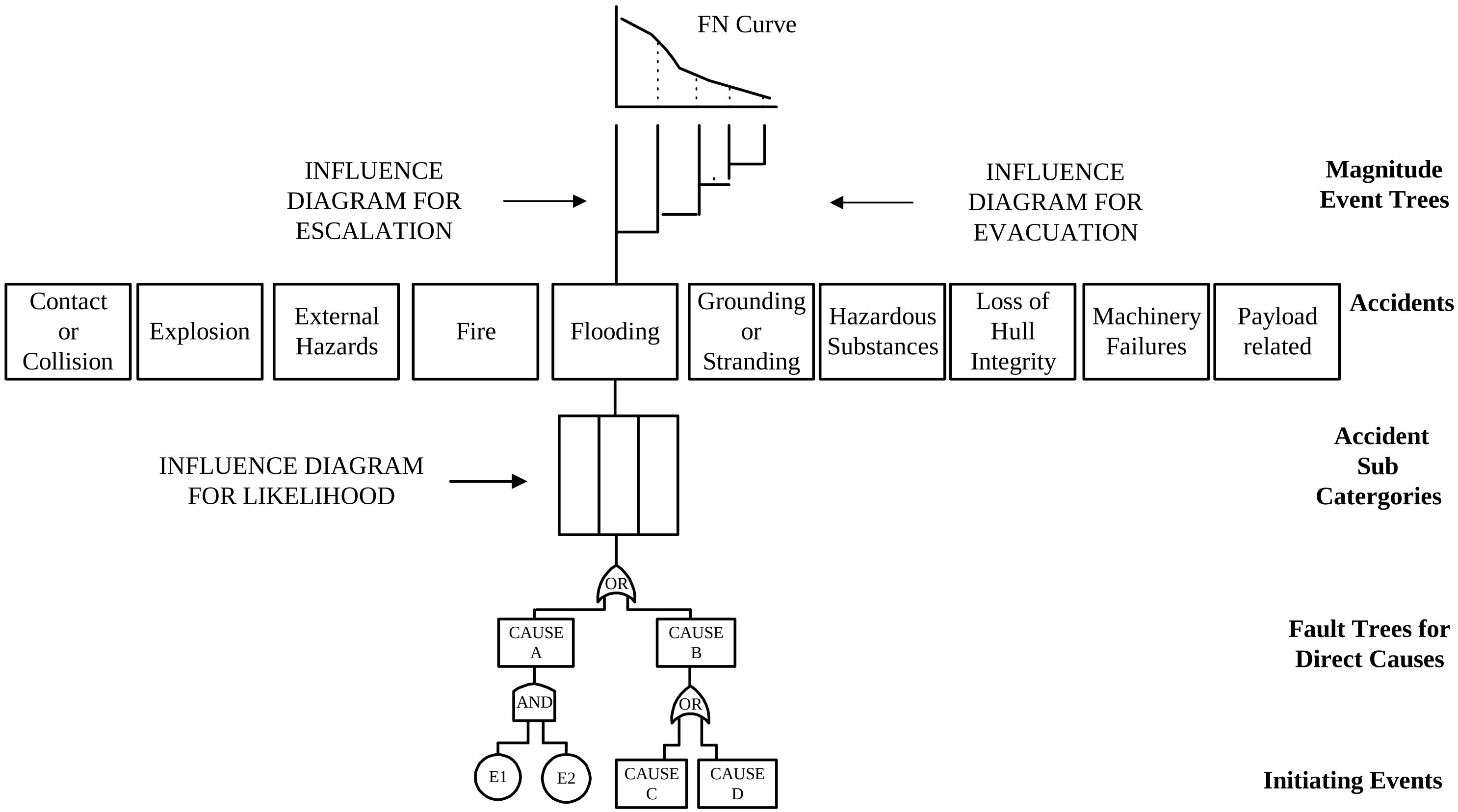


Figure 3.9 Risk Contribution Tree [8]

3.5.8 FSA STEP 3 – Risk Control Options

The purpose of step 3 is to propose effective and practical RCOs comprising the following three principal stages:

• 1 focusing on risk areas needing control;

• 2 identifying potential risk control measures (RCMs);

• 3 evaluating the effectiveness of the RCMs in reducing risk by re-evaluating step2; and

• 4 grouping RCMs into practical regulatory options.

The focus of step3 is to address both existing risks and risks introduced by new technology or new methods of operation and management, by creating risk control options. Both historical risks and newly identified risks (from steps 1 and 2) should be considered, producing a wide range of risk control measures. Techniques designed to address both specific risks and underlying causes should be used. It is largely a simultaneous process often requiring reference to the previous steps.

The purpose of focusing risks is to screen the output of step 2 so that effort is focused on the areas most needing risk control. The main aspects to making this assessment are to review:

• 1 Risk levels, by considering frequency of occurrence together with the severity of outcomes. Accidents with an unacceptable risk level become the primary focus;

• 2 Probability, by identifying the areas of the risk model that have the highest probability of occurrence. These should be addressed irrespective of the severity of the outcome;

• 3 Severity, by identifying the areas of the risk model that contribute to highest severity outcomes. These should be addressed irrespective of their probability; and

• 4 Confidence, by identifying areas where the risk model has considerable uncertainty either in risk, severity or probability. These uncertain areas should be addressed.

As in step1structured review techniques are typically used to identify new RCMs for risks that are not sufficiently controlled by existing measures. These techniques may encourage the development of appropriate measures and include risk attributes and causal chains. Risk attributes relate to how a measure might control a risk, and causal chains relate to where, in the "initiating event to fatality" sequence, risk control can be introduced.

RCMs (and subsequently RCOs) have a range of attributes, like preventive risk control, mitigating risk control etc. The prime purpose of assigning attributes is to facilitate a structured thought process to understand how a RCM works, how it is applied and how it would operate. Attributes can also be considered to provide guidance on the different types of risk control that could be applied. Many risks will be the result of complex chains of events and a diversity of causes. For such risks the identification of RCMs can be assisted by developing causal chains which might be expressed as follows:

causal factors ? failure? circumstance ? accident ? consequences (Figure 3.10)

RCMs should in general be aimed at one or more of the following:

• 1 reducing the frequency of failures through better design, procedures, organizational polices, training, etc;

• 2 mitigating the effect of failures, in order to prevent accidents;

• 3 alleviating the circumstances in which failures may occur; and

• 4 mitigating the consequences of accidents.

RCMs should be evaluated regarding their risk reduction effectiveness by using Step 2 methodology including consideration of any potential side effects of the introduction of the RCM. The purpose of this stage is to group RCMs into a limited number of well thought out practical regulatory options. There is a range of possible approaches to grouping individual

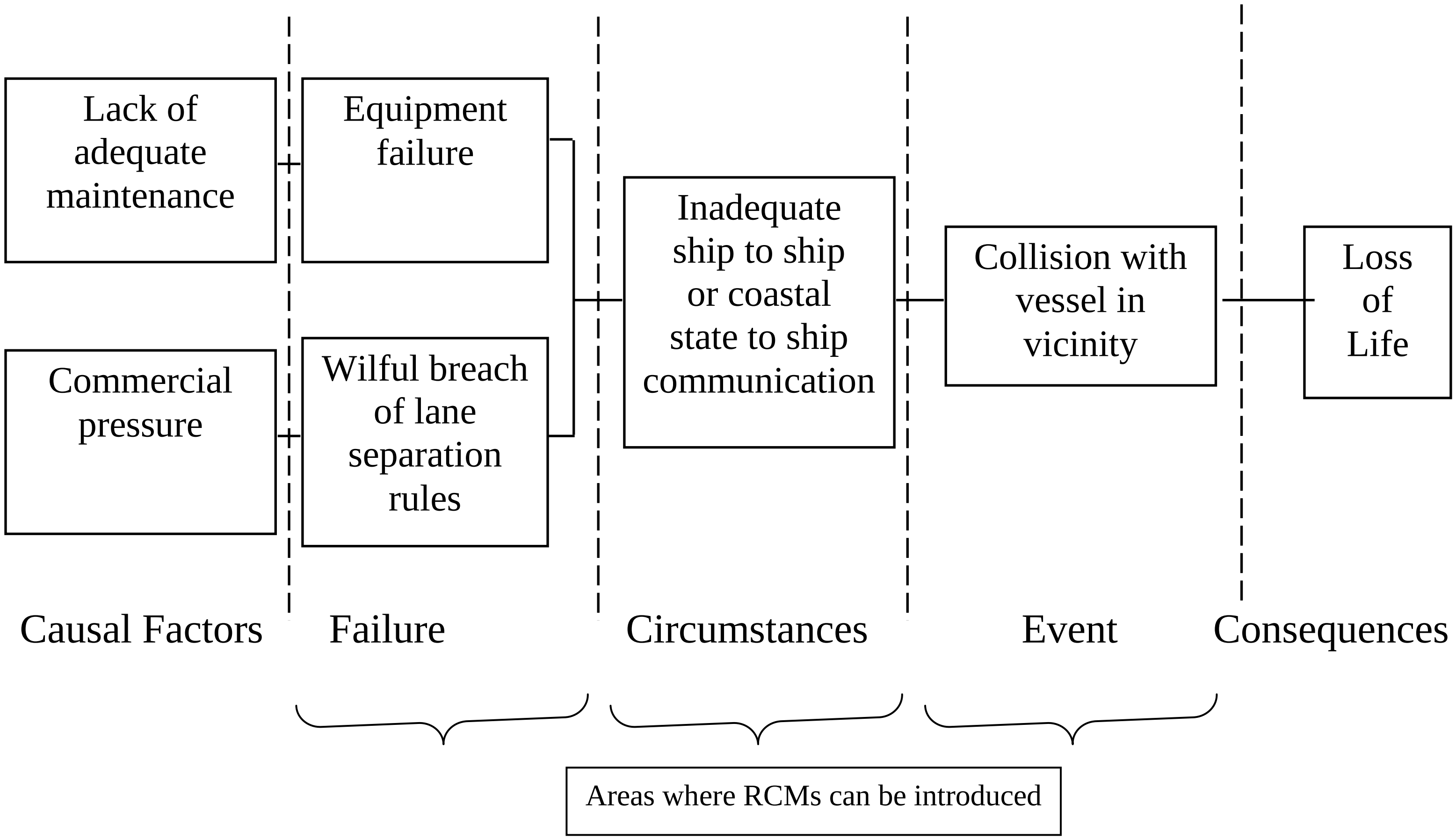


Figure 3.10 Example of causal Chain and areas needing RCMs

measures into options. The following two approaches, related to likelihood and escalation, can be considered:

• 1 "general approach" which provides risk control by controlling the likelihood of initiation of accidents, and may be effective in preventing several different accident sequences; and

• 2 "distributed approach" which provides control of escalation of accidents, together with the possibility of influencing the later stages of escalation of other, perhaps unrelated, accidents. In generating the RCOs, the interested entities (stake holders), who may be affected by the combinations of measures proposed, should be identified.

The output from step 3 comprises:

• 1 a range of RCOs, which are assessed for their effectiveness in reducing risk; and

• 2 a list of interested entities affected by the identified RCOs.

3.5.9 FSA STEP 4 - Cost Benefit Assessment

The purpose of step 4 is to identify and compare benefits and costs associated with the implementation of each RCO identified and defined in step 3. A cost benefit assessment may consist of the following stages:

• 1 consider the risks assessed in step 2, both in terms of frequency and consequence, in order to define the base case in terms of risk levels of the situation under consideration;

• 2 arrange the RCOs, defined in step 3, in a way to facilitate understanding of the costs and benefits resulting from the adoption of an RCO;

• 3 estimate the pertinent costs and benefits for all RCOs;

• 4 estimate and compare the cost effectiveness of each option, in terms of the cost per unit risk reduction by dividing the net cost by the risk reduction achieved as a result of implementing the option; and

• 5 rank the RCOs from a cost benefit perspective (Figure 3.11) in order to facilitate the decision-making recommendations in step 5 (e.g. to screen those which are not cost effective or impractical).

Costs should be expressed in terms of life cycle costs, and may include initial, operating, training, inspection, certification, decommission etc. Benefits may include reductions in fatalities, injuries, casualties, environmental damage and clean-up, indemnity of third party liabilities, etc., and an increase in the average life of ships.

