The Potential of Simulation As a Strategy for Teaching At the Andragogic Niveau

With Special Reference to Maritime Training

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DECLARATION

I, the undersigned, hereby declare that the contents of this thesis:

The potential of simulation as a strategy for teaching at the andragogic niveau, with special reference to maritime training.

represent the personal work of William Roderick Douglas. The opinions contained therein are therefore those of the author, and not of the Cape Technikon.

Signed ....

W.R.Douglas

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OORSIG.

Die groeiende belangrikheid van die konsep van "leer deur ondervinding" word deurgaans sterk na vore gebring deur die erkenning wat deur die Amerikaanse Kolleges verskaf word aan voorafgaande leerondervinding. Dit is egter nie altyd moontlik om beginners die geleentheid te bied om ondervinding op te doen op apparaat wat tydrowend of duur is, en moontlike lewensverlies mag veroorsaak nie.

Die snelle ontwikkeling in tegnologie het gelei tot versnelde veranderinge in toestande en instrumente in stuurkajuite van vliegtuie en op die brûe van skepe. In seevaartopleiding word die las van die instandhouding van simulasieopleiding deur die opleidingsinrigtings gedra. Ook die las van die stygende onkoste en die verskeidenheid gepaste sintetiese opleidingstoestelle (simulators) van 'n groot verskeidenheid van toerusting wat wissel in gesofistikeerdheid van die redelik eenvoudige tot die volle verteenwoordigende, hoogs betroubare skeepsimulator. Besluite wat deur opleidingsinrigtings geneem word, sentreer rondom die wenslikheid van hoë betroubaarheidsimulators, die doeltreffendheid van goedkoper deeltaakopleiers, en of die doeltreffendheid van simulators die finansiële uitgawe en die instandhoudingskoste van simulasiegereedskap regverdig.

Hierdie besluite word aanvanklik beïnvloed deur die doeltreffendheid van simulasie as 'n onderwysstrategie in die beroepsopleiding van volwassenes in aanmerking te neem, en of dié strategie die onkoste en moeite daarvan regverdig. Dit was daarom nodig om die potensiaal van simulasie te ondersoek met betrekking tot sukses in die verlede, asook die huidige status, gebruik, en aanvaarding van simulasie in seevaartopleiding.

Een gevolgtrekking wat gebaseer is op 'n bestendige toename in die gebruik van simulasie word aangedui deur die gewildheid van simulasie in sekere gebiede van beroepsopleiding, wat sy doeltreffendheid bewys.

Ondersoek na die opleidingsteorie (insluitend die Gedragsontleders, Gagné, Gestalt, die Bewussynskool, Dewey, Lewin en Piaget, Rotter, Bruner, en Kolb) onthul dat die begrip van effektiewe opleiding plaasvind deur interaksie met die omgewing, en dit word in 'n mindere of meerdere maate ondersteun deur al die leerteorieë. Wat belangrik is van die interaksie met die omgewing, is dat dit doelbewus, toepaslik, doelgerig en betekenisvol moet wees sover dit die verwerwing van kennis en vaardigheid betref. Dus word direkte doelgerigte ondervinding geïdentifiseer as die algemene faktor wat die verskillende leerteorieë verbind.

Verdere ondersoek is oorsee gedoen deur die seevaartopleidings- inrigtings met simulators te besoek by CAORF aan die kampus van die U.S.Merchant Marine Academy, te Kings Point, New York; Seamen's Church Institute, Stad van New York; MITAGS in Maryland; Glasgow College of Nautical Studies; Blackpool and The Fylde college, te Fleetwood, Lancashire; en Liverpool Polytechnic, Liverpool. Besprekings het daar plaasgevind met dosente wat betrokke is by skeepsimulasie, asook waarnemings van simulasies. Dit het inligting verskaf vir vergelyking met metodes in Suid-Afrika, in die besonder die Opleidingsentrum vir Seelui en die 'Generaal Botha' Kampus van die Kaapse Technikon, om die aanvaarding en gebruik van simulasie as 'n onderwysstrategie te verseker, asook 'n didaktiese metodologie vir die bestuur van opleidingsimulasies te vestig.

Uiteindelik is 'n sintese verkry gebaseer op die toepaslike leerteorieë, tesame met gesonde didaktiese beginsels en die bogenoemde waarnemings, ten einde 'n voorstel te verskaf vir die bestuur en uitvoering van simulasie in beroepsopleiding, veral op seevaartgebied. Ook sal dit moontlik gemaak word om 'n voorstel te verskaf vir die oplossing van besluite met betrekking tot die "koste-doeltreffendheid" in die keuse en ontwerp van simulasietoerusting.

Die potensiaal van simulasie was duidelik, mits die ondervinding hierdeur opgedoen, van nut is. Dit is dus noodsaaklik dat simulasie-ondervinding deurgaans onder die streng toesig van leerbeginsels geskied, vanaf die beplanning en formulering van doelwitte tot met die onderhandeling en evaluering.

Aanbevelings erken dat die fokus te alle tye gemik moet wees op die student, wat sy opleidingsbehoeftes en doeltreffendheid tydens die leerproses betref. Deur die identifisering van opleidingsbehoeftes en die isolasie van die presiese tipe onderrigondervinding wat benodig word, is dit moontlik om die omvang van die realisme wat benodig word, te bereken. Hierdeur kan die prioriteite vir die keuse van simulasie- toerusting onderskei word.

SYNOPSIS.

The growing importance of the concept of learning by experience is highlighted through the credit given by American colleges for prior learning experience. However, it is not always possible to provide learners with the opportunity to gain experience where this involves equipment and tasks which are too costly in terms of time, expense, or risk of life and equipment.

The accelerated development in technology has led to rapid changes in conditions and instrumentation in the cockpits of aircraft and on the bridges of ships. In maritime training, the burden of maintaining the contemporary relevance of simulation training has been born by the training institutions, who have had to face increased costs and the selection of suitable synthetic training devices (simulators) from a wide variety of equipment offered which ranges in sophistication from the relatively simple to the fully representational high-fidelity ship simulators. Decisions faced by training establishments revolve around the desirability of high-fidelity simulators, the effectiveness of less expensive part-task trainers, and whether the effectiveness of simulation justifies the financial layout and running costs of simulator equipment.

These decisions would be influenced initially by the consideration of whether or not simulation is an effective teaching strategy in adult vocational training, and whether this strategy justifies the cost and effort which the application of simulation demands. It was therefore necessary to examine the potential of simulation in the light of historical success, and also the present status, utilisation and acceptance of simulation in the field of maritime training.

A conclusion based on the steady increase in the use of simulation would be that the evident popularity of simulation in certain fields of vocational training proclaims its effectiveness.

Investigation into the learning theories (including the Behaviourists, Gagné, Gestalt, the Cognitive school, Dewey, Lewin and Piaget, Rotter, Bruner, and Kolb) revealed the concept that effective learning takes place through an interaction with the environment, and this is recognised to a greater or lesser degree by all those theories of learning. What is important about this interaction with the environment is that it should be deliberate, relevant, purposeful, and meaningful in order to provide for the acquisition of knowledge and skills. Thus direct purposeful experience is identified as the common factor binding the various theories of learning.

Further investigation was conducted abroad during visits to the maritime simulation training establishments at CAORF on the campus of the U.S.Merchant Marine Academy, in Kings Point, New York; Seamen's Church Institute, New York City; MITAGS in Maryland; Glasgow College of Nautical Studies; Blackpool and The Fylde College, Fleetwood, Lancashire; and Liverpool Polytechnic, Liverpool. During these visits, discussions with those who were involved in marine simulation and the observation of simulations being conducted, provided material for comparison with methods in South Africa, particularly the Training Centre for Seamen, and the 'General Botha' Campus of the Cape Technikon, in order to ascertain the acceptance and utilisation of simulation as a teaching strategy, and to establish a didactic methodology for the conducting of training simulations.

Finally, a synthesis was derived based upon the appropriate theories of learning together with the application of sound didactical principles to the above observations in order to provide a suggestion for the management and execution of simulations for vocational training, particularly in the maritime field; together with a suggested approach towards the resolution of decisions relating to cost/effectiveness trade-off in the selection and design of simulation facilities.

The potential of simulation was evident, provided that the experience gained through this strategy is valid. It is important, therefore, that simulation be provided through the observance of sound didactic principles throughout all stages, from planning and the formulation of objectives to debriefing and evaluation.

Recommendations acknowledge that at all times the focus of activities should remain on the student, his learning needs, and the effectiveness of the training. It is not always imperative that complex and expensive equipment be specified. Through identification of learning needs and isolation of the exact nature of the experience required in order to fulfil those learning needs, it is possible to delineate the extent of realism required, and to discern the priorities in the selection of simulator equipment.

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CHAPTER 1

Simulators and Simulation, Introduction and Overview

This chapter serves to introduce the subject of simulation as a strategy for teaching and to discuss the general rationale behind simulation and the problems involved. The need for simulators and simulation is outlined, and the hypothesis is stated.

1.1 Introduction

Since teachers began to recognise the didactical methods initially advocated by Comenius (Cole, 1950), more attention has been given to the use of teaching media, from the lowly chalkboard and textbook to the harnessing of all that a well-equipped media centre can produce. An examination of various types of media in regular use in post-school education and training invariably use the recognised didactical principles as criteria (Conradie, 1979:3, Duminy & Söhnge, 1983:21). The attempts to represent subject matter in the classroom, which involve as many of the senses as possible, solicit the use of pictures, charts, video, models, etc. which can bring into the classroom what is either too abstract, too large, or too small to use in reality. However, nothing can replace realia[1] in cases where effective transfer of learning under specific conditions of behaviour and stress is vital to the task being practised by the trainee[2].

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1. **Realia** - It is not always possible to bring the real object into the classroom, especially if it is too large (eg. Planets), too small (eg. Molecules) or too abstract. However, according to Dale (1969:111) direct, purposeful experience is the most fundamental level of effective learning.

2. It will become apparent in this work that in a simulation the trainee should more readily be referred to as the "participant".

Unfortunately, in vocational education, the equipment for which the student is being trained, or the situations in the use of such equipment which must be experienced, are either too expensive, or the consequences of mistakes can be disastrous. In these cases realia would limit the time period of training severely, or even make it impossible. Regarding the advantages of simulation, Stein & Kobrick (1984:12) state: "Safety is both an ethical and a practical consideration." As a result, a trainer would be very reluctant to cause a fire or dangerous malfunction deliberately for training purposes in an airliner full of passengers.' However, pilots must have experienced such a problem and have dealt effectively with it in order to face such an occasion again with confidence and safety. The answer is to represent reality in such a way that the essential aspects of the problem are experienced. Such a representation has come to be known as a simulation; and the equipment facilitating this representation, usually controlled by a computer, is referred to as the simulator. To be more precise though, there are those who would assert that the environment, the situation, and the participants are the simulation.

1.2 The Need for Simulators and Simulation

It can be seen from the figures tabled below that simulation equipment is an expensive and sophisticated investment in post-school education. It is aimed at training for a specific task or group of tasks in an environment which is specific to the vocation in question.

The rationale behind such an expensive outlay is that training in real time and in the actual operational situation would be more expensive in terms of time, the consequences of a possible mistake, as well as cost and availability of the real equipment than it would be if the situation were simulated.

An example of cost difference in air pilot training is supplied by IATA[1]:

Aircraft	cost/hr.	Simulator cost/hr.
DC-9	$3696.00	$391.00
B-747	$10370.00	$672.00

Aircraft costs include: Fuel, Direct maintenance, Handling, Crew allowance, and Aircraft hire.
Simulation costs include: Interest, Labour, and Repairs/updating.

It can be seen from the above figures that the simulators are very costly. However, it cannot be denied that the comparison with the price of the real aircraft renders it essential for training. The above figures do not even make allowance for risk of life and equipment whilst teaching a novice in a real machine. It can also be appreciated that there would be a great reluctance to repeat certain experiments too often, both in terms of finance and time available as well as of risk.

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1. **TOTAL SIMULATION**, a flight crew training bulletin. (undated)

Some tragic incidents occurred during training in real aircraft:

- In New York in 1959, a B707-123 crashed killing five crew whilst making a simulated engine-out approach.

- In 1965 a Convair 880-22-1 crashed and burned in Kansas City because the trainee pilot lost control during a simulated engine-out take-off.

- Six people were killed in Lebanon in 1979 when a B707-327C crashed after a take-off with a simulated engine failure.

- Also in 1979, a DC-9-14 crashed into a swamp in Florida. When the aircraft reached 100 feet, the instructor cut the starboard engine. Control was lost, the aircraft veered to the right, struck the ground and broke up.

These incidents are some of many affecting turbo-jet aircraft. It would be a sad task indeed to investigate the numbers of similar tragedies in smaller, propeller aircraft.

The recent costly wreck of the Exxon Valdez, and consequent oil spillage in Alaska, might have paid for several hundred hours of training in the most expensive marine simulators. It is said that one learns from one's mistakes. Would it not be better to make those mistakes in a simulated environment?

In the Maritime field, to train just a few navigation officers under a specified condition or for a particular traffic situation in a ship would necessitate the charter of the ship, preparation for sailing, pilots, tugs, berthing gangs, crews and instructors. Several hours would elapse before the ship reached the desired location, with no guarantee of exactly the right conditions. Then the ship might need to return to port at the end of the day. By contrast, during one daily session in a simulator, several specific situations could have been set up anywhere in the world, and extraneous formalities could be dispensed with by placing the vessel at sea and already in the training situation. One wonders how many years of experience would be needed to present officers with the variety of traffic problems which a simulator can present within only a few weeks of training.

In addition to the advantages described above, a further advantage of simulations (especially if computer driven) is that of measurement (Stein & Kobrick, 1984:12). Data during the simulation can be collected and analysed. If sufficient data is collected, it can even facilitate a complete playback of the run during debriefing for critical analysis and the resultant recognition of mistakes and an opportunity to suggest corrections and improvements to decisions made.

1.3 What is a Simulation?

There is much misconception regarding this subject. The terms role-play, games, simulations, imitations, playing, and exercises are intermixed and alternated as though they had the same meaning. The word '**simulation**' and the word '**similar**' sound alike, which makes it very easy to give them the same meaning. The Oxford Illustrated Dictionary (1962) defines the verb '**simulate**' to be to feign, counterfeit, pretend or mimic. The Universal Dictionary (1987) gets closer. It defines the word to mean imitating or creating conditions as for an experiment or for training, but the connotation of pretence is still there. One computerised thesaurus (Wordstar 5.0) associates the word '**simulate**' with the word '**duplicate**' which is an interesting direction to have taken, because the suggestions of Roget's Thesaurus (1970) include the word '**duplicity**' - hardly the same meaning as '**duplication**'.

Before discussing the meaning of simulation, it would be pertinent to examine the meaning of some of the other terms used, in order to establish their validity when considering the subject of simulation:

> **Role-Play**: This is a theatrical representation in which a person or group of persons takes the part (role) of fictional or real characters, and behaves as he does, either to a prepared script or along the lines of a brief (Dale, 1969:252). It has significant educational value, but the role players are nevertheless conscious that they are playing the part of somebody else in a supervised or directed environment.

> **Game:** This conjures up images of a competitive event in which there are winners, losers, rules, a referee and perhaps an element of fun. Valuable lessons can be learned through the playing of a game, but this does not bring the participants into the real world. It is still a process of pretence (Jones, 1987:15).

It is evident that simulation is a great deal more serious than a game, although it can and should be motivational, if not fun. It is also less directed than role play, although the question of roles does apply in a different, non-dramatic connotation.

A comparison is made by Jones (1987:11,12) between case study and simulation. Although they deal essentially with an actual event, those performing a case study are detached observers of the event whereas in a simulation they participate with the "power and authority of professionals who are trying to cope with a developing situation".

Jones (1980:20) very briefly defines simulation thus: "Simulations are reality." He further offers the following definition (Jones, 1987:17):

> **"A Simulation"** . . .[in education]. . . **"refers to untaught events in which the participants have roles and are required to accept the responsibilities and duties of professionals."**

Jones goes to great lengths to describe simulations as a real event in which the simulation is the real world to the participants. They do not play a part, but must make decisions and act, knowing that they must take responsibility for their actions. He indicates that the actions of participants might affect other participants and can change the nature of the event in an unpredictable way. The participant learns from his actual experience and is allowed to make mistakes from which he will learn. He asserts that the participants own the simulation; they are the simulation. The hardware and the institution outside the event are merely the facilitators of the simulation. The result of a simulation is that the participant gains experience, not just cognitive perception. In the definition, untaught events refer to the events which take place in the simulation.

Essential techniques used to perform the duties required in the simulation would already have been covered before entering the simulation. Throughout this work the above definition as given by Jones will be adopted, and will form the basis of understanding of this term.

1.4 A Clarification of Terminology

The glossary at the end of this work will provide brief definitions of many of the terms in use; however, some of the more important concepts, as used here, must receive attention at this juncture because of their frequent use throughout this study:

Controller is the term used to describe the person in charge of conducting the simulation. It will be stressed in Chapter Four that the controller is not so named because of a power of control over the simulation. It is an expression of didactical accountability whereby he is responsible for the control of all activities involved in the planning, presentation, evaluation, and adjustment of the overall facilitative structure (see paragraph 4.2).

Exercise is the term chosen for the purpose of avoiding the erroneous (paragraph 1.3) term "game". An exercise would be the planned programme involving a simulation which would be designed and run in order to achieve set didactical objectives.

Facility embodies the building, organisation, equipment and staff which run a simulation.

Fidelity concerns the degree to which a participant's action varies with the same action in a real job situation. Stein & Kobrick (1984:14) report on a literature survey by Hays (1980)[1] in which two types of fidelity are identified: Stimulus fidelity (appearance or "feel", and reponse fidelity (the actual outcome of the task). Fidelity could refer either to the mode of action (a control switch) or the type of action (answering questions on a computer rather than an actual diagnosis of a problem) (Alessi & Trollip, 1985:188).

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1. Hays, H.T. 1980. Simulator Fidelity: a concept paper. Army research Institute Technical report 4(90).

However, in this work, the term "fidelity" will be used only in the context of consequences of the participant's action in the simulation (response fidelity) unless preceded by a qualifier, either "stimulus" or "response".

High-Fidelity is a term used to describe a simulation device which provides facilities with a high degree of stimulus fidelity as well as response fidelity. The participants would identify strongly with the simulated world and its analogy to the real world.

Objects in the context of simulation are any physical entities being represented.

Participant is the designation of the trainees/students who are being given the chance of obtaining vocational experience resulting from the participation in a simulation which might form part of the total training programme.

Real World refers to the material, concrete job situation in which learning or training is not the primary objective, but is in fact the situation for which the student is being trained.

Reality in a simulation refers to the situation within the simulation. Contrary to the perception of those not participating in the simulation, reality is not what is outside. Jones (1980:20,21) emphasises that "reality exists - genuine and actual - in the essence of the simulation ... ". Any reference to the reality of a simulation in this work will refer to the essential features of the environment inside the simulation.

Realism is not essentially associated with the term "reality in a simulation". It refers to the extent to which the simulation reproduces for the participants the actual atmosphere and sensations of the real world job situation. Alessi & Trollip (1985:186) also relate this term with the degree to which a particular component is like its real counterpart. Alessi & Trollip (1985:186) point out that "... increased realism is not necessarily tied to increased effectiveness". There is a danger of confusing the term "realism" with the term "fidelity". In a Maritime simulation, the Electronic Bearing Cursor could be operated by a mouse or touch screen instead of a rotating knob. This would refer to its stimulus fidelity or "realism". The way in which the function of this control provides the desired result refers to its response fidelity.

Representation is a term which will be used in its capacity to represent the rest of the outside influences upon the simulation (Jones, 1980:20,21). In a maritime simulation, this would be facilitated by radio communications with a representation of the nearest coast radio station, or by telephone to the Engine Room, which does not exist materially in the simulation, but must be represented to those inside the simulation. The representation of the exercise area, weather conditions, traffic, system failures, etc. is introduced into the simulation by the controller and his team. They are therefore representational, and unlike the simulation itself, can be manipulated whenever necessary from outside the simulation.

Role as indicated in paragraph 1.3 (page 7), refers to the professional function of a participant in a simulation. The participant does not merely play the part of the professional but takes the responsibilities and performs the functions of the professional. In the performance of such a role, the participant affects other participants as well as the outcome of a simulation through his decisions and actions.

Simulated World refers to the world being experienced by the participants during the simulation.

Simulator applies to the hardware directly associated with the construction of a simulation and its representational features, frequently but not necessarily computer driven.

Student refers to the post-school learner in the andragogic perspective.

1.5 Purposes of Simulation

Simulations are not dependent upon computers. Many simulations do not use them, even to effect calculations as a tool in the simulation. The purpose of this work, however places its emphasis on the use of computers in simulation and simulators. Sometimes the simulation is represented on the computer screen or other output device, but expensive installations use computers to control sophisticated machinery and instruments to facilitate the degree of realism required for the simulation, and affect as many of the senses as possible.

Simulation seems frequently to fall under the category of "Computers in Education" as though all simulations were computer controlled, or that simulation falls somewhere into a subcategory of teaching media, namely computers. However this rather simplistic approach allows neither importance nor room to develop for something as prominent in some avenues of vocational training as simulation. Many institutions, not least the military, have invested heavily in simulation equipment and put it to good use. It seems wise therefore to regard simulation not merely as a teaching aid, but as an important method of vocational training, with its own system of objectives, criteria, methodology, and terminology. Simulation can then be subdivided into categories (Alessi & Trollip, 1985:162) such as:

Physical Simulations.
Procedural Simulations.
Situational Simulations.
Process Simulations.

Examples of various simulator installations include the following[1]:
Civil flight simulators.
Military flight and air-combat simulators.
Numerous space-travel simulators for various purposes.
Air navigation simulators.

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1. This list is based on the author's own knowledge. It is quite conceivable that the actual list could be much longer, since imaginative trainers would be able to devise simulations for most vocational applications.

Maritime navigation, collision avoidance, and ship handling.

Submarine control.

Submarine and naval warfare simulators.

Machinery and engineering simulators.

Air hostess training - cabin, and emergency procedures.

Tank warfare and tactical warfare.

Plant control and process simulators (e.g. SASOL II).

Reactor control (e.g. Koeberg).

Business simulations, including merchandising.

Some of the simulators mentioned above are in use by the South African Civil Aviation, Air Force, and Navy. The South African Armed Forces are typically using tactical exercises for training of officers and troops. Some of these exercises are widely publicised by the media. In the Merchant Navy, use is made of simulation installations at the Cape Technikon's General Botha Campus, and at the Training Centre for Seamen in Table Bay Docks.

Not all simulation is used primarily for training. Some simulations are used to test a hypothesis which would be difficult to examine in any other way. For instance, astronomers would use a computer to create a mathematical model in order to study the aggregation of stars by their mutual gravitational pull. Some training institutions use simulators also as a research tool. A recent example was the re-enactment on the Simulator at the Computer Aided Operations Research Facility (CAORF), Marine Academy, Kings Point, New York, of the grounding of the Tanker "Exxon Valdez" on Bligh Reef in Prince William Sound, Alaska.

1.6 Categories of Simulation

Simulation can be divided into the following categories (Alessi & Trollip, 1985:162):

Physical Simulations: A physical object is portrayed by the computer. This class of simulation is used to demonstrate the operation of an instrument or machine. The emphasis is on cognitive perception.

Procedural Simulations: A physical object is portrayed for the purpose of teaching the operator to use the machine or instrument portrayed. These simulations are used for Psychomotive training or diagnostical problem solving.

Situational Simulations: Here, a situation deals with attitudes and behaviour. The simulation can be used to confront the participant with himself, or for observation and assessment of personnel.

Process Simulations: This is an observational simulation in which a process can be studied after input of certain critical data. For example, population growth can be examined subject to different life-expectancies, infant mortality rates, etc. This category would also include mathematical models of scientific events so that they can be demonstrated or investigated. There are no direct participants.

1.7 The Problem

There are those in civil aviation who advocate 'Total Simulation' in which the pilot's first experience in a real aircraft is as the co-pilot of a commercial, non-training flight. This places tremendous emphasis on total realism.

In the maritime arena it has become evident lately that there is a tendency to rush to develop better simulators. The rapid development of technology facilitates the achievement of amazing realism, with wrap-around scenery, sounds, and even ship vibration and motion. At the same time, technology in navigational equipment is also accelerating at an alarming pace. There is therefore a definite need to keep abreast of new developments in the training establishments. Traffic is becoming more congested, and more responsibility is placed upon tanker crews especially to keep their ships away from trouble.

The accelerated development of technology renders expensive simulation equipment obsolete[1] with startling rapidity. It is the contention of the writer that a detailed investigation into simulation would indicate economical and more effective options which might be considered by educators in the field of vocational training as well as the developers of simulation hardware and software.

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1. It was pointed out to the writer, however, by Captain R.Beadon of the Seamen's Church Institute in New York that although many of the simulators in use are becoming quite dated (e.g. those at Southampton and Glasgow), very effective training was still being achieved through the use of those installations. Nevertheless, Southampton has recently purchased a new simulator ("Safety at Sea" 1992).

Simulators are becoming more and more sophisticated, and installations are becoming larger and more expensive. Manufacturers are competing with each other for greater realism. Institutions compete for students on the basis of status, to which the sophistication of their equipment contributes. This raises the question as to whether there a danger that these institutions would thus lose their conception of the aims and objectives of simulation in training.

Questions which need to be answered refer to: the objectives of simulator courses and simulation in general; the extent to which realism is necessary; inexpensive alternatives to expensive hardware which might be considered; facilities and attributes required by industry and/or the training situation; didactical methods best suited to training by simulation; evaluation of performance as well as the effectiveness of the training received (including competency based progress); the effect on the student involved, taking both didactical as well as andragogical considerations into account.

1.8 Questions addressed by this thesis

a. To what extent does the application of simulation contribute to the training of students in technological activities?

b. What didactical approach is best, and which methods of teaching are most effective, not only in the cognitive and psychomotor domains, but also as an influence for a lasting and positive effect on the mind, and the attitude of the student to the tasks and circumstances for which he is being trained?

c. What is the reaction of the student to specific stimuli in the simulated environment, and to what extent does this approximate his reaction to the same stimuli under real conditions?

d. How does the student cope under stress, and how closely does the simulation reproduce causes of possible stress in the real situation?

e. Does the lack of stress produce dangerous complacency and a false sense of well-being in the face of danger?

f. What is the description of the student who is typical of those who successfully complete the course, particularly in respect of personality, social and academic backgrounds, aptitude, previous experience in the real task, and level of education?

g. To what extent does theoretical preparation of the students for the simulation course contribute to the success of that course, and how is this preparation best carried out?

h. To what extent does realism of a simulation in respect of general surroundings (ambience, sounds, sensations, lighting, time of day, etc.) contribute to the actual perfection of the tasks being reproduced?

i. What is the level of importance of the approximation of the appearance and 'feel' of the simulated instruments to the real instruments for which training is taking place?

j. What is the ultimate result of simulation in the student's overall confidence, fulfilment, motivation, and sense of achievement?

k. What is a general description of the type of hardware and software which would adequately fulfil the objectives of simulation as a result of the answers obtained to the above questions?

l. What is the description of the effective lecturer/instructor who would be called upon to present a simulation course?

m. What are the criteria related to the type of tasks which would render training under simulation desirable?

n. What methods of evaluation during and after the simulation course would give the best control regarding content, quality, and didactical methods used?

o. How should the educator in a vocational training situation assess the relevance of the simulation to the overall training task and objectives?

p. In view of the diversity of makes of instruments and layouts of equipments, as well as the rate of technological advances, to what degree of generalised or specific simulation does an installation and associated course contribute towards the capability of the student who has completed the course to adapt to change and/or situations different from those which the simulation reproduces.

1.9 The Hypothesis:

Simulation is a powerful strategy in the training of vocational tasks in which cognitive, affective and psychomotor functions are stimulated under conditions which approximate the real situation for which the post-school student is being prepared. However, it must be recognised that this statement would apply only provided that the simulation facilities are utilised correctly and didactical considerations to be addressed in this project are followed.

1.10 Arrangement and Research Methodology

The presentation of this thesis will comprise five chapters:

Chapter 1 introduces the subject of simulation, reviews the problem and states the hypothesis.

Chapter 2 briefly outlines the historical background to simulation, highlighting the development of maritime simulation. The historical information portrayed will be gleaned from the perusal of literature on the subject.

Chapter 3 attempts to provide a psychological view of the theories of learning with respect to simulation in education, and also describes the participant. Evidence will be drawn from a study of literature regarding simulation, education and psychology.

Chapter 4 provides a framework for the didactical application of simulations for the training of professionals. The effective controller is described. The information used in the completion of this chapter will be obtained as a result of personal observations and also interviews with members of the profession in South Africa, as well as the United States of America and the United Kingdom, who are involved with the application of simulation in training. Institutions with simulators in these countries were visited for this purpose, including CAORF at the U.S. Merchant Marine Academy, Kings Point, New York; SCI, Manhattan, New York; MITAGS in Maryland, USA; Glasgow College of Nautical Studies in the UK; Fleetwood College in the UK and Liverpool Polytechnic in the UK.

Chapter 5 provides for the conclusions to be drawn from the research and recommendations to be proffered.

Finally, an appendix will be included which will provide further documentation and illustrations (including a sample simulation devised by the author) not included in the main text, a glossary of terms, and an index.

1.11 Summary:

In this chapter, after introducing the subject of simulation and the role of simulation in vocational training, the basic need for simulation was discussed. It was suggested that whenever a need for experiential training existed for situations which rendered the real equipment or situation too costly, time-consuming, or dangerous, the desirability of a simulation was indicated. The nature of simulation was compared with that of role-play and gaming, and the term "simulation" was defined, after which the various purposes for which simulation is used were discussed, as well as the categories under which simulations fall. Finally, questions which relate to the problems of simulation were tabulated, the hypothesis was stated, and an outline of the research methodology was presented.

In the next chapter a brief overview will be conducted regarding the history of simulation, followed in chapter three by an investigation into the application of current and past theories of learning to simulation, and a description of the participant.

CHAPTER 2

A Brief History of Simulation

In this chapter a brief review is made of the historical background to the present simulation techniques and equipment in use, including maritime simulation.

2.1 Review of the previous chapter

In the previous chapter, the nature of simulation and its role in vocational training were discussed. The purposes and categories of simulation were explained. The nature of the problem was introduced, and the hypothesis was stated. In this chapter a brief history of simulation will be related, with particular reference to maritime simulation.

2.2 Simulation in its infancy.

Upon reflection regarding the use of certain aids in warfare training in ancient times, consideration of the wooden swords of the Spartan boys as they practised in the Gymnasia, and the swivelled quintain with which the knights of old jousted, poses the rhetorical question as to whether they could not be regarded as a precursor to the modern simulators.

It has been claimed that the game of chess, first played in India 1500 years ago, was a "crude attempt to simulate battle between two nations" (Maidment & Bronstein, 1973:9). Usually played for pleasure, the potential of "adapting chess-like games for serious military purposes became apparent".

The origins of simulation in the modern context were primarily developed as a method of assessment of behavioural characteristics of individuals for certain tasks in the military. The Prussian army are said first to have used organised simulation in the nineteenth century. Their method was described by Stein & Kobrick (1984:2) as a "low technology form of simulation involving boards, player pieces and detailed rules". Maps and terrain models replaced checker boards, pieces representing infantry, artillery and cavalry units were used, and "the rules governing the strength and movement of the various pieces were more realistically prescribed" (Maidment & Bronstein, 1973:9). The simulation was participated in by a team on each side, and was monitored by a judge and referees (Maidment & Bronstein, 1973:10).

In order to augment pen and paper tests and interviews, simulations were devised as an improvement in the recruitment of officers. The purpose of these simulations was to observe the behaviour of recruits in a realistic situation rather than merely to ask the candidate how he would cope if that situation were to develop (Jones, 1987:19).

The British army developed the idea of simulations in order to test behavioural situations. Aspects of military life which were revealed included varying degrees of ingenuity, co-operation, leadership, and courage (Jones, 1987:19). By the time the second world war had begun, the Americans were faced with the problem of identifying the best type of personalities for undertaking dangerous espionage.

The consequent American simulations (performed in Station 'S', Virginia which was established in 1942) were organised by the Office of Strategic Services (OSS) for recruitment and training for espionage where they structured situations in which the candidates might blow their cover or be faced with frustrating human relationships (Stein & Kobrick, 1984:4). The tests included such behavioural qualities as co-operation, patience, stress, alertness, and complacency (Jones, 1987:20).

In the 1960's and the 1970's armies developed war gaming into sophisticated, organised engagement simulations (ES) which served to examine behaviour under stress, decision making, and inter-staff communication (Stein & Kobrick, 1984:7,8).

A system was developed at Fort Hunter Liggett, California which uses lasers instead of real bullets to assess casualties in a simulation training event (Stein & Kobrick, 1984:11). The National Training Centre at Fort Irwin, California, is described by Stein & Kobrick (1984:11) as being capable of placing a level of realism on units "considerably higher than anything else they are ever exposed to, short of actual combat".

Political scientists, sociologists, and psychologists saw the research potential of simulations, and the RAND corporation started to develop "crisis games" in the mid 1950's (Maidment & Bronstein, 1973:9). These simulations attempted to create various possible future international crises in order to examine foreign policy alternatives. In the 1960's these were extended to cover other fields, including health care, transportation, welfare, fiscal and monetary planning, and the conduct of war (Maidment & Bronstein, 1973:11).

Training in business management received special attention in May 1966 when the European Research Group on Management (ERGOM) was formed (Tansey & Unwin, 1969:8). ERGOM published a series of ten simulations to be conducted by trainers in their own organisations dealing with aspects of management, including budgeting decisions, leadership, organisation, communication, negotiation, and evaluation. At the same time, business and industrial applications were utilised in order to assess managerial staff (Jones, 1987:20). This was the start of the general use of simulations, and now simulation finds wide acceptance in the observation of behaviour, and as a method of providing vital experience necessary in vocational training and recruitment.

2.3 Flight simulators and training devices

One form of flight simulator used by the Wright brothers in the development of their early gliders and powered flying machines was the wind tunnel (Bonanni, 1991:5), a device which had already been invented, and which has now been developed into a sophisticated computer-driven research instrument.

The history of synthetic training aids dates back to the early twentieth century. The unacceptable frequency of fatalities in flight training during the first world war precipitated the introduction of primitive flight simulators, frequently consisting of no more than a stick and a chair (Stein & Kobrick, 1984:3). Despite the primitive nature of these early machines, the mere continued use and development of flight simulators demonstrates their acceptability as a training medium, and they provided the basis for the development of modern high technology training simulators.

The initial development of these simulators took place between the two world wars with the introduction of the forerunner of the fully functional flight trainer, the Link 1, nicknamed "the Box". This unit consisted of a movement platform which responded to the pilot's control, displayed essential instrument readouts, and provided feedback on the actions of the trainee. Invented by the son of an organ builder, Edward Albert Link Jr., the Link 1 Trainer was officially named by him the "Pilot-maker" (Bonanni, 1991:6).

Although it was patented and completed in 1929, the Link Trainer met with scepticism, not finding general acceptance by aviators until 1934 during the winter of which 10 pilots were killed when the U.S. Army Air Corps began flying the mail. Subsequently "an entire generation of pilots" were trained using the Link Trainer (Bonanni,1991:7).

A description of the Link Trainer by Robert Glaser (1962:223) is quoted by Dale (1969:235) as follows:

> "Seated in the covered cockpit, the operator of such a device carries out nearly all of the activities required in a real airplane. He makes pre-flight checks, starts the engines, goes through a typical take-off procedure, flies a prescribed mission, contends on the runway with the various weather and emergency conditions, and carries out the activities involved in landing. During all this time, he observes instruments and operates controls which simulate those of the real airplane with a degree of precision; even the movement of the cockpit and the noise of the engines may be simulated in a highly realistic manner."

Following the tradition of the Link trainer, the first computer- controlled flight simulators (which emerged during the late 1950's) were "motion-based and focused on instrument training" (Bonanni, 1991:8). The flight decks were exact replicas of those in the commercial aircraft which they were designed to represent. Many of these early flight simulators proved so effective that they are still in use (Bonanni, 1991:10).

Computerised simulators for military aircraft through the late 1950's to the late 1970's were more conservative (Bonanni, 1991:10). However, the success of the motion-based simulators for commercial aircraft combined with the oil crisis, increased the importance of simulation in training. The result was that in 1978 high-fidelity motion-based simulators with visuals replicating the Northrop T-38 combat aircraft were produced for the US Air Force (Bonanni, 1991:11), whilst similar units for heavy aircraft were also being manufactured.

Modern flight simulators now range from the simple cockpit procedures trainers and instrument trainers to units which feature a full flight deck, movement, sound, and visual reproduction of the scene outside the aircraft. High-fidelity flight simulators cost "tens of millions of dollars" (Bonanni, 1991:12). Consequently full advantage is being taken of the low cost computers which have been increasing since the 1980's. Part Task Trainers (PTT) have been made possible as a result of the micro-computer.

The trend in flight simulation, therefore, is towards low cost, high performance PTT's (Bonanni, 1991:13), which can be networked in such a way that a high volume of candidates can be trained, and also that each unit can be interactive with the others on a "realistic battlefield". These PTT's sacrifice high-fidelity for greater availability and lower cost. Bonanni (1991:13) reports that "the trend towards low cost, high performance PTT's is irreversible in fighter aviation, and all fighter units are clamouring to get them".

Contrasting with the trend towards PTT's there appears at the same time to be a trend towards "total simulation" as opposed to "in-flight training" for the purpose of the upgrading or conversion of qualified pilots to aircraft they had not previously flown. In total simulation, the pilot completes his training entirely in high-fidelity simulators before taking the controls of the real aircraft (as co-pilot) for the first time. The concept was discussed and supported in a General Flight Crew Training meeting in Montreal during May 1984 (IATA publication, undated:2).

2.4 Space-flight simulation

The exploration of space has made notable demands upon simulation techniques (Farmer & Hamblin, 1970:168). Of interest especially are those which prepared spacecraft and astronauts for environments not yet actually experienced by them, including the near vacuum and extreme temperatures of space (Allward, 1969:264,309,333); contingency procedures (Farmer & Hamblin, 1970:168); orbital rendezvous and docking (Allward, 1969:313,314) (Hall et al., 1974:35); weightlessness (Allward et al., 1970:374); in-flight procedures (Briggs, 1972:51); lunar landing (Farmer & Hamblin, 1970:168-171); and lunar exploration (Farmer & Hamblin, 1970:172,173) (Briggs, 1972:54,57). The effect of space exploration upon the development of micro-computer technology, in the opinion of the writer, has indirectly contributed to the development of comparatively low-cost micro-computer based simulators.

2.5 Maritime simulation

In the Maritime field, the writer recalls practising in the 1950's on an electrically driven steering trainer which responded to the operation of a ship's wheel, and could be used to teach a trainee to respond to conning commands as well as steering a course by compass. The unit is still in existence and could until recently be seen at the General Botha campus of the Cape Technikon. It has now been donated to the Navy League of South Africa.

The first radar simulators came into being during the sixties (Meurn, 1990:152), no doubt partly due to the determination of trainers and legislators to reduce the danger of so-called radar assisted collisions and the appalling consequences of dangerously misinterpreted radar information resulting from inexperience, complacency or ignorance. These early radar simulators were driven by analogue computers and analogue coastline generators (Meurn, 1990:152). The Nautical Department of the Liverpool College of Technology, with financial aid by the Liverpool Steamship Owners Association, installed the "first **'Two Own Ship'** collision avoidance radar simulator to be built" (Bole, 1983:99).

Manned ship models on a scale of 1:25 provided the basis of the first physical ship handling trainer. First built in 1967 (Meurn, 1990:152), this arrangement, still in use, replicates the handling characteristics of real vessels in an "ocean" represented by a lake eight acres (3.24 hectares), now ten acres (4.05 hectares), in extent at the Marine Research and Training centre of Port Revel, Grenoble, France.

This installation has steadily been developed and now features a fleet of vessels representing ships between 17 000 dwt and 400 000 dwt (Tassan, 1985:publicity brochure).

The facilities at Port Revel include various berths and loading towers, movable breakwaters and buoys, as well as wave and current generators. The manoeuvres are recorded and displayed by a sophisticated computerised tracking system (Port Revel Information Brochures). A similar system is now in use by the College for Nautical Studies, Warsash, Southampton (Wright, 1979:32).

Also in 1967, a visual display was announced by the Japan Radio Communications Company Limited. The display was taken from a television camera which moved over a 1:1000 scale model of a harbour and presented by television monitors on the position of the front windows of a wheel house which rolled, pitched and heaved (Meurn, 1990:152).

In 1968, the first application of digital computer graphics was provided at the Swedish Maritime Research Centre; and in Delft, Netherlands, a point light source projected the shadow of a three dimensional scale model onto a screen (Meurn, 1990:152).

Credit for the first modern computerised maritime training simulator seems to go to England. The January 1975 edition of the periodical Safety At Sea, announced the then recent commissioning at the Hull Nautical College of "the world's first special-purpose digital radar simulator designed specifically for mercantile marine applications".

The fully integrated digital simulator, designed by Marconi Space and Defence Systems Limited, featured a full replica of a ship's bridge fitted out with radar, steering and engine controls, and navigational aids including Decca, track plotter, echo sounders, radio direction finder, sonar, net sounder, warp tension indicator, walkers log, gyro repeater and others (Prince, 1975:23).

The simulator at Hull could reproduce the handling characteristics of any size of vessel, and was used for training in collision avoidance, navigation, pilotage, and fishing. The simulation installation was capable of being used in one of four modes: Own'Ship 1 provided advanced courses in navigation for senior navigation officers.

