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How the human factor in shipboard marine engineering operations has influenced ship accidents in Mozambique : assessing the reasoning : a proposal towards safeguarding against future casualties

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HOW THE HUMAN FACTOR IN SHIPBOARD MARINE ENGINEERING OPERATIONS HAS INFLUENCED SHIP ACCIDENTS IN MOZAMBIQUE

Assessing its reasoning: a proposal towards addressing safeguard against future casualties

By

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CHAPTER ONE

Introduction

It has already become a common understanding that the human factor has had major contribution behind most accidents at sea and Mozambique shipping is surely not an exception. The concept of human factor in many countries has very much been studied and its influence and behaviour is widely known in the maritime industry today. So, the purpose of this dissertation is to identify, analyse and assess the possible specific causes for accidents in marine engineering operations and how (where) the lack of safety interacts with the lack of commitment and perhaps the quality in the Mozambican case and propose appropriate and comprehensive approach to avoid recurrence.

Many studies have shown that the majority of maritime casualties are caused to a higher extent by the human error of one sort or another. It is to minimise these errors that the STCW Convention and the ISM Code were introduced. Therefore, while the STCW Convention's key points are that it emphasises on education and training of people as these are of a critical importance to develop the required skills and competence for safety at sea; the ISM Code focuses on the improvement of safety management skills of personnel ashore and afloat. The effective implementation of these two IMO instruments is in the end aimed at reducing the human aspect of accidents, thereby making shipping safer.

The dissertation is also intended to underline and clarify those aspects of safety which although need to be recognised and dealt with properly by the authorities in Mozambique, are however neglected and perhaps not tackled more seriously. Proper comparative study of the ship accidents provoked by the *people factor* on the world-

wide basis can be helpful to understand the need for a proactive approach to the human factor element in marine engineering in Mozambique.

Based on the lectures at the WMU, research material available and personal experience, the project is divided into five chapters. In Chapter I, the introduction answers the need for selection of the topic, the purpose and goals, including defining and specifying the aspects which the dissertation will be about and the general views on the sources of the human factor contributing to casualties. Chapter II gives a background of the maritime industry in Mozambique and its approach to safety at sea outlining the main aspects that can influence safety at sea. In Chapter III, a comparative study of certain maritime casualties is made and the role of the human behaviour in marine engineering casualties is assessed. The Chapter IV takes a critical look at the outcome, deals with the reasons, including the managerial, operational and technical accomplishments for safety. Finally, conclusion and recommendations are proposed in Chapter V. Some statistical figures and tables are also used in chapters II, III and IV to sustain the analysis.

The Indian Ocean Memorandum of Understanding on Port State Control signed in June, 1998 of which Mozambique is a founding member will require not only implementation of the IMO standards, but also an adequate approach to safety at sea including focus on the human element emerging from the enforcement of synchronised and updated national laws.

In short, the dissertation is not intended to analyse and discuss concepts, but rather identify which aspects of human factor in marine engineering are applicable in Mozambique shipping and what measures would be appropriate.

1.1 General Overview

The loss of people, property and the damage to the environment makes safety at sea a common interest for society both privately and publicly. In particular, the human factor now is considered a very important component of safety wherever is the site of work.

The working conditions of the engineering officers in Mozambique, in addition to the fact that most of the ships at sea are difficult to operate, being relatively old and nearly to be scrapped, are the primary reasons for having chosen this topic. It is also the objective to identify the main implicit or explicit causes behind the accidents, which were primarily provoked by either equipment failure or engineering officer's error.
R. Sunders and T. Weeler, who have studied safety management issues, concluded that almost all accidents are preventable…the weak link is still the human link. Even more, that in everything that we do as human beings there is a risk attached to it (handbook of safety management, pp 90, 173, 192-198). Therefore, there is a good reason for studying deeply this phenomenon to tackle it properly; given that the human factor is differently influenced by the cultural situation of each country.

The limited amount of information (material) available may however be a strong constraint. This constraint is a direct result of the fact that none has studied before, the human aspect of safety at sea as such in Mozambique. This being perhaps the first time that it is being dealt with as study subject. So, the project will limit itself to what is possible to say with reasonably scientific relevance in the described situation. Moreover, the study can be a medium (not an end) to deepen a specialised research in future with a view to draft a comprehensive approach to the human behaviour, particularly in marine engineering.

It is always said that *the engine room is the heart of a ship*. This could lead one to say whatever goes wrong in an engine room will determine the future operations of a ship. The blame for these breakdowns is to be equally placed on the participants involved in the design and operation of the engine room.

In summary, the goal in this work is to help the maritime industry improve from the engineering point of view the safety of performance at sea in Mozambique shipping industry.

1.2 Human Factor Overview

Defining human factor, which is the number-one subject of this work may be the best way to approach it before going into its main body. Many scholars have defined this in different ways depending of course upon the intended approach. Sanders and McCormick, for example, defined human factor as being something referring to *designing for human use*. A clear indication of this is perhaps what has been normal to hear in an engine room or elsewhere: *what a dumb way to design this; it is so hard to use! If only they had done this or that, using it would be so much easier.* This is a consideration by users as to how it should look and be used, to reach increasingly higher perfection. Therefore, it is an indication of human weakness or strength: an approach of the human factor. The alluded perfection can be in relation to human use, safety, decoration, quality, and others. It should, may be, added that human factor refers to designing for a perfect or to fit in its purpose, optimising working and living conditions.

Another definition for human factor is that *it focuses on human beings and their interaction with products, equipment, facilities, procedures, and environments used in work and everyday living. It emphasises on human beings and how the design of things influences people. It seeks to change the things people use and the environments in which they use these things to better match the capabilities, limitations, and needs of people* (Sanders, p.4).

Chapanis (1985) however seems to have summarised reasonably all these approaches into the following definition:

> "Human factor discovers and applies information about human behaviour, abilities, limitations, and other characteristics to the design of tools, machines, systems, tasks, jobs, and environments for productive, safe, comfortable, and effective human use".

The fact is that many expressions are used today to mean human factor, such as human element, human error, ergonomics, human engineering, engineering psychology, and others. Some people even distinguish between them. But, at least in practical terms and for the purpose of this particular work they mean the same thing. In addition to this, it is also important to note that the human factor covers a wide range of aspects, some of them are listed below:

- Fatigue
- Morale
- Motivation
- Loyalty
- Knowledge, skills and attitude
- Standards of Certification
- Conditions of Service
- Management Policies
- Working environment
- Language and Communication

This work is about how these and other factors influence the human behaviour and the accidents involving casualties in marine engineering operations on board ships in Mozambique. What are the sources of errors? Do fatigue, experience, communication have an influence at all?

When analysing the human factor in marine engineering emphasis lies both on people and on technical aspects involved. Here is where there is a tendency of addressing human factor as a blame that should necessarily be put on somebody. The aspects covering human factor listed above are unavoidably related to human beings. So, if nothing is done to minimise their effects we can expect what the situation is now and even worse. Emphasis should be put on preventing their adverse effects rather than on remedying.

CHAPTER TWO

Present Maritime Industry Overview in Mozambique and its Approach to Safety at Sea

2.1 Overview of the Present Maritime Industry

For the purpose of having full understanding of the ideas being discussed in this project, overview is given of the present stage of the maritime industry in Mozambique. As a result of continuous rise in maritime traffic, involving transportation of passengers, cargo and mainly increase in fishing activities and realising that existing level of authority for control of safety at sea was inadequate, the new structure of the maritime authority at the national level was established, in 1994.

The article 3 of the Decree 34/94 (September, 1st, 1994) that establishes the so called SAFMAR (the Mozambique National Maritime Safety and Surveillance Administration) and its framework, states the following:

"It constitutes responsibility of SAFMAR to administer and control maritime activities within the waters under the jurisdiction of the Republic of Mozambique, along with:

A. Exercising authority within the maritime jurisdiction areas, the lakes, rivers and the maritime public domain,
B. Exercising control upon the vessels, national crews wherever they are as well as upon the foreign vessels within the territorial waters,
C. Participating in the drafting of working rules in the maritime field and to ensure its implementation" (above is the English translation of the relevant portion of the Decree).

A better structure that can enhance efficiency and effectiveness, safety at sea is very much dependent upon the human element. That is to say how human resources are motivated, educated and trained.

With particular regard to the human aspect, SAFMAR deals with it through its section for certification and seamen's registry, where a national record of the seamen is kept with their rank, level of education and training, experience and other such details. According to the invigorating Decree 35/94 (September 1st) in relation with STCW 1978, the following levels for engineer officers are recognised:

- Chief Engineer and 1st Engineer, Class A (STCW regulation III/2)
(Chefe de Máquinas e Primeiro-oficial de máquinas, grau A)

- Chief Engineer and 1st Engineer, Class B (STCW regulation III/3)
(Chefe de Máquinas e primeiro-oficial de Máquinas, grau B)

- Engineer Officer in charge of an engineering watch (STCW regulation III/4)
(oficial chefe de quarto de máquinas).

For engineering ratings under the same Decree:

- 1st Motorman (STCW reg. III/6 + 30 months sea service)
(Primeiro motorista)

- 2nd Motorman (STCW reg. III/6 + 30 months sea service)
(Segundo motorista)

- Engine Seaman (STCW reg. III/6 + 24 months sea service)
(Marinheiro motorista)

- Engineboy (STCW reg. III/6 + 6 months sea service)
(Ajudante de motorista).

2.1.1 Maritime Education and Training

Good manning is heavily dependent upon the training of the seafarers and their experience. According to a report on manning with reference to human factor, by one of the UK P & I clubs, manning has now become an increasingly important factor in the regulation of ships as required by international conventions. Mozambique has ratified most of the conventions regarding good manning, excluding the ILO Convention no. 147. The following relevant IMO instruments have been ratified:

- The STCW Convention (1978) amended in 1995 (certification)
- The International Safety Management Code (chapter IX of the SOLAS Convention)
- SOLAS 74 (new amendments).

The Mozambique Nautical college (ENM) is the only institution in charge of the maritime education and training for officers, and occasionally it also runs short courses for ratings to help the industry overcome shortages in skilled support level seafarers both for engine and deck departments. The younger practitioners mainly follow these courses and the companies do not normally include the older (who represent significant part of the support level seamen as demonstrated later). This is of course an undue practice on the part of the shipping companies. A good shipping company must invest in the long run on human resources and at the same time establish a reliable, effective replacement of seafarers retiring by those coming in. If the company chooses to keep older and experienced seafarers, it should then ensure their continuous training on board or elsewhere to keep up with the requirements. Taking the lesson of the UK P & I club report, it is not necessarily true to say that substandard ships always have substandard crews. However, a substandard crew almost certainly means a substandard ship.

During the 1970s and 1980s, all shipping and fishing companies were owned in one way or another by the state, including the unique maritime college itself (ENM). The education at the college was complemented by the students' practical on job training on-board state-owned ships, without any difficulty. The field studies lasted until the

students had fulfilled all education and training requirements established by the STCW 78 Convention of which Mozambique is a member since 1985 (BR, p.6). One of the requirements was to conclude the record book (designed together with the shipping companies and the college) with the supervision of a senior engineer officer on board.

At the end of the training, the Chief Engineer officer would sign on the record book assuring that the student is capable of carrying out basic level requirements and activities in an engine room. The record book was required to be concluded in this manner twice in students' education and training period: at *pre-sea* level when the student was preparing to join the college and at *post-school* level when preparing to graduate.

