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The enhancement of operational safety of engine room machinery through training on CBT type of engine room simulator on board ships

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THE ENHANCEMENT OF OPERATIONAL SAFETY OF ENGINE ROOM MACHINERY THROUGH TRAINING ON CBT TYPE OF ENGINE ROOM SIMULATOR ON BOARD SHIPS

By

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Declaration

I certify that all the material in this dissertation that is not my own work has been identified, and that no material is included for which a degree has previously been conferred on me.

The contents of this dissertation reflect my own personal views, and are not necessarily endorsed by the University.

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Abstract

Title of Dissertation: **The Enhancement of Operational Safety of Engine Room machinery through training on CBT type of engine room simulator on board ships**.

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This dissertation is geared towards the enhancement of safety of engine room machinery operations through the help of the engine room simulator of the computer based training type on board ships. It examines the current training and safety measures required by various IMO instruments namely SOLAS, STCW 95 and the ISM Code, their implementation onboard and their relevance in the present changing time. It identifies some of the competence related causes of engine room accidents/incidents associated with the operation of machineries in view of new technology.

The study reviews various shipboard maintenance procedures and the management techniques that are being practiced. It looks at the current problems associated with training practices onboard. It critically assesses these practices and then suggests CBT as an appropriate tool for training onboard as part of the solution to some of these problems thus viewing the cost- benefit and risk analysis that the administration, management and seafarers would attain.

Common problems faced by seafarers in machinery operations and their level of knowledge in computer based training are presented. Views of the manufacturers on the development of software so as to assist seafarers in their daily operations of their machineries looking at the cost, benefit and risk analyses posed on the administration, company and seafarers are presented. The dissertation gives conclusions and recommendations that are intended to help the industry in reducing accidents and improve safety onboard.

KEY WORDS: Safety, Machineries Operation, Simulator, Computer Base Training, New Technology, Maintenance, Training, Management. Seafarers.

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List of Abbreviations

3D	Three Dimensions
BMA	Bureau of Maritime Affairs
CBT	Computer Base Training
CD	Compact Disc
DNV	Norwegian Class Society
ER	Engine Room
ERS	Engine Room Simulator
FM	Full Mission
FO	Fuel Oil
IMO	International Maritime Organization
ISM	International Safety Management Code
ISO	International Standards on quality
IT	Information Technology
KPT	Karachi Port Trust
LT	Limited Task
MET	Maritime Education and Training
MSC	Maritime Safety Committee
MT	Multi Task
OWS	Oily Water Separator
ROI	Return on Investment
SLMV	Slip Lapse Mistake Violation
SMS	Safety Management System
SOLAS	Safety of Life at Sea
ST	Special Task
STCW	Standard Training Certificate for Watch keeping
STW	Standard Training Watch keeping
UNCLOS	United Nation Convention Law of the Sea
VIT	Variable Injection Timing
WMU	World Maritime University

Chapter One

1. Introduction

Safety remains a human issue, and a human solution has to be found to safety problem.(Boisson, 1999)

1.1. The Beginning

According to the IMO resolution A.884 (21), human behaviour is categorized into 3 modes, i.e., skill, rule and knowledge based behaviours. Human error and violation are classified into 4 modes, i.e., slip, lapse, mistake and violation. The background of error occurrence is assorted into 4 groups correlated with software, hardware, environment or live ware (Makuto UCHIDA, 2004). The general cargo ship Jaipur, carrying 13,000 tons of rice to Madagascar, went out of control in the channel of Karachi's Port in Pakistan and struck a bulk carrier Uang Hai anchored at Berth No. 1 as reported by Karachi Port Trust (KPT). The Jaipur had lost its steering system. Vossborg, a general cargo ship with containers on board had an engine room blackout and had to be towed to a port. Misama, a Roll on Roll Off ship built in 2007 sustained rudder failure in Holtenau, Germany damaging some quay infrastructure and drifted back into the traffic lane (Lloyd's List November 23 and 27 2007). These are a fraction of the numbers of engine room related cases reported. Studies have shown that human factors such as inadequate skills, insufficient competence or fatigue are responsible for the majority of maritime accidents. The Maritime community and International Maritime Organization (IMO) have been striving not only to improve the safety standards on board ships but also to raise the standards of seafarers who man them.

In view of this, a higher demand must be placed on those on board responsible for operational activities. Also higher demand must be placed on the management and the organization of the ships safety procedures (Steen, 2005). The International Safety Management Code (ISM Code) has provided provisions on safe manning, maintenance and operation for the operators, management and administration. The International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW) Section A-III/1, Chapter III also stipulates standards regarding the engine department.; that is, the competency and responsibilities of the various engine personnel.

However, the manning of ships by a lower number of crew members has created a situation where the technical maintenance demands all their capacity, so little or no time is left for on-board training by traditional methods; that is, when the 3rd Engineer would teach the 4th Engineer and the Chief the 2nd Engineer. This chain of training exists no longer. Training through a shore based institution gives a generic idea of the equipment as a component of a larger system; examples are the auxiliary engines, pumps, purifiers etc. Hence many seafarers learn only their assigned duties relating to individual components rather than a complete system. Therefore, having a simulator installed on board will enable the officers to see the system as a collective unit and do self training. It is known that the introduction of the Engine Room Simulator (ERS) is good and very resourceful for seafarers. Training on simulators give a clear vision of what is happening within the systems as scenarios can be repeated, practiced and fault findings can be shown. This is also helpful for those who can not comprehend schematic diagrams well since simulators give a visual image of the machineries from different angles.

STCW 95 Section A-I/12 talks about standards governing the use of simulators for navigators. The training as required by STCW is of an internationally agreed minimum level, and it is further assumed that improved navigator training would have a positive effect on the safety level of the vessel. In order to maintain effective and efficient ship operations, minimize maritime causalities and marine pollution, it is of crucial importance that seafarers are continuously trained with the help of simulators. As regarding to engineers, STCW 95 Section A-III/1.2 makes provision for training on-board but did not specify the type of training. In any case, if training on a simulator is done in an institution why can this not go further onboard at sea when the sea becomes the final battle ground?

Perhaps the administration, management and seafarers are not looking in the right direction to help improve engine room safety. Maybe, a Computer Based Training (CBT) type of ERS, including all software of the design of that ship and its machineries, could be installed on board apart from the blue prints would be of a great help.

1.2. Inquiries Statement

What does the ship's machinery space in times of difficulties looks like? What is the experience? What if as a chief engineer or engineering watch officer, in a crisis where a decision must be made; an important decision on which the fate of the ship and the entire crew rests on the chief or engine room watch officer but he/she does not know what to do? What if the officer is placed in a position where he/she has no clue of how the machinery under him/her supervision works? What if the officer knows what to do but can not do it because he /she does not have the spare nor the support? What will a senior officer do when the junior officers are not that experienced and he/she does not have the time to help teach them? How will these situations be arrested? So many questions and so many answers!

Often, when in this sort of situation, an engineer is usually under severe pressure to restore the system within the shortest possible time. To arrive at a solution the engineer may rely on one, or a combination of the following:

- The equipment's service manual or blue print
- Experience
- Trial and error etc

Now, what if the system manual cannot be reached under certain circumstances or if he/she has never experienced this particular system failure or the blue print is not comprehensible? No chief engineer would like to be placed in such a situation hence he/she must make attempts to solve the problem, obviously by trying various possible solutions until he/she restores the system to its working condition.

Sometimes the Chief can fail and such failure can be catastrophic with severe casualties. Who takes the blame (Obara, 2002)?

1.3. Purpose of the research

In the last decades shipboard technology has changed extensively, mainly in the form of automatic controls which demand higher and updated skills and knowledge from seafarers. Besides these demands technology has had an impact on the daily operations in the engine room. Operations with reduced shipboard personnel, stringent regulations, competitiveness and commercial pressures which are common onboard hence there is virtually no time for training onboard which is a traditional method of developing operational skills.

On the other hand, 85% of accidents onboard have been attributed to the human error. Notwithstanding, a comprehensive view of the circumstances of these accidents depends on many different actors. It may be deficiencies in the safety rules issued by authorities or non-observance of valid rules. The cause of an accident may also rest with the company such as deficiencies in its manuals, in the education, use of unqualified personnel and reluctance to use the right training techniques.

In view of these demands that the new technology has placed on seafarers this research is geared towards examining the current training and safety measures through the various IMO instruments namely STCW 95, SOLAS and the ISM Code, their implementation on board and relevance in these changing times. This research is intended to know and identify the causes of engine room problems with the operation of machineries in view of new technologies. It suggests an appropriate tool for training onboard as part of the solution to some of these problems with the cost, benefit and risk analysis that the administration, management and seafarers would attain. The suggestion for the training tool is through the help of ERS of the CBT type. The question is why the CBT simulator and not any other training aid such as video, posters or audio tapes? One of the main reasons of suggesting CBT was that it is interactive. Moverover, CBT is more effective for training and education over these other mutilmedia. In that, videos and other media can only broadcast information which may be effective for some training and education, it often lacks one of the major elements required by many individuals for effective training and education and that is CBT interactivities. The major objective of this simulated programme is to achieve safe and effective operation. As a device it offers a potential for improved efficiency in many tasks using the mental and physical processes.

Finally the research also expands on finding answers to the following questions:

1. What are the views of administration, management and the operators (seafarers) as to the level of risk?
2. How is safety incorporated into simulator training?
3. How will the training be carried out by seafarers on board?
4. How can ERS be used to improve safety?

As stated, maybe the administration, management and seafarers are not looking in the right direction in helping to improve engine room safety. A solution could be having the CBT simulator installed onboard with all the necessary functions as a training aid for smooth operations of important sub-systems in the engine room. This will be a good opportunity if introduced for engineers as many of these equipments are not touched unless there is a breakdown.

Chapter two examines the training and safety measures of the various IMO instruments namely through STCW 78/95, SOLAS and the ISM Code. Chapter three identifies the root causes of engine room accidents, whereas chapter four gives an apparent solution to reducing these accidents. Chapter five looks at the cost-benefit and risk assessment of the CBT simulator as a training tool installed onboard. Finally, chapter six gives the conclusions and recommendations to this research.

1.4. Research Methodology

The research methodology was structured into three different elements. A literature review combining all relevant material related to the topic, much of which was found in the World Maritime University (WMU) Library and Malmö City library whereas a portion was sourced online sources. The second element was through observations and interviews during the field trips organised by the University, mainly to two major manufacturers of simulators namely: Marine Soft and Kongsberg. A glimpse at Seagull as one of the programmers of the software was examined. The third and final element was a questionnaire, the purpose of which was to have feedback from the engine room personnel with sea-going experience about the various machineries they have worked on. The reasons for doing this were to see the common trend on the line of difficulties they have faced in dealing with their machineries, and then formulate a question for the manufacturers as to whether software for training on a CBT simulator can be designed so as to alleviate the difficulties that the seafarers faced.

1.5. Limitations

A technical research of such kind needs a great deal of on the job contact with seafarers onboard various ships. Unfortunately, time constraints for the completion of this research and the unavailability of cash to visit seafarers on site became the strongest limitations for this research. Hence, the information gathered was limited to students at WMU, ex-seafarers and seafarers in various locations namely Europe, Asia, the United States and Africa. Limitations were also placed on the questionnaire due to its technical nature. Therefore, it could not be widely distributed. Also on its technicality it was specifically designed for engine room personnel with at least a sea going experience.

Chapter Two

2. Revision of STCW 78, as amended

Almost every Convention, its amendment or revision is a reflection of an accident, innovation of technology and evolution of time; the revision of the Standards of Training, Certification and Watchkeeping (STCW), is no exception. This is the first international convention to define qualification requirements applying to ship's officers and other seagoing personnel. The convention was something of a milestone when it was adopted; it represented an inevitable compromise and an assumption of good intent by those countries which ratified it (Dearsley, 1995). The STCW 78 had had its setback and was amended in 1995. STCW78/95 set a framework by introducing minimum standards of knowledge, understanding and proficiency in specified competencies from the viewpoint of safety and pollution (R. Prasad, 2008), thus providing three levels of responsibilities; namely Management, Operation and Support.

The amended version of STCW 78 had made so many provisions and specifications that some of these provisions had been over emphasised but at the same time leaving many under emphasised so that there is now a need for a comprehensive review. Over the last two decades there has been extensive changes in shipboard technology in all working areas of the ship (R. Prasad, 2008); technologies that involve a high degree of precision in automatic control, by which the need for adequate manning was compensated but demanded higher and up to date seafarer skills.

According to STW 38 (IMO, 2007), there was an impending need to have a comprehensive review of STCW 78, as amended, since there were numerous accidents at sea, due to seafarers' unfamiliarization with equipment, modern technologies, negligence and so on. Various parties to the convention agreed that the review should only embrace the following principles: retain the structure and goals of the 1995 revision; do not down scale existing standards; do not amend the articles of the convention; address inconsistencies, interpretations, outdated provisions, MSC instructions, clarification already issued and technological advances; address requirements for effective communication; provide for flexibility in terms of compliance and for required levels for training and certification and watchkeeping arrangements due to innovation in technology; address the special character and circumstances of short sea shipping and the offshore industry; and address security-related issues.

Finally, a number of recommendations had been made through the promulgation of a number of IMO circulars which have provided further guidance to Administrations, training providers, seafarers and stakeholders to enhance the benefits to be gained and also strengthen the framework for the implementation of uniform standards globally. In March 2008, the STW sub-committee met and commenced the comprehensive review as instructed. The associated work is expected to be completed in 2010 (Fuazudeen, 2008).