Own Ship 2 was for formal training in correct decision making, operation and interpretation of fish detection equipment, and the handling of fishing gear on board a trawler. Own ship 2 provided the simulation of a trawler using bottom or mid-water trawling gear, and included depth, tidal influences, hard and soft bottoms, and the presence of fasteners. Own Ship 3 was used to train pilots in manoeuvring skills and collision avoidance. The Shore Surveillance Cubicle gave pilots training in traffic control from the shore (Parker, 1974:31).

2.6 Present trends in Maritime simulation

Developments have been continuous to the present stage at which certain ship simulators have all that the first simulator in Hull had plus sound, vibration, movement, and wrap around view of the world of the ship outside the bridge windows.

An example of this is the installation at the National Maritime Research Centre of Marine Safety International, New York, where in 1989, viewers stood in the replicated bridge of a super tanker and relived the passage of the ill-fated tanker "Exxon Valdez" down Prince William Sound (Garrigan, 1989:1).

In Maritime simulation, attention has not only been given to radar simulators and bridge simulators, but also to other maritime vocational activities. Apart from bridge simulators and radar simulators, the writer has viewed submarine simulators, tanker loading and discharging simulators, liquid gas carriage simulators, and engine room simulators.

The latest trend in bridge simulation has been influenced by the development of micro-computer technology and the RISC 32 bit chip on the one hand, and escalating costs on the other. This has paved the way for relatively inexpensive micro-computer based simulations over a wide range of complexity (Pollitt, 1990:17). Some of the simulators present their visuals and data on standard colour monitors in a similar manner to the flight Part Task Trainers referred to above (SISradar brochure and Microsim brochure). Similarly to the flight Part Task Trainers, micro-computers offer the ability to provide low cost task-priority simulations featuring two or more own-ship stations which through networking, would be fully interactive with each other in a typical traffic situation.

High-fidelity bridge simulators nevertheless enjoy a high profile. Following the International Marine Simulation Forum Conference in 1984 (MARSIM 84), training in the United States (implemented in July 1985), the United Kingdom and elsewhere, places emphasis on the advantages of "Whole Task Training" in which the performance of all normal and contingent bridge procedures are addressed as a complete effort incorporating the integrated activities of ship-handling, navigation and watch keeping at sea (Meurn, 1990:157).

2.7 Summary

In review of this chapter it will be seen that the concept of simulation is not entirely new, although modern technology has accelerated the availability and necessity of the use of simulation in many fields of vocational training. In Chapter 3 an examination will be made of the persons involved with reference to the psychological perspectives of a simulation. With particular regard to the student, the influence of theories of learning as applied to simulation will be investigated in order to understand the value of simulation in the learning process, and to serve as a guide to the conducting of simulations in vocational training.

CHAPTER 3

The Potential of Simulation in the Process of Learning

In this chapter a psychological study of those participating in a simulation is made. Learning theories are examined and the concept of experiential learning is related to simulation.

3.1 Review of the previous chapter

Following the first chapter in which the nature of simulation and its role in vocational training was discussed, chapter two related a brief history of simulation with particular reference to maritime simulation. This chapter will examine the role of simulation in psychological perspective, whilst also examining the roles of the participants in the context of an empirical androgogic approach to theories of learning.

3.2 Simulation and the learning process

It will be seen from the previous chapter that simulation in the modern sense was intrinsically devised for the evaluation and selection of military personnel, and we can therefore conclude that the use of simulations as a training medium was not immediately apparent to the Prussian Officers who devised those early simulations. It would seem that for some considerable time simulations were used principally by the military, and that they were used for evaluation primarily in the affective domain[1], where behavioural qualities such as co-operation, patience, stress, alertness, and complacency were monitored.

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1. The cognitive, affective and psychomotor domains postulated by Bloom will be discussed later in this chapter.

However, the time-span covering the two world wars[1] saw the emergence of an awareness of the value of simulation as a training medium, and any assessment during these simulations also formed part of the didactical process. Thus the question is raised: what is it that has lent such credence to this method of training, and why is it that training establishments around the world are prepared to invest large sums of money on simulations which in certain fields occupy a relatively short time span (days or weeks) during an overall training period lasting several years?

An answer begins to emerge with an examination of Dale's Cone of learning (Dale, 1969:107). In the diagram of his "cone of experience" (Fig. 3.1) the eye is quick to notice that the base of learning according to Dale is "direct purposeful experience". It can be suggested after reading the explanation in Chapter 1 that if one agrees with Jones then simulation would fall directly into this fundamental category. It could be argued that simulation is not direct experience, but consensus might be reached if simulation were placed into the category of "contrived experiences" with the proviso that every effort should be made to effect as close an approach to the former as possible, taking care not to omit the essential aspects of the task in its operational context (Dale, 1969:235).

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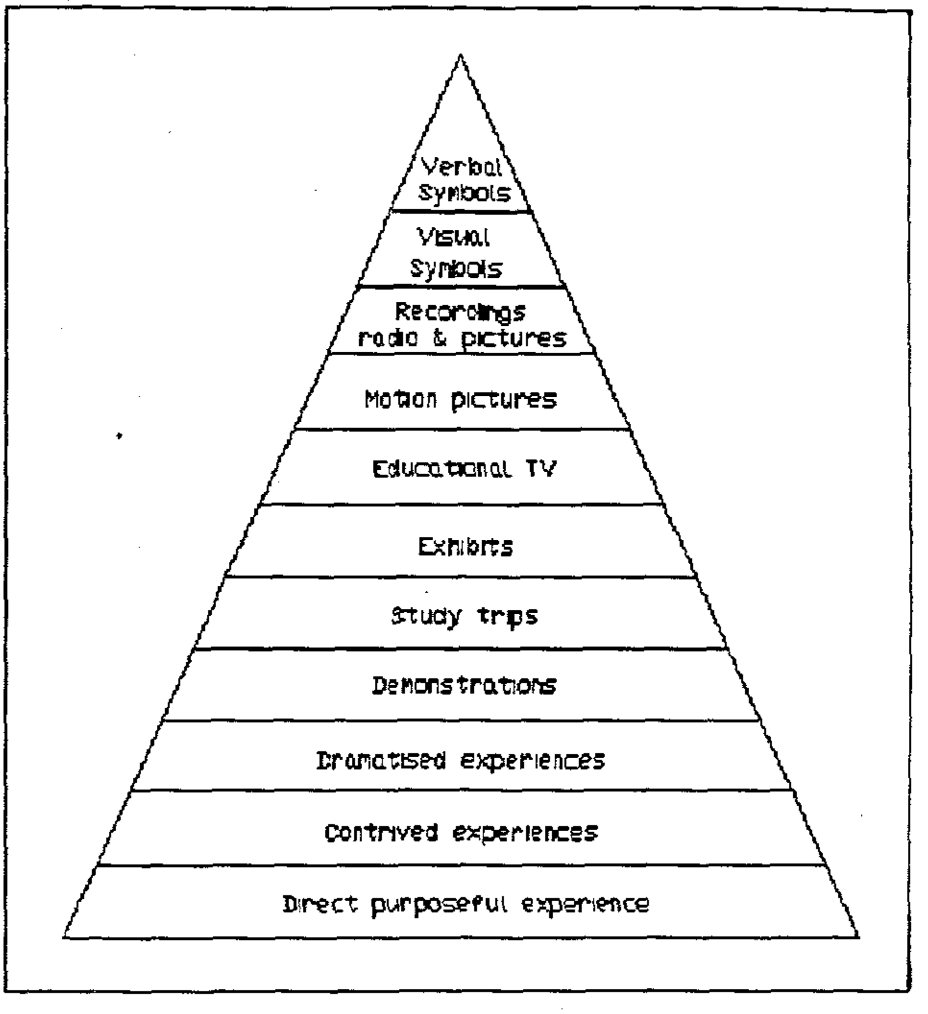
1. Referring here to the development of flight training units including the Link 1 trainer mentioned in Chapter 2.

Figure 3.1



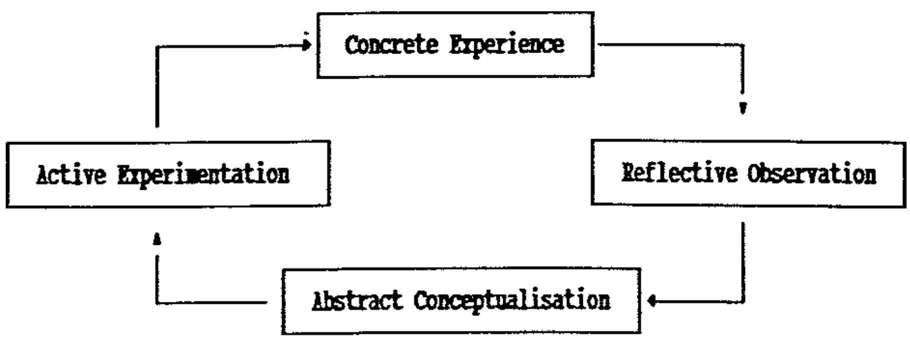
Dale's Cone of Experience (Dale, 1969:107)

The above figure demonstrates according to Edgar Dale, the progression of learning experiences from direct, first-hand participation to purely abstract symbolic expression. The progression is: direct purposeful experience; contrived experience; dramatised experience; demonstrations; study trips; exhibits; educational television; motion pictures; recordings, radio, and still pictures; visual symbols; and verbal symbols.

Educators are reminded by Jennifer Rogers (1982:67) of E.L.Thorndike's discovery that older subjects can learn as well as or better than those much younger than they. This observation was conditional upon the relevance of the material to their requirements. Rogers concludes that, in the case of vocational training, techniques taught "... must be as like the final skill as possible"(1982:67).

Kolb (1984:21) discusses Lewin's (1951) postulation of a four stage cycle of experiential learning (Fig. 3.2). This cycle of **concrete experience, reflective observation, abstract conceptualisation, and active experimentation** integrates observation and action into what Kolb calls "an effective, goal-directed learning process" (Kolb, 1984:29). If a simulation is run with such a process in mind, then it provides an atmosphere for learning by doing.

Figure 3.2



Lewin's Experiential Learning Model (Kolb, 1984:21)

3.3 The typical participant in a simulation

Kenneth Richmond has been quoted by Conradie (1979:5) as follows: "The biggest variable in the learning situation is the learner himself." If this statement is to be accepted, then it would be to the mutual benefit of the teacher, the student, and to industry if the whole direction of the training effort were student-centred. For that reason, the student is given prominence in this chapter.

The assertion was made in chapter 1 (Par. 1.3) that those who present themselves for training by simulation are not merely observers or role players, but become a vital part of the simulated world. The learning process is therefore facilitated through practical experience in what the learner perceives during the simulation as the real world. They cannot help but participate in the same way that they participate in the real world job situation. The conclusion therefore is that they should be known as the participants in a simulation.

Simulation is certainly not confined to adult vocational training. Indeed, simulations have been used in schools with success (Jones, 1987:98). However it is the purpose of this work to concentrate more in the field of vocational training of adults, with special reference to Maritime training. The description, then, which follows, is one of an adult who is seeking training or re-training in an aspect of his or her chosen vocational field.

The first question to be addressed regarding the typical student involved in simulation is "WHO?". Who is the person that would present himself for a course in which simulation forms the central role?

It can reasonably be argued that anyone who needs training for a task or series of tasks to which simulation could be applied would be suitable. In that case it would be contended that it is not "who?" but "for what application?" that matters. The objection which an educator in vocational training would have against this approach would be that the student is being omitted from the scene, which negatively affects the priorities of training (Par. 3.2). An empirical-didactical approach is therefore indicated.

Stein & Kobrick (1984:7) report that many participants become so involved with a simulation, that despite the relative comfort of an indoor simulation, they remain in a what they call a "set" as much as an hour after the exercise has been completed. Whilst running a course in the use of Electronic Navigation Systems at the General Botha Campus of the Cape Technikon, Captain K.Cox[1] was demonstrating the operation of a simple real-time radar plotting trainer which was run on a standard desk-top micro-computer. There was no intention at that stage to run a simulation at all.

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1. Discussed in conversation with Capt. K.M.T.Cox, lecturer in Electronic Navigation, in June, 1992.

During the demonstration a radar screen was portrayed with a few targets some distance away from the "ship". Despite the completely informal nature of the demonstration, and the fact that the status of the targets was not pertinent at that stage, one of the students recognised a potential "close-quarters" situation and became uneasy, anxiously pointing out the danger. It would seem that such a student would very quickly be absorbed into the "world" created by a simulation. Contrasting with this reaction, Capt. Cox related that some students, although they might seriously endeavour to co-operate, seem totally unmoved by a fully orchestrated simulation, and don't appear to be able to sense the realism at all.

This phenomenon would be due possibly to personality differences in much the same way that a good film show would leave one viewer deeply moved, whilst another watching the same show would remain somewhat detached, fascinated rather by the photography or the technology required for the special effects. It would appear that not enough is known about the individual's response to the "simulated world" at this stage, and needs further investigation (referred to on page 211 in the concluding chapter).

Returning to Thorndike's observation (par 3.2) that adult learning is facilitated by relevance to the real task, it can be argued that if a simulation involved the essential aspects of the task for which it is being used, then the most suitable student would be the student who most readily appreciates its relevance and relates to it. It would seem, therefore, that one of the factors affecting the suitability of the student rests upon the extent to which he or she senses the relevance of the simulation.

The empirical approach to the reaction of individuals to simulation would involve the examination of certain disparate schools of thought. Depth psychology and behaviourism do not give enough credence to the individual's personality, and so cannot provide an answer in this instance. Although the Gestalt (Curzon, 1985:45) theory takes behaviourism to task, it is not applicable here either, because of its emphasis on insight and problem solving.

Most appropriately, the Social Learning theorists, of whom Bandura is representative, place emphasis on the person's relationship with the environment. Bandura's postulation,(Meyer et al., 1990:221) claims that behaviour is learnt mainly through environmental influences, that genetic factors are essentially immaterial, and that learning takes place through experience and involvement. A return to the social learning theory will be made later in this chapter, but in the present context it is nevertheless interesting to note that Rotter's (Meyer et al., 1990:239,240) concept of what he calls the "locus of control" indicates personalities which, he asserts, evolve in two ways: those who believe that they exert a considerable amount of control over events, and others who attribute subsequent events as largely independent of their own influence. These attributes are known respectively as an internal locus of control and an external locus of control. It might be logical to conclude here that if Rotter's research can be applied to the participant's acceptance of the simulation as real experience, then those persons with an external locus of control are usually more easily persuaded of the reality of the simulated experience.

The problem (discussed above) of the student's conception of the simulation in which he or she is participating, and his appropriation of the simulated world, would seem to raise questions on the validity of the experience as perceived by the individual, hence the extent of the participant's learning process through simulation. At this stage there does not seem to be sufficient evidence to warrant the selection of suitable participants in a simulation based upon this personality trait. Furthermore, the question regarding the desired extent of realism and fidelity in a simulation is somewhat complicated by this phenomenon.

A closer examination of the advantages and disadvantages of both personalities might shed light on the following theory: It could be stated that those with an external locus of control would achieve a more creditable experience, and that they would therefore learn more through simulation than those with an internal locus of control. However, since the latter are more likely to "think on their feet" and take positive action in a real situation, it could be argued that they would more assertively put into action in the work-place what they had learnt in the simulation.

Essentially, the person who would be most likely to present himself for a course in which simulation forms the central role, would be the person <u>who needs vocational experience</u> of a distinct nature, and which must meet certain criteria. The description of the typical participant, therefore, would probably be that of a typical member of the profession for which the simulation is being facilitated.

In all probability, the participant would not have a choice in the matter, since he already would have committed himself to a prescribed training scheme of which simulation is a part. It is reasonable to assume, then, that the participant would already have reached a stage in the training programme at which the essential nature of the task is already known, and that the theory of the equipment and the processes for which the simulation is being provided would previously have been covered. The typical participant, therefore, would already have had limited experience in the real world, and will have some idea of what is to be expected. The acceptance, then, of the simulated world for each individual, would largely depend on the extent to which he recognises similarities to the real world.

Ideally, the prospective participant would have a good perception of the task to be undertaken, as well as its place in the whole realm of activities of his chosen vocation. It is intriguing to note that man's first landing on the moon required a considerable measure of expertise, but nevertheless had been performed by astronauts who, because they were the first, had never done so before. Yet they expressed comparisons with the simulated landings which they frequently had rehearsed back on Earth (Farmer & Hamblin, 1970:5). The participant would therefore be well versed in the essential aspects of the real task, and would expect of the simulation that it would represent those aspects of the real situation which would be pertinent to the tasks for which the participant is being trained.

Following from the previous discussion, an attempt to describe the typical participant in a simulation would state that he is an adult (not necessarily a young adult) who is undergoing training in a certain field. He would have a measure of experience and a good theoretical preparation for the simulation exercise. The participant might not completely embrace the realism of a simulation, but in any event would expect of the simulation that it represent the essential aspects and problems of the real world which it is intended to portray. Finally, the participant would expect of the simulation that the experience gained in the simulation would be relevant to the task and that he could usefully harness the knowledge gained through that experience in the future.

Before marine simulation came into general use, many a young navigating officer who had recently qualified to stand a watch would suffer doubts that the theory he had learnt would apply to his own performance on the bridge of a ship. Some young officers have stood their first watch in the busy North Sea or in the English Channel. The presence of the commanding officer on the bridge does not always reassure them. On the contrary, his presence would more likely serve to increase their own awareness of perceived inadequacy. These considerations would suggest that an important factor in the effectiveness of a watch-standing officer is his self-confidence in that situation. Thus it would seem that a participant would not only gain experience from a simulation, but that the participant would be able to prove to himself that he is capable, thereby generating self-confidence as well. Self-confidence and a sense of achievement would therefore be a tacit expectation of the outcome of a series of well-planned simulations.

It would be expected of the participant that he would make every effort to co-operate with the controller and with the other participants, so that the atmosphere of the simulation, although stimulating and motivational, should nevertheless be taken seriously. He should always be aware of the possibility that events occurring in the simulation could well be replicated in real life during his or her career. The participants should expect that the experience gained would equip them for their roles therefore, and contribution to their chosen profession.

3.4 Learning theories and simulation

When considering the role of simulation in training, the value of simulation in its role within the whole training effort should be contemplated. Having raised the question: "WHO?", the more perplexing question: "WHY?" should be asked. What is it that has steadily increased the fervour of the advocates of simulation since the advent of the "Link Trainer" (Chapter 2)?

A pragmatist or phenomenologist would no doubt be tempted merely to point out its ever-increasing acceptance in so many fields, and its steady development and expensive technological enhancements. However, in order to understand the role of simulation in vocational education, it would be of benefit to direct investigation in the context of experiential learning, which indicates the desirability of an empirical androgogical approach. The following theories of learning are reviewed in a bid to search them for an application to simulation as a strategy for vocational training.

3.4.1 Behaviourism

Behaviourism is a theory which appears at first to be applicable when considering the nature of some of the tasks performed in simulations, particularly aircraft simulators in cases where sudden emergencies requiring the instant and correct response of the pilot are emphasised. A closer study of behaviourism necessitates consideration initially of E.L.Thorndike, Watson, Pavlov and their followers who emphasise that learning takes place as a result of measurable responses to stimuli in the subject's environment (Curzon, 1985:17). The theme of the behaviourists is that the subject learns from experience, and that it is the environment which is particularly of greatest influence upon the learner. J.Watson (Meyer et al., 1990:175) rejects consciousness and introspection. He emphasises the connection between stimuli and responses, maintaining that classical conditioning is regarded as the most important learning method. Thorndike modifies this view by introducing the law of effect (Meyer et al., 1990:176) where the relevancy of a response is a positive factor. Similarly, Hull (Meyer et al., 1990:176) introduced the concept of reinforcement (drive reduction) whereby a stimulus which most satisfies a need would strengthen a habit.

A lesson to be learned from the behaviourists is that of ensuring the relevance of stimuli in the environment of the subject and to provide the subject with a measure of the success of his response. It would seem on the face of it that simulation is a most apt application of behaviourism because of its allusion to relevance and experience. "What a person does is what a person will learn." (Curzon, 1985:31).

However, much is missing from these theories. Cognition is generally rejected by the behaviourists, as is the personality of individuals. Learning cannot be a wooden series of trial and error experiments where insight plays no part (Meyer et al., 1990:176). The writer is not convinced that behaviourism adequately explains why reactions to the same stimuli differ between individuals. In any case, behaviourists do not attempt to consider the understanding of man, or the individual's aptitudes and attitudes. The writer is not aware of any research to prove that animals could be trained to stand watch and navigate on the bridge of a ship. In spite of Watson's research with Little Albert (Meyer et al., 1990:175), it would appear that deconditioning, or corrective training cannot satisfactorily be applied by the behaviourists (Curzon, 1985:24). The last word goes to Bronfenbrenner (1977:19) who states: "Much developmental psychology as it now exists is the science of the strange behaviour of children in strange situations with strange adults for the briefest possible periods of time" (Kolb, 1984:29).

Although lessons can be learned from them, the behaviourists do not seem to offer relevant answers in the realm of modern sophisticated simulations and in this context must therefore be discounted.

3.4.2 Neo-behaviourism

Robert M. Gagné (1977:16), as a neo-behaviourist, modifies behaviourism. He attempts to answer the following (paraphrased) questions regarding human learning:

1. How does an individual learn the skill of threading a needle or parking an automobile?

2. What conditions are necessary for the student to learn to understand Newton's laws of motion?

3. How can one account for the learning of factual information, such as the events of history or descriptions of the natural world?

4. How does a learner acquire increased competence in finding new solutions to the many practical problems of life?

5 How can conditions be arranged to bring about the learning of positive social values such as honesty and respect for others' feelings?

Briefly, these questions seek to address five major categories of learnt human behaviour, viz. motor skills, cognitive skills, verbal skills, intellectual skills, and attitudes (Gagné, 1977:47). This is a positive direction to have taken because it differentiates between different levels of learning activity.

The instructional techniques for the five learning outcomes mentioned above are suggested as follows (Gagné, 1977:247):

Informing the learner of the objective:

1. Intellectual skills: Demonstrate an example.
2. Cognitive strategies: Verbal communication, demonstration and problem solving.
3. Verbal information: Statement, question and answer.
4. Attitudes: Provide learning guidance using concrete examples, and relationships with ideas already in memory.
5. Motor skills: Demonstration.

In discussing the above, Gagné recognises thought systems in the human brain, calling learning a "process". He notes eight phases of learning, viz: motivation, apprehension, acquisition, retention, recall, generalisation (lateral and vertical transfer), performance, and feedback. It could be argued that the role of simulation finds itself categorised with generalisation, performance and feedback.

However, this assertion would appear to ignore the act of learning by doing, of experiential learning, and of the moulding of one's judgment and decisions regarding a situation as a result of previous encounters.

A hierarchy of eight types of learning is enumerated by Gagné:
Signal learning (stimulus), Stimulus-response (discriminating between stimuli), Chaining (sequencing S-R bonds), Verbal Associations, Multiple discrimination between stimuli, Concept learning, Rule learning, and Problem solving.

What is interesting about Gagné's work is that he recognises the need for differential instruction for the different learning outcomes. Applying his theory of the learning process to instruction, he suggests the following sequence (Gagné, 1977:244):

1. Motivate by gaining attention.
2. Inform the learners of the objective.
3. Stimulate recall of prior learning.
4. Present the stimulus as applied to any of the individual learning outcomes.
5. Provide learning guidance.
6. Elicit performance.
7. Provide feedback to the learner.
8. Assess performance.
9. Enhance retention and transfer.

In application to simulation, this sequence provides for the principles of motivation, prior knowledge, performance, evaluation and feedback. However, the sequence would largely be of use as a guide to the operation of a simulation rather than a theoretical exposition of the learning processes as a result of simulation.

Other than "eliciting performance", it is somewhat difficult to see where Gagné's conditions of learning could apply to simulation. Gagné does mention simulation as being available as a choice of media (Gagné, 1977:284) but disappointingly relegates its importance ultimately to "special contexts" only. He proposes that simulation would be used primarily for repeated rehearsals for fault-free "on the job" performance in life-threatening situations. This would seem to be a retrograde step towards stimulus-response theory, and the application suggests motor skills only. In spite of his recognition of attitude, cognition and the intellect, it is a pity that he did not appear to see the relevance of simulation to the development of confidence and sound judgment which a participant gains as a result of his real-life encounters juxtaposed with the success of an action or the later consideration of an improved solution in retrospect.

Curzon (1985:44) points out that the hierarchical nature of the learning processes postulated by Gagné prompts the educator to provide a prepared grounding for a particular phase of instruction, and has stressed the importance of feedback and careful, regular evaluation.

If Gagné is to contribute anything to simulation, then it is reasonable to suggest that the participant should have reached a stage in his training where the experience would be most appropriate, that the outcome of the simulation in the short term as well as the long term should be monitored and evaluated, and that the participant at a suitable stage should be made aware of this evaluation, either during debriefing or through his experience of the ensuing consequence of a decision made during the simulation. It is pertinent to suggest in the light of Gagné's emphasis on feedback, that simulation provides an ideal medium of direct, independent feedback resulting from the observation of the effect of the actions of the participant upon the "real world" created by the simulation.

3.4.3 Gestalt Theory

The Gestalt School strongly criticises the behaviourist theories. As an alternative to mere responses to the environment, they offer a concept in which the individual has "transactions" with the environment (Curzon, 1985:46). The focus of what the Gestaltists postulate is that "the whole is greater than the sum of its parts". According to them learning is not merely a series of responses, but is a structured pattern of activities which they refer to as "insight".

Köhler, (1929:373) defines insight as "Our experience of definite determination in a context, an event or development of a total field". Vrey (1984:266) describes insight as consisting in becoming aware of the relationships between data in such a way that a pattern emerges. Thus it involves the understanding and the ability to place facts in a clear pattern. It takes time to draw conclusions based upon these patterns of thought, allowing learning to take place.

The relevance of the Gestalt theory to teachers is that students should be provided with continued opportunities to observe patterns and relationships for themselves. This involves practice and problem-solving. Mechanical, habitual repetition is to be discouraged. In this context, simulation provides the opportunity for bringing together as a cohesive whole as many of the individual facets of operations as possible, so that the student can perceive them in their interaction towards the comprehensive scheme of the overall task. For example, a navigation student will have had to study various facets of the theory and practice of navigation, collision avoidance, and watch-keeping procedures. A simulation of watch-standing at sea would facilitate the complete interaction of all these activities in practice as a co-ordinated whole. At the same time it also affords the learner an opportunity to practise intelligently what he has learned in the classroom.

3.4.4 Cognitive Learning Theories

The Cognitive theories contrast with behaviourism because, instead of emphasising external forces, the learner's internal processes (knowing and perceiving) are studied. In Cognition (Curzon, 1985:53), formation and use of concepts is combined with a knowledge of the environment as the result of interactions by the learner and his surroundings and the organisation of knowledge. During the discussion of the Cognitive School, four proponents of this theory will be discussed: Dewey, Piaget, Bruner and Ausubel.

In examining Dewey's work it is not intended necessarily to dwell upon his philosophical persuasions but rather his theories on the processes of learning. His thoughts regarding the learning by evaluating experiences lends impetus to the consideration of simulation as a strategy for learning. Dewey's view of education was that it is an intelligent, "continuous evaluation of experiences", ultimately producing a "redefinition of purpose" (Fig. 3.3)(Curzon, 1985:54).

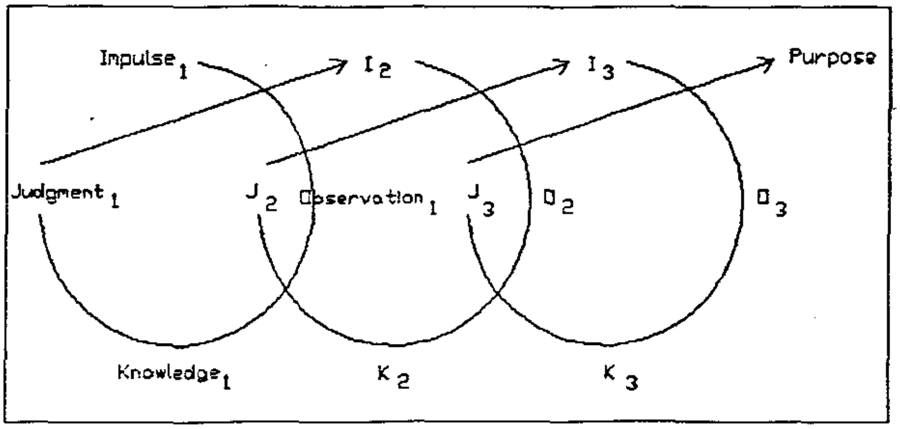
Dewey's emphasis was upon 'reflective thinking', an intellectual process of 'turning things over' in the mind based on five problem-solving steps (Curzon, 1985:54):

- Suggestion for a solution.
- Clarification of the problem.
- Formulation of several hypotheses.
- Reasoned consideration and selection of one hypothesis.
- Testing that hypothesis by thought or action.

Four central notions of Dewey's suggested educational practice are itemised by Curzon (Curzon, 1985:54):

- Aim of the activity.
- The teacher.
- The learner.
- The curriculum, which must be relevant.

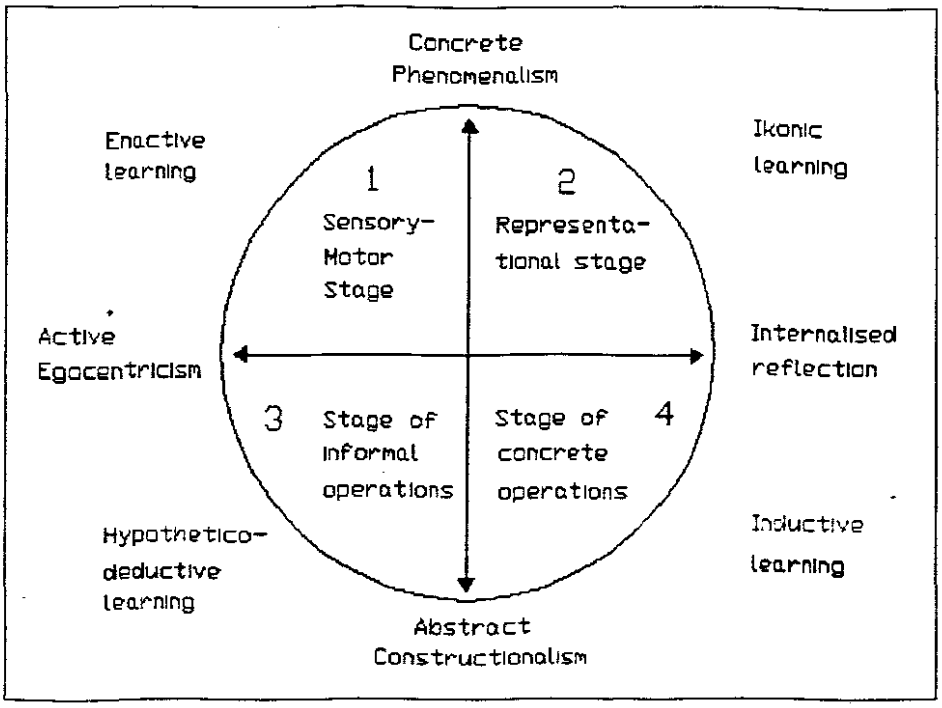
Figure 3.3



Dewey's model of Experiential Learning (Kolb, 1984:23)

The application of Dewey's concept to the learning process, according to Curzon (1985:55), is that learning has to be viewed as part of an interaction of the learner and his environment. He does, however, emphasise that experience is not merely thoughtless action, but that the activity must involve a change in the learner's cognitive structures. Thus the principle of "learning by doing" is modified to a process of learning by thinking about what you are doing. Intellectual processes are therefore stressed in their function within the environment.

Figure 3.4



Piaget's Model of
Learning & Cognitive Development (Kolb, 1984:25)

Jean Piaget insists "that experience must be organised before one can adapt oneself to the environment" (Vrey, 1984:281). Piaget (Fig. 3.4) distinguishes distinct stages of cognitive development in a child: the sensori-motor stage; pre-operational phase; concrete-operational phase; and the final phase of formal operational thought. In this final phase of development, the learner mentally adapts his experiences and a changing environment based upon accommodation and assimilation.

These organised thought structures (which he called 'schemas'[1]) are subject to changes resulting from the learner's encounters with the environment.

Jerome Bruner (Curzon, 1985:57 to 61), influenced by Piaget, places emphasis upon perception in the process of learning whereby it bridges the gap between stimulus and response. A positive response will be meaningful, and will link with previous similar stimuli from past experience. Thus learning is built upon knowledge already gained, and therefore depends upon previously acquired frames of reference. Learning is a cognitive process involving the acquisition of new information, transformation of existing knowledge, and verification of its relevance to new situations.

The application of Bruner's theories is the encouragement of discovery activity. Any lesson should be supplemented by activities which would be designed to inspire creative and critical thought. He emphasises the importance of a thorough understanding of underlying principles (concepts and relationships) involved in a subject.

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1. Piaget has been credited by some with the first use of the word: "schema" but Neisser, (1976:54), attributes the term to Bartlett. Neisser (1976:54) defines a schema as "that portion of the entire perceptual cycle which is internal to the perceiver, modifiable by experience, and somehow specific to what is being perceived".

Curzon(1985:60) lists four advantages of discovery activity:

- Growth of intellectual abilities.
- Intrinsically, rather than extrinsically motivational.
- Learner is better equipped to apply his knowledge in life.
- Improvement in memorising ability.

Central to Bruner's theories of learning is the active use of the intellect to build upon the known in order to learn about the yet unknown through active discovery. Bruner's views had weaknesses. Ausubel finds fault in one of his statements (Curzon, 1985:59), that "any subject can be taught effectively in some intellectually honest form to any child at any stage of development". He disagrees with Bruner, indicating that complex concepts "could not be made understandable to persons below a certain level of cognitive maturity".

Ausubel (Curzon, 1985:62-65) stresses the need for an existing reservoir of knowledge upon which to build. The introduction of new ideas must be related to existing knowledge before it can be meaningful to the learner (Vrey, 1984:282). New concepts would therefore be subsumed under broader subject categories in the mind of the learner. ". . Hence new material in the sequence should never be introduced until all previous steps are thoroughly mastered" (Ausubel, 1968:230).

The teacher, when considering the learning process according to Ausubel, should structure the arrangement of topics in such a way that they are organised sequentially. This sequence would stress the importance of 'anchoring concepts' so that a learning unit would be a link in a chain. Ausubel states that consolidation requires "confirmation, correction, clarification, differential practice, and review" (Curzon, 1985:63). The teacher therefore uses 'organisers' to introduce more abstract or difficult concepts, and seeks always to 'bridge the gap' (Curzon, 1985:64) to the next step.

Here once more, relevance seems to be an important factor in the teaching process, and the needs of the student should be taken into account. Ausubel does emphasise that student decisions alone should not influence the structure of subject matter, since this would be an abdication of the teacher's responsibility.

The Cognitive School stresses that learning is achieved by the attribution of significance to the world based upon what is experienced by the senses (Vrey, 1984:279). Moreover, learning takes time, so that the more one considers and experiences, the better one would comprehend and consolidate the meaning of a concept. Repeatedly approaching concepts from different but relevant viewpoints would result in repeated and enriched perception through critical viewing, analysis, differentiation and further integration.

Following from these observations, one must conclude that if simulation is used in training, one cannot regard simulation as merely a method whereby repeated practice of certain operations provides a response which would be adequate and relevant in each subsequent event in the real working world. On the contrary, if the Cognitive School are to be considered, then simulation must provide an environment which is conducive to thoughtful problem-solving and the inspiration of reflective judgments coupled with the cognitive application to relevant events in the work-place. The result would thus be that the learner is equipped for hitherto unknown situations which might develop so that they can be dealt with confidently.

3.4.5 Social Learning Theories

The social learning theories are a more recent attempt by psychologists to integrate Behaviourism and Gestalt (Meyer et al., 1990:221). They reject Freudian concepts, preferring concepts originating in Cognitive Psychology, Gestalt and Phenomenology, taking a 'common sense' view of man. Social learning theorists adhere to the basic assumption that chiefly the environment influences behaviour, and this they attempt to observe empirically. Thus Social Learning can be categorised as a "revised Behaviourism" (Meyer et al., 1990:221).

Rotter (1954) is credited with the original theory (Meyer et al., 1990:221) whereby he asserts that behaviour is influenced by the expectations of the individual rather that a mere objective reinforcement of a response. He also points out that behaviour is acquired in social situations through contact with other individuals - hence the name: "Social Learning".

Evidently regarded as the most important advocate of the social learning theory, Albert Bandura maintains that a child learns by observing and imitating the behaviour of a model. It is an intriguing aspect of Bandura's observation that although the behaviour of the models would effectively have been learnt, models who are observed to have been positively rewarded appear to attract the most spontaneous imitation by the subjects. It seems logical to conjecture that this observation surely touches upon the affective domain, and therefore effects motivation in the learning process as well as in the appropriation of the attitudes of respected senior colleagues, leaders and teachers.

The basic assumptions of Social Learning Theory as identified by Meyer et al., (1990:221) are:

- Behaviour is learnt through social/environmental influences.
- Genetic factors are relatively unimportant.

- Learnt behaviour results from:
  - Classical and instrumental conditioning.
  - Observational learning.
  - Thinking and expectations.
  - Planning, activity and self-evaluation by the learner.

Where Social Learning theory deviates from Behaviourism is that Behaviourism regards behaviour as being determined by forces beyond the individual's control - by the environment. Social Learning Theory regards the learner as an active participant who perceives and evaluates stimuli. During this process, the learner plans future behaviour, judges past behaviour, and modifies subsequent behaviour in the light of personal evaluation. There is an interaction between the learner and the environment in which he actively plays a role by selecting influences and subjectively rewarding himself for his behaviour.

Bandura points out that man's behaviour sometimes persists in spite of environmental changes (Meyer et al., 1977:226). This he explains by taking into account cognitive processes such as thinking, interpretation of stimuli, and expectations of future events. He also indicates that motivation is not only extrinsic, but largely intrinsic to the extent that an individual will be motivated in a way that behaviour will lead to self-reward (e.g. pride rather than guilt or shame).

Three types of learning are enumerated by Bandura (Meyer et al., 1977:227):

- Direct experience.
- Observational learning.
- Self regulation.

He also recognises three types of reinforcement with corresponding forms of punishment:

- Direct - external sources of reward or punishment.
- Vicarious - observation of another's reward or punishment.
- Self-reinforcement - self praise or incrimination.

Direct experience is recognised by the Social Learning Theorists, but they explain it by involving the cognitive processes of the individual. Essentially, the theories of experiential learning look somewhat similar to those of the Cognitive School. Thinking plays an important role in learning in which the learner interprets stimuli and hypothesises about the results of various courses of behaviour. These considerations are influenced by interpretation, even of what other people might say regarding the results of certain choices of behaviour. Direct reinforcement is not as important as self-reward.

Observational learning is considered by the Social Learning School to be more important than direct experience, which they believe forms only a minor portion of all learning. They emphasise the role of observational learning, and hasten to point out that it is not a process of mindless imitation but a complex procedure in which observation would not necessarily lead to imitation of the behaviour of a model; a person who would be either living, historic or fictional. According to Bandura (Meyer et al., 1977:229), observational learning as a four-fold process consisting consecutively of attention, retention, and reproduction, with motivation involved in all three consecutive steps (Fig. 3.5).

Figure 3.5

Attention	**Retention**	**Reproduction**
The observer is exposed to the model ↓		Imitation: model's behaviour is spontaneously copied or Counter imitation:
If he attends well →	The model's behaviour is acquired or retained →	different behaviour to that of the model is produced or
If he does not give attention →	The model's behaviour is not acquired	No imitation: No spontaneous imitation but can reproduce on request

Three steps of Observational Learning (Meyer et al., 1977:229)

Factors which influence observational learning include the following:

- The modelled behaviour - complexity, novelty, acceptability.
- Characteristics of the model - age, sex, status, personality.
- Characteristics of the observer - motivation, interests, confidence, opinions, intelligence, perceptiveness, personality, expectations of results of behaviour.
- Results of the model's behaviour - vicarious outcomes (punishment or reward), whether or not there was a noticeable consequence for the model, perceived importance of the outcome, comparison of outcome with previous experience, indirect imitation.[1]

Bandura (Meyer et al., 1985:232) explains that vicarious reinforcement would be influenced by the type of information gathered by the observer, motivation as a result of the outcome, emotions observed in the model, evaluation of the outcome, the observer's perception of the model's status as a result of the outcome, and a a perception of the behaviour of others.

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1. Meyer (p.232) explains that direct imitation might not be appropriate to the situation, so that a child observing his parents contributing to a street collection might respond by sharing toys with others.

Self-regulation concerns the regulation by the individual of his own behaviour, by making choices for himself between different situations which will expose him to different influences. He will also evaluate his own behaviour. Two basic types of self-regulation are identified by Meyer et al., (1985:234):

- Internal self-regulation - the individual praises or admonishes himself.
- External self-regulation - the individual uses material rewards or concrete forms of self-punishment.

The application of Social Learning Theories to education is one of bearing in mind the impact which teachers and other figures of authority have on the students. It is also pertinent to point out that students might not accept what has been taught, which draws attention to the attitude which the student might have and his motivational priorities. Ultimately, Social Learning implies that learning is an overall function incorporating experience in the environment, cognitive processes, as well as emotional, moral and attitudinal issues. Social Learning involves the whole person as a distinct individual whose co-operation is essential to the learning process.

3.4.6 Further deliberations on the theory of Learning

Vrey (1984:239) states the following general categories of learning in order to consider the classification of learning actions, viz. learning by: reading, listening, doing, writing, repetition, meditation, reflection, imitation, practice, acquiring insight, teaching. He then goes on to consider the work of C.F. van Parreren in which a distinction is made between the following processes of learning as observed in school pupils (Vrey, 1984:241):

- **Intentional (conscious) learning** in which the subject is willingly and actively co-operating in the learning process.