The evaluation of the above costs and benefits can be carried out by using various methods and techniques. Such a process should be conducted for the overall situation and then for those interested entities which are the most influenced by the problem under concern. In general, an interested entity can be defined as the person, organization, company, coastal State, flag State, etc., who is directly or indirectly affected by an accident, or by the cost effectiveness of the proposed new regulation. Different interested entities with similar interests can be grouped together for the purposes of applying the FSA methodology and identifying decision making recommendations.

From Figure 3.11 it can be seen that RCO 3 is providing maximum reduction of risk with minimum cost. BASE represents the initial risk levels, prior to the introduction of RCOs.

There are several indices which express cost effectiveness such as Gross Cost of Averting a Fatality (Gross CAF) and Net Cost of Averting a Fatality (Net CAF) as described below.

The estimates given refer to Gross Cost of Averting a Fatality (Gross CAF) and Net Cost of Averting a Fatality (Net CAF). Their definitions are

Gross CAF = C/R and,

Net CAF = (C - B)/ R

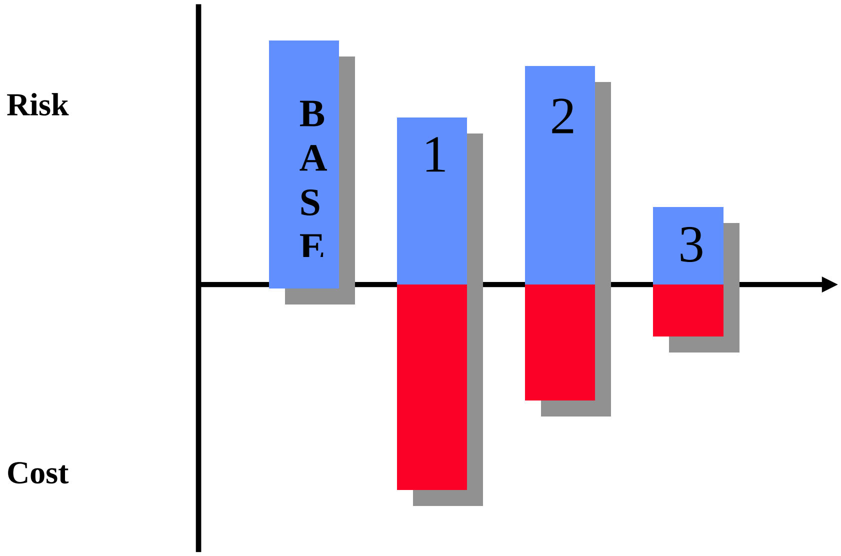


Figure 3.11 Comparisons of Risk and Cost

Where

C is the cost per ship of the risk control option;

B is the economic benefit per ship resulting from the implementation of the risk control option (this may also include pollution prevention);

R is the risk reduction per ship, in terms of the number of fatalities averted, implied by the risk control option.

Another method to assess the RCOs is by calculating Cost of Unit Reduction of Risk (CURR).First step in this process is to the evaluate RCO cost and benefits in Net Present Value (NPV) terms.

Then, evaluate net cost of RCO,

= RCO Cost - RCO Financial Benefit

Next step is to divide the net cost by potential risk reduction there by evaluating how much each unit of risk reduction costs and is termed as – CURR - Cost of Unit Reduction of Risk.

$$\text{CURR} = \frac{\text{Net cost of Implementation}}{\text{Probable Reduction in Risk}} \quad \text{i.e.} \left(\frac{\text{Cost}}{\text{Benefit}} \right)$$

Other indices based on damage to and effect on property and the environment may be used for cost benefit assessment to such matters. Comparison of cost effectiveness for RCOs may be made by calculating such indices.

The output from step 4 comprises:

• 1 costs and benefits for each RCO identified in step 3 from an overview perspective;

• 2 costs and benefits for those interested entities which are the most influenced by the problem under concern; and

• 3 cost effectiveness expressed in terms of suitable indices.

3.5.10 FSA STEP 5 - Recommendations for Decision Making

The purpose of step 5 is to define recommendations which should be presented to the relevant decision makers in an auditable and traceable manner. The recommendations would be based upon the comparison and ranking of all hazards and their underlying causes; the comparison and ranking of risk control options (RCOs) as a function of associated costs and benefits; and the identification of those risk control options which keep risks as low as reasonably practicable(ALARP).

Recommendations should be presented in a form that can be understood by all parties irrespective of their experience in the application of risk and cost/benefit assessment and related techniques. There are several standards for risk acceptance criteria, non as yet universally accepted. While it is desirable for the Organization, and Member Governments which propose new regulations or modifications to existing regulations, to determine agreed risk evaluation criteria after wide and deep consideration, those used within a FSA should be explicit. .

The output from step 5 comprises:

.1 an objective comparison of alternative options, based on potential reduction of risks and cost effectiveness, in areas where legislation or rules should be reviewed or developed; and

.2 feedback information to review the results generated in the previous steps.

A more detailed frame work of FSA is provided in Figure 3.12.

When we compare, even though methods (b) to (e) are somewhat similar, FSA seems to be one of the most viable options for addressing safety of ships including fishing vessels [9][21]. Because it enables the cost-effective acquisition of as much practical safety as possible by choosing risk control options that give an overall reduction of risk and good value for money. FSA is a proactive method, which can address new problems, arising due to new technology, equipment or management practices. FSA can evaluate how much and at what cost a particular safety measure will improve safety, and if that safety measure is equitable to all stakeholders involved or not.

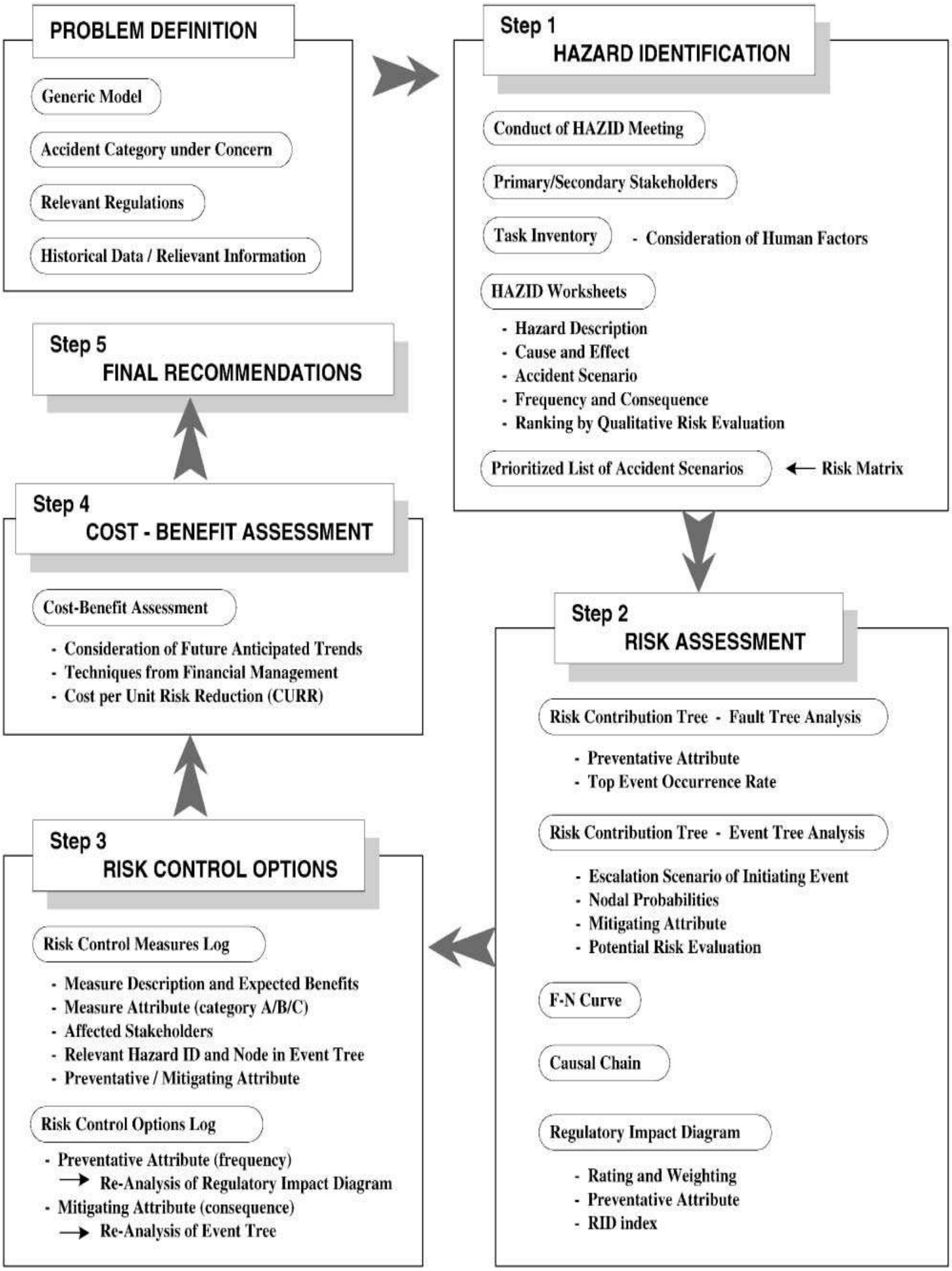


Figure 3.12 FSA in detail [13]

Chapter 4

Safety Standard of Fishing Vessels

Fishing vessel safety standards tend to be lower than for other similar vessels worldwide. In terms of numbers of vessels, the fishing sector represents the largest proportion of the total fleet of commercial vessels. For many years, injuries and fatalities in the workplace were often accepted as being part of the job. In terms of safety, crews on fishing vessels have traditionally been treated as second class citizens. Worldwide, standards for safety on fishing vessels have generally been significantly lower than for passenger or trading vessels. For example the SOLAS Convention (Safety of Life At Sea) explicitly excludes its application to fishing vessels. SOLAS has 146 signatory countries and is in force internationally, while the fishing vessel equivalent, the Torremolinos International Convention for the Safety of Fishing Vessels has only 9 signatories and has not yet had sufficient support to be adopted. This is despite the standards required in the Torremolinos Convention being lower than those required for the equivalent cargo vessel under SOLAS [5].

Some of the possible reasons for this difference include:

a) A historic acceptance by the fishing industry and society as a whole that fishing was a risky occupation for which human injury and death were inevitable;

b) Many owners of fishing vessels also operate the vessel resulting in a voluntary assumption of risk. Owner/operators tend to take comfort in the perception that they are in control of the situation, well prepared and able to anticipate, face and overcome the risks of their profession.

c) The perception that if a fishing boat gets into trouble, it is because of a lack of judgment or skill of a particular individual rather than a failing of the vessel, its safety systems or its management.

d) Crews on fishing vessels frequently have had a direct economic stake in the success of the venture and so they, too, have been prepared to accept greater risks than might be accepted by someone on a wage.

e) Concern that safety standards applicable to other vessels are not practicable on fishing vessels and that the economic impact of imposing those standards would be disastrous to the economic viability of fishing operations; and

f) A lack of interested third parties such as cargo shippers and insurers. The safety of cargo vessels has a direct bearing on the risks associated with the carriage of valuable cargoes owned and insured by others. The cargo of fishing vessels does not involve a third party until it has been delivered and sold.

Another possibility is that fishing vessels have characteristics, such as operating near shore, that make them in some way safer than other vessels and so they do not justify the same standards. This supposition requires further investigation.

When comparing the risks faced by fishing vessels with other vessels it can be shown that fishing vessels are more exposed to risks than others. In most of the scenarios risk is equivalent or greater compared with other vessels.

It is to be noted that Table 4.1 is reasonably conservative in its highlighting of differences in risk. The table suggests that exposure to heavy weather and seas is reasonably equivalent for trading and fishing vessels; however, fishing vessels tend to operate in more severe environmental conditions than many other vessels. It is been suggested that in order to make living, fishermen must often be prepared to work in less than ideal conditions.

The table serves to show that there is no clear reason why trawlers are any less likely to suffer from exposure to risk than cargo vessels. It is suggested that the same holds true for fishing and trading vessels generally. When we consider the risk involved with a tanker causality involving pollution, the risk levels are quite different from that of a fishing vessel accident but at the same time it is also to be noted that the number of causalities resulting from fishing vessel accidents is much higher than the other vessel types [6].

Table 4.1 Comparison of risks between trawlers and cargo vessels [5].