Nevertheless, all this has become difficult today, the shipping companies being either fully private or with the state shares at a symbolic level only. While the maritime college can cope with carrying out the theoretical education and training, putting the students on-board for their practical on job training however requires reaching tough agreements with the shipping companies. This has not always been possible.

The STCW 78 revised in 1995, requires in its Regulation III/1 paragraph 2.3 that:

"Every candidate for certification (as an officer in charge of an engineering watch) shall have completed approved education and training of at least 30 months which includes on-board training documented in an approved training record book and meet the standards of competence specified in section A-III/1 of the STCW Code."

In addition to this, the on-job training program including emergency drills are critically important for all seamen, specially the older ones who are not included in the short courses training intended to get them in touch with the day-to-day and emergency equipment. The older seamen represent major part of the auxiliary personnel in engine rooms, as it has been graphically demonstrated in 2.1.4.

On the other hand, given that the shipowners prefer to fly FOC flags on their ships (and they are surely free to do so) there is little that the Mozambique administration can do to control the education and training standards.

The manning procedures have also played a significant part concerning the human factor effect in ship accidents. The shipowner hires on his own whomever he is interested in. The participation of the Local Maritime Administration (LMA) during this process is at the time when the employed is to be registered on the ship's manning list. The registry will occur whenever the requirements have been fulfilled.

This process is good enough for the administration for ensuring that the crewing process follows the national and international instruments adopted. However, in the author's opinion, it may be necessary to improve it by creating private crewing agencies with full understanding of the invigorating manning requirements. They would need to be issued with an authorisation confirming their ability and knowledge of the relevant instruments to perform this job properly according to the national and international requirements. Further, they would need to be made responsible to make the administration aware through concerned companies, of any illegal act, if any, for appropriate measures.

2.1.2 Standards of Certification and the national law

The maritime education and training has gained its standards with regard to syllabuses on the world-wide scale after entry into force of STCW 1978. However, today it is widely acknowledged that the STCW 78 Convention left gaps leading to different interpretations. Mozambique implemented the Convention in 1985 through the Ministerial Diploma (DM) no. 17/85 (June, 5th). In 1994, this was changed into the invigorating Governmental Decree (DG) no. 35/94 (September, 1st) alluded before. The reasons so given for the change were as follows:

1. The DM no. 17/85 contemplated standards only for merchant marine officers. The ratings were only required to be issued with a seaman's book (renewed every 10 years) and no certification took place at their level, apart from the required

examination at the time they were issued seaman's book. This document is mainly an administrative one, much more concerned with national laws. Therefore, the amendments undertaken in 1994 were to consider the need for a comprehensive act that would include all certification for all the seafarers regardless of their rank, to upgrade them for the international requirements.

2. The DM of 1985 left major gaps. One of which is mentioned in the above paragraph. Even the 1994 Decree is not specific regarding the gaps referred to. However, the enforcement of the STCW 1995 amendments which entered into force later are also to be considered to bridge the gaps. It is to be remembered that years before the adoption of the amendments their necessity were widely acknowledged.

3. After a certain period, the DM of 1985 became even obstacle to the development of the merchant marine labour qualifications. The DM should have addressed the problem of the old legal system to avoid ambiguity in its interpretation.

One fact mentioned above, which is also relevant and is directly implying on the seafarers, including the engine room personnel is the old national maritime legislation in force in Mozambique. Following are some of the most directly related provisions:

- General regulations for local maritime administrations (LMAs), in force since the end of last century, including several amendments, and
- Regulations for seamen's registry (RIM), in force since the 1930s.

In many cases, these regulations go against the present day spirit of the maritime qualifications and skill development of the Mozambican seafarers having been drafted in a colonial view. For example, according to the invigorating regulations for seamen's registry, sea service completed by nationals onboard foreign vessels is not considered relevant for the purpose of enhancing rank. Such provision finds no back up either in any of IMO instruments or in any other national maritime law.

The STCW 78 itself was prone to varying interpretations worldwide which were recognised by the IMO. In 1995 IMO adopted the amendments to STCW 78. The

revised Convention, STCW 95 is already in force since August 1998, but Mozambique is still now, as this dissertation is written, hardly working onto its implementation.

2.1.3 Working Conditions, morale and motivation

Some of things that strongly influence the performance of human beings at work are surely the working conditions, morale and motivation (see Appendix 'Human Element Analysing Process Flowchart). It has been common for shipowners to acquire old ships, nearly to be scrapped and put them sailing in Mozambique. Furthermore, the low salary structure, the long working periods, very often of 12 hours a day during sailing, to which the seafarers are subjected, lead to many problems. With this scenario fatigue is unavoidable and morale and motivation, factors directly related to these working conditions, suffer. It is not difficult to imagine that the people in these circumstances work under heavy stress.

Moreover, as it was alluded in the report of the joint session of the joint MSC/MEPC Working Groups on the human element and on formal safety assessment, "as fatigue increases, the brain appears to fall asleep involuntarily, against the will of the operator, especially (but not exclusively) when his performance demands involve sustained attention and monotony; thus the effects of fatigue on performance are based in changes in brain function." This demonstrates how fatigue is very much linked with the brain performance, leading one to fall asleep; a situation that must be avoided at all cost. Among other things the report concludes that the following aspects are direct effects of fatigue on performance:

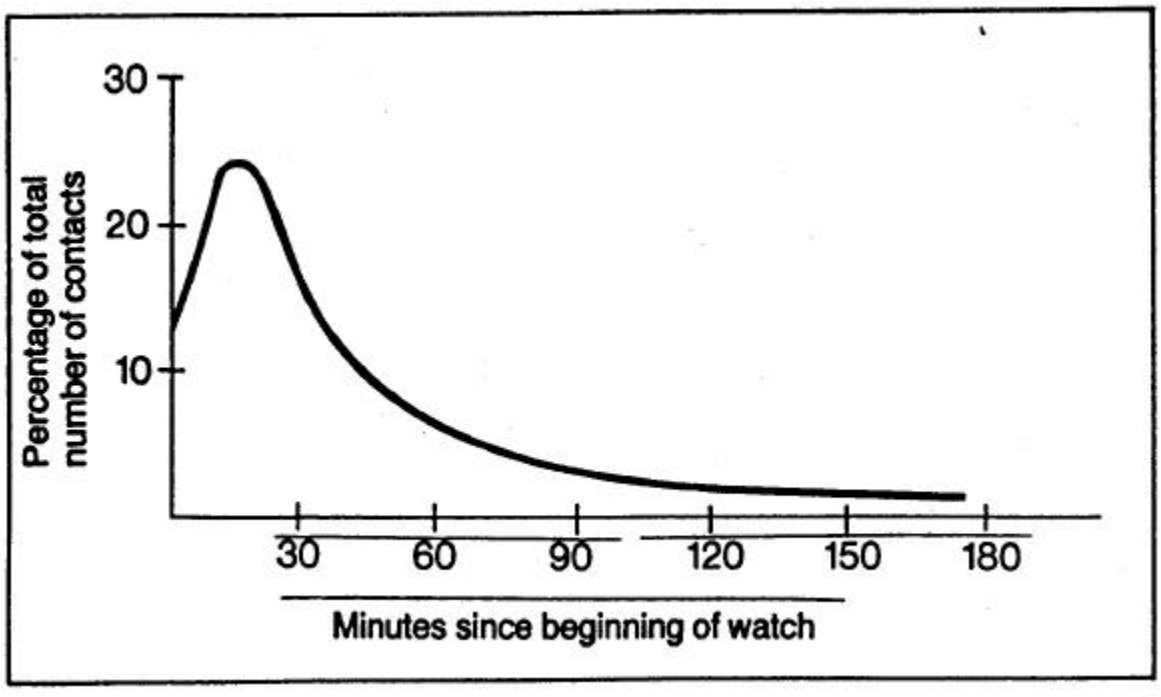
1. When a person is suffering from fatigue, his or her performance on the job will be affected.
2. During night time hours, and to a lesser extent during the mid-afternoon dip, most types of human performance, whether manual dexterity, mental arithmetic, reaction time, or cognitive reasoning, are significantly impaired.
3. Fatigue affects the ability to judge distance, speed and time.

Furthermore, the problems related to attention and 'perceptual errors' by seafarers may be connected to ageing in addition to capability for a duty.

One good example of this, studied at the DMI, is the influence of duration of a watch (Control Panel monitoring) which varies according to the percentage of signals that are detected on the screen. As a result, the number of contacts tends to fall within a matter of 3 hours. This means that if a man is put on watch for 6 hours as it happens in several cases in Mozambique, the watch will only be effective during the first half and for the next half he will be almost ineffective. This should be considered when allocating work to the seafarers.

Graph 1

Signal detection and vigilance (attention span)



Source: Psychology of Human Factor, by Michael May, DMI

The influence of duration of watch (Control Panel monitoring) on the percentage of signals detected on the screen

These are perhaps the reasons why the STCW Convention provides for some precautions within the companies and the ships. In fact, the regulation III/1 of STCW deals with fitness for duty, and sets the standards as follows:

"Each administration shall, for the purpose of preventing fatigue:

1. establish and enforce rest periods for watchkeeping personnel; and
2. require that watch systems are so arranged that the efficiency of all watchkeeping personnel is not impaired by fatigue and that duties are so organised that the first watch at the commencement of a voyage and subsequent relieving watches are sufficiently rested and otherwise fit for duty."

Manning, qualifications of the crew, number of crewmembers, its composition, personnel culture, working language, medical conditions, and competence are considered to be of a critical importance. So, by strictly following the ratified STCW provisions the administration can ensure that problems related to fatigue can not be alluded in accidents.

Other aspects discussed in this item come under the umbrella of ILO Conventions, some of which Mozambique has not yet ratified. Those are minimum standards for medical examination, prevention of accidents, accommodation of crews, food and catering, and others. But, not being party does not impede the country from enforcing them on a national level and for the purpose of safety. In fact, some of these requirements are part of national maritime legislation being implemented since the colonial period. Another reason for implementing this is the upcoming Indian Ocean MOU on Port State Control where surely the *no more favourable treatment clause* will be one of the requirements. So, Ships flying Mozambican flag will not be exempted from the requirements comprised in ILO conventions.

Table II/1

Status of ILO relevant conventions in maritime field in Mozambique

Convention	Ratification date	Status
C1 Hours of work (Industry) Convention, 1919	6 June 1977	ratified
C17 Workmen's Compensation (Accidents) Convention, 1925	6 June 1977	ratified
C18 Workmen's Compensation (occupational diseases) Convention, 1925	6 June 1977	ratified
C122 Employment Policy Convention, 1964	23 December 1996	ratified

Source: ILO web page: http://www.ilo.org

However, in the author's opinion, regarding influencing aspects of human behaviour, there are, yet to be ratified by Mozambique some critical ILO instruments that are listed below:

- Convention 73, regarding medical examinations;
- Convention 109, regarding wages, hours of work;
- Convention 133, regarding crew accommodation;
- Convention 134, regarding prevention of occupational accidents; and
- Convention 147, regarding (minimum standards) merchant shipping.

Another important aspect, yet in the opinion of the author is the ships' origin. A company like NAVIQUE has just scrapped or about to scrap ships acquired from several and different countries. The difference in origin may not be very important for the navigational aspects of a ship; but, for engineering aspects it is certainly critical, especially when the crews are moved from ships to ships in a matter of months.