- **Incidental or fortuitous (but conscious) Learning** whereby learning is achieved, not deliberately, but as a result of a particular interest which the subject has for the knowledge or skill being learned. This form of learning would not intentionally be structured, neither would the results achieved be as effective as those of the intentional learning.

- **Unconscious Learning** (proved by Thorndike, Vrey:241) is learning which has been achieved without the learner being aware of the fact. This category of learning would include incidental learning while being entertained, or in conversation.

As a result of learning, the learner demonstrates his newfound knowledge or skill. The results of learning are insight, facts, accurate reproduction, and automatism. Van Parreren therefore categorises learning into three types (Vrey:242):

- **Insight-promoting learning:** in which the learner understands the situation/material in such a way as to enable him to solve problems effectively.

- **Acquisition of factual knowledge:** whereby items of information can be learned and then reproduced when asked. Factual information such as regulations, history, geography, and theoretical definitions and formulae which might promote insight and understanding of a task, but which might not primarily have been learned for that purpose.

- **Memorising:** is the learning of words or figures by rote, in which knowledge regarding certain material is not as important as the way in which it must be reproduced - word for word, in exactly the way it was originally learned. It is quite possible that the learner here would also "assimilate them as facts".

- **Automatism:** is in evidence when the learner has repeated an action until he can perform that action without needing to think about what he is doing. An example of a desirable automatism is writing, so that the writer can concentrate more upon what he is writing rather that the action of writing itself.

When applying these types of learning to simulation in vocational training, the first (Insight-promoting learning) and the last (Automatism) appear to be most involved. With particular reference to maritime training in navigation and ship-handling, problems arising from circumstances such as traffic situations, equipment failures, scheduling, poor weather/visibility and routing would involve problem solving of a nature very close to the problems experienced in the real world. Here the solution to a problem would involve the secure knowledge of the consequences of certain actions, and would involve the making of decisions which depend upon past experience, effective factual knowledge, sound judgment and a mature attitude to his responsibilities. Also involved would be automatism; being able to operate controls and equipment as well as the performance of routine or emergency actions arising from events which would demonstrate and improve the competence of the officer on watch, particularly under conditions of stress, fatigue, influence of the biological circadian rhythm (D'Amico, 1984:177), complacency or boredom.

In consideration of types of learning, Vrey (p.244) also outlines the two categories of learning differentiated by Coetzee; actions which result in physical skills, and conscious mental imagery. Coetzee's categorisation (arranged in order from the most basic to the most complex) is as follows:

- **Motor, Objective processes (mainly muscular reaction)**
  - Sensory-motor learning - acquiring simple habits.
  - Perceptual-motor learning - skills and social habits.

- **Representational, subjective processes**
  - Perceptual learning - activities learned by observation.
  - Associative learning - facilitates the memorising of facts.
  - Conceptual learning - assimilation and formation of concepts.
  - Imaginative learning - development of original ideas.

Vrey (p.245) then offers a categorisation of types of learning according to meaning, in which he places emphasis on meaningfulness, and in which the learner must be involved in his learning task. His categorisation (which, he points out, is not new) is as follows:

- **Motor learning:** Repetition of tasks until automatism is achieved. Conditioning is rejected, because "meaningfulness, personal involvement and the gradual experience of success" are regarded as necessary for the achievement of proficiency.

- **Meaningful verbal learning:** This means that the learner gains understanding of the subject matter being learned, which leads to intelligent action. This type of learning is considered under the following subdivisions:

  - Language and meaningful learning; cognitive development takes place along with language development, thus highlighting the importance of language in meaningful learning.

  - Representational learning in which the learner names or symbolises (e.g. words, frequently nouns) subject matter in order to categorise or "represent" the subject matter, thus involving meaningful association.

  - Conceptual learning, in which ideas and concepts (which are processes inside the brain) are largely personal to the learner. They are assimilated as a result of the concept being conveyed by explanation. The concept is then linked with others to form meaningful comprehension within the mind of the learner.

* Propositional learning:

(a) Image formation, in which the learner constructs a mental image of the learning material. Even in the absence of visual assistance, the learner visualises verbal descriptions as images. Vrey (p.254) places great emphasis on the formation of images, and stresses the necessity to encourage visualisation, even of fairly abstract subject matter.

(b) Verbal composite ideas. Relationships of between already present concepts and new material being learned are established, and classified in three ways:

<u>Subordinate relationships</u>, where the new concept is included in a more comprehensive cognitive structure.

<u>Superordinate relationships</u>, in which the new concept gives the existing cognitive pattern a more complete character.

<u>Combination relationships</u>, where completely new concepts are introduced. There will nevertheless be some accommodation within the mind of the learner, provided that the material for learning is presented in a logical and well organised way.

- Learning by discovery. The learner is encouraged to learn by re-arranging, re-organising, or re-structuring the subject matter, probably involving analysis and synthesis in order to discover for himself rather than having the subject matter explained to him.

- Problem solving requires that the learner perceives the situation as a problem, and must be involved in its solution. Problem solving incorporates knowledge already available, but also requires organisation of that knowledge in order that it might be applied to the solution of the problem.

- Creativity, as opposed to problem solving where thinking is essentially convergent, and concentrated towards a solution of a specific problem; facts are rather used to provide self-expression, where there is no previously set correct answer. Creativity is therefore divergent.

What Vrey has clearly asserted in these pages (p.239 - p.258) is that learning must be a meaningful cognitive function, which consciously involves the learner, and must elicit the cooperation of the learner. It must be recognised that although certain involuntary learning does take place, purposeful meaningful learning rather than conditioning of reflexes (behaviourism) is the best psychological approach to the learning process.

Simulation cannot be looked upon as an avenue for conditioning, but rather as a strategy for harnessing the cognitive structures outlined above. Any degree of simulation would appear from what is stated above to be an adequate setting for repetition of physical activities, as well as for problem solving, creativity, learning by discovery, and consolidation of concepts by physical application.

In rounding off the comments of Vrey on the theories of learning, it would be advantageous to examine what he discusses regarding successful learning. In his chapter on this subject (Vrey:261-274) he highlights involvement and experience. Describing successful learning, Vrey (p.262) states that the learner's "..initial mastery becomes permanent when the content is assimilated into the cognitive structure: the pupil then knows the subject". He then organises the factors influencing successful learning into three categories:

- **Cognitive factors (Vrey:262):**
  - Aptitude - aptitude is "not a significantly disturbing factor" since the majority of learners would master study material given enough time and suitable assistance.

- Ability to understand instruction - Communication is important, and recognition should be given to placing the level of the lesson in such a way that the class will understand what is being said. Also, terminology, and language usage should be such as to accommodate the linguistic level and cognitive structure of the class.

- Attention - This is neither continuous nor is it guaranteed. It is dependent upon external conditions (unexpected stimuli or relevance of the subject) and inward conditions (interest, health, aptitude and ability to concentrate).

- Perseverance - The time which a student is willing to spend on a learning task depends on his attitude, interest, enthusiasm and frustration threshold. Much depends upon the personality of the student.

- Learning time - This varies depending on the student; which indicates the need to provide for the individual.

- Cognitive style - Some learn by understanding whilst others will attempt correctly to reproduce the material after memorising it. It is largely a matter of personality, but a flexible cognitive style would best facilitate understanding and learning.

- Insight - in line with the thinking of Gestaltists, insight is seen as the way in which a pattern emerges in the mind of the learner, and his ability to form mental associations. Vrey points out that understanding depends upon insight.

- **Affective factors (Vrey:266):**
  - Interest - The personal involvement of the learner in a learning task. The student already must know something of the subject in order to show interest. Interest is stimulated by relevance, success and encouragement.

  - Attitudes - The ability of the learner successfully to complete a learning task depends very much on a positive attitude toward the learning task.

  - Self Concept - Another personality trait which influences successful learning is the confidence in the learner's own ability and image of self-worth. Vrey (p.270) stresses that the learner's academic self-concept is a precondition for success.

  - Mental health - Tension and anxiety will reduce the success levels. Praise and encouragement are important because the develop the student's ego-development.

- **Teaching factors (Vrey:271):**

  - Teacher-student relationships - The classroom atmosphere must be conducive to a healthy interrelationship between the students and the teacher. A relaxed atmosphere of mutual trust is to be aimed for.

  - Extrinsic motivation - This is aimed and imbuing the learner with the will to learn. Positive extrinsic motivation is achieved by awakening interest and formulating achievable goals.

  - Teaching quality - this can be improved by taking into account the student's individual learning needs.

  - Development and readiness for learning - the cognitive development of pupils requires that material be organised into discreet stages of development. New material should not be imparted until the class has been prepared with a foundation of earlier knowledge upon which it is to be based. Individuality is a notable ingredient.

What is particularly noteworthy to those involved in simulation is what Vrey (p.274) asserts in his conclusion of this chapter in the highlighting of involvement and experience. The learner "must WANT to be involved as a person".

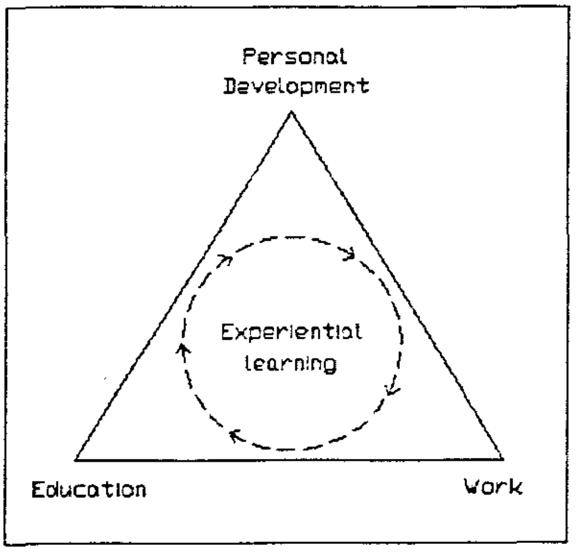
This implicates to a great extent the cognitive factors of successful learning. The learner's experience and significance of what he is learning leads to a "lively participation" in what he is learning. Finally, Vrey sums up by stating that "total success is made up of a progressive series of successes"..

3.5 Experiential Learning

The growing importance of the concept of learning by experience is highlighted through the credit given by American colleges for prior learning experience. In 1980-1982, "1¼ million quarter credit hours were awarded for prior learning experience" (Kolb, 1984:3). Author David A. Kolb of the Case Western University, Cleveland, Ohio builds a synthesis chiefly around the works of Dewey, Lewin and Piaget, although other learning theorists have also been considered in his book Experiential Learning (1984). Kolb develops his work by focusing upon the thesis of the Russian cognitive theorist L.S.Vygotsky that "learning from experience is the process whereby human development occurs" (Kolb, 1984:preface). In investigating recent thought regarding experiential learning, therefore, it is important to consider this book, and examine experiential learning as it might be applied to simulation.

Figure 3.6 demonstrates experiential learning as the process that links education, work and personal development (Kolb, 1984:4). In the words of Kolb: "It pictures the workplace as a learning environment that can enhance and supplement formal education, and can foster personal development through meaningful work and career development opportunities" (Kolb, 1984:3).

Figure 3.6



Kolb's figure of Experiential Learning (Kolb, 1984:4)

Kolb reviews the major traditions of experiential learning by highlighting the contributions of Dewey, Lewin and Piaget, and discusses their individual models of experiential learning, drawing attention to the similarities between those models (Kolb, 1984:25).

While comparing figures 3.2, 3.3, and 3.4, it will be seen that the circular (immediate experience and feedback) learning process modelled by Lewin (figure 3.1) is modified by Dewey to a spiral towards a purpose or objective (figure 3.2). The model of Piaget is one of a development through childhood to the adult style at the hypothetico-deductive learning stage. During development the child progresses through the sensory-motor period (0-2 years) in which environment plays a major role, to the second stage (2-6 years) in which the reflective orientation is begun through the manipulation of observations and images. In the third stage (7-11 years) the child uses experience to develop concepts and theories. During the final stage the adolescent moves from "symbolic processes based on concrete operations to the symbolic processes of representational logic" (Kolb, 1984:24). The emphasis of Piaget's model highlights the systematic organisation (combinatorial analysis) of data towards logical justification and proof (Kolb, 1984:25).

In synthesising the learning processes suggested by Lewin, Dewey and Piaget, the six characteristics of experiential learning are itemised as follows (Kolb, 1984:26-38):

- **Learning is conceived as a process, not an outcome.** On this point Friere (1974:58) is quoted as follows: "Knowledge emerges only through invention and reinvention, through the restless, impatient, continuing, hopeful enquiry men pursue in the world, with the world, and with each other" (Kolb, 1984:27).

- **Learning is a continuous process grounded in experience.** This implies that "all learning is relearning" (Kolb, 1984:28). Those involved in teaching therefore introduce new ideas and also "dispose of or modify old ones" (Kolb, 1984:24).

- **Learning processes require the resolution of conflicting ways of dealing with the world.** To illustrate this concept, Lewin's emphasis on the conflict between concrete experience and abstract concepts, observation and action, is used. According to Piaget, the learner assimilates ideas and experiences into existing conceptual structures (Kolb, 1984:29). The learning process is filled with tension and conflict among the four modes of experiential learning:
  - Concrete experiential abilities (involvement).
  - Reflective observational abilities (meaningful observation).
  - Abstract conceptualisation abilities (forming theories).
  - Active experimentation (decisions and problem solving).

- **Learning is a holistic process of adaption to the world.** It involves the total being in thinking, feeling, perceiving and behaving. "Learning is the major process of human adaptation" (Kolb, 1984:32) which occurs not only in the classroom, but in all situations in personal relationships, social, vocational and educational spheres, throughout life.

- **Learning involves transactions between the person and the environment.** Experience involves subjective as well as objective and environmental connotations. It involves not only physical interactions with the environment, but also influences attitudes and desires. Dewey (1938:39) describes it thus: "The word 'interaction'[1] assigns equal rights to both factors in experience- objective and internal conditions. Any normal experience is an interplay of these two sets of conditions. Taken together . . they form what we call a situation", and: "The environment, in other words, is whatever conditions interact with personal needs, desires, purposes, and capacities to create the experience which is had" (Kolb, 1984:35).

- **Learning is the process of creating knowledge.** Knowledge resulting from transactions with the environment (experiences) is a process called learning. It is therefore important to understand the relationship between knowledge and learning (epistemology) (Kolb, 1984:35). It is also essential to understand the nature of knowledge itself.

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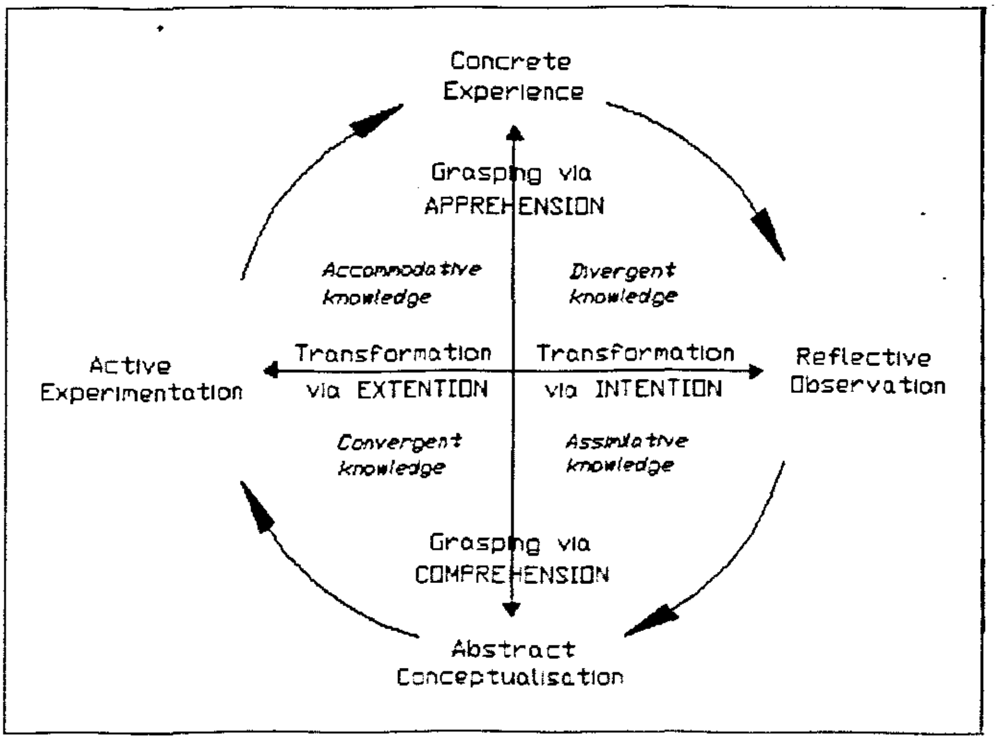
1. Kolb prefers the term: 'transaction'. (Kolb, 1984:36)

3.5.1 The Process/Structure of Experiential Learning

A cycle of the four adaptive learning modes in Lewin's model of experiential learning (concrete experience, reflective observation, abstract conceptualisation, and active experiment-ation) is adopted by Kolb as he seeks to identify the essential aspects of learning (Kolb, 1984:41)(Fig. 3.7).

Figure 3.7



Structural Dimensions Underlining the Process of Experiential Learning and Resulting Basic Knowledge Forms (Kolb, 1984:42)

The model shown in figure 3.7 demonstrates the state of conflict between concrete experience and abstract concept-ualisation on the one axis, and between active experimentation and reflective observation on the other. The four modes are structured in pairs, or "fundamental dimensions" (Kolb, 1984:74), of opposed orientations:

a) Abstract/concrete "Grasping": The structured process of learning "grasps" experience in the world either through reliance on abstract modes which Kolb calls "Comprehension" or through concrete modes which sense the immediate experience called "Apprehension" (Kolb, 1984:41).

b) Active/reflective "Transformation" transforms the above grasp as a figurative representation either through internal reflection, "intention", or through active external manipulation of the world, "extension" (Kolb, 1984:41).

The structural arrangement of the learning process as illustrated in figure 3.7 forms the basis for examining and describing individual learning styles (Kolb, 1984:64).

A summary of the four basic learning modes are as follows (Kolb, 1984:68):

- Concrete Experience: "Being involved in experiences and dealing with immediate human situations in a personal way". This mode emphasis feeling rather than thinking.

- Reflective Observation: "Understanding the meaning of ideas and situations by carefully observing and impartially describing them". This mode emphasises understanding rather than practical application.

- Abstract Conceptualisation: The use of logic, ideas and concepts. This mode emphasises thinking rather than feeling.

- Active Experimentation: "Actively influencing people and changing situations". This mode emphasises practical applications rather than reflective understanding.

Thus the full structure of experiential learning involves feeling, understanding, thinking, and practical application in order to complete the structure of learning, though situations influence the extent to which each of these modes is emphasised.

3.5.2 Individuality and learning styles

Learning styles vary from individual to individual, and these will be modified (because they are stable but adaptive states) through patterns of transaction with the world. Forces which shape learning styles can be viewed as separate planes on a three dimensional model, so that learning styles on each plane might be different, but influence the final outcome of the individual's total learning pattern (Kolb, 1984:97). These forces are arranged from current circumstances to previous experience and habits thus:

Adaptive competencies,
Current job,
Professional career,
Educational specialisation, and
Psychological type (personality).

On each of these levels, a map of the basic learning styles of each individual can be determined according to the learning mode in figure 3.7 above. Generally those with an orientation towards concrete experience are involved in real situations, and have an open-minded approach to life. Those who oriented towards reflective observation rely on their feelings and thoughts. They value patience, impartiality, and prudent judgment. An orientation to abstract conceptualisation typifies people who value precision, analysing ideas, and forming concepts.

People who are oriented towards active experimentation are goal directed and actively influence their environment (Kolb, 1984:69).

The fourth chapter of Kolb's book deals extensively with individuality and learning styles, using as examples learning style profiles from research previously carried out (Kolb, 1984:69). In order to approach the (simulation) training of maritime personnel better, the advantage of similar research into the learning-style profiles of deck-officers and engineering officers becomes evident while reading this chapter.

3.5.3 Characteristics of the basic learning styles

Experience gained through socialisation (Kolb, 1984:76) enables the learner to resolve the conflicts between the active and reflective, and between the immediate and analytical in four typical learning styles: Divergence, Assimilation, Convergence, and Accommodation. The characteristics of these four styles are outlined below (Kolb, 1984:77):

- Convergence. Reliance upon abstract conceptualisation and active experimentation is evident. Problem solving, decision making and the practical application of ideas is most suited to this style. Expression of emotion is controlled, and tasks related to things is preferred to people.

- Divergence. Emphasis is placed upon concrete experience and reflective observation. Those with this style have imaginative ability and awareness of meaning and values. They have the ability to view situations from many perspectives into a meaningful 'gestalt'. Divergent learners prefer adaptation by observation rather than action, and will tend to examine many alternative ideas. Persons in this category are interested in people, imaginative and feeling-oriented.

- Assimilation. Learners in this style category rely upon abstract conceptualisation and reflective observation. They learn by inductive reasoning and the creation of theoretical models. This group are less concerned with people than with ideas and concepts, and show an interest in the theory rather than its practical application.

- Accommodation. Accommodative learners depend upon concrete experience and active experimentation. They like doing things, carrying out plans and tasks, and getting involved in new experiences. Their emphasis is on seeing, risk taking and action. They are able to adapt to changing circumstances, although theories which do not fit the facts will probably be discarded. Problems tend to be solved by intuition and trial and error, and heavy reliance is placed on others for information rather than their own analytical ability. Although persons in this group are at ease with people, they might seem assertive and impatient.

The examination of the above characteristics of the individual learning styles gives an indication of the role of personality in learning.

3.5.4 Practical applications of experiential learning

The structure of knowledge depends essentially upon the "fabric" of experience. Personal knowledge is thus shaped by apprehensions which validate thoughts derived from the experience in the mind of the learner by giving them content, and comprehension which enables the learner to select those aspects of the experience which are considered relevant and which thus form concepts (Kolb, 1984:106,107).

There must therefore be a harmony between reality and theory in the structure of knowledge. David Bohm (1965:220) is quoted as follows: "All knowledge is a structure of abstractions, the ultimate test of the validity of which is, however, in the process of coming into contact with the world that takes place in immediate perception" (Kolb, 1984:107). Kolb draws attention to the importance of relevance of the experience to the system of knowledge, recommending that the system be treated in specific contexts (Kolb, 1984:119).

Another important factor in the process of learning by experience is that the learning process is one of constant development rather that a series of discrete learning tasks. Learning therefore shapes the course of development in the individual (Kolb, 1984:140).

3.6 Application of learning theories to simulation

On the preceding pages a brief overview of some of the theories of learning has been made. It can be noted that a silver thread highlighting **interaction with the environment** is woven through the fabric of the theories considered in this chapter, starting with the behaviourists. Although not all the theories of learning concur regarding how learning is accomplished as a result of that interaction, it becomes apparent that the relationship of the mind with the environment is prominent in the learning process.

A general conclusion which can therefore be drawn is that the prominence of the role of experience in the learning process emphasises a corresponding importance of real performance situations in the teaching task. If this cannot be achieved, or is impracticable, then simulation is an alternative which is worthy of serious consideration. As a corollary, if simulation is suited to a particular learning objective, then careful attention should be paid to the nature and extent of the experience gained in that simulation. This latter statement articulates an aspect which will receive more attention in Chapter 4.

Experience can broadly be defined as learning through an interaction with the environment. If that is the case then it might be argued that the term 'experiential learning' is redundant, because 'experience' means 'learning' within a certain context. The Reader's Digest Universal Dictionary (1987) offers five definitions for the word '**Experience**':

- The apprehension of an object, thought, or emotion through the senses or mind.
- Active participation in events or activities, leading to the accumulation of knowledge or skill.
- The knowledge or skill so derived.
- An event or series of events participated in or lived through, especially one that makes a powerful impression on the mind or senses.
- The totality of such events in the past of an individual or group.

Isolating key words from each of the five definitions above, and bearing in mind the postulations considered by Kolb, one can compile a fusion of those definitions for the purpose of this work thus:

> **Experience can be defined as the derivation by apprehension and ongoing accumulation of knowledge and/or skills through purposeful involvement and meaningful participation in events within a specific learning context.**

None of the above definitions refer exclusively to experience in the real world, nor do they exclude simulation. Moreover, all the above definitions could be deemed to apply as much to simulation as they do to involvement in the real world. It has been demonstrated in the preceding pages of this chapter that meaningful experience is of great importance to the learning process. Hence if simulation is used as a teaching strategy, the five definitions itemised above must be considered in the application of simulation programs to the extent that simulations provide effective reproduction of the tasks, events, and situations for which the training program has been selected. The emphasis is therefore on (meaningful) experience, involvement, and the performance of tasks. As a result, it can be inferred that the extent to which the replication of atmosphere and environment contribute to the ambience of realism is of less importance. They do, however, contribute to the experience and so cannot entirely be discounted.

3.7 Summary

The psychological aspect of simulation is one which deals especially with the reasoning behind the harnessing of simulation as a strategy in vocational training. The questions: "WHO?" and "WHY?" were asked and addressed.

In paragraph 3.3, an answer to the question "WHO?" was provided during the discussion of the typical participant in a training simulation. It was seen that he would not necessarily have chosen to participate, although the choice of vocation would indicate a tacit assent to the training methods used for that career choice. Personalities differ in respect of how the participant reacts within the simulation in a way which might or might not influence the effectiveness of the simulation to the individual.

The rest of the chapter addressed itself to the question "WHY?". A progression of the schools of thought regarding the learning process was examined, including the Behaviourists, Neo-behaviourists, Gestalt, the Cognitive School, Social Learning, and Experiential learning. Although the Behaviourists treated learning as a largely unconscious response to stimuli, they nevertheless acknowledged the influence of the environment upon learning. Successive theories highlighted to a greater degree the deliberate involvement of the heart and mind within the environment in order to learn and to accumulate knowledge or skills.

It was noted that a variety of theories exists regarding the process of learning. It became apparent that 'experience' is a concept which strikes a common chord throughout the chapter, and that deliberate personal involvement in the process of learning by doing is a principle which must be stressed in the overall training effort. *Simulation must thus inevitably be seen as a vehicle for the provision of* an environment where this principle can be harnessed. Simulation cannot therefore be regarded merely as a medium or a teaching tool, but as a strategy in the overall activity of vocational training.

Peterson and Stakenas (1981:63, in Hendrikz, 1990:30) are quoted as follows: "Concrete experience, reflective observation and abstract conceptualisation - three different learning processes - in combination provide a basis for understanding the problems with which one must deal in managerial life. A fourth generic learning process - active experimentation - is a further requirement for the attainment of managerial competence. Only when business school faculty commit themselves to encouraging these processes while educating students, will competency based curricula be successful". It will be noted in this chapter that only experience (and hence, simulation) utilises all four of these learning processes.

In Chapter 4 the lessons learned from the learning theorists discussed in this chapter will be applied to addressing the questions: "HOW?", "WHEN?", and "HOW COSTLY?". A description of the controller of a simulation and his duties will be provided. The problems of the presentation of simulations, software, hardware, methodology, evaluation, and cost factors will be discussed and solutions offered.

CHAPTER 4

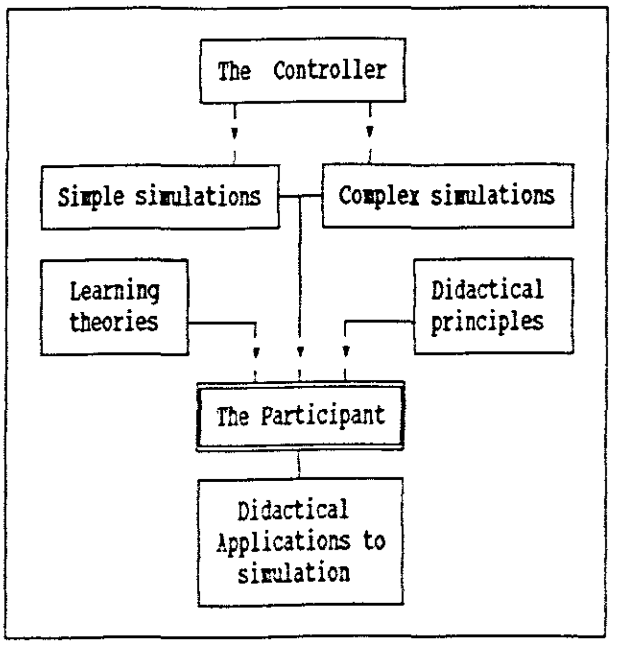
Simulation and Simulators in Didactical Perspective

This chapter outlines a recommended didactical methodology involved in the *incorporation of simulation as a strategy in vocational training.*

4.1 Review of previous chapter

In the previous chapter certain psychological considerations regarding the strategy of simulation were discussed. The typical participant was described; and the application of the theories of learning were examined in order best to apply them to simulation. Since the hypothesis is conditional upon didactical considerations, this chapter will examine the role of simulation in didactical perspective, as well as the duties to be performed by the control staff before, during, after the simulation session, and in assessment. Figure 4.1 illustrates the approach of this chapter to the application of theory to simulation. A practical application of this chapter will be the use of a hypothetical (but quite probable) simulation programme, in which a vessel rounds Cape Point, which will be planned and followed together with the relevant documentation provided in the appendices.

Figure 4.1



Application of theory to simulation

4.2 A profile of the effective controller

The trainer who is in charge of the simulation facility and who organises and runs the simulation has been named by Ken Jones (1980:21) as the 'controller', and also as the 'organiser' (Jones, 1987:65). The term 'controller' has some merit.

It could be argued that the term 'controller' implies one who would manipulate a simulation in such a way that he interferes with the natural outcome of a simulation scenario, and that he could be accused of "playing God" in the simulated world. For this reason other terms should also receive consideration. The person leading the simulation performs a role of manager in the sense that he coordinates, organises, motivates and plans the simulation. He also controls the equipment and the instruction programme. Terms like 'manager', 'organiser', 'coordinator', and 'director' would be quite apt in this light. Similarly, the leader leads and operates the facility in a manner akin to a facilitator in a programmed modular student-paced learning environment thus accepting the title of 'facilitator', 'resource coordinator', or 'leader'.

In education one cannot help but consider the historical role of the '**paidagogos**' of the ancient Greeks (Cole, 1950:35). He was the custodian of the student's morals and learning activities, accompanying him to and from school, and at home. He was charged with the stewardship as chaperone, nurse and tutor of the pupil; the one who always remained at the side of his charge. It is in this context to simulation that no modern English term seems adequately to apply.

In his discussion on the control of communication, Curzon (1985:82) points out that "the use of a strategy of instruction designed to attain a teaching objective requires control". The elements of control, he asserts, would be: measurement, assessment and adjustment, without which control cannot be effective. Thus a person involved in the application of a teaching strategy must measure attainment quantitively and qualitatively, in order to assess the significance of the measurable results. Finally, he makes adjustments to his strategy in order to reinforce success and to correct shortcomings.

It will be explained later in this chapter that the simulation, once in session, must not be manipulated or disturbed in any way which would destroy the consequences of a valid decision made by participants within the simulated world. The person using simulation as a teaching strategy must not therefore consider himself to be the controller of the simulation itself. However, in the didactical context of one who not only controls the facility and its equipment, but more importantly, controls the programme, organises the curriculum, motivates and guides the participants during briefing and debriefing, correctly evaluates the effectiveness of the simulation techniques which might be in use, and adjusts techniques and the way the simulation is promoted according to measurable parameters, he is very much the controller. Thus it would appear that a logical acceptance of the term '**controller**' could be achieved, and is hereby suggested, though with a measure of reluctance due to its vulnerability to misuse.

4.2.1 Personality and character

The controller is seen as being responsible for the provision and execution of the simulation programme, but not to a very great extent involved in the simulation itself, except where he accepts the role of ancillary personalities expected to exist in the simulated world. An example would be the voice of the duty engineer on the telephone in a bridge simulation where the participant might need to communicate with the engine room. It will be stressed later in this chapter that although he has the means to interfere with the simulation, the controller must appreciate the inherent dangers of direct, manipulative intervention, and should exercise circumspection and restraint when tempted to do so (Jones, 1987:67).

It might be contended that because the controller is outside the simulation, relationships with the participants are not as important as in the conventional classroom situation. The time spent with the participants before and after the execution of the simulation mitigates against that point of view however, notwithstanding the fact that the approach of the controller during the execution and monitoring of the simulation very closely depends upon the relationship between the controller and the participants. His presence at all times should promote a relaxed environment and the potential to be forgotten while the participants become immersed within the simulated world (Jones, 1987:66). Thus the success of the simulation itself is influenced by the atmosphere of the entire programme.

A significant consideration is that the participants should not be mindful of pleasing the controller so much as behaving exactly as they would in the real world.

It must be emphasised that the controller should demonstrate the maturity and ability to remain detached and objective at all times. This calls for 'self-acceptance' whereby the controller has the ability to put himself third on his personal priority list under the participant, and the course programme, in that order (Potterton, 1990:1). Self-acceptance also means that the controller has the ability to respect his own interests, abilities, temperament and aspirations in order to maximise effectiveness through sincerity and concerned leadership.

Leadership qualities play a predominant role in the character and personality of the controller. An approachable demeanour, demonstrating a patient, friendly, impartial, tactful and confident personality inspires participants and colleagues to respond positively and enthusiastically. The effective controller will promote an atmosphere of mutual respect and dignity; an atmosphere which encourages a free interaction of ideas and questions without fear of ridicule, criticism or judgment. In humility, the controller should not take himself too seriously. A sense of humour is very beneficial, although humour should be controlled so that it is apt, and does not interfere with a serious ambience of purpose and endeavour.

The ability to lead is difficult to define, but broadly lies between a domineering, authoritarian approach and a 'laissez-faire' neglect of leadership responsibility (Rogers, 1982:85). In an atmosphere free of tension and aggression, a team that is well-led usually demonstrates a sense of teamwork and mutual accomplishment, tending to claim at the end that "we did it".

Another aspect of the controller's presence amongst the participants is that he must earn their respect. This cannot be achieved unless he presents a strong, mature, and confident presence. He should be in a position that inspires the participants to follow his example as a role model (see paragraph 3.4.4 on Social Learning). This demands of the controller that he live an exemplary life, exhibiting a high standard of professional pride and loyalty whilst also free of professional and social indiscretions.

One last deliberation regarding the controller's function as leader touches upon the establishment which employs, directs and supports the staff running the simulation unit. The effective controller is aware of his obligations to his profession, industry, colleagues, and employers. This is a natural and expected phenomenon, but can lead to pressures from outside. Other pressures include the size of the group, location, wishes of the students, and shortcomings in the facility's equipment or infrastructure. These pressures might conceivably influence the leadership style of the controller (Rogers, 1982:92), who should be capable of dealing effectively with them.

An institution led by wise directors would recognise the effect of these pressures, and would provide reasonable understanding and support.

4.2.2 Talents and artistic attributes

During the visit of the author to establishments abroad, it was noted that many of the controllers possessed a subtle sense of dramatisation in the presentation of the simulation. The writer is quick to discourage any allusion to drama or role-playing as part of the simulation itself (refer paragraph 1.3 on role-play), however when used by the controller as a tool for the representation of reality in the simulation, a talent for drama is an advantage.

The writer observed that Captain A.Bole of the Liverpool Polytechnic and Captain R.Beadon of the Seaman's Church Institute in New York both displayed this talent to the extent that members of staff who could afford the time were invited to play the parts of other vessels or traffic control stations on radio. Captain Bole particularly was observed to be able to use a variety of accents and dialects to represent on the telephone the voices of members of crew, including the lookout (Liverpool), radio officer (Irish), and engineer (Scottish). In December, 1991, the writer was invited by Captain Beadon to be the voice of the master of the 'Cape Town Castle' leaving Europort bound for Southampton during a Bridge Management simulation in the Seamen's Church Institute, New York.

During another simulation observed at the same establishment, a New York pilot known to the participants 'boarded' and conned the vessel from the Verrazzano Narrows to her berth near the Bayonne bridge in the Kill Van Kull, New Jersey.

Carrying this dramatisation further, an imaginative and resourceful controller would incorporate objects, sounds, and structures which he would design or construct in order to enhance reality in the simulation. An ability to detect opportunities to enhance the representation of reality in the simulation portrays an artistic flair and a rich imagination on the part of the effective controller. His initiative and willingness to extend himself thus is a valuable trait, and for him it should be enjoyable in order to be successful.

4.2.3 Knowledge and experience

Emphasis was placed, towards the end of the Chapter 3, upon the importance of experience in the acquisition of knowledge. Simulation provides the participant with an opportunity for gaining experience. It is evident then, that the controller should be well versed in that experience. He should be a well qualified, experienced member of the profession for which the participants are being trained. If that is the condition, then in the case of flight simulation, no less than a qualified pilot should be in control.

In the case of a Marine Bridge Simulation, a Master Mariner with watch-keeping and command experience should be a pre-requisite. In this manner, not only will the controller be experienced, but he also will be well versed in the theories of the tasks and problems of the participants.

Simulation in training is a function of education. Therefore a mere qualification and experience in the profession would not be adequate. It must be required of the effective controller that he be a qualified teacher (Duminy & Söhnge, 1983:8). A point worthy of consideration would be that the controller should have had some experience in teaching and have demonstrated an ability to communicate successfully before being trained as the controller of a simulation facility. His knowledge and experience as an adult educator would also equip the effective controller with a clear appreciation of his role in the training effort, and of the significance of simulation as a function of any specific training course. A result of being both a professional in the vocational training field and a qualified educator will enable the controller to develop a sound knowledge of the participants, in order to appreciate their problems and learning processes.

Generally, it can be stated that simulation programmes should be dynamic in the sense that they must remain relevant to the tasks and functions for which the participants are being trained (see paragraph 3.2 regarding relevance). This dictates that simulation programmes should be flexible enough to be kept abreast of the latest technological developments and current trends.

For this principle to be observed, the controller must be well acquainted with the latest developments, current trends, and the requirements of industry. In order to accomplish this he will need to keep in touch with key figures in the work-place by regular personal contact as well as by attending symposia and courses. He will also need to be alert to current trends by the reading of professional periodicals, casualty reports, research findings, and the latest text books on his subject (see paragraph 4.3.15).

4.2.4 Organisational abilities

One of the most demanding aspects of the controller's function is that of organisation. The planning and preparation of simulation courses would require research, the preparation of notes, charts, documents, staffing, and the provision of equipment. The participants will need to be briefed and given assignments in preparation for their simulation programme. They will need to be assessed, debriefed, and an evaluation of the programme made and acted upon.

Programmes will not be successful, unless a strict time schedule is prepared and followed. These will of necessity have to fit into the training programme of the establishment and the college calendar. Records of equipment maintenance, meetings, simulation evaluation, and progress will have to be kept. The ability to organise and to manage the simulation facility would therefore be an asset to the effective controller.

4.3 Review of general didactical principles

Throughout this work, simulation is being considered not merely as a didactical method, but as a strategy in vocational training. In the application of simulation as a didactical strategy, it is intended to adhere to the following general didactical principles as outlined by Avenant (1990:53) as well as by Duminy & Söhnge (1983:21). In their introduction to the subject, Duminy & Söhnge introduce their chapter on didactical principles (Duminy & Söhnge, 1983:21) thus: "Teaching is a practical matter, and learning through doing is a very important aspect of the training of students . . .". However, they emphasise (Duminy & Söhnge, 1983:22) that the application and recognition of the didactical principles should take precedence over the visible outer accoutrements of teaching activities. In the discussion of simulation as a didactical strategy, these principles will be borne in mind.

Not all authors agree on the exact number and definitions for the principles of didactics; however a general statement can be made regarding the overall didactical technique (Fraser et al., 1990:53): ". . . instruction and learning will be effective only . . ." when the teacher:

- Exposes the selected subject content to the students.
- Ensures that the content is scientifically correct.
- Determines whether the subject matter has been mastered, and that the student is able to use and apply it (Fraser et al., 1990:53).