Nature of hazard	Suggested comparative risk
Exposure to heavy weather and seas	Equivalent
Grounding	Equivalent
Collision	Equivalent
Dangerous cargo or stores	Trading>Fishing
Loss of stability due to initial loading	Equivalent
Loss of stability due to changes in loading during voyage	Fishing>Trading
Excessive overturning moments	Fishing>Trading
Overloading	Fishing>Trading
Fire	Equivalent
Exposure to personal injury of persons working on deck	Fishing>Trading
Fatigue	Equivalent

As can be seen, for some hazards, the risks would appear to be reasonably equivalent. Safety standards to control such risks should therefore be similar for both trading and fishing vessels.

On the other hand, where exposure to hazards varies significantly between the two vessel types, it is suggested that standards to control risks should be customized to meet the particular risks associated with the type of vessel and its operation.

Chapter 5

Analysis of collisions involving Cargo Ships and Fishing Vessels

Safety of fishermen and their vessels is a substantial problem all over the world. It is considered to be one of the most hazardous industries in the world with very poor safety record. Fishing vessels have a high loss percentage in case of an accident compared to other ship types, which implies high fatalness and low safety standards followed in the industry [12]. Involvement of fishing vessels in marine collisions is very prominent. Human failures and accidents are directly related. Studies have proved that more than 80% of all marine accidents are associated with human error [2]. Trends show that rate of accidents involving fishing vessels has reduced during recent times, mainly due to reduction in mechanical failures, but the issue of collisions and groundings remains largely unaffected (Figure 5.1), even with the introduction of novel technology and equipments.

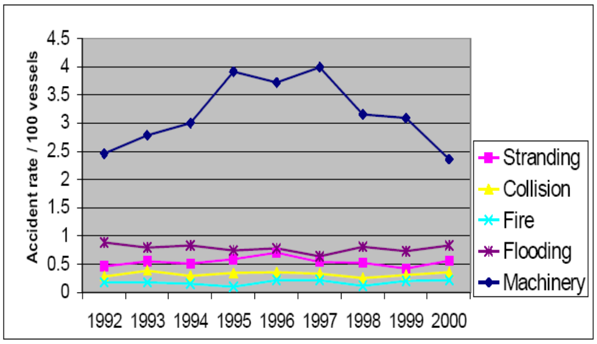


Figure 5.1 Accident rate - Initial incident category/100 registered fishing vessels in UK [16]

Due to the very nature of fishing industry it is difficult for international bodies to involve too deeply getting results. So it is rather down to individual governments and organizations to do appropriate measures to improve safety. However, international bodies like IMO have a larger role in providing adequate rules and guidelines regarding safety in fishing industry and a much important role regarding safety and safe practices onboard ships.

Aim of this study is to understand the collision phenomena involving fishing vessels and better understanding of the underlying causes of these accidents including impact of introduction of new technologies such as Automatic Identification System (AIS) on them. For the analysis, data from three accident data bases were used Australian Transport Safety Bureau (ATSB), Marine Accident Investigation Branch, UK (MAIB) and Korean Maritime Safety Tribunal (KMST). Data for this study consists of reports of 18 collisions involving fishing vessels investigated by ATSB during the time period of June 1995 and January 2004 [3], data from KMST during the time period of 1995 to 2003 [10] and two study reports by MAIB, Bridge Watchkeeping Safety Study (July 2004) [15] and Report on the Analysis of Fishing Vessel Accident Data 1992 to 2000 [16]. Main analysis is based on ATSB data while other data sources serving as reference, but on many occasions there is a lack of data for comparison and deductions are based on available data.

Methodology adopted for the study was to collect and organize data, find out general trends and scenarios, find out unsafe acts/decisions leading to accidents/incidents and analysis of those unsafe acts/decisions to find out underlying causes and possible solutions. Findings are strikingly similar in almost all data bases suggesting strong professional culture in fishing industry leading to unsafe acts/decisions.

5.1 Comparison and Analysis of Data

Data from all three databases shows that about 70% of all marine collisions involve fishing vessels (Figure 5.2). Most of these collisions happen in coastal areas or narrow waters. Fatalities of these 18 collisions investigated by ATSB involve death of 1 person, loss of vessel on 3 (17%) occasions and damage to fishing vessels on all other cases. 8 (44%) of the collisions occurred when fishing vessels were en-route to fishing grounds, on 5 (28%) occasions accidents happened during fishing operation, on 4 (22%) occasions were at anchor and on 1 (6%) occasion fishing vessel was returning to port. This data is consistent with MAIB findings where 46% of the collisions occurred while fishing vessels were underway and 21% of the collisions occurred during fishing operations [15]. Average length of vessels involved is around 19 meters. Ships involved were generally dry cargo ships (89%) out which 15 (83%) were bulk carriers.

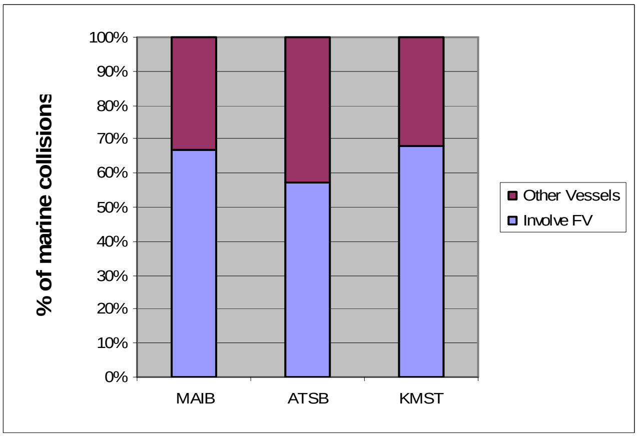


Figure 5.2.Role of fishing vessels in marine collisions

On 5 (28%) occasions colliding vessels were on reciprocal course, another 5 (28%) were crossing situations, 4 (22%) were at anchor and 3 (17%) were overtaking situations. It implies that there is no definite trend in collision course of the vessels involved in collision.

Traffic density is also a factor to be addressed during the analysis of collisions. Australian coast generally has low traffic density, on 10 (55%)out of 18 occasions only colliding vessels were involved, on 4 (17%) occasions one foreign vessel was involved and on 5 (28%)occasions more than one foreign vessels were involved. This implies relatively low traffic density during the time of accidents. Low traffic density may have some bad influence on the perception of risk of collision, as watchkeeping officers may feel unreasonably safe.

5.1.1 Weather, Visibility and Light Conditions

Most collisions happened in good or moderate weather (Figure 5.3), at good visibility conditions and at night time. However, radar detectability of fishing vessels is a concern, as vessels made of wood and fibreglass are poor radar targets, even more so during poor or moderate weather conditions. 9 (50%) of the 18 vessels were made of wood 2 (11%) of fiberglass and 6 (33%) of steel.

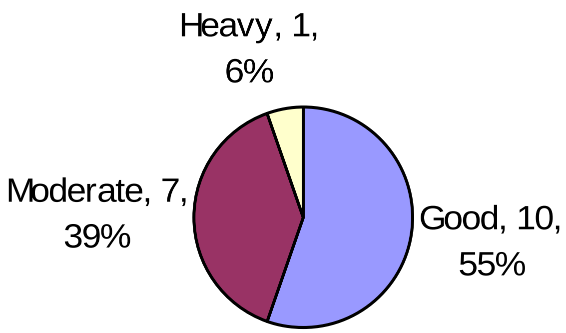


Figure 5.3.Weather conditions during collisions [3]

Around 90%of collisions(Figure 5.4) happened in good to moderate visibility conditions (ATSB), while this figure is around 80% in other databases indicating rather lesser role of visibility in collisions and implies good conditions for visual lookout during the time of most of the accidents. It is also interesting to note that the scenario is, most collisions are taking place at night time but often in good visibility and weather conditions. It indicates a serious problem as these conditions are supposed to be suitable for good lookout.

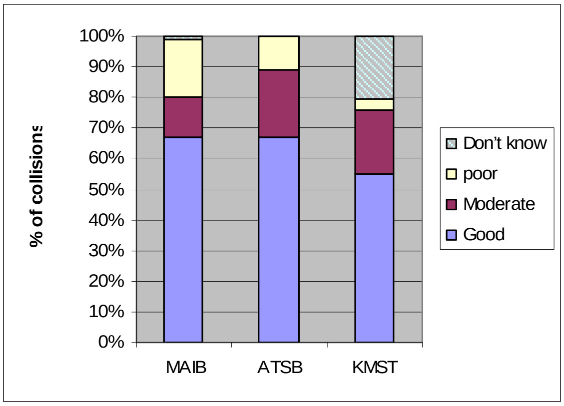


Figure 5.4 Visibility

Most collisions took place at night time (Figure 5.5), indicating the low alertness level experienced by watchkeepers at night time. This aspect is considered in detail in section 5.1.4.

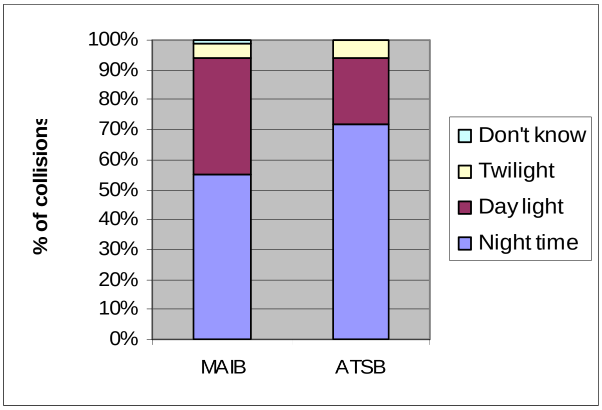


Figure 5.5 Light conditions

5.1.2 Manning of fishing vessels

Most of the fishing vessels (78%) carried a crew of 2-4 people and on five occasions (28%) a crew of 2 or less was carried. Though it may be according to the rules, it appears to be insufficient to keep a proper lookout and do fishing at the same time. This fact further came to light on a collision when FV was carrying a crew of only two; both were at work under bright work lights, apparently not keeping any sort of lookout, resulting in loss of its skipper along with the vessel. It is to be noted that fishing vessels are obliged to keep a lookout at all times regardless of engaged in fishing or not, but this aspect appears to be contradicting with manning rules of regional administrations and making it impractical to keep a lookout at all times at sea.

5.1.3 Lookout and awareness

Lookout onboard fishing vessels are generally faulty, on 6 occasions (33%) fishing vessels failed to provide any sort of lookout, 3 of this 6 were at anchor, and on 5 occasions (28%) unqualified persons were on lookout duties. None of the fishing vessels apparently kept an effective visual lookout. Lookouts kept onboard many cargo ships were also equally ineffective (50%) as they failed to detect fishing vessels in sufficient time prior to collision. According to the MAIB [15] poor visual lookout can be linked to poor employment of the ratings on the bridge. It further notes that many ships use an additional lookout at night but his or her presence is often seen as a token gesture aimed at meeting regulatory requirements. As mentioned before most of the collisions occurred in good to moderate visibility indicating a serious deficiency in terms of lookout duties.

Awareness on the presence of other vessels and knowledge about their actions are very important to prevent collisions. Out of 18 incidents on 10 (55%) occasions either one of the vessels was aware of the other and had sufficient time for avoiding action, on 5 (28%) occasions it was too late for any avoiding action to be effective and on 3 (17%) occasions vessels failed to detect each other prior to collision (Figure 5.6). It seems that lack of detection of possible target in sufficient time is a concern and is attributed to the possible means of detection, visual lookout and radar.

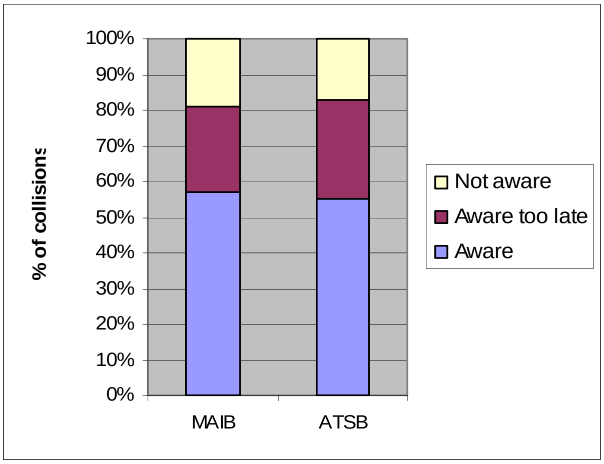


Figure 5.6 Awareness of other vessel prior to collision

5.1.4 Fatigue and Time of the Day

It is to be noted that in most of the cases fatigue does not appear to be a contributory factor. In 15 (83%) of 18 cases fatigue does not appear to be a contributory cause. This is consistent with MAIB finding which suggests less than 25% of collisions attributed to fatigue [15]. This can be true for fishing vessels also as about half of the 18 collisions happened during fishing vessels trip to fishing grounds from port. This suggests a change in environment, especially after their stay at home; it might have had some influence on their actions. It seems that collisions are more likely to happen during their trip to fishing grounds rather than returning home.

