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The utilization of engine room simulators for freshmen and career personnel : training and assessment

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THE UTILIZATION OF ENGINE ROOM SIMULATORS FOR FRESHMEN AND CAREER PERSONNEL:
(TRAINING AND ASSESSMENT)

BY

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A dissertation submitted to the World Maritime University in partial fulfilment of the requirements for the award of the degree of

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in

MARITIME EDUCATION AND TRAINING
(Engineering)

1996

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 been previously 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

The dissertation is a study of the use of simulators for training and assessing marine engineering students, considering the inclusion of simulation objective training courses into the curriculum of the Saudi Border Guard Naval Institute as a means to fill the gap between theory and practice.

The introduction of new technologies, especially in propulsion and marine equipment in general, the downward trends in on board training experienced during past years and the requirements for more stringent environmental regulations are pressing the SBGNI to find new methods of training and assessing to help solve this problem.

The dissertation has its framework in IMO's 1995 STCW Convention. A brief analysis is made of the relevant regulations and recommendations in regards to the use of simulators in training and assessment of marine personnel.

A brief look is taken at the present organizational needs of the SBGNI in light of the implementation of the 1995 STCW Convention, comparing relevant points with those in place at the Institute.

The ERS as a training tool, area of application, the role of instructor and the advantages and requirements of these teaching devices are examined. The role that PC-based diesel simulators can play in the familiarisation of students with ship engine and equipment operations is also considered. The stages that interested institutions should follow in the installation of simulators in their premises are enumerated.

A discussion of methods to assess trainees' performance as a basic requirement in simulator training is included.

The basic conclusions include the need that the SBGNI has to update its programs according to the standards of the 1995 STCW Convention. A number of recommendations are made concerning the use of ERS and PCDES to complement the program of instruction at the SBGNI.

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LIST OF ABBREVIATIONS

ARPA	Automatic Radar Plotting Aid
CPU	Central Processing Unit of a computer
ERS	Engine Room Simulator
ICERS	International Conference on Engine Room Simulators
IMO	International Maritime Organization
LAN	Local Area Network (Computer Network confined to a building).
MET	Maritime Education and Training
MCC	Motor Control Centres
QSS	Quality Standard System
PC	Personal Computer
PCDS	Personal Computer Diesel Simulator
PTS	Part Task Simulator
SBG	Saudi Border Guard
SBGNI	Saudi Border Guard Naval Institute
SOLAS	Safety of Life at Sea International Convention
STCW 78	International Convention on Standards of Training, Certification and Watchkeeping for Seafarers, 1978.
STCW 95	International Convention on Standards of Training, Certification and Watchkeeping for Seafarers, 1995.
UMS	Unmanned Machinery Space
VR	Virtual Reality

INTRODUCTION

The dissertation addresses two main questions: the first deals with the implementation of the regulations, dispositions, annexes and guidelines of the 1995 STCW Convention (STCW 95) for the design of the technical courses for regular students and for in-service personnel at the Saudi Border Guard Naval Institute (SBGNI). The second question has to do with the introduction and implementation of simulator training facilities for practical courses and for assessment purposes.

This dissertation considers the use of simulators as a means to complement the actual training at the Institute and in particular using engine room simulators (ERS) and PC-based diesel engine simulators. This is oriented to the preparation of the SBGNI to keep up-to-date with developments in training standards around the world, as those intended with the implementation of the STCW 95.

In the STCW 95, for the first time in maritime conventions, the updating of knowledge and demonstration of skills, according to advances in technology are made mandatory. One of the most important requirements is the validation of certificates, especially for seafarers from countries where a certificate, once obtained is for a life time without updating the knowledge.

The STCW 95 improves the STCW Convention of 1978 in areas such as responsibilities for shipping organisations, uniform standards for particular maritime skills, the use of simulators in training, the qualification of instructors and assessors.

Small crews on high-tech ships, a decrease in the number of training vessels, a reduction in the availability of a supervised introduction to shipboard work, a reduction in the number of officers and the change of maritime training systems to front-entry, have increased the gap between training and job and acerbated the need for finding ways and means to ensure that students can take over shipboard duties as soon as possible after graduation.

In spite of all these factors, maritime training can however be brought closer to shipboard practice. The training job gap will hardly ever be completely bridged, neither in the training of ship officers nor in vocational training. Simulators can be used to provide training that is in important sectors so close to shipboard practice that a transfer of training becomes possible. This also opens the possibility to use the training tool for the assessment of competence.

The dissertation is divided in seven chapters. **Chapter 1** considers the need of the SBGNI to keep up-to-date with technological developments in training. It reviews the standards governing the use of simulators, the general performance standards and simulator training objectives, the performance standards for simulators used as training and assessment tool, as well as the qualification of instructors and assessors. Of special interest are the dispositions of the Convention on the minimum requirements for certification of ratings.

One of the most important aspects of the STCW 95 Convention is the introduction of the way training of seafarers should be carried out. The convention places an important role on simulators and qualification of trainers.

The coming into force of the STCW 95 in February 1997, provides a rare opportunity to bring the Institute's standards in line with the international standards required and suggested by the Convention.

Chapter 2 examines the requirements of the STCW 95, regulation I/8 and the standards specified in section A-I/8 and the guidance stipulated in section B-I/8 of the Code. It compares the requirements of the Code with the relevant points at the Institute. The main interest is to determine, to a certain degree, whether the Institute, in its present organisational structure, can comply with the regulations and the Code's requirements and guidance, and the measures that the Institute can take in order to fulfil the obligations stipulated in the new Convention. An examination of the STCW 95 regulation I/12 and sections A-I/12 and B-I/12 of the Code, regarding the use of simulators as a possible means for modernising training at the Institute is also included.

Chapter 3 introduces the most important concepts of engine room simulator (ERS), and their evolution in the maritime field. The advantages and uses for training are also analysed. Special consideration has been paid to simulators for the acquisition of practical skills through repeated training, analysis and removing faults.

The chapter also considers the implementation of simulators in training institutions, the area of application, objectives, and a classification of simulators, their typical components, as well as the role of the instructor and assessor during training.

Chapter 4 deals with the PC-based diesel engine simulators (PCDS) as a training tool. This is based on the fact that students in most MET institutions has no opportunity to train in modern vessels, for a variety of reasons. The author states that well planned educational and training programmes aided by state of the art simulators would be the solution to this problem. The teaching possibilities of the PC-based diesel engine simulator are explored.

The lesson from ship accidents teaches that modern navigation equipment has to be operated by navigators who have a good understanding of the possibilities and limitations of the equipment. Seafaring personnel have to be trained in the use of modern navigation technology.

The new technology of simulator-based training provides an alternative for solving the problem. In simulators the trainee can acquire the necessary operational skills, with no risk for him, the ship, property or the environment, while helping the understanding and development of necessary skills.

The chapter describes the components of a PCDES, the training requirements, structured training materials and an example of a teaching program.

Chapter 5 discusses the stages for the installation of a diesel engine simulation in the SBGNI. It begins with the background of the simulator training, the aims of a simulator training programme, its objectives and its requirements.

The chapter considers the installation of new simulation facilities and sources for knowledge and experience. An analysis of the training needs of the Saudi Border Guard (SBG), the development of the training profiles, the type and level of student intake, some simulator training programs and in particular the aims of marine diesel simulation training, its objectives and types of training.

Chapter 6 considers simulators as an assessment tool. What assessment is in the context of simulator training, the development of tools, assessment of trainees' performance, performance-based assessment methodology according to category and level of the trainee.

Chapter 7 is dedicated to conclusions and recommendations. Finally, it is stated in this dissertation that the use of modern learning/teaching tools, such as engine room simulators and PC based diesel engine simulator, would help the development of practical critical skills at different levels of trainees at the SBGNI. It is also stated that objective assessment is done more effectively using simulators than through oral or written examination. The use of simulators, as an assessment tool, is justified on the grounds that the evidence of student performance is visible and measurable.

The issue of certificates of competency, on completion of the training program, entitles mariners in the merchant fleets to work on board ships. These persons have been found qualified to perform certain tasks on board. They have also been certified as being competent to meet national and international training requirements. This is also the case with naval mariners, when transferred or retired from naval duties to merchant fleets. In short, both categories of seafarers have to be trained to comply with national as well as international standards.

CHAPTER 1

THE FRAMEWORK: RELEVANT REGULATIONS OF THE 1995 STCW CONVENTION

1.1 Introduction

The standards for the construction and equipping of vessels, their inspection, survey and certification adopted by most maritime nations in the International Conference for the Safety of Life at Sea, SOLAS 1960 was the most serious effort to safeguard life and property at sea. In its more than 30 years of implementation, the Convention was updated and totally upgraded in 1974 and later on in 1978, 1981, 1983 and 1994 making SOLAS the most important piece of international legislation for maritime safety and the protection of the marine environment.

Since the first SOLAS 1960 discussions, governments and the industry recognized that "a ship is only as good as the people manning it." This still holds true today. No matter how updated a standard or a regulation might be, it can not achieve the goals on its own.

The demands for new technologies, in order to comply with the requirements of SOLAS 1974, has made available to the industry a myriad of new equipment, construction materials, methods of construction, inspection procedures, resolutions, conventions, etc. with the objective of safeguarding life, the environment and property at sea.

According to today's technology it is difficult to explain the technical causes of many accidents that have ended as shipwrecks. Never in history have ships been so sophisticated and perfect in their design and construction. In spite of this, accidents still happen. One thing is clearer now: technology has made the safety of today's ship more dependable upon the professionalism, the skills and the dedication of the crew than in technological factors. These technological developments have also influenced the development of naval vessels, equipment and communications.

Unfortunately accidents involving modern vessels have become more serious and its consequences more far reaching. The frequency of these accidents is far greater than the one envisaged by drafters of international conventions. One common factor of these accidents, on which almost all experts agree, is that most of the accidents have occurred due to human errors.

In conclusion, if existing technology is not the problem today, this indicates that the training of the human factor is the next variable to concentrate on. Recent cases such as the Brauer, Exxon Valdes, Estonia, just to mention a few, constitute a sad testimony of the latter.

Similar problems were identified right after the ratification of SOLAS 1960. For this, efforts began in IMO to provide an instrument that could help governments and the industry to train their seafarers. The adoption by most nations of the International Convention on Standards of Training, Certification and Watchkeeping, (STCW) 1978, constituted the first attempt to harmonize training of seafarers and ensure that the man on board a sea going vessel was properly trained for the job he was hired to do. This Convention has been one of the most important international treaties adopted by any international organization for many years.

As the industry develops and technologies accrued the STCW 1978 was left behind. It was necessary to adopt new approaches to the same old problem: how to improve standards of competence worldwide. The revision of the STCW 1978 of July 1995

(STCW 95 hereon) for the first time establishes standards of competence related to the actual ability of seafarers to perform their tasks safely and effectively.

Although this dissertation deals with the training of naval engineering cadets at the Saudi Border Guard Naval Institute, it has its framework in regulations and recommendations of the STCW 95. At first it seems that the dissertation contradicts what Article III of the Convention points out: the Convention applies to seafarers serving on board seagoing ships other than war, naval, government and fishing vessels, being the option left open to the Member States whether to extend it to their own vessels.

In the opinion of the author, the STCW 95 contains international requirements, dispositions and guidelines that are in everybody's interests. They should apply to the marine profession as a whole. Taking this into consideration the author proposes to take the STCW 95, as the model and a point of reference for the training of the Saudi Border Guard Naval Institute cadets. This is what this dissertation is about, to use the minimum standards specified by the Convention and let the specifics of the naval training surpass these minimum standards.

Taking the above into account, this dissertation addresses ways in which the Saudi Border Guard Naval Institute accommodates the regulations, dispositions, annexes and guidelines of the STCW 95 for the design of engineering courses for SBGNI cadets.

1.2 The 1995 STCW Convention

The original STCW Convention 1978 contains requirements for certification common to all categories of seafarers whether they are to serve on deck or in the engine room. These minimum requirements are:

a. Minimum age for the various grades of certificates
b. Periodic examinations to hold the certificate
c. Medical fitness
d. Minimum period of approved sea going service
e. Proficiency in survival craft
f. Fire-fighting courses, etc.

The most important of these requirements is the validation of certificates, especially in those countries where a certificate, once obtained is for a life time without updating the knowledge. In the STCW 95, for the first time in maritime conventions and treaties, the need to update knowledge according to advances in technology is recognized.

Three important points can be noted from the original convention, among many others:

1. The recognition that every seaman must hold a valid certificate and that the certificate entitles the holder for specialized duties.
2. The recognition for the first time that certificates have to be periodically revalidated.
3. The prerequisite of 12 months sea experience for the lower officer's ranks.

Unfortunately the original convention lacks the precise standards of competence. Those seafarers that, in opinion of the administration's interpretation of the Convention, have the minimum knowledge are granted the certificate of competence. However, different administrations have different interpretation(s). The result is the lack of uniform minimum standards and the subsequent loss of confidence in the reliability of STCW certificates.

The STCW 95 improves the STCW Convention of 1978 in three important areas:

a. Responsibilities for shipping organizations:
"...the seafarers they employ meet minimum international standards of competence". Governments through port state control inspectors can question the operational competence of seafarers.
b. Uniform standards for particular maritime skills.
The importance of this point is that the new convention details the standards of knowledge and proficiency to be achieved by candidates and the criteria for evaluating them.
c. A significant measure which is of paramount importance to this dissertation is the inclusion of simulators in training and the qualification of instructors and assessors.

1.3 Details of the Convention

The Convention will enter into force on 1 February 1997
The new training standards will begin on 1 August 1998
Any transitional measure will end on 1 February 2002
The Convention applies to ships of 750kW and 3,000kW main propulsion machinery.

The Convention has 17 articles, and an Annex of Regulations and a new STCW Code. The STCW Code is divided in two parts: Part A which contains mandatory requirements that parties to the convention will have to implement. Part B contains guidelines and recommendations.

The regulations contained in the Convention are supported by sections in the Code. Generally speaking, the Convention contains basic requirements which are then enlarged upon and explained in the Code.

This dissertation is faced with the identification of those parts, sections, dispositions, regulations or articles that could be applied to the design of courses at the Saudi Border Guard Naval Institute. Therefore, the following dispositions could be extracted from the STCW Code and implemented in the Institute. Relevant to this dissertation are the disposition shown in Table 1.1.

Table 1.1 Relevant STCW Code Regulations, Guidelines and Recommendations

Part	Chapter	Section	Tables(Standards)
A	I	A-I/1, 6, 8, 10, 11, 12(1 to 9)	
	III	A-III/1, 2, 3, 4	A-III/1, 2, 3, 4
	VIII	A-VIII/1, A-VIII/2(part 3-2,	
		4-2, 4-4)	
PART B	I	B-I/11,12	B-I/9
	III	B-III/1, 4	
	VIII	B-VIII/2, Part 3-2	

Part A, Chapter I, **Section A-I/1** refers to definitions and clarifications. In this chapter the importance is placed on the definition of 1) standards of competence 2) operational level serving as engineering watch and 3) evaluation criteria.

Section A-I/6 contains the regulations on training and assessment, qualification of instructors, supervisors and assessors, in-service training, assessment of competence and training and assessment within an institution.

Section A-I/8 Quality standards

Section A-I/10 Recognition of certificates

Section A-I/11 Revalidation of certificates

Of special interest to this dissertation is **Section A-I/12** on Standards governing the use of simulators.

Because the dissertation is about the use of simulators in training, the next pages will concentrate on the concepts in the STCW 95.

The standards governing the use of simulators are contained in Part 1 of Section A-I/12. The general performance standards is aimed at ensuring that the Parties to the convention use suitable equipment according to the training objectives, with appropriate physical realism as close to the real shipboard behaviour as technically possible, i.e. producing operating environment and conditions to provide training experiences in emergency and unusual situations. Paragraph 2 of this section also establishes the performance standards for simulators used as an assessment tool.

Although the revised Convention contains extensive mandatory requirements and guidance concerning performance standards, they are only concerned with the use of radar and ARPA simulators in training as a method of demonstrating competence.