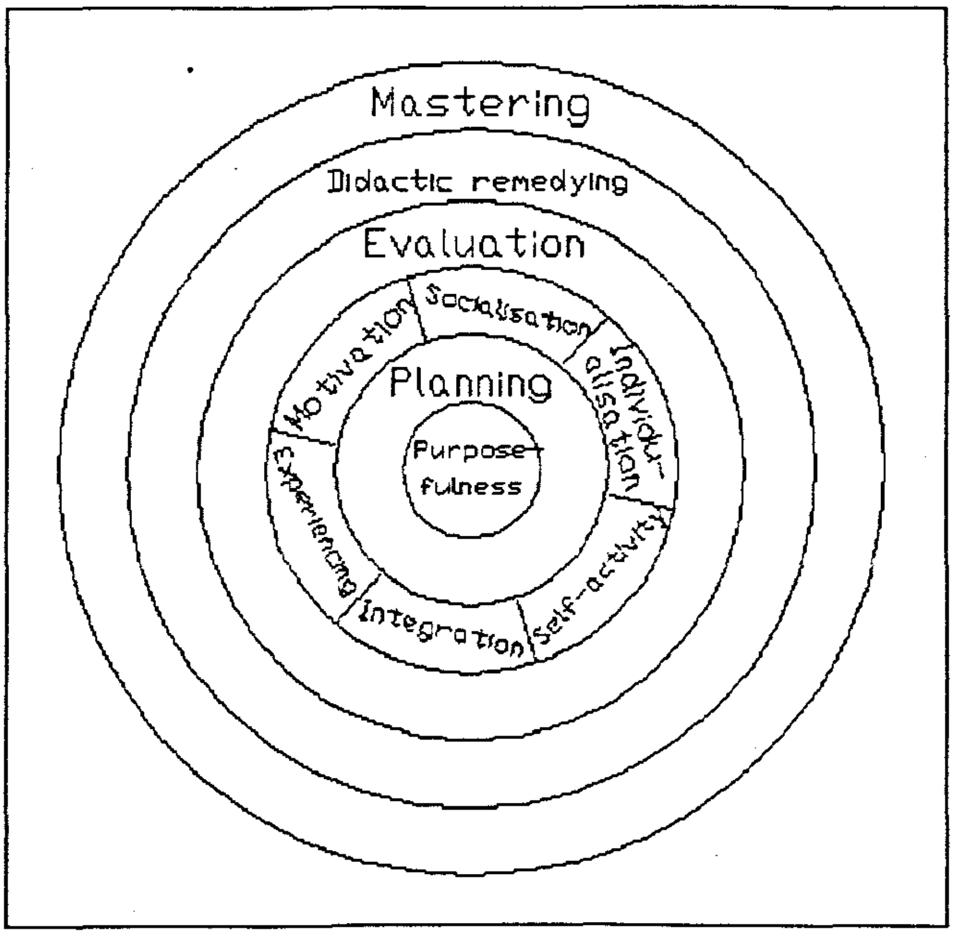
Figure 4.2

Cawood (1982)	Duminy (1981)	VdStoep(1984)	Shipley(1972)	Avenant(1990)
Individualisation	Individualisation	---	Individual difference	Individualisation
Global perception	Totality	Systemisation	Integration	Integration
Self-activity	---	---	Active learning	Pupil self-activity
Motivation	Motivation	---	Motivation	Motivation
Socialisation	---	---	---	Socialisation
Planning	---	Planning	Lesson planning	Planning
Evaluation	---	Surveyability	Remedial teaching	Evaluation
Mastery	Perception	---	---	Mastering
---	---	Balance	Balanced curriculum	---
Experience	---	---	---	Experience
...	...	...	...	...
Objectivity	Mother tongue instruction	Clarity	Suggestion	Purposefulness
	Example	Tempo	Encouragement	
	Primary environment	Dynamism	Democratic environment	
		Sympathy	Stimulation	
		Problem formulation	Perceptualisation of reality	
		Stating the problem	Independence	
		Scientific character	Variety of methods	
		Control		

Comparison of the principles suggested by Cawood, Duminy, Van der Stoep,and Shipley (Fraser et al., 1990:53), adding Avenant (1990:53) (Re-arranged by author)

Avenant draws attention to the didactical principles displayed in his schematic diagram (figure 4.3) as being arranged in concentric circles around the first principle: **Purposefulness** (Avenant, 1990:53). Surrounding purposefulness, but still central to the didactical structure, is **Planning**, after which six principles, namely **Socialisation**, **Individualisation**, **Self-activity**, **Integration**, **Experiencing**, and **Motivation** are treated with equal importance. Peripheral to these are **Evaluation**, **Didactic Remedying**, and **Mastering**.

Figure 4.3



Avenant's Schematic exposition of the didactical Principles
(Avenant, 1990:53)

It will be seen in figure 4.2 that some concurrence exists among the authors under review. In the brief description of the principles which follows, similarities will be indicated where they occur:

4.3.1 Purposefulness: Unless the teaching programme has a purpose, a knowledge of what is to be taught, and a statement of desired outcome, it will be very difficult to plan, execute and evaluate what is being taught (Avenant, 1990:55). Goal directedness enables the drawing up of short and long term plans, and serves as guidance for the setting of criteria, for the preparation of lesson programmes and evaluation against given criteria.

Purposefulness entails the definition of ultimate, distant and immediate aims respectively. Once the aims have been defined, the objectives, i.e. "immediate, cognitive, affective or motor reaction" expected from a student as a result of having completed a lesson or module can be formulated (Avenant, 1990:59). The purpose of the lesson is central in the scheme of didactical principles and should thus occupy a pivotal position in the planning of any teaching programme including simulation.

4.3.2 Planning: Systematic presentation is facilitated by good planning. Planning cannot take place in isolation, but rather must embody all the didactical principles, taking them into account so that the lessons being planned incorporate the didactical principles of purposefulness, activity, integration, experience, motivation, socialisation, individualisation, evaluation, and mastering (Avenant, 1990:79). More will be discussed under the heading of planning later in this chapter, but it must be stated that planning involves long term, as well as short term planning in accordance with long term and short term goals (Avenant, 1990:81).

4.3.3 Integration (placing in context): The importance of relevance and contextualisation was evidenced in the previous chapter (see paragraph 3.5.4 regarding Kolb's emphasis on relevance in specific contexts) and also the learning process indicated by Ausubel whereby concepts are subsumed under broader subject categories (see paragraph 3.4.3, and globalism on page 127).

The principle of integration implies that learners must be encouraged to perceive relationships. This is best accomplished by comparing and sorting, moving from the abstract to the concrete, and from the known to the unknown (Avenant, 1990:54). Lessons should be structured so as to link new material with familiar concepts, in accordance with the learners' thoughts and understanding, relating disparate details to each other, and gradually increasing difficulty step by step. In applying integration the following principles of orderliness distinguished by Van der Stoep are delineated by Avenant (1990:101): Logic, chronology, progression, local lore (use of familiar environmental features), detail, analysis-synthesis, symbiosis (parallel examples), and horizontality (synchronism). In considering the principle of integration, the theory of "Gestalt" psychology (see paragraph 3.4.2) draws a strong parallel.

Under the heading of Development Conradie (1979:4) depicts the gradual unfolding of the subject matter in congruence with the development of the student. Also, Duminy raises 'Local Lore' as a distinct didactical principle, namely Environmental Teaching (Duminy & Söhnge, 1983:46) under which heading he explains that the student will be able to assimilate more effectively what he is being taught by drawing on his own background and experiences. In moving from the known to the unknown, the environment of the students becomes a basis from which and within which to teach and to learn. "Subject matter and the method of instruction are closely interrelated" (Duminy & Söhnge, 1983:48).

The teacher should cultivate more alert and open minds, and to stimulate initiative and critical evaluations. In applying this principle to simulation, the teacher is not only teaching by drawing upon the vocational experience of his students, but is furthermore providing an environment which is contiguous with that of the real world.

4.3.4 Student self-activity: Also described as active student participation and contribution (Avenant, 1990:117), active learning by Shipley, and Self activity by Cawood (Fraser et al., 1990:53). The intellect must not be ignored, and learning should take place at the learner's own initiative. Teachers must motivate the learners to form their own concepts (Avenant, 1990:117). The student must be involved in the learning process to the extent that he is an active participant rather than merely a passive recipient of knowledge.

In the application of this principle, feedback is a factor which results in the determination of the student's progress and the direction of the lesson. Also, activity can be used to facilitate motivation (Conradie, 1979:4).

The following advantages of self-activity are enumerated by Avenant (1990:118):

- Participation leads to an atmosphere which would be less taxing on the mind.
- Participation encourages greater interest and closer attention.
- Initiative, responsibility, and independent thought are stimulated.
- Creative abilities are developed due to the need to become independent during involvement in self-activity.
- Participation encourages the development of certain skills associated with the current activity.
- Learners experience the subject matter more intensely.
- Learners become responsible to the teacher and others in the group, thus inculcating character traits such as team work, loyalty etc. In marine bridge simulation, for example, this advantage encourages the concept of the bridge 'team'.
- Because the student is responsible for the results of his own activity, a cultivation is achieved of the desire for accuracy and effectiveness in his work, as well as a receptiveness of mind coupled with a sense of objectivity and impartiality.
- Meaningfulness of the knowledge gained is imparted through an appreciation of its perceived relevance.

- Participation facilitates better practice in the techniques of problem solving, accurate observation, and scientific thought.
- The teacher is freer to observe mistakes being made. Feedback and evaluation is therefore more immediate.

Types of class activity suggested by Avenant(1990:119) include: creative activities (e.g. painting), mastering activities (e.g. developing skills), concept forming activities (e.g. experiments), assessing activities (e.g. judging a result or painting), co-operative activities (e.g. joint activities), and judgment activities (e.g. debates).

4.3.5 Experience: (see page 128: 'Perception') It will be noted in Chapter 3 that experience should be regarded as being of significant importance in the process of learning (see paragraph 3.5 on experiential learning). Avenant (1990:131) stresses that "Learning can occur meaningfully only if the sensory stimuli perceived are assimilated internally . . . put differently, the more one becomes emotionally involved in the subject-matter, the more easily it is assimilated (learnt)". Thus it is that the teacher brings the students into contact with reality, objects, places and events. In this way, a phenomenon named 'concretising' by Avenant (1990:133) is achieved whereby concepts can be moved from the concrete through the schematic to the abstract.

In addition to concretising, Avenant (1990:133) also offers the following principles of experience: practical experience, visual education, dramatisation and actualisation. It is a pity that Avenant relegates simulation to being merely one of the suggested techniques of dramatisation (Avenant, 1990:137) because of its apparent contradiction of the thrust of this thesis in which simulation is regarded as being a means for bringing realism and concrete experience to the students (see paragraph 1.3 on the meaning of simulation). It is suggested by the writer that if simulation does not meet this criterion, then it has no claim to the title 'simulation'.

Certain requirements which must be recognised are that the experience must

- fulfil a defined need,
- apply within the parameters of the abilities, knowledge and development of the students,
- not be misleading,
- be well planned,
- be meaningfully followed up,
- approach as near as possible to the actual experience, and
- not be unrealistically expensive in terms of funds as well as time (Avenant, 1990:140).

4.3.6 Individualisation: "The educational principle of the consideration of and provision for individual differences in pupils is called the principle of individualisation" (Avenant, 1990:150).

"Every child must be assisted to develop according to his own capabilities" (Duminy & Söhnge, 1983:26). Allowance should be made for the individual's stage of development, capabilities and learning style. This does not mean that every student should be taught in isolation as it would not be practical from a time and cost point of view, as well as the fact that motivation and socialisation would be reduced.

Avenant distinguishes between individual education where a one-on-one teacher to student situation occurs and differentiated education in which, because it is more practical, individual differences in a class or group are allowed for (Avenant, 1990:152). Factors according to which differentiation takes place are listed by Avenant (1990:154 to 156) as: intelligence, scholastic achievement, skill, aptitude and interest, character and personality traits, domestic and environmental factors, and the physical condition of the students.

Duminy & Söhnge (1983:28) stresses that in spite of certain disadvantages of classroom situations, "provision for individual differences should be made within the boundaries of class education". Because of this, it is recommended that "a synthesis of the class and individual education" would seem to be a solution (Duminy & Söhnge, 1983:28).

The way in which this synthesis can be applied should include group formation within the class in which ". . . smaller groups within the class can work effectively towards a common goal". The relationship too between the class and the teacher, where the principle of differentiation prevails, is a more open interaction, and less authoritarian (Duminy & Söhnge, 1983:32). Moreover, it is pointed out that, as far as possible, classes should be kept small (Duminy & Söhnge, 1983:32).

An outline of the basic requirements for effective grouping is provided by Avenant (1990:162) as follows:

- Classification must be flexible and that sometimes linking a slow student with a faster one could be advantageous to the slower student.
- Grouping must be a means to an end.
- Grouping should take place after careful consideration of the individual differences.
- Planning of groups should also be concerned with availability of equipment and facilities, as well as the social relationships within the groups.

4.3.7 Socialisation: "Iron sharpens iron, so a man sharpens the countenance of a friend" (Proverbs 27:17). In applying the principle of socialisation Avenant (1990:169) quotes the above proverb and offers the following definition of socialisation: "The principle of socialisation implies that the teacher should organise his daily teaching so that favourable social relationships prevail in the classroom and pupils also learn for and from each other."

Amongst activities which could be used to apply this principle, simulation is included (Avenant, 1990:187). Conradie warns that in the atmosphere of modern teaching methods, socialisation is in danger of being relegated to a lower priority (Conradie, 1979:4). The writer of this thesis recognises the importance of acknowledging that man is a social being, and that the stimulation of group discovery and the power of peer pressure are advantageous in the learning process.

4.3.8 Motivation: The importance of arousing and maintaining the will to learn should be regarded as an important part of the teacher's work (Duminy & Söhnge, 1983:33). Intrinsic motivation can be harnessed by making the subject matter interesting, relevant and meaningful, while extrinsic motivation can be applied (preferably positive) through recognition of achievement and competition. Emphasis is placed on the importance that the teacher should have a clearly defined purpose before embarking on a certain activity. Duminy & Söhnge (1983:37) itemises the following motivational principles:

- A learner who is motivated will learn more quickly.
- Motivation should not be too intense.
- Moderate rather than excessive motivation is more productive.
- Intrinsic motivation is more effective than extrinsic motivation.
- Purposes and goals should be meaningful and relevant to the learner.
- Positive rather than negative extrinsic motivation should be applied.

It is pointed out by Conradie (1979:5) that the adult does not need motivation, nor should be motivated, in the same way as the child. Klevins (1978:260) provides three reasons why adults would wish to learn (Fraser et al., 1990:55):

- Achievement of objectives - e.g. promotion.
- Social acceptability.
- Self realisation - self enrichment.

Four divisions in the application of motivation are suggested by Avenant (1990:197):

- Linking up subject-matter with student needs; i.e. the need for success, the need for love and security, the need for acceptance, and the need for sympathy (Avenant, 1990:197).
- Linking up subject-matter with students' urges; i.e. curiosity, play, adventure, construction, and collections (Avenant, 1990:203).
- Application of attention determinants by providing a stimulating atmosphere, making the subject matter interesting to the students, and eliminating negative influences (Avenant, 1990:206).
- Meaningful utilisation of incentives, ensuring that intrinsic and positive extrinsic incentives are mostly applied (Avenant, 1990:207).

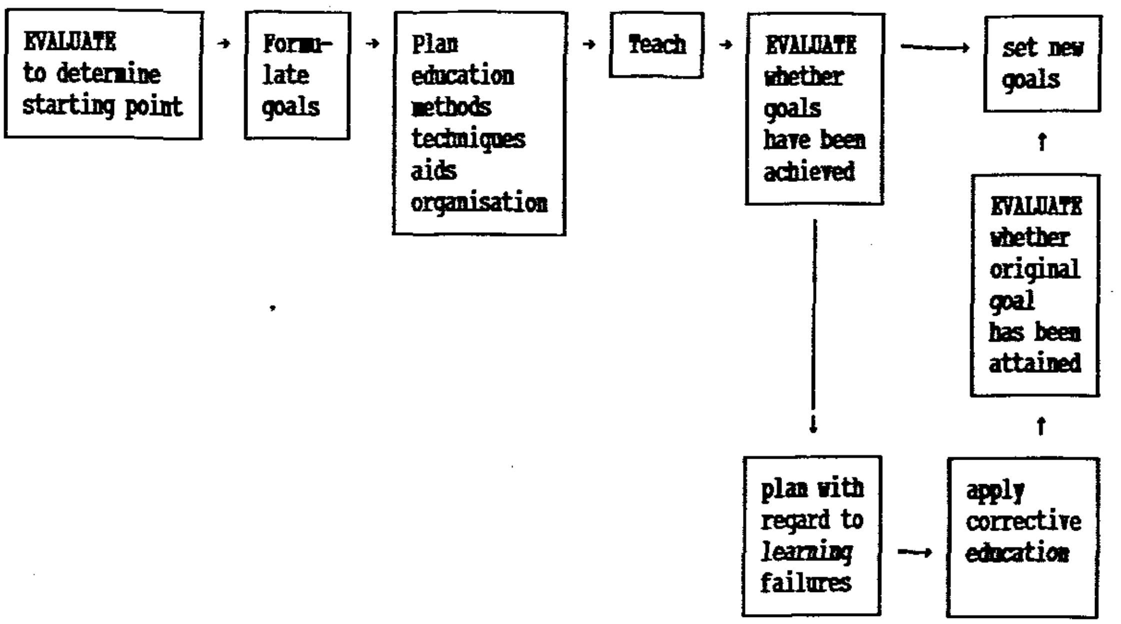
4.3.9 Evaluation: (see page 130: 'Control') As stated earlier, purposefulness and goal setting are central to the didactical effort. This naturally enables the delineation of criteria which must be measurable in order to assess the effectiveness of the teaching endeavour. Thus evaluation is the activity by which the effectiveness of learning is determined (Avenant, 1990:217).

Evaluation is not a process of measurement alone. It is described as "the process of subjective appreciation with the specific aim of determining a person's worth in the light of evidence gathered by measuring and observation" (Avenant, 1990:217). During evaluation, measurements are made regarding books, activities, and tests followed or accompanied by observation and personal judgment. Ultimately these results are compared with norms in order to arrive at measures to be taken wherever necessary in the teaching method. Figure 4.4 indicates schematically the prominence of evaluation in the teaching-learning situation.

The aims of evaluation (Avenant, 1990:219) are:

- To determine whether goals have been achieved, whether the subject matter has been understood, whether there are any who have not yet understood the subject matter, and what work must be repeated.
- To determine whether teaching methods and techniques have been successful, and where changes are needed.
- To identify backlogs and problem areas.
- To ascertain personal success of the teacher in order to achieve standards.
- To validate the awarding of qualifications.
- To motivate students towards greater achievements.

Figure 4.4



The Functions of Evaluation in the teaching-learning situation

(Avenant, 1990:218)

4.3.10 Mastering: The subject-matter is considered mastered when students not only understand the subject-matter, but will also remember it for a long time (Avenant, 1990:247). In applying this principle, teachers will take measures to ensure that this is achieved by clinching or rounding off the lesson through summaries and follow-up measures such as assignments, homework and revision. It is also important that students are assisted in their efforts to study, and to create an atmosphere and spirit which promotes independent study (Avenant, 1990:271).

Supplementing the above principles, the following additional principles of didactics can be suggested:

4.3.11 Totality: (see also integration on page 116) Fraser includes the term 'globalisation' under this heading (Fraser et al., 1990:64). As opposed to an emphasis being placed on the intellect alone in an attempt to impart knowledge, and to treat all facets of the human psyche as being separated from each other (atomastic), Duminy & Söhnge (1983:23) draw attention to the importance of viewing man in his "multi-dimensional unity", and that the intellect, emotions and will should ". . . never be divorced or separated." In the teaching effort a focus towards a synthesis of these psychological aspects should be sought.

This can be achieved by being mindful of factors outside the classroom (social and family), ensuring a continuity and a broader perspective and appreciation of relevance of the topic being taught, not only in the world of the student, but in its relation to the curriculum and the subject as a whole (see paragraph 4.3.3).

Some characteristics evident in the implementation of the principle of totality (Duminy & Söhnge, 1983:25) are as follows:

- A general theme.
- Subject matter should be drawn from the immediate environment.
- The manner of teaching should be influenced by circumstances such as the nature of the subject matter and the background and abilities of the student.

- Pupil activity is stressed. The hand, head and heart should be involved.
- The aim should be gaining insight rather than just knowledge.
- As in the principle of Integration (paragraph 4.3.3), the approach of the principles of "Gestalt" psychology is emphasised, namely that the subject should be introduced in totality before attending to the details (Duminy & Söhnge, 1983:25).

4.3.12 Perception: This principle has parallels with Avenant's term: 'Concretising' (paragraph 4.3.5), and 'experience' (see page 119). ". . . perception will result in the attribution of meaning, which will be influenced to a large extent by the learner's cultural background and previous experiences" Fraser et al. (1990:61). Duminy & Söhnge recall the first illustrated textbook of Comenius, and points out that the stimulation of the senses (sense perception) is not entirely new (Duminy & Söhnge, 1983:38). Experience would fall into this category but he also places emphasis upon sensory stimuli dependent on thought (abstraction), and language (Duminy & Söhnge, 1983:40).

Regarding language, Duminy & Söhnge (1983:41) make this point: "Language is the means by which thought unties itself from the observational and becomes abstract." This sentence implies not only the importance of language in the principle of perception, but highlights the inseparability of the three functions. For this reason, language should convey meaning in the clearest and simplest terms. Conradie (1979:3) places emphasis under this heading of "starting with the concrete and proceeding to the abstract".

Two pitfalls in the use of language are identified by Duminy & Söhnge (1983:42): Verbalism, in which the teacher uses "words with disregard for their meaning". This implies that learning of material cannot be proved merely through the accurate repetition of the words if the meaning is not understood, and also that the use of jargon and unnecessarily complicated words should be limited. Secondly, misuse of audio-visual aids (Duminy & Söhnge, 1983:44) implies that if audio-visual material is used excessively or indiscriminately, it leads to the reduction in the use of language, with its disadvantageous consequences. Ultimately, the teacher should ensure that assimilation of the new knowledge is followed by self-activity; and then expression should be the natural outcome (Duminy & Söhnge, 1983:44).

It is recognised by Duminy (1983:45) that the principle of perception has the disadvantage that it could not be applied to abstract concepts in certain philosophical and theological fields. However, since this work is primarily concerned with vocational training, it follows that this disadvantage can be regarded as less important in that respect, although the writer deems it important to indicate that the inculcation of positive attitudes forms a part of a good simulation.

4.3.13 Mother-tongue Teaching: In a situation such as experienced in South Africa where a variety of mother tongues is in existence, this principle becomes more pertinent. The mother tongue is not only the student's primary medium of communication, but also his thought reference. Since his mother tongue embodies his cultural and national identity as well as attitudes and thought processes, it becomes an important didactical principle, especially for the initial teaching stages (Duminy & Söhnge, 1983:52). The use of the mother tongue "is the only medium . . ." which secures the teaching-learning situation where the acquired knowledge must be transposed into its abstract form (Duminy & Söhnge, 1983:55). It is acknowledged (Duminy & Söhnge, 1983:56) that occasions arise where the use of a foreign medium might become necessary for practical purposes.

4.3.14 Control: This principle is declared by Fraser as a separate principle which includes the process of evaluation (Fraser et al., 1990:67) (see page 124). Control is the principle whereby responsibility and accountability for the teaching activities are applied. Control is not merely evaluation, but serves to guide the teacher and the student in such a way that remedial intervention can be exercised in order to ensure that the learning approaches the set objectives (Fraser et al., 1990:68).

4.3.15 Scientism: As a didactical principle, scientism embodies the application of the science of teaching and the use of the most appropriate teaching methods. It also implies the knowledge and profitable exploitation of the science of learning psychology. Finally, the teacher should be well acquainted with the science of the subject he teaches. Thus not only will the knowledge of the subject matter be verified and systemised, but kept current in its context commensurate with progress regarding the latest usage and technology (Fraser et al., 1990:67). In order best to apply this principle, care should be taken to ensure that the teacher is not only a qualified educator, but is also a qualified expert in his field (see paragraph 4.2.3 regarding the knowledge of the controller).

4.4 Brief overview of the simulation process

The main emphasis of this thesis is that of the potential of simulation as a strategy for teaching by providing the student with the actual experience necessary to accomplish the mastering of skills and subject matter related to his chosen vocational field (see paragraph 3.6). Each simulation should be planned and regarded as a new and unique experience for the participants, with due regard to the principles of didactics, not least, the principle of individualisation (see paragraph 4.3.6). Thus the aim of each simulation should be considered afresh in preparation for each occasion.

The overall activities of the simulation must be seen within the broader training curriculum of which the simulation is a part (observing the principles of totality and perception, paragraphs 4.3.11/12), and also in terms of the needs of the participants (individualisation, paragraph 4.3.8). The simulation must take place in recognition of the general aims of the course and the particular aims of the simulation. In terms of these aims and the training needs of the participants, the exact nature of the simulation can be identified and defined.

Once the aims of the simulation and the nature of tasks and events to be experienced are identified, the setting of specific objectives can take place. The objectives not only serve to guide the controller, but will be used as criteria for evaluation and control purposes. Objectives, therefore, precede, guide, and direct the entire simulation process, because they are the tools of the evaluation and control process.

Preparation and planning of the simulation by the controller will be guided by the aims and objectives already identified. Provision of equipment, documentation, preparation assignments, relevant computer data and software, setting of times, and actual preparation and testing of the facility and hardware will then be attended to.

Preliminary to the simulation, the participants should be prepared in terms of the teams selected, duties and roles of the participants, a declaration of objectives and intended achievements expected of the participants, preparation assignments, and finally the briefing just prior to the simulation.

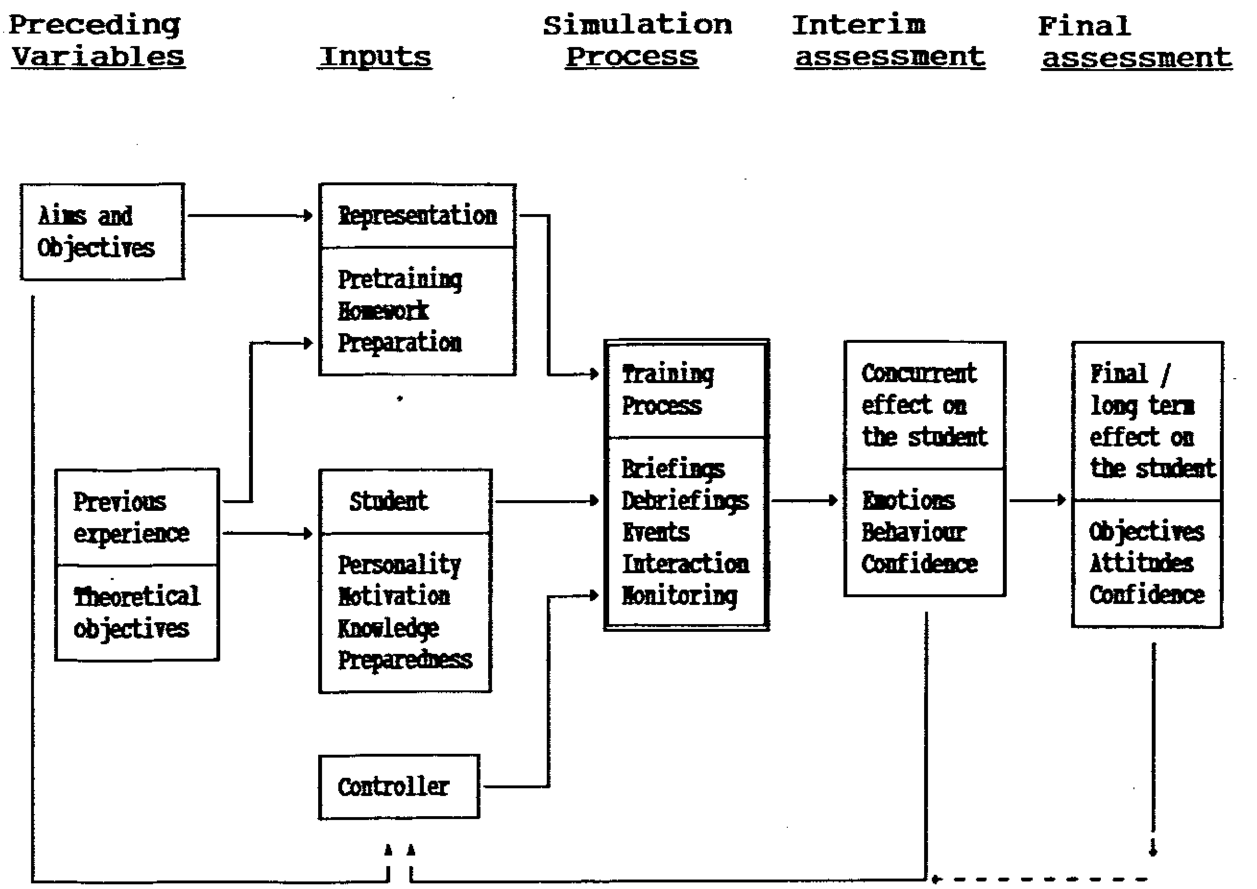
During the simulation itself, the controller is responsible for ensuring that the hardware is operating correctly, contributing to the representation of reality in the simulation by responding to telephone calls, etc., monitoring the simulation and the participants, and seeing to it that participants are provided with everything necessary to ensure that their experience of reality meets the objectives.

The debriefing session (also informally referred to by some as the 'wash-up meeting' or 'post-mortem') enables the controller to involve the participants, by general discussion, in an active review of events which occurred in the simulation. At this time mutual assessments should be made regarding mistakes made, improvement potential, lessons learned, and the application of the simulation to future performance in the real world, thus ensuring a continuity between the experience in the simulation and the real world.

Ultimately the controller must take stock of the events in the simulation and the results of evaluation in order to assess the effectiveness of the simulation, areas for improvement, and the short term and long term effects on the participants. Records must be updated, whilst corrective measures must also be taken and improvements made wherever this is indicated.

Figure 4.5 was compiled following a discussion with Dr. Anita D'Amico and Captain R.Beadon in New York in December 1991. It provides a schematic illustration of the overall simulation process.

Figure 4.5



Schematic illustration of the flow process in a simulation programme

It will be noted that in the above schematic diagram, the student is the central input to the simulation. Also, before the participant enters the simulation, the necessity to have achieved a prerequisite measure of experience is apparent, and he already should have met certain theoretical objectives regarding the duties he will be expected to perform within the simulation.

The controller is not prominent in the scheme. However, he is strategically placed to convey and monitor the achievement of the objectives through the process. In this way, the diagram indicates a connection with the objectives throughout the process, and they prevail as the terms of reference for the controller.

The measurable and observable results of evaluation are returned via the controller, for improvement, modification or remedial action, to the simulation.

4.5 Selection of simulation aims

Dependent upon what is required to be simulated and the extent of representational hardware needed, certain simulations need not be expensive. The level of sophistication in the choice of hardware and the design of educational software will need to be designed to fulfil specific aims. Consideration regarding the actual design and selection of hardware and software will be discussed elsewhere in this thesis (see paragraph 4.11). Unless a fairly modest simulation is contemplated, the availability of the representational hardware, time constraints, and facilities will limit to some extent the aims of simulation programmes. This means that the facility would already have been provided in order to satisfy the broad aims of the institution which provides the simulation facility. Nevertheless, within these parameters, the control staff, other staff in the training programme, and more importantly, the student will need to be aware of the aims of the specific simulation session being planned.

"All educative actions must be aimed at a special goal, otherwise it would be aimless and meaningless.." (Van Rensburg & Landman, 1988:285). In order to follow the principle of purposefulness (Paragraph 4.3.1), one embarks first upon the establishment of general and specific aims. Aims are a first step to the preparation of a training programme and are therefore essential to the controller. It should not be forgotten, though, that the student/participant should also be made aware of the aims (Bentley, 1991:75), since this directly affects him, lending direction and motivation to the individual's personal approach to the simulation exercise. The formulation of aims results from the identification of learning needs (Bentley, 1991:73) which (for the purpose of this thesis) might best be satisfied by simulation.

There does not seem to be a general concurrence regarding the terminology regarding the differentiation between 'aims' and 'objectives'. Fraser et al. (1990:101), for instance, refer to 'aims and objectives' together. Duminy & Söhnge (1983:108) are also somewhat nebulous in his approach to this topic, inserting the term in parenthesis after "Objectives". He further states that "the modern tendency is to speak about objectives rather than aims" (Duminy & Söhnge, 1983:108). Robert Mager appears not to recognise aims at all. He opens his first chapter by referring to "objectives or goals" (Mager, 1962:1), although in a later work, job description, task analysis and target population are considered before setting objectives (Mager & Beach, 1967:28). Taber et al. (1965:62) follow Mager by launching directly into the defining of objectives. Hartley (1972:189) also makes no mention of aims.

Following the example of Avenant (1990:58), however, the usage of the term 'aim' in this work will refer to a statement of intention (or goal) to address the satisfaction of an identified learning need (Fraser et al., 1990:89). 'Objectives' will be dealt with separately, the selection of which would be influenced by the stated aims. Clarity of goals is essential in order to proceed meaningfully and to follow the principle of purposefulness (Avenant, 1990:58). In the preparation and declaration of aims, the following categories are identified by Avenant (1990:58):

- The ultimate aim This would more likely be in line with the stated mission of the establishment, and the main purpose for which the simulation facility was financed and equipped. It is logical, therefore, to conclude that all other aims should follow the general direction of the stated ultimate aim. In marine simulation the ultimate aim might conceivably be the provision of a well qualified manning of industry's merchant vessels for the general economic and cultural welfare of the nation.

- Distant aims These are the intermediate aims which delineate stages in a series of intermediate goals towards the ultimate aim. Distant aims in a ship simulation might identify the educational requirements of the industry and the students themselves. For example, the training of cadets, junior watchstanding officers, commanding officers, etc. Distant aims would also include aspects of their duties which relate to their responsibilities, such as in their handling and safe navigation of vessels in traffic in all weathers.

- Immediate aims Having identified the distant aims, specific aims can be stated. In this case one or more aims of the course, and specific aims of events or stages during the course will be stated. An example here would be to undertake a passage including a major alteration of course around a headland in busy traffic and in fog. The statement of this aim, starting with the word "To . . ." would therefore read:

"To provide the participants with experience in the preparation and undertaking of a passage, including a major course alteration, around a headland in moderate traffic in restricted visibility."

It is the writer's suggestion that the considerations which must be taken into account while establishing aims are:

- Relevance to the subject matter in context with the overall training programme (see paragraph 3.2 and 3.3).
- Identification of specific learning needs.
- Affective disposition of the participants (totality, paragraph 4.3.11).
- The aspirations and abilities of the students (individualisation, paragraph 4.3.8, Totality, paragraph 4.3.11).
- The stage reached by the participants in the theoretical aspects of the subject matter relating to the simulation programme required (perception, paragraph 4.3.12, integration, paragraph 4.3.3).
- The nature and extent of previous experience of the participants (Totality, paragraph 4.3.11).
- The stage of development in the participants (Integration, paragraph 4.3.3).
- Feedback from evaluation of previous simulation programmes (control, paragraph 4.3.14).

4.6 Setting Objectives.

Once having stated the immediate aims of the simulation, the establishment of the criteria against which the activities of the simulation programme will be quantitively and qualitatively evaluated must be established in detail. An objective is defined by Avenant as "... **the immediate cognitive, affective or motor reaction a teacher expects his pupils to exhibit on completion of a specific lesson or module**" (Avenant, 1990:59). Objectives are the instruments of evaluation, and as such should satisfy the following requirements:

According to Avenant (1990:59), they must

- clearly be understood by teachers as well as the students.
- be realistic and attainable.
- relate to the stated aims.
- be stated in terms of an expected pupil reaction.
- be defined in terms of precise measurable achievement.
- clearly define the conditions under which the reaction would be measured (this requirement was added by the writer).

Because a precise measurable achievement must be specified, it is necessary to make use of "action verbs" in order to describe the behavioural change. Examples of ten "action verbs" (Cohen & Manion, 1983:43) follow:

identify	distinguish
interpret	order
describe	name
evaluate	locate
apply	construct

4.6.1 Bloom's Taxonomy of Objectives.

According to Bloom (Woolfolk & McCune, 1984:389) and (Fraser et al., 1990:104), Objectives are classified under three categories as follows:

- Cognitive Domain:

Knowledge	(remembering)
Comprehension	(understanding)
Application	(Solving)
Analysis	(analysing)
Synthesis	(creating)
Evaluation	(judging)

- Affective Domain:

Receiving	(awareness)
Responding	(new behaviour)
Valuing	(involvement)
Organisation	(appropriating a new value)
Characterisation by value	(commitment)

- Psychomotor Domain:

Reflex Movements	(e.g. blinking)
Basic Fundamental	(e.g. walking)
Perceptual abilities	(e.g. following instructions)
Physical abilities	(e.g. riding a bicycle)
Skilled movements	(e.g. musician)
Nondiscursive communication	(e.g. gestures)

Although it is admitted that behaviours from all three domains generally occur simultaneously (Woolfolk & McCune, 1984:389), Bloom's taxonomy is of value in providing guidelines for the "organisation and formulation of explicit teaching objectives" (Fraser et al., 1990:104).

In the preparation of a lesson, for example on sewing on a button, it will be appropriate to define the objective in such a way that the student, not previously being able to do so will be able to demonstrate this new skill at the end of the lesson.

The objective could be worded after this fashion:

"At the end of the lesson the student will be able to sew a four-hole button to a shirt front within five minutes, given a length of cotton and a sewing needle."

The change of behaviour resulting from the lesson is measurable because a specific change of behaviour is expected which will or will not take place. Referring to the preparation of simulator exercises, Bole emphasises that such programmes should have a "clear (and preferably unequivocal) objective" (Bole, 1983:102). Although the purpose of a simulation would not necessarily be a simple lesson in methodology, it could be used as a method of assessment itself, in which case similar wording could be utilised.

An example of such an objective might be worded thus:

> **"During the radar simulation in which the vessel (a typical stern trawler) will encounter one other vessel in a starboard to port crossing situation in restricted visibility, the participant will use a conventional radar plot to ascertain whether risk of collision exists, and will decide upon, if necessary, and take suitable action to avoid a close-quarters situation."**

However, depending on the sophistication of the simulation planned, a more comprehensive expression of objectives will usually be needed. Because of time and cost restraints, additional objectives will be selected which would best exploit the nature of the simulation being conceived. Thus it is that Bloom's Taxonomy is of particular assistance to the controller of a simulation.

Being mindful of the emphasis placed in Chapter 3 that direct purposeful experience is the most direct learning process (and therefore the purpose of a training simulation) the objectives of a training simulation programme should reflect this factor and convey its meaning and criteria within the framework of experience. In other words: The lesson is the experience gained through the simulation. It is evident, therefore, that knowledge and skills gained by experience, and lessons learned through mistakes made will be achieved during run time and reinforced during the debriefing session.

If, for example, one of the aims of a simulation being contemplated is to draw the attention of the participants to the danger of complacency through boredom on the bridge (Schuffel, et al. 1989:60), then the participants will either cope, thereby demonstrating that they have not become complacent; or else they will make a mistake from which they will learn that lesson, and reinforcement will occur during the debriefing session. This example leans towards the affective domain in Bloom's Taxonomy.

Coupling this latter reasoning with an analysis of the desired learning task against Bloom's taxonomy, one of the objectives of such a simulation might be worded as follows:

> **"After a prolonged period of routine events during this simulation, the participants will demonstrate by successfully executing an unexpectedly more difficult manoeuvre, that they appreciate the danger of becoming complacent during an uneventful watch."**

For a comprehensive bridge simulation lasting several hours, a number of objectives will be needed, because the nature of sophisticated simulations provides for the realisation of several concurrent learning objectives other than the those initially set by the training staff. For instance, the main objective might be the practical interpretation of Rule 19 (conduct of vessels in restricted visibility) in the International Regulations for Preventing Collisions at Sea. However, the handling characteristics of the ship model might be different from those of vessels with which the participants are familiar, hence providing them with the opportunity to gain wider ship handling experience.

Alessi and Trollip (1985:181) draw attention to what they term "intrinsic", "related" and "arbitrary" instructional goals in training simulations as follows:

- Intrinsic Goals: are those which are directly related to the context of the simulation.

- Related Goals: are those which are merely associated with what is being learned.

- Arbitrary goals: are those which are neither related nor associated with what is being taught.

These three relationships can be regarded as forming the corners of a triangle which is typical of most simulations, and which can be useful where simulations have multiple objectives (Alessi and Trollip, 1985:181).

For the simulation (rounding Cape Point) chosen as an example for the purpose of this thesis, objectives will be as follows:

Ultimate objective: (intrinsic)

> **"During this simulation, the participants will co-operate as a bridge team in performing their duties to negotiate moderate traffic in restricted visibility, whilst rounding Cape Point on board a typical trawler."**

Functional objectives: (related and arbitrary)

1. "During this simulation, the participants will successfully navigate a typical stern trawler/freezer around Cape Point (Eastward bound) using all charts and navigational publications necessary, but with unstabilised head-up radar display, gyro compass and autopilot only."

2. "During this simulation, the participants will effect an alteration of course around Cape Point in fog, whilst ensuring that the alteration does not endanger the vessel in dense traffic."

3. "During this simulation, adequate assessments of the status of targets detected on radar will be made using a conventional plotting sheet provided."

4. "During this simulation, the participants will avoid a close quarters situation whilst overtaking a vessel in restricted visibility."

5. "During this simulation, the participants will avoid a close quarters situation whilst negotiating oncoming traffic, and simultaneously being overtaken by another vessel in restricted visibility."

7. **"During this simulation, the participants will avoid a close quarters situation with a vessel crossing in restricted visibility."**

8. **"During this simulation, the participants must demonstrate their ability to complete their navigational and collision avoidance tasks effectively in spite of anxieties and distractions caused by the need to attend to several situations at once."**

9. **"During this simulation, the participants will demonstrate their ability to perform the navigational functions of master and mate respectively."**

4.7 Selection of exercise and material

Once the learning need and aim has been identified (purposefulness), the resulting objectives enable the controller to proceed with the planning stage, having a meaningful conception of the nature of the intended simulation programme (principle of planning). He is now ready to prepare a detailed plan. As discussed in paragraph 4.3.1 and 4.6, it is necessary that objectives be strictly followed in the planning of a simulation, although the very nature and outcome of a simulation depends upon the behaviour of the participants. In view of this factor it must be borne in mind that ". . . rarely can the whole scenario be preplanned" (Bole, 1983:102).

Thus, planning must ensure that the objectives are followed independently of how the problems introduced might be solved by the participants during the simulation. Flexibility in planning is therefore an advantage, so that the controller can take unobtrusive action to ensure that objectives are followed during the simulation. It is not the purpose of this thesis to be entirely generic in terms of simulations discussed. Maritime training is the emphasis, although the underlying principles discussed are those related to simulation in general, following the learning processes discussed in Chapter 3 and the didactical principles discussed in this chapter.

4.7.1 Selection of scenario/exercise area

Many maritime simulators are provided with a finite number of prepared exercise areas (i.e. coastlines and navigation marks) in which to set up exercises, some of which might be required by the local transport authority.

The area to be selected from those available to the controller should be the best suited to achieve the objectives, and should take into account the nature of the exercise, including the following:

- Open sea.
- Coastal navigation.
- Approaching or leaving a port or canal.
- Traffic behaviour and density typical of the area to be selected.

