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Engine room for simulator for Akademi Laut Malaysia

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WORLD MARITIME UNIVERSITY

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ENGINE ROOM SIMULATOR FOR AKADEMI LAUT MALAYSIA.

by

GAN BOON SONG
• MALAYSIA •

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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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 had previously been conferred on me.

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

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DEDICATED TO

my wife,

POH LIAN

and children

HAN MENG & HAN YANG

TABLE OF CONTENTS.

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Finally I would like to dedicate this paper to my loving wife (Poh Lian), sons (Han Meng) and (Han Yang) who have provided the support and inspiration for the successful completion of this paper.

ABSTRACT.

The availability of modern training equipment like Engine Room Simulator (ERS) offers a new dimension for effective education and training of marine engineers.

This dissertation looks into the problem of training on board ship's today and examine how ERS can be used to overcome some of these problems.

A brief look into the history of ERS is given together with specific definition on simulator and simulation.

Various type of simulator for training on equipment, machinery and systems in the machinery space were discussed, finally focusing on 3 different makes of Full Mission (Operational) ERS. Important points to be considered in ERS specification were highlighted.

The range of ERS courses that could be conducted in ALAM were examined and funding for the proposed ERS were discussed.

The concluding chapter summaries the importance of having an ERS in ALAM and recommendations are given on how to initiate the process of securing an ERS in ALAM.

LIST OF FIGURES.

ABBREVIATIONS.

ALAM	Maritime Academy of Malaysia (Akademi Laut Malaysia).
CPU	Central Processing Unit.
DPS	Diesel Propulsion Simulator
ERS	Engine Room Simulator.
ICER	International Conference on Engine Room Simulator.
IKM	Institut Kemahiran Mara.
IMO	International Maritime Organization.
IMSF	International Maritime Simulator Forum.
L.O.	Lubricating Oil.
LAN	Local Area Network.
MATES	Malaysian Training and Education for Seaman.
MET	Maritime Education and Training.
MISC	Malaysia International Shipping Corporation.
MTC	Maritime Training Center.
PC	Personal Computer.
PID	Proportional, Integral and Differential.
PPT	Propulsion Plant Trainer.
PTS	Part Task Simulator.
PUO	Polytechnic Ungku Omar.
STCW	International Convention on Standards of Training, Certification and Watchkeeping for Seafarers, 1978.
STW	Standards of Training and Watchkeeping.
UK	United Kingdom.

UMS	Unmanned Machinery Space.
UTM	University Technology of Malaysia.

LIST OF APPENDICES.

CHAPTER 1.

INTRODUCTION.

1.1 BACKGROUND OF THE STUDY.

The advance in technology has greatly influenced the way in which ships are designed, managed, operated, and manned. This has affected the way in which engineers are usually trained during their training phase on board ships. Crews of today also needs to be highly skilled and educated to ensure that ships are operated safely and efficiently without causing accidents and marine pollution.

New training methods have to be explored, identified and implemented to ensure efficient training of future marine engineers. One of the methods identified in this direction is the use of Engine Room Simulator (ERS) in the training of marine engineers.

1.2 PURPOSE OF THE STUDY.

The main aim of this study is to discuss the use of ERS as a training aid in the education and training of marine engineers in Akademi Laut Malaysia (ALAM). It is also the intention of this study to initiate the process leading to the eventual purchase of an ERS in ALAM.

The broader objectives include the followings:

1. Shows the impact of modern technology on today's ship and the need of having modern training methods like ERS to complement conventional methods.

2. Show different makes and types of simulator suitable for marine engineers education and training with the view to identify the type and specification of ERS most suitable for ALAM.

3. Discuss and develop some ERS courses that could be conducted in ALAM and the staff requirements to run such courses.

4. Discuss funding for the proposed ERS.

1.3 METHODOLOGY OF THE STUDY.

Once the dissertation topic has been identified the heading and sub heading of the chapters are drafted. This is then followed by a literature search from various sources for materials. Verification of materials collected is then carried out. Further, the first draft of the dissertation is prepared and reviewed by the supervisor. Any corrections are adjusted and the document is then send to the assessor and co-assessor for assessment. Final amendment is then carried out on the document to produce this dissertation. The various stages and process involved in producing the dissertation are shown as in Fig. 1.1.

1.4 THE EDUCATION AND TRAINING OF MARINE ENGINEERS IN MALAYSIA.

1.4.1 MALAYSIA AN ASPIRING MARITIME NATION.

Malaysia lies in the heart of Southeast Asia. A picture illustrating the above is shown in Fig. 1.2. Malaysia is a federation consisting of 13 states, 11 states in Peninsular Malaysia and two states, Sabah and Sarawak on the island of Borneo.

The whole country lies between one degree north and seven degrees north of the Equator. Peninsular Malaysia forms the southern tip of the Asian mainland, bordered by Thailand to the north and Singapore to the south. It is separated from Indonesia on it's western and eastern side by the Strait of Melaka and the South China Sea respectively. Sabah and Sarawak shares a common border with Kalimantan (Indonesia) in the south and Sarawak also has a common border with Brunei.

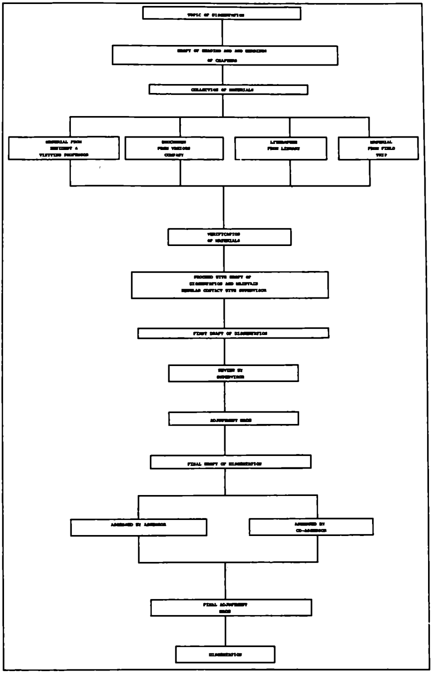

Figure 1.1 Methodology Plan.

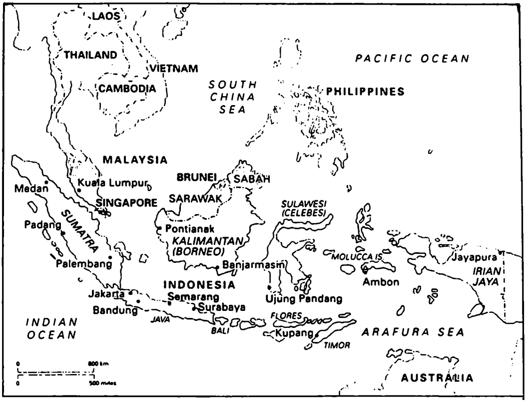

Figure 1.2 Malaysia Within the Context of South East Asia.

Source: Whitakers Almanac 1994.

Malaysia's coastline extends for nearly 4,830 km from the Indian Ocean to the South China Sea. Peninsular Malaysia covers an area of 131,598 sq. km and has a coast line of about 2,730 km, whereas Sabah and Sarawak occupies 198,160 sq.km and their combined coastlines is about 2,100 km long

Malaysia is a country rich in natural resources and it has one of the most rapidly growing economy in the region. A strong leadership and a stable government has ensured uninterrupted growth in all sectors since independence in 1957.

According to Khalilah (1994, p. 26), this year (1994):

> Malaysia's economy is projected to grow by 8.2% and the government is confident the growth can be maintain beyond the year 1999 and into the next century.

During the Third Malaysian Plan (1976-1980) the government began introducing shipping policies with the view of making Malaysia a maritime nation. This becomes apparent as the government realized the important role that the maritime sector can play in the national development of the country.

With the implementation of policies like the UN Code of Conduct for Liner Conferences (UNCTAD'S 40-40-20), Cabotage policy, various financial schemes like soft loans for ship purchase and tax incentives saw national tonnage increased rapidly. Other maritime sectors too were undergoing a similar pace of development like port, shipyard, oil and gas industries.

1.4.2 MALAYSIA INTERNATIONAL SHIPPING CORPORATION (MISC).

The national line, namely the Malaysia International Shipping Corporation was established in 1969. Starting with just one ship in that year, MISC has steadily and quickly developed it's fleet in tonnage, number and ship types. It is now the largest shipping company in Malaysia owning more than 50 ships and account for more than half of the registered gross tonnage in Malaysia.

1.4.3 POLYTECHNIC UNGKU OMAR (PUO).

The rapid development of the shipping fleet in Malaysia resulted in a demand for trained engineering personnel to man the ships. In 1972 the Marine Engineering Cadet Program was set up in PUO. Under this plan, the Japanese Government provided advisers and equipment to implement the scheme. The Malaysian Government provided the grounds, workshops, local teaching staff, additional equipment and operating budget. The Marine Engineering Cadet Program is a sandwiched 4 years course leading to a Diploma in Marine Engineering award. The course is divided into 5 phases (I to V) as outline in the next page.

PHASE	ACTIVITY	DURATION
I	First year at PUO	12 months
II	Industrial training/shipyard	6 months
III	Second year at PUO	9 months
IV	Sea training	12 months
V	Final Year at PUO	9 months
	TOTAL	48 months

1.4.4 AKADEMI LAUT MALAYSIA (ALAM).

Encouraged by the support shown by the government to the shipping industries through the implementation of various policies as mentioned earlier, in 1976, the national shipping line (MISC), together with Kuok Foundation and International Maritime Carriers of Hong Kong initiated the incorporation of a foundation to be known as the MATES Foundation (Malaysian Training and Education for Seaman Foundation).

In the same year, the foundation established the Maritime Training Center (MTC) at Melaka, primarily to train Pre-Sea Deck Cadets and Ratings for MISC.

The demand for highly qualified officers for the Merchant Navy and the anticipated demand for such former seafarers in the industry ashore, prompted the then government in 1981 to upgrade the status of the MTC to that of an academy. It was executed through the award of a government charter . The name MTC was then changed to Akademi Laut Malaysia (ALAM). The management structure of the academy is shown in Fig. 1.3.

In response to the growing demand for upgrading facilities for marine engineers and also to answer the call for a more vigorous maritime sector, ALAM first conducted the Second Class Engineers Certificate preparatory course in 1983. The First Class Course commenced the following year. The courses are held regularly three times a year to meet the needs of the industry.

The academy also conduct courses for the marine engine drivers. These marine engine drivers are the unique group of seagoing personnel that forms the bulk of the engine room personnel that man Malaysia's big coastal fleet. There are three classes of engine drivers, namely the first, second and third class. Engine driver courses of all the three classes are conducted three times per year.

In June 1992, the marine engineer cadet course was introduced at ALAM to overcome the shortage of marine engineers for the country's maritime industry. The cadet course forms part of the whole sandwiched type education and training program of marine engineers. A chart showing the program is provided in Fig. 1.4.

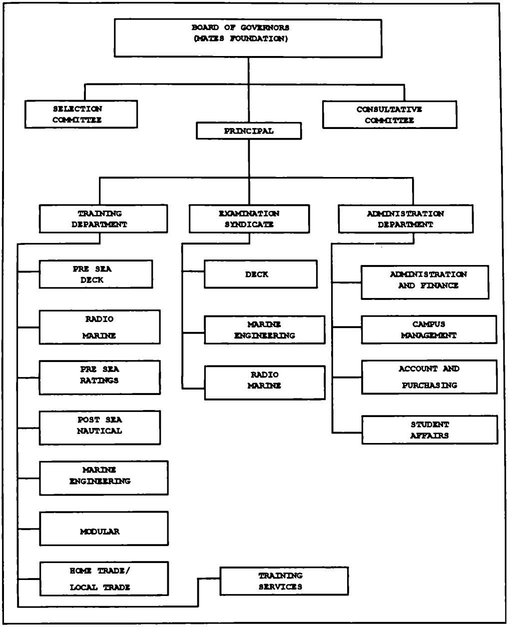

Figure 1.3 Management Structure of ALAM.