Part 2 of Section A-I/12 establishes the simulator training objectives, training and assessment procedures as well as the qualification of instructors and assessors.

Chapter III of Part A contains the mandatory minimum requirements for certification of seafarers in charge of the engine department. Of special interest for this dissertation are the dispositions of Section A-III/4 on the minimum requirements for certification of ratings.

A reference is made in regulation 14 to the International Safety Management (ISM) Code, which was adopted by IM0 in 1993 and was made mandatory under the May 1994 amendments to the International Convention for the Safety of Life at Sea (SOLAS), 1974. The regulation details further company responsibilities for manning, certification.

Part B of the Code contains guidance intended to help Parties implement the Convention. Its dispositions are not mandatory; however, the recommendations in general represent an approach that has been harmonized by discussions within IMO and consultation with other international organizations.

The STCW 95 Convention is now a reality. With it, educational and training institutions are required to compare the standards they are actually using with those intended in the STCW Convention as revised. The Saudi Border Guard Naval Institute has a unique opportunity to update the training program to accommodate the intended minimum standards. Of particular interest is the amendment A-I/12 referring to the use of simulators. This dissertation is particularly framed by this disposition.

No doubt the most important change in the STCW 95 Convention is the introduction of the way training of seafarers should be done. The convention places an important role on simulators and qualification of trainers. Training at the Naval Institute of the Saudi Border Guard is basically theoretical in nature, due to restrictions for practical training. Simulators today are proven tools in providing a highly realistic training environment for all mariners. The use of these devices is already extended and the benefits from training as a whole have begun to accrue.

This dissertation considers the use of simulators as a means to complement the actual training at the Institute and in particular using engine room simulators (ERS) and PC-based diesel engine simulators. This is all oriented to the preparation of the Institute to keep up-to-date with developments in training standards around the world, as the intended with the STCW 95 Convention.

CHAPTER 2

THE BORDER GUARD MARITIME INSTITUTE AND THE STCW 95

2.1 Introduction

Chapter 1 considered the need for the Saudi Border Guard Naval Institute (the Institute here onwards) to keep up to date with technological developments in training. The coming into force of the STCW 95 provides a rare opportunity to bring the Institute's standards in line with the international standards required and suggested by the Convention. In the training area, full compliance of the STCW 95 requirements depends on the preparation and implementation of sections A-I/8, A-I/9. Modernisation of the curriculum and syllabuses of the Institute would depend on compliance of regulation I/12 of the Convention and the implementation of sections A-I/12 based on the guidance provided in section B-I/12 of the STCW Code.

This chapter examines the requirements of the STCW 95, regulation I/8 and the standards specified in section A-I/8 and the guidance stipulated in section B-I/8 of the Code. It compares the requirements of the Code with the relevant points at the Institute. The main interest is to determine, to a certain degree, whether the Institute, in its present organisational structure, can comply with the regulations and the Code's requirements and guidance, and the measures that the Institute can take in order to fulfil the obligations stipulated in the new Convention. An examination of the STCW 95 regulation I/12 and sections A-I/12 and B-I/12 of the Code, regarding the use of simulators as a possible means for modernising training at the Institute is also included.

Since the Institute is a hybrid organisation, in the sense that it includes both military and civil duties, with a strict military central command, it seems strange to examine the contents of the STCW 95 Convention and the Code. The opinion of the author, this has a simple explanation in the fact that training activities, at least for the civil components are the same for both categories of functions. If the Institute is to be shaped after modern technology and teaching methods, the consideration of the latest advances and requirements of the STCW 95 seem adequate at this point in time.

2.2 The Institute

The foundation of the Institute in 1973 was the direct result of the Saudi Border Guard's needs to expand and modernise its operations. The initial purpose the Institute was to train the marine personnel required to operate and maintain vessels, equipment and naval bases. Since that time, the Institute has been providing the different SBG's units with trained personnel at the vocational level, and also specialised courses for Saudi officers freshly graduated from foreign academies, and for mandatory refresher courses for the in-service personnel.

2.2.1 Objectives of the Institute

Today the Coast Guard Institute has the following objectives:

1 To be the national centre for the training of nautical, engineering, and technical personnel of diverse backgrounds in different nautical and technical skills required by the operations and workshops of the SBG.

2 To develop the skills of crews and maintenance/repair personnel to increase both performance and the level of efficiency of vessels and equipment, and the personnel involved.

3 To provide training to the in-service personnel according to the needs expressed and requested by the different units and workshops.

The Institute, as the specialised training unit of the SBG, sees the need for a continuous educational and training program for officers, ratings and technicians within the Saudi Border Guard organisation. Therefore, it is imperative to modernise the curriculum and also the syllabi of the education provided by the Institute. It is necessary to complement the theoretical courses with a more practical training, making the courses more outcome oriented.

An institution such as the Institute can not embark on such modernisation without first reviewing the actual administrative and academic structure. Here is where the requirements and guidance of the STCW 95 plays an important role. Annex 1 of this dissertation contains a comparison between the requirements of the Convention and the Institute's structure.

2.2.2 Requirements of the STCW 95 Convention

In the training area, the STCW95 Convention places more emphasis on skills acquisition and demonstration of ability to perform tasks. The modernisation of the curriculum and syllabuses of the Institute will depend on compliance of the following regulations, and related sections of the Code:

Annex to the Convention, Chapter I, Regulation I/12
Use of Simulators
Annex 1, Part A of the Code, Section A-I/12
Standards governing the use of simulators
Annex 2, Part B, of the Code Section B-I /12
Guidance regarding the use of simulators
Chapters II, III and IV and VII of the Code Part A
Standards of competence for deck, engineering and radio operators
Annex to the Convention, Chapter I, Regulation I/6
Training and assessment
Annex 1, Part A of the Code, Section A-I/6

Training and assessment

Annex 2, Part B, of the Code Section B-I /6

Guidance regarding training and assessment

Chapter VII of the Convention on Alternative certification

Annex 1, Part A of the Code, Section A-I/8

Quality standards

Annex 2, Part B, of the Code Section B-I /8

Guidance regarding quality standards

One of the most important aspects of the STCW 95 Convention is that it introduces measures to ensure that the standards of competence contained in the Convention are implemented uniformly world-wide. Controls have been adopted to ensure both compliance by the industry and effective implementation and enforcement by governments.

Regulation I/8 of the Convention states that:

" .1 ...

all training, assessment of competence, certification, endorsement and revalidation activities carried out by non-governmental agencies or entities under its authority are continuously monitored through a quality standards system to ensure the achievement of defined objectives, including those concerning the qualifications and experience of instructors and assessors; and .

.. .2 where governmental agencies or entities perform such activities, there shall be a quality standards system. "

This regulation requires governments to demonstrate that the training and certification systems approved in the respective countries incorporate quality standards which are subjected to independent evaluation.

In order to find out to what extent the Institute requires adjustments to its academic and administrative structures, to be modelled after the STCW 95, this dissertation considers in detail the requirements for the internal self evaluation and independent, external evaluation of sections A-I/8 and B-I/8 of the STCW Code.

The requirements for an internal evaluation of quality assurance activities and the 5-year external evaluation have the purpose of assuring that the standards for training and certification are applied by all governments world-wide. IMO hopes to control the implementation of the Convention through these mechanisms.

The objective of an internal self-study is to enable MET institutions to self assure that the quality standards being implemented achieve the desired results at all levels of the administration as well as in all training and academic activities.

2.2.3 The administration

The first element required by a Quality Standards System (QSS) is a policy aimed at achieving the objectives of the administration of the MET system. This policy should constitute commitment that included all levels of the administration of the certification and training activities.

The policy of the Directorate General of the Border Guard (DGBG) stated in "Naval Institute Training Courses", (1991) :

"... we are committed to continuous progress in the field of training."

Thus, the Institute developed this policy in the following documents approved by the DGBG :

- Strategic planning,
- Training plans,
- Training programs,
- Institute administrative standing orders,

- Instructional standing orders,
- System of examinations,
- Curriculum and syllabi

These documents are subjected to review annually to make sure that the Institute comply with the commitment to

"... achieve the required standards for accomplishing the aims and mission with which the Naval Institute was entrusted with."

As can be seen, quality standards are a concept already present in the Institute since its foundation in 1973. Unfortunately, the system has yet to be designed and later on implemented. Some elements of a quality standard system are present, but they have to be treated more systematically and consciously implemented as such.

2.2.4 Organisational Structure

The second element of a QSS is an organisational structure. Little can be said about this point, since the administrative structure of the Institute follows the military administrative structure of the Kingdom's Armed Forces. It is a vertical structure with little or no horizontal deviations.

The organisational structure does not include the function of quality standards, nor monitoring, instead these functions are spread over in the Training Department.

2.2.5 Responsibilities

A third element of a QSS is <u>responsibilities</u> within the training institution. All instructors, in the Institute have their own responsibilities. A problem still subsisting is the absence of a horizontal co-ordination scheme.

2.2.6 Procedures

A fourth element of a QSS is the presence of clear procedures. It means the administrative procedures for distribution of responsibilities and work loads, financial and disciplinary procedures. These are all in place by means of ordinances from the DGBG, but so far a document has to be compiled to substantiate it.

2.3 Resources and needs

A yearly budget is prepared by the Directorate General of the Frontier Forces, and presented to the Ministry of the Interior for approval. This budget is intended to be a reflection of the programme of courses for the corresponding year. The process of resource allocation is on the basis of everyday needs. These must be authorised by the Director.

2.4 The academic organisation

In the absence of an academic council, the Head of the Training Department plays an active role in the academic decision making. As mentioned before the Director of the Institute is responsible for both the management and the academic organisations. The Institute lacks a formal system of programming and course evaluations. Instructors carried out among themselves informal evaluations and co-ordination when courses are in sequence. Every instructor is in charge of his course from start to finish. This shows the absence of real procedures for evaluation and course performance assessment. Ideally the Institute should move to structure the following:

1. An Academic council
2. Administrative and academic procedures.
3. Resources to implement practical training.
4. It needs to develop assessment criteria for examinations and skill acquisition.

2.5 Quality Control Functions of Teaching, Training, Examination and Assessment.

a) Learning and performance objectives

The objectives of every course are defined in general terms on the documents already mentioned. In particular a document describing the courses assigned for that year is issued by the Institute for recruitment purposes.

b) Policies and procedures for student admission

There is an admissions committee formed by high ranking officers and executives of the SBG in charge of selecting candidates among the applicants. The criteria for selection is applied by the Committee's members in a session held at the General Directorate of the Border Guard.

To join the Institute, the candidates have to fulfil the following requirements:

1. Be a citizen of the Kingdom of Saudi Arabia.
2. Be between 16 and 24 years of age.
3. Be a high school graduate
4. Get approval of parents for those under 18 years of age.
5. Single male
6. Not less than 168 cm in height and weigh 50-80 kg.
7. Never been convicted of any crime.
8. Pass the prescribed medical examinations.
9. Pass the physical and knowledge tests required by the Institute.

c) Curriculum content

The content is decided in accordance with the needs of the SBG departments. The DGFF produces a document with the number of required courses for the particular year. The Department of Training of the Institute plays an important role in this respect.

Table 2.1 shows the main specialisation courses offered by the Institute. The list is representative of 1994-95 courses, since most of the courses are designed and implemented according to the SBG units' request.

Table 2.1 Core Courses at the Border Guard Naval Institute

A. Courses for Officers

A.1) Mechanical engineering

A.2) Electrical engineering

A.3) Electronics engineering

A.4) Advanced navigation course

A.5) Supply and administration

B. Compulsory and refresher courses for officers and ratings

C.1) Nautical Officers refresher course

C.2) Power electric operation and maintenance

C.3) Electronics operation and maintenance

C.4) Deck Nautical Petty Officer

C.5) Nautical Petty Officer navigation

C.6) Nautical Petty Officer radio operator

C.7) Nautical Petty Officer rescue

C.8) Nautical Petty Officer welding

C.9) Nautical Petty Officer supply

Source: Training Courses, SBGNI, 1994.

Many of the courses require a good theoretical background, but most importantly a solid practical base to develop skills and improve performance not to mention the development of know-how for the decision making processes.

d) Assessment and Criteria for examinations

Every instructor, being responsible for the course, designs and administers the course examinations.

e) Skills acquisition tests

Students of the last years of the studies are sent, whenever possible, to practice skills onboard the training ship and also to familiarise themselves with workshop procedures.

The Institute has its own training ship, the T/S Tebouk with dedicated specialised marine personnel and instructors. Because of age and maintenance problems, students have not been able to fully use the facility that this ship is supposed to offer for training at sea. Here the use of a simulator can partially fill the gap and take some of the pressure from the training ship.

f) Resource availability and its allocation

Whenever necessary the Institute can make use of resources available on workshops, besides the resources allocated by the budget.

g) Skills acquisition for competence purposes

Being a dedicated training institution, the Institute produces personnel for just one client (the SBG). Certificates granted by the Institute do not have the intent of being certificates of competence in the sense stipulated by the Convention. In other words, these are not nationally recognised certificates. Competence is acquired while on the job, with years of experience.

h) The assessment criteria

The Directorate General of the Boarder Guard issued a document addressing this point. In this document a set of rules are set forth in order to assure objectivity in assessment. This general rule applies now.

i) Real/simulated equipment

Real equipment is used for demonstration purposes, but not real hands-on practice is done. There are some non computerised single task simulators. The availability of simulators at the Institute is the only way to close the existing gap between theory and practice.

j) Appropriateness of instructor qualifications

Instructors assigned to the Institute are officers graduated at naval and technical institutes. Their qualifications as instructors are taken for granted. It is the experience as instructor that really qualifies the trainers and instructors.

k) Experience of assessors

The Institute has had some bad experience with assessors contracted in foreign countries, which means that the qualifications of assessors are not properly checked.

A comparison between the requirements of the STCW 95 and the way the Institute carries out its duties today indicates the need to implement a QSS at the Institute. A strong component of academic and administrative monitoring has to be contemplated to make sure the objectives of the program are achieved. It is also concluded that a quality control procedure is urgent, including the one for the administration.

2.6 The Independent, External Evaluation

The STCW 95 Code section B-I/8 requires an independent examination of all training activities carried out in the Institute. This regulation reinforces the implementation of the Convention. A proof is required that the MET institutions are doing what they are committed to and that the government demonstrate that the training and certification systems incorporate quality standards. This external evaluation is supposed to take place at least every five years. Evaluators are also subjected to show that they are competent to do this particular job.

Correction of deficiencies encountered by the external evaluators is a matter of administrative will. In order for the external evaluator to keep track of corrective measures in a time span of 5 years, it has to be rewarded appropriately and hold a long term contract with the MET institution.

2.7 Challenges and Problems in the Implementation of QSS at the Institute

The implementation of the STCW 95 represents challenges and problems that maritime institutions in general and the Institute in particular will have to face in introducing and implementing a QSS. Some of the challenges that the Institute will have to face can be summarised as follows:

2.7.1 Challenges

1. The implementation of the regulations of the STCW 95 Convention, and the implementation of the dispositions of the Code, beginning in February 1997.
2. The development of a national quality standard system for training, assessment, certification, endorsement and revalidation of seafarers' certificates of competence, following the STCW 95 requirements.
3. To implement the national standards including the administration of programmes, qualification and experience of instructors, assessors, advisors, as well as the equipment.
4. The adoption of a structural planning approach for MET training.
5. A system for monitoring training activities so as to detect deficiencies and take appropriate corrective actions.
6. Governments will have to produce independent evaluations of MET institutions.
7. Governments will have to present reports to IMO on the results of the independent evaluation.

2.7.2 Problems

Among the problems that the Institute will have to face are:

- Lack of expert personnel in quality standards and systems
- Training of instructors and administrators
- Attitudes and resistance to change

A quality standards system requires a structural way of planning training programs and courses. These will require experienced instructors and the training of the existing staff.

Although the STCW 95 Convention exempts naval institutes, the intention expressed in documents of the General Directorate of the Border Guard points to the application of standards of training in programmes and courses held at the Institute.