2.1. STCW 95, Section A-III/1-2

Today's ship owners, managers and operators are under constant pressure to demonstrate that the vessels which they operate are safe both in the material sense and with respect to the ability of the crew to operate them safely (Seatec, 2003). Training on the job is an essential ingredient in achieving this.

STCW 95, Section A-III/1-2.1 (On-board training) states that the administration and the company should:

"Ensure that during the required period of seagoing service the candidate receives systematic practical training and experience in the tasks, duties and responsibilities of an officer in charge of an engine-room watch, taking into account the guidance given a section B-III/1 of this Code;"

However, this section of the Code is not so effective due to numerous reasons. The faster turn around of ships with short port stays coupled with the lack of social interaction on board due to reduced crew size and culture differences (R. Prasad, 2008); the concept of continuous training has not been used within the shipping industries because of short contracts, uncertainty of retention and the movement of crew members between the vessels within company (Ign T. E. Berg & Skotgard, 1996), these are just a few of the reasons training has been reduced onboard.

To re-enforce this section, and thus make it more effective the attitudes toward safety must be embraced by the owners, administration and operators. Training is an expensive venture, and ship owners should not be so short sighted in undertaking such venture. The initial cost of training maybe higher but they pay the industry and ship owners back in terms of competency and safety of operations. Ship-owners, administrations and seafarers should combine their efforts to enable the delivery of training courses on-board so as to promote and enhance seafarers' skills for safe and efficient shipboard operations. The collaboration of these three parties would certainly aid to minimize maritime causalities and raise seafarer's competency standards in order to reach the goal of safer, secure ships and cleaner oceans (Hanafi & Fouda, 2004).

2.1.1 STCW 78, as amended Resolution 8.3

Resolution 8.3 asks to "encourage all officers to participate actively in the training of junior personnel". There must be a need for the industry to adhere to this resolution; however, due to the innovations in technology it is no longer effective. The manning of ships now calls for a smaller number of crew members which creates a situation where the technical maintenance demands all their capacity and little or no time is left for on-board training by traditional methods.

A traditional method where the 3rd Engineer would teach the 4th Engineer and the Chief the 2nd Engineer, this chain of training does not exist any more. The reason could be two-folded. On one hand, the number of ships has been reduced due to the increase in the individual ship's tonnage; on the other, the development of technology and the increase of labour costs reduce the number of seamen on a vessel, while the demand on a seaman's personal qualifications and levels has been raised (Futian, 1999). A well-trained crew is an essential part of a safe and effective operational ship hence if training is lacking onboard, problems are deemed to exist in all areas. One of those areas is within the machinery space.

2.2. The Machinery Space Associated Problems

A ship's machinery space is where the main engine(s), generator(s), compressors, pumps, fuel/lubrication oil purifiers and other major machinery are located. It is sometimes referred to as the 'Engine Room'. A lot of accidents associated with human factors occur in the machinery space, including near misses, but unfortunately only a fraction is reported.

The ISM Code requires that the safety management system should include procedures ensuring that non-conformities, accidents and hazardous situations are reported to the company, investigated and analysed with the objective of improving safety and pollution prevention (ISM, 2002).

The statistics have shown that 80% of all accidents can be attributed to the human factor. There is no such thing as a person who is accident abstained; human errors affect us all without fear or favour and lack of training and experience make people ignorant of the correct procedure.

Within the Engine Room space various factors that are associated with incidents and accidents are improper training, not following procedures, quality of hardware, inadequate design and maintenance management, error enforcing conditions, poor housekeeping, incompatible goals, poor organization, and ineffective communication. It is well known that technological development in the maritime field is proceeding rapidly. Modern shipbuilding can be characterized by a tendency towards well-equipped and faster ships of different types, specially built to be manned by small crews. The SOLAS, STCW and Load Lines conventions contain specific provisions for designing, building, equipping and maintaining ships to meet the demands of safety, both for the ship itself and for all those on board (Steen, 2005). To supplement these conventions, there is a reference code of safe working practices on almost all merchant ships for seafarers to consult frequently, but how many do consult this code before undertaking a task?

2.3. Analysis of SOLAS, Chapter II-1, Part C, Regulation 26.10

The technical manuals, drawings, plans and tables of the engine room and the machineries are very important for familiarization, guidance and regulation purposes. SOLAS, Chapter II-1, Part C, Regulation 26.10 states that "Operating and maintenance instructions and engineering drawings for ship machinery and equipment essential to the safe operation of the ship shall be written in a language understandable by those officers and crew members who are required to understand such information in the performance of their duties."

Recently, a tanker (AMBA BRAVANSE) was held in position by four tugs off the coast of the Shetlands while the crew struggle to rectify a fault in the ship's cooling water system. Another separate accident was on the Roll on Roll Off ship (VARDEHORN) that went aground when one of her thrusters had broken off (Lloyd's List, 2008). Even though, there were operational and maintenance procedures available these accidents still occurred. However, design failures can not totally be erased from these problems.

Some of the designs were vulnerable to predictable human failings. For instance, the design of a single skin fuel injection pipe, that is, when broken, fuel can easily splash onto hot surfaces and then cause fire. Indeed, SOLAS Chapter II-Part B Regulation 4-2.2.5.2 compensated for this by allowing a double skinned fuel pipe system so that fuel is contained from the high-pressure line in case of failure. This new system also includes means for the collection of leaks and an alarm in case of a fuel line failure.

Deficiency in design is a handicap that hinders engineers' endeavours to ensure crew safety. To avoid this, the design process must be managed effectively to ensure that the human factor is considered at design conception, and throughout all the design stages, including final installation and testing (Withington, 2001). The lessons learned from here is that accidents could be reduced if the operators were better trained, effectively designed and maintenance procedures adhered to. Good design is most likely successful in preventing accidents.

However, due to the modern technologies employed in today's ships, the industry should go a little step further in enhancing these instructions, and guidance for the safety of ships and the seafarer.

2.4. Implementing and Supplementing SOLAS Regulation 26.10

The implementation of SOLAS regulation 26.10 had been enforced onboard every ship; it had also been re-emphasized through out the ISM Code and STCW 95 Section A, Table A-III/1. However, with these regulations the accidents and incidents within the machinery space have not declined. Almost all the studies and maritime disaster inquiries conclude that human error accounts for more that 80% of marine accidents. Many accidents were caused by poor maintenance or the mal-adjustment of equipment which did not appear to comply with the existing provisions of SOLAS regulation III/20 (Operational readiness, maintenance and Inspections), while some followed failures of communication and /or procedures. The causes of such accidents need to be established and addressed as a matter of urgency (IMO, 2001). Is it because of poor equipment design, poor judgement; inadequate information or generally or the lack of adequate technical knowledge?

The ship has become so complicated that it needs a high degree of professionalism at all levels. It is quite expedient that SOLAS regulation 26.10 has been backed up by the ISM Code Part A-10, but this also has to be supplemented by the introduction of a computerized system to help the operators. This should include diagrams, drawings of machineries and operational procedures which can easily be depicted on a CBT simulator.

2.5. ISM Code as it Relates to Maintenance of Equipments

The ISM Code Part A – 10 talks about the "Maintenance of the Ship and Equipment" for the administration, company and seafarers to implement. Implementation of the Code is good but is it effective in reducing accidents? Part A – 10.3 states that "The Company should establish procedures in its safety management system to identify equipment and technical systems the sudden operational failure of which may result in hazardous situations. The safety management system should provide for specific measures aimed at promoting the reliability of such equipment or systems. These measures should include the regular testing of stand-by arrangements and equipment or technical systems that are not in continuous use." However, statistics still show that 80% of accidents at sea are due to human error. Is it that the operators ignore the regulations or should there be additional support to warn these operators about the consequences of not adhering to these regulations?

The Norwegian class society (DNV) made a survey covering 300 seafarers. During this survey over 50% of the seafarers admitted that they had broken safety instructions frequently. This clearly demonstrates the safety risk in shipping. On the other hand, the maritime community and the International Maritime Organization (IMO) are striving not only to improve safety standards on board ships but also to raise the standards of seafarers who man them.

There seems to be a conflict. Whist the IMO is trying to improve situations by putting higher demand on the various managements and administrations to improve safety standards onboard, seafarers sometimes do something else. Should management/administration look in a different direction to promote safety on board or are the seafarers too tired of looking at instructions, diagrams and blueprints?

A recent study, carried out by a group of independent experts on the impact and effectiveness of the ISM Code concluded that ISM Code compliance could be made easier through the reduction of the administrative process by streamlining and reducing the paperwork that supports ISM compliance, particularly concerning the Safety Management System (SMS). It further laid emphasis on the use of technology and information technology (IT) and the reduction of paperwork, (Seatec, 2003).

2.6. Synopsis of Simulators

The advancement in technology has meant a faster turn-round in port placing further demands upon the master, who does not have the manpower support today to provide watchkeeping and operational backup in difficult situations as in the past. The unmanned machinery space has increasingly shifted monitoring operations to the bridge and led to the integration of navigation and engineering functions on the bridge (Muirhead, 2008).

The Simulator is defined as a mechanical, electro-mechanical, or computer device for producing a realistic representation of an event or a system. It is used where the real equipment is very expensive and inaccessible, and to train operators in safety (Song, 1994). The DNV placed the simulators into classifications due to the limitation in tasks that each simulator can perform. The important training role marine simulators can play in raising safety standards has been given increased recognition through the incorporation of this advanced technology in the recently amended 1978 STCW 95 (Fisher & Muirhead, 2001).

The levels of simulator systems that can be distinguished are suggested in the design drafts and are categorized as: Category 1 which is the Full Mission type (FM); Category 2 is the Multi-Task type (MT); Category 3 is the Limited Task type (LT) and Category 4 is the Special Task type (ST). However, the purpose of the classification of a simulator is to ensure that simulations provide an appropriate level of physical and behavioural realism in accordance with training/assessment objectives as stated in the STCW code Section A-I/12. Category 1 (FM) are used for full immersion training with maximum possible control of the simulation environment. They have a complete bridge system installed, including sound and realistic visuals and are capable of advanced manoeuvring and pilotage training in restricted waterways. Category 2 (MT) are capable of simulating a total navigation environment, but excluding the capability for advance restricted water manoeuvring. Category 3 (LT) are capable of simulating an environment for limited (blind bridge) navigation and collision advance training. Category 4 (ST) are appropriate to provide multiple trainee stations for familiarization training in preparation of a more comprehensive simulator (Cross, 2000).

It can be said that any dynamic process or complex operational equipment is a suitable model for a simulator system. Some of the types of simulators in use in the maritime and related industries include: navigation equipment simulator, communication equipment simulator, ship handling simulator, dynamic positioning simulator, ballast control simulator, propulsion plant simulator, refrigeration plant simulator and drill technology simulator.

However, under the mandatory part of the Code, parties are required to ensure that the aims and objectives of simulator-base training are defined within an overall training program with the emphasis on objectives and tasks relating as closely as possible to shipboard practices. Table 1 below, indicates the tasks that can be performed by the various simulators as stipulated in STCW 95:

Table 1: Simulators Tasks as stipulated by STCW 95

Type of Simulator	Colreg Rules	STCW 95	IMO Model Course
Full Mission	5 – 10 12 – 19 20 – 31 34 – 37	table A-II/1 item 1-6 table A-II/2 item 1-8 table A-II/3 item 1-5 section A-VIII/2	1.07 1.08 1.09 1.22
Multi Task	5 - 8, 10 12-19 20-30 34-37	table A-II/1 item 1-6 table A-II/2 item 1-6 table A-II/3 item 1-5 section A-VIII/2	1.07 1.08 1.09 1.22
Limited Task	6–10 19	table A-II/1 item 3-6 table A-II/2 item 6 table A-II/3 item 3-4	1.07 1.08 1.09
Single Task	19	table A-II/1 item 3	1.07
CBT	23-31	--	--

Source:(Cross, 2000)

2.7. Computer Based Training (CBT) Simulator

CBT can simply come in the form of a desk top computer with graphics and text or with more enhanced facilities such as audio facilities. It is like an interactive video. It is also a generic term to describe how computer-run software can be used in support of training applications; these may include initial training, or for imparting or reinforcing underpinning knowledge. CBT can be used to review a topic or procedure already learned, or it can be used as a readily available reference source (IMO, 2002).

The need for improved and more efficient training methods has been stated by administrators, shipping company executives and seafarers themselves. A number of isolated minor improvements have been proposed, developed and tested. A basic conclusion is that these improvements have made no major difference with respect to the competence levels of ratings or officers. Hence, the introduction of a video training tool had been mentioned by some companies so as to get the full value of new training tools as an integral part of the seafarers' living environment (Ing T.E. Berg, 1996).

The working environment onboard has become more complex over the last few decades with a drastic reduction in manning levels, increase in the use of automation, unmanned machinery spaces, aging fleet and highly congested sea lanes. For example, at first the conventional method information processing was done by the operator. That is the operator had to be in the process at every stage but the operator had a limited processing ability. Some of these limitations included reading and understanding, external and internal stresses. Therefore, it will be quite important to bring in incentives to help in the modernization of ship's operation so as to reduce human error. Hence, the deployment of a CBT simulator will be a good supplement for training onboard. With the aid of the CBT simulator for the engine room, some of these complex problems especially within the machinery space will be reduced. CBT has the ability to rapidly store and recover information, respond to the user's interaction, and integrate multi-media applications which can incorporate visual, audio and physical stimulus thus providing rapid operational knowledge and developing operator experience.