- Navigational marks and beacons provided with the exercise area.
- Nature of manoeuvres required.
- Nature of techniques being practised, e.g.
  - Collision avoidance.
  - Man overboard.
  - Search and rescue.
  - Anchoring.
  - Terrestrial navigation (pilotage).
  - Electronic navigation.
  - Bridge procedures and teamwork.

4.7.2 Selection of ship model

Whether the simulation equipment has been provided with the mathematical model of the handling characteristics of a limited selection of vessel types, or provision for the design of vessels by the controller, the performance of the vessel selected should be relevant (see paragraph 3.2 regarding relevance) to the exercise being prepared and the experience (past and future) of the participants. The ship's characteristics for the chosen example simulation is shown in figures 4.6, 4.7, and 4.8.

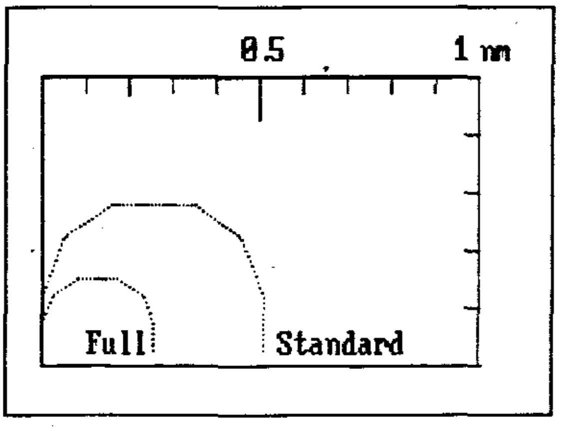
Related to the selection of the ship handling characteristics represented by the simulator, the controls and instruments to be made available to the participants will need to be provided on the basis of the nature of experience to be gained during the simulation as defined by the objectives.

Figure 4.6

SHIP CHARACTERISTICS	
Period of Yaw (centiseconds)	150
Standard Rudder	20
Duration of speed alteration	160
Maximum ahead speed	14.0
Maximum astern speed	10.0
Rudder timelag (seconds)	7
Rate of turn (deg/centisecond)	100

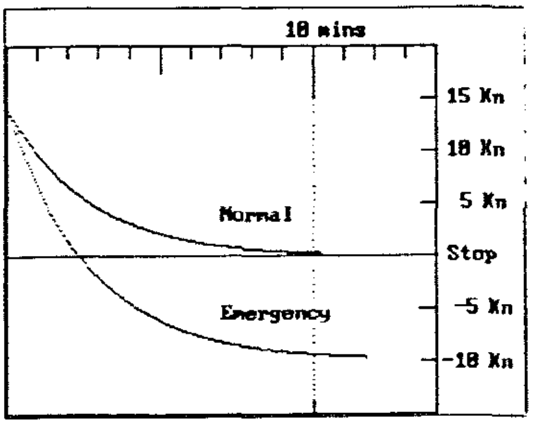
Ship model design characteristics.

Figure 4.7



Represented ship's turning circle

Figure 4.8



Represented ship's stopping time

4.7.3 Selection of roles/duties

The type of exercise being prepared will often dictate the number of participants, and the nature of the duties to be performed. Depending on the nature of the course being run, it is likely that the participants would already have been selected by virtue of their enrolment for the course (see paragraph 3.3). Selection is not so much a selection of participants as the duties' which they must be called upon to perform during the simulation. This selection would follow the objectives of the simulation as well as bearing in mind the principle of individualisation (see paragraph 4.3.6).

It has been the experience of the writer that unsuitably selected participants in terms of personality and learning styles might diminish the value of the simulation for some participants. Situations occur where the less confident participant will allow the others to dominate in the problem solving and decision making, thereby negating their own responsibilities, with consequent loss of validity for those individuals. On the other hand, it has been observed in practice that careful teaming of a less experienced or capable participant with a more competent participant enables him to learn by observing (see Social Learning theories, paragraph 3.4.5) and assisting, thereby benefiting from the application of the principle of socialisation (see paragraph 4.3.7) and also gaining confidence. Depending how well the participants are known to the controller, selection of participants into teams or pairs should recognise this aspect of individualisation.

4.7.4 Selection of materials

Certain of the materials for a simulation should be selected by the participants themselves in their own preparation of the exercise. However, their choice must not be limited by virtue of the fact that the controller has not provided all that is necessary for this purpose. Documents, instruments, charts, references, and other equipment will need to be planned for well ahead. In a maritime bridge simulation, a selection of charts and sailing directions must be provided.

Nautical tables, list of lights and radio beacons as well as tide tables and other publications normally found in the chartroom of a vessel must also be available. Other documents relating to the particular scenario being represented can be prepared and submitted in a portfolio to each participant at a suitable time before the simulation (see paragraph 4.8).

In the simulation being used as an example for this thesis, the coastal area of the Southern Cape Peninsula and False Bay has been selected due to the importance of the traffic patterns in this region of a strategic international shipping route, and the proximity of fishing grounds, an important headland, Simonstown naval base, as well as the fishing harbours of Hout Bay, Kalk Bay and Gordon's Bay. The vessel being represented in the simulation would be a stern trawler with factory and freezer facilities on board, typical of those belonging to local trawling companies.

Because emphasis is being placed upon radar navigation, no other electronic navigation equipment will be provided. There is no intention in this simulation exercise to introduce the further frustration of having to use a magnetic compass, so a gyro compass and autopilot will be activated. South African charts of this region include SAN 119, SAN 1016, and SAN 150. Two participants will be involved in each cubicle which will each be configured identically as one own ship. The Bridge team will comprise the master and the navigating officer of the watch.

4.8 Preparation of the simulation

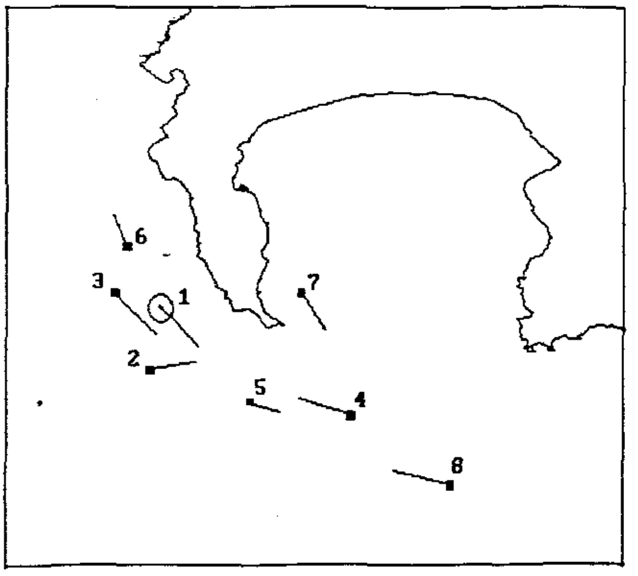
Apart from the physical configuration of the hardware and computer software for setting the coastline and ship model (see figure 4.9) with its navigation equipment, it will be necessary to insert the targets which will be represented on the radar screen.

Figure 4.9

INITIAL EXERCISE DATA	
Coastline	FALSEBAY
Ship type	FREEZER
Game Time	01:20:00
Yaw value (0 - 5)	2
Mode (0-Head Up 1-North Up)	0
Current direction (0 - 359)	0
Current speed (max 20 knots)	-

Set-up Table for exercise setup.

Figure 4.10



Controller's setup display of own ship and targets

It will be noted in Figure 4.10 that targets have been placed in such a way that the objectives can be met. Item 1 is the 'own ship' (the vessel being operated by the participants). It is on a course of 140°(T) and travelling at a reduced speed of 10 knots. Item 2 is a vessel crossing and on a collision course. Item 3 is an overtaking vessel which prevents the 'own-ship' from altering to starboard. Items 4 and 8 are approaching vessels at distances of 15.4 and 23.3 nautical miles respectively. Item 5 is a vessel being overtaken by 'own ship'. Item 6 presents no danger, but adds to the representation of a real situation so that the participants perceive a typically current and continuing watchstanding situation. For the present (i.e. at initialisation of the simulation) only item 2 is a target which demands early attention. The small lines are vectors indicating course and speed of each vessel.

Alessi and Trollip (1985:179) itemise factors which determine the nature of the simulation and the nature of the interactions of the participants. The following should be considered during preparation:

- Objects - These are the objects in the simulation, e.g. the vessel.

- Precision - This refers to how well what is being simulated is understood by the participants. Objects are predictable, but human behaviour is not. This makes precise planning difficult. In a marine simulation, participants might not be able to predict the actions of other vessels, especially if they are being controlled by other participants in their 'own ship'.

- Level of realism - This will depend on the facilities available and the requirements of the objectives. Spurious distractions (e.g. a lifeboat cover needing to be secured) can conveniently be omitted from a simulation, isolating the essentials of the exercise.

- Sequence - Not only the sequence of events but the sequence in the simulation which might be linear, cyclic or complex.

- Number of solutions - There are usually correct alternatives to any solution.

- Time-frame - The duration of the simulation will be influenced by the sequence and nature of events. Sufficient time should be allowed, without wasting valuable time in a simulation.

It was pointed out to the writer by Captain K.Cox, Lecturer at the S.A.Merchant Naval Academy 'General Botha' that in his experience, bored or idle participants have time to contemplate the realism of the simulation. For them, realism can thus be lost. In some simulators, the time reference can be speeded up. It has been observed by the writer that participants (without visuals) do not notice the shortened periods resulting from accelerations of as much as 1.7 of real time, since their reference has been the bridge clock, which (being controlled by the computer) runs at the same speed as the simulation.

Once the scenario has been set, the controller is in a position to prepare the brief for the participants. Depending on the nature of the simulation, every effort within reason must be made to facilitate the safe navigation of the represented ship in the simulation as much as for a real vessel at sea. The participants should receive, prior to the simulation, all information which they would need in a real or simulated vessel. Included in the participants' portfolio would be a relevant weather forecast, pertinent notices to mariners, local navigation warnings, details of the vessel's handling characteristics, enough information to enable them to select the correct charts and publications for the area, and a detailed brief outlining their voyage and their duties during the simulation. Added to these, any simple details which might subtly enhance realism could be items such as the ship's log, master's night order book, master's standing orders, company standing orders, etc.

Finally, the briefing area and areas which are the ship's bridge and chartroom should be checked, and equipment tested to ensure readiness for the simulation.

4.9 Student preparation assignments and briefing

It has been demonstrated that the interest and performance levels in a simulation are directly influenced by the attitudes of participants and by the introduction they receive (Maidment & Bronstein, 1973:51). In order for the participants to reap maximum benefit from the simulation, it is important that what they do during the simulation will not only be seen to be relevant to their stage of training and vocational development (see paragraph 3.2 regarding relevance), but also that the simulation is seen in continuity with other facets of their training (see paragraph 4.3.11 on totality). A thorough introduction is therefore an important prerequisite to the participation in a meaningful training simulation.

To ensure that the proposed simulation will be relevant, the participant's level of past experience and training must have reached a stage at which the experience gained during the simulation and the duties to be performed will not be entirely strange. Another consideration regarding relevance (and this affects the validity and fidelity of the simulation), is that it is important that they enter the simulation with the deliberate impression that what they have embarked upon is a continuation of a real world process. If, for example, a team of participants enters the bridge of a simulation facility, it must appear to them that although they know that they have just arrived, the ship has in fact been at sea for many hours, and that they are performing a resumption or continuation of the voyage without interruption, as though they have just taken over a watch, or have just been called to the bridge.

Preparation, therefore on the part of the participants must create for them a thorough understanding of what they must do, and why they must do it. It was noted by the author in December, 1991 at the U.S. Merchant Marine Academy at Kings Point, New York, that their midshipmen performed a whole-task bridge simulation under the guidance of Capt. R. Meurn (Professor, Division of Nautical Science) using the CAORF facility towards the end of their training, in order to place all the practical aspects of their navigational tasks in perspective by actually being in a position to perform them. This followed a period during which they prepared a detailed passage plan relevant to the voyage which they would be undertaking during the simulation (similar preparation was observed by the writer at the Maritime College in Glasgow in January, 1992). In addition, during a Bridge Watchstanding Course (figure 4.11), each successive simulation during training would be associated with each other in such a way that they encountered certain important stages of the same voyage from New York to arrival and departure at Port Internationale (Meurn, 1990:161).

In good time prior to their simulation period, the participants should have attended lessons which will cover methods or techniques which must be carried out during the simulation, and also a briefing session during which they will receive material enabling them to plan and make preparation for their simulation session. In the case of a bridge simulation involving navigation, they must be able to prepare a passage plan, determine and lay off courses, and acquaint themselves with the area in which the simulated vessel will travel. During this period, the participants will need to have ready access to all charts as well as references such as a light list, list of radio beacons, sailing directions, details of climate and ocean currents, etc. in order to carry out their preparations fully.

A suggestion by Jones (1987:72) is that of having a checklist prepared beforehand of points to be made, or items to be issued or made available during the briefing so that the simulation need not be interrupted and spoiled in order to introduce a missing document. Further items which participants should possess, include clean note pads, pencils, erasers, parallel rules, dividers, compasses, calculators, etc.

Figure 4.11

Voyage, New York to Port Internationale

Week	Duration	Simulation Event
1	30 minutes	Bridge and vessel familiarisation
and	45 minutes	Preparation and departure Stapleton (day)
2	1 hour	Night arrival New York
3	1 hour	At sea, unrestricted visibility (day/night)
4	1 hour	At sea, reduced visibility (day/night)
5	1 hour	Arrival Cristóbal anchorage (sunrise)
6	1 hour	Departure Cristóbal (Sunset)
7	1 hour	Change watch, Singapore Straights (night)
8	1 hour	In traffic lane, California coast (day)
9	1 hour	Arrival Santa Cruz Channel (day)
10	1 hour	Departure Port Internationale (night)

Simulation times, U.S.M.M.A. Bridge Watchstanding Course

(Meurn, 1990:158) abridged by writer

The brief might consist of two separate sessions; one before the students' own preparation and one just before the simulation. In order best to exploit the principle of socialisation (paragraph 4.3.7) as well as individualisation (paragraph 4.3.6) the briefing sessions should be open, conversational and relaxed. The briefing session plays a prominent role in setting the tone for the entire simulation programme. Thatcher (1990:276) underscores the importance of the emotional environment in learning. Thus although the simulation must be taken seriously, it should not be a chore. A positive and cheerful setting enhances enthusiasm.

So that the participants can be weaned from the dependence of the student upon the teacher in a classroom situation and to remove the controller from the role of instructor, the relationship between the controller and participants at briefings and debriefings should be that of a relationship between professionals (Jones, 1987:66). These sessions provide the occasion to explain the objectives and to answer any questions which arise, thereby also following the didactical principles of purposefulness (paragraph 4.3.1) and planning (paragraph 4.3.2).

The opportunity to enhance realism begins in the planning and preparation stages. Also, this opportunity should not be overlooked in the briefing sessions prior to the simulation. The writer was intrigued to note that in order to provide continuity and realism before the simulation, the briefing room of the simulator facility at the Maritime Institute of Technology and Graduate Studies (MITAGS) in Maryland, U.S.A. was fitted and furnished as an officers' commonroom on board ship.

From there, a short walk along a ship's alleyway, complete with subdued lighting, hand rails and officers' cabin doors, brought the participants to a flight of stairs leading up to the bridge deck and into the wheelhouse. The control and monitoring station were not visible to the participants at any stage, unless they were deliberately taken there. Such attention to detail, when compared with the overall cost of the installation, hardly needs to cost more than conventional furniture, but subtly adds to the overall effort to replicate the atmosphere of the real world experience.

4.10 Running the Simulation

The simulation is the focus of the activities which have been discussed in this work. However, it will be recognised, especially during the reading of this chapter, that this stage of the simulation programme should never be viewed in isolation, nor should it be regarded as an end, but as the means to an end. In other words, the principle of totality (paragraph 4.3.11) and perception (paragraph 4.3.12) should receive a high profile amongst the other principles being followed during the execution of the simulation.

As has been expressed in Chapters 3 and 4, execution of the simulation is the means whereby the participants are given the opportunity to gain knowledge and skills by involving themselves in the experience of performing the duties for which they are being trained, of identifying and solving problems, of making informed decisions, acting upon those decisions, and of learning from their own mistakes.

In Chapter 1 (paragraph 1.3) emphasis was placed on the acceptance of the participants of the responsibilities and duties of their role in the simulation, and that the interpretation of the term 'role' in simulation relates not to the mere re-enactment of somebody else's actions, but of taking upon themselves the duties required of them as they would in the real world.

Irrespective of the nature or sophistication of the simulation or the facility which represents the simulated world to the participants, it was stressed in paragraph 1.3 that the simulation is in fact the world which the participants are experiencing. It is thus the performance of duties and the experience gained by the participants which are the simulation in essence.

For this reason it is necessary to emphasise that a well planned simulation, represented by an expensive simulation facility, is still only as good as the participants' involvement. In the same way, making do with less than ideal equipment can nevertheless be successfully executed if this aspect can be appreciated: the participants are the simulation (paragraph 1.3). Thus it can be stated that simulations are not the machines; they are the people. An androgogic approach is therefore indicated, where student centred activities are paramount, and the controller is urged to bear this in mind throughout the simulation.

4.10.1 Commencement of the simulation

After the final briefing session just prior to commencement of the simulation, the participants will move through to the area in which the simulation will be experienced. In the case of a ship simulator, this would be the 'bridge' of the ship. If the participants have not previously familiarised themselves with the simulation area, instruments available to them and important facets of the objects, such as the handling characteristics of the vessel, then they should be given some time in which to do so in the form of a short informal simulation (see figure 4.11). For the purpose of this chapter, it will be assumed that this has already been done. A few moments should nevertheless be allowed for the participants to acclimatise, collect themselves, and ease into the situation.

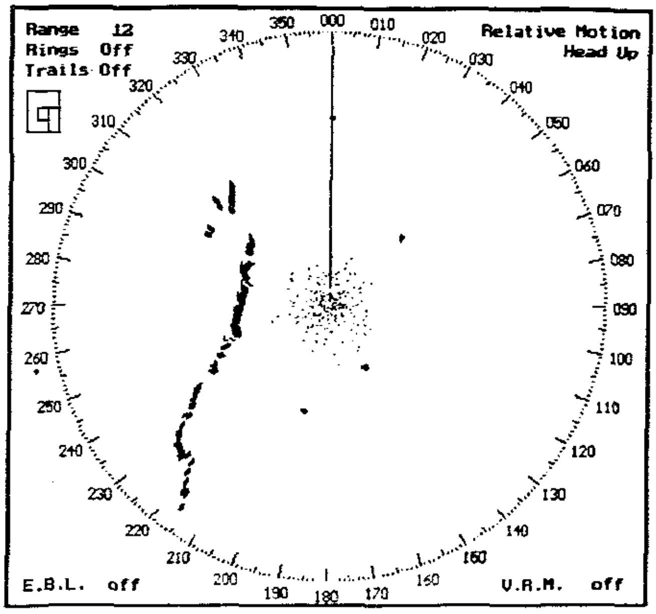
During the settling down period, communications can be checked and a final inspection of the simulation area, as well as the setup of the representational equipment, can be made. It is not always practical, but in order to enhance continuity (paragraph 4.9) an attempt should be made to plan the commencement of the simulation so that the situation is already in process. In a ship simulation, this would mean that the ship was already under way, and proceeding on its planned course before the participants entered. To accomplish this, careful timing is important in order to ensure that part of the planned simulation run time is not lost, and that the settling down period utilises an unimportant interval prior to the commencement of actual run time.

The official commencement of the simulation can be signalled by an announcement over the public address system, in which case this should be the last occasion in the simulation that the voice of the controller will be recognised as such. Preferably, the signal for the start should rather be an unmistakable pre-arranged sound, or some agreed event can be used, such as the appearance of a target or shore light, or when the ship reaches a specific easily ascertained position (e.g. as soon as a shore light or radar conspicuous object is directly abeam of the vessel). Another signal could be a specific VHF radio communication with the vessel or one overheard between two other fictitious vessels. Whatever imaginative system is used, it is important that the start is clearly marked and understood by participants and controller alike.

4.10.2 Detachment during the simulation

Because the very nature of a simulation depends upon human action and interaction, the simulation cannot be expected to proceed strictly according plan. With the exception of very simple independent micro-computer based simulations, the controller must monitor the simulation throughout, and be in a position to keep the simulation on track regarding objectives. Care must also be taken to ensure a smooth flow of the activity and that the timing of events does not culminate in a final rush towards the end of the allotted period (Maidment & Bronstein, 1973:53).

Figure 4.12



The radar display at the commencement of the simulation

In the simulation of a passage around Cape Point being used as an example for this thesis, the initial radar display which would confront the participants at the start of the simulation would appear as shown in figure 4.12 above. The participants' own vessel is at the centre of the radar screen. By comparing this radar display (from which the participants must identify the targets) with the setup display (figure 4.10), the coast line can be recognised on the port (left) side of the vessel and the targets identified. Target 6 is astern of the vessel, target 3 can be seen on the starboard (right) quarter, target 4 appears dead ahead, and target 2 will need to be recognised as a problem quite soon.

A caution is nevertheless expressed by Jones (1987:66) that methods and habits which have been derived from the experience of teaching or instructing should be guarded against. A simulation therefore could be ruined if the controller were to interrupt, guide, explain, give hints, or try and help participants in any way.

The writer acknowledges that not all would agree with this last assertion. In December of 1991, the writer was introduced to Commander John M. Nunnenkamp, Associate Professor of Marine Transportation at the U.S. Merchant Marine Academy, Kings Point, N.Y. who strongly maintained that the radar simulation he was running was an open laboratory, and that the students should therefore be allowed to seek guidance. The hardware arrangement was one of four 'own ships', but each own ship was represented in two separate cubicles. The crews of each cubicle in a pair were free to confer, and also had free access to crews of the other 'own ships' in the simulation. The writer was informed that good results were achieved. In contrast with the method of Cdr. Nunnenkamp, the radar simulation arrangement in the Maritime Institute of Technology and Graduate Studies (MITAGS) was observed to be a high fidelity radar simulator having eight enclosed cubicles, each equipped as the bridge of an 'own ship', and that any communication would be via VHF radio communications in a serious simulation. It is the writer's personal conclusion, after observation and discussion at the other simulation facilities visited, and the personal experience of the writer, that the assertion of Jones (1987:66) has merit, and appears to reflect a broad consensus.

The need to allow the simulation to place emphasis on learning from mistakes and problem solving, rather than a situation in which participants are tutored, is supported by the postulations of the Cognitive school. Dewey emphasises the 'reflective thinking' aspect of problem solving, where the learner is involved in thinking about what he is doing (see paragraph 3.4.4). Reflective thinking would be discouraged by 'spoon-feeding' the student. Another aspect worth considering regarding simulation is that since it has been recommended above that simulation should follow a period of teaching, the simulation is an opportunity to put what has already been learned into practice, thus applying the principles of concretising (paragraph 4.3.5), perception (paragraph 4.3.12), and mastering (paragraph 4.3.10). It has been argued in this thesis that a simulation is the vehicle for gaining experience. On that premise, if the facility is used as a teaching laboratory, then there is a valid argument that it is no longer a simulation in the true sense of that term.

The methods of using a simulation facility as a teaching laboratory can be considered as a valid didactical method, and has merit in view of its evident success, provided that the method follows accepted didactical principles. It is a method which could even be considered for the participants in preparation for a simulation. It is thus a useful alternative function for the simulator facility. What the writer wishes to emphasise, however, is that a simulation is an independent didactical strategy.

If a simulation is intended, then by definition it cannot be a teaching laboratory, and should not be run as such. Thus the writer concludes that the controller should not intrusively intervene in a simulation during its execution. A closing reflection on this topic is that operating a simulator cannot necessarily be considered a simulation. The hardware is only as effective as the use to which it is put, as well the nature of involvement on the part of the participants.

4.10.3 Shepherding the simulation

Early analogue radar simulators, such as the one previously installed at the S.A. Merchant Navy Academy 'General Botha' in Cape Town, had the severe limitation that participants could avoid problems by merely stopping the ship and allowing all the targets to pass by without any risk of collision. The major disadvantage to such a participant is that meaningful involvement is avoided. In any case, such action on the part of a watchkeeper would never be sanctioned on board ship.

The fully interactive simulator which has since replaced that equipment enables the controller to overcome such contingencies by introducing a situation (e.g. a previously unplanned target) which believably compels the participant to move on. This is undoubtedly an intervention on the part of the controller. However, it would not be perceived by the participants as such, and this form of intervention helps to ensure that objectives are met. The function of an intervention like this is strictly representational, and forms part of the simulated world.

It is therefore apparent that the controller must constantly monitor the progress of the simulation, and that he must be on guard at all times to ensure that objectives are achieved. He participates in the simulation, not in the same way that the participants do, but by representation of outside influences which connect the participants to the outside world of the simulation. In this pursuit, the controller of a ship simulation, and those who might be assisting, would provide the natural reactions of the engineer, lookout, boatswain, radio officer, traffic and port control, and other vessels.

Using his power to intervene by representation, the controller who notices that the participant is using the main engines in such a way that problems would occur in a ship, could represent the voice of the Chief Engineer who would call the 'bridge' from the 'engine room', warning the participants of the consequences of their actions. If the participants persist, then an engine failure can be introduced into the simulation.

The participants thus learn of the consequences of careless operations at sea from their own mistake, and not through a lecture by the trainer. The writer observed such an intervention in the simulation facility of the Seamen's Church Institute, Manhattan, New York, where an error was introduced to the rudder indicator after it had been noticed that the participants were not paying sufficient attention to the helm.

Figure 4.13

FALSEBAY FREEZER [No message] 01:20:24

Ship	Co	Speed	Latitude	Longitude	Range	Bear	CPA	TCPA	D.Co	D.Sp	Rng
OS 1	140	10.0	34°20.03S	18°20.03E					140	10.0	12
Tgt 2	079	7.6	34°24.57S	18°19.41E	4.57	186	0.00	30			
Tgt 3	137	11.0	34°19.03S	18°16.29E	3.26	288	0.00	**			
Tgt 4	290	10.7	34°28.02S	18°35.77E	15.32	121	1.07	46			
Tgt 5	110	6.8	34°26.81S	18°26.68E	8.75	141	5.39	77			
Tgt 6	339	6.5	34°15.63S	18°17.29E	4.95	333	0.52	18			
Tgt 7	150	8.4	34°19.02S	18°31.35E	9.46	084	2.61	**			
Tgt 8	286	10.4	34°32.92S	18°43.26E	23.21	124	0.41	71			
Tgt 9											
Tgt 10											
Tgt 11											
Tgt 12											
Tgt 13											
Tgt 14											
Tgt 15											
Tgt 16											
Tgt 17											
Tgt 18											
Tgt 19											
Tgt 20											

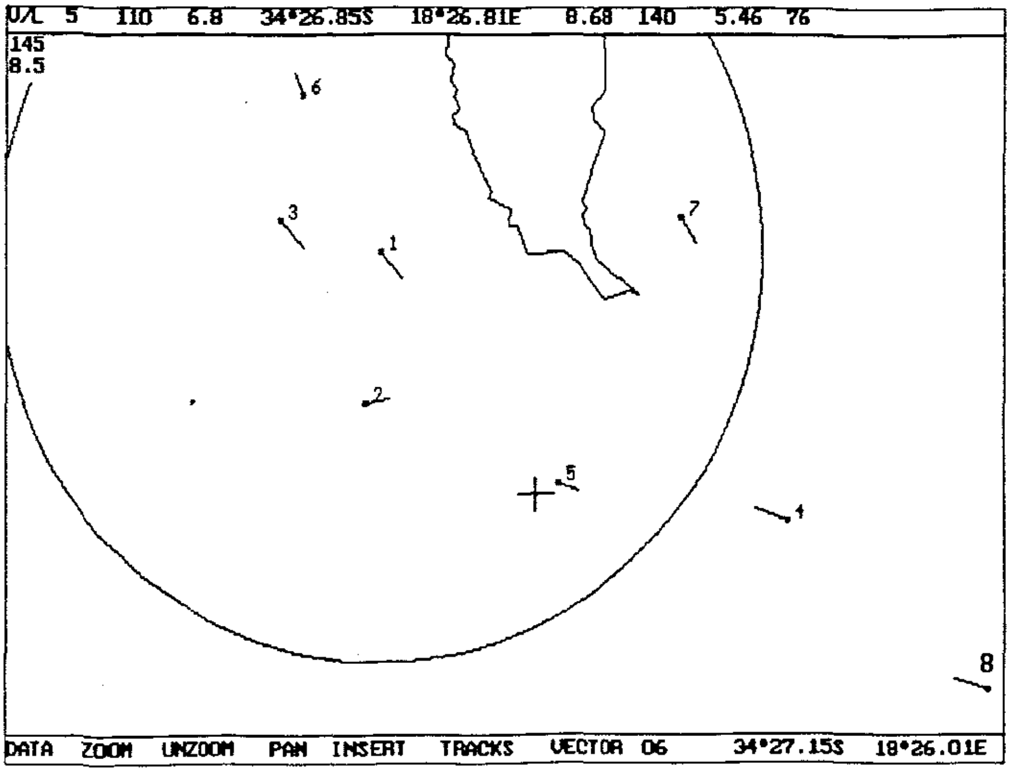
DECCA☐ ENGINE■ RDF☐ GPS☐ HELM■ RADAR■ CURRENT 000x0.0 YAW 2 SEA 8

Controller's data display, Cape Point simulation

In figure 4.13, an instant readout of all courses and speeds is displayed, as well as the present instrument status, time, and information relating to the radar setting in 'own ship' 1. Eleven more targets can still be introduced. Targets can be re-utilised. Allocation of more 'own ships' reduces numbers of targets available.

Efficient monitoring also provides the controller with the tools to regulate the pacing of events in order that time is not wasted and the session runs to schedule.

Figure 4.14



Controller's dynamic graphic display, Cape Point simulation

In figure 4.14, the graphic presentation of the simulation status can be monitored. Vector values can be varied according to time period. The data on the top line refers to the target nearest the cursor indicated by a '+'. Targets can be controlled by altering the direction and length of the vectors of the targets nearest the cursor. The large circle demarcates the present range scale in use by 'own ship' 1, while the present bearing and range of the cursor from the selected 'own ship' is displayed at the top left corner.

Whilst monitoring the simulation, observation should not be disruptive. In all fairness the participants should be warned during the brief that their actions and words would be monitored and recorded. However, once this is known, no further attention should be given by the participants to that fact. As many monitoring facilities as possible should be provided in order to observe, not only data regarding the objects, but also human behaviour during the simulation. At CAORF in Kings Point, in addition to the visual representation displayed on a row of monitors, run time data on all essential aspects of the simulation was being displayed also, and recorded. In addition, closed circuit TV cameras monitored individual stations on the bridge including the chart table and the radar. The conversations were being relayed via loudspeakers to the controller, and in the facility at the Seaman's Church Institute, New York, a one-way window allowed unobtrusive direct viewing of the proceedings.

In addition to observation and ensuring that the simulation meets objectives, the controller should be actively involved in a representational role, providing realistic contact with objects outside the realm of the simulation area, but still in the simulated world. In a marine bridge simulation this would entail replying to radio calls, and responding to instructions given to 'crew' by telephone. An example would be a simulation of a search and rescue mission. The participants should have called for extra lookouts, have instructed them on what to look for, and then should receive a telephone call from the 'lookout' when the object is sighted.

None of the participants would have been performing the duties of the lookout, but those in the simulation should be under the impression that their instructions are being followed, and that they are not isolated but part of a continuing world 'out there'. A further representation in the case of a marine simulation would be the continuous relaying (preferably pre-recorded) of VHF channel 16 chatter, in the same way that it is heard on the bridge at sea, but taking care to edit out any exchange of a sensitive or confidential nature. Fog signals (an important facet of a ship simulation) and sound effects such as the clatter of the windlass when anchoring also provide an ambience of realism.

This representational role demands much of the controller. Alertness and a vivid imagination coupled with a sense of fun and drama contribute to the effectiveness of the simulation. Preconceived contingency plans and the ability to improvise during a radio telephone conversation can avoid a serious hitch during the simulation. One example of this was observed during a search and rescue simulation at the S.A.Merchant Navy Academy in Cape Town. The 'helicopter' had incorrectly been guided far away from the search area by the participants crewing one of the 'own ships' in the search. In order to avoid confusion during the simulation, the controller, Captain K. Cox, representing the voice of the helicopter pilot, informed the ships by radio that he had run low on fuel, necessitating a return to base for refuelling.

Another consideration which renders the representational role of the controller essential to the simulation is that not all the feedback (consequences of the actions of participants) can be provided by the representational equipment. The manipulation of an object causes a reaction (feedback) in the real world and should therefore also apply in a simulation (Alessi & Trollip, 1985:190). For instance if the engines are stopped, then the ship's instruments should indicate that the ship is slowing. However, if an object not represented by the simulation hardware is manipulated, (e.g. a target is expected to alter to starboard either in response to an agreement by VHF radio, or (more likely) in compliance with the International Regulations for the Prevention of Collisions at sea, then the controller will have to make that manipulation in order to complete the feedback.

The simulation chosen as an example for this thesis is simplified for clarity by involving only one own ship. However, with respect to feedback, the consequences of a somewhat less than optimum decision on the part of one 'own ship' in a simulation whose main objective is manoeuvring in traffic, should cause an unpredictable, but essentially human element in the response of the other vessels. If some of the other vessels are in fact also being operated as 'own ships' by participants in the same simulation but in other cubicles, this human element is complete, and feedback is valid. Since a training simulation is essentially human in character, the desirability of several discrete 'own ships' in a radar simulation lends authenticity to the consequences of the decisions and actions of the participants.

This arrangement is thus highly desirable, and for this reason it is called for by the Department of Trade in the United Kingdom who specify at least three independently operated 'own ships' to be incorporated into the simulator (Department Of Trade, 1980:1.1).

In a normal didactical situation, the student usually receives prompt feedback which is corrective and positive. This is termed 'artificial feedback'. The feedback which results from interaction with events is known as 'natural feedback' (Alessi & Trollip, 1985:188). While it is evidently most desirable to render natural feedback as much as possible during a simulation, such consequences of actions which cannot accurately be facilitated for practical reasons, must take the form of artificial feedback. For instance, a grounding or a collision should be communicated, perhaps by abruptly terminating the simulation (at least for the 'own ship' which is directly involved) and the reason given for doing so. Naturally, certain objectives might not be met under such circumstances, but the gravity of the event might be emphasised in this way, and another simulation would then have to be planned in order to achieve outstanding objectives. If the simulation is valid, then what happens in the simulation might well be possible in the real world. Serious or potentially dangerous consequences in a simulation therefore should not be treated lightly.

Feedback can be either immediate or delayed in the real world; or sometimes no feedback results at all (Alessi & Trollip, 1985:189). If for instance if the navigator loses his way, it might not immediately be apparent to him. Similarly, it is possible in the real world, that a watchkeeper might make a bad decision regarding another vessel. The other vessel might take avoiding action, with the result that the watchkeeper might never realise the full implications of his decision. The controller has to rely on his own judgment as to whether or not feedback, either natural or artificial, might be disruptive to the flow of the simulation. The objectives would be the guide. In any case, at the discretion of the controller the feedback can be reserved until the debriefing session, and would thus be artificial feedback.

In the case of very long simulations, or at any time when calls of nature necessitate that participants leave the 'bridge', it is important to continue the voyage without interruption. Minimum disruption of the simulation can be accomplished by insisting that the bridge is not left unmanned, that the ship is still at sea, and is proceeding with the voyage in the same way that it would in the real world. The participants remaining on watch should continue with their duties, and the absent participant should be encouraged to return as soon as possible.

Occasionally a simulation might be run during which a stage is reached (planned or otherwise) at which a problem is experienced necessitating further exploration, so it might be apt to suspend the simulation for a *short mini-brief, giving the participants an opportunity to reflect,* confer and explore their options (Jones, 1987:76). This method might be suitable where distinct stages present problems or tasks of a different nature, and the simulation could deliberately have been planned to run in separate successive mini-simulations.

4.10.4 Terminating the simulation

The termination of the simulation should not be too abrupt. Neither should it be premature. Criteria for the termination of a simulation might be laid out during the planning stage, and should include the following:

- The time span allocated having run out.
- The objectives having been achieved.
- A stage having been reached during the simulation which is convenient to interrupt and terminate.
- A serious 'fatal' mistake having been made by participants.
- All planned events having taken place.
- The simulation having reached a hiatus or impasse.

It is logical to suggest that one or more of these criteria should be met in order to justify the termination of the simulation, and the controller will have to rely on his judgment as to the exact moment to end the session.

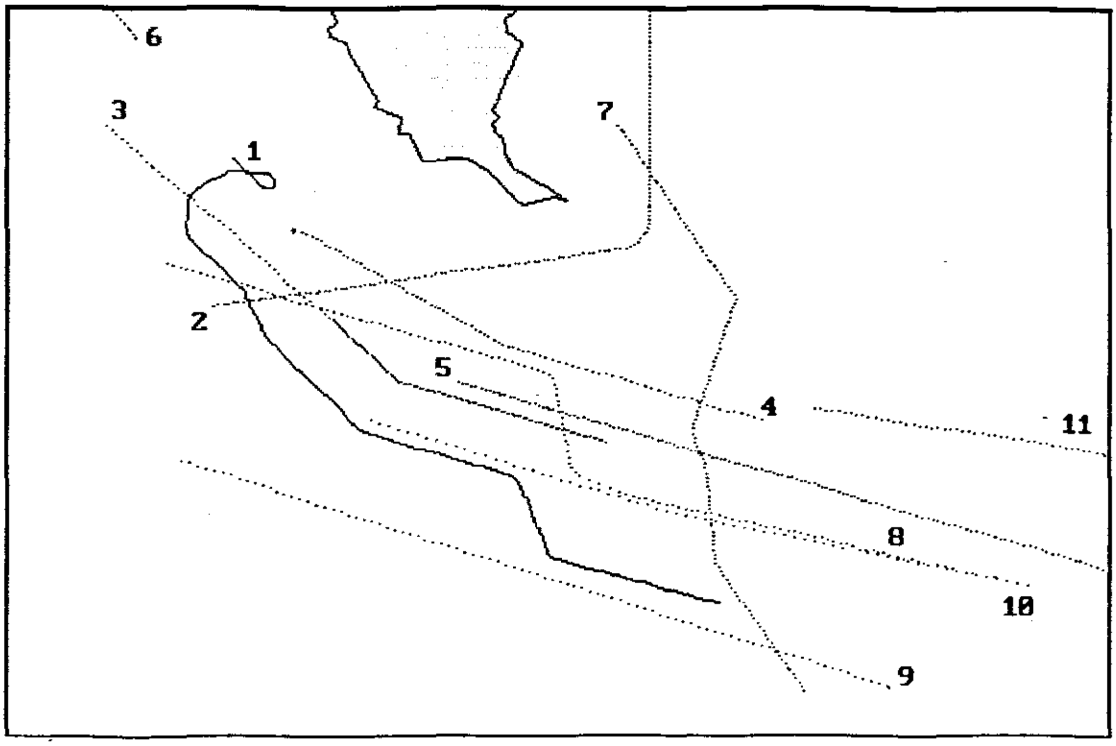
Marking the end of a simulation signals the end of the representation of reality in the simulation; hence it is less critical than the signal which starts the simulation. An announcement over the public address system marks a clear ending, although consideration for the participant's involvement and fulfilment should prevail. For this reason, the machinery could be allowed to run on for a few more minutes so that participants can satisfactorily round off their activity. After that, the cessation of the functioning of all the equipment will bring the participants into the briefing area for the debriefing session.

4.11 Assessment and Evaluation

"The act of evaluation compares a measurement with a standard, and passes judgment on the comparison" (Mager, 1984:8). It is possible to make short and long term evaluations by measuring recorded data from the simulation, behaviour, decisions and actions of the participants against the stipulations laid out in the carefully worded objectives (see paragraph 4.6). Thus it is important that records have been kept of all the monitoring, observations by the controller, and electronic run-time measurements of the simulation. Ever mindful of continuous evaluation, the controller should have been jotting down notes regarding events and behaviour he had observed during the simulation in order to supplement the video, audio, and digital data gathered. The electronic data might be printed out or plotted on graph paper; but would be more effective in the debriefing if it were possible to review animated reruns of selected events or periods.

The calculations, notes, charts and plotting sheets of the participants should also be brought into the debriefing in order to augment the data gathered during the simulation.

Figure 4.15



Screen dump of animated rerun of the Cape Point simulation

In figure 4.15 the solid trace is the track of the 'own ship'. The dotted lines (dots are one minute apart) indicate the tracks of the targets. It is a paper printout of what is displayed in colour on the controller's monitor after termination of the simulation. While displaying it to the participants during the debriefing, it can be paused at any stage. Minutes elapsed are displayed, and sections of areas where critical events occurred can be selected, magnified, and closely examined for analysis and discussion.

4.11.1 The Debriefing Session

The debriefing session should really be regarded as the climax of the simulation programme because it is here that reinforcement is applied to the lessons learned during the simulation. It is also a vital stage for evaluation and feedback. Debriefing also provides an opportunity for limited participatory evaluation. Ken Jones (1989:166) condemns debriefings which are too short, unimaginative, and too teacher dominated. Referring to the controller as 'facilitator', he provides the following example of a poor debriefing:

"Facilitator:	Well how do you think you did?
Ex-participants:	We think we did OK.
Facilitator:	Very good. (Bell rings) That's it then."

Jones continues by stressing that adequate time should be allocated, and that curtailment of the debriefing, because the simulation has been allowed to overrun, should be avoided.

It was suggested in paragraph 4.9 that the relationship between the controller and the participants should be that of a relationship between professionals. During the debriefing session this is vital in providing the participants with the liberty to express misgivings and admitting to mistakes without fear of penalty or ridicule. The reason for this is that participants should be encouraged to perceive for themselves where they could have performed better, so learning thereby.