1. The Institute will have to develop the policy for the administrative, academic and support levels as well as for standards of courses and equipment.
2. The institute will have to adopt a training process incorporating the structure planning process.
3. A system to assure the qualification of instructors, trainers and administrative staff will have to be implemented.
4. A method or technique for quality control (Planning -- operation -- evaluation -- correction -- planning, etc.) will have to be implemented.
5. A systematic monitoring arrangement to detect whether the training objectives are achieved by all the parties.
6. An internal evaluation of how they are achieving the objectives and be sure they have the corrective mechanisms.
7. An independent evaluation of all the training activities, administration, qualifications, institutional framework. This evaluation will take place at least every 5 years.

CHAPTER 3

ENGINE ROOM SIMULATOR (ERS)

3.1 Introduction

The instrumentation of merchant and naval ships has become increasingly complex over the years. Everybody agrees that the introduction of new technologies into the maritime field will continue with no apparent end in sight. The installation of electronic and electro-mechanical equipment onboard has resulted in the reduction of personnel onboard and more specialized tasks for those who go onboard. Today it is essential that the seafarer, merchant as well as naval, be skilled in both automated and manual operations of ships and equipment.

To keep up with these trends, the training of seafarers is more important than ever before. The rapid technological innovations in the field and the growing demands for safe and efficient operation of ships require that trainees (cadets, junior officers and in-service engineers) exhibit their competence to do the job, before they go onboard. Due to reduced crews the traditional way of technology transfer onboard ships is rapidly disappearing. This is the reason why today's cadets of the Saudi Border Guard Naval Institute need to be involved in more realistic situations than the typical classroom or laboratory instructions can offer to them. Today's simulation technology is able to fill this pressing needs.

3.2 Evolution of Simulation in the Maritime Field

Some factors that have played a significant role in the introduction of simulation technology in the maritime field, specially in the engineering operational areas are summarized as follows:

- The introduction of automation onboard ships.
- The increased thermal loads on engines due to low quality fuels.
- Prices of fuel is very pressing.
- Reduced crews due to the elimination of many manual tasks on board.
- The lack of interest of young people in the sea as a carrier, due to the
- competitiveness and attractions of land-based jobs.

Simulation is not the product of a single process; many technical inventions have contributed to the development of what today is called a simulator. Examining here the most important developmental landmarks would help to bring the picture of the simulation process into focus.

As reported by Muirhead, 1985, the first simulators in the marine field were used for research purposes in Goteborg, Sweden, in 1967. They were used mainly to predict the behavior of new ship designs, new materials and procedures as well as for port design. But simulation have had long since a history on the training of operators of dangerous and inaccessible places in industries such as the electro-nuclear and aviation.

Before going further, a definition of simulator, in general, is necessary at this point. A device which could duplicate real equipment or environments is a simulator. In order to accomplish a good duplication, this equipment called simulator ought to include as much detail of the equipment and environments that it intents to duplicate, as is technically possible. With today's technology sophisticated simulators are widely and intensively used in many fields: aeronautics, nuclear plants, medicine, industry in general, universities, business, ecology, space research and operations.

Most simulators continue to be employed mainly to predict the behavior of humans and equipment in large, complicated, far reaching, dangerous and expensive systems.

Since a simulator reproduces, under controlled conditions, the behaviour and interaction of multiple variables in order to duplicate phenomena likely to occur in the real world, its role continues to expand in larger fields of application in research and training,. It can be said today that any complex equipment requiring equally complex procedures in its operations could be simulated. Specifically engine simulators are now able to generate environments where groups of trainees can be trained in operational procedures, routines, corrective measures, faults detection and corrections and many other processes.

It is a fact that in order to have an adequate experience in a number of engine and machinery failures and malfunctions, the seafarer must have many years of experience at sea. There are some types of failures, too expensive to practice in real life, which the trainee can have the chance to practice in a simulator and be prepared when encounter at sea. In this training area is where the ERS plays its more important role. An engine room simulator can produce the impossible situation. It can provide the trainee with the required experience to handle or at least minimize the effects, in considerably fewer practice hours than traditional methods. A simulator running in real-time can compress years of experience into a few weeks.

3.3 The Advantages of Using Simulators for Training

The advantages in using ERS for teaching are summarized by W. Heng et al, 1995 as: economy of the simulation training, the possibility of repeated training, improving the ability of the students to analyze and remove the faults, the shortening of the damage process, the possibility of special training and special studies The technical side of engine operations is discussed in this study.

3.3.1 Economic Advantages of Simulator Training

A simulator does not consist of large and complicated engine room mechanical equipment. In the Ship Control Systems Symposium, 1978 was reported that compared with the real ship, simulators not only save large sums of money in initial investment, they are also cheaper to operate because they do not consume large amounts of fuel, steam, water and electricity. It was found that the training costs of simulators equals 1/8 to 1/10 of that on a real ship.

3.3.2 Acquisition of Practical Skills Through Repeated Training

The trainee can engage in operational training of all kinds on a simulator in the same way as on the real engines and machinery. It is safe, reliable and can be done repeatedly. With the use of simulators in all the categories mentioned, trainees might be able to develop necessary skills, in a step-by-step approach, without pressures and repeat sessions and situations that need to be practiced or improved. All this can be done in a safe environment, at significantly lower costs for the organization and for the marine environment.

3.3.3 Analyzing and Removing Faults

A simulator software includes many codified faults. The trainees at the control console and in the engine room can check the various parameters and analyze them to determine the cause of the fault and propose a procedure to remove the fault. Besides the programmed faults the instructor can create many others, expanding in this way the application of the simulator. Another advantage is that instructors can program the most frequent faults detected in real ship operations, thus way helping the organization to get rid of operational deficiencies.

Through analyzing and removing the faults, the students can further understand the use of the various power plants and the connection between them. They can also learn what to do in an emergency. They can have comprehensive training in the technical management.

3.3.4 Analysis of Machine Deterioration Conditions

The deterioration process of some machines is very slow. This condition can be detected and felt only after a long time in real operations. In simulators some serious faults and malfunctions due to wear and tear of machinery and parts can be demonstrated at once and the effects felt almost instantly. This allows the trainees to learn to take preventive and corrective measures.

3.3.5 Simulation of accidents and special situations

Emergency training was one of the main reasons to develop simulators in the first place. An ERS enables the trainees to meet dangerous situations, otherwise impossible to experience. The situation is carried out under safe conditions, at no risk of life or damage to the vessel, the equipment or the environment Some emergency situation which occur in the engine and control rooms can be exercised on the simulator whereas they cannot be safely carried out on board a vessel without jeopardizing the safety of the ship, the crew and in all cases the marine environment.

It is, therefore of paramount importance that the engineer/technical cadets' pre-sea training provide a basic understanding of engineering systems and how they work and interact with one another under realistic conditions. Taking this into account, the author is of the opinion that simulators based as an interactive trainer can be an effective way of achieving safety in engine, machinery and equipment operations.

3.3.6 Demonstration of special studies

Many special studies can be trained and researched with simulators due to the randomizing functions of parameters. An example of such studies could the selection of the optimum economical speed of the main engine. The effect of different fuel oils and cooling water on the main engine. This tests will produce valuable conclusions.

In spite of the need expressed above there are many questions to consider before a decision is taken to implement an ERS. These refer to the way training should be conducted and the way to assess the results and not necessarily the disadvantages that this type of training represents. Most detractors of the new technology point out that simulation training is not equal to real life training. The author recognizes the criticism is valid, but on the other hand simulation has never pretended to be real life, it just represents it.

One important point in simulator training is how to judge if the trainee is competent to perform in real life. Competence is not just about the skill, the knowledge and the understanding that the simulator is capable of transferring to the trainee, competence refers also to other dimensions of the human being. Competence it is also an individual's ability to solve problems in difficult situations, to cope under stress and to be able to organize and lead a team.

Many aspects of simulation training have been appropriately regulated in the 1995 revision of the STCW Convention 1978. The new STCW Code details the competencies required of marine engineers and technicians, and specifies general performance standards for simulators if used for training and assessment. These general performance standards are discussed in Chapter One of this dissertation.

3.4 The Implementation of Simulators in a Training Institution

The aim for applying engine room simulators in any organization should be clearly stated before even contacting manufacturers. For clarification purposes the following aims should be considered if an ERS is to be implemented in the SBGNI.

3.4.1 Area of application

a. ERS to be applied to the basic theoretical education

1. For this application the simulator is a modern interactive teaching aid that could be integrated in the teaching in all levels of education.
2. ERS is an element that enable the students to prove their proficiency in a number of technical and operational fields where teaching and examination otherwise have been of a very theoretical character, specially in the SBGNI.

b. ERS to be applied to the training of in-service engineers and new personnel

A simulator could be applied in operations and procedures training courses for new and junior engineers in the force.

It could be also applied to engine room management courses for crew teams.

Engine-room courses according to the demands from the service.

According to Lem, S.,1993, before any implementation of simulators in teaching, four main steps have to be considered. An appointed working group should be the one in charge of carrying out tasks as the following:

1. To prepare the specifications according to the type(s) of simulator(s) chosen.
2. To prepare a model for how education and teaching should be structured and performed when using simulators.
3. To develop courses specific for cadets for in-service engineers, according to the demands.
4. To prepare examples of simulator application in the basic theoretical marine engineer education and test them accordingly.

Equally important to the application of ERS in teaching is the setting of clear objectives for the teaching process. Some of the operational training items often used in teaching are: operation of the main engine remote control equipment, main engine stand-by operation training, training for correct maneuvering of the equipment and training for duty in the engine room. The training of marine engineering and technical cadets is guided by a set of objectives as follows.

3.4.2 Training Objectives

Certain training objectives can properly be reached only by means of real equipment and experience. Per Branstad (1993) considers that color graphic workstation presentation and practice will be sufficient for some types of training. Some trainees are able to cope with higher grades of abstraction than others, all depending on their experience and the specifics of the training objectives.

The precision to define the training objectives is of paramount importance in simulator training. Some training objectives have been considered by Van der Marel, Harms and Teekema (1995). The trainees are to be trained in the following areas and conditions:

- To respond to operational conditions
- To optimize plant operation
- Procedures for ER operational control onboard and in port.
- Actions, procedures, processes, management and equipment of the engine room procedures and routines
- Alarm procedures reported from the bridge
- Procedures to respond to emergencies

Specific training for cadets may include:

- Standing watches at sea
- Power calculations for normal operations
- Preparation of engine plant for departure
- Switching of auxiliary diesel driven generator
- Treatment of oil residue, engine room bilge
- Starting and stopping shaft generator

- Operating instructions and engine parameters
- Engine start, stop and load change.
- The engine parameters when stopped.
- The engine parameters when running.
- The engine parameters under different speed and load.

Different operation conditions simulation

- Pressure and temperature.
- Lubricating oil, cooling water

When a single simulation the objectives should include the training in the following aspects: Handling of air filters, air blower, air flow efficiency, gas turbine, gas leaks, fuel efficiency, injection, cooling efficiency, friction coefficient, engine speed, engine load.

In a multiple process simulation, training objectives may include the following conditions and equipment:

- Air filter fault related to all other systems involved in the simulation session
- Air blower fault and all other simulated systems
- Gas turbine and all other simulated aspects
- Air cooler fault and all other simulation
- Gas leak through piston rigs or valves with all other simulation
- Fuel efficiency and all other simulation
- Injection advance changes and all other simulation
- Cooling efficiency and all other simulation
- Friction coefficient and all other simulation
- Engine speed and all other simulation
- Engine load and all other simulation

3.5 Classification of ERS

Simulation is a complex computer system about any radar, navigation, shiphandling, engine, machinery, equipment, cargo, propulsion, or other ship systems. Simulation provides a realistic imitation of a particular system's operating parameters in real time and has an interface suitable for interactive use by a human operator or group of operators. Functions are achieved through specially designed and programmed software operating on general or specialized computer hardware under a computer communications network environment.

According to Cross (1995), simulators for ship engine and machinery operations can be classified in the following types:

a. **Engine Operations**
    - Propulsion plant simulators
    - Replica of engine control room
    - Alarm and control panels as in engine room
    - Actual engine usually replaced by mimic consoles
    - Added noise to create lifelike operational influences
    - PTS for specific engine parts and procedures

b. **Steam generation plant simulator**
    - Stand alone or part of engineroom
    - Specific function of steam equipment
    - PTS
    - Full generation plants

c. **Electrical plant simulators**
    - Stand alone or part of engineroom
    - Specific function of steam equipment
    - PTS
    - Full generation plants

d. Refrigeration plant simulation

- PTS
- Specific equipment and physics to be simulated and practiced

e. Full mission engine room simulator

- The engineroom simulator

All the types considered require different hardware configurations. Some types may be upgraded, and expanded because of their modular arrangement, while others are function-specific (single task and PTS).

Simulators can be used in an optimal way only if the configuration required for the training intended and a planning effort precedes their installation and use. This is the reason for considering some of the steps in implementing an engine room simulator project.

3.6 The Instructor

One of the most important problems in the initial stage of implementation of a simulator is the availability of qualified instructors. Instructors with the necessary qualifications for simulator training are difficult to find among the existing permanent staff of the SBGNI.

An instructor besides being responsible for the completion of courses they is also responsible for carrying out regular debriefings and evaluations to the satisfaction of the trainees, the SBG and possibly also the maritime authorities.

Instructors of different qualifications are necessary since they are to be involved in all the stages of course planning and their implementation.

For **instructors for the basic operational training course** the following qualifications are required:

1. Pedagogical qualifications

- Awareness of the importance of using learning objectives and learning outcomes
- Knowledge of how to perform debriefing and evaluation in accordance with the learning objectives and the learning outcomes.

2. Professional qualifications

An experienced marine engineer being able to set up qualified and realistic scenarios and supervise that the progress is realistic and

- be able to recognize and interpret the response of trainees.

3. Psychological qualifications

- Communication manners, leadership and briefings
- Human needs and motivation
- Attitudes and skills
- Norms
- Authority
- Problem solving behavior, delegations and ways of thinking
- How to cope with stress

For engine room resource management courses the instructors should have the same qualifications as in the other courses. However, this course also requires the attendance of a co-instructors who should be a qualified active Chief Engineer from the in-service staff in order to support:

- the SBG policy concerning the way of operating and managing the ships
- an assertive authority in the field
- the final course evaluation, which could influence the career of the trainees

3.7 Types of Simulator

Over the years a large number of simulators have been developed. These have all tried to use the latest in technological advances. The simulators of today could be classified in the following categories:

1. According to the work-load that it has to performed, part task simulator (PTS), multiple task simulators, and full-mission operation simulators.
2. According to the number of people that can be trained on PC simulator, simulators for small groups of trainees using computer networks known as Local Networks (LAN) or for the training of entire team management in unmanned machinery space (UMS) and watchkeeping.
3. According to the area of application (e.g. research and training simulators).

The increasing availability of computers at work, school and at home has enabled enthusiasts and also professional simulator staff of installations around the world to develop their own programs for training, assessment, games, entertainment as well as for research purposes. All this has resulted in a multitude of new simulator exercise scenarios and databases. These situations have created a wide variety of computer programs, new tools and even entirely new simulators capable of duplicating from one or a few tasks to full-mission simulators.

These developments are not estranged to the maritime field. During the late 1980's and early 1990's the use of simulators has become widespread in all the categories of training. In many countries today all types of marine personnel from engineers, nautical people, technicians, cargo handlers, etc. are being trained on simulators.

3.7.1 The Part Task Simulator (PTS)

The IMO Intersessional Working Group report of October, 1993 defines a PTS as an instrument or facility which is capable of simulating a single ship's system or a limited combination of tasks relating to a system.

PTS can replicate, for example electrical power plants, motor and marine diesel engines. PTS forms the bridge between the PC computer based simulator and the more complex full-mission engineroom simulator.

PTS types of simulators are essential in the pre-full-mission simulator training. They allow trainees to practice part of the tasks before entering a full-mission ERS simulator. PTS allows cadets to gain confidence in specific pieces of equipment that they will encounter in training on a full-mission ERS. In the real full-mission simulator, it permits candidates to work without the pressure and stress of having to learn the procedures and how the equipment works. This approach also allows to measure more objectively the acquisition of skills on the part of the trainee knowing that any mistake he makes is not due to not knowing how a particular piece of equipment functions, but to the complexity of the exercise.