2.8. CBT simulator onboard as a training tool

The Seafarers, Training, Assessment and Operations are the key words. Knowledge is the basis for all technical solutions. Extensive, well designed relevant, up-to-date and adequate training play an important role in the safe, economical operation of the ship and its machinery and in controlling arising problems. The shipping industry has gone through the following changes during the last few decades; it has involved the reduction in manning levels along with technical sophistication on board resulting in socio-technical problems. The increase in international competition, requiring ships and its machinery to be in optimum condition at all times and the increased use of automation and unmanned machinery space (Ray, 1999).

Traditional forms of training, using time spent in the work place as a way of ensuring competency, are based on the principle that through a series of experiences, a trainee will absorb sufficient knowledge and develop adequate skills so that when presented with a novel situation, he/she will be able to deal with it effectively. This type of experiential learning relies on a sufficient length of time for enough sets of circumstances to arise, and a sufficient length of time for reflection and synthesis before an individual takes on responsibility (MSA, 2000). Today, modern technologies, fast turn around and the manning of ships by a smaller number of crew members has created a situation where there is little or no time left for training onboard by traditional methods. Hence, there must be alternative means of training onboard if the industry wants a safer, more secure operation in cleaner oceans. The simplest and less expensive means is through the CBT simulator. However, CBT, as any other training tool has its advantages and disadvantages as seen in table 2.

2.8.1 Advantages and Disadvantages of CBT as a training tool onboard

Table 2: Advantages and Disadvantages of CBT

	Advantages of CBT	**Disadvantages of CBT**
1	conveniently available	Too convenient, sometimes leads to reduced interest.
2	Trainee can work at his/her own pace	The pace of training must be a course design feature. If the course is too slow the trainee will be bored and if too fast are likely to retain less knowledge.
3	Trainee can often go back over instructions and procedures to reinforce understanding	Trainee must be motivated to progress as quickly as possible.
4	Three-dimensional images of equipments and structures can be depicted clearly to be understood	The designers must assume that the target audience can assimilate the information displayed.
5	The software can also be explained in many languages	Care must be taken in translating training material to ensure that the intended message does not change through the translation process which will pose a significant risk

6	Training can be designed for multi-level training so that the same course is suitable for a range of target audiences or to let the trainee progress to higher knowledge levels in controlled stages	
7	Training records are easily stored, and managed for audit and verification purposes	
8	Long-term knowledge retention can be higher with CBT than many other means of training	Computer equipment and software can have compatibility problems and some means of proving user support is required
9	The help function will assist the trainee in case of difficulty in finding solutions	Computer can only provide training where the objective is to transfer knowledge; computer can not transfer practical skills to trainee
10	CBT is less expensive and most importantly, it can be used for self training	There is limited ability for group learning

Source : (IMO, 2002)

CHAPTER THREE

3. Safety Awareness within the Engine Room

‘Safety First’ is made as a sign that is quite visible almost in all engine rooms. But what does this mean and is it really enforced? The International Maritime Organization (IMO) has long been promoting safety of life and property at sea along with environmental protection. Today, we now have a new safety management code (ISM Code) instructing the industry that the most important matter to be addressed, both ashore and afloat, is that safety must come first (Anderson, 2003). Moreover, this Code requires operators to embrace safety as an integral part of their policy and working practices but gives no descriptive rules to say how this must be done.

Safety is defined as the control of accidental loss. Accidents will occur because a problem that was not adequately defined; a problem whose consequences were not fully perceived, or simply a problem that was not considered to exist (Kuhlman, 1977). However, within the engine room the immediate cause of an accident may appear to be equipment related or human-related. Nevertheless, a need for a pro-active, holistic approach to safety must be considered. The pro-active approach is the identification of potential dangers of accidents which requires the involvement of all on board (Rajendra Prasad, 1999). This may significantly change the way ships are run and operated thus safety awareness is the very first step to this approach.

How can safety awareness be carried out in the engine room? These methods have been used on board ships and were found to be good and effective (Lavery, 1990).

- **Films:**

  The showing of safety films is good so as to keep the crew abreast with safety matters.

- **Posters:**

  This can be an effective method of bringing particular dangers to the attention of engine room members.

- **Informal talks:**

  The idea of having a safety meeting once a month to build up crew morale is effective.

- **Warning and Working Signs:**

  This serves as a notice to the other crew members.

- **Maintenance of Safety Equipment:**

  It is advisable to keep a record of the dates and work done on any machinery.

- **Permit to Work system:**

  For dangerous work or hot work a permit must be issued which is also effective.

The whole aim of this safety awareness is to create a safety culture which will reduce accidents, damage, personal injury and lost-time incidents in competitive, commercial ship operations.

3.1. Developing a Safety Culture

Safety culture is more than merely avoiding accidents or even reducing the number of accidents, although these are likely to be the most apparent measures of success. The quality and effectiveness of training will play a significant part in determining the attitude and performance and the professionalism that the seafarer will subsequently demonstrate in his, or her, work. The attitude adopted will, in turn, be shaped to a large degree by the "culture" of the company (Hanza-Pazara & Arsenie, 2007). The product of an individual, group values, attitudes, perception, competencies to, style and proficiency of an organization's safety management are the words used to describe Safety Culture.

Tor Christian Mathiesen in 1994 defined safety culture as "describing a situation where owners are engaged in a continuous process to improve safety and see this as their management philosophy and operational mode to reduce losses" and he added that "this implies focus on the entire management chain, from the board room to the ship." As a supporter of the safety culture he emphasized that "to control safety is the answer to regain credibility for the shipping industry" (Velga, 2001).

Safety Culture is not only a way of complying with organizational rules but rather a way of life, individual inner motivation and an acceptance to do the right thing. Therefore, to develop this culture onboard certain parameters must be put in place. These parameters are in the form of five different components; Informed, Reporting, Just, Flexible and Learning Cultures (Reason, 1997).

Informed Culture involves creating a safety information system that collects analyses and disseminates information from accidents and near-misses as well as regular pro-active check on the system's vital signs. Reporting culture depends on the atmosphere whereby the people are willing or prepared to report their errors and near misses without fear of being punished. Just Culture involves an atmosphere of trust in which people are encouraged even rewarded, for providing essential safety-related information. Flexible Culture means the shifting from that conventional hierarchical mode into a professional structure of somewhat being more friendly. Learning culture which involves the willingness to draw the right conclusions from its safety information and implement major reforms when the needs are indicated (Mejia, 2008). In establishing safety culture within the engine room, the crew must start with realistic expectations, be patient but persistent in their implementation, target the human element in the safety equation and above all be intolerant of substandard practices Finally, the objective of developing a safety culture is that it should aim at inspiring the seafarers towards firm and effective self-regulation and to encourage their personal ownership of establishing best practice (Iarossi, 1999). With this in mind it will be quite understandable that the approaches in handling machinery onboard should/must be scrutinized.

3.2. Machinery Maintenance Approach in the Engine Room

The old saying ‘prevention is better than cure’ is extremely important to mariners due to the isolated nature of the employment and to the lack of immediate repair and spares facilities. Good preventive maintenance means that large sums of money are not wasted on emergency spares, overtime, delays, and operational incidents (Lavery, 1990). The maritime industry recognizes three basic approaches to monitoring and maintaining machinery and these are; Reactive, Preventive and Predictive. The Reactive approach may monitor machinery operating using certain condition monitoring measurements, but utilizes very little or no maintenance of machinery until that machinery exhibits operating problems or fail to operate. The Preventive approach monitors machinery by tracking calendar or running hour elapsed time. The Predictive approach to maintenance gathers certain condition monitoring measurements regularly (Alexander, Starr, & O'Donnell, 1990).

There are still some shipping companies engaging in the reactive approach towards maintenance. Having a reactive engine room crew means that the equipment is running the plant and not the crew. Sad to say that those working with the reactive approach rely on the saying ‘when it is not broken, why fix it.’ Reactive maintenance is also known as corrective maintenance. That is, this approach is mainly a response to machine breakdowns. If the equipment breaks down, they fix it as quickly as possible and then run it until it breaks down again(Jarrett, 2004). This is an unpredictable approach which sometimes can disrupt the smooth operation of the ship.

Preventive maintenance encompasses activities, including adjustments, replacement and basic cleanliness, that forestall machine breakdowns. Preventive activities are primarily condition based (Laskiewicz, 2005). This approach is done on the actions performed on a time-or machine-run-based schedule that detect, preclude, or mitigate the degradation of a component or system with the aim of sustaining or extending its useful life through controlling degradation to an acceptable level. Many manufacturers' instructions are based on this approach. Hence, a full set of maintenance manuals and associated documentation issued by the manufacturer will be available on board for use in all operations involved in the inspection, maintenances adjustment and resetting of the machinery (IMO, 2006). Hence, the guidance is in the form of a checklist, diagram, table, or a procedure on the performance of any given task that should be done on that machinery.

Finally the Predictive approach is almost similar to the preventive but differs in the sense that it is unplanned and unscheduled. It involves performing maintenance on a machine in advance of the time a failure would occur if the maintenance were not performed. That is, it involves vibration, sound, temperature, lubricant analysis programs to forecast the machinery conditions and then assesses and decides on the machinery maintenance scheduling.

These three approaches have their pros and cons depending on which type of management is executing such an approach. Therefore, for evaluating the various methods one needs to weigh the advantages and disadvantages and then conclude.

3.3. Evaluating the Approaches of Machinery maintenance

Table 3: Advantages and Disadvantages of machinery maintenance

APPROACH	ADVANTAGES	DISADVANTAGES
Reactive	• Low Cost • Less Staff	• Increase cost due to unplanned downtime of equipment • Increased labour cost, especially if overtime is needed • Cost involved with repair or replacement of equipment • Inefficient use of staff resources
Preventive	• Cost effective in many capital intensive processes • Flexibility allows for the adjustment of maintenance period • Increase component life cycle • Energy savings • Reduced equipment or process failure • Estimated 12% to 18% cost savings over reactive maintenance program	• Catastrophic failures still likely to occur • Labour intensive • Includes performance of un-needed maintenance • Potential for incidental damage to components in conducting un-needed maintenance
Predictive	• Increased component operational life/availability • Allows for pre-emptive corrective actions • Decrease in equipment or process downtime • Better product quality • Improved worker and environmental safety • Improved worker moral. • Energy savings • Estimated 8% to 12% cost savings over preventive maintenance program	• Increased investment in diagnostic equipment. • Increased investment in staff training • Savings potential not readily seen by management

Source: (Mitchell, 1998)

In evaluating the three approaches it was discovered that many companies tend to use the preventive approach because it reduces the cost, it is flexible and increases the component's life cycle. However, in most instances, there is little recognition of the idea that these three approaches to monitoring and maintaining machinery may be integrated to work together, to the benefit from an overall comprehensive machinery maintenance program. If such integration takes place it will eliminate unexpected equipment failure; eliminate unnecessary maintenance activities; plan maintenance and repair activities to minimize loss of operating income. There is a need to ensure personnel are qualified to manage the program, perform the required maintenance and interpret condition monitoring measurements (Alexander et al., 1990). The Comprehensive Machinery Program comprises Personnel Training; Machinery History; Equipment Condition Monitoring; Maintenance & Repair Scheduling and Spare Parts Inventory Control which all have a common relationship. The personnel training form the basis of support in enabling the effective and efficient implementation of the program. Good record keeping is an essential part of the machinery history. The equipment condition monitoring provides input for the machinery history in a quantitative form by analysing the determination of maintenance or repairs. Maintenance and repair scheduling is optimized by a knowledgeable personnel who must utilize the machinery history. Finally, the spare parts and inventory control is enhanced in coordination with maintenance and repair scheduling.

If there is such a brilliant program put into place in the engine room why over the last two decades has the accident rate risen so high? Even though the program embeds personnel training there is still the human element which accounts for 80% of onboard accidents.

3.4. Human Errors in Engine Room Safety

According to the IMO resolution A. 884(21), human behaviour is categorized into 3 modes, i.e., skill, rule and knowledge base behaviours. Human error is classified into 4 modes, i.e., slip, lapse, mistake and violation. The background of error occurrence is sorted into 4 groups correlated to software, hardware, environment or liveware (M. Uchida, 2004). It is quite explainable that accidents/incidents occur in the engine room due to various reasons and it is imperative to take appropriate actions to prevent or reduce these accidents/incidents.

Slip is an unintentional action where the failure involves attention. Lapse is an unintentional action where the failure involves memory. Whereas, mistake is an intentional action, but there is no deliberate decision to act against a rule or plan. There are errors in planning. Violation is a planning failure where a deliberate decision to act against a rule or plan has been made (Reason, 1999). Below is a box diagram showing the various errors and the immediate cause that will lead to various circumstances.