Source: ALAM.

CLASS 1 ENGINEER C.O.C.
Examination
3 Months Upgrading Course at Academy

18 mss as Engineer Officer

CLASS 2 ENGINEER C.O.C.
Examination
3 Months Upgrading Course at Academy

18 mss as Engineer Officer

CLASS 4 ENGINEER C.O.C.		
EXAMINATION		
DIPLOMA		
4th Year	Phase 5	Study at Academy
3rd	Phase 4	6 Months Sea Training as Cadet
Year	Phase 3	3 Months Shipyard Training
2nd Year	Phase 2	Study at Academy
1st Year	Phase 1	Study at Academy

Figure 1.4 The Education and Training of Marine Engineers in Malaysia.

Source : Zainorin (1993).

Students who have completed 11 years of general education are eligible for enrollment. The course has a duration of 4 years and leads to a diploma award. Upon completion of the course, graduates can also take the oral examination for the Class 4 Engineer's Certificate of Competency. The graduates can then proceed to sea as Junior Engineers.

1.4.5 UNIVERSITY TECHNOLOGY MALAYSIA (UTM).

UTM is situated approximately 200 kilometers due south of ALAM. To meet the demands of the shore based maritime industry, the Mechanical Engineering department of the university was reinforced with a marine technology specialization. A degree level program of 5 years duration and a diploma program of 3 years duration were added. Graduates of these courses will satisfy the needs of the oil and offshore segment, and the shipbuilding and ship repairing industries amongst others. The number of students in the degree and diploma program are 15 and 35 per year respectively. Although very few graduates finally go to sea, their input from the shore side of the industry is very important.

1.4.6 INSTITUT KEMAHIRAN MARA (IKM).

IKM offers a proficiency certificate course in Marine Mechanics. Upon graduation the trainees are mainly employed on board government crafts and private inshore vessels and marine craft repair facilities. A small number may embark on a career in the Merchant Navy.

CHAPTER 2.

MODERN TECHNOLOGY AND IT'S IMPACT ON MARINE ENGINEER TRAINING ON BOARD MERCHANT SHIPS.

> Ten years ago ship simulators were regarded as useful aid to maritime training. Today they are generally regarded as essentials not least by IMO.
>
> Mr. William O'Neil.
> Secretary General, IMO
> (Fairplay, June, 1993).

2.1 MODERN TECHNOLOGY IN SHIPS.

In the last few decades engineering design and operation of ships have greatly influenced the development in the field of electronics. The microchip and microprocessor have allowed control and operation of many processes to undergo tremendous improvement over the years. Automation is now commonly found on board ships. With automation, most operations in the engine room can be controlled from the bridge. This means that some of the jobs in the engine room can now be carried out by deck officers on the bridge and unmanned machinery space (UMS) operation in the engine room is now possible.

With UMS a common feature on board ships today, cadets watchkeeping experience has been greatly reduced. This disturbing situation can greatly affect the safety of the ships in which they are going to sail on tomorrow.

Today, modern ships are operated more efficiently and effectively due to technology being harnessed to it's utmost. Developed countries possessing the know-how and financial capability have lead the search for new ways and means to even better the presently enviable standards achieved. Japan has conducted "ship of the future" projects since the sixties. Sweden and West Germany have similar programs in varying forms and names. All share the same objectives of using modern technological advances to optimize ship operation and competitiveness.

It is unlikely that implementation of modern technology will stop. The drive for enhanced optimization of ship operation and safety will ensure continuos research and development. Many ship of the future projects have run their term. New studies were initiated to further explore possibilities uncovered during the initial projects. West Germany, for instance, has continued with an advance project upon completion of the original project. The present advanced technology is certain to be very common in the future. Already many ships have been built incorporating many features of the 'ship of the future' project.

In Malaysia, new ships acquired have also incorporated many of the new technology found today. The question that often arise is "Are the present education and training methods capable of imparting the necessary knowledge and skill to the future marine engineers in Malaysia?".

2.2 CREW AND MANNING LEVELS.

In many developed countries, ship's crew has reduced from about 35 in the 70's to between 20 and 25 in the early 80's. Today a crew of 15 (and fewer on some ships) is not uncommon on modern vessels. Experiments are continuing especially with the ship of the future projects to bring this even lower. With parallel developments taking place in other facets of the industry the target of even smaller crew will be a reality in the very near future.

During the International Maritime Organization (IMO), Sub-Committee on Standard of Training and Watchkeeping, 25th session meeting, delegates from Japan further support this by showing the evolution of the present shipboard manning structure in Japan as in Fig. 2.1.

On modern seagoing vessels, the traditional shipboard organization of deck, engine, radio and

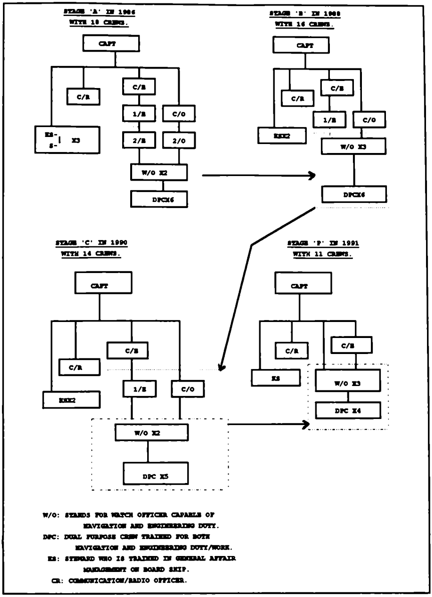

Figure 2.1 Evolution of ship manning structure in Japan.

Source: IMO Standard of Training and Watchkeeping 25th Session meeting. Information number 7.

catering departments have largely disappeared. It is however, still a common feature on ships of the developing countries. On modern vessels with small crew, the junior officers are dual certificated able to keep bridge as well as engine room watches. At the senior officers level specialization as an engineer or a deck officer is still prevalent. On UMS ships the engineers would only be involved in the day maintenance task. As for the radio officer, his role has changed mostly to that of the maintenance technician of electronic equipment. The master, although still in traditional command of the vessel is increasingly assuming the role of a ship manager.

Shipboard operations, along with crew size and organization structure are undergoing profound changes. Major shipboard maintenance, for example, long the pre-occupation of ship's crew has now been taken over by shore crew and more urgent repairs and maintenance by flying squad.

Advances in technology and the application of highly automated machinery with small crew means that today's crew must have increased knowledge and experience to operate machinery efficiently. Traditionally, Fault diagnosis procedures were learnt mostly by job experience, from other engineers on board and from training. The current situation indicates that many engineers have insufficient experience, caused probably by reduced manning on ships and increased reliability of equipment. There is now neither the manpower nor the time for traditional learning method and experience.

In Malaysia, new ships are now manned by less but more experienced crew although we still maintain the traditional departmental system.

Due to shortage of seagoing officers in Malaysia, crew of mixed nationality is still a common feature on board Malaysian registered ships. This is also not conducive for training on board because of the diverse background of language, values, culture system and societies of the crew. Thus, more of the teaching and training load has to be transferred to maritime colleges.

2.3 SHIFT OF TRAINING TO MARITIME INSTITUTION.

In former days, young men entered their sea career at the age of 12 to 14 and worked their way up through the stages of engine room rating, greaser and oiler until they eventually left for a short, shore-based educational period. Having qualified for an officer certificate they come back on board for at least 2 to 3 years before attending further upgrading preparatory course in order to upgrade their qualification.

Today in Malaysia, marine engineers on board are given a longer period of formal education and training by means of a 4 years diploma course. With further upgrading courses after their required sea time they can sit for their Second and First Class Certificate of Competency Examination.

2.4 ENGINE ROOM SIMULATOR TO ENHANCE THE TRAINING OF FUTURE MARINE ENGINEERS.

The current methods of MET used in Malaysia consist of classroom teaching, workshop practice and sea time are proving to be insufficient to train marine engineers of the future. New training methods and techniques which can effectively impart the necessary competencies and skills are required. Simulator is one of the methods used to overcome the shortcomings. A recent report from International Shipping Federation (STW 23/14) states the following :

> Experience in the shipping industry has demonstrated that simulators permit knowledge and skills to be imparted with greater speed and effectiveness than traditional method.

A dynamic real-time computerized simulator can compress years of experience into a few weeks. It is also particularly useful in training area where an error of judgment can endanger life, environment and property. Proper simulator training will reduce accidents and improve efficiency, give the engineers the necessary experience and confidence in their job. Practicing decision making in a simulator environment where decisions and their effects are monitored, opens a unique possibility to evaluate the effects of the decision.

The application of the ever increasing innovations in computer science and information technology such as expert systems, artificial intelligence and virtual realities are making the engine room simulator more and more sophisticated, creative and valuable.

CHAPTER 3.

SIMULATORS FOR MARINE ENGINEERS EDUCATION AND TRAINING

You do things right because you have experience;
You have experience because you did things wrong.

(Chinese Proverb).

3.1 INTRODUCTION.

The concept of simulation has emerged over a long time. Any dynamic process or complex operational equipment are best taught by means of a simulator. Several industries especially the aircraft industry has incorporated simulator into it's training program for many years. Simulators enable skill training, concept training and interactivity of the system to be easily understood. The first simulator that emerged in the marine field were bridge simulators in the late 60's. This was a direct result of large number of major accidents occurring at that time. Insurance companies have strongly recommended that simulators be used as a training aid, especially for crew on Very Large Crude Carrier (VLCC) ship.

At the same time around 1965 the 1st fully automated ship was commercially built. During the early stage there were a lot of problems and breakdown in automated ships(UMS). To boost the confidence of the engineer in handling such ship, engine room simulator were build for such training. The 1st engine room simulator was installed by Norcontrol in 1978 at Trondheim Maritime Training School, Norway. A diagram of the range of marine simulators available today is shown in Fig. 3.1.

From P. Muirhead (1994, Table. 3.) records on engine room simulators, there are about 110 engine room simulators installed world wide as from March, 1994.

3.2 DEFINITION.

To ensure better understanding of this topic it is important for us to define the term simulator and simulation clearly. Probably the best definition for simulator is given by The Cambridge Encyclopedia (1991, p. 1110) as :

> A mechanical, electro-mechanical, or computer device for producing a realistic representation of an event or system. It is used where the real thing is very expensive and inaccessible, and to train operators in safety.

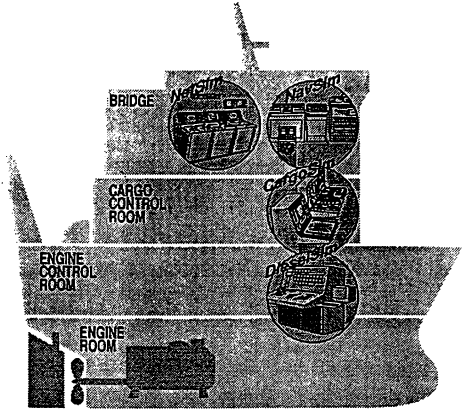

Figure 3.1 Range of marine simulators available.

Source: Norcontrol.

Simulation in education according to Encyclopedia Britannica Micropeadia (Index IX, p. 222) :

> A research or teaching technique designed to reproduce under test conditions various phenomena likely to occur under real condition.