Following didactical methods used for conducting group discussions, in which discussion is termed a fundamental didactical form by Fraser et al. (1990:140), the floor should be open for a frank discourse between as many of the participants as possible. Socialisation (paragraph 4.3.7) during the conversation and individualisation (paragraph 4.3.6) resulting from the opportunity for each participant to air his views are principles which apply particularly to the debriefing.

Avenant (1990:301) lists four advantages of discussions:

- Discussion stimulates critical thought.
- Participants learn to substantiate their statements.
- Discussion encourages participants to systematise thoughts.
- Discussions are capable of meeting all of the didactical principles.

However, there are traps into which a leader of a discussion could fall (Avenant, 1990:301):

- Discussions can be time consuming.
- Not all participants share in the discussion.
- Not all educators have the ability to lead discussions in the right direction meaningfully.
- Social tensions and politicising could develop.
- If there is a lack of concretising, misunderstandings and misconceptions might arise.

It is important to lead the debriefing in such a way that, continuing with the strategy of learning by doing, participants are encouraged to draw the right conclusions for themselves.

For this reason, the guidelines below are offered in order to ensure that the debriefing is conducted satisfactorily. One advantageous feature of a vocational training simulation is that all are adults. In an atmosphere where everyone, including the controller are mutually accepted as professionals, the controller can discreetly participate in the discussion in such a way as to guide its direction towards the desired conclusion. Avenant (1990:300) provides the following list of requirements for conducting meaningful discussions:

- **The subject matter must be relevant.** In a debriefing, the compliance with this requirement is intrinsic to the discussion. There is a possibility, though, that less important aspects of events might receive more attention than necessary, which might lead to the oversight of more important issues. The controller will need to refer to the notes which he has made during the simulation and the list of objectives in order to ensure that time is not wasted.

- **Participants must be willing to engage in dialogue.** If the participants are unwilling to engage in lively discussion, the debriefing will fail as such. The participants must be encouraged to talk by creating a conducive atmosphere. Complimenting valid points raised and praiseworthy actions during the simulation are important motivators.

- **Social factors should promote favourable participation.**
  Jealousy and animosity would diminish the chance of a frank and open discussion of mistakes or suggestions for improvement.

- **Constantly guard against wandering from the topic.** This can best be achieved by gently returning to the subject. Ask pertinent questions or raise apt viewpoints.

- **Summarise and support the important findings.** It was observed in the simulation facility of the Seaman's Church Institute in New York, that notes had been prepared. At the end of the debriefing, the controller, Capt.R.Beadon distributed them while concluding the session. If this is done, then any other important points raised which are not covered by the notes should be mentioned once more, and if necessary, followed up very soon with an additional note.

Referring to the notes which the controller has made during the simulation and using the data recorded during the simulation, the controller is able to proceed in chronological order through the events of the simulation. Animated computer playbacks are a great advantage here, because events can be isolated and watched over and over as necessary while analysing errors or examples of desirable actions (Seshamani, 1983:117).

The debriefing is the focus of feedback from evaluation during the simulation. It also affords the participants the important opportunity to practice self evaluation, as well as to establish a foundation for future development (Williams, 1992:91). Evidence that the discussion during the debriefing has efficiently dealt with the correct issues indicates the success of the simulation, thus providing the controller with a valuable assessment tool.

The debriefing provides not only feedback from short term subjective evaluation, but also furnishes the controller with material for further objective evaluation of the programme, and ongoing long term evaluation of his own methods and avenues for improvement in subsequent programmes.

4.11.2 Meeting the Objectives

The debriefing is not only an evaluation function. It is also a period of reinforcement and consolidation of the experiential learning processes having taken place during the simulation. By the same token, evaluation does not take place only during the debriefing. The principle of evaluation, discussed in paragraph 4.3.9 is one which permeates throughout the didactical activities (see figure 4.4).

Evaluation can serve two functions (Nevo, 1986:17):

- Formative Evaluation: is used for improvement and development of an ongoing activity.
- Summative Evaluation: is used for accountability, certification or selection.

Both functions should apply to simulations.

The process of evaluation starts with the setting of the objectives, continues throughout the simulation, and provides material for the short term and long term behaviour of the participants as well as of the simulation process itself in order to adjust methods and make improvements in future simulations wherever necessary.

The evaluation process might differ according to the nature of the *simulation and the stage of the participants in their overall training*. Basically, though, in determining whether objectives have been achieved, evaluation consists of stating objectives, defining the measurements, collecting data, interpreting the findings, and making recommendations (Nevo, 1986:21).

Regarding evaluation of the participants, whether or not the evaluation is largely subjective or not, participants should receive feedback on their performance if evaluation is to be of worth to them. It is nevertheless possible to evaluate teams or individuals during a simulation and award competency status or grading to those who achieve the criteria detailed in the objectives.

Established evaluation methods are frequently 'norm referenced', whereby the performance of the learner is compared with that of other students, while 'criterion referenced' evaluation is based upon the comparison with the measurement of an objective standard rather than with other measurements (Mager, 1984:10)(Smith & Adams, 1972:29). Criterion referenced measurement is supported by those who require a very clear, but narrowly defined topic or skill, and in which a predetermined standard separating acceptable from unacceptable standards is required. "Its place is restricted to those areas where there are clear and narrowly defined domains" (Wolf, 1979:76). The question of whether evaluation is criterion referenced or not should be considered in the light of the tasks for which the objectives have been formulated.

It is unlikely that all objectives of a simulation could be criterion referenced. Pointing out that the basic notion of criterion referenced measurement was not new, but on the contrary had "existed for years", Wolf (1979:76) highlights the need to "measure actual levels of achievement rather than some single arbitrary level". He then points out that important educational objectives are highly complex, requiring abilities which use a broad range of competancies. Thus evaluation should suit the objectives, both subjective and objective, and the methods of gathering data must be appropriate.

Careful design of the evaluation process is necessary for this to take place in such a way that the simulation does not lose its unrehearsed character, nor should it invoke the disadvantages of examination tensions. It should be possible to design a performance sheet, for use during the simulation, which itemises criteria to be met as set out by the objectives. Each item could then be followed by a column for grading, or two columns to identify satisfactory or unsatisfactory performance of the tasks. Further space should be provided for remarks.

Sample grading sheets given to the writer by Capt.R.Meurn, of the U.S.Merchant Marine Academy at Kings Point are included in Appendix III for perusal.

The training programme might well have been planned in such a way that weaknesses identified during the simulation can be addressed in a rerun of the same simulation, or a similar simulation which meet the same objectives. The evaluations of the two successive simulations can then be compared.

Figure 4.16 demonstrates this procedure.

Figure 4.16

Voyage planning/port approach observations	
EARLY RUNS	**LATER RUNS**
• Lax VHF procedures.	• More timely, concise and clear VHF procedures.
• Lack of appreciation of effect of current.	• Better understanding of effects of current.
• Lack of team coordination.	• Improved team coordination workload evenly distributed
• Poor wheel commands.	• Improved wheel commands.
• Lack of understanding of ship characteristics as evident by overshoot and track-keeping.	• Less overshoot with prior plotting of wheel-over position, improved track-keeping.
• Poor navigational fixes with little DR plotting.	• Excellent fixes using all aids to navigation and comparing to DR position.
• Difficulty in using range, too much reliance on fixes for being centre of channel	• Better understanding of range[1] than fixes.
• Lack of understanding / coordinating of PPI(radar) and visual scene	• Better comprehension of PPI (radar) scope with visual scene. Parallel indexing utilised.

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1. The term 'range' is used in the U.S.A. regarding transit beacons used as leading marks (Maloney, 1985:48).

4.11.3 Long Term Evaluation

The ultimate objective of a training simulation, along with the long term objectives of the training programme as a whole, is that the participants become competent professionals. The short term evaluation provides an indication of their potential ability to fulfil their functions in the work place. However, whether or not they live up to expectations is not measurable until some time after they have performed their tasks safely and to the satisfaction of criteria (defined or implied) set out by the employer, professional body, or controlling authority. This is an area which does not appear to the writer to have been sufficiently addressed by educators in the maritime field. The revalidation of certificates of competency required by the S.A. Department of Transport goes some way to addressing this problem, but does not provide a guide to controllers for the long term evaluation of participants. A suggestion by the writer is that successive periodic 'refresher' courses involving simulations are encouraged. A negative and very limited feedback can be provided by scrutinising records of marine casualties for the names of past participants. This latter does not, however, reveal weaknesses in past participants who have so far escaped mishap.

Finally, the following quote provides an apt conclusion regarding evaluation: "...assessment would appear to be the major problem crying out for a solution" (Bole, 1983:104).

4.12 Considerations in the selection of hardware

In Chapter 2 it was recognised that simulation equipment has reached a high level of realism and technological sophistication (paragraph 2.6), incurring high levels of expenditure in terms of both capital and running costs. The complexity of such equipment necessitates maintenance by experts and places a burden upon the owners to justify the effort and expenditure through maximum effective utilisation. Thus not only should there be considerable initial demand, but the long term utilisation would need to be predicted accurately before embarking upon a venture of that nature. Captain A.Bole (1983:103) of the Liverpool Polytechnic referred to changes in the maintenance requirements of simulators. Usually the project engineer in charge of the installation would no longer be available after having withdrawn, with the result that microprocessor equipment is covered by a maintenance contract whilst less complex equipment would be repaired by a laboratory technician or the control staff. For these reasons, and because of their success, it was mentioned in Chapter 2 that high fidelity flight simulators built in the fifties are still in use (paragraph 2.3). The writer's attention was also drawn by Capt. R.Beadon of the Seamen's Church Institute, New York, in December 1991, to the fact that the then aging simulator in the College for Nautical Studies, Warsash, Southampton, was at that time still in use, and had still been achieving satisfactory results. A similar installation was visited by the writer in the Maritime College in Glasgow in January, 1992.

On the other hand, less sophisticated installations have become possible due to the rapid development of microcomputers, and the escalation of the cost of purchasing and running a high-fidelity installation. In an article published in the Journal of the Nautical Institute, Seaways, the concept of fully interactive marine simulators using 32 bit RISC microcomputers is reported. Several such microcomputers can be linked to each other, providing flexibility and cost effectiveness (Pollitt, 1990:17).

The simulation equipment used by the writer to demonstrate the simulation around Cape Point is also microcomputer based, the software having been developed locally by Capt. K.Cox, lecturer in charge of the simulator facility at the S.A. Merchant Navy Academy in Cape Town (now part of the Cape Technikon), with the assistance of the writer. This software enables up to five microcomputers to be connected via serial ports so that a controller's station and four independent 'own ships' are incorporated. Each 'own ship' is equipped with radar, Decca navigator, Global Positioning System, Radio Direction Finder, as well as autopilot, manual helm, rudder indicator and engine controls. Failure of the equipment can be inflicted by the controller, and efficient monitoring of the status of control settings of each own vessel as well as course and speed of all own vessels and targets. The setup arrangement enables the controller to 'design' ship models as well as to prepare exercises. Data from the entire simulation is recorded on disc and can be played back during debriefing.

Inexpensive simulations can be designed which are run on one self-standing microcomputer. An example of this is a part task radar plotting trainer which was jointly developed by Capt. K.Cox and the writer. The monitoring is performed by the computer itself in competency based steps until the learner completes all the tasks. Another example, programmed by the writer, is a simulation of a vessel with a magnetic compass, enabling the learner to practice adjusting a magnetic compass by the tentative method. This software is included with this thesis for scrutiny.

The variety of simulation arrangements described above range from complex high-fidelity whole-task simulators to inexpensive part task trainers. All have the following characteristics in common:

1. A dynamic simulation model is represented, conveying the simulated world to the participants, and updating the status of the objects.

2. The introduction of variables into the simulation in order to present the participants with tasks to perform and/or problems to solve.

3. The participants interacted with the simulation to make changes and receive feedback resulting from those changes.

4. Provision for a didactical input and evaluation.

In support of these characteristics, comparison can be made with the design characteristics of the tactical training simulation being developed by the U.S.Navy (Thorndyke & Wescourt, 1984:19). The architecture of the simulation for this research was arranged around the following modules:

<u>A tactical simulation comprising:</u>

- A world model providing the dynamic battle simulation.
- An intelligent opponent simulation generating decisions of a generated enemy force by artificial intelligence.
- A human/machine interface which receives the participant's decisions and actions.

<u>An instructional model comprising:</u>

- A diagnostic model which performed the evaluation functions.
- An instructional planner for preparation according to instructional objectives.
- A feedback and helping system that delivers instructional feedback.

The need for providing experience for learning has been proved in Chapter 3. However, whether or not the extent of realism directly influences the effectiveness of the process of learning from experience cannot be asserted. It has been suggested by Andrews (1983:70) that "...it has been assumed that by merely exposing the trainee to a group of high fidelity simulated events and conditions from the real-world, training will automatically take place. Such an assumption is not always valid".

Caro (1973:502) is quoted regarding training as follows: "Even now, there is substantial applied research evidence that much of the training conducted in expensive simulators could be accomplished in less expensive devices .... a realistic simulator is a poor substitute for competent training" (Andrews, 1983:71) (the emphasis in this quotation is that of the writer). Bole (1983:103) relates the efforts made at the Liverpool Polytechnic to enhance the realistic appearance of the bridge in the simulator. Referring to this as "cosmetics", he questions the extent of its effectiveness. He concludes the topic thus: "There is no doubt that the visitors are easily impressed ... but as yet the opinions of the students are far from clear."

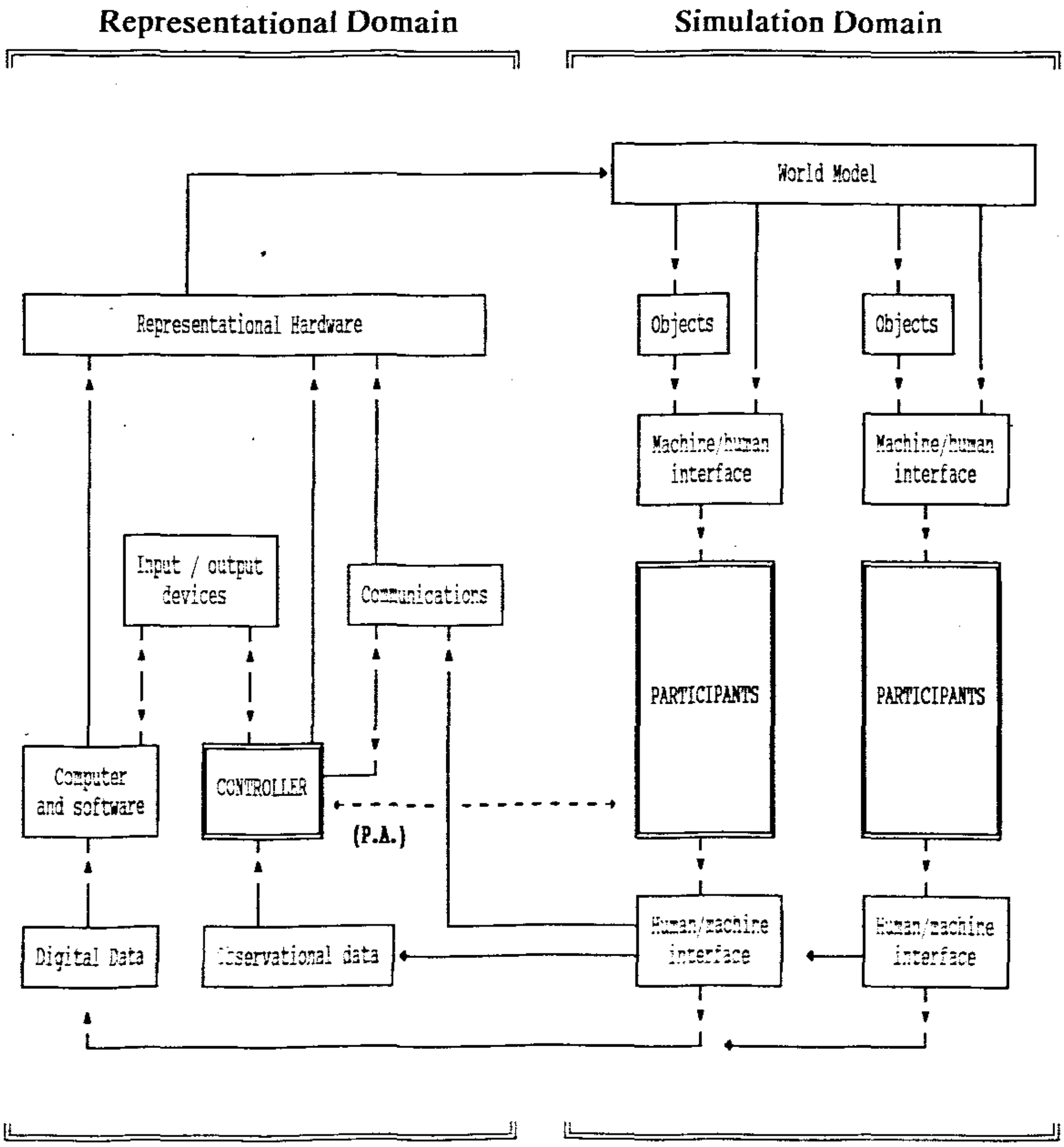
When compared with the expense of training in the real-world situation, then it cannot be denied that simulators gain favour both in terms of cost as well as of time and risk. However, once having realised the effectiveness of simulator training, the extent of realism must be governed by funds which are available, the aims and objectives of the training programmes, and the nature of the tasks for which the simulation is being used for training.

Basically when examining the requirements of simulation equipment for teaching purposes, it is necessary to relegate aesthetics to a secondary status, and didactical principles should be the deciding factor. Carpenter (1984:147) offers two considerations when selecting equipment:

- Accurate mathematical modelling of the objects.
- Sensory inputs should resemble the real system wherever possible.

Whatever the resources available, the simulation facility should offer the four characteristics itemised earlier. Incorporating those characteristics, the writer has developed the schematic flow of a working two 'own-ship' marine simulation shown in figure 4.17.

Figure 4.17



Author's schematic model of a working marine simulation

It will be noted in the diagram (figure 4.17) that all interfacing with the simulated world should only take place through the representational hardware. The participants are the principal components of the simulation, whilst the controller performs a vital function in the monitoring and representational domain. The horizontal dotted line represents the function of the Public Address system which should not be regarded as part of the simulation, and therefore its direct use should be avoided after the simulation has been started. Equipment fitted into a simulation facility should contribute towards the functions illustrated. Thereafter, wherever possible, additional representational 'cosmetics' will enhance realism by helping to approximate the environment of normal experience, and therefore should be valued as such.

A useful contribution towards the representation of the real world in marine simulators has been the introduction of intelligent radar targets which respond to the encounter of the participant's 'own ship' manoeuvres (Colley et al., 1986:81). One advantage of this feature is that the controller is further removed from the simulation world, which, for evaluation purposes, is less subjective than if the targets are manually controlled.

In accordance with what has been discussed above, response fidelity should be regarded as more important than stimulus fidelity. Too much emphasis placed upon the 'feel' of a control, for instance, is negated by the fact that manufactured items differ widely, and the introduction of keyboard, touch screen, joystick and trackerball interfaces with electronic navigation equipment have been seen to have accelerated with the technological advances.

In the experience of the writer, computers and keyboards are no longer the novelty they were, and students relate well to them. Controls which are of a more generic nature can therefore be viewed as being more appropriate. Nevertheless, the outcome of the use of the controls should respond accurately in accordance with the mathematical model of the object. Control response which is not absolutely representational becomes progressively more apparent to those who have participated more frequently in the same simulator (Smith, 1977:33).

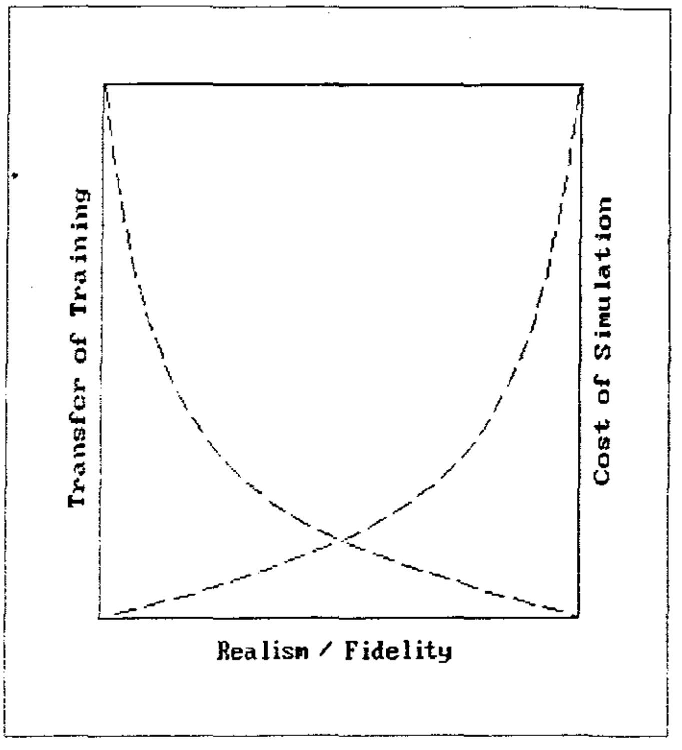
In the final analysis, the decision lies with the extent to which realism best meets the requirements of the didactical principles discussed in paragraph 4.3. A fully dynamic platform with wrap-around computer generated imagery (CGI) cannot be justified for a radar simulator, but would be indispensable for certain whole-task simulations.

During a discourse (and subsequent correspondence) between the writer and Dr K.Lindsay of the Liverpool Polytechnic in January 1992, regarding the cost of simulation, an effectiveness/cost trade-off curve was discussed. The model below (figure 4.18) is not the work of the writer, but is attributed in essence to an unknown source.

In determining the cost/effectiveness trade-off, the reducing cost due to simulation should be plotted against the left hand scale (typically as much as fifty percent of time and eight percent of cost for aircraft pilot training - Orlansky & Chatelier, 1983:298). The increasing cost with fidelity should be plotted against the right hand scale. Theoretically, the optimum trade-off value should lie in the region where the curves intersect.

A possible weakness in this form of analysis arises from the difficulty of estimating cost saving due to simulation against real world experience. Other hidden costs, such as the long term costs of running the simulator, are also not fully addressed by this analysis (Orlansky & Chatelier, 1983:298).

Figure 4.18



Simulation Cost Trade-off Analysis

A method of measurement of equipment effectiveness could be developed in order to establish the time saved in training in the real world with the time saved by training in a simulation (Orlansky & Chatelier, 1983:297), though even with this method, it would be difficult to effect useful measurement of the effectiveness of one simulation against another, or whether didactical applications differ from simulation to simulation.

The question of the extent to which complexity and cost relate to effectiveness is one which needs further investigation (Orlansky & Chatelier, 1983:299).

In most cases, marine simulation equipment must conform to minimum requirements in order to receive approval for recognised training, such as laid out in the Specification for a Marine Navigational Equipments Simulator (D.O.T., 1980), and the Regulations and Guide: Electronic Navigation Systems Course, Automatic Radar Plotting Aids Course (D.O.T., 1981). These regulations should not be regarded as a limitation, because there is seldom any objection to exceeding the specification, and also, simulation need not be restricted to the training purposes for which specifications and regulations exist, but expanded to wherever the didactical principles of simulation can best be applied. In the light of the changing technological world, and the changes in simulation methods and training requirements, it is evident that frequent review and revision of these requirements is worthwhile.

Finally, since the emphasis of this chapter has been the didactical application of simulation, it is suggested that qualified educators with experience in simulation training should be involved in the design and development of simulation software and hardware, as well as the formulation of requirements and specifications for training by simulation. If the manufacturers of marine simulation equipment lose sight of the didactical and androgogic principles involved in the use of simulations in training, then the possibility exists that simulators will be built more to impress than to provide valid occupational experience for the apprehension of knowledge and skills.

4.13 Summary

This chapter addressed itself to the didactical aspects of the simulation by applying the fundamental theme of chapter three, experience, as the most effective learning process.

The controller was revealed as an educator with the responsibility to effect control, in the didactical sense, of all the activities associated with the application of simulation as a strategy for training. The requirements of the effective controller in terms of talents, knowledge, experience and organisational abilities was reviewed.

Then, after a brief summary of didactical principles, the application of the theories of learning (principally experiential learning) were associated with the principles of didactics in order to suggest a methodology for the effective use of training simulations. A hypothetical simulation of the passage of a vessel in reduced visibility around Cape Point was used to illustrate the points put forward. It was demonstrated that a simulation is essentially the experience which the participants gain through their involvement in which a representation of the essential aspects of the real world objects, tasks and environment provide the opportunity to perform their vocational functions. The controller's responsibility is to plan, define objectives, prepare, coordinate, monitor and evaluate the process, consisting of a period of student preparation, briefing, simulation run, and the debriefing. During the performance of these duties, it is best that the controller assume a low profile, whilst nurturing the qualities of leadership.

Finally, design and development aspects regarding simulation equipment were outlined. It was clear that high-fidelity simulators have a place in the maritime training context, but these installations would more probably be used for whole-task training (for which there is a need) in order to be cost effective. Ultimately, a cost/effectiveness trade-off would result in the spread of low cost microcomputer based part-task simulators, with the suggestion that educators with experience in simulation should be involved in the development of simulation installations so that their effectiveness for training be ensured as opposed to unnecessarily expensive elaborations. Attention was drawn to the effectiveness of the simulation not resting entirely upon the fidelity of the simulator, but more especially upon the way the didactical principles are applied to simulation.

Throughout the chapter, the needs of the learner/participant were held to be at the centre of activities surrounding the management of the simulation through all stages. In this way, all principles and theories considered were directed through the andragogic needs of the participant in their application.

CHAPTER 5

Summary, Findings and Recommendations

This chapter reviews the thesis and provides recommendations regarding the application of the findings in view of the potential of simulation as a teaching strategy.

5.1 Review of the previous chapters

'Experiential learning' suggests that our greatest learning potential lies in our ability to apprehend skills and knowledge through interaction with our environment. If this statement can be supported, then any means of enabling the learner to experience the phenomenon with the intention of apprehending knowledge (readily available for recall) becomes a valuable asset. One such means which can be invoked as a strategy for learning by experience, whilst also being able to control or exclude spurious stimuli, is simulation.

In Chapter 1, simulation was presented as a means of providing the essential aspects of the real experience which is convenient, safe, and, when compared with the real world experience, economical. An argument in favour of simulation was mentioned in chapter 1 in which a comparative price breakdown (provided by IATA) of flight simulators in comparison with aircraft time, was shown. Examples of disasters during training flights were narrated, and the expensive consequences of the Exxon Valdez grounding in Alaska were compared with the cost of a period of simulation training. Apart from the savings in economical terms and elimination of risk, simulation was also presented as a convenient and time saving process, with the added advantage that data can more readily be collected and analysed for evaluation in training as well as research.

Simulation was revealed as a real world experience to the participants; they, in fact, are the simulation. The facility and the hardware associated with simulation were identified as the representational features only, thus being excluded from the simulation itself.

Taken in its proper context, games and role-play cannot be regarded as simulations, nor do they fall into the same category as simulations, because participants of a simulation do not review events from outside, following a script or a set of rules of competition, but participate in events, taking responsibility for their own decisions. This personal involvement on the part of the participants also precludes case studies from this category of experience.

After a brief clarification of terminology, some of the purposes of simulation were enumerated, and simulations were categorised as Physical Simulations, Procedural Simulations, Situational Simulations, and Process Simulations, all of which can be utilised for training or research. Resulting from the findings in this work, the nature of the more complex marine training simulations may be seen as falling into the combined categories of Procedural Simulations, Situational Simulations, and Process Simulations.

The nature of the problem was outlined in chapter 1 as the question regarding the best understanding of the useful and economic use of simulations as a strategy for vocational training, in the light of changing learning needs, changing simulation technology, and the competition between simulator manufacturers as well as training establishments. Concern was expressed that unless a circumspect view of simulation in the light of sound didactical and androgogical principles was maintained, then simulation would be in danger of losing its standing as a means to an end.

In the conclusion of the first chapter, questions were raised, which will receive closer examination later in this chapter, and the hypothesis was stated as follows:

The Hypothesis:

Simulation is a powerful strategy in the training of vocational tasks in which cognitive, affective and psychomotor functions are stimulated under conditions which approximate the real situation for which the post-school student is being prepared. However, it must be recognised that this statement would apply only provided that the simulation facilities are utilised correctly and didactical considerations to be addressed in this project are followed.

Chapter 2 provided the background to the first step in the investigation of the potential of simulation as a teaching strategy. It was learned that simulation was not new to the twentieth century, although it became a more serious tool in training and recruitment by the Prussian military, followed by the defence forces of other nations, leading to the 'Crisis Games' of the mid 1950's, and the subsequent development of business simulations for training.

Flight simulators, in the form of the 'Link Trainer' were developed and improved since the first world war. The concept of synthetic training aids, at first reluctantly accepted, achieved recognition of its success.

The result was that simulators have proliferated throughout the military, space exploration, and shipping, together with a remarkable technological development towards modern high-fidelity simulation devices and combat trainers. It was noted that a recent trend in simulators has accompanied the development of micro-computer technology towards a preference for more cost-effective Part Task Trainers, which produce the essentials of response-fidelity for the tasks only which are defined by the current objective in the training program. However, whole-task simulation is still regarded as important, as illustrated by the support by IATA for 'total simulation' (IATA, undated:2) in which all the practical experience in flight training is gained under simulated conditions, and the call for whole-task simulation advocated during the International Marine Simulation Forum Conference of 1984 (Meurn, 1990:157). Regarding the potential of simulation in training, the chapter highlights the steady adoption and gain in popularity of synthetic training devices for training through the strategy of simulation. A pragmatic conclusion would be that the popularity of simulation in certain fields of vocational training proclaims its effectiveness.

Chapter 3 concentrated on the participant and the significance of learning theories as applied to simulation. A brief survey of the relationship of the learning process to simulation highlighted relevance and meaningful experience (learning by doing) as being of importance to adult learning.

The participant was emphasised as being the most important variable in any simulation. A caution against the over-emphasis of the tasks for which the training course is being envisaged as opposed to the individual learner. Thus an empirical-didactical approach is stressed as being vital to the success of simulations.

It was revealed that personality reactions to simulations fall into two broad categories; those who allow themselves to readily become immersed in the simulation, and those who remain detached, even though their willingness and cooperation is unquestioned. The comparison of this phenomenon with the postulation of Rotter (Meyer et al., 1990:239,240) regarding locus of control raises the question as to whether those with an internal locus of control are more readily absorbed into a simulation than those with an external locus of control. A further consideration regarding this personality difference is the effect of the phenomenon on the learning effectiveness of the simulation for the individual.

It was pointed out that the participant should have reached a stage in training whereby similarities in the real world would be recognised and be perceived as relevant in the simulation. Thus preparation and relevance are seen as an important prerequisite for participants. The expectations of the participant would be that experience be gained which would provide him/her with experience, a sense of achievement, self confidence, and usefulness in their chosen occupation.

The theories of learning were then explored in order to discover their relevance to the use of simulation and to establish the nature of the learning processes through simulation. The theories of the behaviourists, neo-behaviourists, Gestalt, the cognitive school, social learning theories and Kolb's synthesis on experiential learning were discovered, as expected, to highlight different aspects of the learning process. However, all theories to a greater or lesser degree related learning processes with the environment.

Although the early theories did not make allowance for the cognitive processes in the interaction (transaction) with the environment, certain aspects of the strictly motor functions of learning can justify simulation for learning. Insufficient attention having been given to the affective processes and personality was remedied by the cognitive school and the social learning theorists, despite the fact that the latter echoed to some extent the postulations of the behaviourists, but differed in their approach to the role of the environment. They emphasised that the learner is an active participant in the process of selection, rejection and interaction with the environment, through direct experience, observational learning, and self regulation.

Social learning placed a heavy emphasis on learning by observing models, and regarded direct purposeful experience as less important. Experiential learning was seen in chapter 3 as a remedy for this inadequacy. Kolb's view was revealed in chapter 3 as a synthesis of the theories of Dewey, Lewin, and Piaget by which a more complete theory of the processes of learning by direct, deliberate involvement and interaction with the environment was formulated.

Viewing learning as a continuous process of creating knowledge through internal conflict within the environment, through experience, adapting to the world, Kolb analyses four basic learning modes: concrete experience, reflective observation, abstract conceptualisation, and active experimentation.

In the application of these learning theories, it became evident that the common chord struck was interaction with the environment. Thus it cannot be just experience that provides a vehicle for learning but meaningful experience. Since simulation is the best way to bring many vocational experiences to the student, it becomes evident that its importance has been long underestimated, and should be *elevated to prominence in vocational training.*

Resulting from the deliberation on meaningful experience, the writer offered the following definition of experience in the context of this work:

> **Experience can be defined as the derivation by apprehension and ongoing accumulation of knowledge or skills through purposeful involvement and meaningful participation in events within a specific learning context.**

The emphasis is therefore on (meaningful) concrete experience, reflective observation, abstract conceptualisation, and active experimentation. It was noted in chapter 3 that only experience utilises all four of these learning processes.

Chapter 4 dealt with the application to simulation of the learning theories and sound principles of didactics. After outlining the profile of an effective controller, a review of the didactical principles (as outlined mainly by Avenant) were discussed. Then the application of these principles, together with the emphasis on meaningful experience were applied to the planning and execution of a simulation. During preparation, it was stated that the learning needs should be analysed in order to state the aims and formulate the objectives by which the simulation would be controlled and evaluated.

Then the participants should be prepared, and make their own preparations, before attending the final briefing just prior to the simulation session. During execution of the simulation, the controller is responsible for the meeting of the objectives of the simulation, and for the continuation in representing the simulated world to the participants. During this time, close monitoring and data gathering should be carried out for use during the debriefing and for further evaluation.

The debriefing was seen as a critical stage of the program, and should not be rushed nor treated as a lecture. It was pointed out that the debriefing is discussion which presents an opportunity for evaluation, reinforcement, and self-evaluation. It was admitted, however that problems exist in the evaluation of a simulation, especially in the long term.

5.2 **Findings**

As indicated in the title, the subject of this work relates to the potential of simulation as a teaching strategy in vocational training. The conclusions drawn from the chapters 2 and 3 support the view that simulation presents an opportunity (in certain cases stated in paragraph 1.2, the only opportunity) to allow the participants to gain knowledge and skills through meaningful experience. Since experience was proved in chapter 3 to be the most universally recognised learning process, it can be argued that a simulation based upon the didactical principles and methods laid out in chapter 4 is a powerful strategy, not merely for teaching, but *being learner oriented, it is a powerful vehicle for learning.* Thus it can be stated that simulation is fulfilling the expectations of its proponents, and has the potential, as its value in training becomes more evident, of being utilised in ever widening fields of educational endeavour.

5.2.1 Questions raised in Chapter 1:

a. Question: To what extent does the application of simulation contribute to the training of students in technological activities?

Finding: As a result of the conclusions drawn at the end of chapter 3 attention is drawn to the vital importance of **meaningful experience** in the learning processes.

Because simulation provides this type of experience in a carefully controlled environment, it is logical to conclude that simulations therefore (in a learning program which includes simulation) contribute very largely to the training of students in technological activities. However, it must be pointed out that the extent to which simulation is used affects the contribution of simulation to the overall training effort. Furthermore, following the didactical methodology set out in chapter 4, cognisance must be taken of the fact that the quality and effectiveness of simulations are effected by numerous *variables mentioned in chapter 4, including the reaction of the* student himself. Thus, a quantitative answer to this question would be difficult to provide. Nevertheless, it is possible to conclude from these chapters that a great potential does exist for the use of correctly applied simulations where direct experience of very expensive and/or potentially dangerous techniques must be taught.

b. Question: What didactical approach is best, and which methods of teaching are most effective, not only in the cognitive and psychomotor domains, but also as an influence for a lasting and positive effect on the mind, and the attitude of the student to the tasks and circumstances for which he is being trained?

Finding: The didactical approach and methods recommended by the writer are laid out in chapter 4.

The influence on the affective domain is supported by the social learning theories discussed in paragraph 3.4.5, which emphasise the effect of vicarious reinforcement by observation and by self regulation. Furthermore, since Bandura (see page 65) maintained that learning takes place by observing and imitating the behaviour of a model, the attitudes of the controller and of fellow participants will affect the attitudes of the learner. It is therefore possible to address affective issues during a simulation, such as a sense of responsibility, caution against complacency, and overcoming anxiety by enhancing self confidence in a simulation. The assessment of the long term effects are the subject of paragraph 4.11.3, and requires further investigation.

c. Question: What is the reaction of the student to specific stimuli in the simulated environment, and to what extent does this approximate his reaction to the same stimuli under real conditions?

Finding: The subject of the reaction of students to the simulated environment is complex, as illustrated by the discussion in paragraph 3.3 regarding the personality traits of the participant regarding the individual's locus of control. What was nevertheless born out in that paragraph and in the subsequent examination of the learning theories, is that **relevance** is of fundamental importance to the individual's perception and apprehension of his experience.

The extent to which stimulus fidelity contributes to the simulation is complicated by the variety of responses depending upon the personality of the participant. The subject of fidelity was raised in chapter 1, paragraph 1.4, and again in paragraph 4.12. The importance of relevance has already been emphasised. For this reason it is desirable to enhance the representation of realism as far as possible.

However, as discussed in paragraph 4.12, in the consideration of features to be eliminated in the cost/effectiveness trade-off, priority should be given to retaining the features which provide response fidelity rather than those which provide stimulus fidelity, because the benefit of learning by doing stems primarily from the **consequences** of the actions of the participants. Thus, provided that the participant has had sufficient prior real world experience with the instrumentation being used as objects in the simulation, and had properly been prepared for that simulation, the exact nature of the actions are not vital to the effectiveness of the simulation. The opinion is supported by Hayes (Stein & Kobrick, 1984:14), that reponse fidelity is the more important.

An example (chosen here because of its local topicality) would be the controls of a radar set in a radar simulation. The participant is unlikely to be brought into a radar simulation until he/she is already familiar with the theoretical aspects and the correct operation of a radar set.

Thus, if a mouse or a Qwerty keyboard were used in a simulation to control a video display similar to a rasterscan radar screen, the effect would be the same, provided that the 'controls' achieved the same **results** as a conventional knob on the actual radar set.

The principle outlined above suggests a cost/effectiveness priority only. It is not intended to belie the desirability to provide the maximum possible realism to a simulation. Furthermore, since personality plays a part, some participants would easily be absorbed into a simulation, but for others, greater efforts at representing realism is necessary.

d. <u>Question:</u> How does the student cope under stress, and how closely does the simulation reproduce causes of possible stress in the real situation?

<u>Finding:</u> The substance of this question has been answered by the conclusions of (b) and (c) above, since a stress reaction would develop resulting from the degree of involvement in a normally stressful situation in the simulation. The writer has been informed by participants during debriefings of their experience of stress during the simulation, and the writer has experienced stress as a participant himself. The ability to cope under stress does not really fall into the realm of this work, other than to highlight the ability to monitor the reactions of the participant with greater objectivity, ease and effectiveness in a simulation than in a real world situation.

e. Question: Does the lack of stress produce dangerous complacency and a false sense of well-being in the face of danger?

Finding: This question can be answered in very much the same way as in (d) above. Simulations can provide a safe means to present the consequences of dangerous attitudes. A simulation exercise prepared by Capt. Cox of the S.A. Merchant Navy Academy "General Botha" for this purpose is frequently used by him. This exercise causes complacency due to the fact that a prolonged period is spent performing routine traffic encounters, and invariably produces a close-quarters situation in spite of the relative simplicity of the final unexpected encounter.

f. Question: What is the description of the student who is typical of those who successfully complete the course, particularly in respect of personality, social and academic backgrounds, aptitude, previous experience in the real task, and level of education?

Finding: The typical participant is described in paragraph 3.3. Attention must be drawn, however, to the didactical principle of individualisation, and to the necessity for thorough preparation of all participants prior to the simulation. An empirical/androgogical approach is vital to the success of a training simulation.

g. Question: To what extent does theoretical preparation of the students for the simulation course contribute to the success of that course, and how is this preparation best carried out?

Finding: Preparation of the participant has been discussed in paragraph 4.9 and mentioned in (c) above. In order to exploit the full potential of simulation as a teaching strategy, relevance must be ensurêd. It is therefore important that the simulation is relevant to the participant. Some prior experience and training is necessary before the participants' own preparation for the simulation exercise. Fine & Kobrik are quoted as follows: "Meaningless tasks performed by untrained subjects inevitably will result in performance decrements even under relatively moderate conditions" (Stein & Kobrik, 1984:14).

h. Question: To what extent does realism of a simulation in respect of general surroundings (ambience, sounds, sensations, lighting, time of day, etc) contribute to the actual perfection of the tasks being reproduced?

Finding: As pointed out in (c) above, the simulation should be represented as realistically as possible. However, certain representational features can be disregarded due to their high cost, and the fact that they provide no stimulus specific to the tasks for which the simulation is being run.

Exterior visual stimuli and motion become more important where whole-task training is required. However, if features of greater realism are available, they should not be omitted, provided these do not become novelties which distract.

i. <u>Question:</u> What is the level of importance of the approximation of the appearance and 'feel' of the simulated instruments to the real instruments for which training is taking place?

<u>Finding:</u> This question directly targets the subject of stimulus fidelity and response fidelity. It was revealed in paragraph 3.2 that the **essential aspects** of the task are not omitted. The importance of stimulus fidelity is regarded by the writer to be of secondary importance when compared with the response fidelity of an object. This view is supported by the deliberations in (c) above. However, (although sometimes subjective) the question of whether or not the stimulus fidelity of an object falls into the category of 'essential' to the task must be considered.