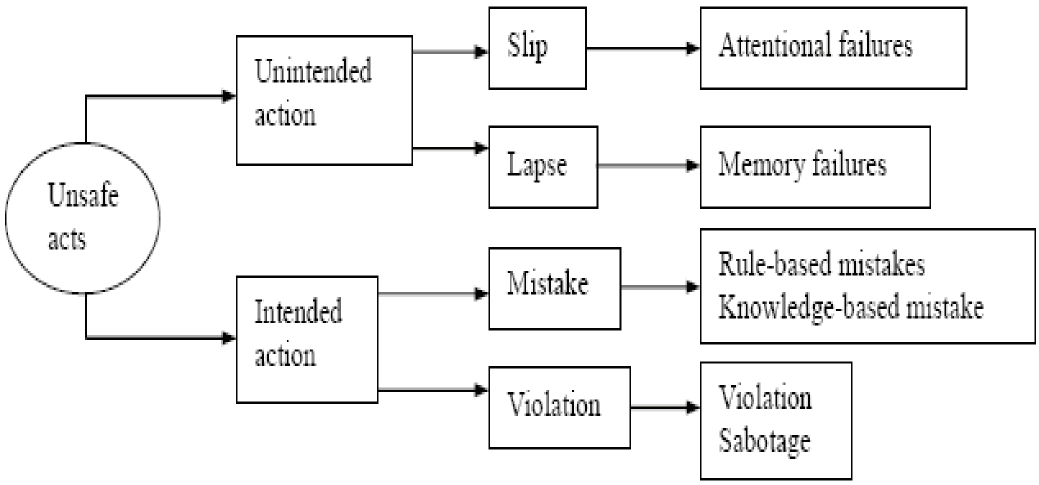

Figure 1:SLMV Diagram
Source: (Reason, 1999)

However, human error is not just about humans neither is the human factor about humans alone. It is about how features of people's tools and tasks and working environment systematically influence human performance (Dekker, 2006). In 80%-90% of injuries, some type of unsafe behaviour was the final common pathway of the incident (Krause, Hidley, & Hodson, 1990). For instance, an engine crew member tightening a bolt suffered a contusion from striking a hand against something when the wrench slipped. This contusion caused the crew member so much pain that he/she could not work until the hand had healed. The probable cause of this accident could be that the bolt was rusted, wrong seating of the wrench on the bolt, bad ergonomics of the tools design or wrong positioning, or wrong torque applied. Whatever the scenario is, unfortunately, it is all brought down to human failure.

There are other accidents that happen within the engine room that are concluded to be human errors. Examples, electric shock, caused by defective installations and equipment or faulty insulation, hand injuries caused by sharp tools, slipping of tools use of faulty hand tools, etc.; slips, trips causes by greasy flooring, poor housekeeping or bad weather; work shop accidents due to rotating machinery, belts, shaft, cable, pulley etc. among others are accident/incidents that are not considered serious.

No matter what the circumstances are, it can all be traced to human failure. The machine is designed, built and operated by man. Thus a failure of the machine is really a failure of man.

3.5. Interaction of Seafarers, Machineries and Environment

The design of a ship should aim at reducing the likelihood of human error, in that the machineries should not be complicated in handling so as to accommodate human error. If errors are not self-evident, their occurrence should be clearly signalled to the crew. Maritime safety therefore involves the integration of three elements. Man (Seafarer), Machine and Environment into one system. Each element influences the other to varying degrees and the elements are often depend on each other. A hazard in one element can start a chain reaction leading to an accident in which all three elements are involved. Many of the hazards that occur are brought about by difficulties at the interface between these three elements.

Figure 2 below depicts man and machine within the environment and tries to explain that accidents caused by machines in shipping over the years have dropped while that of man is still rising.

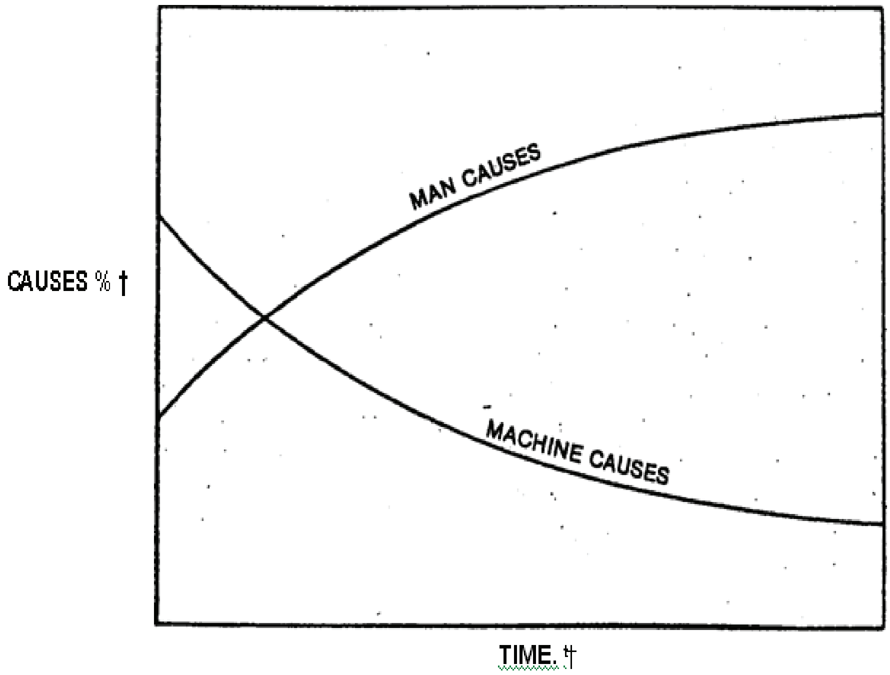

Figure 2: Man and Machine causes
Source: (Steen, 2005)

However, as man is involved in all three, it is vital that man's inherent limitations are considered (Steen, 2005). The limitations include his/her knowledge, skills, physical and mental strength, judgements and decision making. The environment includes internal and external items. The internal environment consists of working conditions that may affect his/her reaction. Vibration, noise, humidity and the temperature fall under the internal environment, whereas political, cultural and economical factors fall under the external environment.

To ensure adequacy of knowledge and the skills of seafarers, attempts are made by STCW 95 to set up a competency-based system so that seafarers may use their ability to apply them (knowledge and skills) in different situations (Potts & Holder, 2007). An effect of this has led to a high degree of specialization of individuals that respond to individual responsibilities/accountability. For example, engineer officers will usually cover only the machineries that are assigned under their jurisdiction thus their knowledge and skills will be limited to those that are assigned under them. This limitation has made these officers interdependent on others in the workplace.

Physical and Mental strength as regards to STCW 95 Code A, Section VIII must be adhered to. Judgement and decision making is a skill and like any skill, it may be honed through practice, by reducing cognitive (connected with thinking or conscious mental processes) load through practice, the more skilled will be less stressed in threatening situations (Fuazudeen, 2008). However, judgement can be impeded through other human traits such as emotions, ego or temperament. Many companies are trying to reduce these human errors by adding in more modern technologies, but more technology does not remove the potential of human errors, it merely relocates or changes it (Dekker, 2006).

3.6. Impact of Technology on Engine Room Crew

Over the last two decades shipboard technology has changed extensively mainly in the form of automatic controls which demand higher and updated skills from seafarers (R. Prasad, 2008). Beside these demands technology has had other impacts on the daily operations in the engine room. The widespread use of automation has allowed substantial reduction in manning to be made. Ships continued to be automated at an increasing rate with the introduction of periodically unattended machinery spaces and integrated bridge control systems which facilitated 'one man on watch' operations so that today, in some ships, there are crews numbering as few as six (Bucknail & Freire, 2003).

Unmanned machinery spaces have become the norms in many ships with watch keeping being carried out by machinery control and surveillance systems. Systems have also been fitted to allow engine diagnostics to be carried out remotely at the equipment suppliers. The main factor limiting further crew reductions by increasing automation onboard appears to have shifted from technology to the ability of seafarers to cope with a working routine where limited onboard companionship, aggravated by a life style of working watches and very short port stay has a commonplace (Bucknail & Freire, 2003). Hence, the social life onboard has declined.

Technology has shaped and influenced the way in which engine crew make errors. It has also affected the crew's opportunities to detect or recover from the errors they make and thus, in certain cases, accelerated their journeys towards breakdown. With the limited amount of man power and stringent regulations coupled with an extensive amount of paper work has put more stress and strain on seafarers rather than relief. To obtain the views of current and earlier operations, questionnaires were sent out to ascertain the views of seafarers about the problems they had onboard with their machineries and the use of a CBT simulator as a training aid; the responses came with different views as shown in the next section.

3.7. Views of Seafarers on Technology

The purpose of the questionnaire is explained in Chapter one and a copy is provided in Appendix I-A, whereas, responses to the questionnaire are seen in Appendix II. The questionnaire is in two parts: (a) Problem with the Machineries and (b) CBT as training aid. To gain a comprehensive view the questionnaire was sorted into the three management levels onboard namely the Management, Operational and Support level.

The objective of this research was to find a common problem that almost all operators within the engine room working with the various machineries faced and to develop a question so as to ascertain from the manufacturers if they can develop software to be used on a CBT simulator so as to help solve some of these operational problems. A total of 80 copies of the questionnaire were distributed amongst WMU students with engine room experience and institutions in Europe, Africa, Asia and the United States. Finally, the total number of received responses were 35 with the following distribution:

Management Level	-	10
Operational Level	-	13
Support Level	-	12
Total	-	35

From the various responses, it was found that the machineries had common related problems, which ranged from minor to highly technical.

There was a unanimous answer at all levels regarding CBT onboard as a good training aid. On the line of instructions provided by the CBT, many agreed that it was easy and almost all were familiar with the CBT simulator. However, there was a mixed response about the time allocated for Senior Officers to help train Junior Officers; two thirds of those responding agreed that time should be three hours monthly.

Hence, the question posed to the manufacturers is: can software be developed or is it already available for CBT simulator for training and maintenance purposes simulating trouble shooting of the following engine room machineries: turbocharger of the M/E, governor of the A/E, Centrifugal pumps, Purifiers, Air compressors, Safety valves of the boilers and the 15ppm monitor of the OWS?

3.8. The Role of Technology in MET Institutions

The problem of assessing engine room safety goes far beyond technology, crew size or the ISM Code but also extends to the basis of training which starts at the maritime institutions. With appropriate training, organizational innovations and ergonomics design, new vessel technology should not degrade safety. The Training programs need to change as new technology is adopted (NRC, 1990), hence, a look at the role of technology at MET institutions has to be considered.

Automation has been the major cause for crew reduction but will this result in the neglect of essential maintenance? Or to what extent will automation and technology advances improve the reliability of ships' operating systems? The lack of attention to these concerns will raise the risk of injuries and vessel accidents with a social, economic and environmental cost (NRC, 1990). Today, it can be said with some confidence that the introduction of new technology is often the catalyst for applied innovation in techniques or methodology. New technology, of course, may raise the expectations by those working in the related fields that such developments will lead to the accruing of advantage, such as increased productivity, greater efficiencies through cost savings, and the sheer excitement of developing new ideas and ways of achieving specific objectives (Fisher & Muirhead, 2001).

Technology continues to change at an ever-increasing rate. This also has an implication on maritime education. People working in the industry need increased skills to operate the new high technology equipment used by the maritime sector and there is a training requirement as a result. At the same time, technological improvements in pedagogy now allow maritime training to be delivered in a range of different ways, including not requiring students to physically be in a classroom. Use of the Internet, visual/audio CD Rom, simulation laboratories or videoconferencing or CDs, for example, enable people to study without having to base themselves at an educational institution for extended periods (Otway, 2004). In fact, it is difficult for educators to teach without these services. Many Maritime Training Institutions are judged by the educational technologies they offer.

The training aims of maritime education are to cultivate superior shipping management personnel, and the leading industry personnel in the maritime technology, to develop innovation abilities and to give birth to the internationalized knowledgeable and strategic management personnel. This vision should not be set only on the industrial market but also on the cultivation of practical marine persons with the ability and the task of superior seafarer training and should be transferred as soon as practicable to higher vocational education (Xangwen, 2002)

CHAPTER FOUR

4. Route map to safety in the engine room

The previous chapter established and elaborated on the root causes of accidents. This chapter focuses on finding solutions to these causes. Hence the route map is there to show how we can achieve this.

When considering maritime safety, it is necessary to address both the human factor and the technical solutions in the broadest sense, not just the immediate causes of actual or potential failure (Er & Celik, 2005). The IMO regulations are required to be implemented to ensure safer and secure shipping and cleaner oceans, for the setting up of common standards for ship and system design and build; for the education and training of the appropriate personnel in the industry, and for operational procedures. Seafarers also need to be protected through regulations that can provide them with a safe and secure working environment, decent working and living conditions, fair terms of employment and healthy lifestyles.

Many of the resolutions, conventions, recommendations and standards developed by the IMO affect the “Human Element” either directly or indirectly. It is important therefore, to remember that the purpose of regulations is to protect the people, machines, systems and the environment from danger, injury, damage or destruction. Human nature is such that we at times break the rules either unintentionally through slips, lapses or mistakes; or simply we do not understand them. Furthermore, sometimes breaking the rules may be intentional because of commercial or operational pressures force us to cut corners (Alert, 2006). The statistics tell us that the majority of accidents are a result of human failings, and many can be put down to violations of the rules and regulations. Therefore, what is the apparent solution to safety? Is it the numerous regulations or the technological approach?

4.0.1 The Guidelines for Safe Operations

Maritime safety regulations save lives (Robe, 2006), they focus on lifesaving equipment and crew training and were aimed at improving crew survivability after an accident.

4.0.2 SOLAS

The intent of this convention is to safety of life at sea. Looking at Chapter II-2 (Construction – Fire protection, fire detection and fire extinction), part E deals with the human element matters such as training, drills and maintenance issues, and part F sets out the methodology for approving alternative design and arrangements. Chapter V-16 features the maintenance of equipment and Chapter IX deals with the management of safe operations of the ship.

4.0.3 STCW 78 as amended

This convention set up the minimum international standards of knowledge, understanding and proficiency in the specified compentencies from the viewpoint of safety and pollution prevention (R. Prasad, 2008). It provides engine room watch keeping procedures and safe working practices as related to engine room operations. It provides for three levels of responsibilities namely at the Management, Operational and Support levels. It has two Codes; Code A, which is mandatory, has the competence tables specifying the standard of knowledge, understanding and skills required, to be developed through theoritical inputs, laboratory training, workshops and or by simulator and shipboard training to understand the underlying principles and to perform the work related to watch keeeping, operations, faults identification and the maintenance of systems in a safe manner including response to emergency operations. Code B provides recommendations and guidance.