3.7.2 Typical Components of the Engine Room Simulator

By definition the ERS represents the complete engine environment. It consists of an engine room system created by the interaction of computer(s) hardware and software and computer network linking all parts of the virtual engine as if they were onboard the ship shown in Fig. 3.1. The system is designed in such a way that the actions of a trainee produces operational responses typical of a real propulsion plant and auxiliary components. These simulators are classified in steam plant simulators, medium-speed diesel plant simulators, and slow-speed diesel plant simulators. The engine room, as defined, is a full-mission simulator and as such may comprise at least the following sections:

1. Large Scale Mimic Panel

The large scale replica of the control panels represents the various engine room systems. In most of the systems distinctive colors outline each system in line or block diagrams. Each system contains the filters, header tanks, pressure gauges, pumps, strainers, temperature measuring devices, temperature controls, and valves essential to the operation of each system.

The panel interacts with facilities for local. operations of pumps, valves, auxiliaries and main engine. The state of operation is indicated by lights and also by indicating instruments. Instruments are of the analog readout type and some may be of the dual scale face to accommodate readings appropriate to the engine characteristics.

2. Local Panels

Panels represent the various motor control centers (MCC) of engine room systems on board. These are fitted with start/stop and open/closed buttons and running lights, gauges and controls as applicable. Features for resetting faults and simulating repairs are included on each panel.

3. Visual Display Unit

High resolution visual display units, when available, located in the engine room is used for the presentation of alarms and inspection of the process model variables .

4. Synthesised Sound System Equipment

Loudspeakers reproduce the simulated sound from the machinery located in the engine room.

5. Private Intercoms and Telephone System

A telephone system to connect the engine room, control room and instructor's station is provided in order to provide simulation of on board communications between engine room and bridge.

6. Control Room

The simulated control room is an extension of the engine room to be employed as a remote sensing and control center for the propulsion machinery systems as found on-board today's diesel engine driven ships. The control room simulation units interface and operate the functions of the engine room and at the same time provide a link in the remote plan/energy management configuration. The control room is also the prime link in the bridge, control room/engine room and unmanned simulated operation mode.

7. Plant Management System

The plant/energy management system is primarily a stand alone system with interface to the engine room, control room and briefing/debriefing room. These systems are intended for use for individual exercises or for integrated total plant simulation.

8. Process Analysis Station

An integrated multicolor process analysis station may consist of three trainee positions with high resolution monitors. Each work station has the capability to allow either the instructor, or trainee to modify both the graphic presentation and analysis parameters and to store the results for use during future exercises.

9. Briefing/Debriefing Room

The briefing/debriefing room equipment has the capability to interface with the simulators or to stand alone for separate exercises. It will also function at the same time as exercises are in progress on the simulators repeating the trainee activities and to playback the trainee exercise to assist in the correction of errors in procedures.

10. Instructor Facilities

The instructor (or examiner) is provided with a composite set of facilities which will effectively enable him to prepare exercises in advance, to supervise exercises in progress and to debrief the trainee at the close of an exercise.

These facilities include an interactive command and control terminal with possibly an integral plan view display , intercom, and a debriefing facility. It is important that the overall design and integration of this instrumentation do not overload the instructor with exercise controls duties to the detriment of trainee instruction. Easy of entry and retrieval-of information is expeditious and straight forward with structured prompt and paging sequencing procedures.

11. Console

The console is divided into two sections, the maneuvering section and the communication section.

12. Sound and Noise Simulation

For achieving realism to simulate real life situations, a sound generation system is an option, for producing audible sound in the control room and in the engine room. The system is controlled by the computer and can mix characteristic sound-pictures from the various types of equipment during normal run, shut-down and start-up as well as the effect from waves and unsteady ship movement (e.g., hull creaking, pitch noise, propeller torque noise, empty tanks surface noise).

3.7.3. The Workstation (Color Graphic) ERS

A workstation simulator is actually a higher version of a PC computer based simulator. The memory and speed of the processor is much higher. This allows more speed and memory for better images and real time processing of engine systems and plant procedures. It also allows operation commands to be executed in real time for interactive use. This simulator system is appropriate to be used at all levels in basic theoretical education.

A typical configuration of the workstation simulator consists of a computer main Central Processing Unit (CPU), a graphic display, and the instructor and the trainee stations. The typical workstation consists of a color graphics display (screen), a keyboard and a printer, all in a network environment (LAN) that allows the communication between the instructor(s) and the trainee's workstations. This configuration allows the practice and in depth studies of the different processes and systems involved. Since this type of simulator is mainly a computer it can run many different programs. In this way the use of the simulator is not restricted to a specific type of software. This diversification is important for training purposes and in optimizing the use of the simulator. The simulator can go from a shiphandling

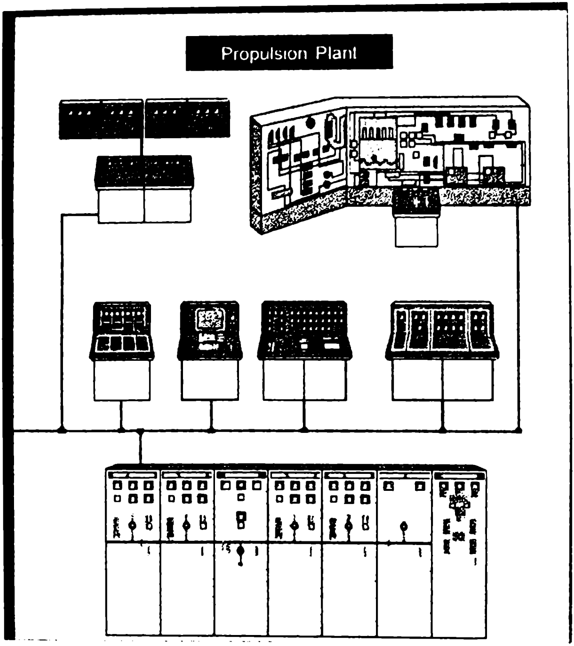

Fig. 3.1 Typical Component of ERS
Source: NORCONTROL

simulator to a cargo handling simulator allowing the training of different groups of trainees.

3.7.4 The Colour Graphic Full Mission ERS and the Workstations

This combination of full display of operations and views and remote-operated workstations (e.g. a PC) offers increased great flexibility and training capacity. Here, it is usually the instructor station (called server) that connects the two parts through a computer communication LAN (Local Area Network). The trainee can experience realistic operational actions which allows him to analyze the different processes and procedures involved. Fig. 3.2 shows the typical configuration of a full mission ERS.

3.7.5 The Use of Personal Computer Simulators

The latest developments in simulation technology come with the increased power of computer processors. Until 1994, small computers, such as PCs, XTs, ATs, Macintoshes and Compaqs based simulators have used programs designed to simulate a single ship system or a set of operations in interaction with the individual at the keyboard. This technology, although still in use, restricted the development of simulation to simple and basic forms of simulation to be applied to basic training. Today, the power of new microprocessors, (Intel 80486 and Pentium series, Mac-Power PC series) greater working memory capacities, new enhanced graphics and multimedia features (sound, animation) make the generally called PC computer simulation fast and therefore more realistic. No doubt the new power of computers has extended the simulator's capabilities. With the introduction of Virtual Reality (VR) to the PC world a further development is now under way: VR will make possible functions and processes unthinkable by today's standards, specially in the confines of the engine environment.

The training potential of the PC computer simulators, as stand-alone or in networks, is beginning to be recognized. PC simulators are used more and more as an individual training aid to students in their own time, at their own pace (stand alone). Many functions make these systems an adequate tool for training. One of these features is to be able to save any situation and the subsequent repetition and correction of errors and mistakes in operations. This and other features allow trainees to develop skills and thinking processes necessary in real life.

The use of PC computer-based ERS and PTS allows the trainee to be involved, motivating him to learn. Simulators also provide a facility for the development of competencies that cannot generally be acquired in the workplace and simulators are good places to learn correcting mistakes.

Today, a PC computer simulator can use GigaBytes of storage memory, enabling the system to save a great number of situations and incidents. This allows trainees and instructors to instantly replay or clarify and discuss the training during debriefings and also the repeat the exercise if that is the case. It also allows performance comparisons between team-training under identical inputs. This is important because it opens the possibility to use the ERS as an assessment and examination tool.

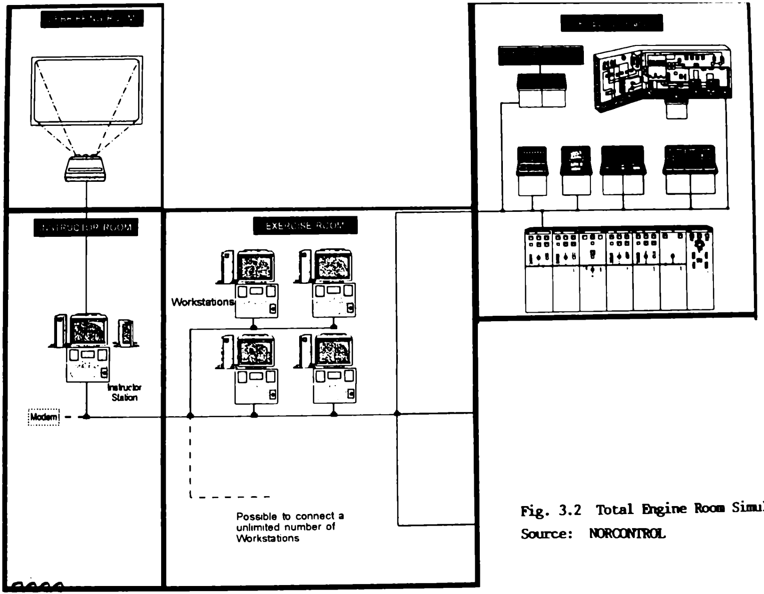

Fig. 3.2 Total Engine Room Simulator System

Source: NORCONTROL

CHAPTER 4

PC-BASED DIESEL ENGINE SIMULATORS AS A TRAINING TOOL

4.1 General Considerations

In chapters 3 and 4 simulator aided education and training for maritime personnel is mentioned to be mandatory under the provisions of the STCW 95. Students in most MET institutions have no opportunity to train in modern vessels, for a variety of reasons. The author states that well planned educational and training programmes aided by state of the art simulators would be the solution to this problem.

One of the strongest arguments to justify the use of modern teaching-learning technology in the maritime field is stated by Zade (1987) when faced with the proof that seafarers have not always been able to use modern navigation technology without endangering safety at sea and the marine environment. It is the lack of training and over-confidence in technology that have resulted in marine casualties. Terms such as "radar-assisted collision" and "computer-assisted collision" have been used in this context. This terms imply that accidents have partly happen because of the use of radar or ARPA.

The lesson of this experience teaches that modern navigation equipment has to be operated by navigators who have a good understanding of the possibilities and limitations of the equipment. Seafaring personnel have to be trained in the use of modern navigation technology. This also applies to the engineering department, where most of the changes have occurred.

The new technology of simulator-based training provides an alternative for solving the problem. In simulators the trainee can acquire the necessary operational skills, with no risk for him, the ship, property or the environment, while helping the understanding and development of necessary skills.

For Stammers et al (1975) training is

"The systematic development of the skill behaviour pattern required by an individual in order to perform adequately a given task or job."

Using simulators effectively, in a realistic way and with well trained instructors, the transfer of knowledge and the development of skills are not only possible today, but require less time to develop, than the real solution. Examples of the latter can be found in the aviation and nuclear industries.

The stages to install a new simulation facility is treated at length in Chapter 5. One of the ways that an MET institution has to install a simulator facility, regardless of the type of simulator and assuming it lacks the internal expertise, is to understudy at another institution experienced in simulator training and operations. In the opinion of the author this is the right approach.

The development of the mini and desk top computers, colour graphics, networking, interactive work stations has led to a considerable growth in software for use in MET. On the software side, many programs have been developed to be used in the maritime field. Many of them are not designed for teaching, but quite a few have been designed for onboard applications, and as such they are good teaching tools.

The level of sophistication of automatic systems now being installed on vessels, with high reliability and the continuing trend to unmanned machinery space operations, means that "hand on" training becomes more difficult to provide, due to the automatic nature of the plant. However, a number of computer programs have been designed to provide this hand-on experience in the area of marine diesel monitoring, operations, diagnostics, and research.

This chapter explores the teaching possibilities of the PC-based diesel engine simulator. In many MET institutions, and certainly this is the case of the SBGNI, simulation is still taken as another computer game. The intention of the detailed explanation of the PC simulator that follows is to show to those who read this dissertation that simulation is today a fully developed technology and that the SBGNI can improve its training activities by adhering to the new technology.

4.2 The PC-Based Diesel Engine Simulators

All teachers lecturing in the subject of marine diesel engine operation maintenance and diagnostics required a teaching aid to support the lectures or illustrate certain aspects of a diesel engine operation. A real engine to make the demonstrations directed to basic training is out of the question. It takes a great deal of time to set up and then monitor faults. The same applies to more advanced courses where the knowledge of operational conditions is required and subject to more pressures.

Computers e.g. PCs, desktop and laptops are relatively low cost tools that can be applied for training, as stand alone or in network environments. At the level of basic training the use of PC-based simulator programs could be used as personal teaching aid by trainees in their own time, at their own pace. Kluj, S. (1995) has shown that the more the trainees use the simulation software, the more they are able to follow lectures and practice, on the real engine becomes a lot easier. This shows the training potential of this kind of aid.

4.2.1 Components of a PC-Based Diesel Engine Simulator (PCDES)

The main component of any PCDES is a diesel engine mathematical model. The model is based on factory test bed results and the classic thermodynamic equations. Most PCDES simulator considered allow engine operations under selected initial conditions (torque, RPM, ambient air pressure) and variable technical state (dirty air blower, broken piston rings, a worn fuel pump). These simulator programs react to almost all combinations of these factors. They can be called diagnostic simulators. They are used to teach the principles of diesel operations irrespective of the type of engine. They are designed to teach how any diesel engine operates.

All simulator, nowadays are designed taken the greatest care for the human-computer interrelationship (interface). PC simulators today incorporate the typical multimedia features (audio, video) and take into account most limitations of PC systems in use in regard to graphic speed, screen resolution and hardware costs. After all, most final users are the students.

4.2.2 Training Requirements of a PC-based diesel simulator

The decision to acquire PC simulators for training purposes has to fulfil some requirements. Among those are the aims of the simulator package Vs the subject teaching objectives, tutorials and demonstration program. The specific PCDES software should be able to do the following:

To teach the theory and practice of marine diesel engine operations

One of the first requirements for the simulation software is to teach the theory of the diesel engine and illustrate the theory in a practical way. Using this concept the student can freely change engine elements as well as engine load an operating conditions, and see the effects of these changes by inspecting the engine parameters.

The student learns to understand the relationship between an engine state and engine parameters. This is important particularly for students in basic training. It also makes clear the importance of engine room watchkeeping since even very minor faults can be diagnosed from the engine parameters.

To put into practice the acquired knowledge

Another requirement for the PCDES is to allow the student to put his knowledge into practice, i.e. run the simulated engine and take responsibility for its condition and maintenance. The student should be able to develop the necessary skills to closely monitor the engine and carry out repairs when necessary. The simulator should also generate random wear and tear factors. This would make every session unique. The trainee's performance should be able to be logged and scored for assessment and debriefing. This would also open the opportunity for scoring and assessment.

The PCDES requirement has to do with the design and implementation of course materials, allowing both instructors to be able to create their own specific course materials, and for students to practice. The instructor's materials could then be loaded into the main program for students to complete as required.

The fourth requirement is related to the use of computer networks allowing many students to use the system at the same time, and bringing down the costs for the MET institution.

Perhaps **the most important requirement** for a PCDES simulator should be the capability for working in different modes, for example:

1. Standard Mode, designed as the default operational mode of the program.
2. Live Run Mode or exercise test specific knowledge is required for engine operations.
3. Lesson Mode, designed to teach subjects of the diesel engine step by step.