The electrical plant on a Russian or Hungarian ship, for example, has shown to be widely different from that of ships built in Spain or even in Japan, in terms of their operations. Examine the following table concerning some of the ships scrapped:

Table II/2

Name of ship	Year built	Origin/country	Brand/Main Engine
LUGELA	1974	Spain	Deutz 358
INHARRIME	1974	Spain	Deutz 358
LICUNGO	1966	Hungary	Lang 8Id3, srf
CHINDE	1966	Hungary	Lang 8Id3, srf
POLANA	1966	The Netherlands	Deutz
N'GURI	1977	Spain	BMV, 8NVD 48
LUGENDA	1977	Spain	BMV, 8NVD 48

Source: SAFMAR, section for ship surveys, 1998

Examining carefully the Table II/2, it can be seen that although a normal lasting age for a ship is at least 25 years, four of the ships were scrapped even before that age. One reason for this is bad maintenance, both for hull and machinery. The factors fatigue, low morale and bad maintenance that can lead ships to be prematurely scrapped, these very reasons can also lead to an accident and vice versa.

2.1.4. Age and Experience

When Mozambique got its independence in 1975 the sea traffic of Mozambican ships went quickly down, as a direct result, among others, of shortages of officers who were Portuguese and left Mozambique shipping services. Prior to 1975, higher maritime education and training was not in principle directed to indigenous people. To keep the shipping operations going, the government then took measures to employ foreign officers on its ships simultaneously establishing a core maritime training centre in 1977 which came to be the maritime college (ENM) in 1985. The movement of seafarers after independence did not however involve ratings who were nationals employed since the colonial period. This is probably why there has been a prevailing tendency towards having older people employed as support level seamen in engine rooms compared to engineering officers. According to the SAFMAR data available to date, 20% of the auxiliary personnel in engine rooms are between 51 to 55 years old whereas only 7% of engineer officers are of that age profile. This can be demonstrated in the following graph, where the different bands of age are as follows:

Band 1 - Under 25 years old

Band 2 – between 26-30 years old

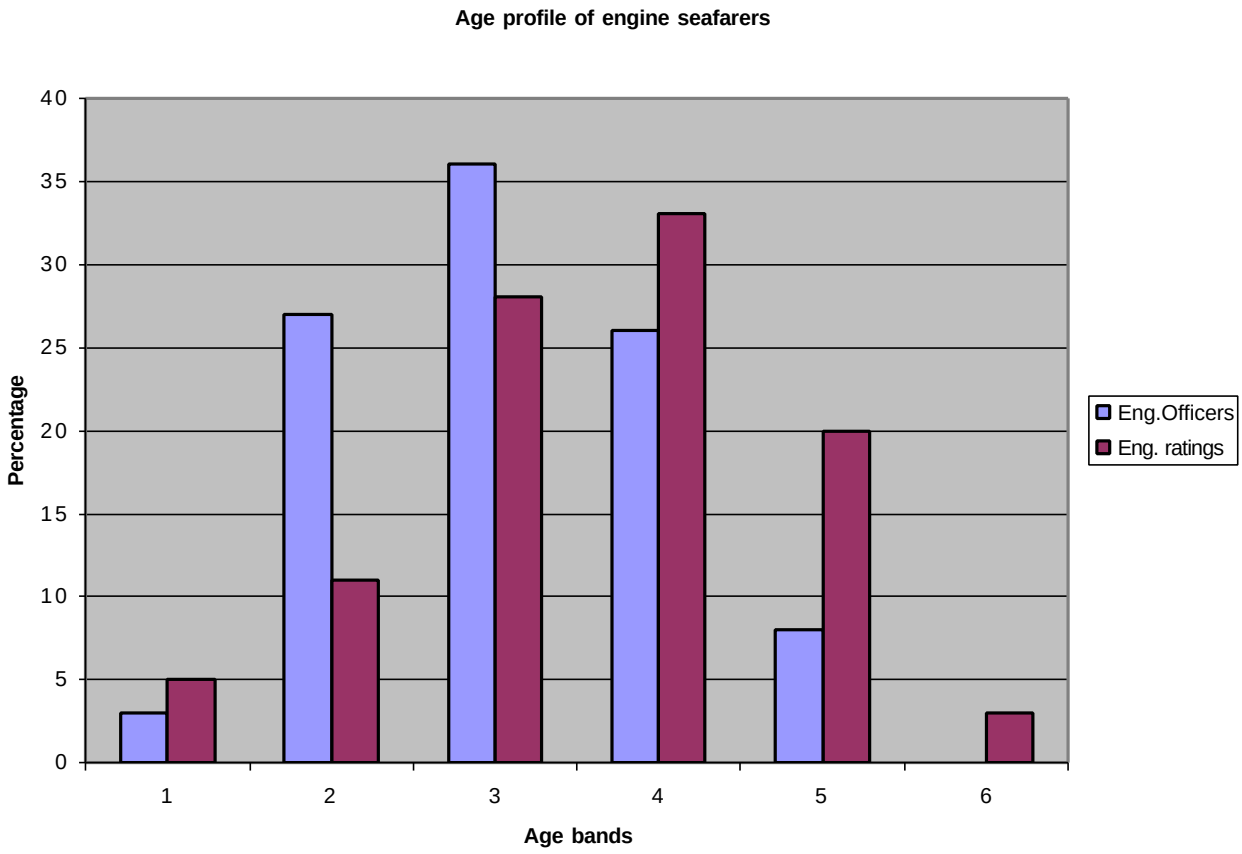
Band 3 – between 31-40 years old

Band 4 – between 41-50 years old

Band 5 – between 51-55 years old

Band 6 – over 55 years old

Graph 2



Source: SAFMAR, section for certification and seamen's registry

A quick study of this data will lead to a conclusion that the replacement process is ineffective. In other words, the number of younger auxiliary people getting in is far smaller compared to the number of people retiring. Another reason that leads to this situation is the fact that there is no training school for ratings in the country. As

mentioned before, occasional short courses are provided by the maritime college for ratings when they are requested and paid for by shipping companies. However, it can also be that the shipowners have preference to older ratings either because not only they can pay them less but also they have much experienced persons for work because of their longer career.

In fact, auxiliary people who are on their job since last 30 years are certainly more experienced in their duties than the officers considering the long period in the career. Taking random samples of 40 engineer officers and 40 engineering ratings, the scenario found was as the table II/3 shows below with respect to the period they joined the sea career.

Table II/3

Rank/Period	1965	1975	1985	1995
Engineer officers	0%(0)	7%(3)	56%(22)	37%(15)
Engine ratings	58%(23)	28%(11)	10%(4)	4%(2)

Source: SAFMAR, section for certification and seamen's registry, 1998

What is addressed in the previous paragraph may not be totally true if taken into consideration that of the problems facing the shipping industry was due to the lack of corresponding rewards and incentives. So, the relatively easy access to job on land by officers than their colleagues at lower level could be pointed. The smaller number of officers working onboard in the age bands of 5 and 6 may respond to the position demonstrated in the graph 1, for which the author calls for attention. This shows that old ratings keep working onboard for longer periods of their lives. The age and experience can influence both positively and negatively. What is required is to make sure that those performing their duties are reasonably able as far as safety is concerned. Similarly, the manning procedures play a significant role not only in minimising the problems related to age, but also concerning the need to minimise the human factor effect on accidents. While manning ships, the agencies and companies must ensure compliance with the STCW 95 requirements concerning manning.

On the other hand, as demonstrated in a study by Michael May, of the Danish Maritime Institute, errors are classified in four different dimensions:

- Skill-based error (e.g. slips, lapses)
- Rule-based error (e.g. wrong rules, misapplication of rules)
- Knowledge-based error (e.g. biases, mistakes, and symptoms)
- Violations (e.g. exceptions, routines, and sabotage)

Within the skill-based error types these could comprise, in the opinion of the author, the error resulting from the age-related problems such as poor eye sight reflexes, inflexibility, lack of vigour, and others such as lack of training. The comparison between the age pattern of seafarers world-wide and those in Mozambique clearly shows that whereas the Mozambican engineer officers follow almost the world's pattern of age profile, the situation seems different in case of ratings, where the Mozambicans tend to be older as it is demonstrated bellow.

Table II/4

Comparison of Age of Seafarers (World-Mozambique)

Age bands	Officers		Ratings	
	World	**Mozambique**	**World**	**Mozambique**
Under 25	8 %	3 %	10%	5 %
26-30	15%	27 %	16%	11 %
31-40	31%	36 %	30%	28%
41-50	28%	26 %	26/	33 %
51-55	10%	8 %	9%	20 %
Over 55	6%	0 %	5%	3 %

Source: BIMCO, 1997, and SAFMAR's certification and seamen's register section

2.1.5 Language and Communication

Regarding communication aspects of the human factor, it seems irrelevant for the purpose of this subject if it is considered that not many foreign people are employed on Mozambican ships with whom communication has been or can be a major problem. In

fact, the shipping companies have not employed significant foreign crew and further they are engaged in traffic, which is limited mainly to the defined cabotage borders. However, attention should be paid to the fact that not many seafarers or shipping managers have realised the problem that it can be there due to lack of good flow of information among the involved people in the net. One of the UK P & I Club report on human factor mentions that "in some quarters in recent years, it has been suggested that a range of serious risks can be attributed to mixed crews". That is not the case here. Nevertheless, the same report states: "while it cannot be denied that mixed crews present problems not found among crews of a single nationality with a common language, such assumptions may be proved to be too simple." And it continues "the fact that so many ships are crewed in this way itself argues against such conclusions."

Many scholars today are bringing all this about. In fact, Jerry Dzugan, in his invaluable work on *Cross cultural communication: implications for maritime mariners*, mentions That "mariners work in one of the world's most international environments" and he calls for "a need to educate them fully in aspects of cross cultural communication to ensure safer and more effective shipping". He added value to the debate pointing out eleven cultural barriers that he considers to often get in the way of effective communication with a great impact on marine safety.

Although the Mozambique shipping industry does not face the problem of mixed crews, the communication problems still exist, which may be due to the power difference, cultural backgrounds and traditions. For example, a ship where the Master, because of differences in opinions with the personnel, communicates with the Chief Engineer or the crew through the Mate and avoids direct dealing. It is not necessary to say this is unacceptable. Differences in opinions in general is one of that aspects that are very much common onboard ships in Mozambique leading to non-effective communication among the key crew members. This is a matter for both the management and the Safety Management Certificate (SMC) and Document of Compliance (DOC) issuing authority to take measures against.

In the author's opinion, neither of this can however be taken as a serious challenge in an environment of a single nationality with a common language, which would be applicable to the present question.

2.2. Quality and safety in management policies and operation of ships

In Captain Jan Horck's opinion, a demonstration of quality is becoming a condition of doing business in the maritime industries and that choice elevates quality requirements. It would be to add that quality also has much supplementary benefit besides increasing safety and improving an overall operational performance. Indeed, demonstration of quality classifies those that are competent from the others and gradually quality brings its own reward.

Investment in training to keep staff updated contributes to quality and pays for itself. The final result will take to cost reduction of an implemented quality management system. As the ISM and STCW 95 recommend, there is a need for company loyalty and continuity of staff on board ships. This goes back to the question of familiarisation, experience, and effective communication among the crew members required from the personnel on the ship where they perform. Hence, it is considered to be a very important ingredient in quality assurance required for all institutions involved in maritime education and training. The requirements for quality and documentation of training under the STCW regulation 1/6 and 1/8 forces administration, training institutions and company to be in control of all competence building activities. In addition, the documentation and these procedures must be approved by the Administration in order to be a part of the professional education.