4.0.4 ISM Code

Since safety involves the management at all levels and engineering operations of systems are underpinned by human factors, the ISM Code was adopted by IMO for the intended purpose of management of safety. The purpose of the Code is to provide an international standard for the safe management and operation of ships and prevent marine pollution. The Code comprises 13 sections that cover aspects from safety and environmental protection policies through the responsibilities and authority of individual organisations to documentation and certification, verification and control. Through these provisions the ISM Code addresses important issues relating to human factors and is one of the most significant documents to be produced by IMO (Kuo, 1998). The starting point is for everyone associated with shipping to gain an appreciation of the key issues involved in safety.

4.0.5 Other Appropriate rules and regulations

- Conventions, protocols, recommendations, codes guidelines, and resolutions, relating to standards of maritime safety, efficiency of navigation and prevention and control of marine pollution from ships;
- Maritime conventions on working and living conditions and basic human rights
- International Regulations for Health and Hygiene
- Regulations for design, construction and through-life compliance with rules and standards
- Classification society rules for hull structures and machinery

These rules and regulations are all developed with the intention of making the maritime industry, and the workers in it, more safe, responsible and dependable. The intentions are all good but the implementation on board is another matter. These regulations on the other hand have made Senior Officers merely managers and administrators, who are spending far too much time completing paperwork and administrative tasks to satisfy legislation thus lagging behind their duties mainly in helping to train their Junior Officers (Cooper, 2006). This distraction has caused the Junior Officers and ratings to work and learn in isolation. For the fear of causing an accident, junior officers learn only their assigned duties. There is a need to train the Junior Officers and support staff on specific equipment systems on board that will expose them properly in safety precaution and routine maintenance. Hence to help alleviate such a problem with a CBT simulator should be installed in the engine room so as to help with training and trouble shoot engine room machinery problems.

4.1. Finding an Apparent Solution to Engine Room Accidents

Education is the gradual process of acquiring knowledge through learning and instruction. It is as much about the development of personal attributes through upbringing and observation as it is about gaining knowledge through textbooks. It is a lifelong process; we never stop learning.

Training is the development of skills or knowledge through instruction or practice. If correctly applied, it is a planned systematic development of the aptitute, knowledge, understanding, skill, attitude and behaviour pattern required by an individual so that he/she can adequately carry out a given task or perform a particular job. The combination of education and training are about the development and maintenance of the human component of ship systems. The compentence of a mariner will depend not only on good and effective education and training, but also on his/her aptitude, knowledge and understanding of the subject, on the availability of opportunities to develop his/her skills and, ultimately, experience. Competent seafarers make the difference; they make the ship safe (Alert, 2005).

On the other hand, the burning problem of the lack of “competent” manpower is, a result of the industry’s short-sightedness in the policies towards tackling human resource issues (Bajpaee, 2006). Despite, this some ship managers and owners are investing substantial sums of money on the latest technology and the best training facilities to attract and train young professionals, while others continue to wonder about the wisdom of investing time and money in training.

In a nut shell, the solution to solving this problem is brought down to Maritime Education and Training since MET relates to the human element. It is important that all stakeholders encourage and promote the highest standards of education and training and a common spirit of professionalism in the industry. The industry should not sit back and think that through the increase in automation and electronic systems the problems onboard will be easily solved technically. As technology (automation and electronics) is revolutionized so must the seafarers meet these challenges through a continous and effective training chain. One of the best ways to achieve this is through self training with a CBT simulator since technology, commercial pressure and drop in crew size has left almost no time for the Senior Officers to train the Junior Officers.

4.2. Integrating CBT Technology into Training in the E/R

Technological developments cause changes in system concepts and operations and thus changes in training needs. Over the years, the traditional marine engineering training has transcended into comprehensive computer software to be used on computers for the training and assessment of seafarers, first appearing at colleges and training centers. Hence it is more of a reason that such training should be enhanced at sea and it is in this regard that a CBT simulator is used.

CBT systems are quite straightforward branching systems: the seafarer is presented with some domain knowledge, followed by a number of questions or exercises to make sure that he/she has understood the information presented and can be applied in different contexts or environments. For example, the training objective is to teach or test the seafarer to dismantle or assemble a centrifugal pump, in this case the program is strictly focused on this task. It is desirable to limit the seafarer's attention to only those elements of the simulation which are relevant. The errors the seafarer might make are foreseen, and feedback or remediation is also pre-programmed (Farmer, Rooij, & Moraal, 1999). The training on CBT should be used to improve the level of proficiency. The major objective of this simulated programme is to achieve a safe and effective operation. As a device it offers the potential for improved efficiency in many tasks using the mental and physical processes.

Other multimedia could be used for training onboard, like videos, audio, photographs or graphics. However, CBT is more effective for training and education over these other multimedia. In this respect, videos and the other media can only broadcast information which may be effective for limited training and education. These often lack one of the major elements required by many individuals for effective training and education; a simple hyper-navigation system that allows the users to decide where they will go next. Another major benefit of CBT over other multimedia is user interactivity. This allows the users to delve as far into a subject as they wish and can manipulate figures to see the outcome (Hick, 1997).

What is the reason for integrating CBT technology into the training arrangements for engine room equipment and systems? The inexperienced seafarer is likely to make errors of judgement in any practical situation. The consequences of such errors could be costly and catastrophic. On the CBT simulator the seafarer can make errors, and receive extrinsic feedback to assist in an improved performance. Rapid repetition of difficult situations allows a review of tactics to take place until a satisfactory conclusion is reached (Cross, 2008). Some tasks cannnot be experienced at sea but with the software installed in the CBT the seafarer will be able to carry out such a task. The integration of CBT technology into training in the engine room is to prepare the seafarer for any real problems on any given machinery. The use of the CBT simulator as a training tool can play a vital role in raising the safety standards in the E/R. Furthermore, STCW78/95 (Chapters III and IV in Part A of the Code) has strongly recommended the application of engine room simulators in the teaching and learning process.

4.3. Assessing the Safety Measurement of a CBT Simulator

It has been learnt through experience that the application of simulation in teaching complex control systems leads to a better understanding of the principles of operation of both the equipment and the systems in comparison with traditional education methods. The application of CBT interactive programs plays a very important role. The CBT interactive program provides familiarisation with individual auxiliary machinery and associated systems, preparing the seafarers to better deal with potential emergencies during operations on board (Cwilewicz, Tomczak, & Pudlowski, 2004). In this regard, interviews were carried out during this research with students at WMU, instructors at maritime institutions and seafarers so as to ascertain the degree to which CBT had assisted them with the aspects of safety.

Coincidentally, all those that were interviewed also had experience with CBT simulators and expressed that CBT had helped them solve numerous problems onboard. One of the marine engineers who is sailing on vessels owned by STOLT Nielsen said that he had used CBT onboard also, and that the CBT modules are also used to relate to safety procedures for the correct use of various machineries. Some interviewees explained that the schematic diagram is not well understood as compared to the three-dimensional (3D) presentation given by a CBT simulator.

The application of 3D simulation techiques in teaching the operation of complex marine machinery leads to a better understanding of the functioning principles of both the equipment and the systems compared with traditional educational methods (eg. schematic diagram)(Tomczak, 2005). The comparison of both is seen in figures 3 and 4. The 3D can be animated and tracking faults can easily be detected.

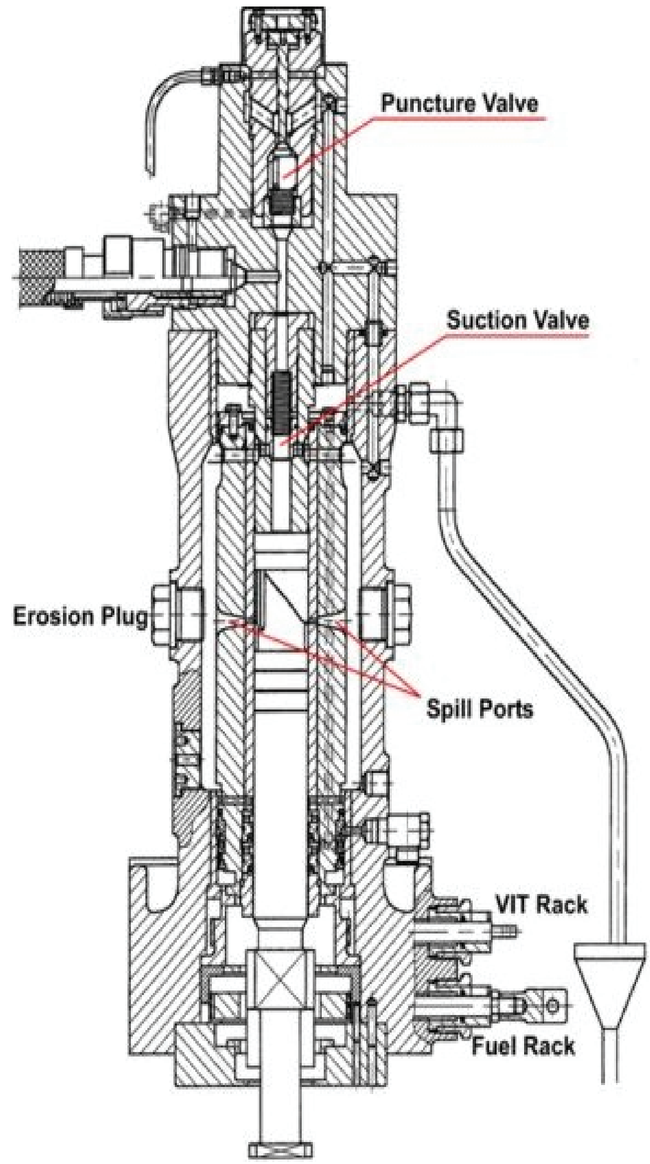

Figure 3: Schematic Diagram F.O. Pump with Variable injection Timing
Source:(Manbw, 2007)

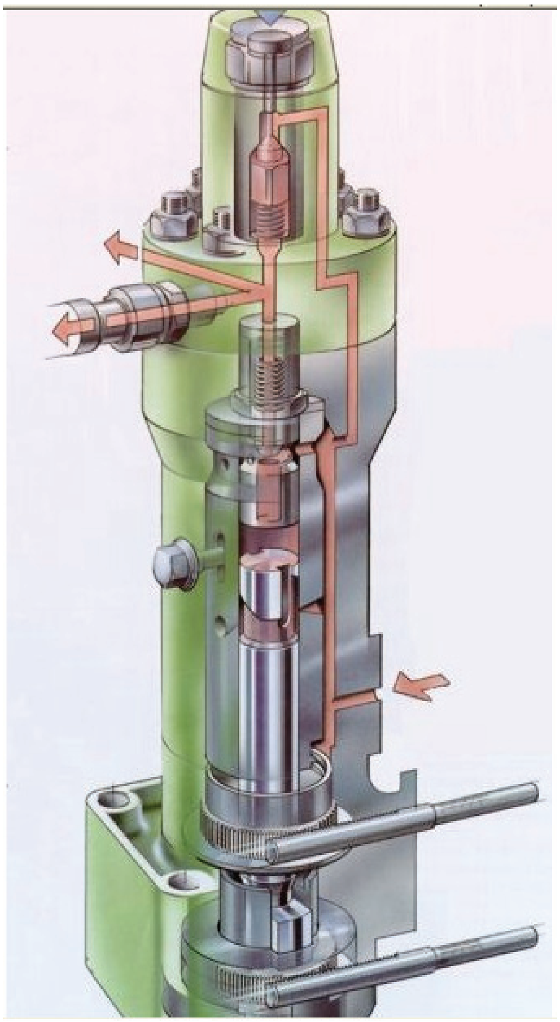

Figure 4: 3D Presentation of F.O. Pump with variable injection timing (VIT)
Source: (Manbw, 2007)

With this assessment, it is proven that the CBT simulator can help in the promotion of safety in the E/R. Hence, if one of the aims of the industry is to make shipping safer and promote competency at sea, CBT simulator training is one the ways to achieve this since Senior Officers are bombarded with administrative work leaving them virtually no time to train Junior Officers. Moreover, training onboard is mandatory according to STCW 78/95 therefore shipping companies need to implement it so as to help prevent accidents.

4.4. Training onboard an Essential Ingredient to Safety

Ships have become more technologically advanced, but because of the present operational environment of fast turn around and the smaller number of staff onboard, seafarers have less time to increase their ship knowledge. Increased bureaucracy has, of course, also added to the fact that Senior Officers have less time to actually navigate the ship or to handle the ship's machinery equipment (Mortimer, 2008). More is expected of them both during their hours of work and keeping abreast of extensive maritime legislation. The following example supports the need for training normally not available in shore based academics: Scavenge space explosion: While discharging in port the second engineer was told by the engine room watch that two cylinders of a running auxiliary diesel engine were displaying abnormally high exhaust temperatures. While he was inspecting the running engine, the cover of scavenge space suddenly blew out and he suffered third degree burns on his hands, arm and legs (SASI, 2008). Probably, the reason for this injury when working onboard and when there is an absence of written or operational procedure, the crew is bound to be exposed to danger. How could this accident be avoided? When equipment or machinery like the auxiliary engine shows signs of abnormality or strain it must be stopped immediately and taken off load. It should be investigated by using all available resources onboard. Proper training onboard would have helped also to avoid such accident.