4. Network Mode, designed to allow the simultaneous use of the same software in all work stations logged in to a network's server.
5. Tutorial, this is the self study application, designed to teach the use of the program and specifics of the diesel engine.
6. Turbocharging system faults simulation
7. Static or dynamic mode, taking into account time or not, deterioration, corrections.

4.3 The standard and the live run modes

4.3.1 The standard mode

The objective of this mode is to let the trainee learn the relationship between the technical state of the engine or the operating conditions, on the one hand and the operation parameters on the other. The following list could well be a training plan for students :

1. The trainee has to start the engine and observe the operation parameters
2. Later, he can increase and decrease the engine load and observe the parameters
3. The trainee should find his way around the engine by changing some of the parameters and observing the effects on the gauges.
4. The current simulation session and the engine parameters can be saved on disk.
5. The trainee can also load the previously saved file rather than making new calculations. The current simulation exercise and the engine parameters can be printed directly from the program..

4.3.2 The live run mode

Like any other computer simulation programmes, in the live run mode the trainee acts as a qualified user. The trainee works against the computer, and the latter simulates dangerous situations, faults and so on. The computer also introduces random factors. These exercises are frequently saved for assessment and/or scoring.

Each live run starts with the engine in a particular technical state (set by the instructor of course, or loaded from a previously saved file). As time proceeds, any existing faults continue to deteriorate and this affects all the parameters. The trainee monitors the engine state and carries out repairs or maintenance; corrects actions leading to more efficient and economical running. Negligence, wrong or unnecessary action, leads to a loss of economical efficiency.

If the exercise lasts for a week, the computer recalculates the state of the engine, gives the trainee a summary report of the failures, and gives the scores measured in monetary values. The higher the score, the more efficient the student is.

In live mode the student is free to inspect all the available engine parameters, perform maintenance and repairs and change the load, but cannot change the engine set-up directly.

In certain circumstances, constant engine deterioration can cause an emergency stop. This means an additional penalty on top of the repairs needed to restart the engine. The accumulating score is permanently shown to the trainee. It will be saved together with the engine set-up while saving a session.

The live run can be ended at any time. The current results and the cost factors are saved automatically in the results of the exercise file. A list of the last fifty session scores is shown and the student can save the current status in a special file.

The trainee has to take into account the following rules in all sessions:

1. More steps completed during the run means better results
2. More repair and maintenance means worse results, but on the other hand, absence of necessary maintenance means higher fuel consumption and the danger of an emergency engine stop.

3. Operating the engine in a poor technical state means worse results.

4. An emergency engine stop caused by a poor technical state imposes a large penalty.

The following general principle applies throughout the exercise: repair only what is necessary, when it is necessary.

In PC-based diesel engine simulators the gauges are combined into panels to group related parameters logically:

1. Shaft parameters panel

To show engine speed, torque, specified fuel consumption and mean effective pressure.

2. Combustion parameters panel:

To show cylinder combustion pressure curves and cylinder exhaust gas temperature.

3. Air parameters panel:

To show air pressure, air filter, air cooler, air temperature after the air cooler and scavenge air temperature.

There are many different diesel engine and ambient parameters which can be continuously monitored during a session in a PC-based simulator as the one described here. The latter is just an example of the ones available.

All readings of the gauges show more than one value: the current and reference value. When reading multiple gauges the actual value for each cylinder and the reference value for all three are shown. The bigger the difference between the dual and reference values the worse the technical state is. The principle that the deviations should be used rather than the actual parameter values is very important especially for the basic training trainees.

The technical state of the engine elements as well as the engine load and operating conditions can be changed with the program set-up. The engine fault simulations are connected with a turbo charging system, combustion chamber, fuel system, cooling system and a lubricating system. The simulations can be mixed freely although some combinations make operations impossible as they would in real life.

The turbo charging systems simulations could be the following:
- air filter- increase in air path resistance
- air blower- decrease in air flow efficiency
- gas turbine - increase in gas path resistance
- air cooler- decrease in air resistance

Some of the operating conditions listed below can also be changed
- engine speed
- engine load
- ambient air pressure and temperature
- cooling water pressure and temperature
- lubricating oil pressure and temperature

Every change in the technical state or in the operation conditions starts the calculation process. It takes from a few seconds up to a few minutes depending on the actual set-up and on the Governor toggle being ON or OFF.

The package enables a students to carry out maintenance and repair in the live run mode. The trainee will be told when a particular activity was last carried out, as well as its price. The example maintenance and repairs are listed below :
- cooling pump repair
- water cooler cleaning
- cooling system washing

- oil filter and cooler cleaning
- turbo charger air side washing
- turbo charger gas side washing
- air filter cleaning
- air cooler cleaning
- exhaust system cleaning
- fuel pump adjustment

The global cost of the selected repairs is added to any previous repair and maintenance costs. This is a very important measure of his competency and can be used for his assessment. The engineer officer who has spent less in maintenance, repairs and fuel for the simulated engine operation will usually be more wanted by the owners than the other one who produces higher operation costs. The author's experience has shown that the trainees with significant practice as engineer officer require less money on the simulated engine running than the young inexperienced cadets.

4.4 Structured Training Materials

A PCDES should have a lesson feature to allow its use in the absence of an instructor. Lessons can also be developed by the instructors.

A lesson should contain a full engine set-up and a set of instructions, comments and multiple choices questions. It should consist of four main parts :

- Instruction box, which can show an instruction, comment or question
- Question box, which shows two or more possible answers or may be empty
- Answer box, which shows the answer button and the lesson statistics
- Control box, which contains a set of topic manipulation buttons and the topic number sub window.

The trainee should be able to move freely between the lesson topics using the manipulation buttons He can select any topic as often as he likes, but if it contains a question he can answer it only once. When he does this, all the wrong answers disappear and if the answer is right his score goes up. The answered question count is also incremented.

The instructor can also prepare and edit simulator lessons himself. The lesson preparation consists of the following steps :

- Planning, what should be the main subject of the lesson.
- Analysing, how the lesson aim can be achieved using the twin tools of prepared engine set-ups and questions. The questions not only test knowledge, they also force the student to check the parameters he needs to find the answer. For example if the trainee is asked whether the exhaust gas temperature for a particular cylinder is higher than the before-turbine temperature, he will be forced to find all the necessary parameters, note their values carefully and than compare them, so the trainee learns by doing and cannot rely exclusively on academic knowledge.
- Preparing, the engine set-ups that will be necessary for the single lesson topics.
- Editing the single topics, i.e. connecting prepared set-ups and questions. Every question should have only one right proposed answer and several similar false answers.

The lesson results will be shown as the percentage of the properly answered questions, which makes the result evaluation and the student assessment very simple.

4.5 The Simulator and the Trainee

The simulator forces the student to confront the situation designed to test him and this can give the student the means to avoid certain situations. Another case when the control over the student is necessary is his work in the absence of an instructor. A

PC-based simulator should provide this necessary control so every action the student takes is recorded in a special log file, together with the date and time, so the instructor can see what he did and when he did it. The log is a standard text (ASCII) file and can be viewed with any text editor.

The contents of the log file are compact and readable. If an instructor or student needs information for even more precise evaluation, the user can check the Option/Full Log switch to expand the information stored in the log file. The additional information includes the engine parameter values stored after every finished calculation. The parameter deviation is the difference (+ or -) between the actual and the normal parameter values.

The information stored in the log file is required to assess the students competency and understanding. The quality and speed of the trainee action in the comparable conditions can be used for the student comparison and can be analysed in depth.

4.6 An Example of a Teaching Program

The possibilities of PC-based diesel engine simulators are best seen through an example of a teaching program. This program complies with the STCW training requirements. In practice this program was designed for 27 work hours per student and has the following aims:

1. To teach how the engine parameters change under different loads and engine . speeds
2. To teach how the engine parameters change under different operating conditions
3. To teach how the engine parameters change when a single fault occurs
4. To teach how the typical fault symptoms change when other faults occur
5. To teach the maintenance strategy rules
6. To test the diagnostic and maintenance knowledge level.

Introduction.: simulator basics, operating instructions, engine parameters inspection, first steps.

Engine start, stop and load change: - the engine parameters when stopped, the engine parameters when running, the engine parameters under different speed and load, the actual and the reference parameter values.

Different operation conditions simulation (minimum and maximum value of the range) the ambient air (pressure and temperature), the cooling water (pressure and temperature), the lubricating oil (pressure and temperature).

Single simulation (middle and maximum value of the range) air filter increase in air path resistance, air blower - decrease in air flow efficiency, gas turbine - increase in gas path resistance, air cooler - decrease in air resistance, gas leak through piston rigs or valves, fuel effective quantity decrease, injection advance angle change, decrease in cooling efficiency, friction coefficient increase, engine speed, engine load.

Multiple simulations (mixing every single simulation with other simulations) air filter fault with all other simulations, air blower fault with all other simulations, gas turbine fault with all other simulations, air cooler fault with all other simulations, gas leak through the piston rings with all other simulations, the fuel effective quantity decrease with all other simulations, injection advance angle change with all other simulations, decrease of cooling efficiency with all other simulations, friction coefficient increase with all other simulations engine speed with all other simulations, engine load with all other simulations.

Live Run exercises: the first 20 steps followed by a save for discussion, the next 20 steps followed by a save for discussion, the final 20 steps followed by a save for discussion, general maintenance strategy discussion based on the examples.

Live Run test the first test, the second test, results, discussion.

For more than a decade of development, different types of PC-based part-task diagnostic simulators have proved that these kinds of simulators can be successfully used for education and assessment of marine engineers. The power of new personal computers combined with multimedia features, like sound and animation, makes the simulation fast and more important, realistic. Even if this kind of simulator cannot replace the full-mission simulators, it can surely extend their capabilities.

The very important feature of PC-based part-task simulators is its low cost and the possibility to also be used for stand-alone education. This makes this simulator very attractive for many colleges in developing countries, and also for shipowners, because of the possibility to be installed on board. A well cut, complete tutorial program and a set of pre-prepared lessons should always be a part of a simulator package.

CHAPTER 5

STAGES FOR THE INSTALLATION OF A DIESEL ENGINE SIMULATION IN THE SBGNI

5.1 The Background of Simulator Training

The maritime education and training (MET) establishment of the world will face the implementation of the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers, 1995 (STCW 95) coming into force in February 1997. MET institutions have to adapt to the new requirements of the Convention and further develop many aspects of their training programs. Perhaps skills acquisition is the aspect of training that will have to undergo the most changes. For this the Convention provides the necessary provisions to allow the introduction of new teaching and assessment methods. Among these new technologies is the use of simulators for training and assessment.

The STCW 95 now establishes specific and uniform standards for the attainment of competence in particular maritime skills. It contains specific criteria detailing the standards of knowledge, understanding and proficiency to be achieved in each element of competence by candidates for certification, and the criteria for evaluating them.

Part A, section A-I/12 of the STCW95 Code contains mandatory requirements concerning performance standards for simulators and section B-I/12 contains guidance regarding the use of simulators.

Furthermore, as a result of the adoption of the Convention, governments will have to comply with the mandatory requirements of section A-I/8 using the guidance on quality standards specified in section B-I/8.

The STCW 95 Convention, article III, excludes explicitly seafarers serving onboard naval vessels, and warships. The SBG has both characteristics, it is a military force by organisational structure and a civil institution administratively. In order words, the SBG is in charge of enforcement of the civil law, in the territorial waters of the Kingdom of Saudi Arabia, policing the activities on coast and sea areas, using modern naval vessels and military hardware.

The SBGNI, as the MET institution of the SBG, faces the modernisation of its curriculum in order to be able to comply with the standards set forth by the STCW 95 Convention. Future graduates of the Institute would be able to comply with the requirements for the national competence certificates as well as the international requirements.

The nature of the SBG makes it highly dependent on efficiency of operations. Rapid deployment of men and equipment, in daily SBG operations, requires planning, good preparation and equipment in peak performance. Personnel in these departments have to be competent to respond to all circumstances. Therefore, they require appropriate training in facilities with the most advanced training equipment and systems available.

Because of the variations of manning requirements across the SBG fleet of patrol boats and smaller fast vessels, the SBGNI has to cater for a relatively large span of navigation, communication and engineering education and training needs. On the marine engineering side the bulk of the effort has to be in diesel propulsion, since the conversion from steam turbines has since long been accomplished. A large demand for this kind of training is already felt at the Institute.

This chapter deals principally with the stages that need to be followed in the implementation of diesel engine simulators in general.

Depending on the particular competence, or desired skills, there are several methods specified for the demonstration of competence:

- Examinations
- Assessment of evidence obtained from:
  i) Approved in-service training
  ii) Simulator training.

This chapter concentrates on the ways to develop a simulation training facility.

5.2 Aims of the Simulator Training Programme

A simulator is capable of performing the following tasks:

- meet the criteria of the international regulations
- give a proper assessment to assist in taking the right decision
- enable the trainee to operate the engine in a cost-effective manner
- evaluate the ship in emergency cases
- use new high technical methods for optimum ship operation and
- process all the internal and external data for safe and effective operations

5.2.1 The Objectives

The exercises in the simulation training courses incorporate various objectives:

a. To provide an understanding of the engine room with the interdependence of all systems and machinery.
b. To familiarise the trainee with the unmanned machinery space which includes

alarm system, remote control of propulsion plant, alarm logging, conditions monitoring, remote control of all main pumps and automation system.

c. To increase the trainee's practical skills and experience in the operation of the main engine control equipment.

d. To provide practice in responding to malfunctions, the recognition of such malfunction, the causes and measures to take.

e. To train fresh junior engineers in basic engine room operations, routine operations.

f. To increase the confidence of trainees in demonstrating and testing the effects of varying parameters and component deterioration and plant behaviour.

5.2.2 Requirements for Simulator Training

The first element of simulator training is the consideration of the contents of training. Nakamura, T. and Ikenishi K. (1995) when dealing with training contents consider the following elements:

(.1) The national qualification criteria

This includes the knowledge required to obtain the certificate of competency according to the national law. The knowledge required is theoretical and practical as shown in Table 5.1.

Table 5.1 Knowledge Required by a Certification System

Level		
I	Basic engineering knowledge (thermodynamics, mechanics, materials)	
II	Working principles of machinery	
III	Design of structure and configuration	
IV	a) Checking, trial and operation	b) Performance characteristics
V	a)Troubleshooting. Maintenance	b)Particular phenomena

(.2) The contents of practical jobs on board

Engine operation and maintenance is a practical skill. All engineers need to be able to practice that skill to feel confident when they are at sea. Skills onboard are classified according to the contents of the practical jobs (Nakamura, T and Ikenishi K., 1995)

1. Planning, commanding and supervising the operation of the engine room system.
2. Carry out running trials of machinery and equipment
3. Normal running of machinery and equipment
4. Monitoring the condition of the engine room system
5. Normal adjustments of machinery and equipment
6. Trouble shooting and emergency procedures
7. Preventive and corrective maintenance

Today's technology requires the engineer to exercise more judgement and make more decisions than the routine jobs of an engine room system.

(.3) The hierarchical structure of training

According to the same authors, a marine engineer should be trained in the following systems:

1. Propulsion system
2. Electric power generation system
3. Steam generation system
4. Compressed air generating system
5. Transfer system
6. Bilge and ballast system
7. Refrigeration and air conditioning systems
8. Deck machinery systems

5.3 Installation of new simulation facilities

According to Muirhead (1996), there are three elements to take into consideration when faced with the installation of new facilities,

1. Guidance in instructional techniques
2. Practical simulator operational experience and
3. Practical assessment experience on the simulator

The MET institution installing the facility, but not having the expertise has a number of options to go about:

a. **Manufacturer's training programs:** These are usually short and intensive and designed to get the instructor up and running on the system as part of the contract. Pedagogical aspects may receive light treatment, although some companies such as Norcontrol offers broad training packages.

b. **Learning on the job**: Unless there is an experienced staff member, the techniques acquired may be incorrect or inappropriate leading to invalid training outcomes.

c. **Understudying at another institution experienced in simulator training and operations:** This is the recommended approach to take where skills and operational knowledge of using a simulator for effective training and assessment can be acquired in the shortest possible time. Members of organisations such as IMLA and IMSF can be of assistance in making arrangements on an institution to institution basis. Many such institutions will provide training at little or no cost.

d. **IMO model courses:** The STCW95 incorporates many of these modules by reference into the Code. It is recommended that new operators take note of the core features of these structured simulation training programmes and use them on a starter basis until they have developed further experience. The main simulation programmes are:

1.09 Radar simulator

1.22 Ship simulator and Bridge Teamwork

2.06 Cargo and ballast handling simulator

2.07 Engine room simulator

In addition, IMO model course 6.09-Training course for instructors can be of assistance in developing basic instructional techniques. However if instructors and assessors follow the guidance provided in the new STCW95 Code, they will be following in the footsteps of many experienced simulator operators who contributed through the STCW Sub-Committee to the development of such standards.