Moreover, with the ISM Code and the STCW Convention so nicely harmonised, it is necessary to document training related to STCW in the ISM safety management system (see Appendices C and D). In other words, the fact that these two instruments have common goals, the STCW requirements regarding this aspect can be integrated and documented into the procedures and requirements of the safety management system. When the company has implemented and is operating a formal training system within its SMS, it would hardly be practical to maintain voluntary company training outside the

scope of the SMS. The STCW Convention shifts a major part of the responsibility for competence building related to professional certificates over to the shipping company, as more and more of the training is to be done in-service. The fact, however, is that without top management's attention and commitment, the implementation of STCW 95 and ISM Code are likely be less effective, more costly and time consuming, and hence will reduce the company's competitive advantage. So, even in Mozambique it is better that the companies move towards the implementation direction.

Enforcing the STCW and ISM Code is not all. A quality assurance scheme should be considered not only as a requirement for the maritime college (ENM), but also, as a system to be consistently established in all governmental and private organisations related to ship operations. Consistently because it should be a system of which feedback should be seriously taken into consideration for re-examining their contents. Prof. Mottram warns that "the objective of a quality system should certainly not be seen as increasing bureaucracy. On the contrary, defining processes and procedures should be seen as a golden opportunity to simplify things, and more importantly, push decision making down the organisation." In fact, the risk for heavier bureaucracy has to be recognised when evaluating the need for these schemes. On the contrary, this requires innovation and need for a proactive attitude. In the opinion of Prof. Mottram, "true quality can only come from giving people not only procedures, but also authority." To satisfy the Administration's demand, some shipping companies may feel tempted to nominate people for certain alluded tasks without necessarily giving them the authority they need to act. This will not produce desired results. Secondly, there should be right persons for the right positions to give them the required authority.

As specified by the ISM Code, for example, on ships there is required designated person (DP) with authority and direct access to the highest level of management. His specific task is monitoring the safety and pollution prevention aspects of the ship operation. In the author's opinion, the DP ought to be a person with shipboard knowledge and experience. In the case of Mozambique, many of the shore-based personnel in most shipping companies have no background of maritime subjects and this makes the management in general and safety management in particular difficult as required today by international instruments. A change towards appropriate and

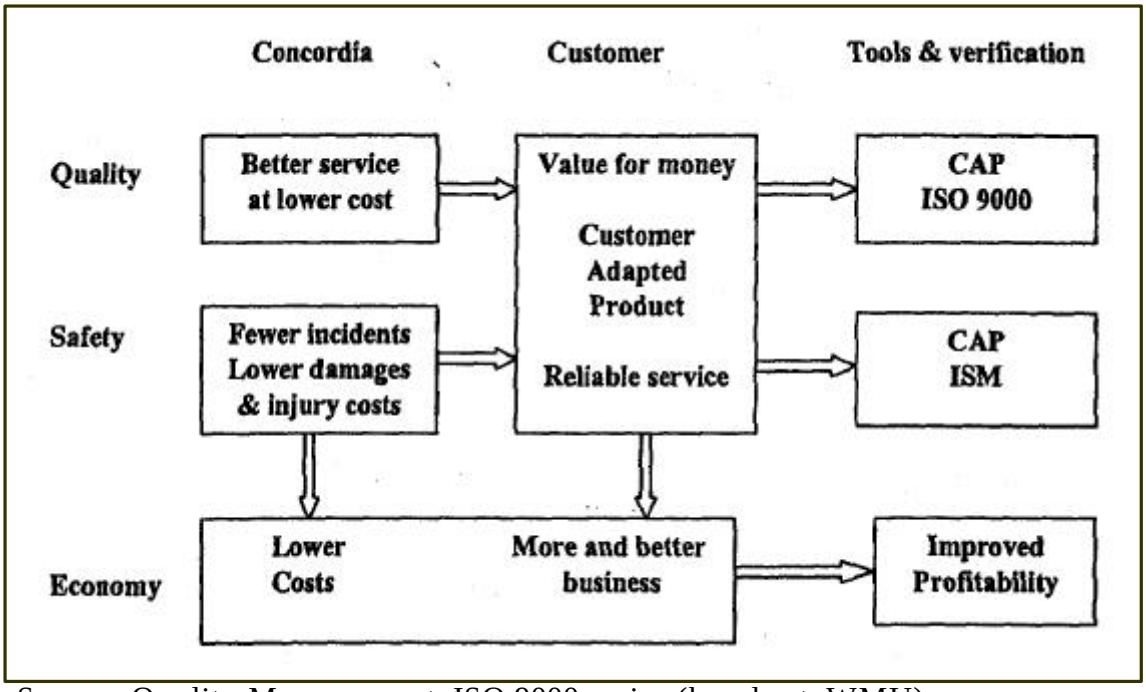
‘exceptional’ people will have to take place by either training the employed or by hiring suitable people accordingly.

If quality is defined as being best satisfaction of customer’s requirements at the lowest cost (ISO 9000 series); safety is defined as having control over accident risks and damage costs; and environmental protection is defined as reducing and avoiding harmful effects by different means; one can affirm that the three concepts are interconnected in a way that they all aim at reducing risks and improving the performance of shipping trade and therefore they have the same priority. Hence quality is important and comes hand in hand with safety and accident prevention which is the subject here.

As more and more companies today are finding that certification is a requirement for obtaining critical contracts, it has to be assumed that quality standards are there to help for a better quality management and for the industry to reduce casualties. In Mozambique, audits are usually conducted at the Administration and if they are taken seriously they will become, after a certain period of time, a culture, a day-to-day tool for work and management in that governmental office. But, this move should also go on to encouraging the companies themselves in the industry to enforce quality systems and the administration to make sure that these are in place and seriously tackled.

In Sweden, for example, shipping companies are successfully implementing this strategy. The Swedish shipping company Concordia Maritime AB is one example of that and the sketch below describes this.

Sketch 1



Source: Quality Management: ISO 9000 series (handout, WMU)

Therefore the quality system to be implemented require establishment of written procedures. It improves operations (engine room operations in this case) and thus reduces the risks associated with human factors that have led to accidents.

CHAPTER THREE

Casualties and the role of the human factor in marine engineering. A comparative study

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Ship safety involves many aspects beyond the people, ashore and aboard involved in direct operations. Among other things it involves:

- ship construction and equipment (design),
- ship management system (management),
- Skills and abilities of employed people (operation).

This chapter is particularly concerned with analysing safety as it relates to the crew and its performance. However, there can also be reference to the human aspect of ship construction and management considering the influence they can pose to ship's safety.

3.1 Shipboard maintenance approach

As it was discussed in chapter II, shipboard maintenance plays an important role in avoiding casualties. In Mozambique, there has been a lack of funds availability in most shipping and fishing companies to address all the needs of maintenance, including the high cost for spare parts. In addition, the lack of commitment by management, are the primary reasons for bad maintenance in ships.

In marine engineering operations, many scholars believe that mainly the general and running repairs of deck machinery, hull integrity, and lifting gear, are very sensitive sectors of engineering where regular attention is required. There exists lack of

proactive approach to safety and creation of the habit for maintenance planning is to be strictly fulfilled by engineer officers. The following table, compiled from an inquiry report to seafarers, demonstrates how seafarers are not really aware and pay less attention to the need for maintenance in engineering.

Table III/1

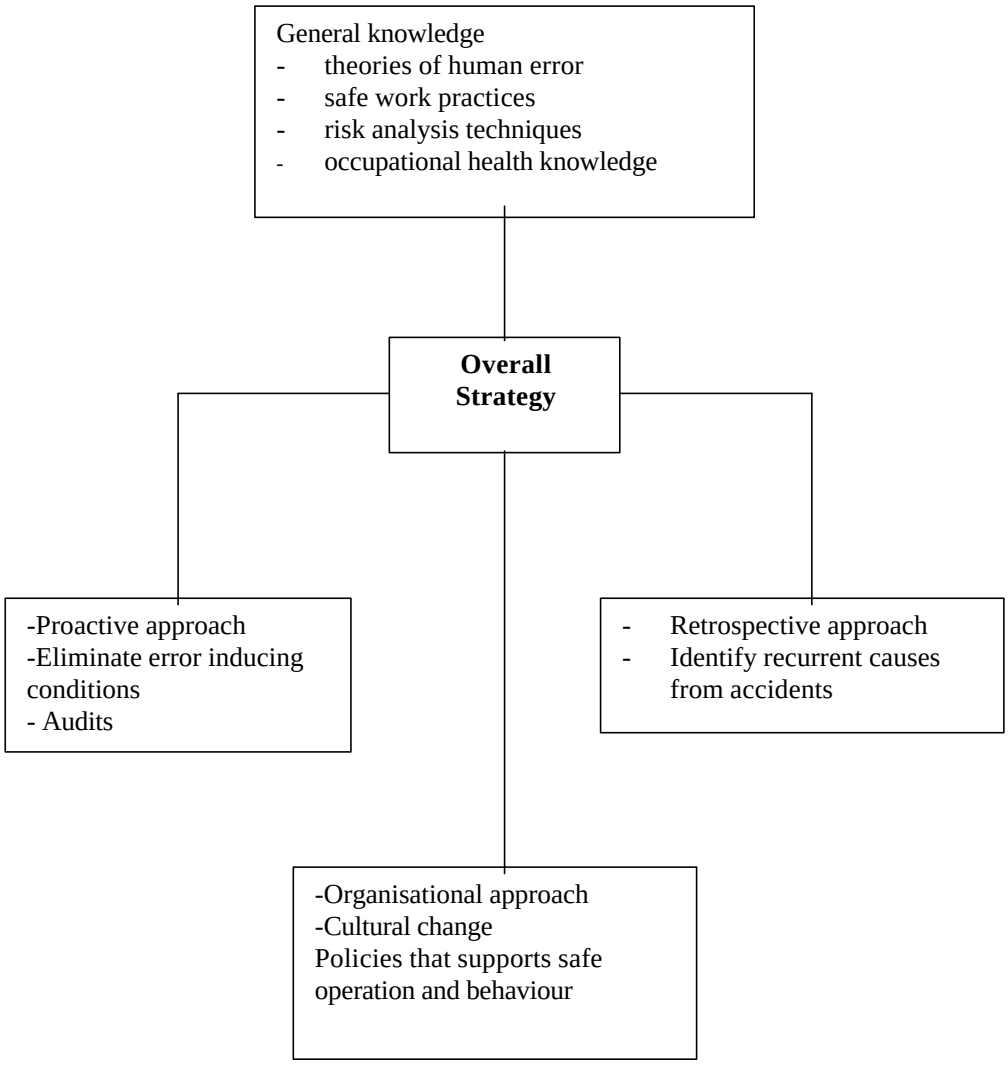
Risk areas identified by seafarers	**Percentage of seafarers**
Safety equipment (LSA & fire fighting)	84 per cent
Deck machinery	62 per cent
Hull integrity (incl. Hatches, WT doors)	54 per cent
Lifting gear	50 per cent
Corrosion prevention/painting	50 per cent
Electronics (incl. Bridge & navigation equipment)	38 per cent
Engineering (general, running repairs)	32 per cent
Maintenance planning	24 per cent

Source: Bimco review, 1996: "setting the industry's training agenda"

To Comment on the table III/1, it can be said that the seafarers themselves did not, in this example, think that maintenance in engineering is as important as say safety equipment. However, in Prof. Mottram's opinion, there is a need for a proactive culture towards safety at sea by way of risk management. Officers should tackle it in a manner that the first priority should be laid for the more risky elements of the ship. In the author's opinion, the running devices of the engines are critically essential. The following sketch brings together these ideas.