For safe and efficient operations at sea, ship's crews must be trained so as to improve their operational skills. Consequently, shipping companies cannot avoid training the crew to enhance their safety, behavior standards if they need to promote safety and improve economic performance. Not only should they be trained before going to sea, but the seafarers should also be continuously trained on board (Guohua, 1999); merely providing more equipment will not prevent accidents. Improved training and education to operate the equipment safely can help prevent maritime accidents and casualties. Many agencies and companies are looking to simulation as one vehicle to improve mariner competency (NRCS, 1996).

Humans learn most effectively by being given a chance to undertake a task, making a mistake and then correcting it. However, sometimes the mistake is costly. According to theory, when someone makes a mistake the cause becomes firmly fixed within the brain, so the chance of that person repeating the same mistake is less. This process is known as learning by doing and is the reason why simulators are much more effective at delivering knowledge and expertise (SASI, 2007). Using technology such as the CBT simulator to teach safety will minimize some of these accidents, improve efficiency and give the crew the confidence in carrying out their duties thus saving companies from unwanted spending.

4.5. Manufacturer's Prospective

People have a tendency to blame themselves for difficulties with technology but at the same time they do search for causes for specific events. Hence, when designing equipment for usage the designer must assume that all possible errors will occur and must design it so as to minimize the chance of the error in the first place, or its effects once it gets into use. Errors should be easy to detect, they should have minimal consequences and, if possible, their effects should be reversible (Norman, 1988). The designing of programs on CBT is of no exception. The designers have to make the program easily accessible and clearly understood so that the users can look at the situation and try to discover how and what operation can be done.

One of the objectives of this research was to gather information on the CBT simulator. As this relates to safety onboard a suitable questionnaire was formulated to be answered by the manufacturers; the questions and replies can be seen in Appendix C. From the research it was concluded that almost all the engine room personnel had similar problems in handling machineries thus the question posed to the manufacturers was: **“Can Software be developed or is it already**

available for CBT Simulator for training and maintenance purposes onboard simulating trouble shooting of the following engine room machineries?"

They were asked to put a check mark in the appropriate box

Table 4: Machineries

	Machinery & Parts	Available	Can be developed	Can not be developed
1	Turbocharger of the M/E			
2	Governor of the A/E			
3	Centrifugal Pumps			
4	Purifiers			
5	Air Compressors			
6	Safety Valves of the Boilers			
8	15ppm monitor of the OWS			

Source: Author constructed, 2008

The questionnaires were sent to MarineSoft, Seagull and Kongsberg. Fortunately, Kongsberg's reply came soon. Kongsberg is one of the simulator manufacturers and is located in Horten, Norway. Their products have a high quality standard which exceeds the international standard on quality (ISO) 9001. They try hard to put more effort into understanding maritime training requirements including the philosophy, methodology and the development of training programs to meet the user's objectives. This understanding is applied through their design, configuration and operation of all their simulators.

The reply came back from Kongsberg with an affirmative answer and with an attached folder: SM-0501-B1 Neptune ERS, indicating that all these machineries and parts are being developed and used on the MAN B&W SL90MC VLCC-V engine series. It is a training package that teaches the logical approach to fault finding, handling normal and anomalous situations without danger to life or equipment and allows the crew member to access varying degrees or levels of understanding. It is designed to meet the demands for the basic operational training of junior engineers to carry out fault studies by senior engineers as well as economy and optimization studies by the chief engineers. The training on simulators over the past years proved to be an effective training method especially where an error of judgment can endanger life, environment and property. Hence proper training will reduce accidents and improve efficiency, and give the engineers the necessary experience and confidence in their job-situation (Kongsberg, 2008).

Since this software is available, shipping companies should take advantage of it and place it onboard for the engine crew's benefit. Through this software the engine crew will gain more training knowledge and skills in handling the machineries onboard.

Training is an essential part of safety and the promotion of it calls for an attitudinal change in those who are to implement it, both ashore and onboard. Hence, there should be a cognitive approach towards safety and its implementation.

4.6. Collective Approach towards Safety Onboard

Safety involves the core idea that all marine operations be planned and executed so as to ensure, as far as is reasonably practicable that no person or property will be exposed to danger. It is in recognition of this that IMO Resolution A. 647 (16) deals jointly with the two concepts: safety and environmental protection. The main emphasis of the resolution is to promote sound management and operating procedures within the industry as a whole in order to ensure safety, prevent human injury or loss of life and to avoid damage to property and the marine environment (Alleievi, 1991).

In recent years the high profile casualties which have brought the industry into the public eye are primarily the result of organizational and managerial failure rather than technical failure. It is a pity that seafarers can not do anything about this. Seafarers have no say in the manning levels and it is at the mercy of the owners and managers who are also under relentless pressure to reduce operating costs. There are frequent incidents where watchkeepers have been so tired that they are incapable of performing their duties reliably. Others become preoccupied with other tasks, or rely too much on technology, and they fail to fulfill their prime objective to be responsible watchkeepers. In the event of an accident, the final mistake in each case is blamed on the seafarer. It is a fact that the safety of the vessel depends upon the action of those individuals onboard and ashore. Management experts argue that operators at the lower end of the organization chart have to work within the system which is established for them by their managers, and so a good proportion of the mistakes they make are built into the system itself (Millican, 1993). For good management to exist there must be commitment from the top, manifested through the company's safety and environmental policy, the provision of the necessary resources and personnel, the need for good communication, methods of reporting accidents, concise guidance and instruction on safe operations and pollution. In brief, education and training in the management of marine safety and environmental protection is of crucial concern.

The last two decades have seen a tremendous improvement in the design and equipment of ships. Today, it can be said with some confidence that the introduction of new technology onboard ships is often the catalyst for applied innovation in technique or methodology. New technology, of course, may raise the expectations of those working in the related field that such developments will lead to the accruing of advantages, such as increased productivity, greater efficiencies through cost saving, increased employee motivation and job satisfaction, the creation of innovative concepts and ideas, and sheer excitement of developing new ideas and ways of achieving specific objectives (Muirhead, 2004). The value of training the crew must be understood by those with the desire to get the best of their money's worth. The absence of it (training) can lead to disaster onboard, especially, when the industry is in an era of multicultural manning which demands a particular understanding and a sophisticated level of skilled people.

It is good to see a companies making the most of their own facilities onboard to run training on a regular basis (Seaways, 2004). A genuine spirit of teamwork requires people to help each other to make sure that mistakes are not made, and this means being open to advice and criticism (Millican, 1993) without fear or favors. Safety onboard can not be the responsibility of the seafarers alone but the collective effort of safety involves the administration, ship owners, shipyards, insurance companies, manufacturers and classification societies. With a cohesive effort safety onboard can be established.

Chapter Five

5. Cost Analysis

Using CBT onboard as a training tool has been proven in the last chapter as helpful, however it comes with a price. Therefore one needs to know the cost and its analysis. This Chapter will focus mainly on the cost, risk assessment and quality assurance of training on CBT brings to the industry.

5.0.1 The Company

It is a known fact that companies need to take active steps to develop and train their crews so as to improve their performances, skills and knowledge. But the question is why, when shipping is like any other business is about maximizing profit? Rather than measuring the cost of education and training inputs by the prices paid for them, the whole concept measures them by the value they would have in their most profitable alternative use. The logic behind this is that since the company has a limited supply of economic resources to use in any given period, a decision to use some of them for specific purposes, such as education and training, means sacrificing the opportunity to spend these same resources on something else (Coombs & Hallak, 1987). In short, the cost analysis is not only to compare cash but it helps the company to see the various options and trade-offs available to them clearly, and assesses their relative merits and feasibility. In chapter three it was explained that many companies try to reduce human error by adding in more technologies, but in the end the result is that human error still remains or is relocated. The cost analysis of new technologies could be traded off by educating and training the seafarers in handling these new technologies. However, it is impossible to erase the money paid for training. Training costs money and the question that must always be asked is: Is training cost effective? The answer to this question is left to the company to decide whether to train or not to train as a business decision. In effect the company must consider training as an investment and therefore it must establish what the return on that investment (ROI) is.

5.0.2 Cost of Not Training versus Cost of Training

For a company to make a business decision in favour of training, it must be able to show that not-training costs more money. It is like a famous saying that if one thinks education is expensive let him/her try ignorance. For example if an engineer is not well trained in overhauling a turbocharger on the auxiliary engines he/she may cause serious damage to an engine and sometimes disable the ship. The cost of not training can lead to customer dissatisfaction and increase the number of complaints, increase crisis/incidents and accidents, under-utilise technology; low morale and a lack of commitment to the company (Angas, 1995). The cost of training gives good and effective performance. It improves the knowledge and skills of the crew in their ship board operations. Figure 6 shows the benefit of Training:

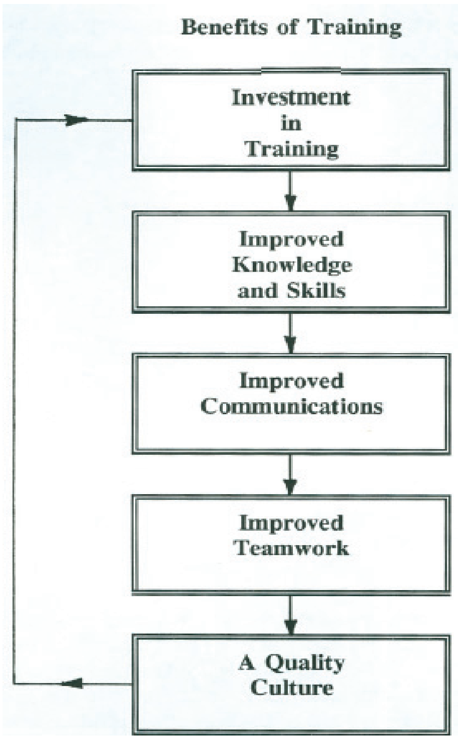

Figure 5: Benefits of Training: Source:(Mitchell, 1998)

The training of crew improves safety standards and efficiency, both of which are vital. An untrained seafarer would be a liability to others and to himself, especially in emergencies (Vanchiswar, 1996).

5.0.3 The Administration

The Administration is referred to as the flag state. What has the administration to lose when it does not consider the financier of the ship? Lets us remember that cost analysis is not only about cash but also the sacrifice or the trade off. Hence, the administration shall take such measures for ships flying its flag as are necessary to ensure safety at sea with regard to the construction, equipment and seaworthiness of ships; the manning of ships, labour conditions and the training of crews, taking into account the applicable international instruments; and the use of signals, the maintenance of communications and the prevention of collisions are upheld according to article 94 (UNCLOS). Violation of such an international convention could make the flag state lose its credibility. The trade off here is for the administration willingness to have a trained and competent crew onboard, thus keeping a good reputation internationally as being safe administration than to be considered less safe hence losing its credibility. According to the Nautical Institute's memorandum on maritime safety, published in 1987, governments have the authority for safety. If they fail to discharge their duties effectively, they add legitimacy to fraudulent acts of non-compliance with international conventions (Seaways, 2001). The idea of installing CBT onboard to help in training the crew is of immense benefit to the company and administration. It is a cost saving over attending class room training, in spite of the capital cost.

5.0.4 The Seafarers

The seafarers here are referred to as the operators of the daily activities onboard the ship. A well trained, skilful, knowledgeable and competent crew makes a safe ship. The final beneficiary of training onboard is the seafarer. Therefore, what part of the cost benefit analysis does the seafarer have to play? Operational competitiveness and commercial pressures have led to the adoption of contemporary technology on board for faster turn around and also provided an opportunity to replace manpower with technology and thus reduce the size of the crew on such ships. Operations with reduced shipboard personnel, however, have become the norm in the industry (Rajendra Prasad, 2004). This has created a need for greater knowledge and improved skills for many seafarers to stay at sea. Hence, a seafarer has to do either one of the two: upgrade so as to keep up with modern technologies or do nothing and be out of a job. One way of doing this is to train seafarers through special IMO Model Courses. Many seafarers who would like to maintain their jobs would take advantage of upgrading themselves or take advantage of their company's training program if there is one. However, despite these IMO model courses, onboard training is still essential for seafarers to upgrade their skills. These courses are generic as they are shore based. It is up to the company to deem whether it is necessary to install a CBT simulator onboard with all the requisite software of the machineries onboard installed so as to assist crews in dealing with all the potential eventualities.

5.1. Risk Assessment

Shipping is an international business. Like any other business it operates under limited resources. However, using part of the resources to purchase a CBT simulator is a calculated risk. As we have seen in the previous chapters that training nowadays in the sea-going environment is somewhat more difficult due to time, cost and other availability factors. The question is why companies should take the risks? Risk is a measure of the severity of the danger which a hazard presents. It is a combination of two factors – the **Probability** of something happening and the **Consequences** if it does (Mitchell, 1998). Risk assessment is a systematic process in which the hazards are identified, the options of managing them assessed and then explored. In the same token, weighing the cost and benefits of the option then implementing the best one and finally monitoring and re-assessing the result.

The concentration here is on the CBT simulator. Is it a risky undertaking for a company to purchase? In this author's opinion the answer is "no". It is quite a normal practice to solve problems before they occur, instead of investigating them afterwards. In other words, learning from mistakes is fine, but it is much better to avoid them. At sea, the degree for mistake is highly intolerable hence training on a CBT simulator is the best option where all mistakes are allowed and through training, knowledge and skills are gained to perfection in the given crisis.