3.3 TYPES OF SIMULATOR FOR EQUIPMENT, MACHINERY AND SYSTEM TRAINING IN THE MACHINERY SPACE.

Based on a draft proposal by STW consultants dated February, 1994 (Muirhead. P. Table. 1) only Category 1.(Full mission simulator) has been define so far under categories of simulator for propulsion systems. For ease of explanation, the author will try to categorize the diverse range of simulators available today for training of equipment, machinery and systems in the machinery space under the following types, namely:

3.3.1 PERSONAL COMPUTER (PC) BASED SIMULATOR.

PC based simulators uses programs designed to simulate a single ships systems or set of operations for interactive use by an individual. Only basic form of simulation can be produced and it's only suitable for basic level of training. Development of software program for such simulator by simulator makers are not popular because of the following reasons :

a) Software could be easily copied.

b) Profit margin for such software are low.

c) Software can easily be outdated.

d) The display lack realism.

Some of the advantages and disadvantages of PC base simulator are as follows:

Advantages:

1. high student to instructor ratio.
2. low cost
3. Students can easily use their personal computer or computer available on board ships to run programs.

Disadvantages.

1. Limitation as to the level of simulation.
2. No opportunity to work on real components.

3.3.2 WORKSTATION (COLOR GRAPHIC) ERS.

A workstation simulator is actually a higher version of a PC base simulator. Here the memory and speed of the Central Processing Unit (CPU) of the computer is much higher, allowing more sophisticated models to be made which results in better image and reality of engine system and plant to be produce. It also allows operation command to be carried out in real time for interactive use.

A typical configuration of the workstations simulator consists of a main CPU in a computer, a graphic processor cabinet, an instructor and student workstations.

Each workstation should consist of :

- a color graphic display unit for picture presentation.
- an operation keyboard for commands.
- a visual display unit with keyboard.
- one printer for all the workstation.

Configuration of typical workstation simulators is shown in Fig. 3.2.

It's main advantage is it's capability for in depth studies of different processes and systems. Another advantage is that different program(software) can actually be run on it for example, program based on a different main engine or a totally different program enabling it to become a Cargo Handling Simulator.

It's major disadvantage is that like the PC based simulator it still lacks the realism of a real engine room.

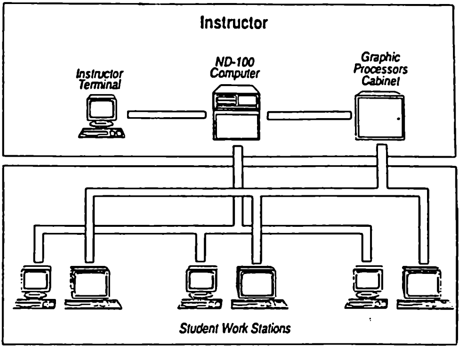

Figure 3.2 Typical Configuration of Workstation Simulators.

Source: Listewnik. J & Wiewiora. A. (1993).

3.3.3 PART TASK SIMULATOR (PTS).

The definition for a Part Task Simulator is given in the STW sub-committee, first session of the Intersessional Working Group (October, 1993) report 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,.....

Haven Automation, a leading automation company in the United Kingdom has recently come up with a series of part task simulator known as the Modeq Series. The Modeq series consists of:

1) Modeq 100 which simulate an electrical power plant.
2) Modeq 200 which simulate motor and motor drive.
3) Modeq 300 which simulate a marine diesel engine.

PTS forms the bridge between the PC base personal computer simulator and the ERS.

3.3.4 ENGINE ROOM SIMULATOR.

Engine room simulator can generally be defined as a simulator having a complete engine room system where all the machinery has been reproduced through the application of a computer programmed to present specific engine room components as they would be on board modern ships. The system is designed in such a way that all operational actions taken by the trainee produce fair operational functions of a typical propulsion plant. The simulated engine room system covers both the main propulsion plant and the auxiliary components throughout the engine room. Operational Engine Room Simulators (Full Mission Simulator) can be divided into three versions:

i) steam plant simulators.
ii) medium-speed diesel plant simulators.
iii) slow-speed diesel plant simulators.

3.3.4.1 MODELING OF DIESEL ENGINE SIMULATOR.

The simulation model is a crucial element within any simulator. The model should not only generate variables which correspond to those at "design", but also give a high degree of perceived realism in a dynamic sense when subject to operator's action or equipment malfunction. To ensure a realistic response of the model over a wide range of operating conditions, the modeling is based on physical laws of nature.

3.3.4.1.1 PRINCIPLE OF MODELING.

Mathematical models consist of equation that describes the relations between variables in a physical system. In a dynamic model the value of important variables will change over time influence by external signals and internal interactions.

The process of modeling can be divided into the following four steps.

1. Specification of the system.
2. Deduction of the mathematical equations.
3. Analysis of the models dynamic behavior.
4. Validation of the model.

Specification of the System.

The system we want to model has to be very specific and suitable for specific use.

Deduction of the mathematical equations.

Basic physical laws and empirical relationships like:

- mass balance
- energy balance.
- impulse balance.
- force balance.
- kirchoff's law.

are used to form the mathematical equation that describe the relations between variables in the dynamic system that have been specified.

Analysis of models dynamic behavior.

The next step is to verify that the model behaves according to the specifications of the simplified system. This can be done by repeated experimental simulations with perturbations of the external signals that influences the model.

Validation of the model.

Finally the models behavior is compared with the true system that it is intended to represent, and verify that the model is sufficiently similar to it.

3.3.4.1.2 LEVELS OF MODELING.

The diesel engine room simulator model consists of three levels, namely the basic models, system models and plant model. Fig 3.3 shows the inter relation between the three models.

A) **BASIC MODELS.**

A basic model represents a specific system component, i.e. a pump, a tube, a valve, a heat exchanger etc.

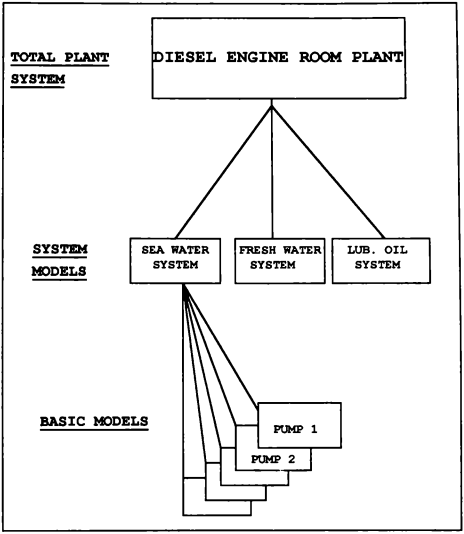

Figure 3.3 The Inter-relation between the Three Levels of Model.

Source: Thorstensen. J. (1993).

B) **SYSTEM MODELS.**

A system model represents a specific major part of the plant, i.e. sea water system, fuel oil system, fresh water system etc. These models consist of various number of basic models. All the basic models are collected in a model library, and used several times through the plant with different set of parameters. The output variables from one basic model are used as input variables to one or several other basic models.

The following samples are some of the system models that can be made:

- fresh water system.
- lubricating oil system for main engine.
- sea water system.
- fuel oil system.
- electrical power supply system.

Fig. 3.4 shows a model drawing for a main engine lubricating oil system.

C) **PLANT MODEL.**

The plant model represent the total engine room configuration and is built up by various system models. For example, a model drawing with a slow speed diesel engine plant is illustrated in Fig. 3.5.

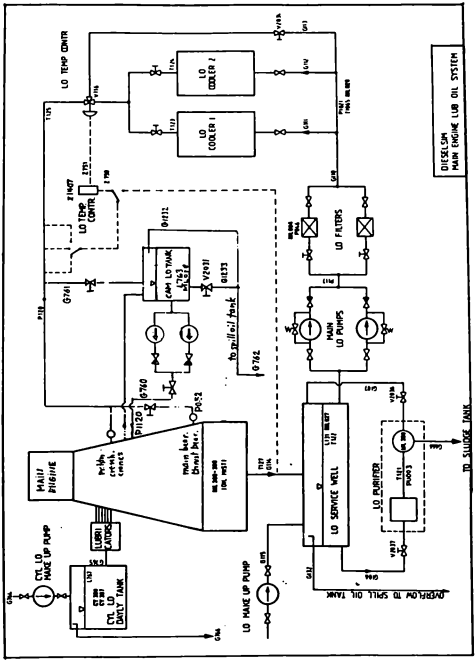

Figure 3.4 Main engine Lubricating Oil System.

Source: Diesel Propulsion Simulator (DPS) Manual,
Norcontrol.

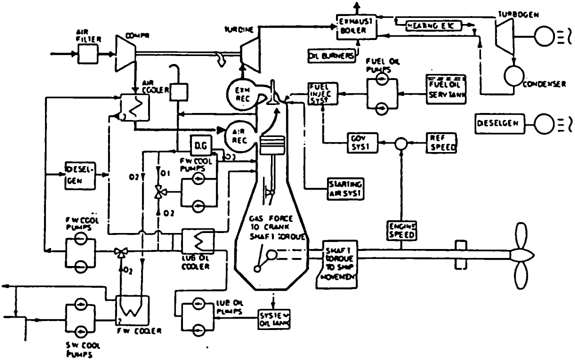

Figure 3.5 Diesel Engine Plant Model.

Source: Diesel Propulsion Simulator (DPS)
Manual, Norcontrol

3.4 COMBINATION OF BOTH THE OPERATIONAL (FULL MISSION) AND WORKSTATION (COLOR GRAPHIC) ERS {COMBINATION VERSION}.

There is now the capability of having the combination version. Here, it is usually the instructor station that connects the two through a Local Area Network (LAN). The resultant benefits are increased flexibility and training capacity.

This version allows the trainees to experience realistic operational training and in-depth analysis of the different processes, which is regarded as the optimum training solution. Fig. 3.6 shows the layout of a combination simulator.

3.5 ADVANTAGES OF ERS.

The use of engine room simulator in training has many advantages namely:

(i) Time Saving in Achieving Operational Experience.

It takes many years for a marine engineer to experience sufficient numbers of various malfunctions and failures in the machinery installation to become an experienced and safe operator. Engine room simulator overcome this by the considerably fewer practice hours for approximately the same experience. The dynamic real-time

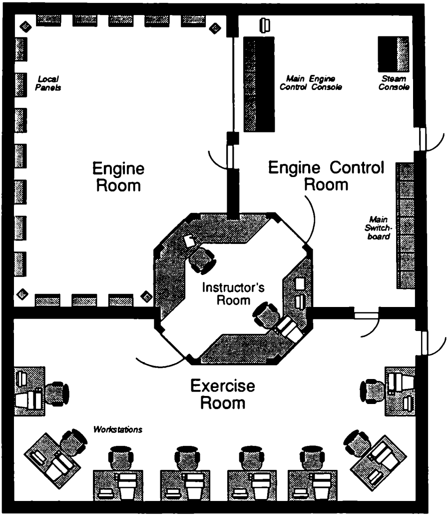

Figure 3.6 Layout diagram of a combination ERS.

Source: Propulsion Plant Trainer (PPT 2000)
Manual, Norcontrol.

simulator can compress years of experience into a few weeks, thus the simulator saves time.

Atlas Elektronik, a German company based at Bremen which has been associated with the design and manufacture of simulators for both civilian and defense application for more than 20 years has found that the use of simulators permits knowledge and skills to be imparted with greater speed and effectiveness than traditional on the job training as illustrated in Fig. 3.7.

ii) Repeatable conditions.