Framework for Risk prevention

Sketch 2



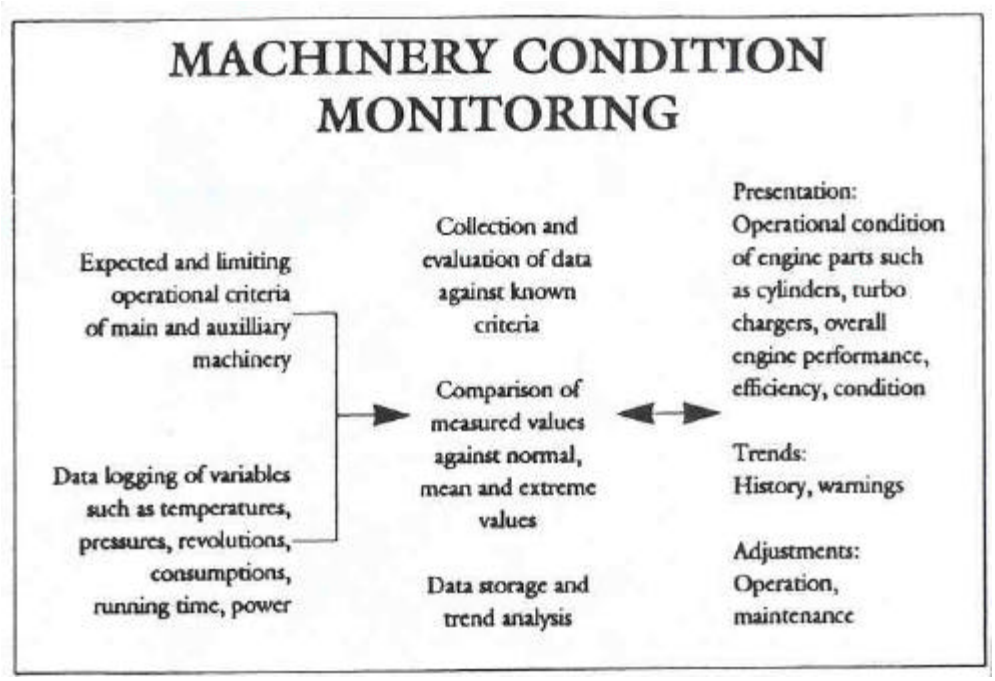
Source: 'risk and reliability in marine technology – human factors in marine accidents

The crew evaluates on their ship what items in the engine room and hull are highly risky and how often they should be maintained. The older the ship, the more demanding the maintenance. Recommendations from the manufacturers are to be strictly followed and a list so written must be distributed or displayed.

Moreover, as it can be seen from the sketch, this approach involves all the system of the shipping company, and it ends on the ship itself. Regarding general knowledge, not only the crew has to get to know the general aspects of theories of human error, safe work practices, risk analysis techniques, and occupational health knowledge; but also the shore management. This can help a company to set up a comprehensive program aimed at reducing or eliminating error inducing conditions, as required by the ISM Code.

Identifying causes from previous accidents is going to be the critical part of such risk assessment for prioritising the risk elements. This is of course a very general and strategic approach which involves company cultural change, involves setting up policies to support safe operation and behaviour. However, it is an approach, which is essential. The following sketch regarding machinery condition monitoring, summarises the result of the elements involved an analysis to the input and output of such an assessment.

Sketch 3



Source: Drewry Shipping Consultants, 1996

It is also important for crew to know how much both, the ship and shore management, are concerned with such a framework for risk prevention and how much they are willing to invest in it to get to safe working practices as a standard principle. Ordering, for example, spare parts for the engine staff has frequently been a matter of disagreement between ship and shore management in Mozambique. The ship management is concerned with safe operations of the ship, which makes them directly involved. But, the fact that they may feel that the shore management is very much concerned with savings, their disposition, willingness and ability to do that is self-discouraged. Therefore, unconditional commitment from both sides has to be demonstrated to reduce the effect of human factor, which may be caused due to discouragement from the shore management towards proactive approach.

3.2 Reports of sample accidents and incidents and the role of the human factor in shipboard marine engineering operations

When an accident occurs, the Government or the Ministry of Transport and Communications, depending on the magnitude of the accident, nominates an inquiry committee. This procedure is undertaken on an *ad hoc* basis to clarify only the accident in question. Further, there is a lack of a legal regime to be followed by the committee in such circumstances.

If the accident is of a great magnitude, there is also a temptation to nominate a committee that is very much political rather than technical or professional. These actions lead to results of inquiries that may help identify circumstances for the particular accident, but very rarely identify safeguards for future and provide guidance for technical or professional purposes. Following some of the examples indicate the errors related to human factors applicable to operations that contributed to accidents.

3.2.1 The *Katina P* disaster

The vulnerability of the Mozambique coast does not only result from the Mozambique-flagged ships, but also from the foreign ships mainly VLCC tankers going from the Middle East, through the Mozambique Channel and Cape of Good Hope in South Africa, to Europe and America.

In April 1992 the Maltese motor tanker *Katina P* broke in two off the Mozambique coast, and substantial pollution was reported to have occurred. The 26-year-old vessel was on her voyage from Venezuela to Fujairan, loaded with 66,700 tons of heavy fuel oil valued at US§4.5m (Lloyd's Maritime Information Services on its report on Maritime Casualties 1963-1996). The *Katina P* was disabled by freak wave which necessitated beaching her on a sandbar at the mouth of Maputo Bay, six miles offshore, to prevent her from sinking, on April 17. Severe damage was sustained to the amidships area, with a gaping hole in her side causing oil to gush into the Indian Ocean waters in a area heavily harvested for prawns and other seafood.

To avoid further pollution of the Mozambique coast, the *Katina P* was refloated and towed out to sea, but she broke in two approximately 100 miles off Mozambique on April 26, sinking. However, a substantial amount of oil escaped from her tanks when she sank.

The Mozambique authorities demanded massive compensation in respect of the pollution problem. There were reports of authorities preparing to file criminal charges against the Greek master Trifon Kalaitzakis for "negligently spilling oil and obstructing the resulting inquiry. The final report on the accident listed the following causes:
Regarding the ship:

- The master neglected the rough weather and did not ask for assistance when cracks were discovered on the hull along the South African coast.

- Despite having valid certificates issued by both the class (HELLENIC REGISTER) and the Maltese maritime authorities, the ship was clearly unseaworthy. It did not fulfil the SOLAS requirements.

Regarding crew documentation:

- There were engineers without certificates to sail on tankers.

The STCW regulation V/1, concerning requirements for the training and qualification of masters, officers and ratings on tankers, states the following:

" 1. Officers and ratings assigned specific duties and responsibilities related to cargo or cargo equipment on tankers shall have completed an approved shore-based fire-fighting course in addition to the training required by regulation VI/1 and shall have completed:

a) at least three months of approved seagoing service on tankers in order to acquire adequate knowledge of safe operational practices; or
b) an approved tanker familiarisation course covering at least the syllabus given for that course in section A-V/1 of the STCW Code"

The Convention establishes the limitations and exemptions permissible, and further, requires issuance of adequate certificates or endorsements for masters and officers including the engineer officers.

Regarding ship operation:

- During inquiry several persons were prompted to mention 'freak waves' as the primary reason, but the log books did not have any mention of that.
- The engine power was kept for full speed all along the voyage despite heavy weather. This was believed to have worsened the conditions of the ship.

Regarding captainship:

- The master joined the vessel after earlier master was dismissed for neglecting further investigation on a spill. The master took over during loading and hence was without any sufficient familiarisation.
- Crew reduction took place immediately before departure resulting in conditions of fatigue and unfitness for the remaining crew.
- The vessel did not have a qualified First Mate. The final report gives no further detail.

Apart from not having appropriate certificates, the engineer officers were at fault for not making proper entries in the logbooks regarding the alluded 'freak waves'. The inquiry concluded that this was one of the contributing faults from the engine department officers. Had there been good relationship among the officers, the engineers could have discussed with the master the problems that could be foreseen due to running engines at full speed in freak waves. This could have resulted in the master ordering slowing down. Furthermore, the crew reduction that took place immediately before departure was a violation of the STCW 'fitness for duty' requirement as was mentioned in chapter II. In a 3 to 4 weeks trip, watches of 6 hours each, leads certainly to fatigue and ineffective performance by the officers.

These data show by itself the influence from the engineering side of the accident, which led to heavy avoidable losses not only for Mozambique as a coastal country, but also to the company itself. Specifically the report outlined losses in the following production sectors:

- Fishing,
- Salt industry,
- Mozambican electrical company (EDM),
- Tourism.

In general terms, except for some missing certificates and documents, the vessel seemed to have documentation in order. The absence of the Minimum Safe Manning Certificate

made it impossible to establish with certainty whether the vessel was properly manned. Doubts could be raised in relation to number of officers.

Document of survey status was presented and showed no major pending items. However, a quick survey on board the vessel by Mozambican authorities gave an impression very much different. The vessel was generally in bad condition and rust was all over decks, plates, pipes etc. It gave the very clear impression of an old substandard ship. South African surveyors got to the same conclusions afterwards.

Another statement, related to human factor, is the changes, which had been made in the entries in the deck logbook. The explanation given by the crew was the situation of stress and panic. Nevertheless, the four categories of human factor as mentioned earlier in paragraph 3.1.2 allude the misapplication of rules as a rule-based error and sabotage as a violation. Probably further examination would have thrown more light in identifying the actual error.

This accident is an example of how a chain of wrong professional behaviour both by shore, ship management, and officers can lead to damages on the people, property and environment. A ship with damage on the hull is knowingly loaded with cargo for a three-four months trip; the master fails to act when the ship is in danger and continues the trip without asking for help, the officers fail to act correctly. The result is a compensation claim of more than USD§10.7m apart from the other damages. Indeed, comparing the values of damages and that of the cargo carried, the situation appears as it is shown below where the damages constitute more than 2.3 times the value of the cargo itself.

Table III/2

Value of cargo carried	Alleged value of damages (claim)
US § 4.5 million	US § 10.7 million

Source: Final report of the Katina P accident and the issue of Maritime casualties 1963 and 1996.

3.2.2 Collision between *NORA* and *SOBROSO*

In the case of the collision accident that took place on August, 8th 1997, in Pebane northern Mozambique between the fishing vessel *NORA* and the bunkering motor vessel *SOBROSO*, the particulars of the two ships were as follows:

NORA is a ship intended for trawling, registered in Sydney (Australia), 31 meters of length between perpendiculars, and at the time of the accident it was licensed to fish in Mozambique waters.

Regarding *SOBROSO*, it is intended to assist fishing vessels on high seas bunkering fuel and lube oil, including similar jobs. Owned by the Mozambican fishing company, PESCAMAR, *SOBROSO* is registered in Mozambique, 48 meters in length between perpendiculars. The two ships collided while on their duties near Pebane, causing heavy damages on both ships, but fortunately without loss of life (see Appendix showing chart of the collision).

The contribution of the engineering operations towards accident was assessed by the inquiry as follows:

- Application of excessive speed by the M/V *SOBROSO* in a situation whereby several ships were engaged in fishing.

- During the operation it was found that rudder response was defective. This is of course the full responsibility of the engineer officers to make sure that the equipment in machinery installations works properly.