Let us take the new technology in the design of a fuel pump with a variable injection timing (VIT) which is meant to economise fuel and also to improve the engine's efficiency at any given load, for instance. An inexperienced seafarer may find it difficult to overhaul and set this pump accurately if he/she has not had experience with it. If a CBT installed onboard has such a module it is a good exercise before attempting to overhaul. It is known that with the improvement in technology almost all problems can be solved onboard technically. It had being observed that companies are adding a little bit more technology to help remove human errors. Is this really true? After all, if technology is there to do the work or to monitor the human doing the work, then we have a new problem. In other words, new technology shifts the ways in which the systems break down and it demands crew to acquire more knowledge and skills, so as to remember new facts (Dekker, 2006). The next point to look at is Time, which is another risk factor in shipping. We know that in shipping Time is of essence. Due to commercial pressure and other factors onboard there is virtually no time allotted to train Junior Officers. Why then should the company purchase a CBT simulator? Won't that be a waste of funds?

5.1.1 Why Take the Risk?

Risk will be present as long as ships sail. The ISM Code 1.2.2.2-.3 states that the company should "establish safeguards against all indentified risks; and continuously improve safety management skills of personnel ashore and aboard ships, including preparing for emergencies related both to safety and environmental protection." This has resulted in efforts to reduce or control risk by all possible means, ranging from the redesign of unreliable components, to improvements in operational procedures and training. The result has been a gradual increase in safety awareness at all levels of shipping and navigation. While maritime activity is one area where the acceptance of risks cannot be completely avoided, it is also an area where the penalties for failure can be high. Accordingly, the taking of risks needs to be carefully weighed against the perceived benefits (Steen, 2005). Below figure 7 shows the Probability against Consequences. The negligible region is where the acceptances of situations which occur infrequently and whose consequences are minor, such as near misses. The other extreme region is the intolerable which is very likely to arise and have catastrophic consequences such as when the engine crew is overhauling the main engine turbocharger and does not have the requisite experience.

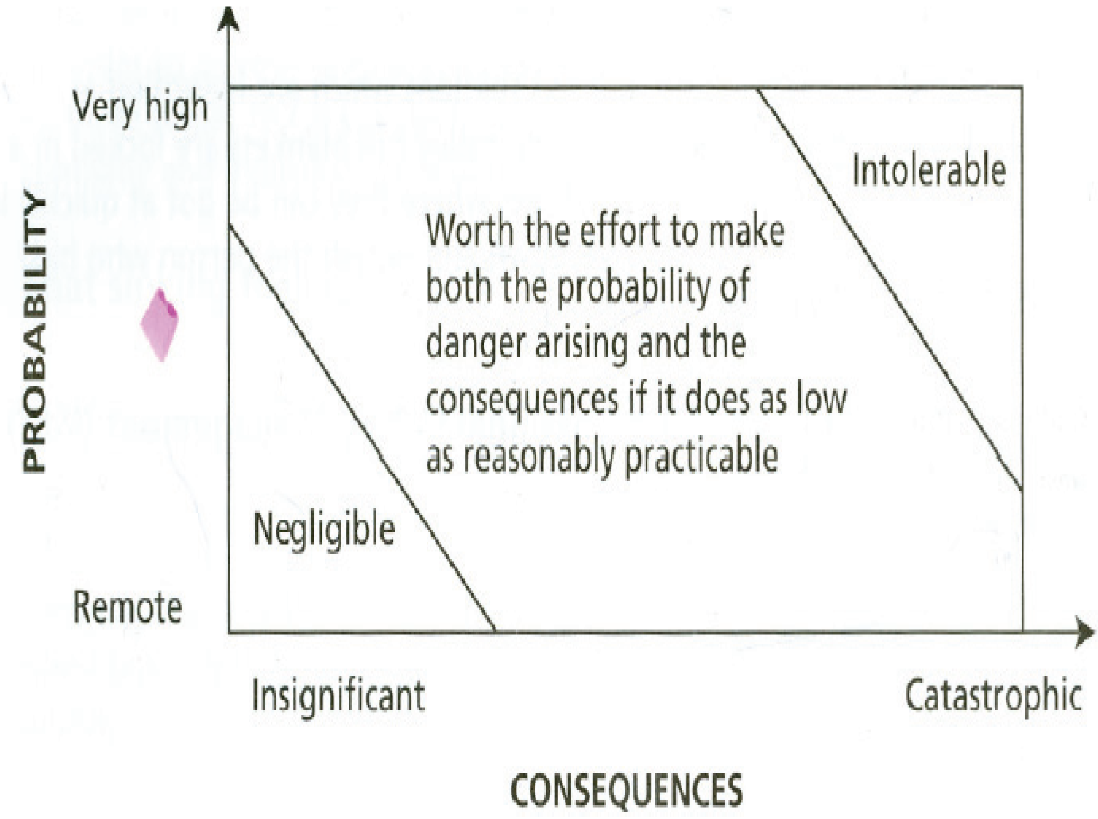

Figure 6: Probability v Consequences
Source: (Mitchell, 1998)

5.2. Risk Treatment by the Company

Identifying the two points (new technology and time) as risk factors an answer can be established to show the risk treatment. It is left up to the company to do either of the four risk treatments that are avoidance, reduction, retention and transfer. Avoidance is not performing an activity that could carry risk. For example, not to buy a CBT simulator in order to not take on the responsibility that comes alone with it. Reduction involves methods that reduce the severity of the loss or the likelihood of the loss from occurring. Example is the purchasing of a CBT simulator which can demonstrate a sprinkler design of putting out a fire to reduce the risk of loss by fire. Retention is accepting the loss when it occurs. For example, running machinery without any maintenance plan until it is damaged. Transfer is spreading the risk with other members of the company (Wikipedia, 2007).

The last two decades have witnessed tremendous changes in shipboard technology which demand seafarers have higher and updated skills and knowledge to meet the technological demands. For a company to sit and do nothing about training its crews mean that it is taking a high level of risk which involves a low level of safety. On the other hand taking the risks of buying all the necessary requirements to help train the crew to meet the demands of the new technology means that the risk level is reduced and the safety level is increased.

The problem is Time; finding the time for Senior Officers to help train Junior Officers has been of great concern to the industry. The advancement in technology in the form of automation and controls has reduced the number of staff in the engine room. This reduction in manning calls for all hands to be active in shipboard operations; commercial pressure and extensive paper work have left no time for training onboard. How should time be allotted for training? On the other hand, just in case the company decides to have CBT for training and the crew can not find the time to use it, a time frame must be established by the company for training.

5.2.1 Training Time Frame

During the course of this research, one of the questions in the questionnaire was the availability of time. Many of those in the management level answered that they would give three hours of their time weekly to help in training their Junior Officers. This is a clear manifestation that training on board can be done only if the company's policy can allot a means for it. Part 6 of the ISM Code deals with resources and personnel and out of the 7 points stated 6.5 is of major concern here. "The company should establish and maintain procedures for identifying any training which may be required in support of the safety management system and ensure that such training is provided for all personnel concerned (ISM, 2002)." The ISM Code is mandatory for all ships hence it is imperative that the company establishes a training policy and procedure to undertake seafarer training (Guohua, 1999). Not allotting time for Senior Officers to help train Junior Officer means the Junior Officers will be left on their own to train themselves. How effective will this be when there is no overseer in the training program? STCW 78/95 Section A-I/6.2 emphasizes an overseer and the time allotted for training purposes. However, it states that the time for training should not adversely affect the normal operation of the ship. A record of training should be kept according to Section A-III/1.2.3 of the STCW 78/95 convention. In addition, the training must have clear teaching objectives, carefully designed exercises, clearly understood briefings and debriefings for each exercise and there should be some means of measuring the effectiveness of the training. Without these the CBT simulator becomes at best a tool with limited effectiveness and at worst an arcade game which might reinforce the button-pressing beliefs and misconceptions of the enthusiastic inexperience junior officer. In order words, there is a need for senior officers to set up exercises, monitor progress, encourage and guide, evaluate outcomes and debrief the junior officers (Murdoch & Holder, 2001). If the company is taking on such a risk by purchasing a CBT simulator for training it must open the grounds for managing the risk involved.

5.3. Managing the Risks

A ship is a risky place to work and it is incumbent upon ship owners and ship managers to develop proper procedures and maintenance programs and to ensure that their seafarers are properly trained. Injuries and fatalities can be avoided if the seafarers follow the correct procedures to assess the risk and ensure that those risks are minimised by checking that the area in which they are about to work is hazard free, and that they are using the correct equipment for the task at hand (Snell, 2005). Ships become a safer environment when the company recruits experienced properly qualified, competent officers and crew and gives them appropriate amounts of relevant training throughout their careers. However, whether this is a cost-benefit or a risk in purchasing a CBT simulator, the company should realise that technological improvements for the maritime industry are evolving at a fantastic rate, fuelled by the desire to improve efficiency and reduce the cost of transporting goods. While these changes are impressive, technology alone will not be sufficient to reach these goals (Kendall & Buckley, 2001). Training of personnel must be addressed in a proactive manner. After all, it is the crew operating the new equipment who will ultimately determine its efficiency.

Chapter Six

6. Conclusions and Recommendations

6.1. Conclusions

To conclude, it can be said that our lives evolve around perpetual changes in standards concerning our daily activities just like education and training. The STCW 78 convention as amended had to be revised not only because it lacked standards or accuracy but mainly because of the advancement in technology. "The "Standards of Training Certification & Watch Keeping Convention was first agreed in 1978, and revised in 1995, and is now being re-shaped for the 21st century reflecting the radical changes in shipboard technology and training methods over the past decade" (Dickinson, 2008).

However, the STCW Convention cannot and should not be blamed for all that goes wrong within the industry such as the competency levels in modern shipping. For example, a member of the support staff was sent to clean a fuel filter from one of the auxiliary engines. After the work was done the member placed the filter in position but forgot to take the air out of the system. When the machinery was to be placed online the air got trapped into the system causing a temporary blackout. Another instance, reported by the Nautical Institute states that a junior officer was told to get the evaporator running but unfortunately the officer could not because he was inexperienced and the instructions contained in the manual were not enough to help the officer with the work. Despite mandatory code A of the STCW, which stipulates the competency level, the instruction manual and diagram of the various machineries that should be available onboard ships are not enough to cope with the knowledge required of today's technologies. A number of accidents/incidents happen in the engine room because of the lack of knowledge and skills to work on the machineries of today's technology.

Technology has advanced beyond man's imagination causing a shift of 90% of the blame of accidents on the human element. The technology of today has made the equipment more reliable and efficient but the problems here rest on the companies that is their unwillingness to put money and time into making sure the equipments are working to specification and investing in the training of their crews to meet the require skills in handling these equipments. That is one of the main reasons why the most part of marine accidents is placed on the human factor and the share of such episodes is kept high and even grow during the last century,. Therefore, it is hard to overestimate the importance of the international regulations on marine safety matters(Anatoli, 2004).

In the past, ship owning companies made the master and his crew an integral part of the company's decision making process however, in recent times these individuals have become marginalised. Vessels have become micro-managed, decisions are being made without consideration of the impact on shipboard staff and there is a failure to value the skills, experience and knowledge of those that serve on board. Ship's senior officers have had a major role in the training of juniors on board but with the ships employment pattern with smaller crews on short contracts, the seniors have no time and interest in training their juniors whom they may never see again or whom the company may or may not employ again (R. Prasad, 2008). Hence, a high turnover of staff and poor levels of motivation are, sadly, not unusual in shipping and are often symptomatic of poor management practice.

However much can be learnt from the ISM Code. The Code has evolved from a long line of quality assurance models that have served many industries well. Although the objective of the Code is safety, the same guiding management principles that achieve a safe operation can equally be applied to creating a commercially efficient environment, with a culture that attracts, motivates and keeps high quality crews. Section six to the preamble of the Code states: "The cornerstone of good management is commitment from the top. It is the commitment, competence, attitude and motivation of individuals at all levels that determines the end result."

When a vessel fails to perform effectively or has an accident the first question often asked is: who is to blame? When a seafarer fails in performing his/her duty, the wrong reaction is to blame him or her. The consequence of following the instinct to blame an individual when something goes wrong is resentment and ineffective communication. A barrier is created between those that should be working together(Maclean, 2008). When things go wrong the appropriate questions to ask is: Was there appropriate supervision? Was there enough provision of adequate resources to do the job? Did the crew member have sufficient training and were clear instructions given to do the job? The company should know that those who perform the tasks on board on a daily basis are best positioned to suggest how shipboard processes can be improved, made safer and more commercially cost-effective rather than closing this valuable source of information by instructive blame.

Safety has always been the major factor for the development of regulations. This has now been expanded to the protection of the marine environment and more recently, maritime security. These developments, however, have raised concerns about whether or not they are having the right effect on the shipping industry. These regulations will always have ‘pros and cons’ but it is the shipping industry, and especially the seafarers who are burdened with all the requirements.

As explained in chapter three, the general accident statistics within the shipping industry show that about 80% of maritime accidents can be attributed to the human element. If all aspects including the design and ergonomic arrangements are taken into account it can be said that the influence of human is in fact 100%. Since the machine is designed; built and operated by man thus a failure of the machine is really the failure of man. Looking at an accident, it is normally a number of occurrences and circumstances which lead to a point where an accident could not be prevented. In the strict sense these human failure functions comprise not only of a human being in a given situation acting wrongly or neglecting to act, but also about all that which directly or indirectly has contributed to the occurrence, such as imperfections in the vessel, for instance in its construction and equipment, deficiencies in the shipboard management or in the administration of the shipping company through faulty motivation or attitude towards maritime safety matters within the shipping company, inadequate education and training and wrong manual/instructions etc., contributing to the error promoting situations. The wrong designs or constructions are beyond the seafarers' ability to change but through better skills he/she can redeem their adverse effects. These better skills are attainable through effective training onboard.