Repeatability enable a simulator to freeze or replay current situation for clarification and discussion. Repeatability also allows performance of different teams under identical inputs to be compared, opening up the possibility of the engine room simulator to be used as an examination tools.

iii) Safer training.

Finally, and perhaps the most important of all, engine room simulator is best suited for emergency training. Training to enable personnel to meet dangerous situations is best carried out under safe conditions where there is no risk of life and damage to equipment for instance the training in emergency stoppage of the main propulsion plant, emergency running, scavenging air box fire, piston seizure, crankcase explosion, engine room fire, lost propeller, heavy hull fouling, electric power supply blackout, and so on, can be practiced safely.

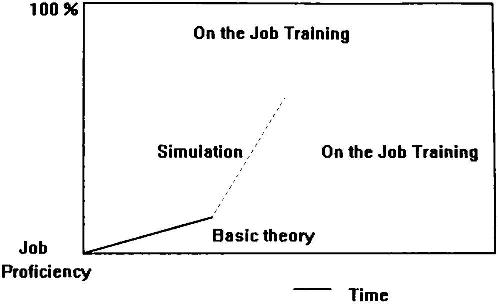

Figure 3.7 Comparison between simulator and On the Job Training in Imparting Knowledge and Skills.

Source: Atlas Elektronik.

Additionally several other emergency situation which occur in the engine and control room can be exercised on the simulator whereas they cannot be safely carried out on board a vessel without jeopardizing the interest of the shipowner or the safety of the ship, her crew and in some case also environment.

iv) More effective training/learning.

The use of ERS allows high involvement of activity which arouse interest and motivates trainee to learn. This is one of the best approach to adult learning as shown in Fig 3.8.

3.6 LIMITATIONS ON THE USE OF SIMULATOR.

Some of the main limiting factors are:

- Lack of standard concerning facilities and equipment.
- Varying level of system fidelity.

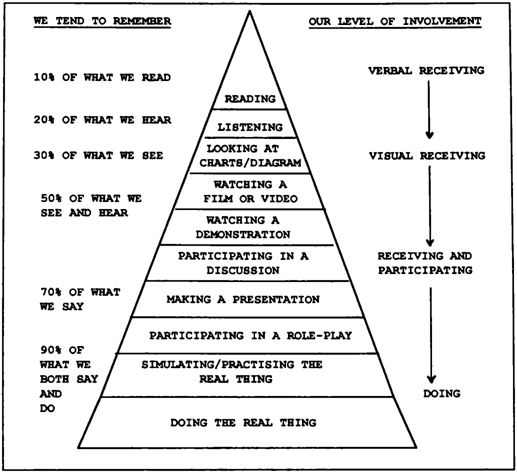

Figure 3.8 Modified Edgar Dale's Cone of Experience Showing the link between Activity, Involvement and Learning.

Source: Zainorin. (1993).

- High cost of facilities and supporting infrastructure (technical staff, instructors, maintenance and system upgrading).
- Difficulty in scheduling of student due to the small group of students that can be train at any one time.
- Lack of uniform training standards (objectives, teaching methodology, use of equipment and monitoring techniques).
- Shortage of experienced instructors.
- Low student/instructor ratio.
- "Over enthusiastic" trainees may over play their role in a team exercise.

3.7 ALTERNATIVE USE OF SIMULATOR.

3.7.1 RESEARCH.

Some of the areas of research that can be carried out on ERS are :

- Control room design and manning levels.
- Human behavioral aspects, including operator reactions and health when under stress (e.g. blackout, fire).
- Plant/operator interface relationships.
- Validation of the use of simulators for operator performance assessments.

- Information gathering and the rate it should be presented to prevent information overload that can result in operator fatigue.

3.7.2 ASSESSMENT OF COMPETENCY.

The issue of a certificate of competency is usually viewed as evidence that the individual is capable of performing certain practical tasks and functions on board in a safe and effective manner. Yet current forms of assessment generally do not relate to demonstrations of actual on-the-job skills. Ideally much of this evaluation would be better carried out in-situ onboard, but limits imposed by ship safety requirements and the reduced manning means that much of the onus for training and evaluating competence rests with the maritime training institutions. The need to narrow the gap between training for knowledge and onboard skill acquisition has become of paramount importance.

The development of simulator can help bring maritime training closer to shipboard practices and examiners to thoroughly evaluate the candidates knowledge and skills to efficiently operate machinery and diagnose operational problems in the unique environment of ships machinery system without imposing the danger of life threatening situation. A simulated environment has the unique capability to assess a person's response under stress to a variety of situations of considerable significance in the prevention of machinery damage that even a lifetime of seafaring experience may fail to produce.

To ensure fair and effective use of simulators for assessment the examiner must be :

- Suitably trained for using simulator as an assessment tool.
- Independent of the individuals or authority using the simulator for training in the skills to be assessed.

3.7.3 REMISSION OF SEATIME.

Some countries like France, USA and Norway have substitute simulator training for sea service required for certificate of competency. Currently this is also one of the areas being discussed in the STCW review. Below is a brief study on how Norway has accepted the use of an operational engine room simulator as a substitute to sea practice for the lowest certificate for engineers.

The background for this was because in Norway, it has become more difficult to get sea practice for young seaman that wanted to have their lowest engine certificate.

The Norwegian Maritime Directorate has decided that 210 hours training in physical laboratories and 105 hours training on an engine room simulator with 2 Engineer on Watch night exercises in addition to accepted test is accepted as 12 months sea practice out of the 18 months required under normal circumstances.

Tonsberg Maritime College a leading maritime college in Norway has as a result develop a Registration Book (program) divided into 3 parts:

Part. 1 : Sea practice on simulator.
Part. 2 : Physical laboratories.
Part. 3 : Onboard practice.

Of specific interest here is part 1 which contains a specific program for 105 hours training .

A. Simulator familiarization		10 hours
B. System start up		30 hours
C. Fault corrections		20 hours
D. Engineer on watch		45 hours
	Total	105 hours

Source: Brandstad. P.(1993).

3.8 IMO AND IT'S WORK ON SIMULATOR.

3.8.1 STCW 1978.

The International Maritime Organization (IMO) was established in 1958. Since its establishment a number of convention relating to maritime safety has been adopted. Concerned with the need to control standards for seafarer education and training, IMO in association with the International Labor Organization (ILO) convened an International Conference on Training and Certification of Seafarers in 1978 where the STCW 1978 convention was adopted. The convention come into force in April 1984, providing for the first time, minimum standards for the training and certification of seafarers.

According to "Status of IMO Convention on 1st, January, 1993" there are 96 signatory nations to the STCW 1978 CONVENTION. These nations represent more than 85% of the worlds tonnage.

The main aim of the STCW 1978 convention is to ensure that merchant ships will operate safely and efficiently with maximum protection of the marine environment against pollution. It is also directed at helping the less experienced maritime nations to develop their seafarers education, training and certification that will meet acceptable minimum standards.

The convention specifies mandatory minimum requirements relating to theoretical and practical knowledge, understanding and experience contributing to seafarers competency. In particular Regulations III/2, III/3, III/4 of the conventions deal with the certification of marine engineer officers.

It can be claimed that most countries are now able to satisfy the mandatory requirements and that many have far exceeded them. In fact many countries have modified and improved their education and training programs to such an extent that the standards of the convention are no longer acceptable.

An analysis of the major casualties suggests that human error is by far the largest single cause of disasters. According to a recent report published by the UK Protection and Indemnity Club covering their experience in the period 1987-1991, 60% of all claims by number are due to some form of human error, 8 % the classic being lack of knowledge and 10% lack of experience.

This fearsome situation has incited the urgent need to upgrade the present level of seafarers education and training.

Appreciating the tremendous developments that have been experienced by the shipping industry, IMO had initiated efforts to review the STCW 1978 CONVENTION. In March 1993, the STW sub-committee started work on the comprehensive review of the convention. The convention revision is expected to be completed by 1995 with adoption following in 1997.

Table below shows the schedule for the revision of the STCW convention.

TIMETABLE FOR REVISION OF THE STCW CONVENTION.

STW 24	March 1993.
MSC 62	May 1993.
Intersessional meeting	September 1993.
STW 25	January 1994.
JCT 9	January 1994.
MSC 63	May 1994.
Intersessional meeting	July 1994.
STW 26	July 1994.
JCT 10	August/December 1994.
Intersessional meeting	December 1994.
STW 27	December 1994.
MSC 64	April 1995.
Diplomatic conference	June/July 1995.
Entry into force	1997.

Key: STW: Standards for Training and Watchkeeping Sub-commitee.
MSC: Maritime Safety Committee.
JCT: Joint ILO/IMO Committee.

Source: Lloyd's Ships' Managers (November 1993). p. 12.

One of the agenda of the STW sub-committee is on simulator training and it's acquisition of core practical skills in competency based training. There is a perception within the maritime education and training establishment that the potential for utilizing training simulator is not being realized to the advantage of the shipping industry compared with other sectors such as the offshore industry, civil aviation and naval services.

3.8.2 INTERNATIONAL MARINE SIMULATORS FORUM (IMSF).

With the present advanced marine technology and sophistication of ship automation, it was found that contacts between researchers, designers, manufacturers and users of marine simulators is of great importance. So in September 1978 the International Maritime Organization established the International Marine Simulators Forum (IMSF). The aims of IMSF are :

- to provide an effective medium for the interchange of views and experiences of simulator development.
- to improve the state of art of simulators.
- to study the manufacture and utilization of marine simulators for training and examination of seamen and to improve their application for training and research.
- to advance the development and to promote the use of marine simulators in order to improve maritime safety and productivity worldwide.

3.9 INTERNATIONAL CONFERENCE ON ENGINE ROOM SIMULATOR (ICER).

Today engine room simulators are no longer considered a novelty, but are necessary training tool. As more and more maritime institution acquire ERS it becomes apparent that there is a need to hold periodic conferences to ensure a proper forum for exchanging information and sharing of experience.

With this in mind, the International Maritime Lecturer Association (IMLA) together with the Nantes Merchant Marine Academy organized the 1 st. Marine Engine Simulator Conference which was held on 7-11 th, June, 1993 in Nantes, France.

Many interesting papers were presented. Delegates wholly supported the idea that similar conference should be held regularly in future.

As a follow up to the above, the next ICER conference will be held in 1995. Venue for the above conference is at Institute Maritime du Quebec, Rimouski, Canada.

CHAPTER 4.

TYPICAL OPERATIONAL ENGINE ROOM SIMULATORS.

"EXPERIENCE IS YOUR BEST TEACHER".

-- Old Saying.

A description of some of the latest Operational ERS by three well known ERS maker is given for comparison.

4.1 PROPULSION PLANT TRAINER 2000 (PPT 2000), NORCONTROL.

PPT 2000 is the latest of a series of ERS produced by Norcontrol, Norway. There are three version in the PPT-2000 model that is the Operational, Workstation(color graphic) and combination of both ERS. Norcontrol is a well known company in the simulation field and also a pioneer in the field of ship's automation. They are also the world's leading supplier of maritime simulators. PPT 2000 has been installed in many MET institutions like Marine Institute(St. John's, Newfoundland, Canada), Shipping and Transport College(Rotterdam, Holland),School of Marine and Navigation(United States) and Hogskolesentret i Vestfold (Norway).

4.1.1 SIMULATED MODEL.

The ERS layout and instrumentation is based on a modern Very Large Crude Oil Carrier (VLCC) ship with a slow speed turbocharged diesel engine.