A good example of this rationale is the use in the simulation facility at the 'General Botha' Campus of the Cape Technikon where the ship's engine and steering controls are knobs on a control box. The writer has been a participant in a simulation at that facility and has subsequently observed simulations there many times. The writer had no difficulty relating to these controls, nor did they spoil the simulation.

Anxiety and impatience were felt while waiting for the vessel to respond in the same way as would have been experienced in the real world. At no time during these sessions has a participant remarked upon the nature of these controls, although the writer has heard remarks regarding these controls by those engaged in training.

j. Question: What is the ultimate result of simulation in the student's overall confidence, fulfilment, motivation, and sense of achievement?

Finding: The question of self-confidence was discussed in paragraph 3.3. It is an undisputed observable phenomenon that self-confidence is partly the result of well-rehearsed skills, resulting in a recognisable expertise. It has been established in this work that simulation is an opportunity to develop expertise through experience. Hence it can be argued that confidence can be the result of simulation.

Fulfilment, motivation and the sense of achievement are not readily measurable, and though it would be logical to assume that these attributes would follow confidence, it is not possible within the scope of this work to provide that assertion. Discussions with past participants in the writer's own experience does indicate support for this assumption, however.

k. <u>Question:</u> What is a general description of the type of hardware and software which would adequately fulfil the objectives of simulation as a result of the answers obtained to the above questions?

<u>Finding:</u> The subject of simulator design has been discussed in paragraph 4.12. It was observed abroad by the writer that at Kings Point, MITAGS, and Glasgow, that two simulation facilities existed; one for whole-task ship simulation and one radar simulator with several (at least three) interactive own-ships, specifically for radar navigation and negotiating traffic in restricted visibility. The whole-task ship simulator at the Seamen's Church Institute in New York featured three cubicles, of which one was equipped with computer generated imagery (CGI) visuals, another was being equipped with CGI visuals, and the third could be used for training in restricted visibility. All three own-ships were interactive in the simulation. In Liverpool, only one cubicle was equipped with CGI visuals. A description of some of these installations, with pictures, are supplied in the appendices.

Thus it would appear that the modern trend has taken two directions: High-fidelity whole-task simulators, and relatively low cost part task simulators. Three micro-computer based radar simulation packages are currently known to the writer: SISradar, and PC maritime of U.K. origin, Poseidon of Norway, and Radsim, developed by K.Cox in South Africa.

Certain other micro-computer based radar simulator packages are designed for increased fidelity, including Swimulation of Hull. BMT Rembrandt of Teddington, Microsim of Cardiff, Maritime Dynamics Ltd. from Llantrisant, and Teklogic of Johannesburg.

Because it is possible to add customised input/output devices to micro-computer peripheral input/output ports as well as the standard interface protocols drawn up by the National Maritime Electronics Association of North America (NMEA), any micro-computer based simulation has the potential to grow in complexity and fidelity, which increases the economic attractiveness of part task simulators.

As was stated in paragraph 4.12. the exact nature of the simulation will be governed, within the parameters described in that paragraph, by the short term and long term aims and objectives of the facility, sound didactical principles, and the funds available.

l. Question: What is the description of the effective lecturer/instructor who would be called upon to present a simulation course?

Finding: The effective controller is described in paragraph 4.2.

m. Question: What are the criteria related to the type of tasks which would render training under simulation desirable?

Finding: The full implications of this question were not fully appreciated by the writer at the outset of this research. but have been revealed by the inspection of the learning theories in chapter 3. Since it was ascertained in that chapter that learning takes place essentially through the affective. cognitive. observational. experimental. and social involvement and interaction with the environment. **experience** becomes a notably important requirement.

The possibilities of selecting vocational tasks suitable for training by simulation are therefore revealed as being vast. since experience should be gained in every field of endeavour. Any of the four categories of simulation itemised in paragraph 1.6 or combinations of these categories therefore can be exploited to the advantage of the learner. and to industry as a result. Because it was proved that intellectual process are vital to learning. experience need not remain in the psychomotor domain. Any learning task which is simplified or made more effective by doing. however rudimentary. should be made experiential in order to stimulate experiential involvement. reflective observation. problem solving. active experimentation. creativity. and abstract conceptualisation in order to gain knowledge. develop skills and to promote confidence.

The *following statement serves to emphasise the potential of* experiential learning, and therefore simulation:

"The Oddity of learning through real time opportunities is that learning from experience is the most frequently quoted source of learning, yet analysis ... shows that the opportunities are rarely taken up consciously and are often ignored altogether" (Mumford, 1980:104).

Since experience is the key, then decision criteria for the use of simulation should be based upon the availability of the real-world experience in comparison to simulation in terms of finance, time, effectiveness and risk (paragraph 1.2).

n. Question: What methods of evaluation during and after the simulation course would give the best control regarding content, quality, and didactical methods used?

o. Question: How should the educator *in a vocational training situation* assess the relevance of the simulation to the overall training task and objectives?

Finding: Both of the above questions (n) and (o) were addressed in paragraphs 4.6 and 4.11. However, it was pointed out that inadequacies exist, and should be the subject of further research.

p. Question: In view of the diversity of makes of instruments and layouts of equipments. as well as the rate of technological advances. to what degree of generalised or specific simulation does an installation and associated course contribute towards the capability of the student who has completed the course to adapt to change and/or situations different from those which the simulation reproduces.

Finding: This subject is addressed by the consideration of the **relevance** of a simulation to the tasks and environment of those in *the real world. and is frequently highlighted in chapter 3 and chapter* 4. Regarding the question of relevance to the task. the adaptability of a learner to a different environment should be akin to a similar encounter of a different environment of instruments when changing the location of the professional's own situation. for example when a navigating officer is transferred to a new ship with different instruments and controls. The adaptability of such a person rests with the extent of his/her experience. and his/her appreciation of the **functions** of the controls or instrumentation. This aspect of training further emphasises the need for broad experience before the simulation and the desirability for repeated update simulation sessions suggested in paragraph 4.11.3.

In view of the need for relevance in a simulation the controller is faced with the question as to what aspects of the simulation should be regarded as needing to be relevant. The principle of totality (paragraph 4.3.11) emphasises the importance of taking an overall approach to the learner as a person. In this way, specifics will be seen in its relationship with the greater scope of the task or tasks being experienced. Thus the selection of instrumentation and objects in the simulation should reflect a concern for the essential requirement of the task being provided by the simulation (paragraph 4.6).

Controls of a generic nature serve the purpose of concentrating upon the **function** of the object rather that its stimulus fidelity, thus assisting the participant to focus attention on its purpose rather than its appearance or feel. In this light, controls of a non-specific and generic nature possess the advantage of facilitating the transition into situations which might be different in a specific nature, but readily recognisable to the learner in its functional role. This does not mean that the operation of the controls should not be covered in the training program. It should be expected that the participant has been properly prepared for the simulation session, including the specifics of certain controls and instruments encountered in past experience. Further reinforcement regarding the functions and variety of control layouts can be applied during the debriefing.

5.3 **Recommendations**

5.3.1 Didactical Application of Simulation

It is recommended that simulations be regarded as a didactical strategy, and therefore should be exercised according to the didactical principles as outlined in Chapter 4 and the suggestions for the application of those principles put forward in that chapter.

5.3.2 Design of Simulators

It is recommended that in the design of training simulators, care should be taken to ensure that clear long term and short term aims and objectives for the didactical utilisation of learning needs of the participants and the didactical requirements as outlined in chapter 4 in fulfilling those needs take priority. It is therefore desirable that qualified educationists with experience in the use of simulation in training become more involved in the design and installation of simulation equipment.

In this way the desirability of costly features which are impressive and attractive, but which are not essential to the fulfilment of the stated objectives can be reconsidered. In the same way, important features which might be mandated by the stated objectives will not be eliminated merely on the consideration of expense.

5.3.3 Cost/Effectiveness Trade-off

It is recommended that the question of the extent to which complexity and cost relate to effectiveness should receive further investigation as stated in paragraph 4.12.

5.3.4 Whole-task Simulation in South Africa

In view of the established potential of simulation, and the trend revealed in paragraph 2.6, it is recommended that consideration be given to an installation capable of high-fidelity whole-task marine bridge simulation. This facility could be jointly financed by industry and be utilised by industry as well as the S.A.Navy. Further training could be offered to foreign students, especially from the continent of Africa. If the aims are extended to research, then even greater utilisation is possible. Incorporating micro-computers with RISC technology, such a facility could be developed in South Africa using the existing local technological and educational expertise.

The existence of such an installation should not, however, limit the use and further development of less expensive part task simulations for specific purposes which would not fully harness the potential of a high-fidelity whole-task simulator.

5.3.5 Evaluation

It is recommended that further research be conducted into the question of run-time, short term, and especially long term evaluation of the success and effectiveness of training simulations. The formulation of objectives should reflect not only professional and vocational considerations, but should be largely influenced by the requirements of the examining authority and the training requirements of industry

5.3.6 Relevance

In order that relevance be perceived by the participants, it is recommended that they already have obtained significant real world experience, that they have received sound technological and theoretical teaching, and that they have been thoroughly prepared before being entered for a simulation program.

5.3.7 Repeated periodical training by simulation

It is recommended that students return periodically for ongoing simulation training, thereby maintaining expertise in tasks and contingency manoeuvres which are not routinely experienced in the workplace except in cases of urgency, and emergency. In this way participants are also kept abreast of the latest trends in technological and professional development.

5.3.8 Personality reaction

It is recommended that personality differences regarding the reaction of individuals to simulation be the subject of further extensive investigation. Personality traits such as that explained by the 'locus of control' are expected by the writer (as a result of the findings in chapter 3) to have a bearing on the perceived level of realism to the individual in the simulation, as well as the ultimate effectiveness of the training program (paragraph 3.3).

5.4 Possibilities for further research

Following from the recommendations listed above, the following possibilities for further research is briefly listed as follows:

- Cost/Effectiveness trade-off (see paragraph 5.3.3).
- Evaluation of training simulations (see paragraph 5.3.5)
- The effect of personality upon the effectiveness of simulations (see paragraph 5.3.8).

5.5 Conclusion

As a result of the findings that experience plays a vital part in the learning processes, and that meaningful experience can be provided by the correct application of simulations, the value of simulations is indicated.

Considering the importance of experience in many aspects of vocational training, and the fact that this experience at times can only be afforded at great cost, use of time, and/or risk of equipment and lives, the merit of the application of the principles outlined in chapter 4 to provide training through the use of simulations is emphasised. Also the availability of affordable equipment and the more readily available software provide increasing opportunities for representational equipment. Opportunities for the use of simulation as a didactical strategy are expanding, and can be envisaged by imaginative vocational trainers for a limitless variety of tasks.

The hypothesis is thus supported by the findings in this work; that simulation is a powerful strategy in vocational training. The proviso that sound didactical principles are followed, and the needs of the individual are addressed, are nevertheless a requirement for the success of this method of training.

A commonly quoted ancient Chinese proverb (Burgess, 1990:303) would be most appropriate at the close of this, the final chapter:

"I hear, and I forget.
I see, and I remember.
I do, and I understand."

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GLOSSARY OF TERMS.

as used in this work.

This glossary was compiled in order to clarify usages of terminology in this thesis. It is not intended to be authoritative.

Abeam - 90° from the direction of the ship.

Aim - a statement of intention to address the satisfaction of an identified learning need.

Alleyway - a corridor in a ship.

Andragogics - the science of mutual adult leading/accompaniment.

Apprehension - a secure cognitive grasp of knowledge.

Astern - behind the ship, or to travel in reverse.

ARPA - Automatic Radar Plotting Aid.

Atomism - the concept of regarding all facets of the human psyche as totality in communication.

Automatism - the performance of tasks without conscious effort.

Bearing - the direction, measured in degrees or compass points, either from the ship's direction, or from North.

Bearing Cursor - the device on a radar screen for measuring the bearing of radar targets.

Boatswain - the rating in charge of the deck crew.

Bridge - the control and operational headquarters in a ship.

CAORF - Computer Aided Operations Research Facility at Kings Point, N.Y.

CGI - computer generated imagery.

Close quarters situation - a term used in the maritime field to describe a situation in which a vessel has been allowed to approach too close, thus drastically reducing any safe margin for error, and necessitating immediate, urgent action to avoid a collision.

Controller - is the term used to describe the person in charge of conducting the simulation.

Course - the direction of a ship, measured in degrees from North.

Criterion - a standard on which judgment or a decision is based.

Debriefing - the discussion between the participants and controller in which they critically review the simulation.

Decca navigator - a medium range terrestrial electronic device used in some parts of the world (mainly Europe) based on a hyperbolic lattice derived from the loci of measurable phase differences.

Deck-officers - the officers responsible for navigation and general operations of the vessel.

Didactics - the study of the meaning of instruction in respect of education.

D.O.T. - Department of Transport.

Echo sounder - An electronic device for measuring the depth of the sea.

Empirical education - the study of the learner as a product of the environment, as an empirical phenomenon, and understanding education in terms of measurable, controllable factualities pertaining to the educand.

Epistemology - the theory of knowledge and the relationship between knowledge and learning.

ERGOM - European Research Group on Management.

Evaluation - the act of comparing a measurement with a standard, and passing judgment on the comparison.

Exercise - the planned programme involving a simulation which would be designed and run in order to achieve set didactic objectives.

Experience - the derivation by apprehension and ongoing accumulation of knowledge or skills through purposeful involvement and meaningful participation in events within a specific learning context.

Facility - embodies the building, organism, equipment and staff which runs a simulation.

Fasteners - a trawling term describing obstructions on the sea bed.

Fidelity - the degree to which a participant's action varies with the same action in a real job situation.

Game - a competitive event in which there are winners, losers, rules, a referee and perhaps an element of fun.

Gestalt - postulates that learning is a process of organising conceptions into patterns in order gain insight, and recognises that the whole is greater than the sum of its parts.

Global Positioning System - the American satellite navigation system (superseding the Transit system) which enables the continuous accurate measurement of a three-dimensional position.

Gyro compass - a device which indicates True North by the exploitation of the laws of precession and gyroscopic inertia.

Head-up - a radar display referenced from the ships heading.

Helm - the ship's steering control system.

High fidelity - a term use to describe a simulation in which the participants would identify strongly with the simulated world and its analogy to the real world.

Horizontality - the study of events which happened at roughly the same time in order to perceive relationships.

IATA - International Air Transport Association.

Log - the ship's official journal recording important events.

Log - the instrument for measuring the distance travelled.

Loran C - a long range terrestrial pulsed electronic device used in some parts of the world (chiefly Northern Hemisphere) based on a hyperbolic lattice derived from measurable time delay differences.

MARSIM - International Marine Simulation Forum Conference.

Mate - nautical term for navigating officer.

Midshipmen - trainee officer, usually naval.

MITAGS - Maritime Institute of Technology and Graduate Studies, Maryland.

Mouse - a peripheral device which translates hand and finger motions into computer instructions.

Nautical mile - the measurement of arc on the earth's surface of one minute of latitude. By convention its length is taken as 1852 metres.

Net sounder - an echo sounder with its transducer placed on the trawl net, designed specifically for fish detection and trawling operations.

Niveau - as used in the title of this work, expresses a plane or level at which education is being addressed.

Objects - in the context of simulation are any physical entities being represented.

Objective - the immediate cognitive, affective or motor reaction a teacher expects his pupils to exhibit on completion of a specific lesson or module.

Paidagogos - a slave who accompanied a male pupil in ancient Greece.

Participant - is the designation of the those who are being given the chance of obtaining vocational experience resulting from the participation in a simulation.

Part-task - simulation for experiencing a specific aspect of a vocational function.

Phenomenology - investigation by allowing reality to describe or explain itself without considering objective reality or subjective responses.

Port side - the left hand side of a ship or aircraft.

PPI - Plan Position Indication; a radar display arranged to present the surroundings in a map-like, two dimensional, horizontal format.

Pragmatism - the view of absolutisation of the utility value of every assertion.

Qwerty keyboard - computer keyboard incorporating alpha-numeric keys arranged in the conventional type-writer configuration.

Radar - a device for radio detection and ranging through the reception and measurement of the echoes of microwave pulses.

Radar assisted collisions - the term used to identify collisions resulting from the misuse or misinterpretation of radar information.

Radar plotting - geometric constructions using time, speed and distance vectors in order to interpret the radar display, especially with regard to the behaviour of targets.

Rasterscan - digitised polar-coordinated radar information displayed on a conventional video monitor.

Real time - a computer simulation process which develops at normal clock speed.

Real world - refers to the material, concrete job situation in which learning or training is not the primary objective, but is in fact the situation for which the student is being trained.

Realia - the use of real objects for teaching in a classroom situation.

Realism - refers to the extent to which the simulation reproduces for the participants the actual atmosphere and sensations of the real world job situation.

Reality in a simulation - refers to the essential features of the environment inside the simulation.

Response fidelity - the extent of real-world similarity to which the replicated object responds to actions of the participant.

Representation - The capacity to represent the rest of the outside influences upon the simulation

RISC - reduced instruction symbols code; a method whereby a 32 bit central processing unit is designed to enable a microcomputer to perform many of the functions of a main-frame computer.

Role - refers to the professional function of a participant in a simulation.

Role-Play - to dramatise and take the part of a real or fictional character, behaving as he/she does, either to a prepared script or along the lines of a brief

Run time - the period during which a computer program (in this case a simulation) is running.

Sailing directions - a series of volumes (descended from the early 'rutters') devoted to the description of climatic, topographic, oceanographic, and other details relating to distinct geographic regions for the purposes of navigation.

SCI - Seamen's Church Institute, New York.

Scientism - the application of the science of teaching and educational psychology.

Sense perception - learning through the stimulation of the senses.

Simulated world - refers to the world being experienced by the participants during the simulation.

Simulation - untaught events in which the participants have roles and are required to accept the responsibilities and duties of professionals.

Simulator - the hardware directly associated with the construction of a simulation and its representational features.

Starboard side - the right-hand side of a ship or aircraft.

Stimulus fidelity - the extent to which the appearance and feel of an object is replicated in the simulation.

Student - as used in this work, refers to the post-school learner, as opposed to a school pupil.

Synchronism - see horizontality.

Symbiosis - the use of parallel examples drawn from the learner's life experiences in order to teach similar concepts.

Targets - refers (not necessarily in combat) to objects indicated on a radar screen, usually, but not necessarily, other vessels.

Total realism - the ability of a simulation to be completely indistinguishable from the real world.

Total Simulation - the concept which provides for all necessary previous experience for competency to be gained through simulation alone.

Trawler - the type of fishing vessel which operates by dragging a net through the water, usually just above the sea bed.

Unstabilised display - a radar display which is not automatically oriented through input from the gyro compass.

USSMMA - United States Merchant Marine Academy, Kings Point, on Long Island in New York.

Wheelhouse - the control station on the bridge of a vessel, analogous to the flightdeck of an aircraft.

Whole-task simulation - a simulation which provides for all of the essential tasks forming the entire operational function of the professional in valid sequence and context within his/her overall duties and responsibilities.

Windlass - the machine which lowers and raises the anchors.

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APPENDIX I

COMPASS ADJUSTMENT SIMULATION

The attached diskette contains two files: WCOEFF.EXE and WADJUST.EXE. The latter is the simulation program. The programs are submitted in order to illustrate the application of the principles discussed in Chapter 4 as applied to a simple independent microcomputer based simulation.

The Magnetic Compass is a subject which is covered by candidates submitting themselves for the qualifications of Master Mariner (Class 1), National Higher Diploma in Nautical Science, and the Command Endorsements. The students receive thorough theoretical training in magnetism and the factors influencing the magnetic field of the earth in a ship. They are then introduced to the error coefficients and the Fourier analysis whereby these coefficients are identified. The program WCOEFF.EXE (not a simulation) can be used by the students to illustrate these coefficients, and their effect on the deviation curve of a magnetic compass.

Once they are well versed with the theoretical aspects of the magnetic compass, they are introduced to the methods whereby these coefficients are counteracted, and the various methods of adjusting the magnetic compass for a minimum deviation on all headings. One of these methods is the Tentative Method simulated in the program WADJUST.EXE.

Once the student has been prepared theoretically (he will also be familiarised with the compass binnacle and the nature of the compass correctors fitted), he is permitted to practise adjusting the compass in this simulation as many times as he needs to in order to be able to demonstrate his ability to perform an effective compass adjustment. The program introduces a random deviation curve, which the student must minimise by moving the correctors.

The following stages in the simulation are followed:

Preparation, by theoretical teaching, practical illustration using WCOEFF.EXE, and familiarisation with a real compass binnacle. He should also spend some time playing with the simulation program, WADJUST.EXE in order to familiarise himself with the operation of the buttons and the mouse.

Briefing, provided by the lecturer, but also by the 'NOTE' and 'HELP' buttons in the WADJUST.EXE program itself.

Simulation, in which the student must swing the ship (as he has been taught) through 360° and choose the correct magnets, moving them towards or away from the compass in order to vary the intensity of the corrective field, and finally to move the spheres towards or away from the compass until the deviation on intercardinal headings has been minimised.

Feedback. Instead of a formal debriefing (which in any case may be given), the student is able to view the deviation curve and compare it with the original curve and the deviation card in order to gauge the extent of his success.

For those who are not familiar with compass adjustment, the operation of the simulation can nevertheless be observed by dragging the correctors towards and away from the compass in order to note the influence which the correctors have on the compass card. Although a mouse is desirable, the simulation does work by using the keyboard as prompted by the program itself.

Insert the Diskette into drive A: and type GO ↵

Description of menu selections on the disk

Once the menu has appeared on the screen, the student is able to select from the menu by moving the highlight bar with the cursor keys and depressing the "Enter ←┘ " key where the highlight bar appears.

The selections are as follows:

1. Read this First - the introduction to the software package.

2. The first programme which demonstrates the coefficients and the Fourier Analysis.

3. The compass adjustment simulation.

4. Exit. Selection of this terminates the session and returns control to DOS.

APPENDIX II

EXAMPLE SIMULATION DOCUMENTATION, CAPE POINT PASSAGE

As discussed in Chapter 4

The following pages provide the following information:

- Participants' Information Brief. (designed by writer).
- Ship manoeuvring data. (Acknowledgements: Training Centre for Seamen.)
- Further data regarding own ship 1.
- Section of the chart of the exercise area.

INFORMATION BRIEF **RADAR SIMULATION**

Name or Team: Team A **Cubicle No.:** 1

Exercise No.: 10 A **Time:** 14:00 Hrs **Date:** Feb.10, 1993

Nature of exercise: RADAR NAVIGATION IN TRAFFIC

Geographical Area: CAPE POINT, SOUTH BOUND

OWN SHIP: **Name:** CRASSULA **Type:** FREEZER TRAWLER

Draught: 4.2m **F.** 4.9m **M.** 5.5m **A.**

TIME FRAME: **Date:** Jan. 28, 1989 **Time:** 01:20

START POSITION **Latitude:** 34° 20.'0 S **Longitude:** 18° 20.'0 E

TRAVELLING AT **True Course:** 140° (T) **Speed:** 10.0 Knots

Proceeding from: CAPE TOWN **Destination:** 6 Mile Bank

Nature of voyage: Two Month Hake Trawling

INSTRUMENTS: **Radar display type:** Head-Up, Unstabilised

Compass: Magnetic (Gyro.) Variation: Per Chart Gyro error: 0°

Decca: NO G.P.S. NO R.D.F. NO Loran: NO

WEATHER: **Visibility:** Poor **Wind:** 250° **Speed:** 5 km

CURRENT: **Set:** 0° **Rate:** 0 Knots **Tide:** Slack H.W. Neaps

INSTRUCTIONS: You are to proceed with caution and observance of the Collision Regulations around Cape Point, thereafter setting course for six mile bank. You should make all necessary preparations for your voyage before final briefing at 13:30 on Feb.10, 1993.

Table of stopping distances

Name of Vessel........CRASSULA........

Conditions during trial:

Displacement..2177:2..tons Draught..4:2..Frd...5:5..Aft.

Wind ....240° (T)....... Force....2..... Sea....2.....

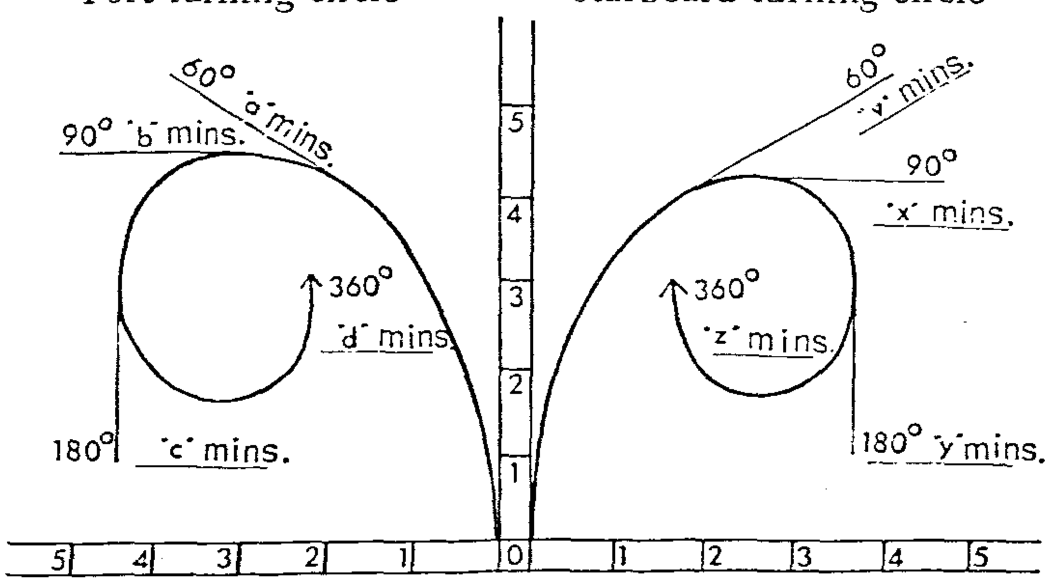
STOPPING DISTANCES						
Manœuvring Speeds			Stopping with Stern Power		Stopping without Stern Power	
Teleg.	Knots	Revs.	Distance	Time	Distance	Time
Full	12		0.3 nm	2½ m	1.16 nm	10 min
Half	10					
Slow	7					
D. Slow	4					

Normal Full Speed ...14:0...Knots ....Revs.

Notice required before Stopping ..IMMEDIATE – BRIDGE CONTROL..

AT FULL SPEED

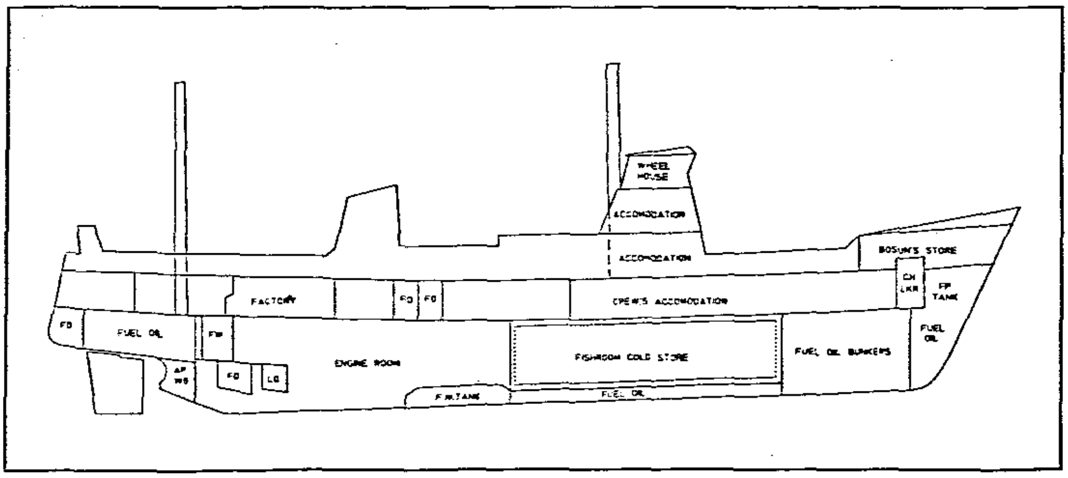
Port turning circle   Starboard turning circle



Advance...518 metres   Advance...518 metres.

T. Diameter...943:5 metres   T. Diameter...943:5 metres.

M.V. CRASSULA



Dimensions

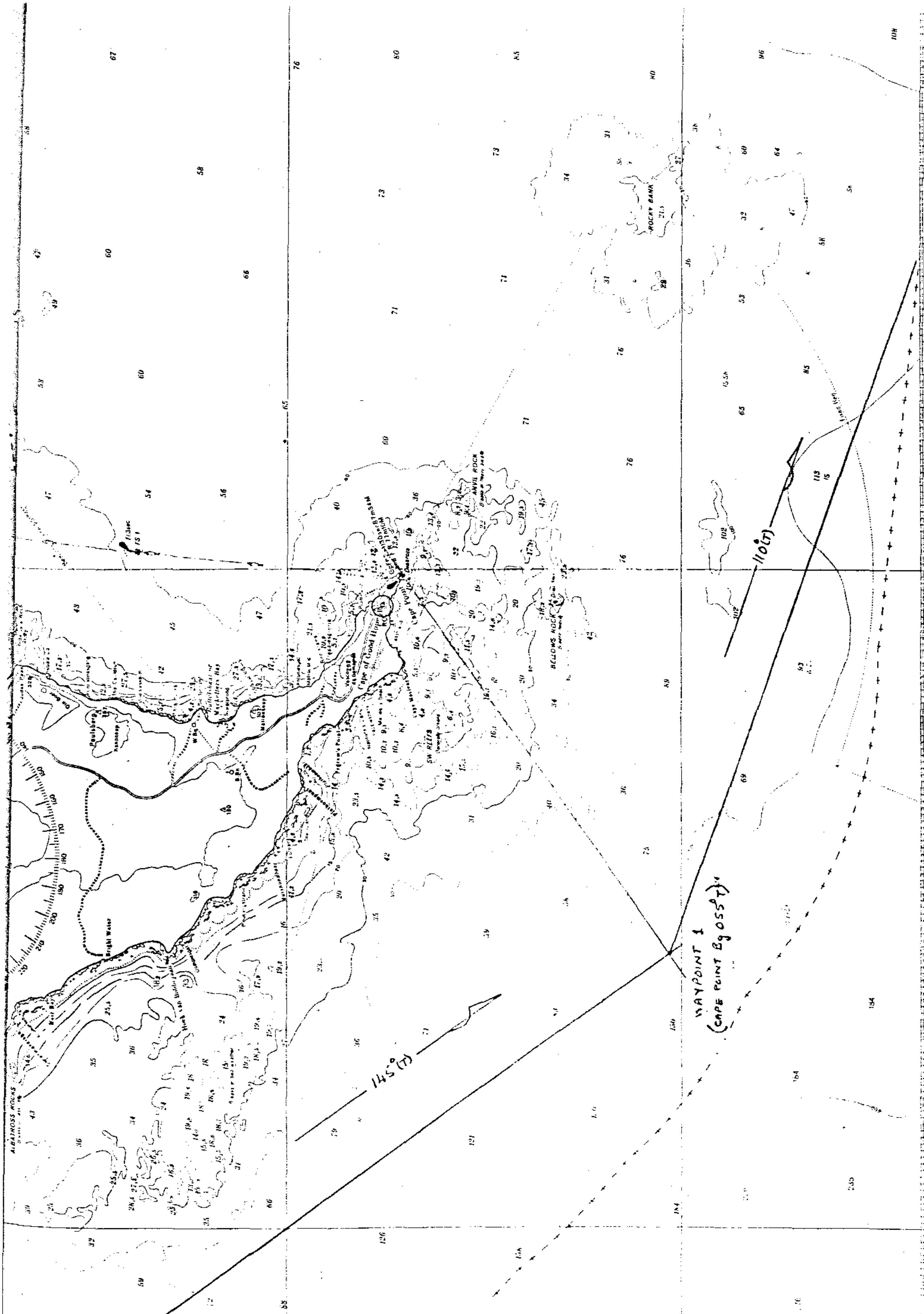
Length Overall	200'00"
Length Displacement	172'06"
Breadth Moulded	38'06"
Depth Moulded to Upper Deck	24'03"
Depth Moulded to Lower Deck	16'03"
Designed Hang of Keel	4'06"

Owners

Irvin and Johnson, Cape Town.

Builders

James Brown & Hamer Ltd, Durban.



WAYPOINT 1
(CAPE POINT Bg 055°T)
145°(T)
110°(T)
ROCKY BANK
ANVIL ROCK
BELLOWS ROCK
SW REEFS
ALBATROSS ROCKS

APPENDIX III

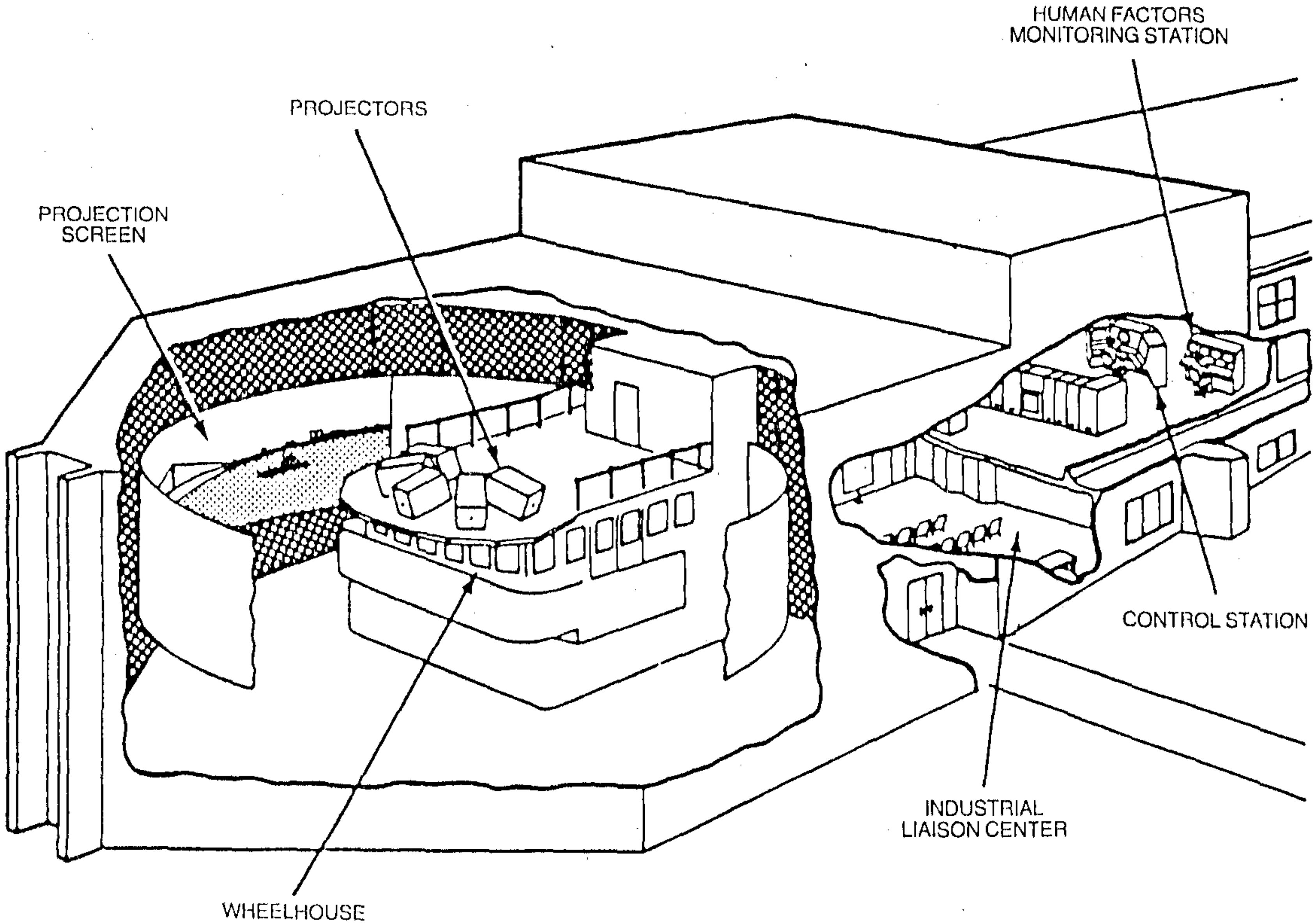
COMPUTER AIDED OPERATIONS RESEARCH FACILITY (CAORF)

Situated at Kings Point, New York

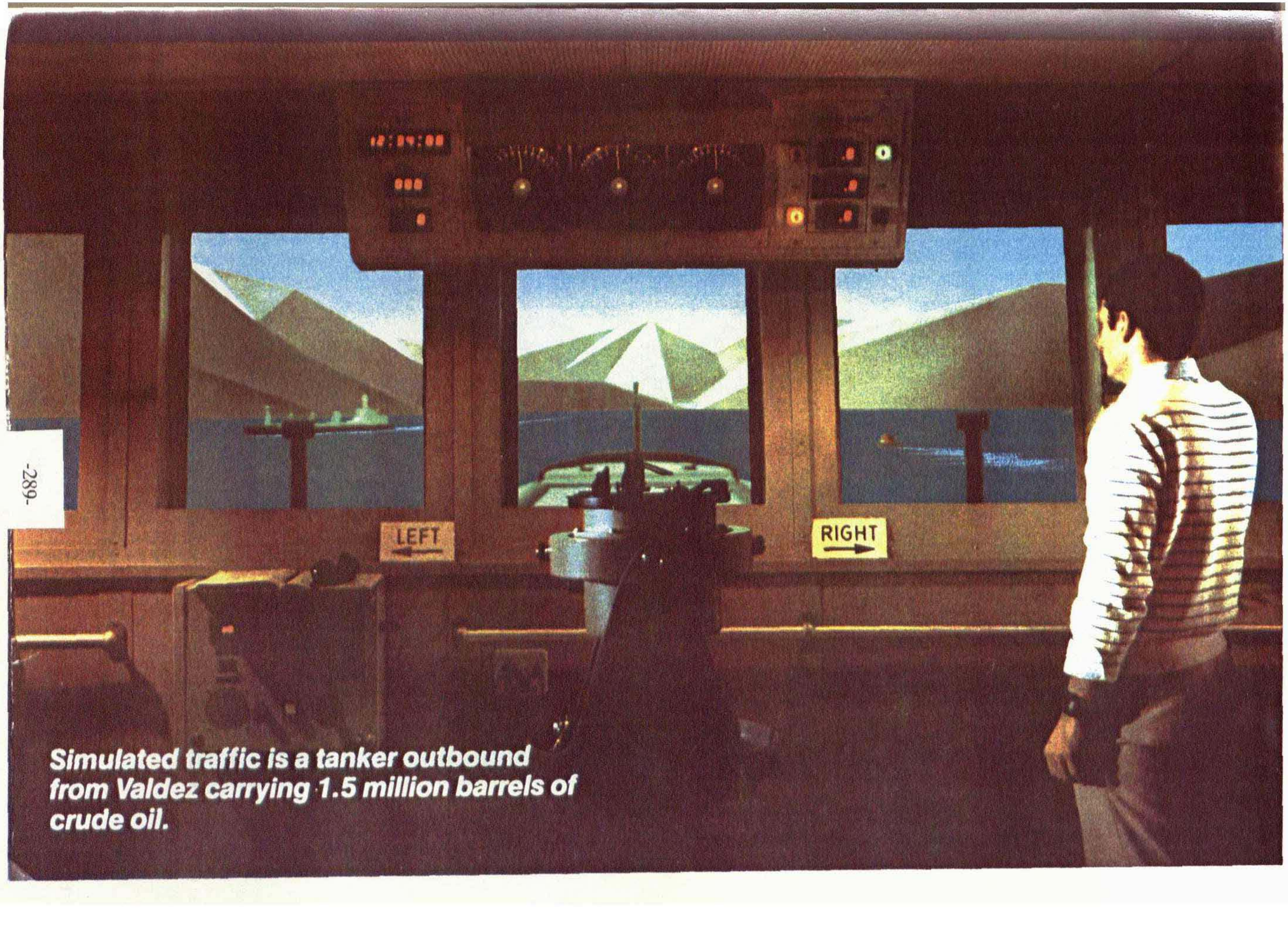
The following pages provide the following information:

- Cutaway plan of the CAORF facility, (CAORF Brochure).
- Photograph of simulator bridge of tanker in Prince William Sound. (Marine Safety International Brochure).
- Photograph of the bridge on the simulator. (CAORF Brochure).
- Debriefing at the control station where the simulation data is played back as required. (Marine Safety International Brochure).
- Aerial view of the CAORF facility, Kings Point, N.Y. (Marine Safety International Brochure).
- Sample briefing document, arrival Cristobal, Panama.
- Sample extracts from briefing documentation.
- Sample passage plan prepared by students, arrival Cristobal.
- Sample team grading sheet, arrival Cristobal.
- Sample participant evaluation, arrival Cristobal.
- Sample chart section of Cristobal anchorage.