As explained in chapter four, ships are becoming more technologically advanced thus increasing in electronics for controls and monitoring, in the operation of ships. These rapid technological developments promote reduced manning and call for new specific knowledge and abilities of these lesser number of seafarers. With this in mind, many companies are thinking this will reduce human error by adding more modern control technologies. However, such electronic controls in the form of automation do not really remove the potential from human error rather they merely relocate or change it to different skill requirements. There is little point of spending thousands of dollars in state-of-the-art automated systems if there is no training in place as to how to use if effectively. The Modern ship demands quality seafarers and training is a vital element in achieving this aim.

In order to attain a consistent level of training and minimum standards of competency across the industry, it is necessary to ensure that the relevant competencies can be gained by the development of specific training and certification requirements. In a nut shell, the solution to solving this problem is brought down to Maritime Education and Training since MET relates to the human element. It is important that all stakeholders encourage and promote the highest standards of education and training and a common spirit of professionalism in the industry. The companies should not sit back and think that the increase in automation and electronic systems can easily solve the problems onboard technically. As technology (automation and electronics) has revolutionized the shipboard systems so must the seafarers so as to meet these challenges through a continuous and effective training chain onboard. One of the best ways of achieving this is through self training with CBT simulators since additional technology, commercial pressure and the drop in crew size has left almost no time for senior officers to train junior officers.

That is, if the software of the machineries is easily available on CBT simulators for training and trouble shooting this will easily reduce the accident rate onboard. It will also alleviate some of the problems of senior officers training junior officers and cost effective as many companies are not in the position to train their crew ashore. The system will bring in a form of standardized operation on the machineries of that particular ship and also assist the crew in the familiarization of the various machineries. This system (CBT simulation) will help in supplementing the manual instruction and the various diagrams of the vessel's engine system. It can be recalled that Kongsberg Maritime did it for MAN B&W 5L90 MC VLCC L111-V product therefore it can be done.

However, industry should bear in mind that seafarers are human and they are likely to make errors, sometimes in judgements and other practical situations where the consequences of such errors sometimes could be costly and even catastrophic. The idea of having a CBT simulator is to help build up their practical skills in handling their machineries thus reducing the chances of error occurring. As known, on the CBT simulator the seafarer can make errors, and receive extrinsic feedback to assist in improving performance. The rapid repetition of difficult situations allows a review of tactics to take place until a satisfactory conclusion is reached. Some tasks cannot be experienced at sea but with the appropriate software installed on the CBT the seafarer will be able to carry out the assigned task. Placing CBT technology into training in the engine room is to prepare the seafarer for any real problems on any given machinery. The use of the CBT Simulator as a training tool can play a vital role in raising the safety standards in the E/R. Furthermore, STCW 95 (Chapters III and IV in Part A of the Code) has strongly recommended the application of engine room simulators in the teaching and learning process. Training is expensive but the cost of not training is even more expensive as explained in chapter five. Providing effective training to the crew creates added confidence and improves performance, motivation and reliability. In any case, if simulators are recommended for classrooms the industry should extend it further at sea through CBT since the sea is the final result from the Institutions.

6.2. Recommendation

Training using modern technology is often done in practice by on-the-job experience, but this research has shown that this may compromise the integrity of watchkeeping. Therefore, to enhance training, mariners need to learn how to work the system, not just how the system works. The most realistic way is to train seafarers through a self learning process which is through the help of the CBT engine room simulator. Operationally, realistic scenarios should be used for seafarers to learn how to use a system's new capabilities.

Ship owners should be expedient in installing CBT simulators including all the necessary software of the design of that ship's machineries to be installed onboard, not only for training but also for trouble shooting. The CBT simulator should be installed during the building of the ship. This means a close co-operation between the builders and the manufacturers of simulators will be needed.

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Appendices

Appendix I Research Questionnaire

Dear Colleagues,

I am doing my dissertation on CBT simulators in the Engine Room as one of the substitutes in helping to train, solve operational problems and promote safety on board.

The reasons for doing this dissertation are due to the numerous problems of accidents and breakdowns of machineries in ship operations. Moreover, the shipping industry over the last decade has been exposed to advance technologies causing quick turn around and need for smaller crew hence leaving no time for training on board which is an essential component for competence development.

In this light, I would be very grateful, if you as ship operators could assist me by answering the following questions so as to support my dissertation. You can rest assure that all questions and answers that you give will be purely confidential. You can also give your feedback without stating your name for confidentiality purposes.

I would highly appreciate it, if the questions could be answered by the earliest possible time and sent by electronic mail to me (s08071@wmu.se) or jboyharvey2003@yahoo.com.

Thanks in advance

John F. Harvey Jr.

Appendix I-A Questionnaire

1. The listed items below from A-G are machineries in the Engine Room; will you please list at least three operational problems you have experienced with each one of them doing your sea term.

(A) Main Engines ______________
____
____

(B) Auxiliary Eng. ______________
____
____

(C) Evaporator ______________
____
____

(D) Purifiers ______________
____
____

(E) Compressors ______________
____
____

(F) Boilers ______________
____
____

(G) Oily Water Separator __________
____
____

2. The problems that you have listed; do you think, training supplemented with practical hands on, could have helped solve some of these problems?

☐ Yes ☐ No

3. If your answer to question 2 is yes, what's your idea about CBT simulator been on board as a training tool?

☐ Excellent ☐ Good ☐ Bad ☐ Not Sure

4. If you have chosen the first two answers in question 3; how much time will you as a senior Operator put into training your junior Operator?

☐ Three hours weekly ☐ Three hours monthly ☐ Unsure

5. How familiar are you with CBT Simulator?

☐ Very Familiar ☐ First Time ☐ Not Familiar ☐ N/A

6. Did you have any problems in using CBT Simulator?

☐ Yes ☐ No ☐ N/A

7. How are the instruction procedures with CBT simulator?

☐ Difficult ☐ Easy ☐ Flexible ☐ N/A

8. To what extent has the CBT simulator training being helpful in your practical training?

☐ Very helpful ☐ Helpful ☐ Not helpful ☐ N/A

9. What is your level of responsibility in your Organization?

Management ☐ Operational ☐ Support ☐ N/A ☐

Appendix II Respond to the Questionnaire

1. The listed items below from A-G are machineries in the Engine Room; will you please list at least three operational problems you have experienced with each one of them doing your sea term.

(A) Main Engines	Fuel Systems Cooling System Starting System	(B) Auxiliary Eng.	Fuel Systems Power Balance Lub system
(C) Evaporator	Low production High salinity Vacuum Loss	(D) Purifiers	Full Seperation Gravity disc Bowl cleaning
(E) Compressors	Low Output Foul Coolers Carbon deposits	(F) Boilers	Smoke density Water quality Automation

(G) Oily Water Separator
Oily water interface
3 way v/v operation
15 ppm alarm

2. The problems that you have listed; do you think, training supplemented with practical hands on, could have helped solve some of these problems?

☐ <u>Yes</u> ☐ No

3. If your answer to question 2 is yes, what's your idea about CBT simulator been on board as a training tool?

☐ Excellent ☐ <u>Good</u> ☐ Bad ☐ Not Sure

4. If you have chosen the first two answers in question 3; how much time will you as a senior Operator put into training your junior Operator?

☐ <u>Three hours weekly</u> ☐ Three hours monthly ☐ Unsure

5. How familiar are you with CBT Simulator?

☐ Very Familiar ☐ First Time ☐ Not Familiar ☐ N/A

6. Did you have any problems in using CBT Simulator?

☐ Yes ☐ No ☐ N/A

7. How are the instruction procedures with CBT simulator?

☐ Difficult ☐ Easy ☐ Flexible ☐ N/A

8. To what extent has the CBT simulator training being helpful in your practical training?

☐ Very helpful ☐ Helpful ☐ Not helpful ☐ N/A

9. What is your level of responsibility in your Organization?

Management ☐ Operational ☐ Support ☐ N/A ☐

Appendix III Letter to the Manufacturers

June 2, 2008

Dear Sir:

I am a student at the World Maritime University (WMU), specializing in Maritime Education and Training. I am carrying on a research for my dissertation relating to CBT simulator for the Engine Room (E/R) machineries and equipments systems as one of the substitutes in helping to train, solve operational problems and promote safety onboard ships.

The reasons for doing this dissertation are due to the numerous problems of accidents and breakdowns of machineries in ship operations. Moreover, the shipping industry over the last decade has been exposed to advance technologies causing quick turn around and need for smaller crew hence leaving no time for training on board which is an essential component for competence development.

The survey was carried out through operators from various localities with Engine Room Sea going experiences. From the results, it was observed that they all had a common problem in handling the machineries onboard.

Hence in this regards, I would like from you as a manufacturer of Simulator to please answer the following question so as to support my position in my dissertation. Please find on the next sheet the question.

I would highly appreciate it, if the question could be answered by the earliest possible time and sent by electronic mail to me (s08071@wmu.se) or jboyharvey2003@yahoo.com.

Thanks in advance,

John F. Harvey

Appendix III-A

Can software be developed or is it already available for CBT simulator for training and maintenance purposes onboard simulating trouble shooting of the following engine room machineries?

Please put a check mark in the appropriate box.

	Machinery & Parts	**Available**	**Can be developed**	**Can not be developed**
1	Turbocharger of the M/E			
2	Governor of A/E			
3	Centrifugal Pumps			
4	Purifiers			
5	Air Compressors			
6	Safety Valves on the Boilers			
7	15ppm monitor of the OWS			

Comment:

Appendix IV Kongsberg Maritime's Respond

Good morning Mr. John F. Harvey

Your questions is answered and a product description of a simulator. VLCC man-b&w mc 90 to give you some information about our simulators.

Can software be developed or is it already available for CBT simulator for training and maintenance purposes onboard simulating trouble shooting of the following engine room machineries?

Please put a check mark in the appropriate box.

	Machinery & Parts	**Available**	**Can be developed**	**Can not be developed**
1	Turbocharger of the M/E	**yes**		
2	Governor of A/E	**yes**		
3	Centrifugal Pumps	**yes**		
4	Purifiers	**yes**		
5	Air Compressors	**yes**		
6	Safety Valves on the Boilers	**yes**		
7	15ppm monitor of the OWS	**yes**		

(See attached file: SM-0501-B1 Neptune ERS MAN B&W 5L90MC VLCC L11-V Product Dâ€¦.pdf)

Best regards

Leif Pentti Halvorsen
Product Adviser
O&M Simulation & Training,

Kongsberg Maritime AS

Phone: +47 33032610
Mobile: +47 48084663

Appendix V CBT Workstation

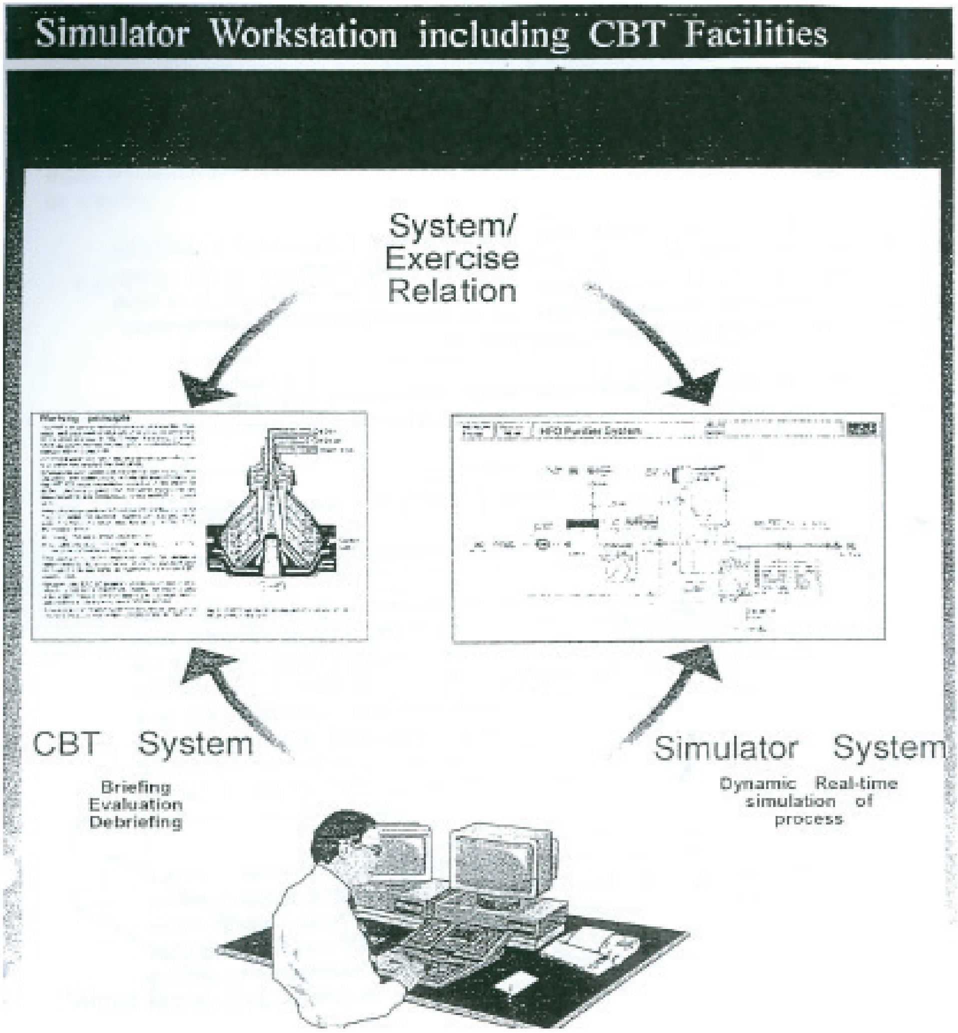

Figure 7 CBT Workstation
Source: (Cross, 2008)