4.1.1.1 MAIN ENGINE.

The main engine simulated has the following data:

Type	MAN B&W 5L90MC.
Cylinder bore	90 cm.
Piston stroke	290 cm.
Number of cylinders	5
Number of air coolers	2
Number of turbochargers	2
Continuous service rating of Main Engine.	17400 KW.
Corresponding engine speed	76 rpm.
Mean indicated pressure	13.0 bar.
Scavenge air pressure	2.1 bar.
Turbocharger speed	8000 rpm
Number of propeller blades	5
Propeller pitch	1.2 P/D.
Specific fuel oil consumption	168 g/kwh.

4.1.1.2 AUXILIARY SYSTEMS.

All necessary auxiliary systems for the main engine as well as the other engine room systems are modeled together with their control systems. A list of the systems are given below:

- Main engine remote control
- Alarm monitoring
- Electrical generation and distribution
- Fuel oil systems
- Lubrication oil systems
- Compressed air systems
- Steam system
- Bilge and sludge system
- Fresh water generator system
- Waste heat recovery systems
- Fire main system
- Sea water system
- Pump diagram.

4.1.2 PHYSICAL DESCRIPTION OF THE PPT 2000- O (OPERATIONAL).

The ERS is arranged over three separate rooms, namely:

i) engine control room.

ii)engine room.

iii)instructor room.

A layout of the ERS is given in Fig. 4.1. Below is a brief description of the equipment in the rooms.

4.1.2.1 ENGINE CONTROL ROOM.

The engine control room is fitted with equipment similar to that found onboard ships.

A) CONTROL ROOM CONSOLE.

The control room console is based on Norcontrol's broad experience with ship instrumentation and monitoring systems and will closely resemble real shipboard equipment.

The console comprises the following three sections:

- Main engine remote control (AutoChief).
- Alarm monitoring (DataChief).
- Pump/compressor/electrical control (PowerChief).

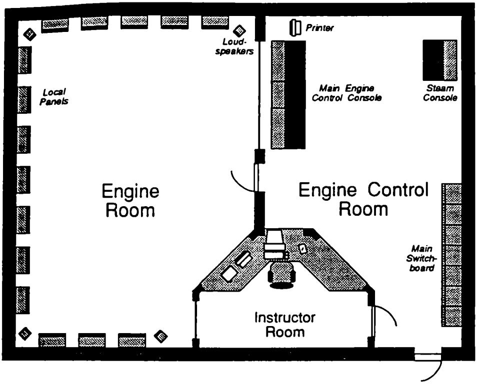

Figure 4.1 Layout of the PPT 2000-O (OPERATIONAL).

Source: PPT 2000-O. Functional Description Booklet, Norcontrol.

B) MAIN ENGINE REMOTE CONSOLE.

The main engine remote control console is one section of the control room console and is based on the Norcontrol "AutoChief". This section includes equipment for operation of the main engine with indication of status and measured values, subsystems included.

C) ALARM MONITORING CONSOLE.

The alarm monitoring console is one section of the control room console. This section, called "DataChief", consists of a high resolution graphical workstation with a dedicated operational keyboard, and is used for alarm handling. A printer is also delivered as a log.

D) PUMP, COMPRESSOR AND ELECTRICAL GENERATION CONTROL.

The above is based on Norcontrol's PowerChief. This section includes automatic and manual control of pumps, compressors and electrical generators.

E) MAIN SWITCHBOARD.

The main switchboard is a full-scale model of a real switchboard. The main switchboard comprises all controls and indicators usually available on a real switchboards, and also includes the sound of the operation.

The main switchboard includes:

- Diesel generator 1 and 2.
- Synchronizing.
- Turbogenerator.
- Shaft generator.
- Emergency generator.
- Miscellaneous.

DIESEL GENERATOR 1 AND 2.

The electrical power supply comprises two identical diesel generators, modeled as high/medium speed engines with all vital sub-systems such as cooling water, lubrication oil, starting air, turbocharger, air cooler and fuel oil.

SYNCHRONIZING.

The synchronizing section contains a double-volt meter, a synchro-indicator and a double-frequency meter. A selector switch enables display of voltage, differential voltage and frequency of all the generators.

A mega-ohm meter indicates possible earth leakage on the main bus bars. A shore connecting device enables monitoring for the phase sequence and cross-coupling of the leads(if needed) before the shore connection is made.

TURBOGENERATOR.

The turbogenerator is modeled with a gland seal system, drain valves, governor, lubrication oil system and steam condenser with cooling water system. The turbogenerator is protected with alarms, automatic stop and shut-downs according to the classification societies requirement.

SHAFT GENERATOR.

A prerequisite for shaft generator operation is that the main engine remote control is in the shaft generator mode.

EMERGENCY GENERATOR.

The emergency generator section contains indicators for voltage and amperage, and operational facilities of a few selected electrical consumers.

MISCELLANEOUS.

The miscellaneous section contains power consumption indicators of :

- Sea water pumps 1 and 2 .
- Low temperature fresh water pumps 1 and 2.
- High temperature fresh water pumps 1 and 2.

* Main lubrication oil pumps 1 and 2.

And these pumps can be connected to a static converter for rpm control.

F) STEAM CONTROL CONSOLE.

The steam control console includes control and instrumentation for the condenser, the steam generator, the oil fired boiler and the exhaust boiler.

G) PRINTER.

The printer is used as a log.

4.1.2.2 ENGINE ROOM.

The engine room can be fitted with local operating panels or with an interactive mimic panel.

A) LOCAL OPERATING PANELS.

The local operating panels represent the various engine room systems found on board a typical ship. Each panel is furnished with start/stop (open/close) button and status light, various numbers of pressure, temperature indicators, etc.

Features for resetting of trip and simulating repair of malfunctioning components are included as well. These panels can be exchanged by mimic panel(s).

B) MIMIC PANEL.

The interactive mimic panel represents the sub-systems found onboard a typical ship. The panel is furnished with various push buttons, status lights, pressure and temperature indicator. The mimic panel can be exchanged for a local operating panel.

C) LOUDSPEAKERS FOR THE SOUND SYSTEM.

Four loudspeakers are located in the engine room and reproduces the simulated sounds from the machinery. They include sounds from the main engine, turbochargers, diesel generators, pump and circuit breakers. There are also two loudspeakers located inside the main switchboard.

4.1.2.3 INSTRUCTOR ROOM.

Inside the instructor room is the instructor workstation which consist of the following equipment:

- Computer
- Hard disc
- Monitor
- Operational keyboard (TEC 2000)
- Tracker ball
- Printer
- Amplifiers for the sound system.

The instructor workstation will be the host computer and act as a server for all other computers. The instructor functions are divided into two groups, the primary and the secondary functions.

The primary functions are:

- Start of simulator
- Stop simulator
- Select of scenario
- Run simulator
- Freeze simulator

The secondary functions are:

- Change of scenario
- Alphanumeric listing of variables
- Alphanumeric listing of malfunctions
- Alphanumeric listing of alarms
- Operating conditions
- Snapshots

- Replay
- Simulation speed (relative real time)
- Sound control
- Inhibit control of alarm systems
- Access control of input.

The instructor has full control of the simulator and the training session through the above listed functions. He can whenever he likes, change the environment during a scenario, and evaluate the operators handling of the situation.

The printer acts as :

- Event log.
- Alarm log.

  Malfunction log.

Each of these logs can be selected by the instructor. If more than one is selected, all the requested events are printed out in chronological order.

4.1.3 COMPUTER SYSTEM.

The instructor station is located in the instructor room, and will normally be the server for all other computers. Together with the alarm monitoring unit and a number of distributed microprocessors it forms a complete simulator computer system. The microprocessors are located in the simulator's local panels and consoles that are intelligently interfaced to the instructor computer. This concept is well proven and extremely efficient for simulation purposes. All Norcontrol Trainers are based on this concept.

4.2 MITSUI ENGINE ROOM SIMULATOR.

This simulator is build by Mitsui Engineering & Shipbuilding, Japan. Some maritime institution which have installed this simulator are Jakarta Merchant Marine Academy (Indonesia), Pakistan Marine Academy (Pakistan) and Maritime Technical College (Japan).

The ERS layout and instrumentation is based on a high speed container vessel with a slow speed turbocharged diesel engine.

4.2.1 MAIN DIESEL ENGINE.

The main engine simulated has the following data:

Type	MAN B&W 7K90MC.
MCR	24,050 KW (32,700 PS) AT 86 RPM.
NSR	21,650 KW (29,430 PS) AT 83 RPM.
No of cylinder	7.

4.2.2 PHYSICAL DESCRIPTION OF THE ERS.

As in PPT 2000-O the ERS is arranged over three separate rooms, namely :

i) engine control room.
ii)engine room.
iii)instructor room.

4.2.2.1 ENGINE CONTROL ROOM (ERS).

The control console in the ERS is a replica of the actual console used on board the model ship. This is to ensure reality in the training environment. The engine control console consists of the following sections:

a) Main Diesel Engine Maneuvering Section.

This section has a remote maneuvering handle, an engine telegraph, main engine control position change over switch, an automatic control switch for main engine scavenging air pressure control, remote control switches for main engine fuel oil change over, instruments for remote monitoring of main engine running conditions, and a telephone for communication with the bridge.

b) The Auxiliary Boiler Control Section.

This section has an automatic combustion controller, a feed water controller, change over switch for superheater steam valve on the exhaust gas economizer, a soot blower remote control switch, instruments and indicator lights for remote monitoring of the auxiliary boiler.

c) Electric Generator System, Switchboard and Group Starter Panel section.

In an actual ship, the switchboard and group starter panel are not part of the engine control, but are independent units separately installed. In this simulator, they are included as part of the engine control console.

d) Logger and Alarm System Section.

This section is fitted with an automatic alarm system and associated logging equipment including an alarm printer and engine log printer.

4.2.2.2 ENGINE ROOM.

4.2.2.2.1 GRAPHIC PANEL.

In the simulated engine room there is a graphic panel which represents the machinery and equipment in the engine room. Full consideration has been given to arrangement of equipment symbols on the panel to permit easy understanding of the various systems in the engine room. The graphic panel is divided into several sections according to the following machinery groupings.

a) Shaft and Steering Gear Group.

This panel section represents the stern tube lubricating oil (L.O) and steering gear systems. In the stern tube L.O. system, symbols are use to represent the stern tube L.O pump, stern tube L.O gravity tank, stern tube sealing oil tanks, piping system for inter connection of the equipment, and the hydraulic oil pumps. In the steering gear system, hydraulic tanks and cylinder rams are represented by symbols.

b) Main Diesel Engine and Turbo-generator Group.

This panel section represents the main diesel engine and turbo-generator system. The equipment symbols used in this section include the main engine, turbo-generators and their auxiliary equipment like L.O pumps, Cooling Fresh Water (CFW) pumps, main and auxiliary Cooling Sea Water (CSW) pumps, Fuel Oil (FO) booster pumps, vacuum pumps, condensate pumps, etc.

c) Auxiliary Boiler Group.

This panel section represents the auxiliary boiler and exhaust gas economizer. The equipment symbols used in this section include the auxiliary boiler, exhaust gas economizer, auxiliary equipment like boiler fuel oil pumps, waste oil burning pumps, boiler feed water pumps, boiler water circulating pumps, forced draft fans, etc.

d) Fuel Oil Transfer Group.

This panel section represents the fuel oil transfer pumps, fuel oil purifiers and other related equipment. The equipment symbols used in this section include; the main and auxiliary fuel oil transfer pumps, heavy fuel oil purifier, diesel oil purifier, heavy fuel oil tank, diesel oil tank, and their interconnecting pipes.

e) Generator Group.