There is a clear trend in the accident curve showing a hump (Figure 5.7) corresponding to the low alertness level of human circadian rhythm (Figure 5.8). Out of 18 collisions 5 (28%) happened between 04:00 and 04:40 in the morning. It is to be noted that there is a peak in accident rate between 04:00 and 05:00 during the morning watch, even if it is not clearly visible from the trend provided. This is also consistent with MAIB data [15] where both collision and grounding data's show a peak during the time period between 04:00 and 05:00. So it is worth arguing that an improvement in watch system, corresponding to the low alertness level may well yield dividends.

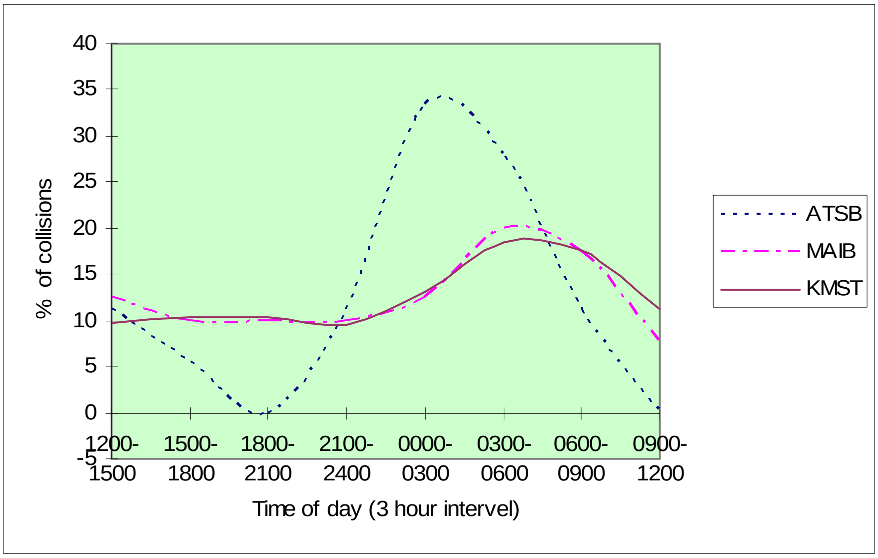


Figure 5.7 Time of accidents

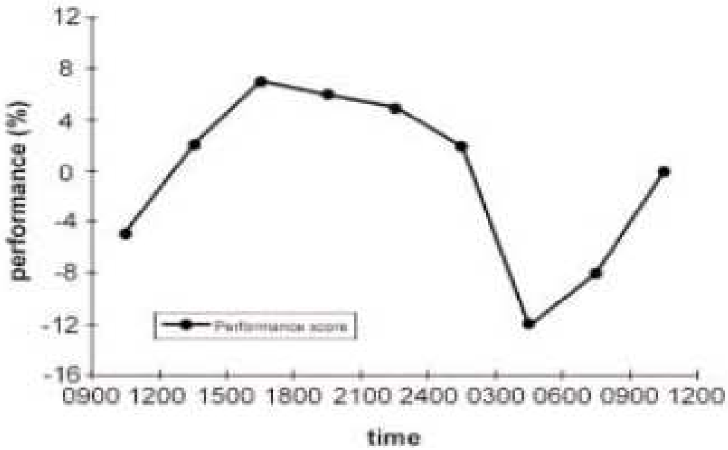


Figure 5.8 Accepted empirical levels of alertness and mental performance against time [15]

5.1.5 Competence and Situational Awareness

As mentioned before qualification of personal on lookout of fishing vessels is a real problem, in more than 60% cases either no lookout or poorly qualified person on lookout were contributory causes. But for cargo ships this does not seem to be a factor since persons on lookout duties were qualified and experienced although this didn't help their situational awareness and judgment. However, lack of situational awareness and poor judgment were main causes on most of the collisions.

The definition of Situation Awareness is "a state of knowledge that directly relates a dynamic environment to the operational target goals". Situation awareness generally involves:

• 1 Assessment of the environment,

• 2 Identifying and updating immediate and long term goals,

• 3 Planning, based on goals and the environment,

• 4 Predicting the results of plan execution [2].

Situational awareness of a person in a particular situation depends on his or her competence, which in turn depends on knowledge, skills and abilities. This is a very important aspect in preventing any type of accident.

There are several steps towards the development of a competent crew. Aptitude is the basic quality required upon which building blocks of competence such as knowledge, skills and experience can be constructed. Training is required to develop skills and various tools can augment those skills [1].

5.1.6 Communication and use of RADAR

Proper use of radar is one of the basic necessities, since detection of the possible target is the first step towards preventing collision at sea. However, this basic requirement is often compromised. As indicated in Table 5.1, more than half of the fishing vessels involved failed to even use the radar to collision avoidance purpose, while only two occasion's ships involved used radar to good effect.

Table.5.1 Use of radar

Use	Ships	FVs
Improper	16 (89%)	7 (39%)
Proper	2 (11%)	None
Not used	None	10 (55%)
Out of function	None	1 (6%)

Communication between the vessels is very important to prevent collision at sea. It is important to note that in none of the 18 cases a Very High Frequency radio (VHF) communication was established prior to collision (Table 5.3) and in only 28% of the cases a communication was established after collision. Lack of willingness to communicate on VHF is a serious concern, especially when the vessel is lost and the fishermen are left behind. In fact this also implies a routine followed in the industry. Use of sound signals along with speed reduction is very effective in preventing collisions, but this aspect too is undermined too often (Table 5.2). This matter is of particular importance considering that none of the vessels tried to reduce speed as a precautionary measure to avoid collision.

Table 5.2 Use of sound signal

Use	Ships	FVs
Used	2 (11%)	None
Not used	16 (89%)	18(100%)

Table 5.3 VHF Communication

<table>
<tr><th colspan="3">By ships</th></tr>
<tr><td>Tried to call FV before collision</td><td>2(11%)</td><td rowspan="4">78%</td></tr>
<tr><td>Tried to call FV after collision</td><td>3(17%)</td></tr>
<tr><td>Denial</td><td>1(6%)</td></tr>
<tr><td>No attempt to call FV</td><td>8(44%)</td></tr>
<tr><td>Called FV after collision</td><td>4(22%)</td><td>22%</td></tr>
<tr><th colspan="3">By FVs</th></tr>
<tr><td>Tried to call Ship before collision</td><td>1(6%)</td><td rowspan="3">72%</td></tr>
<tr><td>Tried to call Ship after collision</td><td>4(22%)</td></tr>
<tr><td>No attempt to communicate</td><td>8(44%)</td></tr>
<tr><td>Called after collision</td><td>5(28%)</td><td>28%</td></tr>
</table>

A rough model of Ship-FVcollision is given in Figure 5.9.It has got four levels before a collision to take place. First level is the detection phase which consists of both human lookout and radar lookout. It is to be noted that in both cases human intervention is essential and proper training and competence plays a phenomenal role in this stage of the accident chain. One of the most important additions to detection aspect will be AIS, as most of the cargo ships will be equipped with such systems in the near future.

Once the other vessel is detected next step towards the avoidance of collision is analysing the situation thoroughly .There are several elements contributing to the situational awareness of an individual such as competence, perception of risk, knowledge of other vessel and fatigue (time of the day effects are one of the prominent aspects in this regard).

Next step towards collision avoidance is the communication between the vessels .It is to be noted that this aspect is regularly undermined which has a very bad effect as in many cases vessels are unaware of the actions of other vessels. Flares are generally used to alert the other vessel in case of a danger.

Finally the actions taken by the crew onboard is what really matters. In case of a collision scenario both vessels should alter course to starboard, but many aspects may prevent such an action, such as hardware failure (e.g. steering gear failure) or human failure, details of which are out of scope of the current study.

5.2 Analysis Using Error Management Models

5.2.1 SHEL and Reason Hybrid Model

This model (Figure 5.10) is used to find out and model initial accident Scenarios. SHEL model consists of four components, *liveware-L, hardware-H, software-S and environment-E*. The