5.4 The Traiuing Nceds of the SBG

The training program is extremely important for the effectiveness of the simulator-based training system. The delivery of a simulator is incomplete without the appropriate information regarding how to use the simulator effectively to conduct training. Hence, guidelines has to be developed that address:

- the training objectives,
- methods to be employed,
- instructor preparation,
- levels of trainees, etc.

These guidelines should represent the handbook for integrating the simulator into the curricula of the Institute and for conducting the training program.

Setting up a training program for diesel engine simulators, based on a quality assurance system as required by the STCW 95 Convention begins with the assumption that the training process is structured and described from start to finish.

The system approach to training for the diesel engine simulator consists of the following stages:

5.4.1. The needs analysis

In the training design procedure it is important to determine what the training needs of the SBG Departments are and the aspects that play an important role. Several aspects have to be determined:

a. The type and level of student intake
b. The type of engines, systems and equipment to be covered
c. The skills in need of development
d. The exercises and their characteristics
e. The teaching and training required

The result of this analysis should provide the description of the problem to be used later on in the design of the training profile.

5.4.2 Development of the training profile

The training profile is the main point of the training design and development process. This describes the content of the entire training, the concrete objectives and the expectations based on the results of the needs analysis.

(.1) The advantages of designing of training profiles

Increase efficiency and better use of training time, since the training activities are more goal oriented. This will have an impact directly on the improvement in the quality of the training. This makes the design of evaluation instruments possible. The training evaluation therefore will result in more useful information for subsequent stages.

(.2) Elements in the design of a training profile

Ter Heder, R. (1995) proposed the following:

The first step in the design of the training profile consists of the definition of the training objectives. (Clear training objectives). The content of the objectives can directly be derived from the results of the needs analysis.

A training objective describes the desirable performance of the trainee in a clear and concrete way.

- specifies an observable final performance;
- states the conditions under which the performance must be executed;
- contains criteria on the basis of which can be determined whether the training objective is achieved by the trainee.

5.4.3 Development of the training products (Syllabus, manuals, scenarios, exercises)

Once the training profile has been designed, the training products can be developed. Training products should have a strong link with the training profile and together will equip instructors for the training. Training products may include the following:

1. A trainee syllabus (theory, ship data, instrument description (a simulator).
2. An instructor manual (knowledge required, training objectives, training materials, elements for briefing, exercise and debriefing, lesson plan, etc.).
3. Scenarios
4. A description of exercises.

The above planning process should result in the definition of the training modules.

5.4.4 The design of training modules

In a typical training product, the design of a training module begins with an analysis of the tasks, skills and knowledge to be trained/learned. As seen before, these elements constitute the input for the training profile and also determine the core of the training module and the content of the training.

Ter Hedde, R. (1995) divides the training modules in three types:

1. Procedure training (for critical situations)
2. Skill training
3. Familiarisation training.

Since the STCW 95, section A-I/8 and B-I/8, require a monitoring process and periodical internal evaluations of the training result, an evaluation mechanism, system or process has to be designed in order to determine where improvements are possible or necessary.

5.5 Methodology of training

The following structure of training courses shown in Table 5.2, is hereby considered by the author being of paramount importance in showing the steps in training.

Table 5.2 The Structure of Training Contents

Operation mode of engine rooms	Hierarchical structure of the system	Training contents by simulator
Dock mode	Security of seaworthiness	Shipment of FO, LO, FW, etc. OPERATION
	Compressed air generation systems	Checking operational conditions
	Electric power generation systems.	Operation (Autom. and manual)
		Monitoring of running conditions
	Transfer system	Adjusting operational conditions
In port mode	Steam generating system	Cooling down and stopping
	Transfer system	Troubleshooting
	Bilge and ballast system	Detection
	Refrigeration, air cond. systs.	Cognition
	Deck machinery system	Decision
		Response
S/B mode		Maintenance
		Preventive and corrective
R/UP	Propulsion system	maintenance

Source: Nakamura T. and Ikenishi, K., 1995.

5.5.1 What is fundamentals for Simulator Training

(.1) The type and level of student intake (Qualifications)

The classification of students levels at the SBGNI looks as follows:

a) Trainees of the first category

The students that have completed their academic and theoretical studies in MET institutions abroad or at the King Fahad Naval Academy and have no sea experience or practical experience or require an introduction on the operation methods of the SBG. These courses are often requested by departments of the SBG.

b) Trainees attending refresher courses

Junior and chief engineers that have experience at sea in the engine room and need to improve their knowledge to meet the requirements of the advanced operational training, fault studies and optimising operating and fuel economy. Trainees at this level perform tasks connected with practical ship maintenance in all modes of operation, in normal conditions and during emergencies. They diagnose the system's technical condition and do whatever might be necessary for a crew member on board ship in order to maintain the ship's plant.

Other categories of in-service personnel attend refresher courses for the following purposes:

- To get more advanced knowledge for promotion purposes
- Training in new and more automated vessels
- Revalidation of diplomas and certificates
- Training for special missions

c) Trainees at intermediate levels

Mostly last year cadets of the Institute who have had some shipboard training practice, on board T/S Tebuk and patrol boats or have acquired basic skills. They are mainly doing troubleshooting during pre-start operations and operations of the system performance analysis of the causes of trouble.

d) **Trainees at basic levels**-solve problems and perform tasks connected with practical study of ship's power plants systems, their maintenance rules, pre-start operations and starting up procedures. Mostly trainees at the beginning of their training. They do not have any shipboard training experience. The training content should be of general understanding of engine room system, operation of machinery and trouble shooting.

(.2) The type of engines, systems and equipment to be covered

Due to the variety of vessels in the fleet, there is a corresponding variety of equipment needs to be covered: high speed patrol boats, medium speed diesel turbines, in many configurations (single and multiple engines and screw, electrical generation and distribution).

Training requirements are more diverse from basic career training as part of normal student development after entry, imparting working knowledge of machinery operations, specific training requirements, such as familiarisation training for new plants and engines and vessels, advanced courses, fuel management, emergency procedures.

Within the past few years a number of engine simulators have become available and they have quickly become accepted as invaluable tools for the training of engine room personnel. This type of diesel simulator is capable of providing more information about the internal operations of engines than those obtained from the real engine at sea. Using the simulator will give better understanding of the process within the engine, trainees can improve their performance and learn more about engine maintenance and operation.

Practical training classes that could be implemented in a diesel engine simulator:

1. Simulator workshop

This is a familiarisation course including problem solving connected with the simulator training, practice in different degrees of complexity.

2. Ship power plant technical maintenance
3. Ship power plant technical operation

   solving problems connected with the efficient running and failure free power plants.
4. Ship internal combustion engines

   practical maintenance of diesel engines and their operation.
5. Boiler systems
6. Auxiliary machinery

   working parameters of parameters of pumps, compressors, separators and the impact they have in the technical conditions
7. Ships turbo machines
8. Electrical power system

(.3) Simulator training programs

a) General aims of marine diesel simulation training

The use of marine diesel simulation for training enables the student to:

1. Have a better understanding of system behaviour
2. Gain experience in practical operational techniques and rules
3. Manage system failures
4. Understand bridge manoeuvring decision making process and their interaction with power plant capabilities.

b) Learning objectives

Learning objective is a format in which the objective describes what the student must do to demonstrate that the specific knowledge or skill has been transferred. By a detailed description of the learning objectives, the evaluation of the student performance will be possible.

c) **Training types**

The main tasks of engineer officers onboard a ship are classified as the following types of training:

c1. Maintenance training

- Supervision
- Procedures
- Handling

c2. Operator training

- principles of operation
- control the process
- rule based sequences

c3. Team training

- co-operation training
- form a perfect team

c4. Decision training

- give a total overview
- implement actions to reach a defined goal
- make correct decisions

d) **Training Levels**

The different types of training can be implemented on the different levels.

d.1 Basic operational level

- Preparation for getting under way
- Manoeuvring to open sea
- steady steaming
- Manoeuvring into harbour
- Finishing with the engine
- Operation of auxiliary boiler and cargo turbines
- responding effectively to abnormal and emergency situations.

d.2 Advanced operational Training

- How will an engineer react when faced with serious problems?
- How will crew operate together when an abnormal situation develops?
- How can errors within the system be traced and corrected?
- How can the engine room system be restored to normal operation?

d.3 Economy and optimising studies

- How to judge the performance of various components
- How to differentiate between external and internal causes of a deterioration in performance. If certain performance deterioration occurs on a given component, how much will this affect overall economy.?
- How can running and tuning of various components or subsystems nfluence overall fuel economy.

d.4 Engine parameters

The following engine parameters can be observed in diesel engine simulators:

Set engine speed

Actual engine speed

Engine torque

Specific fuel consumption

Engine mean effective pressure

For each cylinder separately

Cylinder combustion pressure curves

Cylinder maximum pressure

Cylinder compression pressure

Cylinder exhaust gas temperature

Cylinder indication diagrams

Cylinder indication pressure

Lubricating oil inlet pressure

Lubricating oil inlet temperature

Lubricating oil outlet temperature

Cooling water inlet pressure

Cooling water inlet temperature

Cooling water inlet outlet temperature

Ambient air pressure

Ambient air temperature

Turbocharger revolution speed

Scavenge air pressure

Air flow

Exhaust gas pressure before turbine

Air pressure drop at the air filter

Air pressure drop at the air cooler

Air temperature after the air cooler

Scavenge air temperature

Exhaust gas temperature before turbine

Exhaust gas temperature after turbine

Exhaust gas pressure after turbine

d.5 Maintenance Tasks

The following maintenance and repair activities can be simulated

Cooling pump repair

Water cooler cleaning

Cooling system washing

Lubricating pump repair

Oil filter and cooler cleaning

Engine bearing repair

Turbocharger general repair

Air side washing

Gas side washing

Air filter cleaning

Exhaust system cleaning

Cylinder general repair (piston rings and cylinder head)

Fuel pump general repair

Fuel pump adjustment

d.6 Operation of diesel engines

Diesel engine governing and speed control for main propulsion and auxiliary services. Developments in timing, fuel injection and turbo charging arrangements for modern diesel engines. Balancing engine power output, de-tuning requirements, crankshaft alignment methods, reduction gears for multiple engine installations and for shaft driven alternators. The range of pumps available for auxiliary services with particular emphasis on feed water pump design and construction. Modern developments in pumping systems including centralised cooling systems.

(.4) The teaching and training requirements

The main teaching requirement at the Institute is to impart sufficient technical and engineering knowledge to the trainees at various stages of their career development, in order that the trainee may:

a) Achieve the necessary academic level to secure certification in his chosen vocation.

b) Achieve the necessary understanding of marine engineering to gain competency in the field.

Due to the variety of different requirements, training needs and skills to train, it is highly probable that no simulator alone can cater for all the requirements. The basic criteria should include the possibility for integration into a computer-local area network (LAN) to integrate the modules and with the capability for future additions and integration with bridge simulation to effect total ship simulation systems capable of training complete bridge/engineroom watch teams simultaneously.

Apart from the part task simulators considered, in the last few years a number of PC based diesel engine simulators also become available for training. However, it is clear that a set of criteria has to be specified before any purchase of hardware and the respective programs. In the next chapter this topic will be treated extensively.

CHAPTER 6

ASSESSMENT CRITERIA IN SIMULATORS

The use of modern learning/teaching tools, such as engine room simulators and PC based diesel engine simulators would help the development of practical critical skills at different levels of trainees at the SBGNI. Objective assessment is done more effectively using simulators than through oral or written examination. The use of simulators, as an assessment tool, is justified on the grounds that the evidence of student performance is visible and measurable.

In MET, as well as in all areas of training and learning, there is a need for a system to measure the results of such process. The following reasons can justify the latter:

1. To make sure that the required effect of training has been achieved.
2. Through monitoring make the necessary improvement to the course or teaching.
3. Through administrative and academic monitoring make sure that the teachers or instructors are qualified and performing at a satisfactory level.

As suggested by Percier, M. et al. (1995) assessments are done according to levels:

1. At the start of the training, assessment is concerned with what the trainee has, i.e. the evaluation of the trainee's knowledge and competencies.
2. During training, assessment is formative. It implies the control and monitoring of the training process. What the trainee can do, and how is he reaching his goals (ideas, purpose), are the main questions in this stage of the learning process.
3. At the end of the training, the assessment is concerned with the result of the training. The certification of the learning results. This stage is based on a prognosis on the possibilities of the trainee being able to cope with situations related to the specific training.

The issue of certificates of competency, on completion of the training program, entitles mariners in the merchant fleets to work on board ships. These persons have been found qualified to perform certain tasks on board. They have also been certified as being competent to meet national and international training requirements. This is also the case with naval mariners, when transferred or retired from military duties to merchant fleets. In short, both categories of seafarers have to be trained to comply with national as well as international standards.

6.1 Definition of assessment

The assessment during and after training, and also performance on the job place, is of paramount importance not only for MET but also for the learning process in general "...because assessment is integrated in an intentional process of knowledge transformation and proficiencies development.", Percier, M. et al. (1995).

Terms such as assessment, appraisal, evaluation, grading, measurement, testing, scoring, and validating, are used in the educational environment for something which is more or less related (S.J. Cross, 1993). A short description of the terms follows:

- Assessment .... the evaluation of a student's achievement.
- Evaluation .... the amount or value
- Appraise .... to assess the worth, value or quality
- Grade .... mark or rating indicating achievement or the worth of work done.
- Scoring .... establishing the result of a test or an exam.
- Test/examination ...... measurement device providing information about students.
- Measurement .... assignment of numerals to objects or events according to rules.
- Validation .... range of processes by which assessment can be examined to see how well training elements have worked in relation to the specific objectives.

6.2 Development of assessment methods

6.2.1 Traditional methods of assessment

In the SBGNI as well as in most maritime academies assessment of knowledge is still a result of traditional methods, that is

1. Knowledge is transmitted from experienced seafarers to the students.
2. In most academies also assessment is based on written examinations.
3. Practical examinations are used for testing the ability to use navigation or engineering devices and troubleshooting and repair of equipment.

6.2.2 The use of training vessels

Although it has its limitations, performance in a shipboard situation can be assessed providing more reliable results on a persons ability to cope with a practical task than written examinations.

At the time the SBGNI was founded 25 years ago, the approach to the assessment of acquisition of skills, in other words, the closing of the gap between training and job requirements, between theory and practice, was thought to be reduced by using a training vessels. Therefore, the T/S Tebuk was put into operation. Reality has shown that for countries dependent on technology from abroad, this is a partial solution to the problem.

6.2.3 Supervision of trainees by senior officers

This is a method frequently used by shipping companies. A junior officer is supervised by a senior officer for some time.

Recognising these difficulties on the approach to assessments in MET institutions around the world, a series of assessment methods has been designed with time. Table 6.1 presents several methods of assessment. For each method there is correspondence between the evaluated object, the constraints linked to its utilisation and certain characteristics. The classification is aimed at specifying the limits for each method in terms of goals and load for the instructor. The second column of the table, object of assessment, differentiates between performance, or the practical result and the skills, i.e. understanding and know-how. This is a decision made by the instructor. The third column: constraints refers to work-load imposed upon the mental conditions of the instructor. Physical presence of the instructor for a long time or placing emphasis on one task while others are left unattended. All methods have their constraints. The fourth column of the table refers to the characteristics of each method. An explicit method is when the criteria is clearly defined. An implicit method is when the criteria require an interpretation which cannot be formulated. Static refers to the time when the trainee is assessed at a given instant. The dynamic character refers to the trends observed.