This panel section represents the diesel generators and air compressors. The equipment symbols used in this section include the diesel generators, main and auxiliary air compressors, sea water service pumps, heat exchangers and inter connecting pipes.

f) Fresh Water and Reefer Container Group.

This panel section represent the fresh water, drinking water and reefer container cooling fresh water system. The equipment symbols used in this section include the fresh water pumps, drinking water pump, reefer container cooling water pumps, tanks and inter connecting pipes.

g) Lubricating Oil Purifier Group.

This panel section represents the lubricating oil transfer and purifier system. The equipment symbols used in this section include; the lubricating oil transfer pump, lubricating oil purifier, storage tanks, settling tanks and inter connecting pipes.

h) Bilge Treatment Group.

This panel section represents the bilge treatment system in the engine room. The equipment symbols arranged in this section include the fire and general service pump, oily bilge separator, tanks and inter connecting pipes.

4.2.2.2.2 VALVES ARRANGED ON GRAPHIC PANEL.

The valves arranged on the graphic panel are as follows :

Ordinary valves(including drain traps).

These valves can operate in open/shut position and the associated indicator lights are lit when they are open.

Safety valves.

The safety valves are lit when they are operated. The safety valves found on the graphic panel are the auxiliary boiler safety valve, exhaust gas economizer superheater safety valve and the air reservoir safety valves.

Motor and Solenoid valves.

Motor valves can be controlled while solenoid valves cannot be controlled on the graphic panel. Their open/shut control is done with the associated control switches on the graphic panel or engine control console. The associated indicator lights are lit when they are open.

Various regulating valves.

The regulating valves for temperature, pressure, and level are operated by control air.

4.2.2.3 INSTRUCTOR ROOM.

The instructor console in the instructor room is divided into 2 main sections :

a)Wheelhouse Control Console Section.

This section has a remote main diesel engine maneuvering handle(also serves as the engine telegraph), a sub engine telegraph, a main engine control position changeover switch, remote control switches for main engine starting root valves, a program bypass switch, instruments and indicator lights for monitoring of main engine running conditions, and a telephone set for communication with the engine control room.

b)Simulator Operation Console Section.

This section is fitted with a starting and stopping control switch, an initial condition setting panel, an abnormal condition setting panel and a printer. The initial condition setting panel has the capability to set 8 kinds of initial conditions such as temperature, sea conditions, draft, etc. It is also capable of seven kinds of operation modes from dead ship, full away to finished with engine. The abnormal condition setting panel has the capability to set about 500 kinds of abnormal operations. The abnormal operation triggered in this way can be restored to normal operation when the trainee has taken proper actions.

4.2.2.4 COMPUTER SYSTEM.

This system consists of 4 main computers and other computers for the control of INPUT/OUTPUT, CRT and LAN

(Local Area Network). The two main computers are respectively installed in the Central Processing Unit (CPU) panel and the others are installed in the engine control console and the instructor's console. The four main computers are linked with fiber optic cable .

The concept of the information processing system is shown in Fig. 4.2 and it's functions are as follow :

a) The Main Computer.

This computer uses 16 bit microprocessor (NEC, D70116, Intel 8080 and Intel 8087 for computing), and has 640k byte of ROM and 256 byte of RAM.

The number 1 computer has the function for checking the conditions of all pipe lines and computing the characteristics of the main diesel engine.

The number 2 computer has the function of checking and computing the operating conditions for the main engine, boiler and economizer.

The number 3 computer has the function of computing and controlling the indications and alarms for the main engine control console.

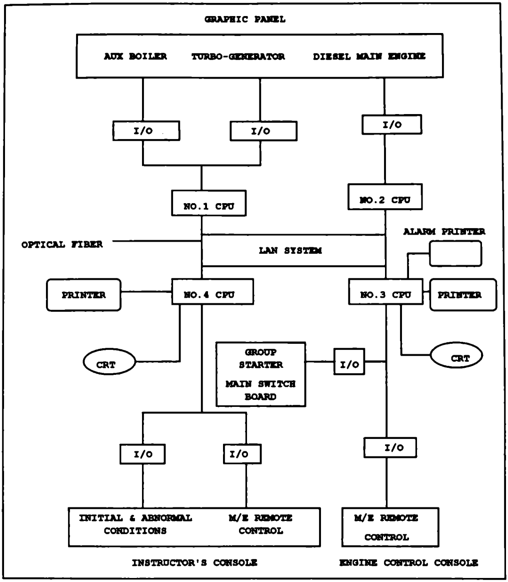

Figure 4.2 Concept of information processing system.

Source : Diesel Engine Simulator Information Booklet, Mitsui Engineering & Shipbuilding Co, Ltd.

The number 4 computer has the function of computing and controlling the indications and alarms for the instructor's console.

b) The Computer for Input/Output.

It contains 8 processors (8 bit, Motoroler 6809), and has the functions of controlling 750 switches, 700 lights and 130 gauges on the graphic panel, the engine control console and the instructor's console.

c) The Local Area Network (LAN).

To ensure reliable data transmission among the computers, this simulator uses LAN which has the following specifications.

- Data Rate: 1 Mbps
- Media : 2 Core Optical Fiber Cable
- Topology : Duplex Loop
- Transmit Distance : 32 Km (max).
- Countermeasure for obstruction: By-pass function, Loopback function.
- Method of transmission control: High Level Data Link Control.
- Access Method: Token passing.

d) The Mimic Sound Generator.

This simulator has a mimic sound generator to make the training environment as close to the actual engine room as possible. The generator has its own computer for the reproduction of various sounds generated by the main engine, the electric generators and the air compressors over four loud speakers according to the operating conditions of these machines. The generator provides for 39 kinds of sounds.

4.3 LLS-2S (SLOW SPEED DIESEL ENGINE) ERS.

This is the top of the range of machinery space simulators based on slow speed engine produced by Haven Automation. Haven Automation is another famous automation company in the United Kingdom involve in the production of ERS. A layout diagram of the LSS-2S is shown in Fig. 4.3.

The components of the simulator consists of :

Main Engine Control Desk (MECD).

The MECD comprises four linked modules, with instrumentation, alarms and controls to operate the main propulsion plant with it's auxiliary systems. Two of the five color graphics terminals, are built into the console, for monitoring and control.

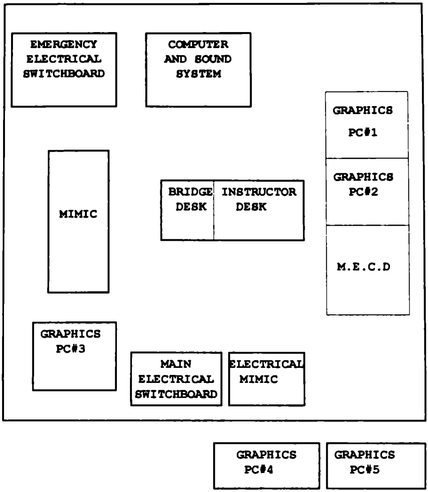

Figure 4.3 Layout diagram of LSS-2S ERS.

Source: Information Brochure on LSS-2 simulator, Haven Automation.

Data logging and printing is achieved using printers and an 8 pen color multi channel chart recorder. A real proportional, integral and differential (PID) controller is also fitted, which can be switched to any of the software control loops.

Main Mimic Panel Console.

This console comprises a large scale mimic panel, of approximately 4 square meter, with representation of all simulated systems using colored flow lines and standard symbols. It supports local instrumentation as well as local controls for valves, pumps, motors and PID control loops.

Bridge/Instructor Console.

This console has typical instrumentation and controls as found on a bridge, for bridge operation of the propulsion machinery, alarms and telephones. There is a desk with monochrome monitors, keyboards and printer. From this station the instructor is able to control and monitor an entire simulation exercise by using extensive facilities available to him.

Main Switchboard (MSB).

It comprises two linked modules which supports instrumentation, distribution breakers, protection trips and controls for the operation of the electrical power generators, which can include :

- Two diesel alternators.
- A steam turbine alternator.
- A shaft alternator.
- An emergency diesel alternator.
- A shore supply.

Paralleling of the main alternators is achieved using a real synchroscope.

Emergency Switchboard (ESB).

This module supports the controls and instrumentation for the emergency diesel alternator and the shore supply. In the event of a total loss of 'simulator' power a relay output is provided to interface to the exercise room lighting circuit to create a 'blackout' effect.

Electrical Mimic Console.

It comprises one module with a mimic presentation and interactive controls for the electrical generating machinery. This unit allows local control of generators with alarms. It is also used for generator control when the electrical system is operated in the split mode.

Main Computer System.

The main simulator computer is normally based on Intel expandable system, and is mounted in a free-standing rack system cabinet, together with the sound system.

Synthesized Sound System.

The sounds produced depends upon the simulator type, but typical for a diesel engine plant would be :

- The main engine.
- Propeller shaft rumble.
- Turbocharger.
- Pumps, fans and compressors.
- Diesel alternators.

Color Graphics System (5 Personal Computer).

There is a five terminal graphics system which displays system diagrams, parameters and alarms. The terminals are linked to the main computer.

One station may be nominated for control, the others are used for monitoring. Two of the terminals may be built into the MECD. The graphics system also incorporates special displays, which can include :

- Diesel engine power card analysis.
- Engine governor limit diagrams.
- Special displays for teaching purposes.

The PC terminals may be used for general purposes when not being used for simulation.

4.4 GENERAL ASSESSMENT.

For meeting the future training challenges expected of ERS, the simulators must from a training point of view achieve the following :

- Meet training objectives.
- Be user friendly to enable instructor to have more time to teach and evaluate the students performance.
- The total propulsion plant must be integrated
- Be based on prevailing international/national certificate requirement.
- Employ modern pedagogical systems to bring students safely to documented learning objectives.
- Have an upgrading capability.
- Have the capability to interface with ship handling and cargo handling simulators.

The proposed ERS should be an Operational ERS capable of upgrading to include colorgraphic student workstations. This is to ensure that ALAM can utilize the simulator to conduct courses ranging from cadets to the highest chief engineer level and also allow possibility of the simulator to be used for assessment and research.

The proposed ERS should be designed and developed on the basis of a real engine room with high propulsive power from a slow speed diesel engine. This is to provide opportunity for trainees to familiarized themselves with large modern engine room, with all the machinery present. The specifications for the ERS should also take into consideration the following factors:

- Reliability.
- Maintenance and service facilities.
- Warranty period.
- Training for instructor and technician on proper usage and maintenance of equipment.
- Ease of obtaining software.
- Capable of running different software programs on the color graphic simulator.

CHAPTER 5.

ENGINE ROOM SIMULATOR COURSES FOR ALAM.

"Tell me and I shall forget
Show me and I shall remember
Let me do it and I shall understand".

(Chinese proverb).

5.1 ENGINE ROOM SIMULATOR UNIT FOR CADET ENGINEER PROGRAM.

To enhance the training of future marine engineers in ALAM, engine room simulator training should be incorporated in the course of the cadet engineer program. Below is a proposed curriculum for the above unit.

CURRICULUM OF ENGINE ROOM SIMULATOR (ERS) TRAINING FOR MARINE ENGINEERING CADETS COURSE IN MALAYSIA MARITIME ACADEMY (ALAM).

BACKGROUND ON THE NEED OF ENGINE ROOM SIMULATOR TRAINING FOR CADET ENGINEERS.

The advance in technology has greatly affected the way in which ships are operated and manned. Today's marine engineer needs to be highly skilled and educated to ensure that ships are operated safely and efficiently without causing accidents and marine pollution.

New training methods have to be explored, identified and implemented to ensure efficient training of future marine engineers.