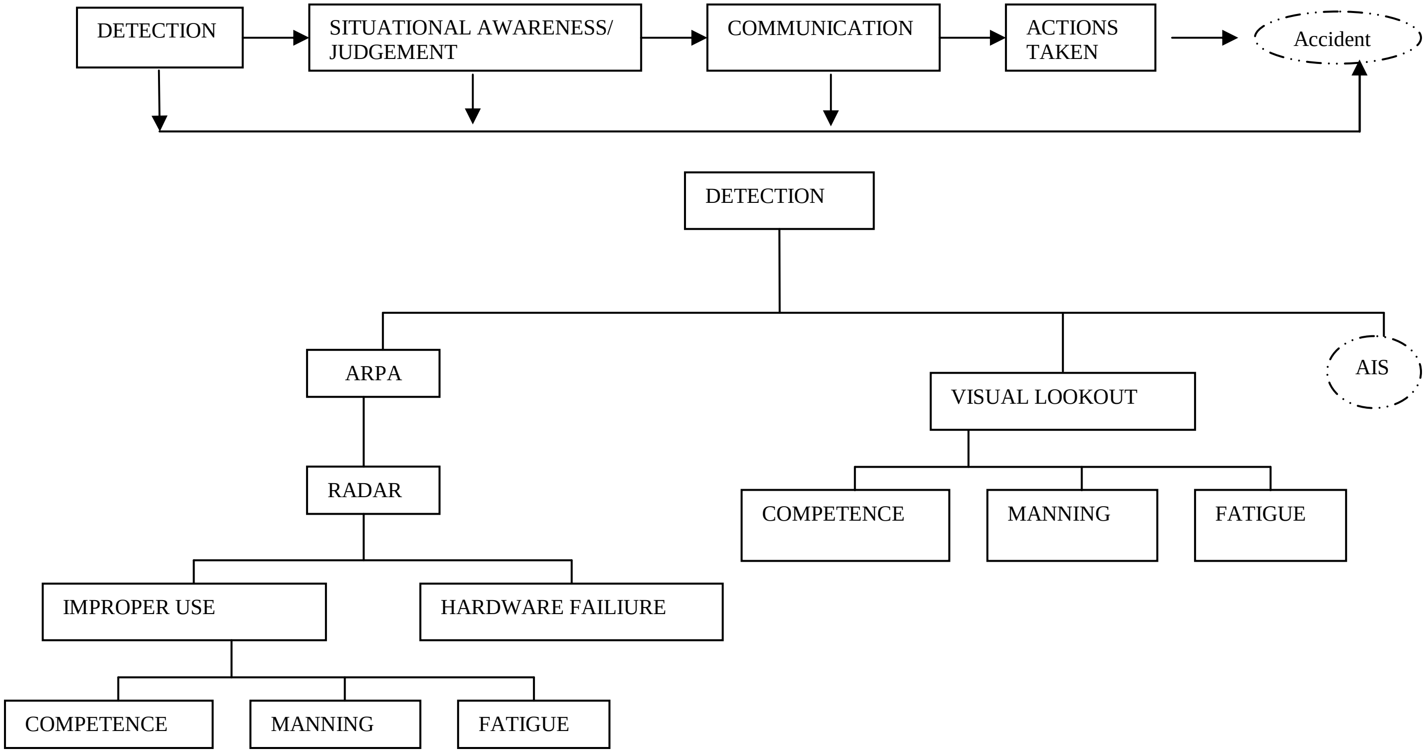


Figure 5.9 Rough model of Ship-FV collision

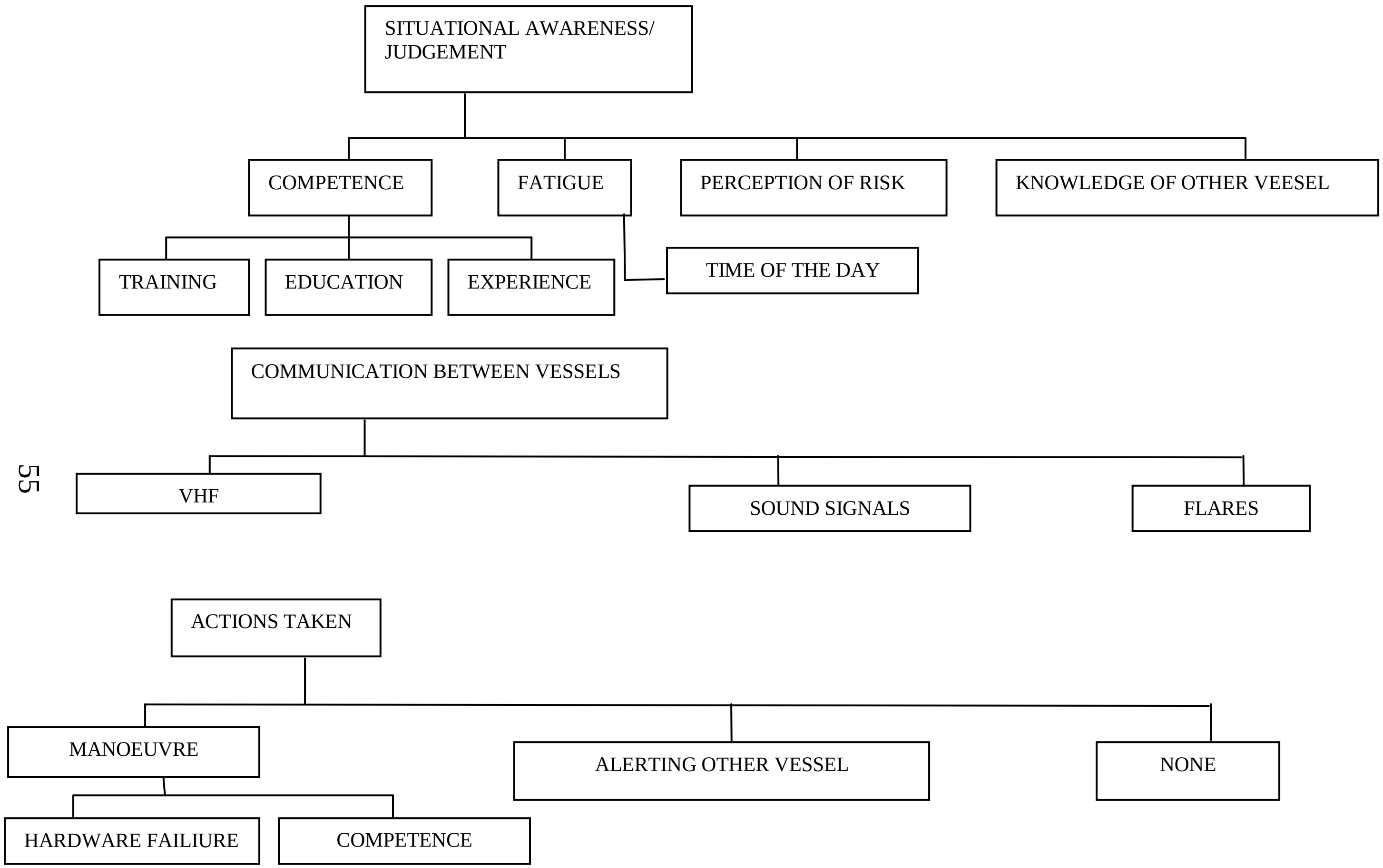


Figure 5.9 Rough model of Ship-FV collision (continued)

SHEL model is commonly depicted graphically to display not only the four components but also the relationships or interfaces between the liveware and all other components. A mismatch between the components can be a source of human error.

Reason's model facilitates further organization of the work system data collected using SHEL model, and an improved understanding of the influence of that data on human performance. It consists of a number of layers or barriers (productive elements) before any accident to take place. Holes in the model consist of system deficiencies and when all the holes align there will be an accident. It is to be noted there will be holes can be due to both active factors and latent conditions.

Active factors are the final events or circumstances which led to an occurrence. Their effect is often immediate because they occur either directly in the system's defence (e.g., disabled warning system) or the site of the productive activities (i.e., the integrated activities of the work system's liveware, software and hardware elements), which would indirectly result in the breaching of the system's defence

Underlying factors may reside at both the personal and the organizational levels; they may be present in the conditions that exist within a given work system (referring to the preconditions element in the model).

The occurrence sequence is developed by arranging the information regarding occurrence of events and circumstances around one of five productive elements, i.e., decision makers (high level decision makers such as international and governmental authorities), line management (refers to management onboard vessel, such as onboard training and maintenance) , preconditions (refers to conditions such as fatigue and fallible working practices), productive activities (unsafe acts/decisions) and possible defences (physical or other defences which mitigates the effect of unsafe acts) [7][18].

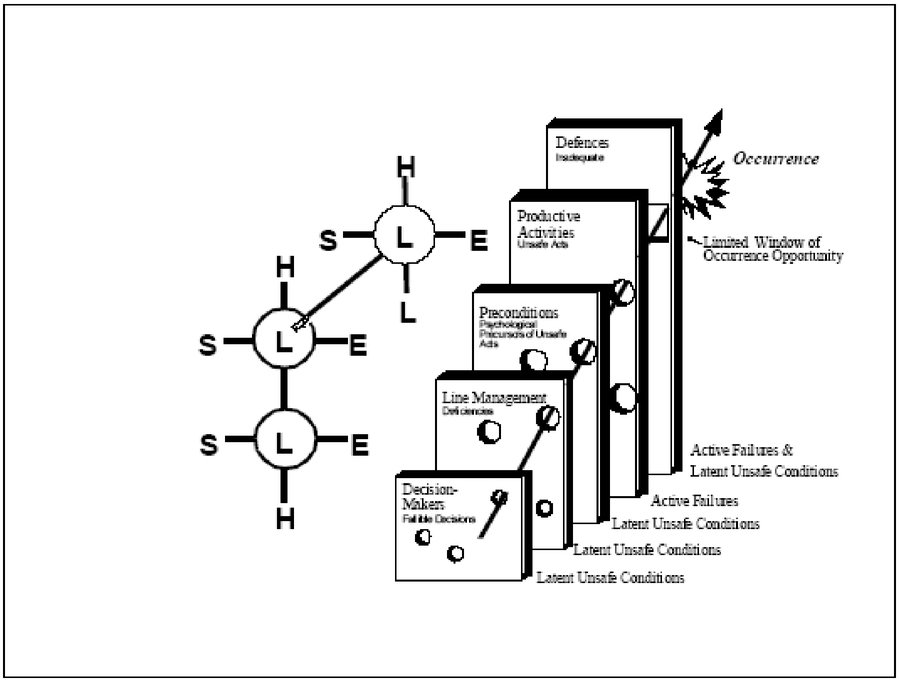


Figure 5.10 SHEL and Reason Hybrid Model [7]

Possible Defences identified using Reason's model are:

Proper visual lookout (all cases)

VHF radio communication (50%)

Better radar detectability of fishing vessels (44%)

Speed reduction along with sound signal (50%)

Unsafe acts identified are:

Improper visual lookout (all cases)

Improper use of radar (all cases)

Poor display of navigation lights (44%)

Poor situational awareness/judgment (all cases)

Lack of communication on VHF radio (50%)

Improper manoeuvring (17%)

Lack of speed reduction / sound signal (50%)

People on lookout duties involved in other than navigational duties (33%)

Preconditions identified are:

Poor perception of risk (all cases)

RADAR delectability affected by weather (44%)

Poorly qualified person on lookout duty (33%)

Lack of lookout (28%)

Fatigue (17%)

Line management:

Not many deficiencies were identified corresponding to line management and frequencies of those are very less, however, some of the issues identified are;

Lack of onboard training (28%)

Improper watch handover (11%)

Relieve deck hand on lookout duty for other works (6%)

Decision makers:

Poor training (61%)

Inadequate rules regarding anchoring positions for fishing vessels (22%)

Inadequate rules regarding manning of fishing vessels (11%)

Poor organizational culture (22%)

Lack of instructions on rest periods prior to joining a vessel (6%)

5.2.2 Causal factors identified during other investigations

Most of the issues are similar to those in other databases. Non compliance with rules and regulations is very common in all data bases as it implies enforcement of rules and regulations is the greatest challenge authorities facing. The main issue remains to be attitudes of people towards safety. As we can see from Tables 5.4 and 5.5 if we can improve awareness and the way in which those involved view things then there will be improvement in safety.

Table 5.4 Causal factors of Fishing Vessel collisions according to MAIB [16]

Category	No of incidents	% of total collision causes
Non-compliance	23	31.51%
Perception of Risk	9	12.33%
Poor Decision-Making/Information use	4	5.48%
Unsafe Working Practices	6	8.22%
Violation of Procedures	5	6.85%
Allocation of Responsibility Inappropriate	3	4.11%
Total	50	68.50%

Table 5.5 Causal factors of marine collisions according to KMST [10]

Category	No of incidents	% of total collision causes
Negligence of lookout	582	49.07%
Violation of navigation rules and regulations	256	21.59%
Negligence of watchkeeping	20	1.69%
Inappropriateness of manoeuvring	87	7.34%
Deficiency of keeping a designated course	13	1.10%
Inappropriateness of ship operation management	3	0.25%
Inappropriateness of crew manning	4	0.33%
Total	965	81.37%

5.2.3 GEMS framework

This framework (Figure 5.10) provides "pathways" that lead from the identification of the unsafe act/decision to the identification of what was erroneous about the action or decision and finally to its placement within a behavioural context. The generic error-modelling system (GEMS) framework facilitates the linkage of an error/violation to an individual's level of performance at the time of failure. Most collisions can be prevented, if vessels obey The International Regulations for Preventing Collisions at Sea, 1972, (COLREGS) and satisfy Standards of Training, Certification and Watchkeeping 95 (STCW 95) requirements.

For analysis using GEMS we select major error types (unsafe acts/decisions) identified during last step.

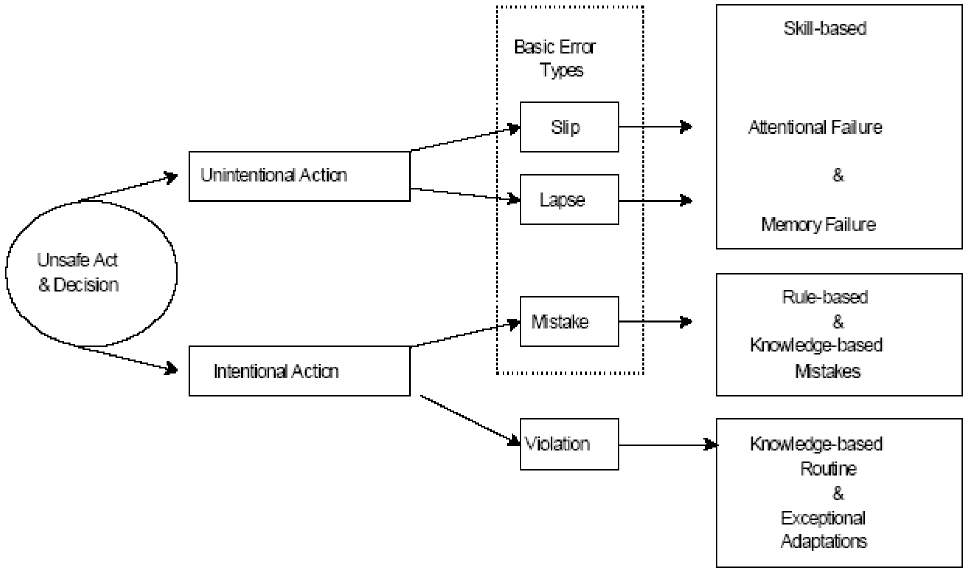


Figure 5.11 GEMS framework [18]

Improper lookout onboard ships seems to be unintentional action resulting from slip or lapse, they are more of a result of attentional or memory failure. Poor lookouts on fishing vessels are results of both intentional and unintentional action, but on many occasions (39%) it seems to be a case of intentional action resulting in violation, having its routes in lack of knowledge of rules and regulations. So the solution seems to be better training in later case and ways to improve alertness in former.

Improper use of radar also seems to be unintentional action resulting from slip or lapse, but they are mainly resulting from lack of skill even though issues related to alertness can be a factor. In case of fishing vessels poor or lack of use of radar is both intentional and unintentional. In many cases it is intentional action not to use radar which is mainly knowledge based- routine-violation and improper use results from lack of skill which is a competence related aspect. In all radar related human errors remedial measure seems to be methods to improve competence of those involved such as training and qualifications.