- Even when the accident was imminent the main engines were still running at full power. In spite of the fact that the master is the only responsible person for taking the necessary measures and ordering slowing down or stoppage, in such circumstances it would have been better for the chief engineer to act within his authority and discuss the situation with the master for safety of the vessel.

The assessment to these given three items involving engine room operations seems very much related to master's ability to evaluate the situation and act accordingly. However, in the author's opinion, the engineer officers have also responsibility in making sure that everything works properly. It should not be at the time of an accident that it is realised that a very important machinery installation like steering gear system does not respond.

Maintenance is, in the author's opinion, the key aspect mainly when it comes to older ships. In this example of *SOBROSO*, built in 1962 and 35 years old at the time of the accident, it is believed that if proper maintenance of the steering gear system was followed this accident would have been avoided and thus the 70 % of blame on it for the damages avoided.

According to the Institute of London Underwriters (ILU), between 1991 and 1998, 95 bulk carriers were totally lost due to accidents with different causes involving machinery. Of these only 8 accidents, representing 8.4 % of total were caused by the failure of machinery or related to it. In addition, it is noticed that among these 8 ships lost due to machinery failure, only one was 3 years old and all the others were ships older than 14 years. It is not difficult to imagine that lack of maintenance may have been the primary cause of the accidents, given their age profile. This stresses much more the need for proper maintenance, especially on such older ships. Table III/3 shows the age profile of these eight ships.

Table III/3

Total losses 1991-1998 in bulk carriers

Year of accident	Vessel name	Age (years)	Cause of accident
1992	Pegasus	20	Machinery, etc
1992	Afthoros	23	Machinery, etc
1992	Arisan	18	Machinery, etc
1994	Shipbroker	14	Machinery, etc

1994	Ocean Lucky	23	Machinery, etc
1995	You Xiu	3	Machinery, etc
1995	Paris	24	Machinery, etc
1996	Herculus	26	Machinery, etc

Source: Modified from The Institute of London Underwriters' table (ILU), 1998

3.2.3 *Aleutian Enterprise* capsizing and sinking

It can also be useful to overview human factor related accidents abroad, to draw an idea on causes and to get clear indication of what is to be done to avoid future recurrence.

The *ALEUTIAN ENTERPRISE* was a US fish processing vessel operating in the Bering Sea. It departed Dutch Harbor, Alaska on 2 March 1990 and conducted normal trawling activities until 22 March, when at 0800 the master relieved the chief officer. This was the last trawl to be conducted before return to port. That day the vessel capsized and sank.

The ship was equipped with trawl cable tension indicators to allow the crew be aware when the trawl net was full and ready to be hauled in. During the early hauling process the ship had a 3-to-4 degree port list that the master considered it to be normal in the existing circumstances. When the vessel's list increased from 15 to 20 degrees (unusual), the master telephoned the chief engineer to ask why such a list. According to the master, the chief engineer answered that he was transferring fuel from port to starboard tanks to alleviate the list.

However, the list increased and seawater ingress started into the ship through hull openings and it sank. Twelve persons were reported dead including the chief engineer in the engine room.

Although the report does not mention what the causes are thought to be, there are interesting points related to human aspects to bear in mind as a lesson to be learnt from

this accident. According to the master's testimony the work shifts were of 16 hours on duty and 8 hours off duty. In case of Mozambique, also this workload is normal especially in fishing vessels where the companies together with the masters decide the workload and the administration has little knowledge of what happens.

Several survivors of the *ALEUTIAN ENTERPRISE* stated that they had received no formal training in commercial fishing, use of safety equipment, survival procedures, or cold water survival. Some of the 12 persons lost, died as a result of bad survival preparedness both, in the use of equipment and survival procedures in water.

Even though the vessel did have videotapes of training courses and safety manuals, the survivors stated that with their workload, sleep was more important than watching the tapes during rest periods.

Further, the assistant engineer stated that the chief engineer was well organised and had been developing a maintenance schedule and logs for all the engineering functions on board the vessel. But, these were supposed to be in place before the ship is put in service or before it departs for its trip. It should not be a thing that is indefinitely developed while the ship is operating. As previously stated a maintenance schedule especially in engineering operations is critical to avoiding not only accidents, but also premature scrapping.

In addition, the *ALEUTIAN ENTERPRISE's* company was reputed to offer a salary bonus to captains who saved money on safety equipment purchases. Which means that if the master could save as much as possible by purchasing cheaper equipment he would be rewarded. Motivation is of course a factor of the human element, but here it was clearly enforced at the expense of safety. This shows how the companies can be heavily involved in discouraging the seafarers to act safely and in promoting breaking safety requirements for money; posing risk to people, property, and environment.

During 1980s and early 1990s, a similar non-written rule was widely spread in some fishing and even shipping companies. It is believed even today in several fishing companies in Mozambique that the lesser is the money asked from the shore

management, the better the reward ship's people get. It is not necessary to say that this is a kick on the ship's safety requirements. In fishing vessels, it has been usual to put pressure on the crews to maintain high fish production and relate it to job retention by the seafarers. Thus making the seafarers work under tremendous pressures of job security and mental stress.

This could be one of the reasons for the drug and alcohol abuse, which has frequently been a problem in the shipping and fishing companies in Mozambique. In this reported accident, a crewmember stated that he was aware of some of his colleagues drinking and smoking marijuana after their work shifts. Which meant that when they went to sleep they could not be easily woken up. It is a question also requiring such comprehensive approach in Mozambique so that appropriate measures are taken to safeguard against these kinds of unsafe practices.

3.3 Man versus Machine Interface

Throughout the previous chapters, matters of human factor affecting technical requirements, manning, training, management and work environment areas were discussed. Turning now over to man versus machine interface, some of the facts in this relationship are sufficiently relevant to address.

The report of the joint session of the joint MSC/MEPC working group on the human element and on Formal Safety Assessment presented to the MEPC 42nd Session, defined man/machine interface as involving the compatibility of ship design and equipment design with the individuals that work on a ship or use the equipment. It continues on to say that the man/machine interface includes issues such as human input aspects, easily understood information display and the interaction between the human operator and the 'machine'.

Looking at the Mozambican case, this is really what happens on the ground. The fact that different ships, in the same company, come from different origins, as mentioned before, from Russia and Hungary to German and Spain, can be a strong constraint for

the men working on them and when being moved from one ship to another within short periods of time.

For example, electrical boards including all engine equipment on Spanish built ships *LUGENDA* and *N'GURI* (now scrapped) had indications written in Spanish. The same happened with Hungarian ships *LICUNGO* and *CHINDE.* Undoubtedly, this situation poses a great danger for the fact that the men could not read or understand neither of these languages. One can argue that familiarisation could take place but in an emergency situation people's behaviour tends to change and even more so when the crewmembers are moved in the circumstances mentioned before.

It would be of a great interest for the maritime industry to reach a common design and layout standard. In fact, the report mentions that the aim is to achieve such uniform design and layout so as to use internationally recognised symbols on equipment controls, using established ergonomics principles, criteria and requirements. This should be combined with appropriate education and training. Furthermore, the STCW Code requires that the officer must have adequate knowledge of the English language to enable him to use engineering publications and to perform engineering duties. In addition, the vessels should have proper translations into a *common language.*

However, it is widely known as to how this is far from being achieved today in the maritime industry. For example, many decades after the international system for units was established, the industry still faces the challenge of conversions from Inches, foot and miles into centimetres, meters and kilometres; from British Thermal Unit (BTU) or Fahrenheit degrees into centigrade; from bar into Pascal and so on. Hence, the best thing for the shipping companies in Mozambique would be to try to achieve uniformity by purchasing ships from the same origin or same standard rules.

In 1990, the then State Bureau for Fisheries in Mozambique (SEP) purchased, from a Japanese shipyard, the bunkering ship *SENA* which was later in the same year handed over to a company that would operate it. At the end of 1996, the ship was laid up off for more than a year due to major mechanical problems. The author believes that maintenance again may have been at the root of this situation based on the fact that most

instruction manuals are in Japanese and not many translated instructions are provided that would help the crew to effectively undertake the recommended maintenance. The damages here are clear, new ship (6 years) laid for more than a year for mechanical problems which could have been avoided if proper maintenance regime could be followed.

LIAZI, formerly *Sternberg*, is one of the ships acquired by NAVIQUE from a Scandinavian shipping company, relatively new and operative but now awaiting for repairs. Since late in 1996, *LIAZI* has had a major problem which is that the engine can not provide astern manoeuvre. Another example is POLANA where steering gear and rudder breakdown led to its premature and undue scrapping while it was well operating.

The representative cases mentioned above are very limited in numbers as it is neither possible nor desirable for the scope of this dissertation to discuss more of such incidents. All these incidents clearly show the pattern of human behaviour and the kind of accidents they might lead to. It is to be recognised that it is difficult to determine with certainty their primary reason. Of course comprehensive analysis must take place to do that. However, this can also be said that there seems to be a frequent, common and chronic pattern of misbehaviour related to human errors, both technical and professional, that implicitly is the root cause for accidents, as the evidence tends to suggest.

3.4 The role of the classification societies in minimising hazards

The accepted and wide practice today is to get the expertise of the classification societies to reduce hazards through delegation of some of the Flag State prerogatives and obligations under IMO requirements. In doing this, the Flag State must bear in mind that while authority is important for the classes to undertake their job on behalf of the Flag State, responsibility still lies on the Flag State. But, many Flag States including Mozambique do not have all the expertise they need to do the job. So, they have to delegate.

The Classification Societies, when authorised by the Flag State, can carry out surveys and inspections mainly on board vessels of 500 GT and above. Of course the conditions for such a job and the tasks must be spelled out in a bilateral agreement involving the Flag State and the Class or Classes. The authorisation usually follows the guidelines of a IMO model agreement set for this purpose to establish the rights and duties with regard to the general conditions, information and liaison, supervision of the Class, applicable instruments, reporting procedures, unscheduled inspections performed by the class, and the corrective action to be taken as well as withdrawal of certificates.

The Class is obliged, under the agreement, to ensure that the work undertaken by the society is carried out by qualified personnel, and will to the best of its ability see that the work is carried out to the satisfaction of the Administration. In addition, for all surveys the Class have a systematic order of rules, instructions, procedures, reporting routines, acceptance criteria where relevant, and routines for checking, all to ensure that the relevant requirements are applicable and that a sufficient versatility is incorporated.

The Administration can also require that the Class is certified under ISO 9001 standards for quality systems in connection with the work carried.

In particular, the Administration in Mozambique will certainly encounter the necessity to hold such agreements, now that the Indian Ocean MOU on Port State Control is in place. The Administration surveyors can then concentrate on surveying and inspecting ships of 500 GT and below where generally SOLAS and MARPOL requirements do not apply.

The classification societies have also the moral obligation to inspire responsibility in their clients, including the flag states. When undertaking their duties on behalf of flag states, they are required to demonstrate responsibility with their job. The contrary would send a bad message. For example, the final report on the inquiry of the *Katina P* disaster, claimed the need to send a protesting report to the IMO and the Greek Ministry of Maritime Affairs, regarding the work undertaken by the class *HELLENIC*

REGISTER, especially on the ships going through the Mozambique Channel. The report indicated the following cases:

- M/V OCEANOS, classed by *HELLENIC REGISTER*, sank in August 1991, in the Mozambique Channel.

- M/T KATINA P, classed by *HELLENIC REGISTER*, sank in April 1992, 95 miles from the Mozambique coast.
- M/V AFTHOROS, classed by *HELLENIC REGISTER*, nearly sank in May 1992, at Richards Bay.