One of the methods identified in this direction is the use of Engine Room Simulator in the training of marine engineers for safe and efficient operation of marine propulsion plant.

This leads to the development of a curriculum as part of a unit in the marine engineering cadet course in Malaysia Maritime Academy (ALAM).

AIM.

To enable student to have a through understanding of the operation and control of the ship's machinery installation in order to ensure safe and efficient operation of ships.

OBJECTIVES.

On successful completion of this unit the students will be :

1. Able to familiarize themselves with the use of instrumentation and control extensively used in the engine rooms of modern merchant ships.
2. Aware of the need for proper pre-planning and use of checklists, and of the timescales involved in start-up procedure.
3. Understand the way in which machinery units are interdependent.
4. Acquire experience in identifying operational problems and trouble-shooting them.
5. Able to improve their ability to make decisions which promote the safety and efficiency of an operational plant.

PRIOR REQUIREMENT.

This unit is only for final year students(phase 5) at the academy after they have completed their seatime on board ship. The marine engineering cadet course is a 4 years course consisting of 5 phases.

a) Phase 1 — 1 year study at the academy.

b) Phase 2 — 1 year study at the academy.

c) Phase 3 — 3 months industrial training in the shipyard.

d)Phase 4 6 months sea time on board ships.

e)Phase 5 1 year study at the academy.

SYLLABUS OUTLINE.

Training Area	Area Objective	Hours. Briefing & Debriefing	Hours. Trainee Exercise.
1.Familiarisation of ERS.	Show understanding of ERS: a)configuration. b)working principle. c)dynamic models. d)alarm system. e)instrumentation f)communication.	1.5	2.5
2.Simulator plant system.	Show understanding of : a)Main propulsion plant system. b)Auxiliary system. c)Symbols used in the systems. d)Parameter checking. e)Feeding of values.	1.5	2.5
3.Operation	Able to carry out : a)General procedure for operation of main propulsion plant. b)General procedure for operation of auxiliary system. c)Starting up procedure of main propulsion plant from "dead ship" to sea passage. d)Shutting down procedure of main propulsion and auxiliary system.	1.5	2.5

4.Watchkeeping.	Demonstrate the ability to: a)Take over and accept an engineering watch. b)Carry out watchkeeping routine and duties.	1.5	2.5
5.Automation	Demonstrate the ability to understand: a)Main engine bridge control system. b)Engine overload system. c)Automation system of auxiliary engines and generators. d)Electrical power supply system. e)Main engine condition monitoring and maintenance prediction.	1.5	2.5
6.Fault finding and trouble shooting.	Demonstrate the capability to: a)carry out fault finding and trouble shooting on main and auxiliary system.	1.5	2.5
7.Main Engine Diagnosis.	Demonstrate the ability to diagnose problem in Main engine working processes like: a) combustion b) starting c) reversing d) scavenging	1.5	2.5
8.Controls	Demonstrate the ability to tune and adjust: a) Main engine governor. b) Generator governor. c) PID controller.	1.5	2.5

TIME ALLOCATED FOR THE UNIT.

Four hours every week for the first 8 weeks of phase 5 will be allocated for each training area as shown above. The training area are conducted continuously to ensure effective training. Total time allocated for the unit is 32 hours.

MEDIUM OF INSTRUCTION.

English language will be used throughout the unit.

MAXIMUM NUMBER OF STUDENTS PER SESSION:

6 (SINCE IT IS A VERY PRACTICALLY ORIENTATED UNIT).

ASSESSMENT METHOD.

This is through the marking of observation form for exercises conducted by the students and through instructor observation of student performance.

EVALUATION.

This is through a form to be filled in by the students after completion of the unit and also through formal discussion with the students.

5.2 ERS COURSE FOR SENIOR ENGINEERS (2ND. AND CHIEF ENGINEERS).

This course is designed for senior engineers on board ships. The course content should be based on IMO Model Course 2.07, instructor's experience, the experiences of maritime colleges all over the world in simulator training and recommendation from engine room simulator makers. The contents of the course should also take into consideration the following :

AIM OF THE COURSE WHICH IS :

To enable the senior engineers to manage the propulsion plant on board the ship in a safe and efficient manner.

OBJECTIVES OF THE COURSE WHICH ARE:

On successful completion of the course the participant will be :

1. Exposed to modern instruments and equipment found on board new ships.
2. Able to analyze deteriorating conditions and faults in a system and carry out corrective action.
3. Improve their organizing ability and work together with the officers and crew as a team.
4. Improve their knowledge on automation and control.
5. Able to communicate effectively with other areas of the total ships system.

6. Develop the skill and confidence of the staff in the engine room department.
7. Ensure that emergency and safety systems are in good condition.

5.3 ERS COURSE FOR DECK OFFICERS (PILOTS, CAPTAIN AND CHIEF OFFICER).

It is common to find misunderstanding between the deck and engine department on ships that still practice the monovalent (departmental) system of MET. One way to overcome such problems is to expose the engine department staff to some knowledge of navigation and cargo operation and the deck department staff to the operation of the main propulsion plant and auxiliary systems in the engine room.

This will allow the deck officers to gain more insight into engine room operation and it's effect on the maneuvering capabilities of a vessel. It will also increase their knowledge on main engine thermal overload and the possibilities of damage that could occur during maneuvering.

With this in mind, it is proposed that the senior deck officer (chief officer and captain), pilots should undergo a short course using the engine room simulator.

The course content should take into consideration the followings :

AIM OF THE COURSE :

To enable the participants to appreciate the use of main engine for ship's maneuver.

OBJECTIVES OF THE COURSE :

Upon completion of the course the student must be able to :

1. Understand the consequences of running the main engine in crash astern.
2. Appreciate the time taken to warm up the engine.
3. Appreciate the time taken to run up the engine to full speed.
4. Understand the limitations of the engine and the conditions that can result in auto slow down and automatic stopping of the engine.

5.4 TEACHING METHODOLOGY.

The main training components of all the above courses are the practical exercises carried out under supervision on the simulated engineering plant. However, before each exercise begins, a briefing and discussion on important aspects of the exercise should be carried out.

As far as possible, the instructor briefing trainees for the exercise should use practical examples involving real ship board equipment and systems, referring to diagrams, layout plans, technical drawings, photographs, and other related technical documents to supplement and reinforce the briefing.

There should always be a final discussion to make sure that everyone understands the role he will play, as well as what is to be done and achieved by the exercise.

After each exercise, debriefing should be carried out. Experiences may remain as experience and the full potential of learning by the participant/student may not be realized without debriefing.

Debriefing should consist of :

1. A review of how the training exercise was carried out.
2. A review to see whether the objectives of the exercise have been met.

Perhaps the best illustration for the importance of debriefing is shown in Fig. 5.1.

5.5 IMPORTANT ROLE OF INSTRUCTOR.

As in all training endeavors, training with engine room simulator is no exception, the knowledge, skills and dedication of the instructor are the key components in the

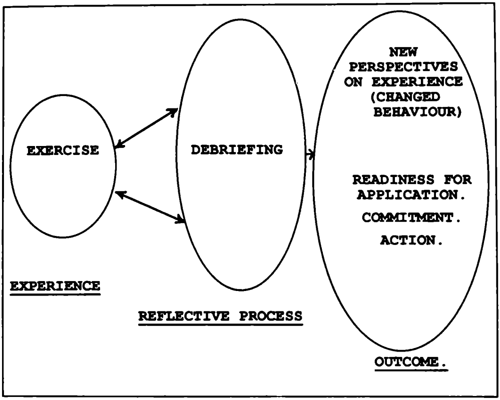

Figure 5.1 Reflection process in context.

Source: Boud. D. et.al (Eds). 1985.

transfer of knowledge and skills to those being trained. As is often said "An instructor can either make or break a course". A diagram showing the instructor and it's interaction with the various elements for an effective training program is given in Fig. 5.2.

5.6 STAFF AND TRAINING PROGRAM REQUIRED.

The instructor in charge should hold a merchant chief engineer certificate, and should have experience in the operation and control of the engine room of a modern merchant ship as well as the training and experience necessary for using an engine room simulator as a training aid. To operate the courses effectively, at least one other instructor is required, preferably with qualifications and experience similar to those of the instructor in charge.

To ensure the smooth running of the simulator a qualified technician should also form part of the staff required for efficient running of the simulator courses.

Instructors and technician should be sent to simulator manufacturer for specialized training, which could be included in the purchase specification of the ERS. Other forms of staff training include :

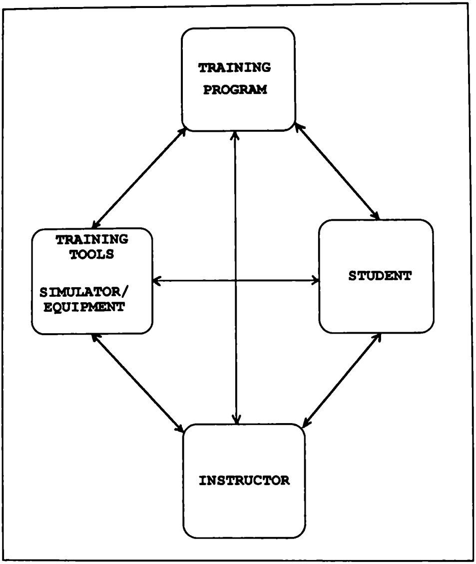

Figure 5.2 Shows the interdependence of 4 elements in an effective training program.

Source: General Simulator Instructor Course, Norcontrol

1. Sending instructor to attend Engine Room Simulator Conference that are held regularly.
2. Sending instructor to established Maritime Institutions like Australia Maritime College(Australia), Marine Institute (Canada), Maritime University(Poland) for attachment to see how ERS programs and exercises can be carried out effectively on engine room simulator.

CHAPTER 6.

IS ENGINE ROOM SIMULATOR(ERS) A SOUND INVESTMENT?.

With the reduction in crew and the advancement of shipboard technology, training institutions are now entrusted to carry out most of the training of future marine engineers. Many institutions are now acquiring engine room simulator or training ships to assist them in training students to the required level of competency.

Investing in an engine room simulator is much more economical than a training ship. ERS in general cost only about 1/2 million US. dollars. In addition, the simulator has no large and complicated engine room mechanical equipment. A main propulsion diesel engine plant on board ship cost millions of dollar.

Therefore using the simulator not only saves a lot of money from the point of view of initial investment, but it also saves a large amount of money in terms of running costs (i.e. the expense for fuel oil, lubricating oil, water, etc.) since the training in continuous engine room operation is carried out without using any oil and moreover power and daily maintenance costs are greatly minimized.

The 5th Ship Control Systems Symposium (SCSS), 1978 in the USA held the opinion that the training cost associated with the use of such a simulator amounts to only one-eight to one-tenth the cost on real ships.

6.1 WHO PAYS FOR THE SIMULATOR ?.

All relevant players in the shipping industry including government, shipowners, seafarers through their unions, charterers, insurers etc should contribute to the funding of the ERS. It is proposed that the government must have some input so that training is sufficient to meet safety and environmental standards which they have enacted and are responsible for enforcing.

Shipowners should look at the acquiring of the ERS as a cheap form of insurance against accidents and collision on board. Records have shown that break down of the main propulsion plant or steering gear can result in loss of ship and cargo worth millions of dollar not taking into account the loss of life or any suits that may occur or clean-up cost, etc.