Poor display of navigation lights is rather a routine followed by some of the fishing vessels. It is a serious intentional violation mainly due to lack of knowledge. This issue is of particular importance since on many occasions this aspect made watchkeeping officers onboard ships confused regarding fishing vessels actions, contributing to collision.

Poor situational awareness/judgment is a complex issue which is prominent in all of the collisions analyzed. It is basically an unintentional action resulting from slip/lapse and having its roots in attention, memory and skill. Only a properly qualified man with good alertness level can make good decisions.

Lack of communication on VHF radio is a big concern. In none of the 18 cases a VHF communication was established prior to collision and only 3 cases accounts for an attempted communication prior to collision. It can be classified as intentional violation, since ship watchkeeping officers are supposed to be aware of this efficient way of avoiding collision. It appears that poor perception of risk and a general feeling of security might be culprits in this regard. Increasing awareness regarding the usefulness of VHF communication as a collision avoidance tool is an urgent necessity. It is to be noted that generally fishing vessels do not keep a proper watch on VHF channel 16, because they communicate on other channels for different purposes and usually do not bother to turn back to original channel.

Improper manoeuvring is another clear issue of intentional action taken by the vessels involved in collisions. In most of the cases it results in violation and is generally a result of quick avoiding manoeuvre (exceptional adaptation). It is to be noted that out of 8 such manoeuvres to port, done by trading ships, 5 were rather good decisions resulting in less damage to fishing vessels. However, there were occasions when the watchkeeping officer manoeuvred to port side based on scanty radar information and turned the vessel to collision course with fishing vessel. Situational awareness and competence are key issues to make good decisions and qualifications and skills are very important to achieve this.

None of the vessels involved reduced speed after detecting other vessel, even in bad weather conditions. This implies both commercial pressure and perception of risk of people involved. Only on two occasions sound signal is used to alert the other vessel. Use of sound signal along with speed reduction would definitely have reduced collision risk. Like VHF communication this aspect also reflects false perception of risk and a general feeling of security of those involved.

The most worrying type of error is people on lookout duties been involved in other works. As the MAIB notes it is going to be the most damaging aspect .It implies the tremendous amount of workload ships officers bearing .They are supposed to do all formalities related to cargo work and ships daily routines along with ships navigational duties, often forced to do their other unfinished duties during watch period. It is a dangerous trend and needs immediate attention of those concerned. As the MAIB rightly points out authorities should take a hard look at workload of seafarers. Even though the ships involved in this study often carried more than two watchkeepers as the MAIB [15] points out there is a need for much clearer regulations regarding manning of ships, as there is a tendency that owners change flag administrations to those interpret regulations more leniently.

5.3 Review of the Collision Accidents on the Basis of Culture

According to Helmreich and Merritt [4], three types of cultures are prominent, which affect the overall safety (Figure 5.12). They are national culture, organizational culture and professional culture. Of these three, national culture is the most distal element of the model and the one least amenable to change. It can influence the organizational culture in the forms of communication

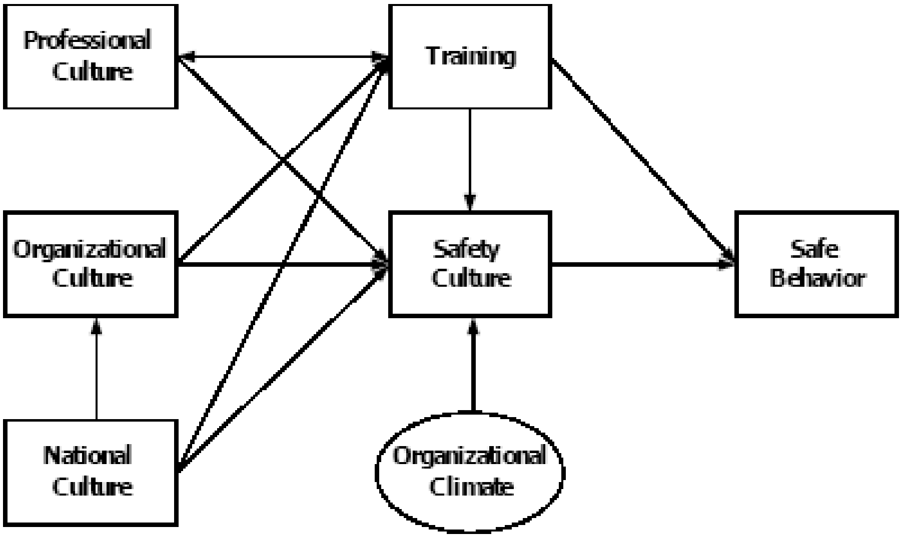


Figure 5.12 Model of the interaction of cultures and their outcomes [4]

and leadership practiced. It can also determine the style of training and the nature of training delivery. In addition, national culture further influences the safety culture.

The organizational culture has a powerful influence on training practices and safety culture. The organizational climate (morale) reflects the positive or negative feeling employees have about their organization. It can influence the behaviour of crew or master onboard the vessel. Poor morale can affect on-time performance, compliance with procedures and willingness to perform to their maximum capacity.

Professional culture may influence the safety culture, through feeling of responsibility, for crew or vessel safety and dedication to execute ones job as effectively as possible. On the other hand, it has a negative influence on safety culture by making the skipper or crew less aware of their personal limitations and less accepting of training that focused on safe behaviours. The model shows a path between training and professional culture because training about human performance limitations can change attitudes about personal vulnerability and influence the professional culture.

The trend from accidents is that the problems faced by the fishing industry is common, which is related to violation of rules and attitudes of people, which in turn has got strong roots in professional and organizational cultures of this industry. As can be seen from this model, solutions lie mainly with training and education of those involved to achieve any realistic goals in long run. However, the factors influencing training is to be carefully studied, it has links with all the three basic elements of the model. So when we adopt training programs these should be considered in detail. For example, the so called Power Distance (PD) relationship [4] is very important when we consider national culture. It means social setup of a nation or community where relations between people differ in a substantial way with that of other. For example it is reflected in the difference between eastern and western cultures where in the former case personal relations are stronger and juniors are not supposed to question the decisions taken by the seniors. It might have a substantial influence on the decisions taken by people.

5.4 Influence of AIS on Collision Accidents Involving Fishing Vessels

From July 2007 onwards most of the vessels above 300 GT will be equipped with Automatic Identification System (AIS). One of the main aims of AIS is to function as a collision avoidance tool by providing watchkeeping officers with adequate information regarding other vessel such as heading, rate of turn etc. AIS has a positional accuracy of less than 10 meters in comparison with radar systems, which has an accuracy of 30-50 meters and has more similar advantages.

Effectiveness of AIS in collision avoidance depends on the navigator's ability to assess so called dynamic information provided by AIS. It has been analytically shown that AIS can reduce collision risk up to 50 % [14], provided vessels involved have functional AIS onboard. However, this situation would not be true in scenarios involving fishing vessels because most of the fishing vessels (under 300GT) are exempted from fitting AIS. When we analyze the situation, navigators onboard the ship will have to handle additional information provided by AIS. AIS is effective only when vessels in a collision scenario are equipped with such system and collision avoidance capability depends purely on ship navigator's ability to act according to the information provided by AIS.

So in ship-FV collision scenarios AIS can not function as a collision avoidance tool and the question remains whether it can assist such collisions to happen. From the analysis done so far it seems that there is a large probability that Ship-Fishing vessel collisions may get aggravated by the use of AIS. If we look into the main reasons of collisions involving ships and fishing vessels such as poor perception of risk, poor situational awareness and lack of proper lookout will largely remain same unless acted on. However, the false sense of security and confidence of passing much closer to other vessels, as allowed by AIS, may prove to be great hazards on days to come. This aspect can be considered similar to those where watchkeeping officers relaying too much on radar and fail to provide visual lookout. Information overload due to AIS, as it augments the existing information, can also prove to be dangerous unless proper training is given to those involved.

An effective solution would be to provide less sophisticated AIS like equipment to fishing vessels, which can provide sufficient information to the watchkeeping officers of ships. Such system can effectively replace VHF communication between vessels and there would not be any language problems. It will substantially reduce the collision risks as watchkeeping officers can get sufficient time to act on. In addition such equipment should be affordable to common fishermen.

Chapter 6

Use of Influence Diagram Methodology for the Analysis of Ship-Fishing Vessel Collisions

The aim of this chapter is to apply Influence Network techniques to identify the most important human and hardware influences that contribute to Ship- FV collision. This methodology is recommended by IMO and was during the FSA study of Bulk Carriers [17].It outlines the critical issues associated with Ship- FV collision scenarios and provides an account of the application of Influence Networks in the context of such accidents. Specifically, the construction of an Influence Network for a generic Ship- FV collision scenario is described, including the approach adopted for defining each factor within the network and deriving the associated rating values for these factors.

The scope of the chapter is restricted to defining the Influence network and assigning rating values. It is rather an qualitative approach and much more scrutiny is required on the identified influences.

6.1 The System Approach

Most accidents are caused by a complex combination of events; they do not happen in isolation, but are part of a wider system of causal factors. It is this foundation that forms the basis of the systems approach to understanding and managing risk. All events / activities are considered within the context of a wider system of influence, such that no one event can be viewed in isolation from its surrounding context. This is illustrated in Figure 3.5 (section 3.5.3) as a set of nested systems or domains that influence the performance of people and hardware in a hazardous situation.

Conventional risk assessment tools focus on identifying the activities, events and failures directly leading to an accident. However, the complexities of the human, organisational and environmental contributions to accidents are often not amenable to analysis using these techniques. This is because the critical influencing factors upon an accident may be latent and remote from the operational situation, existing instead at the level of the organization responsible for planning, controlling and monitoring operations, or within the wider legal, social, economic or political environment.

6.2 Structuring the Influence Network

The Influence Network is developed from consideration of a generic set of influencing factors, which are structured in a hierarchy representing the influence domains of the environmental context, corporate infrastructure, organizational, management and the direct working environment. As a starting point in this process, a Generic Influence Network (GIN), as shown in Figure 6.1, is used to draw out the specific influencing factors that have an effect on any given accident type, in this case Ship-Fv collision. This results in a customized Influence Network which is fully defined in the context of the accident under consideration and the hierarchy of influencing factors upon the accident.

The direct causes of the top event can occur as a result of three areas: human, hardware and external events. The analyses done during the previous chapter along with the study on bulk carrier accidents provides the basis for the development of contextual scenarios that provide the baseline foundation for the customisation of the Influence Networks.

In order to model these influencing factors, the Influence Network has adopted a hierarchy below the direct causal level that reflects the domains shown in Figure 6.1:

Organisational Level, which refers to the underlying organisational influencing factors that affect the human and technical conditions of the working environment and therefore shape the occurrence of human/technical failures;

Policy Level, which comprises the policy and corporate level influencing factors that determine the organisational processes; and

Environmental Level, which refers to the regulatory and wider external influencing factors that determine corporate and organisational policies and processes.

These levels represent varying proximity to the event being influenced; the lower the level the more remote the influence from the event in question. At each level, categories of influence have been identified as shown in Figure 6.1 Other influencing factors can either be incorporated within this generic model or provide a basis for the customization of the network for the accident type under consideration.

6.3 Customization of the Influence Network Definitions and Ratings for the Generic Ship-FV Collision Accident Scenario

The terms rating and waiting may need clarification, in this context they mean;

Current quality of Influencing Factor (IF) across the industry = Rating and,

Relative importance of each IF on other IFs through out the hierarchy that ultimately can lead to an accident = Weighting.