In a way this is an indication of lack of responsibility by a class. Within a matter of one year, three ships classed by the same society having major problems in the same area of the world. It is easy to imagine that the problems are with the class. *Katina P*, for example, was issued all the necessary documents to sail by the class even with rust all over and even some holes on the hull.

CHAPTER FOUR

Examining the managerial, operational and technical complements to the human behaviour

4.1 The need to investigate marine accidents in Mozambique

Accidents do not have to happen. They can be prevented with proper knowledge, preparation, and attention. What is needed first is the knowledge of risk for various accident precursor situations. With a reliable/consistent collection of accidents and incidents data, levels of risk can be assessed and that information can be applied judiciously to achieve safety and efficiency goals. Although accidents are infrequent, but their chances are always present, hence accident investigations provide a source of information that is commonly used as basis for prevention.

In general terms, accidents in maritime industry should be investigated, among other things to:

- Educate people and engage them in prevention of recurrences,
- Determine responsibility and liability,
- Update legal requirements of the involved maritime authorities, and
- Analyse causes to address the actual problem.

But, avoiding recurrence is very much dependent upon the operator's training (professionalism) and thus minimisation of operational and technical wrong doings which goes back to the human element.

In specific terms, it could be said that investigating accidents is also a concern for precise decisions as to how much emphasis on human aspects should be put to avoid such recurrences.

In Mozambique, there is a need to investigate accidents for establishing facts and consider them for training purposes in maritime colleges or training schools for seamen. Not only facts related to put blame and liability but also to the technical, professional doings and the need for updating the national maritime legislation based on the local experience (see Appendices A and B). This requires a bureau of maritime accidents and incidents investigation comprising purely technical and professional people who have the required experience in the field.

The International Maritime Organisation (IMO) report of the MSC 69/13/1 of 30 January 1998 titled, ‘role of the human element in maritime casualties', the Joint ILO/IMO ad hoc working group on investigation of human factors in maritime casualties and the ICAO human factors digest no. 7 'investigation of human factors in accidents and incidents' 1993 provide excellent background to what is called the ‘Shel’ model. Shel Model is an alternative way of collecting and storing data in marine casualties, which involves particular investigating procedures and taxonomies adopted at the US coast guard. These documents (IMO/ILO and ICAO documents) bring together extensive guidelines on gathering human factors information during an investigation of a marine casualty, incident or near-miss.

The Shel model is particularly appropriate since most accidents are usually a series of lapses involving instances of human factors related to deficiencies in design, management, operation, etc which make up either the root causes or many of the contributing situations, previously mentioned in the dissertation, leading to the accident or incident.

The IMO investigation process involves six steps: (1) collect occurrence data; (2) determine occurrence sequence; (3) identify unsafe acts (decisions) and unsafe conditions; (4) identify the error type or violation; (5) identify underlying factors; and (6) identify potential safety problems and develop safety actions. Shel model is a process providing a step-by-step systematic approach to the investigation of human

factors. The Shel model is ideal for steps (1) and (2). It serves as an organisational key to investigator's data collections which avoids problems because:

1. it takes into consideration all the important work system elements;
2. it promotes the consideration of the interrelationships between the work system elements; and
3. It focuses on the factors, which influence human performance by relating all peripheral elements to central human elements.

In Alexander C. Landsburg's words, the components of the Shel model are Liveware (the individual and human to human interface); Hardware (human to machine interface); Software (human to system interface); and Environment (human to environment interface).

As mentioned before, while the Mozambique coast is very vulnerable to this danger of accidents, it is rather unhelpful for the purpose of preventing or minimising them this lack of legal and purely technical proceedings necessary to establish the facts and recover the damages. For example, based on statistics from the report of Nordic Consulting Group (NCG) on Maritime Safety Development Program for SADC coastal states and Malawi, issued in March 1996, between 1993 and 1995, 227 accidents involving fire on board were reported to have occurred with 197 lives lost. Out of those, only two were investigated. Moreover, the establishment of inquiry committees is done on *ad hoc* basis as and when a marine accident or incident occurs.

The need to investigate accidents has been emphasised in the governmental Decree no. 34/94, 1st of September that creates SAFMAR, where the general introduction to it acknowledges the necessity to *prevent Mozambique coast from the lack of control or occurrence of spills of pollutant products that would endanger people's lives, property and the marine environment.* Specifically, in article 8 paragraph (d), it goes on to be precise that it is SAFMAR's responsibility to *conduct inquiries into the marine casualties.*

It is therefore necessary that the government sets up suitable infra-structure comprising inquiry committees with qualified and knowledgeable personnel in the use of different investigation models, who can objectively investigate the accidents/incidents. These persons should be given due authority so that they can solicit the co-operation and help from necessary sources.

For example, the table below highlights the high number of accidents and incidents as well as the lives lost in relatively short period of time, which call upon the authorities for appropriate measures.

Table IV/1

Accidents at sea reported in Mozambique

Year	No. of casualties	Main causes	Deaths
1993	120	Fire	
1994	84	Fire	
1995	23	Fire	
Total	**227**	**-**	**197**

Source: Modified from the NCG report on Maritime Safety Development Program for SADC coastal states and Malawi, March 1996.

4.2 The organisational and individual factor

Latent failures or underlying factors relate to conditions that may exist within systems or organisations, which given the right combination of circumstances, may contribute to an unsafe situation. They include such conditions as, organisational, design, maintenance, communication failures, and others.

As stated before, it may be relatively easy to identify human contribution in accidents. However, to determine with certainty the source of such factors can be very difficult. One reason for such difficulty can be the long chain these factors follow in the organisation from the top management down to operational aspects. Equally, it is

important to remember that the human factor's chain can also start earlier, during design of a ship.

In fact, the causes identified from previous accidents are going to be critical for risk assessment and to find the priorities of actions for future avoidance. Although this is a very general and strategic approach as mentioned above which involves a cultural change, requires setting up policies for safe operations and safety conscious behaviour. It is an important and critical approach to consider.

Similarly, as far as safety at sea and STCW 95 implementation are concerned, the chain of responsibility requires a three-sided net comprising the following:

- Administration's role
- Companies' role, and
- Seafarers' role.

It is indeed administration's role to ensure that training and assessment of seafarers are administrated, supervised and monitored in accordance with the requirements of the regulations I/5, I/6, I/8 and I/10. In addition, it is also administration's role to ensure that:

- ***on-the-job training*** scheme is in place;
- There is an approved ***assessment*** program of the in-service training scheme; and
- Careful ***endorsement*** scheme of certificates approved by the administration is in compliance.

Companies are made responsible, through regulation I/14, for competence, familiarisation and crew co-ordination training onboard, beyond of course the need to ensure appropriate certificates for their seafarers, and to comply with the manning requirements. The ISM Code emphasises the same requirements.

Regarding seafarers, they are made individually responsible for their capability to effectively communicate and for their competence, in addition to the required training.

A study by the DMI, classifies in two the potential safety hazards in maritime work as related to the human factor:

- Latent human error - involving social, moral and design hazards; and
- Active human error - involving co-ordination, communication and performance hazards.

Either of the two errors are caused due to the strategies adopted by the management, on board or ashore.

Regarding latent human error, following are some of relevant remarks to take into consideration. Social hazards of an organisation comprise problems inherent to the organisation and the economy of shipping, insurance, freight and others so related. These are the social aspects within which the company may be heavily involved and its decisions positively or negatively influenced. In Mozambique, for example, decisions concerning safety aspects of a ship are very much dependent upon the freight the companies earn and also upon the economical situation of each. The number of crew members, for example, in several shipping and fishing companies is dictated by the capability of a company to pay salary rather than by the manning requirements of each ship.

Pressure of IMO requirements or from SAFMAR concerning implementation of standards have different response because of economical situation of the companies.

Moral hazards of work, which comprise problems of applicability of rules and regulations, ineffective procedures, including work ethics, determine the dissemination of the requirements in each company, as to how much control is required from SAFMAR and also the introduction of safety culture and accidents and incidents reporting.

The design hazards of man-machine interaction involves the companies to have proper understanding of engine instrumentation and its layout while purchasing ships and

equipment. SAFMAR plays the sole role of making sure that the purchased ships are safe as far as IMO and national requirements are concerned. The companies are responsible for making sure that the man-machine interface is effective. This includes of course, how the crew interacts with the ship's engine standardisation and how familiar they are.

The active human error and co-ordination hazards of co-operative work involve problems in maintenance planning, in task allocation and in distribution of responsibility and control. Ship maintenance is one of the subjects, which was comprehensively looked at in the dissertation. Both the MET institution and the companies must prioritise this as being of a critical importance. It was mentioned also that the communication hazards may not be critically important in Mozambique taking into consideration that not many shipping or fishing companies employ foreign seafarers with whom communication is a problem.

Concerning performance hazards of human perception and attention; which comprises perceptual errors, errors of attention, individual errors (slips, lapses, misapplications, and mistakes), it was also mentioned the problem of engine ratings tending increasingly older, the age-related problems such as poor eye sight reflexes, inflexibility, lack of vigour, and lack of refresher or upgrading training. This goes back again to the companies' responsibility.

4.3 The technical and operational factor in engine operations

It is very important that the shore management understands all the company procedures, which are safety related and the individual goal they are intended to achieve.

The ISM Code requires written procedures, which are clear for everyone to understand. For example, when NAVIQUE nominates a superintendent engineer for ship or ships, he is required to be able to understand the crew 'language' regarding maintenance planning of listed items in the engine room. The same applies to the newly enforced requirement of a designated person (DP). The fact though in most private shipping and fishing companies in Mozambique is that in most cases neither the superintendent has sufficient technical and professional background, nor he is aware of his full responsibility and the procedures to follow. If the superintendents and now the

DPs have their work under control through written procedures, as required, the maintenance planning would be continuously updated and followed to the line.

In the author's opinion, lack or ineffective maintenance that results from lack of spare parts for example should not be acceptable. This is a clear indication of both inefficient superintendence, bad shore-ship co-ordination and performance hazards within the whole organisation. The superintendent is the link between the shore management and the chief engineer. Similarly, regarding safety aspects, the DP is also a link between the two sides of the organisation.

On the other hand, the fact that the ships are usually very old, as previously mentioned, forces the engine room personnel to work much more on remedying repairs rather than in preventive maintenance.

As far as SAFMAR's section for ship surveys is concerned, emphasis should lie on maintenance planning and how far the personnel have fulfilled their scheduled duties. Letting a ship leave the port with a fire pump still awaiting repair is an outstanding risk for which the surveyors are required to take corresponding measure. It is to be remembered that the NCG report showed that over the period starting from 1993 to 1995, the prevailing cause for accidents in Mozambique has been fire on board. The solution of the problem would be firstly to determine the main reasons of fire and eliminate them and secondly to equip the ships with proper means of fire fighting, kept in well maintained ready to use conditions.

CHAPTER FIVE

Conclusion and Recommendations

5.1 Conclusion

The representative cases, which were taken as sample to reach this stage are very limited in number as it is not possible, for the scope of this dissertation, to include all the accidents that have occurred in and around Mozambique. But, they still demonstrate reasonably the pattern of shipboard accidents that occur in Mozambique and the consequences they might lead to.

The establishment of SAFMAR in 1994, has already been a great and right step towards solution of the many problems related to the human factor in shipboard engineering operations and others, in Mozambique. This institution will need to accumulate experience in safety aspects including the human factor issues, implement proactively national and international requirements, and act effectively whenever a problem arises.