Table 6.1 Evaluation Methods

Method	Object Performance/skills	Constraints	Characteristics
Observation drill	Performance	Length of time, focuses on details	Explicit, static, multi-criteria, collective.
Records, catalogue and curves analysis	Performance	Length of time difficulties in interpretation and in selection of variables.	Implicit, dynamic.
Video recordings	Performance	Means, length of time, selection of extracts.	Proof, collective, dynamic.
Replay and explanations	Skills	Time, selection of extracts.	Proof, collective dynamic, gives access knowledge model, static.
After-task questionnaire	Supposed skills	Non connected with actions	Gives access to knowledge model, involves a kind of response.
Holistic assessment	Interpreted skills	Competence in observations, analysis and expertise	Implicit, holistic, stereotypic.

Source: Percier, M., Caillau, M. and Wagemann, L. (1995)

It is clear that no isolated method is sufficient; rather a combination of them helps to make a prognostic on skills and trainee performance.

The predominant method of assessment in MET around the world has been in a form of knowledge-based examinations covering the diverse topics. The examinations provide coverage of nautical, navigation, management, regulations and engineering knowledge. They do not provide recognition of the individual's abilities, skills or operational performance under stressful circumstances.

No written examination prepares the mariner for the difficulties of actual vessel operations today. Today's mariners have to deal with crowded waterways, larger vessels, minimal personnel, economic pressures, more stringent safety and environmental requirements that once in violation of these requirements and laws could cause the financial ruin for owners, and the loss of the mariner's licence and livelihood. It is clear then, that today's ship operations require more skilful and knowledgeable mariners than past generations of ships and mariners.

With the introduction of simulation technology in MET institutions, a further step in the development of assessment methods was necessary. It was not until recently that a new way to measure knowledge was introduced. The radar simulators and flashing light communications were the first used for purpose of assessment for certification of deck officers (Nieri, D., 1995).

6.3 Examination Practice Today

In a traditional training environment evaluation is relatively easy to cope with. The instructor can observe a trainee action, mentally compare this with an expected standard and give a score.

The present and most certainly the future mariner must have a grasp of a vast amount of knowledge to perform his job well. However, as the airline industry has long recognised, the simple retaining of knowledge is insufficient. The use of simulators to evaluate the operator's ability to put knowledge to use and demonstrate skills gained from experience has long been a part of the certification process in that industry.

Still today, the current methods of examination used to certify that a mariner is qualified to hold a responsible position aboard a vessel simply require that the individual squeeze his brain out at the time of the test. For most MET there is a need to develop a demonstrable ability to solve engineering, stability or navigation problems.

It was sufficient for the mariner to prepare for the certification examination by learning the knowledge that was required for the test before taking the test till quite recently. It was expected that this knowledge would be gained, along with experience by years at sea in lower ratings/positions. Factors such as the diversity of vessels, type of power plant, just to mention a few, have made this situation change. The mariner cannot learn all that he is expected to know by picking it up along the way.

One of the main criticism to the STCW 78 Convention is that the Convention did not contain precise standards of competence relating to the abilities needed to perform shipboard functions safely and effectively. The convention only stipulated minimum knowledge requirements for the issue of certificates, while leaving to the "satisfaction of the administration" the determination of the required knowledge for the issue of the certificate or license.

In recognition of the above problems, the STCW 95 Convention establishes, for the first time, uniform standards for the attainment of competence in particular maritime skills. The Convention contains specific criteria detailing the standards of knowledge, understanding and proficiency to be achieved in each element of competence by candidates for certification, and the criteria for assessment, i.e. evaluating them.

The standards of competence specified in the STCW 95 relate to the outcome of training, in addition to the training itself, (ISF, 1995). These standards are presented in detailed Competency Tables throughout Part A of the STCW Code. The standards relating to specified competence are grouped together to form functions at different levels of responsibility. These Competency Tables specify detailed criteria for each element of competence to be achieved. These criteria include:

- Knowledge, understanding and proficiency

  The knowledge that underpins most maritime skills is now clearly allied to the practical skills necessary to carry out tasks safely and efficiently.

- Methods of demonstrating that competence has been achieved

  Demonstration methods include examination and/or assessment of evidence obtained from approved in-service training and simulator training.

  a.- In-service training and assessment

  Among the requirements is the need for on board training to be documented in a training record book. The instructors and assessors are required to be qualified for the specific task for which the training or assessment is being conducted.

  b.- Simulator training Section A-I/12 of the STCW Code

  The use of ARPA and radar simulators in training and as a method of demonstrating competence is a mandatory requirement for watchkeepers in the deck department. Similarly the Convention contains extensive mandatory requirements and guidance concerning performance standards for simulators.

- Criteria for evaluating the competence

The competency tables contain specific criteria for evaluating competence which relate to the actual ability required by a qualified seafarer to perform his job effectively.

In addition to the detailed specification of standards of competence, the STCW95 sections A-I/8 of the Code contains provisions that require governments to demonstrate that the training and certification systems approved in their countries incorporate quality standards which are subjected to independent evaluation. In particular regulation I/8 of the Convention requires that all training, assessment of competence, certification, endorsement and revalidation activities carried out in the country be monitor through a quality standards system to assure that the objectives are met.

Chapter III of the Convention contains precise standards of competence at different levels of responsibility, which are defined in detailed Competency Tables for the function that comprises the engine department, and mandatory minimum requirements for certification.

Section A-I/6 of the STCW95 Code contains mandatory requirements concerning qualifications of instructors, supervisors and assessors.

6.4 Simulator Based Assessment

As far as traditional teaching and learning systems are concerned, considerable ground has been covered and a number of ways and means are available for this evaluation process, as mentioned before. As far as simulation training is concerned the evaluation is behind the development of new types of simulators. As expected, the previous experience of instructors and examiners is the base for assessing trainees' performance, leaving many gaps in objectivity and consistency in the way it is done.

The first task in considering maritime simulation is to distinguish between the assessment and the evaluation required by simulation activities and then how to achieve an objective approach to this issue. According to Cross, S.J. (1993) there are various levels of evaluation, each for a different purpose:

1. Evaluation of reaction to the programme
   This only shows the opinion and feelings of the trainees about the course. Evaluation is usually rather positive as the simulator is regarded as an interesting, useful teaching tool.
2. Evaluation of learning shows the trainees achievement of meeting objectives of obtaining facts, skills and attitudes from the training. The evaluation of learning is the initial goal of the evaluation efforts as learning is considered to be what at least has to be achieved. The next step is to determine what is to be measured.
3. Behaviour evaluation is supposed to identify behavioural change which occur as result of the training effort. These are long term evaluations. A statistical approach can be followed. Theoretically, the number of accidents and casualties should decrease as the number of seafarers having gone through simulator training increases if the training sessions have been successful, the behaviour in operations has changed and the organisation has benefited in general. Statistics over longer periods of time would have to prove this.
4. Result evaluation is used to determine the actual results of the training programme in or on the whole of the organisation.

6.5 Assessing trainees' performance in simulator training

In the last ten years, marine simulators, whether integrated solutions as shiphandling, engine room simulators, single task or part task simulators are now part of many

MET institutions and are being considered by many fleet operators as essential to the training and development of mariners. Similar developments are yet to impact the authorities responsible for the certification of mariners. The STCW 95 Convention intends to fill this need.

In the case of simulator training complex systems have made this measurement difficult. In the opinion of the author there are two very distinctive, though complementary, attitudes to take into account when assessing or evaluating trainees' performance in simulator training:

First, simulator training is more than the relative performance of a trainee in a written examination, it is rather a set of behavioural processes, attitudes, skills development and knowledge that the trainee is prone to exhibit during a simulator training session.

Second, a computer based simulator is provided with sufficient working memory, which enables the instructor to save a great number of training situations and exercises. In addition to the play back possibilities, the instructor or the examiner can analyse the situations. This also allows performance comparisons between trainees, or between groups and training teams under the same set of inputs

Perhaps the latter helps to explain why, in a few years, marine training simulators have reached a great degree of technical sophistication, while the assessment of marine simulator training has not developed at the same speed or at least to the same level of sophistication as would have been expected.

6.6 A performance-based assessment methodology

A performance-based assessment methodology is necessary to assure that the licensed candidate has the required skills as well as the knowledge. Skills cannot be demonstrated through paper and pencil tests based on multiple-choice questions, or other easily-graded testing methods.

It is recognised that simulators provide the opportunity to

1. Gain operational experience in propulsion system operations, cargo system operations, shiphandling, etc. which could otherwise only be gained by observation and on-the-job training over a long period of time, i.e. by compressing many months of onboard experience into a couple of weeks and by providing extensive feedback which would not be available aboard ship.
2. Attempt alternate solutions to problems or develop alternate tactics which would be impractical to try aboard an actual vessel on in-service systems with the attendant risk and expense.
3. Practice emergency response, troubleshooting and diagnostic techniques without damage to actual in service equipment, the ability to repeat procedures, observe others performing the same procedures and to criticise and learn from the problem significantly enhances the experience over on-the-job training.
4. Study system management in a laboratory environment, repeatability of problems and extensive data collection ability that exists with today's simulators permits system studies to develop better operational procedures and monitoring techniques. Such studies would be virtually impossible aboard ship.

The development of performance-based assessment tools would utilise the widely-recognised advantage of simulators and part-task trainers to generate a scenario in which the license candidate must demonstrate his knowledge of system relationships, knowledge of operational procedures, knowledge of regulations, and his ability to follow procedures, monitor systems and situations, respond to unexpected occurrences, identify and diagnose problems, and manage personnel, in a dynamic world. There would be stress to manage. All this in a safe and risk free environment.

Nakamura, T. and Ikenishi, K. (1995) proposed a methodology for the training and assessment utilising an engine room simulator. The methodology applied by the instructor is related to the trainee degree of achievement. This is done by keeping a record of the number of mistakes and errors the trainee makes while performing a given exercise.

In order to be able to make a judgement the instructor, in charge of the training, must have not only a thorough knowledge of simulator operations, but also of the engine room system that the simulator tries to emulate. As it has been well taken by the authors the objective of the exercise is nothing but his ultimate target to lead the trainee to the real engine room system.

Trainees' mistakes and errors refer to abnormal procedures; these include: omission errors, commission errors, redundant errors and order errors. By counting the number of errors that the trainee has made while performing the exercise a general formula for the degree of achievement is defined.

$$T_A = (1 - E_N/E_T) \times 100\ \%$$

Where: T_A = degree of achievement E_N = Number of errors

E_T = Total number of probable errors in the normal procedure.

The degree of achievement is obtained by using Assemblage Technic Inc. The process consists of the definitions of errors while performing the exercise.

1. The trainee performs the exercise according to the normal procedure, i.e. based on the rules.
2. The trainee performs the exercise according to the procedure where there is no possibility of alarm. The trainee notices the error and corrects the mistake.
3. The trainee performs the exercise according to the procedure. The trainee notices the error on the procedure with the information from the alarms and corrects the mistake.
4. The trainee cannot perform the exercise. He is not able to correct the abnormal

procedure, despite the occurrence of alarms.

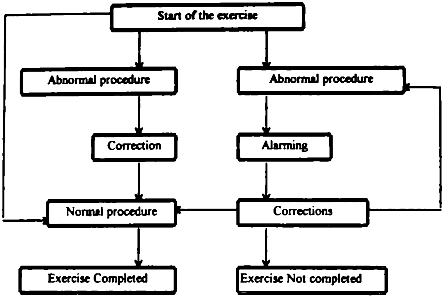

Fig. 6.1 Model of Performing an Exercise

Source: Nakamura, T. and Ikenishi, K. 1995

In Fig. 6.1 error means a procedure that sets on an alarm and a procedure that deviates from the specified normal procedure. If an error occurs, this proves the accuracy of the system operation, the judgement of the condition, the validity of the reaction and the safety measures.

Calculation of E_N and E_T

E_N is obtained by computer print outs, in this case the alarm prints and the events on the simulator.

E_T can be measured by calculating the number of probable errors for each exercise.

6.7 Knowledge assessment criteria

6.7.1 Trainees of the first category

In Chapter 3 this category of trainees includes training to in-service personnel and junior, freshly certified officer from foreign academies.

This category of trainees are trained to maintain power plants. They are also trained to check the necessary practical knowledge on board real ships, in this case patrol boats. The tests, at this level are designed to familiarise trainees with rules and ways of propulsion plant maintenance in normal conditions and emergency situations. Trainees perform duties of the fourth, third and second engineer in turn and also those of an electrical engineer.

According to Oleynikov, Akimov and Gonchar (1995), all tasks and objectives of a training level like this should be divided into the following groups:

(i) Plant preparation

Ship's propulsion plant preparation for the coming voyage after a long period of repair work.

- The preparation procedure includes operations connected with performance efficiency of all ship's mechanism and systems, troubleshooting and filling in necessary documents,
- Manoeuvre trials with the aim of checking all machinery efficiency in different operational modes;
- Formal acceptance of ship after constructions with all necessary procedures involved and filling in all necessary documents;
- Ship's propulsion plant maintenance in different load modes and ambient conditions, troubleshooting and actions in emergency situations that occur during a watch period.

(ii) Maintenance procedures

The final training level should take into consideration the following factors :

1) Ability to arrange independently a full cycle of procedures necessary for proper maintenance of the ship's propulsion plant in different modes mentioned above.
2) Ability to make decisions independently while maintaining ship's power plant equipment in emergency situations, such as bad weather conditions, breakdown of mechanisms). The necessary calculations give the

instructor an opportunity to determine how fast a trainee's reaction is in emergency versus normal conditions.

3) Ability to co-ordinate ones actions with the bridge.

4) Ability to control engine room personnel in different situations.

If a trainee's performance at this level is not adequate, the curriculum should provide some additional training sessions with the aim of drawing the trainee's attention to his mistakes.

(iii) Training

The final stage should conclude with the training on board a ship with a set of tests of trainees performing duties of all crew members under the supervision of a senior teacher and a chief engineer of the ship. The results of the tests could help to evaluate the efficiency and quality of simulator training on the whole, and if necessary to make corrections in the training programme or to design it to a particular type of ship.

6.7.2 Trainees at basic levels

Problems at this training level belong to a algorithm-type problems that are present in the simulator system from the beginning.

During this level trainees solve problems on their own. The main objective of this level is to is to create in trainees skills necessary for maintenance of diesel engines and auxiliary machinery, starting up and shut-down procedures, maintenance of ship's plants in normal working conditions. At this level and for objective knowledge evaluation an instructor performs step-by-step intermediate, as well as comprehensive monitoring of the trainees actions. Step-by-step control and monitoring are necessary to correct wrong actions and make further training operations possible. Comprehensive monitoring aims at exposing all mistakes made by the trainee during one task performance.

6.7.3 Trainees at intermediate levels

This training level includes students in the last years of study. Troubleshooting drills during pre-start operations and maintenance of working systems of power plants are the main subjects of the programme. The main objective of this tests is to inculcate practical skills necessary for diagnosing technical conditions of the system elements, for taking independent and correct decisions during emergency situations and working out measures aimed at the correction of the failure.

CHAPTER 7

CONCLUSIONS AND RECOMMENDATIONS

7.1 Conclusions

This dissertation deals with the training of students of technical and engineering subjects and in particular with the use of simulators as a way to complement the theoretical training at the Saudi Border Guard Naval Institute.

The coming into force of the STCW 95 provides a rare opportunity to bring the Institute's standards in line with the International standards required and suggested by the Convention. In the training area, full compliance of the STCW 95 requirements depends on the preparation and implementation of sections A-I/8, A-I/9. The modernisation of the curriculum and syllabuses of the Institute would depend on compliance of regulation I/12 of the Convention and the implementation of sections A-I/12 based on the guidance provided in section B-I/12 of the STCW Code.