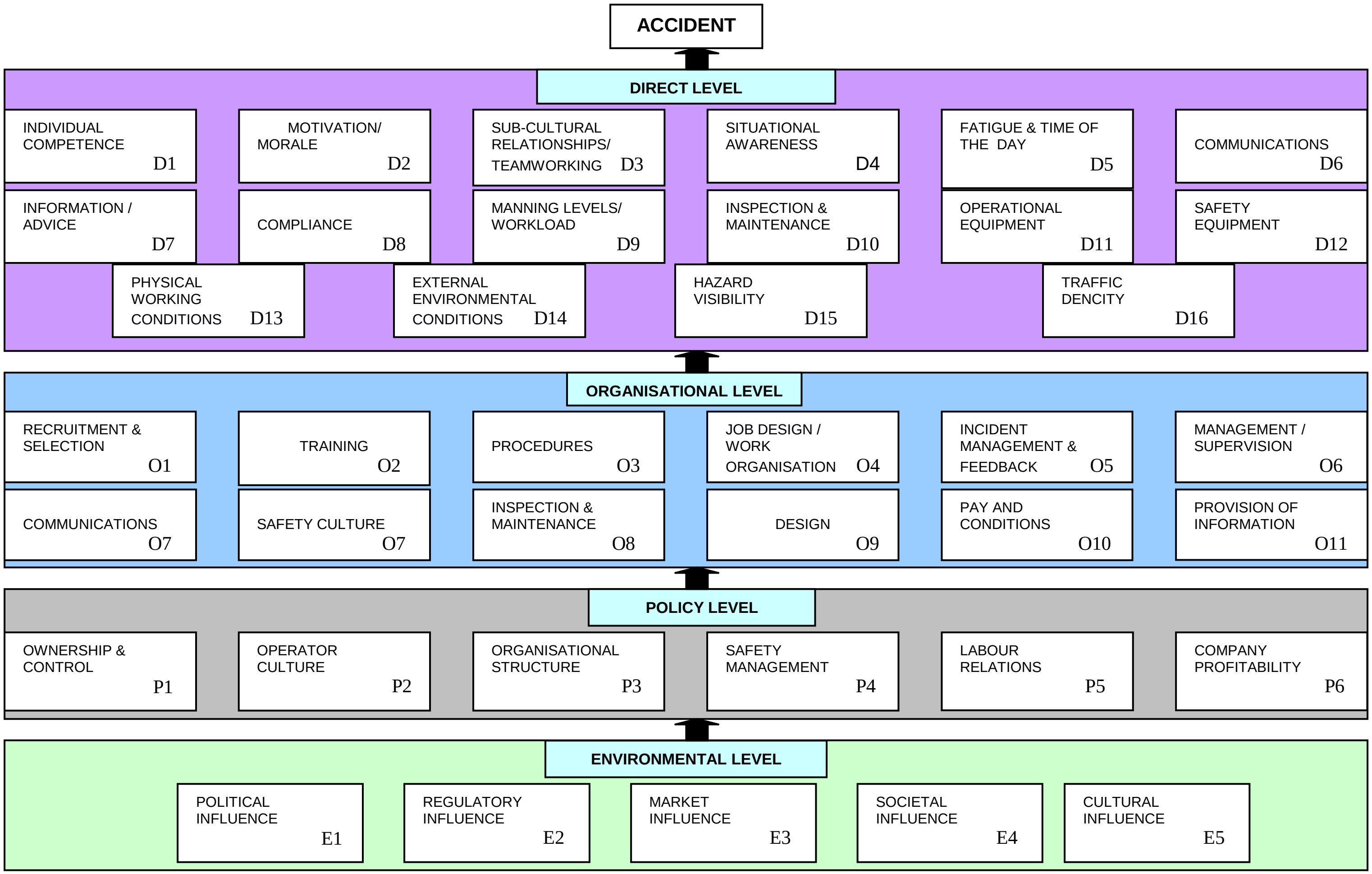


Figure 6.1 Generic Influence Network

A rating value between 1 and 7 is assigned for each IF to reflect the current practice in respect of each IF across the industry (1 being worst and 7 best). This is assigned based on previous analysis and based on the application in bulk carrier safety and may require through analysis by experts. Nevertheless in this case values are assigned based on the limited expertise of the author.

6.3.1 Direct Level Influencing Factors

D1 Competence – the skills, knowledge and abilities required to perform particular tasks safely.

The key components of the competence of seafarers are effective training and appropriate experience. However the competence of fishing vessel crew tends to be below par owing to lack of regulations and difficulties in implementing the current regulations. So based on this poor status a score of 2 is assigned (out of 7).

D1	**2**

D2 Motivation – workers incentive to work towards company, personal and common goals.

Motivation levels are felt to be strongly influenced by personal goals of financial reward and overall working lifestyle. Most of the fishing vessel skippers are owners of their vessels and generally crew wages are according to their catch, which means that there is a strong motivation to work.

D2	**6**

D3 Sub-Cultural Relationships/Teamworking - subcultures within an organisation are the product of distinct group values, attitudes, competencies and behaviours. Whilst teams may work as cohesive units, there may be a tendency for subculture conflict in which two or more groups have irreconcilably different values, attitudes, competencies and/or behaviours.

Since most of the fishing vessels employ small number of crew this aspect dose not seems to affect the scenario adversely. Most of the time fishing vessel crew has a very intimate relationship and often seen as a family business.

D3	**7**

D4 Situational Awareness - the extent to which workers are aware of events surrounding them and their relevance to systems safety both at that time and in the future.

From the analysis done during the previous chapter it is clear that there is a clear deficiency in this regard irrespective of vessels involved. It seems that crew are incapable of handling the dynamic situation. Main issue in this regard seems to be training.

D4	**2**

D5 Fatigue/Time of the Day Effects - The degree to which readiness for degraded through sleep deprivation, or excessive / insufficient mental or physical activity.

It seems that fatigue as such does not have a major say but most of the collisions are happening at night time, especially during the low alertness period of human circadian rhythm.

D5	**5**

D6 Communications- Communication Between Vessels Involved.

One of the most important aspects of the Ship-FV Collision, very few vessels communicates prior to collision. It can be attributed to many reasons which are somewhat lightly described in sec 5.1.6.

D6	**1**

D7 Information/Advice - The extent to which people can access information that is accurate, timely, relevant and usable.

Most of the fishing vessel crew are ignorant to the relevant rules and regulations and behaves erratically, but the same can not be said regarding their counterparts onboard ship but they too behave erratically. Overall this aspect is also far from satisfactory.

D7	**3**

D8 Compliance - The extent to which people comply with or obey procedures, rules, standing orders or regulations.

From the analyses done so far its clear that violations of rules and regulations are too common. It seems that ships have a slightly better compliance rate compared to fishing vessels, but the situation is far from satisfactory.

D8	**2**

D9 Manning Levels& Workload - The relationship of supply to demand for suitable human resources. Relates to the appropriate mix and number of personnel in terms of experience, knowledge and qualifications and the amount of work each person does/day.

Manning levels are currently at their lowest viable level for the minimum operational requirements, however, there is insufficient capacity to deal with high stress periods, so the crew are stretched at peak times. The insufficient staff numbers produce fatigue resulting in possible accidents. However, manning levels vary dependent on vessel size. It is to be noted that on many occasions fishing vessels are under manned and eventually fails to provide any sort of lookout during their fishing operations.

D9	**3**

D10 Inspection and Maintenance – the extent and frequency with which equipments are inspected and maintained.

Fishing vessels are often poorly maintained.Minimum staffing levels and time pressure in port, limits the frequency of maintenance activities. There is a general attitude concerning inspection and maintenance that it can be delayed. Commercial pressures result in limited financial resources being made available for inspection and maintenance and thisinvestment reduces with the increasing age of the vessel. Some operators would be rated as low as 1, thus reflecting the need for a below average rating overall.

D10	2

D11 – Operational Equipment - the extent to which OPERATIONAL systems and equipment conform to best practice and meet the usability needs of the human operator.

Most of the vessels are equipped with modern navigational equipments and such as radar and VHF radio but very little attention is given to their maintenance aspects. But it is fair to say that in collision perspective the level of operational equipments are satisfactory.

D11	6

D12 Safety Equipment - the extent to which SAFETY systems and equipment conform to best practice and meet the usability needs of the human operator.

There is a wide range of safety equipment available, but very little of it is mandatory, resulting in a large disparity between what is available and what is in place. This is because owners will seek to keep apparently unnecessary costs down.

D12	2

D13 Physical Working Conditions – the level of noise, temperature, congestion, light and vibration existing in the workplace.

Fishing vessels have inherently poor working conditions, often the working and accomodation spaces are crowded and there is poor air quality. The length of exposure to the poor conditions is the key to determining the adequacy.

D13	2

D14 External Environmental Conditions – The external meteorological and environmental conditions in which the workplace is based.

External conditions vary considerably. Their effects do not vary significantly between other branches of the shipping industry.

D14	4

D15 – Hazard Visibility - The standard of the physical surroundings in terms of the visibility of potential hazards. Hazards might be flagged with signs, which may be temporary or permanent, or through the inherent design characteristics of the hardware such as markings, warning lights etc.

Fishing vessel working environment is very hazardous and very little effort is gone to improve hazard visibility.

D15	4

D16 – Traffic Density - The amount of traffic likely to encounter during the accident scenario.

Most of the fishing vessels operate in coastal areas and are likely to come across with ships.

D16	4

6.3.2 Organisational Level Influencing Factors

O1 – Recruitment and Selection - The system and procedures that facilitate the employment of personnel that are suited to the job demands.

Recruitment is linked to cost. Most operators aim to get the cheapest crew possible. There are no basic competence standards, expect may be for skippers. Often fishing is a family business and very little attention is paid on to the qualifications of the crew.

O1	1

O2 – Training – The system that ensures the skills of the workforce are matched to their job demands.

Very little attention is paid to the training of the fishing vessel crew, it also important that the way in which training is given. The situation is not much better in the case of ships crew, even though they have to undergo ISM and STCW 95 standards.

O2	2

O3 – Procedures - The system that ensures that the method of conducting tasks and/or operations is explicit and practical.

Fishing vessels often follow poor procedures which inevitably results in accidents One of such action is regarding the display of navigational lights.

O3	2

O4 – Job Design/ Work Organisation – the system that designs and structures the work activities of personnel.

Lack of funding, forces prioritisation of tasks to be undertaken. There is some basic planning of the organisation of work but this is mainly reactive with little regard for safe working methods. There is a lack of a proactive focus on the optimum working conditions and the maintenance of competence.

O4	**3**

O5 – Incident Management and Feedback - the system of incident management that ensures high quality information is available for decision making when and where it is required, including the collection, analysis and feedback of incident and near-miss data.

There is a compulsory requirement for incident reporting in accordance with ISM. However, management generally pays 'lip service' to the requirements and there is a strong culture of blame. Incidents are reported but this is hindered by a focus on hardware incidents rather than human related ones and the overriding perception amongst crew members that they may lose their job. There is a lack of anonymous reporting and near miss data is not seen as important. There is also minimum feedback after reports have been made.

O5	**2**

O6 – Management and Supervision – the system that ensures human resources are adequately managed/supervised.

Low staffing levels means that there is less management and supervision. Work is results driven and managers are not interested in the process. Infrequent visits are made by regulatory bodies and there is insufficient time to supervise. When business is poor the management company may cut corners to save money.

O6	**2**

O7 – Communications - the system that ensures that appropriate information is communicated clearly to its intended recipients.

Modern communications methods have made the exchange of information easier and there is an active exchange between the ship and the shore management, yet most communications

O7	**5**

remain informal and verbal as opposed to written. Communication is driven by costs and managers are keen to report back on action needs so that there is agreement before additional expense.

O8 – Safety Culture - product of individual and group values, attitudes, competencies and patterns of behaviour that determines the commitment to and style and proficiency of an organisations health and safety management programmes.

Information is hidden, messengers are blamed, responsibility is avoided, dissemination is discouraged, failure is covered up and new ideas are crushed. Safety meetings are held but no actions are taken by management, safety is generally neglected due to cost and safety management is seen as an irritation.There is no will for a safety culture.

O8	**1**

O9 – Inspection and Maintenance – the system that ensures equipment and machinery is maintained in good working order.

In the fishing industry in general not much attention is been paied to maintenance issues as such.But regarding the navigational equpments, in most of the cases , they get more attention, maily due to the fact that they are essential for the functioning of the vessel.

O9	**4**

O10 – Design - The system that ensures the designs meet the operational requirements of the ship and that design changes are fully addressed.

There is generally no system in place to ensure that ship designs are modified to reflect the changing operational requirements of the vessel throughout its lifetime. A shipyard design has minimum investment and extras only apply if owners pay for them.

O10	**1**

O11 – Pay and Conditions - The extent to which earnings and other employment rewards match the demands of the job.

In fishing industry monthly wage is a rarity and in most of the cases it depends on their catch .It creates a very peculiar type of situation different from other industries.

O11	**2**

O12 – Provision of Information - The system that ensures that information requirements are clearly identified and up-to-date information is maintained in a readily accessible way.

Contrary to shipping there is no such system in place in most cases of fishing indusry.In many occasions accidents and incidents are not even reported and with out a reliable feedback system it will be difficult to provide suitable information.