6.2 SOURCES OF FUNDING.

There are various sources and means of funding for the simulator that can be explored, from within Malaysia as well as from aboard. Among the sources that can be considered are :

(i)From ALAM's own accumulated funds and budget allocation i.e. :

- The annual operating and developmental budgets which are derived from the Federal Government (50%) and the members of the MATES Foundation (50%)
- Operating budget allocation provided for by the government under the Five-year Malaysia Plan.
- Funds accrued from savings made in previous years expenditure, if any.
- Funds injected through privatization of ALAM. (there has been discussion recently to privatize ALAM, if this materialize, funds acquired could be channel to purchase ERS).

(ii)From the government, private sector and individuals, in the form of grants and donation.

(iii)Special budget allocation from the federal government. For this purpose, a memorandum has to be submitted by ALAM to the Implementation and Coordination Unit (ICU) or the Economic Planning Unit (EPU), both under the Prime Ministers Department.

(iv)Financial assistance provided through the various international technical aid and co-operation program e.g. the European Community (EC), the Japan International Co-operation Agency (JICA) and the Japan Overseas Economic Co-operation Fund (OECF).

(v)The raising of funds through the performance of any acts authorized by the government or any relevant legislation pertaining to ALAM as a MET institution, and through any other means as deemed fit by the management of ALAM.

(vi)The setting up of a fund from levy on all ships calling on Malaysian ports.

CHAPTER 7.

CONCLUSION AND RECOMMENDATIONS.

A-Conclusion.

With the advance in technology affecting the whole way in which ships are being designed, operated and manned new training methods like using ERS has to be employed to ensure effective training for future marine engineers in MALAYSIA. This will also help ALAM maintain the present high standard of competency and safety for marine engineers in Malaysia. Concurrently, this is also in line with the government's intention of making Malaysia the "regional center of excellence for education" .

Other important factors for the acquisition of ERS in ALAM are to :

1. Enable ALAM to carry out simulator based research and assessment.

2. Enable ALAM to comply with IMO recommendations on the use of engine room simulators and also to implement any revised STCW convention concerning the use of simulators.

3. Maintain ALAM as a leading maritime academy with the capability of keeping pace with the latest technology and to tap the potential of engine room simulators.

B. Recommendations

1. A consultative committee should be set up immediately to look into the possibility of acquiring an ERS. This committee should consist of members from the maritime administration, maritime academy, shipping companies, ministry of transport, seaman representatives/ union and other maritime industries/organization of interest.

2. Once the need has been identified, a working committee is to be set up in the maritime academy, consisting of academic staff working closely with their counterparts in the marine industry to identify the ERS most suitable for the training needs of the marine industry.

This will have to take into consideration the type of training and the level (background) of the students to be trained.

3. Once the above has been identified, specifications for an ERS can be drafted which account for some of the factors that has been raised in this study.

4. An inquiry can then be sent to various ERS makers for quotation.

5. The committee will then review the quotation and recommend their findings to a contract committee which will then be set up to determine the supplier for the proposed ERS.

6. Staff for the future ERS courses should then be identified and appropriately trained.

7. Staff should then develop course material for the conduct of ERS courses in ALAM.

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APPENDIX 1.

LIST OF ENGINE ROOM SIMULATORS (DPS & PPT-SERIES) PURCHASED BY COUNTRY/OWNER FROM NORCONTROL.

Source: NORCONTROL.

COUNTRY/OWNER	TYPE OF SIMULATOR
BELGIUM.	
Nautical School, Antwerpen.	Low Speed MAN B&W Engine, PPT 2000-MC90, Workstation.
BULGARIA.	
Varna Maritime Academy.	Low Speed Diesel Engine, Operational version. Low Speed Diesel Engine, Part Task, Color Graphic.
CANADA.	
Marine Institute, St. John's, Newfoundland.	Slow and Medium Speed PPT 2000-Operational and Color Graphic trainer. Computer Based Marine Engineering Assessment System.
Nautical Institute, Port Hawkesbury, Nova Scotia.	Slow and Medium Speed PPT 2000-Operational and Color Graphic trainer. Computer Based Marine Engineering Assessment System.
Institut Maritime du Quebec a Rimouski, Quebec.	Slow and Medium Speed PPT 2000-Operational and Color Graphic trainer. Computer Based Marine Engineering Assessment System.
Great Lakes Marine Training Center, Ontario.	Slow and Medium Speed PPT 2000-Operational and Color Graphic trainer. Computer Based Marine Engineering Assessment System.
Pacific Marine Training Institute, British Colombia.	Slow and Medium Speed PPT 2000-Operational and Color Graphic trainer. Computer Based Marine Engineering Assessment System.
CHINA.	
Dalian Marine University.	UMS Instrument Simulator. Low Speed Diesel Engine, Operational version.

Qingdao Ocean Shipping Mariners College.	Low Speed Diesel Engine, Operational version.
CROATIA.	
University of Rijeka.	Low Speed Diesel Engine, Operational version.
FAROE ISLANDS.	
Foraya Maskinskuli.	Medium Speed Diesel Engine, Operational version .
FINLAND.	
Alands Tekniska Skola.	Medium Speed Diesel Engine, Operational version with additional Color graphic Workstations.
FRANCE.	
Ecole Nationale de La Marine Marchande de Nantes.	Low Speed Diesel Engine, Operational version.
Ecole Maritime et Aquacole La Rochelle, La Rochelle.	High Speed Diesel Engine, Operational version.
Ecole National de La Marine Merchande, de Nantes.	Color Graphic Workstation, GFCA,M42,M21. Operational (Part-task) with color graphic workstations.
Ecole National de La Marine Merchande, Marseilles.	Medium Speed Diesel Engine, Operational version.
GREECE.	
Greek Merchant Navy Kesen School, Piraeus.	Low Speed Diesel Engine, Operational version with additional Color graphic workstation.
HOLLAND.	
Shipping and Transport College, Rotterdam.	Low Speed Diesel Engine, PPT 2000 Operational version. Medium Speed Diesel Engine, PPT 2000, Color graphic version.
HONG KONG.	
Hong Kong Polytechnic.	UMS Instrument and Main Engine Auto Chief Remote Control Simulator.
INDIA.	
D.M.E.T., Calcutta.	Main Diesel Engine Auto Chief Remote Control Simulator.

D.M.E.T., Bombay.	UMS Instrument Simulator.

ICELAND.

Verkmenntaskolinn a Akureyri.	Medium Speed Diesel Engine, Operational version.
Velskoli Islands, Reykjavik.	Low Speed Diesel Engine, Study version with Color Graphic Workstations.

IRAN.

Institute of Nautical Studies, Chabahar.	Low Speed Diesel Engine, Part task, Operational version.
National Iranian Oil Company, Teheran, Kala Naft.	Low Speed Engine, Operational version.

JAPAN.

Terasaki.	Main Diesel Engine Auto Chief Remote Control Simulator.

KOREA.

Korea Marine Training and Research Institute.	Low Speed Diesel Engine, Operational version and Color graphic workstations.

MEXICO.

Mazatlan.	Main Diesel Engine Auto Chief Remote Control Simulator. Low Speed Diesel Engine, Operational version.
Tampico.	Main Diesel Engine Auto Chief Remote Control Simulator. Low Speed Diesel Engine, Operational version.
Vera Cruz	Low Speed Diesel Engine, Operational version.
Mexican training Ship.	Low Speed Diesel Engine, Operational version.

NORWAY.

Agder Maritime Hogskole.	Low Speed Diesel Engine, Color Graphic version.
Bodin Videregaende Skole.	Low Speed Diesel Engine, Color Graphic version.
Bergen Maritime Hogskole.	Low Speed Diesel Engine, Color graphic version.

Haugesund Maritime Hogskole.	Low Speed Diesel Engine, Operational and Color Graphic version.
Hogskolesentret i Vestfold.	Low Speed Diesel Engine, PPT 2000, Operational and Color graphic version. Electric Power Plant EPP 2000, Color graphic version.
Tromso Maritime	Low Speed Diesel Engine, Operational and Color graphic version.
Trondheim Maritime Skole.	Low Speed Diesel Engine, Operational and Color graphic version.
Tonsberg Maritime Videregande Skole.	Low Speed Diesel Engine, Operational version.
Royal Norwegian Coast Guard.	Medium Speed Diesel Engine, Operational version.
Royal Norwegian Navy.	Medium Speed Diesel Engine, Operational version.
Alesund Maritime Skole.	Low Speed Diesel Engine, Color graphic version.

POLAND.

Szcecin Maritime Academy.	Low Speed Diesel Engine, Operational and Color graphic version.

PORTUGAL.

Escola Nautica I.de H.	Low Speed Diesel Engine with Color graphic work station and connected to NMS-90 for dual purpose training.

RUSSIA.

Leningrad Marine School.	Low Speed Diesel Engine, Operational version.
Novorossisk High Marine School.	Low Speed Diesel Engine, Operational version.
Vladivostok High Marine School.	Low Speed Diesel Engine, Operational version.
Murmansk High Marine School.	Low Speed Diesel Engine, Operational version.
Kamchatky High Marine College.	Medium Speed Diesel Engine, Operational version (M21).

Kaliningrad High Marine College.	Medium Speed Diesel Engine, Operational version (M21).
Far East Technical Institute for the Fishing Industry, Vladivostok.	Low Speed Diesel Engine, Operational version (M21).
Vladivostok Fishing Institute.	Low Speed Diesel Engine Simulator EPP 100 Part Task, Operational.
Primorsk Shipping Company, Vladivostok.	Low Speed Diesel Engine, PPT 2000-MC90 workstation.
Astrakhan Technical Institute, Tatisheva.	Low Speed Diesel Engine, Part Task. Electrical Power Plant, Part Task. Refrigeration Plant, Part Task.
Nizhny Novgorod	Low Speed MAN B&W Engine, PPT 2000-MC90 workstation.
Vladivostok	Low Speed MAN B&W Engine, PPT 2000-MC90 workstation.

SINGAPORE.

Singapore Polytechnic.	Low Speed Diesel Engine, with additional Color graphic workstation, Operational version.
Republic Singapore Navy.	High Speed Diesel Engine with additional Color graphic workstations, Operational version.

SWEDEN.

Chalmers Tekniska Hogskola.	Low Speed Diesel Engine with additional Color graphic workstaion, Operational version.
Kalmar Sjobefalsskola.	Low Speed Diesel Engine with additional Color graphic workstation, Operational version. Low Speed MAN B&W Engine, PPT 2000-MC Workstation.

SPAIN.

Escuela Oficial de Nautica de La Coruna.	Low Speed Diesel Engine, Operational version.
Instituto Polytecnico Maritimo Pesquero del Estrecho, Cadiz.	Medium Speed Diesel Engine, Operational version.
Escuela de Formacion Profesional Nautica Huelva.	Medium Speed Diesel Engine, Operational version, Trawler version.

UAE.

Arab Maritime Transport Academy.	Low Speed Diesel Engine, Color graphic version.

Ukraine.

Odessa Marine School.	Low Speed Diesel Engine, Operational version.

USA.

California Maritime Academy.	Low Speed Diesel Engine, Operational version.
Massachusetts Maritime Academy.	Low Speed Diesel Engine, Operational version.
Fort Schuyler State University, New York.	Low Speed Diesel Engine, Operational version with additional Color Graphic.
Texas A&M University at Galveston.	Low Speed Diesel Engine, Color graphic version.
School of Marine and Navigation- MEBA D2.	Low Speed Diesel Engine, PPT 2000-MC90 Operational version. Low Speed Diesel Engine, PPT 2000-RND Color graphic version. Medium Speed Diesel Engine, PPT 2000-M22 Operational version. Medium Speed Diesel Engine, PPT 2000-M21 Color graphic version. Steam Propulsion, PPT 2000- ST, Color graphic version. Diesel Electric Propulsion, PPT 2000-DE, Color graphic version.