In Chapter 1, **The Framework: Relevant Regulations on the STCW 95 Convention**, identifies the regulations and recommendations that can be used to develop new / improved programs in the SBGNI.

No doubt the most important change in the STCW 95 Convention is the introduction of the way training should be carried out. It places an important role on the acquisition and development of navigational and technical skills. This suits the Institute's programs perfectly, due to the decrease in the opportunities that students have for practical training.

Chapter III of Part A of the Convention contains the mandatory requirements for certification of seafarers in charge of the engine department. The dispositions of section A-III/4 are of special interest in this dissertation.

CHAPTER 2 of the dissertation on **The Institute and the STCW 95** examines the requirements of the STCW 95, regulation I/8 and the standards specified in section A-I/8 and the guidance stipulated in section B-I/8 of the Code.

The main interest is to determine, whether the Institute, in its present organisational structure, can comply with the regulations and the Code's requirements and guidance, and the measures that the Institute can take in order to fulfil the obligations stipulated in the Convention. An examination of the STCW 95 regulation I/12 and sections A-I/12 and B-I/12 of the Code, regarding the use of simulators as a possible means for modernising training at the Institute is also included.

Chapter 3 on **Engine Room Simulator (ERS)** is an analysis in detail of the ERS. These are the main factors which are essential for seafarers, merchant as well as naval, to be skilled in both automated and manual operations of ships and equipment.

1 The introduction of new technologies into the maritime field
2 The instrumentation of merchant and naval ships
3. The reduction of technical personnel onboard has reduced the traditional way of technology transfer onboard ships
4. The growing demands for safe and efficient operation of ships
5. Automation onboard ships, thermal loads on engines, reduced crews

This is the reason why today's cadets of the Saudi Coast Guard Naval Institute need to be involved in more realistic situations than the typical classroom instructions can offer to them. The capabilities that today's simulation technology offer to training institutions are able to fill these pressing needs.

One of the advantages of using simulators for training is that they save money in initial investment, and are cheaper to operate because they do not consume large amounts of fuel, steam, water and electricity.

The trainee can engage in operational training of all kinds on a simulator in the same way as on real engines and machinery by analysing and removing faults.

Another advantage is that instructors can program the most frequent faults detected in real ship operations and in this way help the organization to get rid of operational deficiencies.

Analysis of machine deterioration conditions. The deterioration process of some machines is very slow. This condition can be detected and felt only after a long time in real operations. In simulators some serious faults and malfunctions due to wear and tear of machinery and parts can be demonstrated at once and the effects felt almost instantly. This allows the trainees to learn to take preventive and corrective measures.

Simulation of accidents and special situations. An ERS enables the trainees to meet dangerous situations, otherwise impossible to experience.

One important point in simulator training is how to judge if the trainee is competent to perform in real life. Competence is not just about the skill, the knowledge and the understanding that the simulator is capable to transfer to the trainee. Competence also refers to other dimensions of the human being. Competence is also an

individual's ability to solve problems in difficult situations, to cope under stress and to be able to organize and lead a team.
One of the most important problems in the initial stage of implementation of a simulator is the availability of qualified instructors. Instructors with the necessary qualifications for simulator training are difficult to find among the existing permanent staff of the SBGNI.

Chapter 4 the use of **PC-Based Diesel Engine Simulator as a Training Tool** is seen as a way to teach modern operation/navigation equipment to seafarers in order to transfer the understanding of the possibilities and limitations of the equipment. Seafaring personnel have to be trained in the use of modern navigation technology. This also applies to the engineering department, where most of the changes have occurred.

In simulators the trainee can acquire the necessary operational skills, with no risk for him, the ship, property or the environment, while helping the understanding and development of necessary critical skills.

Chapter 5 **Stages for the installation of a diesel engine simulation** deals principally with the stages that need to be followed in the implementation of diesel engine simulators in general.

Because of the variations of manning requirements across the SBG fleet of patrol boats and smaller fast vessels, the SBGNI has to cater for a relatively large span of navigation, communication and engineering education and training needs. On the marine engineering side, the bulk of the effort has to be in diesel propulsion since the conversion from steam turbines has since long been accomplished. A large demand for this kind of training is already felt at the Institute.

A simulator is capable of performing the following tasks: meet the criteria of the international regulations, give a proper assessment to assist in taking the right decision, enable the trainee to operate the engine in a cost-effective manner, evaluate the ship in emergency cases, to use new high technical methods for optimum ship operation and, to process all the internal and external data for safe and effective operations.

The exercises in the simulation training courses incorporate various objectives:

a. To provide an understanding of the engine room with the interdependence of all systems and machinery.
b. To familiarise the trainee with the unmanned machinery space including alarm systems, remote control of propulsion plant, alarm logging, conditions monitoring and remote control of all main pumps and automation system.
c. To increase the trainee's practical skills and experience in the operation of the main engine control equipment.
d. To provide practice in responding to malfunctions, the recognition of such malfunction, the causes and measures to take.
e. To train fresh junior engineers in basic engine room operations, routine operations.
f. To increase the confidence of trainees in demonstrating and testing the effects of varying parameters and component deterioration and plant behaviour.

Requirements for Simulator Training include the national qualification criteria, a knowledge of the content of practical jobs on board, the hierarchical structure of training and installation of new simulation facilities.

The elements to be considered in the installation of new facilities are guidance in instructional techniques, practical simulator operational experience and practical assessment experience on the simulator.

The MET institution installing the facility, but not having the expertise has a number of options to go about:

a. Manufacturer's training programs
b. Learning on the job
c. Understudying at another institution experienced in simulator training.
d. IMO model courses

The training needs of the SBG are set in the following areas: the training objectives, methods to be employed, instructor preparation, levels of trainees, etc.

The system approach to training for the diesel engine simulator consists of the following stages: the needs analysis, development of the training profile, development of the training products (syllabus, manuals, scenarios, exercises), and a description of exercises. This planning process should result in the definition of the training modules for procedure training (for critical situations), skills training, familiarisation training.

In Chapter 6 **Assessment Criteria in Simulators.** The use of modern learning/ teaching tools, ERS and PCDES is helping the development of practical critical skills in many MET institutions. It is also stated that objective assessment is done more effectively using simulators than through oral or written examination. The use of simulators, as an assessment tool, is justified on the grounds that the evidence of student performance is visible and measurable.

In MET, as well as in all areas of training and learning, there is a need for a system to measure the results of the teaching process to make sure that the required effect of training has been achieved, through a monitoring process make the necessary improvement to the course or teaching, and through administrative and academic monitoring make sure that the teachers or instructors are qualify and performing at a satisfactory level.

7.2 Recommendations

To assist in the training of freshmen and career personnel, the Institute should

1. base the basic training programme on the understanding of interactive engineering training systems acting under realistic conditions. Simulators, as an interactive trainer, can be an effective way to achieve safety of engine, machinery and equipment operations.

2. direct simulator training to basic education, refresher courses for in-service engineers and new personnel.

3. use this unique opportunity to update the training programs so as to accommodate the intended STCW 95 minimum standards.

4. follow the steps for installation of simulators facilities and the recommendations of the 1995 STCW Convention, before any implementation of simulators.

5. state the aims and objectives of simulator courses, before contacting manufacturers of ERS.

6. appoint a working group to
   a. prepare the specifications according to the type(s) of simulator(s),
   b. design models of how education and teaching should be structured and performed when using simulators,
   c. develop courses for cadets and for in-service engineers, according to the SBG demand,

d. prepare examples of simulator application in basic marine engineer education, and in advanced courses, and test them accordingly.

Finally, it is important to set clear objectives for the teaching process. The precision to define the training objectives is of paramount importance in ERS and PCDES simulator training.

Simulator training should be implemented using, in the first instance simple solutions, such as PTS, single task simulators for workshops, ship power plant technical maintenance, ship power plant technical operation, ship internal combustion engines, boiler systems, auxiliary machinery, ships turbo machines, and electrical power system. Once experience has been gained with this intermediate solutions, the next step is to implement a full ERS solutions.

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APPENDIX 1

LIST OF SIMULATORS WITH VISUAL CAPABILITIES AROUND THE WORLD 1967-1995

No	Name and location	Year	Type	Manufacturer
1	SSPA, Goteborg, Sweden	1967	CGI/TV	SSST
2	SMS, TNO-Delft, Netherlands	1968	Shadowgraph	IWECO-TNO
3	MARIN, Wageningen, N'Lands	1969	Shadowgraph	IWECO-TNO
4	SSS, Hiroshima Univ., Japan	1971	CGI	University
5	SS Bremen, W.Germany	1975	Slide project	VFW-Fokker
6	IHI, Tokyo, Japan	1975	CG	IHI/NAC
7	SHS, Osaka Univ., Japan	1975	Shadowgraph	University
8	Navy, DenHelder, Netherlands	1975	Nocturnal	Navy
9	TNO-Soesterberg, Netherlands	1976	Modelboard	TNO
10	CAORF, K.Pt., N.Y., USA	1976	CGI	Sperry
11	Marine Safety Int, N.Y.,USA	1976	Modelboard	Sperry
12	MARIN, Wageningen, N'lands	1976	Nocturnal	TNO
13	Warsash College, UK	1977	Nocturnal	Decca 3
14	TUMM, Tokyo, Japan	1983	CGI	NAC/Uni
15.	Bremen FHS, Germany	1978	Nocturnal	VFW-Fokker
16	Mitsubishi, Nagasaki, Japan	1978	Slide Project.	MHI
17.	Ship Analytics N.Stoni'tonUS	1979	CGI	Ship Analytics
18	SMS Trondheim, Norway	1979	Nocturnal	VFW-Fokker
19	Danish Mar.Inst, Denmark	1980	CGI/TV	DMI
20	Warsash College, UK	1981	Nocturnal	Decca
21	MITAGS, Baltimore, USA	1981	Nocturnal	VFW-Fokker
22	S.Shields College, UK	1982	Nocturnal	Decca
23	CASSIM, UWIST Cardiff	1982	CGI/Tepigen	Marconi/Decca
24	SUSAN, Hamburg, Germany	1982	CGI	Krupp Atlas
25	Shipsim, Glasgow, Scotland	1982	Nocturnal	Decca
26	SMS, Trondheim, Norway	1982	Slide Project.	VFW-Fokker
27.	RSSC, Leningrad, USSR	1983	Nocturnal	Norcontrol
28.	Marin, Wageningen, N'lands	1983	CGIGraphic	TNO
29.	Toledo, Ohio, USA	1983	CGI	Ship Analytics
30.	Navy, Sydney, Australia	1985	CGI	Krupp Atlas
31.	AMC, Launceston, Australia	1985	CGI	Krupp Atlas
32.	TUMM, Kobe ,Japan	1985	CGI	na
33.	Taiwan Maritime College	1985	CGI	Krupp Atlas
34.	Piney Point, Maryland, USA	1985	CGI	Ship Analytics

List of ... Continued

No	Name and Location	Year	Type	Manufacturer
35	USCG, N. London, Conn. USA	1985	CGI	ShipAnalytics
36	Finsim, Espoo, Finland	1986	CGI	Racal/Mconi
37	MTC, Ashiya, Japan	1987	CGI	MTC
38	Navy, Kiel, W.Germany	1987	CGI	Krupp Atlas
39	Plymouth Polytechnic, UK	1987	CGI	Racal/Decca
40	Ship.Res.Inst,Tokyo,Japan	1988	CGI	na
41	Korean Mar. T.I. Pusan, Korea	1988	CGI	Norcontrol
42	FETI Vladivostok, Russia	1989	CGI	Norcontrol
43	Petropavlovsk Russia	1989	CGI	Norcontrol
44	Instituto Osservatori Genoa	1989	CGI	Sindel
45	N. Scotia Nautical Inst. Canada	1989	CGI	Norcontrol
46	ENMM St Malo France	1989	CGI	Norcontrol/Thomson
47	Sakhalin Shipping Co Russia	1989	CGI	Norcontrol
48	Chabahar Iran	1989	CGI	Norcontrol
49	Bulgarian MTI, Bulgaria	1990	CGI	Norcontrol
50	Haugesund Mar. Coll, Norway	1990	CGI	Norcontrol
51	NIOC Teheran Iran	1990	CGI	Norcontrol
52	Danube Shipping Co, USSR	1990	CGI	Norcontrol
53	Danish Mar. Inst,,Denmark	1990	CGI	DMI
54	KMTRC Korea	1990	CGI	Ship Analytics
55	Inst.Tec.Nautico, Venezia Ital	1990	CGI	Sindel
56	Kesen Inst.Piraeus, Greece	1990	CGI	Sindel
57	Sakhalin Ship Co, Russia	1991	CGI	Norcontrol
58	State Univ. N.Y.	1992	CGI	Norcontrol
59	Seamans Inst, N.Y., USA	1992	CGI	Norcontrol
60	MSCN Wageningen, N'lands	1992	CGI	MSCN
61	Marine Inst, N'foundland, Can	1992	CGI	Norcontrol
62	Vestfold Poly, Tonsberg, Norw	1992	CGI	Norcontrol
63	World Trade Centre,Singapore	1992	CGI	Norcontrol
64	Indian Navy Bombay	1992	CGI	Ship Analytics
65	Kotha,Finland	1992	CGI	Sindel
66	SMS Trondheim Norway	1992	CGI	Norcontrol
67	Britannia RNC UK	1992	CGI	Norcontrol
68	NAROV, Curacao	1992	CGI	Norcontrol
69	Maine Marit. Academy USA	1992	CGI	Norcontrol
70	Inst.Tecnico Nautico Palermo	1992	CGI	Sindel
71	Kotka Inst. Naut. Studies, Fin.	1992	CGI	Sindel
72	Yusen Mar.Sc.Yokyo, Japan	1992	CGI	Yusen

No	List of ... (Con't) Name and Location	Year	Type	Manufacturer
73	Kalmar Mar. Acad., Sweden	1993	CGI	Norcontrol
74	Nizhny Novgorod, Russia	1993	CGI	Norcontrol
75	Far Eastern T.I. Vladivostok	1993	CGI	Norcontrol
76	Mariehamn, Finland	1993	CGI	Norcontrol
77	STC Sydney, Australia	1993	CGI	Norcontrol
78	Port of Singapore, Singapore	1993	CGI	BA/Ship Analy
79	State Uni.St Petersburg Russia	1993	CGI	Sindel
80	Southampton Institute, UK	1993	CGI	Norcontrol
81	W.Japan Dyn. Inst. Sasebo	1993	CGI	na
82	Star Centre Dania,Florida USA	1993	CGI	Norcontrol
83	MSTC Terschelling, N'lands	1993	CGI	MSCN
84	SMS Trondheim, Norway	1993	CGI	Norcontrol
85	FMSS Navy, Brazil	1993	CGI	Ship Analytics
86	Panama Canal Commission	1993	CGI	Ship Analytics
87	Tromso College Norway	1993	CGI	Norcontrol
88	STAR Toledo, Ohio USA	1993	CGI	Norcontrol
89	WSM Szczecin Poland	1994	CGI	Norconrtol
90	PDV Marine Venezuela	1994	CGI	Norcontrol
91	MSR Rotterdam	1994	CGI	MST
92	Turkish Navy	1994	CGI	Norcontrol
93	HMS Dryad Portsmouth UK	1994	CGI	Norcontrol
94	West Coast STAR Washington	1994	CGI	Norcontrol
95	US Navy, San Diego USA	1994	CGI	MST
96	Bombay, India	1994	CGI	Ishikawajimi HI
97	RT.Navy, Thailand	1994	CGI	Atlas Electronic
98	Volgo Tanker Company Russia	1994	CGI	Norcontrol
99	CCG,Sydney NS,Canada	1994	CGI	Norcontrol
100	Danish Mar.Inst, Denmark	1994	CGI	Norcontrol
101	RNN, Den Helder,Netherlands	1994	CGI	Norcontrol
102	Singapore Water Police	1994	CGI	MSCN
103	Gijon, Spain	1995	CGI	Ship Analytics
104	AMTA Alexandria, Egypt	1995	CGI	Ship Analytics

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