Throughout this dissertation, problems resulting from the action or lack of action by the maritime industry including SAFMAR, were enumerated and evaluated. Specifically, the author indicated the tendency towards purchasing old ships to add to the existing old fleet, which makes maintenance, the working conditions for the engineer officers important issues. There is also the need to follow the old advice to put emphasis on preventing accidents through application of lessons learnt from experience.

Other important issue discussed was better structure within maritime organisations in general to help enhance efficiency and effectiveness which were said to be much dependent upon the investment on human element aspects. The manning agencies are definitely participating parties in the whole net which contribute towards avoiding accidents at sea and so their familiarisation with applicable national and international instruments is of a great importance. In fact, substandard crew, it is to be remembered, almost certainly means a substandard ship.

This goes in line with another issue discussed which concludes that there has to be training school for engine ratings. Further, there has to be an effective replacement policy and process to ensure young and trained seafarers get in to replace the ones retiring.

Another conclusion to draw is that there are power differences, cultural backgrounds and traditions almost everywhere in life. Regarding ship's safety, non-effective communication among crewmembers due to these factors must be addressed by the SMC and DOC issuing organisations. Moreover, the company's Safety Management System (SMS) must conform to STCW requirements. The quality system comprehends assessment of both the ISM and STCW implementation process.

It is an issue for most of shipping companies in developing world including Mozambique, to address the lack of funds availability to resolve all the needs of maintenance, safety, spare parts, human element, and others. This is a real problem, but lack of commitment by management is even worse.

Whereas it will take still long until the shipboard machinery installation reach common international standards of design and layout, such as ISO standards, the industry in Mozambique under co-ordination of the administration can minimise the hazards which result from the differing standards on ships' machinery and layout, and thus make it safer. This could be done by purchasing ships from the same origin or built under same standard rules.

Finally, the duration of a watch on Mozambique ships is to be closely monitored by the shipping and fishing companies, but mainly by SAFMAR. SAFMAR can enforce regulations on this account and the companies ensure compliance with the STCW 'fitness for duty' requirement for hours of work arrangements.

A number of very important IMO and mainly ILO Conventions is very important to comprehensively address the human factor issue in shipboard marine engineering operations. Some are ratified but not incorporated in the national legal framework, others are effective. Not only Mozambique needs their enforcement, but also the *no more favourable treatment* clause, surely to be enforced under the Indian Ocean MOU on PSC, will require implementation of these relevant international instruments. In summary, the key issues to address for minimising the human factor contribution in shipboard marine engineering operations are as follows:

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1. Old ships are put at work;
2. Lack of proper maintenance;
3. Deficiency in familiarisation with applicable legislation by the manning organisations;
4. Substandard crews, especially engine ratings (lack of training schools for engine ratings);
5. Lack of better and effective replacement process (retirement);
6. Lack of commitment from top management within organisations;
7. Defective arrangements for hours of work and resting periods (fitness for duty);
8. Ratified IMO and ILO conventions not monitored or incorporated in the national legal system;
9. Lack of proper investigation procedure, data collection and adequate legal regime
10. Lack of crewing agencies with knowledge in the applicable instruments.

The scope of the dissertation is limited and cannot analyse all the accidents that have taken place in Mozambique, however these sample accidents analysed have, most of the times, indicated involvement of human factor.

Nevertheless, it is to be born in mind that it is the responsibility of the industry to avoid accidents from not happening and not of the administration alone. In other words, even if the laws are well designed and well implemented, if the industry in the end does not obey or at least participate, they will surely be void.

5.2 Recommendations

1. It has already been realised that conventions and regulations for safety at sea are many and quite comprehensive and that if they were properly and effectively enforced, a good deal of improvement would have been achieved. This shows that the problem lies on the edge of their implementation, which is very very low even with the political will. To be specific, although Mozambique has already ratified the SOLAS Convention, which is considered to be the most comprehensive IMO convention, and the STCW Convention, which addresses the human aspects' side, there is still a need to incorporate and ratify the following IMO and ILO relevant conventions which have a great influence on the human factor issues:

IMO:

- STCW-F 95 Convention, concerning standards of training for fishing vessels' personnel

ILO:

- Convention 73, concerning medical examinations;
- Convention 109, concerning wages, hours of work;
- Convention 133, concerning crew accommodation;
- Convention 134, concerning prevention of occupational accidents; and
- Convention 147, concerning (minimum standards) merchant shipping.

2. Not being member however does not impair the country from taking advantage of the experience comprised in those instruments to enforce in Mozambique. For example, the problem of minimum age mainly in fishing companies requires adequate action. Even though there is no data to refer to, regarding deaths of seamen at sea engaged in fishing, it is widely known this is a reality in Mozambique.

3. Taking into consideration the long Mozambique coastline (2650 km), the need for effective coast guard and the need for skilled maritime labour in the industry will all be evident in near future. So, the MET institutions should be viable. One way for that would be to hand over the ENM, working today under the Ministry of Transport and Communications (MTC); and the Fishing Training School (EPM), working under the Ministry of Agriculture and Fisheries (MAP); to the Ministry of Public Education (MINED), or to the public Eduardo Mondlane University (UEM), which are specialised educational and training institutions. Both the MTC and MAP, through the maritime authority SAFMAR, should then take the co-ordinating role to ensure compliance with the applicable international instruments.

4. In this way, the shipping and fishing companies would be involved in ensuring their financial feasibility through payments of scholarships either of the students employed or via public taxes. In addition, both the STCW 95 and the STCW-F 95 (not in force yet) require record book which should then be designed collectively with the shipping and fishing companies to be approved by the administration (SAFMAR).

5. The authority, the companies and the MET institutions should prioritise maintenance planning, as it is known that most ships are old and maintenance schedules must then be enhanced a step further. In fact, scholars today consider that training in shipboard maintenance should be included in the new convention.

6. There is also a need for SAFMAR to establish a permanent maritime accident investigation branch. This should be purely technical and professional comprising experienced people to undertake purely comprehensive technical investigation on the accidents and incidents as they arise. It should not be politicised, nor can it be seen as a danger for anyone in the system. The reports are to be taken as a lesson, including for training purposes at the ENM and EPM.

7. Considering the age profile of ships and the poor maintenance conditions it would be advisable that it is made a national regulation that the shipping companies employ qualified and experienced marine engineers as superintendents ashore to control and co-ordinate proper maintenance of ships. This arrangement will be similar to the

requirement of a designated person (DP) ashore required by the ISM Code. The information flow should run between these people, the superintendent engineers and the SAFMAR surveyors for better control.

8. The ISM Code requires today a Designated Person (DP). Of course, SAFMAR also here must play a part in appointment of this person. SAFMAR should make sure that this DP is sufficiently knowledgeable to undertake safety issues. To monitor the implementation of ISM Code at the national level, especially in the major ports of Maputo, Beira and Nacala.

9. SAFMAR will also need skilled auditors for ascertaining proper implementation of ISM Code requirements. The selected persons should be properly trained in ISM and PSC matters.

10. Creation of crewing agencies that are in compliance and familiar with the applicable IMO and national requirements should be encouraged especially by the maritime authority SAFMAR.

11. Provision of the engine display diagrams and layout for shipboard marine engineering operations both in Portuguese and in English languages.

12. Establishment of a permanent examination committee for seafarers, comprising educated, trained, knowledgeable and experienced people in maritime subjects especially those for Nautical, Radio and Marine Engineering subjects.

13. Delegate but under strict control, some of the items under flag state enforcement to classification societies for tougher surveys and inspections in the implementation especially on Mozambique flagged ships.

BIBLIOGRAPHY

Anderson, Donald; Istance, Howell and Spencer, John (1977). *Human factors in the design and operation of ships.* Gothenburg, Sweden: First International Conference on Human factor in the design and operation of ships (Conference Organising Committee).

Bea, Robert G (1994). *The role of Human error in design, construction and reliability of marine structures.* Berkeley, CA: Dept. of Naval Architecture & Offshore engineering and Dept. of Civil engineering, University of California.

BIMCO (1996). 'Implementation of the amended STCW Convention'. *BIMCO Review*. WH Robinson. Bagsvaerd, Denmark.

Duong, C (1994). *Crew competence, a key factor in safety at sea.* Bulletin Technique du Bureau Veritas.

Dzugan, Gerry (1998). *Cross cultural communication - implications for maritime trainers.* International conference on maritime education and training (IMLA). Malmö, Sweden: World Maritime University.

Government of Mozambique (1993). Inquiry upon the *M/T Katina P accident in Mozambique.* Maputo, Mozambique: Inquiry committee.

Hooke, Norman (1997). Maritime Casualties, 1963-1996. 2nd Edition. London, UK.

International Labour Organisation (1996). *Accident prevention on board ship at sea and in port. An ILO code of practice.* Second edition. Geneva, International Labour Office.

International Maritime Organisation (IMO) (1998). *Role of the human element with regard to pollution prevention and formal safety assessment.* London, UK: Maritime Environment Protection Committee (MEPC).

Kristiansen, S (1993). 'Human factors in marine accidents'. *Risk and reliability in marine technology*. 17th graduate school.

Landsburg, Alexander C; Ferguson, J; Pillsbury, Charles; and Ellingstad, Vernon (1999). 'Accident causation-based human factors taxonomy'. BIMCO BULLETIN, vol. 94, no. 1 (1999). Bagsvaerd, Denmark.

May, Michael (1998). *Psychology of human error*. Danish Maritime Institute. Lyngby, Denmark.

May, Michael (1998). *Error management.* Danish Maritime Institute. Lyngby, Denmark.

Mozambican Official Gazette "Boletim da República" (Serial I, no. 35). *Decrees Law nos. 34/94 and 35/94: Establishment of Mozambican National Maritime Safety Administration (SAFMAR) and Approval of Regulations on certification of competency for seafarers*. Maputo, Mozambique.

Nakazawa, Takeshi (1999). 'The concept of heat engines'. *Thermal Power Engineering* (Handout). Malmö, Sweden: World Maritime University.

Nishikawa, Eiichi (1999). *Marine Propulsion systems II* (handout). Malmö, Sweden: World Maritime University.

NTSB (1990). 'Report PB92-916403: NTSB/Mar-92/03 from the NTSB, Washington, DC. 20594 Marine Accident Report'. *Capsing and sinking of the fish processing vessel Aleutian Enterprise in the Bearing Sea, March 22, 1990.*

Pedro, José Maria dos Santos (1997). *Maritime casualty investigation in Mozambique and related matters.* MSc dissertation. Malmö, Sweden: World Maritime University.

SAFMAR (1997). Report of the collision accident between the fishing vessel *NORA* and the *M/V SOBROSO*. Maputo, Mozambique: Inquiry Committee.

Sanders, Mark S and McCormick, Ernest J (1987). *Human factors in engineering and design.* Sixth edition. Singapore: Chong Moh offset printing Pte Ltd.

Swedish Maritime Administration (1996). 'Summary of reported marine casualties and accidents to persons - Swedish merchant and fishing vessels'. *Notice of the Swedish Maritime Administration' no. 4 (1997).* Norrköping: Sweden.

UK P&I Club (1997). *The human factor - a report on manning*. London, UK

Williams, Jeremy (1994). 'Identifying and reducing the contribution of Human factors into offshore safety cases'. No. 17 pp 1-10.

Zhang, Shiping (1995). *Maritime casualties and the human factor - the focus on issues relating to international crews.* MSc dissertation. Malmö, Sweden: World Maritime University.