O12	**3**

6.3.3 Policy Level Influencing Factors

P1 Ownership and Control – the form of ownership of the organisation and the extent to which decision-making authority is centralised. Ship/FV owner's/operator's commitment to and control of the working process.

In case of fishing vessels owners are usually operators and generally they do not have insurance protection.Regarding safety aspects most of the decisions are taken by the fishing vessel owner operator and they are not much cared about the safety as far their vessels perform satisfactorly.In case of ships owners generally put the management of the vessels out to tender. These management companies compete to give the best deal for the owners, thus driving down standards for financial gain. Similarly, the budget that the manager presents to the owner may not actually be the budget that that vessel is run on. In this manner, owners are able to stay relatively removed from the day-to-day running of the vessels and thus seem unaccountable. The focus once more is not on safety, butthe value of the asset. However, the small numbers of owners/operators that do care about standards on their vessels were also noted, raising the rating from 1.

P1	2

P2 Operator Culture – culture within an organisation consists of assumptions about the way work should be performed; what is and what is not acceptable; what behaviour and actions should be encouraged and discouraged.

The emphasis here is with the manager/owner and how the ship/FV actually operates, which would reflect the culture. Any good culture is likely to be top down, a decision reached at board level, which will be evident both on the vessel and shore side. However, the fragmented nature of the industry means that the structure is not in place for a culture to exist. This is reinforced by the fact that crew are generally contracted and hence short-term employees. There is a wide diversification of management styles, but most tend towards poor quality, giving a lower overall rating.

P2	3

P3 Organisational Structure – the extent to which there is a rigid segmentation of functions and layers and tasks within and between organisations.

The industry is comparatively basic with little delineation of work into specific roles. Generally organisational structure is not good in fishing and shipping in general .The variations in income according to seasons dictate a flexible, informal workplace that therefore, must be unstructured. If no money is being made, the operator will not be able to employ the workforce on board or shore side. It was agreed that the industry polarizes between single owner operators with very little or no organisational structure, through to the larger, well established companies with proper management teams and a good organisational structure in place.

P3	3

P4 Safety Management – management commitment and leadership definition of roles and responsibilities and accountability, and comprehensiveness of policies, standards and procedures for each element of the safety management system.

Safety management is now compulsory for under ISM and a Document of Compliance is required. However, many companies meet the imposed standard by buying a ready made safety management system (SMS) off the shelf. In doing this the company is complying and the law is not broken. However, in this case, the SMS would not be specific and its worth would be reduced, there would not be 'ownership' of the system. But for fishing vessels no such regulations are applicable.It was concluded that the actual worth of safety management was not widely understood in the industry. The fact that it is an imposed requirement also means that it is likely to encounter strong opposition.

P5 Labour Relations – the extent to which there is a harmonious relationship between the management and the work force. It also concerns the extent to which there is the opportunity for workers to affiliate with associations active in defending and promoting their welfare, and the extent to which there is a system in place for pay negotiations.

Labour relations were considered to be basic, but the fact that management generally do not consult the workforce was seen as the accepted norm. The ILO is actively working to improve conditions in an effort to prevent the systematic exploitation brought about through fragmentation. Not every company is union affiliated, as this can prove impractical. The bulk carrier industry is liable to corruption, such as some manning agents taking an additional cut of the wages being paid to the crew.In case of fishing vessels the labour relations are supposed to be good.

P5	**4**

P6 Owners' Profitability – the extent to which the owner is subject to competition over market share and constrained as to the price that they can charge for the services offered.

The nature of the fishing industry is that profitability is a huge variable. The lack of stability in the market means that it is impossible to forecast profitability to allow a realistic safety margin. This is true for some of the shipping sectors also.

P6	**2**

6.3.4 Environmental Level Influencing Factors

E1 Political Influence – the profile of, and practices within, Governments related to the industry.

There are a number of countries that are well known for their tough stance on poor quality shipping e.g. Australia and therefore tonnage of poor standard could expect to inspected and detained in these ports. Fishing vessels generally operate from a home port and do not often visit other ports in a single trip.However the exclusive economic zone and illegal fishing activities influence government decisions on when and where to fish. The conclusionwas reached that there was a huge diversity of ship owner/operators and an equally wide variation in the amount of Political influence that a country may or may not exert and as such the middle rating seems appropriate.

E1	**4**

E2 Regulatory Influence – the framework of regulations, codes and conventions governing the industry and the actions of the Register.

The Regulatory influence involves IMO, international regulations and regeional regulations. As such, it is possible to avoid the Regulatory influence however the operator will then not be able to get insurance. It was noted that good regulation of charterers in other aspects of the shipping industry has resulted in safer ships. The framework is there for the fishing industry but there is a low level of enforcement. In case of ships the cost aspect in deciding the choice of flag state is perceived as important. The wide variation of views was again reflected in an average rating.

E2	**4**

E3 Market Influence – the commercial and economic context affecting the industry.

There is no doubt that safety has a direct link with market fluctuations. When the owner operator of fishing vessels get good pay safety automatically increases. However, to reinforce the narrow margins and cost considerations, it was also noted that a high quality operator is not rewarded. Consequently, there is no incentive for an operator to behave responsibly and maintain his vessels to a high standard.

E3	1

E4 Societal Influence – aspects of the community and society at large, which bear upon the public perception of the industry and influence the future potential labour supply.

The public do not seem aware of the issues surrounding the fishing industry.The media will focus on passenger vessel incidents for human interest and tanker incidents for an environmental story. Hence, the fact that a large number of people die each year on fishing vessel accidents is largely ignored.

E4	1

E4 Cultural Influence- It essentially consists of thoughts and acts of people

Cultural influence is not an independent element, many other elements (such training, social setup etc) has influence on it.this aspect is considered in section 5.3 of this report.However it is to be noted that the cultural environment is very poor in fishing industry leading to a very poor safety sulture and in turn poor behaviors and actions onboard vessels, resluting in accidents.

E4	1

Figure 6.2 summarises the final composition of the Ship-FV collision accident Influence Network, with rating values assigned for each factor in the centre of the box. To clearly demonstrate the factors at the opposite ends of the spectrum, it provides an alternative representation with influencing factors rated poorly (i.e. 1 or 2) in red, intermediate (i.e. 3-5) in yellow and very good (i.e. 6 or 7) in green.

It is to be noted that there are very few Influencing factors in very good condition and most of them are in yellow or red zones, indicating the large scope of improvement. The line between yellow and red is very thin in many cases and examines close scrutiny.

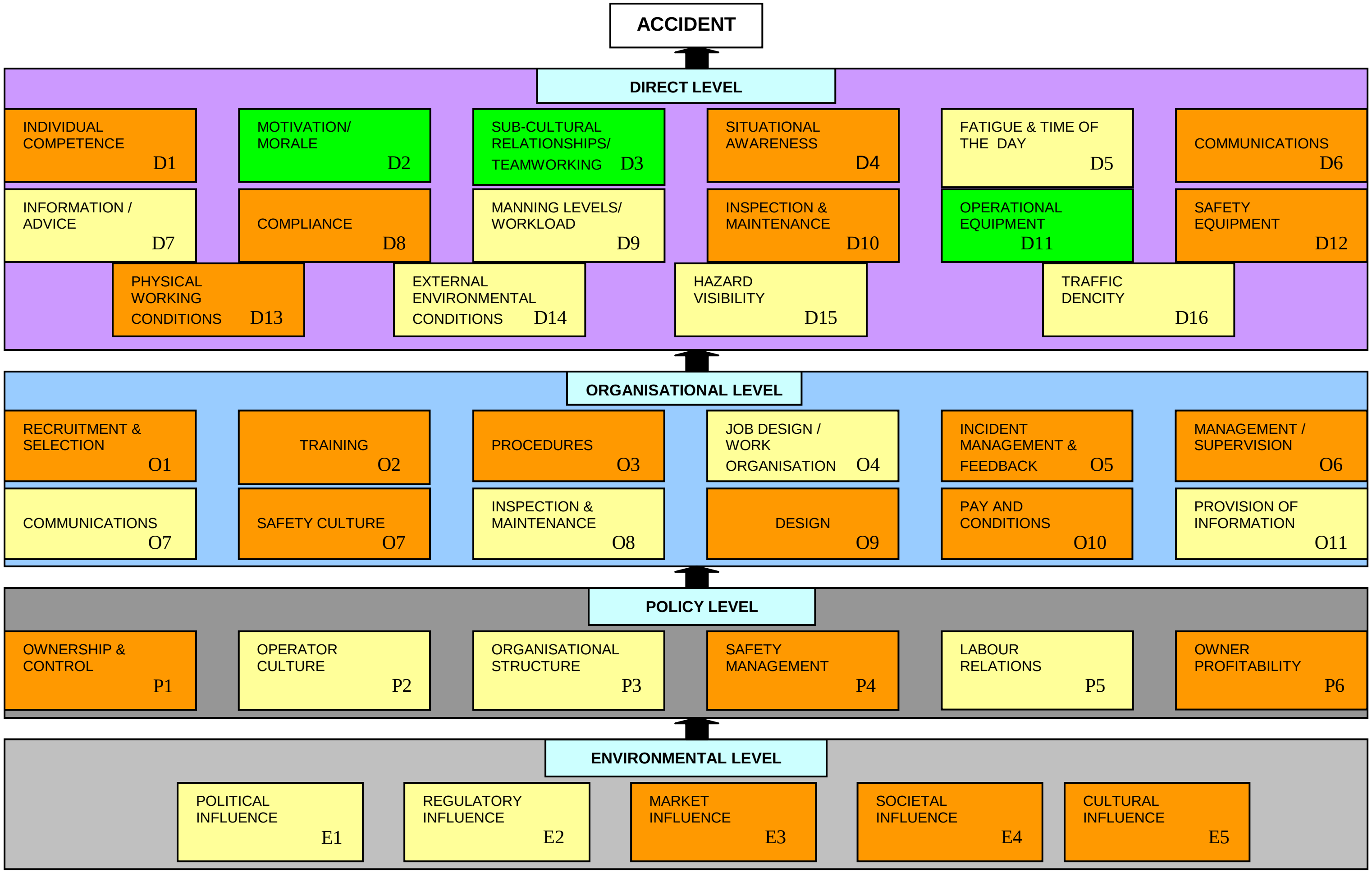


Figure 6.2 Ratings of Influencing Factors

Chapter 7

Conclusions

From the analysis of the collision accidents involving fishing vessels in different countries, it is clear that the reasons and nature of accidents are strikingly similar. Lack of good professional culture, which in turn contributes to safety culture, is prominent in most of the accident scenarios. The attitude of people, which leads to violations of rules, is a very important factor. So training and education remain as only practical tools to reduce this kind of accidents. However, to provide effective training and education proper understanding of culture in its widest aspect is essential.

Technology can prevent accidents, only when it is used properly. In many cases improper use of radar was a contributory cause, and most importantly communication between the vessels, in none of the 18 accidents vessels communicated to each other prior to collision had a communication through VHF channel 16, accident would never been happened. Further more new technologies such as AIS will definitely reduce risk of collision between larger vessels, but effect on smaller vessels is not such promising. So a much detailed understanding of the risks involved and solutions if any are to be explored.

Furthermore the using the Influence Network methodology we can find out root causes of the problem under consideration. From the analyses of the Influence Network diagram formed after the Ship-FV collision accidents various areas relevance were found. These areas are to be thoroughly analysed. The analysis done so far can be used as the background analyses for FSA methodology. It is to be noted that most accidents are results of human error and an attempt is done in this study to address this problem, concentrating on Ship-FV collisions. This information can be useful for the analysis of other relevant accident categories as well.

ATSB, MAIB and other accident investigation bodies have made a lot of valuable recommendations on fishing vessel collisions, which are to be read in conjunction with current findings. Main findings of this study can be concluded as:

1. Quality of training given to seafarers and fishermen should be ensured and better understanding of culture in its widest aspect is essential to achieve this.

2. Unsafe practices followed by fishing vessels such as poor display of navigation lights and lack of VHF communication, should be treated seriously by appropriate authorities.

3. Improvement of the watch system considering human circadian rhythm (especially between 0400 and 0500 in the morning watch) can be beneficial for the reduction of accidents.

4. Introduction of AIS onboard ships may facilitate ship-FV collisions unless suitable measures are taken.

5. Adequate measures are to be taken to ensure fishing vessels are properly manned and a lookout is kept at all times

6. Workload on seafarers and manning issues, which prompt them to engage in other duties during watch period, should be tackled by IMO.

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