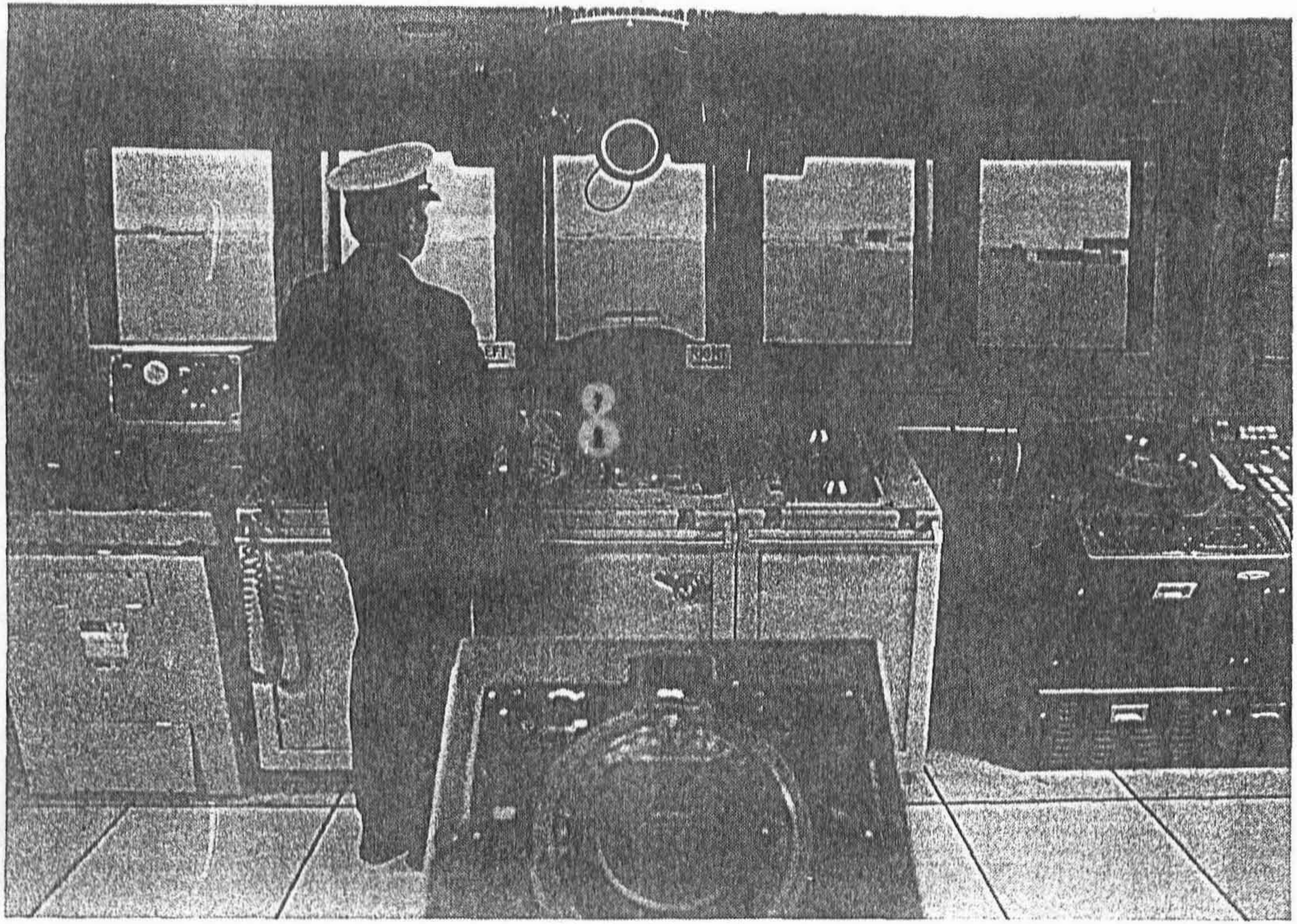
(Sample documentation, courtesy Capt.R.Meurn, USMMA).



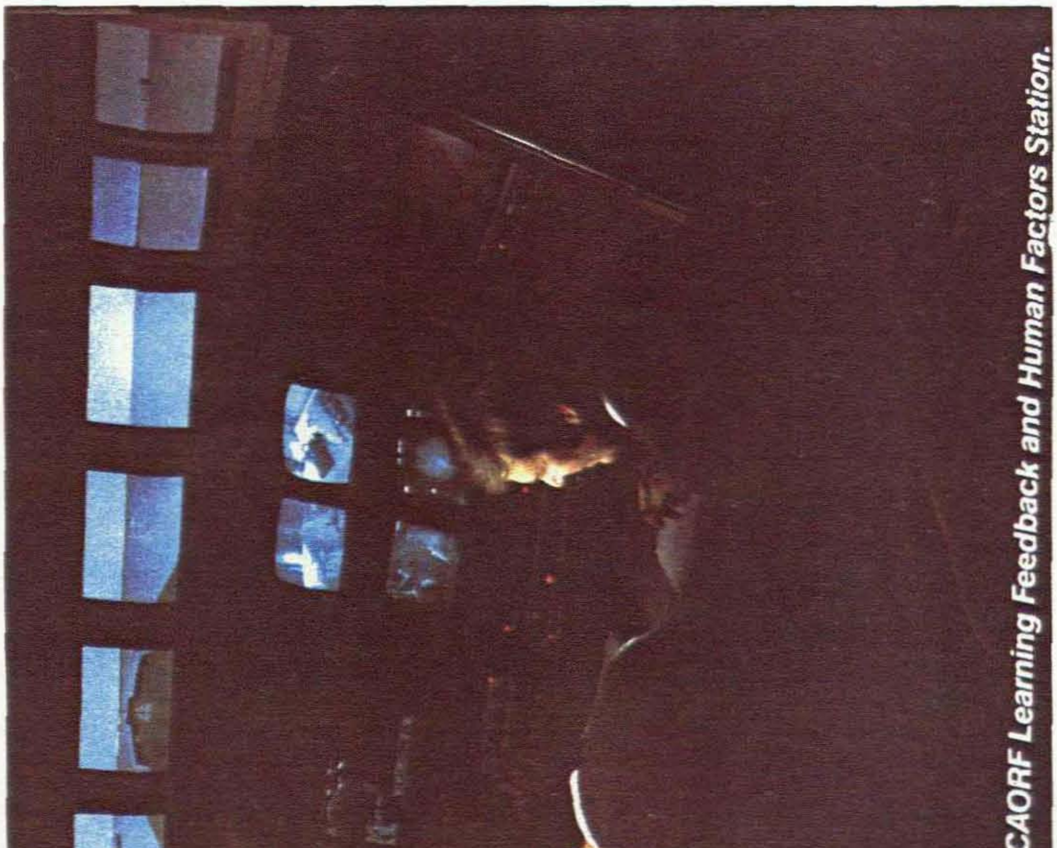
Cutaway of Computer Aided Operations Research Facility (CAORF) Building



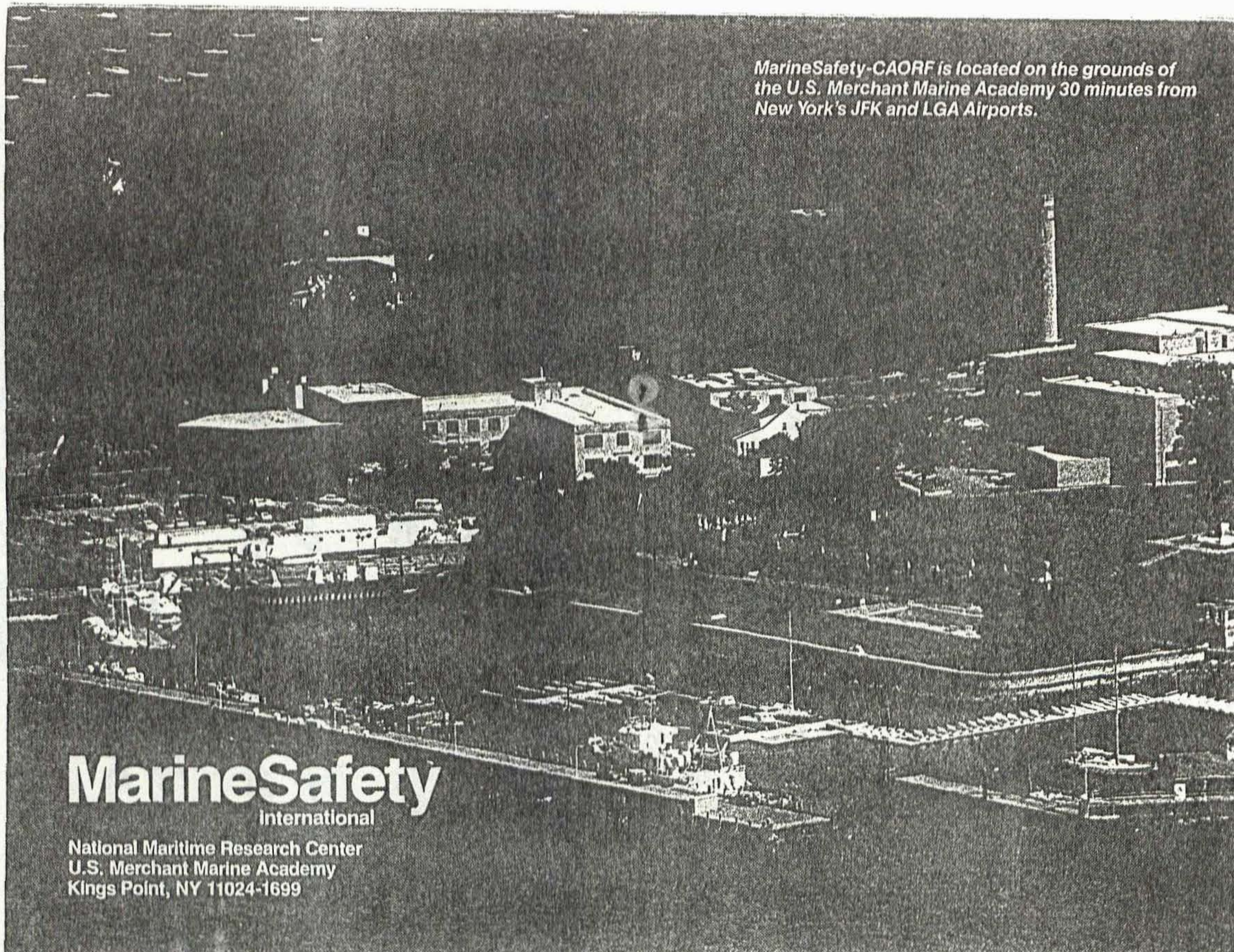
Simulated traffic is a tanker outbound from Valdez carrying 1.5 million barrels of crude oil.



Ship Simulator Bridge
for Training and Operations Research
MarineSafety / CAORF, Kings Point, New York



CAORF Learning Feedback and Human Factors Station.


MarineSafety-CAORF is located on the grounds of the U.S. Merchant Marine Academy 30 minutes from New York's JFK and LGA Airports.
MarineSafety
International
National Maritime Research Center
U.S. Merchant Marine Academy
Kings Point, NY 11024-1699

SAMPLE
EXERCISE

ENROUTE
LIMON BAY
CRISTOBAL PANAMA
DATE: ____________

1. VESSEL WILL BE ANCHORING AT ⚓AGE "B" INDICATED ON CHART. WE MUST BE ANCHORED NOT LATER THAN 0650 WITH 2 SHOTS ON DECK AND THEN AWAIT TRANSIT INSTRUCTIONS

2. MAKE ALL PRE-ARRIVAL CHECKS PRIOR TO BKWTR ENTRANCE. SLOW TO H MANUV. (60 RPM) PRIOR TO ENTERING LIMON BAY & THEN PROCEED TO ⚓AGE.

3. KEEP ME ADVISED & DO NOT HESITATE TO CALL ME IF IN DOUBT.

John Merchant Marine
MASTER

20-24 Salty O'Hara
00-04 Shipwreck O'Malley
04-08 ____________

PASSAGE PLAN SS CAPELLA DATE 16 FEB 88 ARRIVE CRISTOBAL DEPART PANAMA TRANSIT	MASTER: MARINER OOW: LEE Nav: BROWN Radar: BRIDGES Helm: BURLEIGH	VHF INFORMATION CHNL 7 8 EMERG. CHNL. 13 MONITOR AT ALL TIMES - CRISTOBAL SIGNAL STATION CHNL 16 SAFETY DISTRESS	WEATHER WIND NW FORCE 1 SUNRISE 0613	TIDAL INFORMATION NO APPRECIABLE TIDE ON CONCERN 0552 -0.1' LW 1046 1.2' HW 1853 -0.3' LW

WAY POINT	1. POSITION 2. INDEXING INFO	TIME	ENGINE STATUS	SPEED	TRACK	CURRENT	COURSE TO STEER	DISTANCE (To go)	UKC Fm (M)	POS'N FIX METHOD	REMARKS
A	L 09°-27' 51.5"N λ 079°-55' 50.0"W SEA BUOY Ø183° 3.15MI E BKWTR Ø174° 4.5MI	0600	SEA SPD 106 RPM	14.9	180°	SLIGHT SE	180°	0.83 MI. TO B 6.5 MI TO ⚓AGE	34	(Vis) (Radar) Loran Satnav	① PRE ARR TEST ② CALL MASTER ③ CALL E/R ④ SHAPES & FLAGS READY
B	SEA BUOY Ø 186° 2.4 MI CIR ON BKWTRS 0.1 MI	0603	106 RPM	14.9	141°	NIL	141°	1.12 MI 5.67 MI	34	(Vis) (Radar) Loran Satnav	ARRIVAL Ø606 SYNC CLOCKS CALL MASTER
C	SEA BUOY Ø 211° 0.9 MI	Ø608	106 RPM	14.9	180°	NIL	180	3.52 4.55	30	(Vis) (Radar) Loran Satnav	① CLEAR ⚓o SIMON BOW ② CALL CRISTOBAL CLEARANCE TO ENTER ③ 0612 C/S 8.5 KTS
D	BKWTRS ←⊖→ E BKWTR 200 YDS BKWTR W 250 YDS	0621	60 RPM	8.5 KT.	180°	NIL	180°	0.30 MI 1.03 MI	3	(Vis) (Radar) Loran Satnav	① SPEED MUST BE LESS THAN 10.0 KT ② SECURITY CALL ③ FLAGS UP
E	W BKWTR Ø 343° @ 0.7 MI	Ø631	60 RPM	8.5 KT	234°	NIL	234	0.73 MI	2	(Vis) (Radar) Loran Satnav	① WALK ⚓ OUT ② ENSURE ⚓AGE CLEAR ③ CALL MASTER & E/R
F	⚓AGE BRAVO TOWER Ø 2.94 W BKWTR Ø320° @ 2.1 MI BUOY H Ø234° @ 1.1 MI	0650	⊗	0	234°	NIL	234	0	1.5	(Vis) (Radar) Loran Satnav	① ⚓ BEARINGS ② CALL CRISTOBAL FOR WAITING TIME
				SAMPLE PLAN						Vis Radar Loran Satnav	

CADET WATCH TEAM GRADING SHEET

DATE: 16 FEB 88	TEAM: A-1	ARRIVAL CRISTOBAL Day ☑ Night ☐ (Anchorage in Limon Bay)
Watch Officer: LEE		Range and bearing of anchor position arrived at from the planned anchor position: (90) YDS EAST OF ⚓ LAGE
Navigator: BROWN		
Radar Observer: BRIDGES		
Helmsman: BURLEIGH		

EXECUTION
Total 40 Points.
2 points per item

01. Compliance of Masters/Standing Orders	2
02. Proper preparation for Arrival	1
03. Proper internal communications	2
04. Proper vhf procedures	1
05. Master/Engine Room kept informed	1
06. ETA's maintained	2
07. Proper helm orders given	2
08. Frequency and method of pos'n fixing	2
09. Margins of Safety maintained	1
10. Optimum use of all navigation aids	2
11. Correct collision avoidance taken	2
12. Safe speed maintained at all times	2
13. Efficient visual lookout maintained	2
14. Anchoring properly prepared & executed	2
15. Optimum use of bridge personnel	2
16. Bell Book properly maintained	2
17. Log Book properly maintained	2
18. VHF log properly maintained	2
19. Emergencies effectively dealt with	2
20. Ship satisfactorily maneuvered	2
EXECUTION SCORE	34

MONITORING
Total 20 Points
2 points per item

01. Track (Charted fixes and PD)	1
02. Depths	2
03. Traffic	1
04. VHF	2
05. Helm	2
06. Instruments DOPPLER	1
07. Visibility/Weather	2
08. ETA's	2
09. Passing of information	2
10. Watch Officer	2
MONITORING SCORE	17

APPRAISAL & PLANNING
Total 30 Points.
2 points per item

01. All relevant pubs. studied	2
02. Satisfactory plan on form	2
03. Tracks & courses on chart	2
04. Dangers and margins of safety marked	2
05. Tidal times and hts. calculated	2
06. Sufficient ukc/heights ascertained	1
07. Currents marked and effects considered	2
08. ETA's and distances planned	2
09. VHF ch. noted and RP's marked	2
10. Frequency & method of fixing planned	1
11. Relevant Port Regulations considered	2
12. Weather expectations and forecasts	2
13. Ship's maneuvering capabilities considered	2
14. Contingency plans made	1
15. Effective anchoring plan made	2
APPRAISAL & PLANNING SCORE	27

ORGANIZATION & TEAMWORK
Total 10 Points
5 points per item

01. Watch officer composure	4
02. Teamwork	4
ORGANIZATION & TEAMWORK SCORE	8

SUMMARY

Appraisal & Planning (30)	27
Execution (40)	34
Monitoring (20)	17
Organization & Teamwork (10)	8
TOTAL POINTS (Out of 100)	86

COMMENTS: ONLY 1 STG PUMP CHK. AFT STG NOT MANNED. SIGNAL ARRIVAL ZIG ZAG THRU BKWTR. CONFUSION WITH OUTBOUND BRITANIC ENDEAVER & NO VHF TO AM LANCER. EXCELLENT: PLANNING GOOD EXECUTION. ⚓ (90 YDS) EAST OF ⚓AGE. LET GO (0643) WITH STERNWAY

INSTRUCTOR: [signature] B. Meurn

RGB 11.01.87

EVALUATION OF LEE SECTION # 115

Circle AS: (WATCH OFFICER) NAVIGATOR RADAR OBS. HELMSHAN

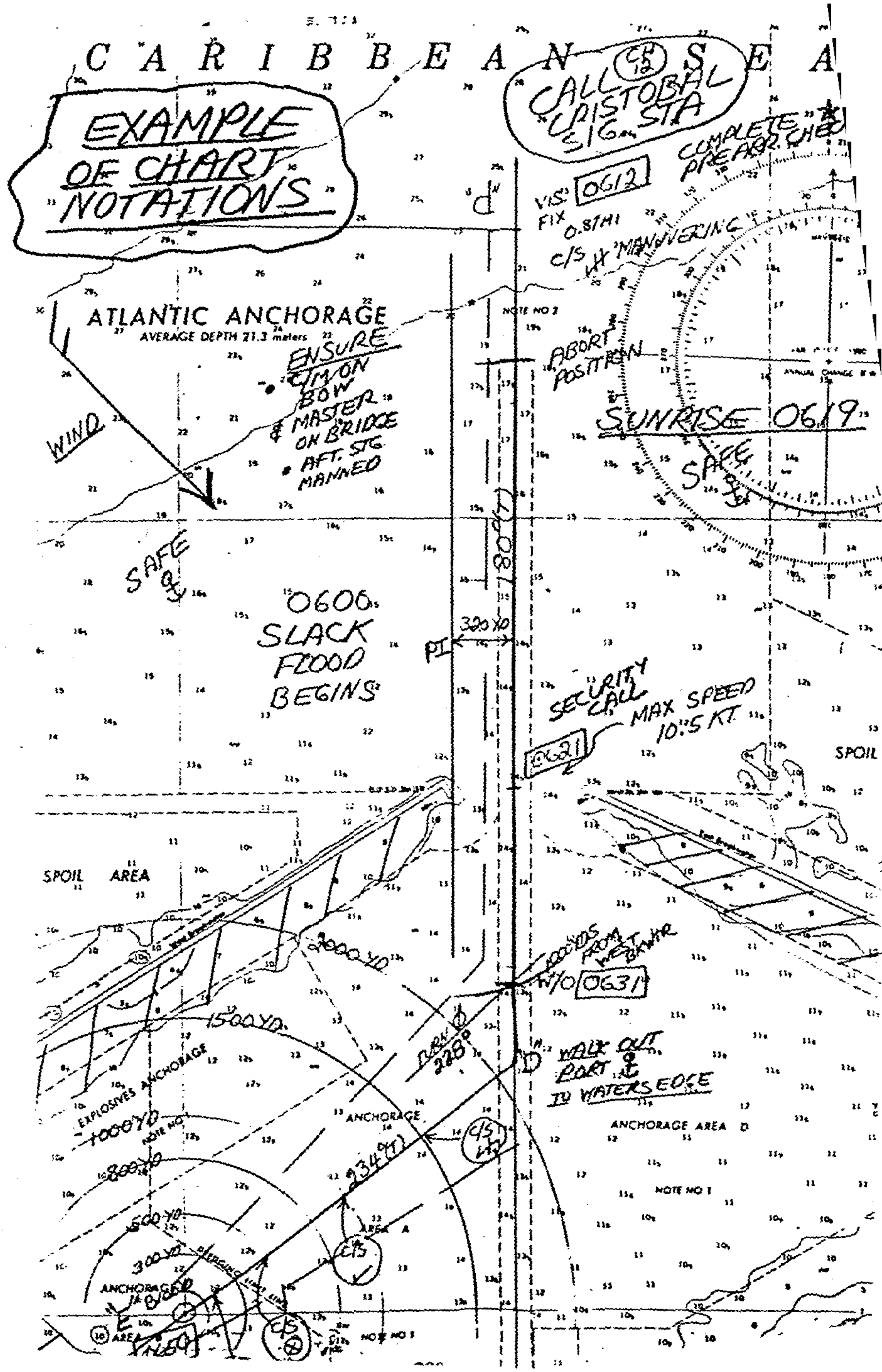
DATE 16 FEB 88 TEAM (A-1) SCENARIO ARR CRISTOBAL

EVALUATION CRITERIA	10 OS	9 VG	8 G	7 S	5 P	0 UN-SAT	Comments
1. RELIBILITY (In class on time & CAORF by0650)		✓					ARRIVED ON BRIDGE 5MIN PRIOR TO START
2. PREPAREDNESS (Fit & ready to assume duty)				✓			NAV. FORGOT BELL BOOK
3. PROFESSIONAL KNOWLEDGE (For duty assigned)	✓						
4. DECISIVENESS (Authoritative decision making)	✓						TOOK CHARGE OF WATCH
5. INITIATIVE (Self initiated activity)	✓						
6. FORCEFULNESS Takes charge to carry out duty)	✓						NO ONE WAS IN DOUBT WHO WAS W/O
7. JUDGEMENT (Sound, mature thinking)		✓					NO ABORT POSITION PLOTTED
8. COOPERATION (During debrief & with team members)			✓				A FEW EXCUSES BLAMED NAV.
9. RESPONSE DURING STRESS (Calm or Excitable		✓					
10. NAUTICAL TERMINOLOGY (Proper phraseology)				✓			POOR TERMINOLOGY IN LETTING GO ⚓
TOTAL	40	27	8	14			

GRADE (89)

Overall Comment (if any) OVERALL EXCELLENT FOR FIRST GRADING PERIOD

[signature]
Master Mariner


CARIBBEAN SEA
EXAMPLE OF CHART NOTATIONS
CALL CH 12 CRISTOBAL SIG. STA
COMPLETE PREARR. CHECK
VIS 0612
FIX 0.87MI
C/S MANEUVERING
ATLANTIC ANCHORAGE
AVERAGE DEPTH 21.3 meters
NOTE NO 2
ENSURE C/M ON BOW & MASTER ON BRIDGE
AFT. STG. MANNED
WIND
ABORT POSITION
SUNRISE 0619
SAFE
SAFE
0600 SLACK FLOOD BEGINS
180°(T)
300 YD
PI
SECURITY CALL
@0621
MAX SPEED 10.5 KT
SPOIL
SPOIL AREA
2000 YD
1500 YD
1000 YD
800 YD
600 YD
300 YD
600 YDS FROM WEST BKWTR
W/O 0631
TURN 228°
WALK OUT PORT TO WATERS EDGE
EXPLOSIVES ANCHORAGE
ANCHORAGE
ANCHORAGE AREA D
NOTE NO 1
234°(T)
C/S
AREA A
NOTE NO 3

APPENDIX IV

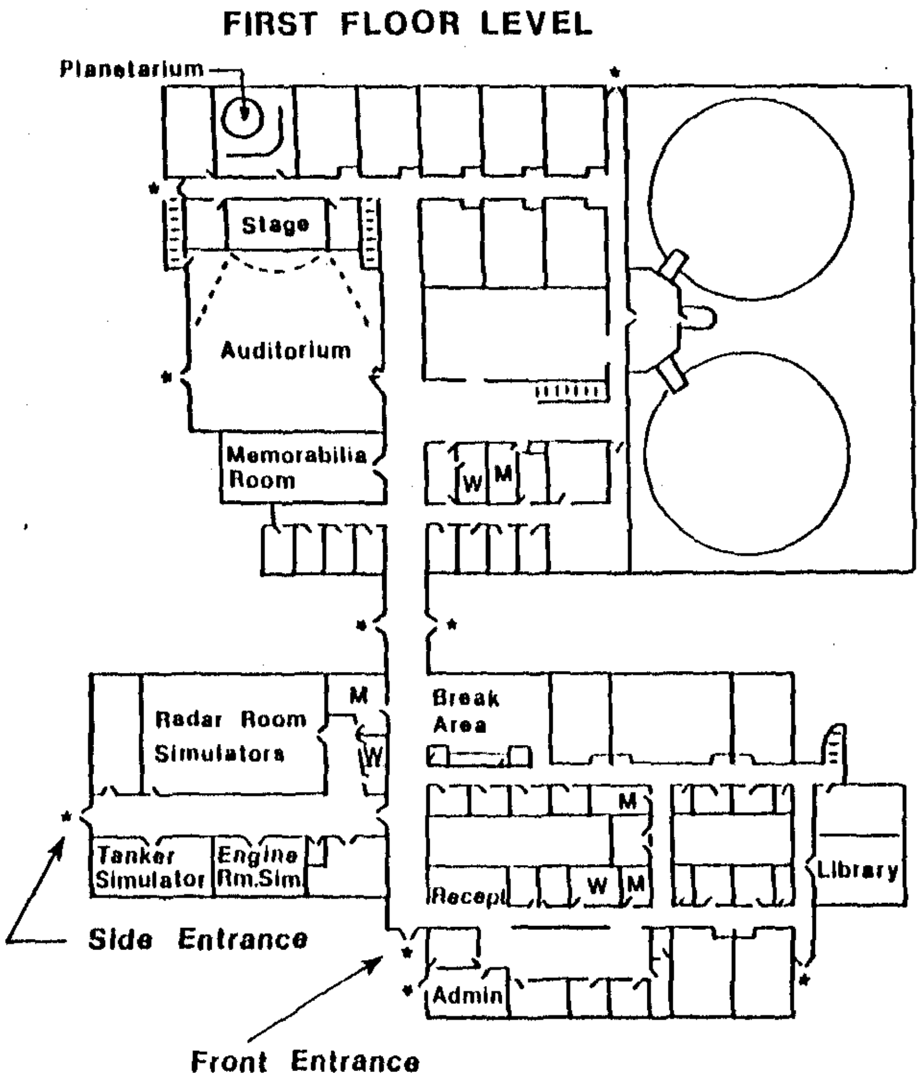
Maritime Institute of Technology and Graduate Studies

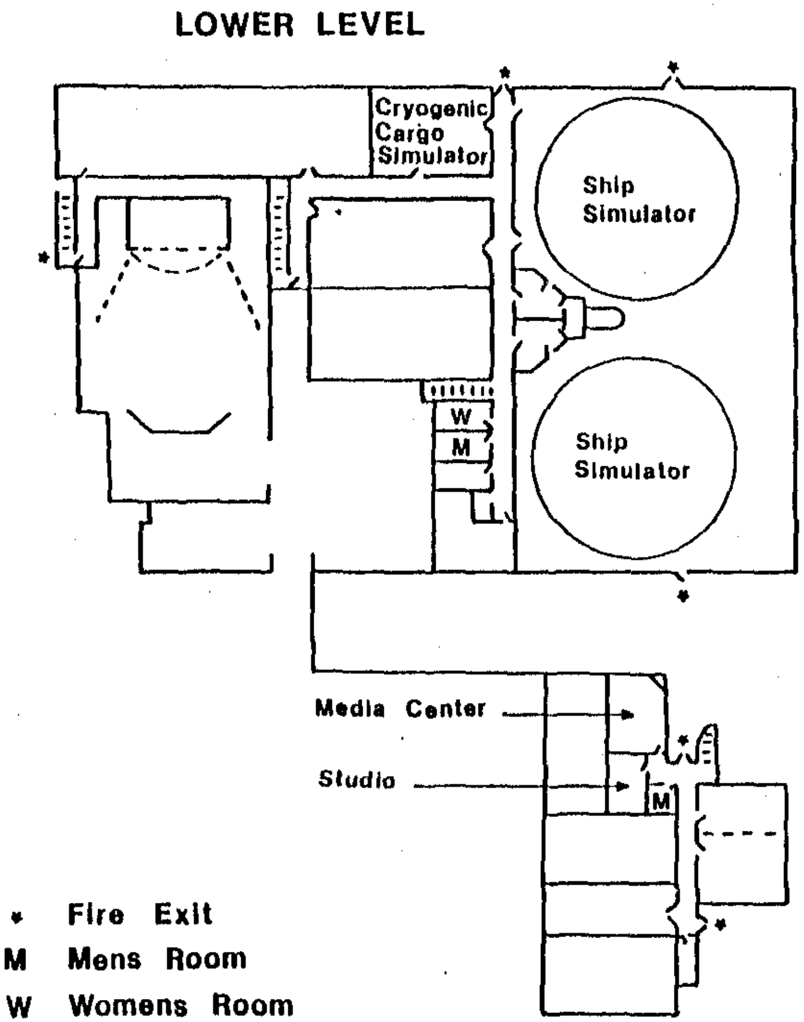
Situated at Linthicum Heights, Maryland

The following pages provide the following information:

- Floor plan of the academic building showing the situation of the various simulation facilities. (MITAGS publication).
- ARPA course schedule showing simulation times. (MITAGS publication).
- Simulation in process in the ship simulator with point lighting visuals and full motion. (MITAGS publication).
- Exterior view of the full motion ship simulator. (MITAGS publication).

ACADEMIC BUILDING FLOOR PLAN





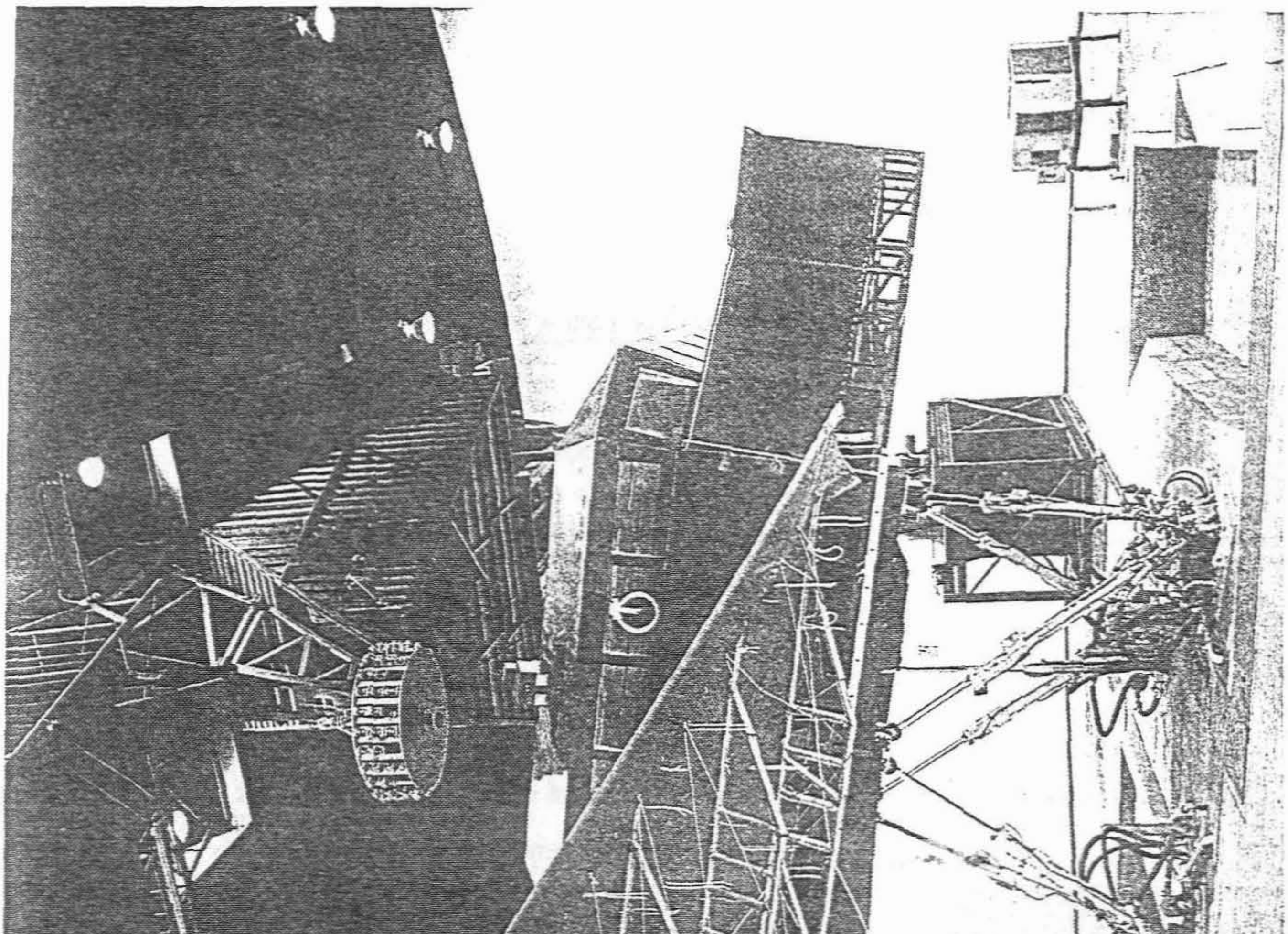
* Fire Exit
M Mens Room
W Womens Room

AUTOMATIC RADAR PLOTTING AIDS
MARITIME INSTITUTE OF TECHNOLOGY -- CLASS SCHEDULE

Session Number: **220-2** Dates: 12/2/91 - 12/6/91

Time	Monday	Tuesday	Wednesday	Thursday	Friday
0830 to 0930	Handout Materials, Explain Course Schedule, Explain Use of *Books*	ARPA Lecture VT-105[8] *Classroom*	ARPA Lecture Classroom	ARPA Lecture Classroom	VT-105[8] Classroom
0945 to 1030	RTM Plot Classroom	Introduction to *Machine* Simulator	Introduction *to Machine* Simulator	Introduction to *Machine* Simulator	ARPA Exercises Simulator
1030 to 1130	RTM Plot Simulator	Practice Tasks Simulator	Practice Tasks Simulator	Practice Tasks Simulator	Maneuvering TEST Simulator
LUNCH BREAK					
1230 to 1330	Collision Avoidance Maneuvers Classroom	*Practice Tasks* Simulator	*Practice Tasks* Simulator	*Practice Tasks* Simulator	*Written Test* Classroom
1345 to 1430	Collision Avoidance Maneuvers Simulator	Demonstrate Tasks Simulator	Demonstrate Tasks Simulator	Demonstrate Tasks Simulator	Test Review Classroom
1430 to 1530	↓	Avoid Close Quarters Using ARPA's Simulator	Avoid Close Quarters Using ARPA's Simulator	Avoid Close Quarters Using ARPA's Simulator	Critiques & Certificates
1530 to 1630	TEST Simulator	↓	↓	↓	
NITE *VIEW*		VT-105[8]	→	→	

Reference:	The Radar Book by Van Wyck & Carpenter pp. 1 - 34; DRM-RTM Plotting pp. 65 - 67; Tuning pp. 86 - 94; ARPA
MONDAY:	First Section of Homework Binder and material on ARPA assigned for Tuesday
TUESDAY:	(1) ARPA Manual, Bole & Jones Chapters 5, 6, and 7 (2) Homework Binder, material on ARPA assigned for Wednesday
WEDNESDAY:	(1) ARPA Manual Chapters 4 and 10 (2) Homework Binder, material on ARPA assigned for Thursday (3) Homework Binder, "Food for Thought" section
THURSDAY:	Study class notes, and review all material previously assigned.

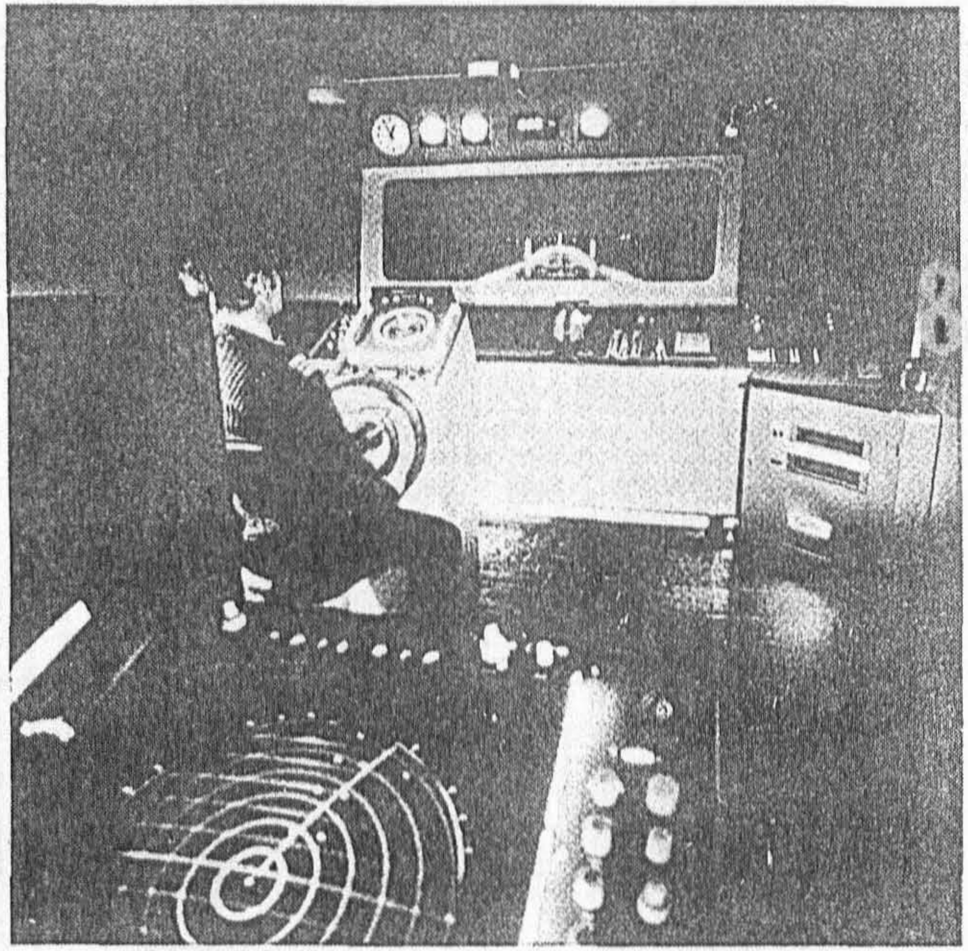


APPENDIX V

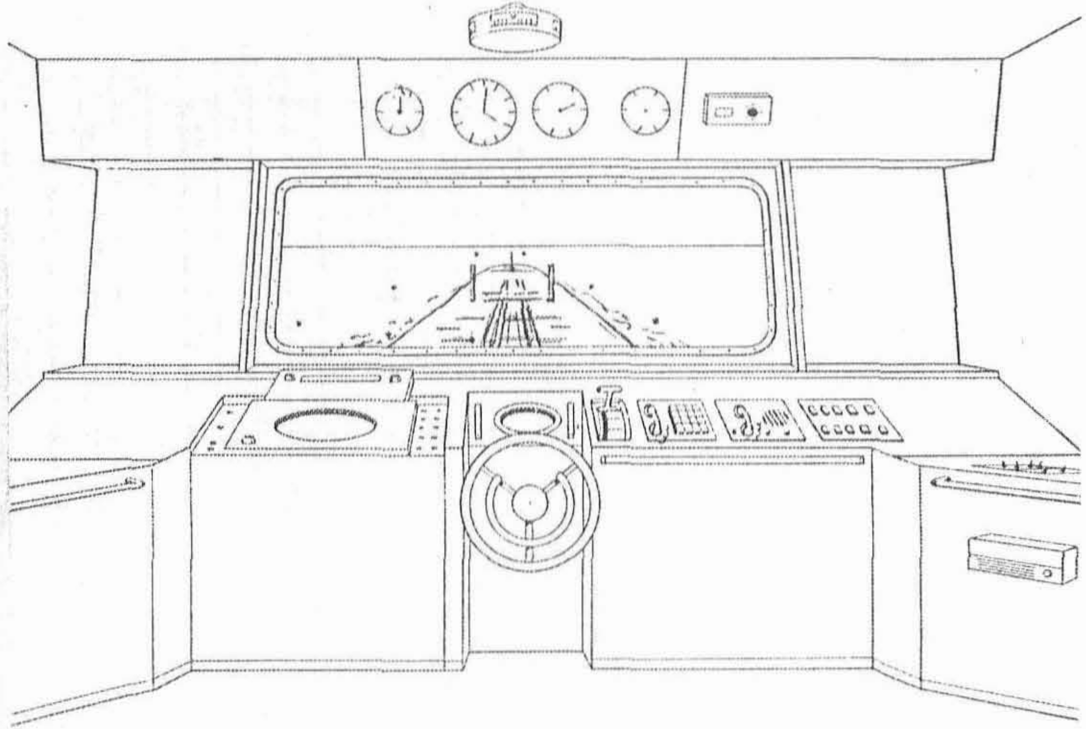
Glasgow College of Nautical Studies

The following pages provide the following information:

- Illustration of the bridge of the simulation facility. (Glasgow College of Nautical Studies publication).
- Instrument readout providing feedback from the simulation.
- Computer plot of vessel and target tracks during a simulation.



The Ship Simulator in action.



WHEELHOUSE

Principal Features:

★ Other ships and navigation marks in same exercise.

★ Approach channels of any length and complexity can be set up—no artificial restrictions on position of own ship.

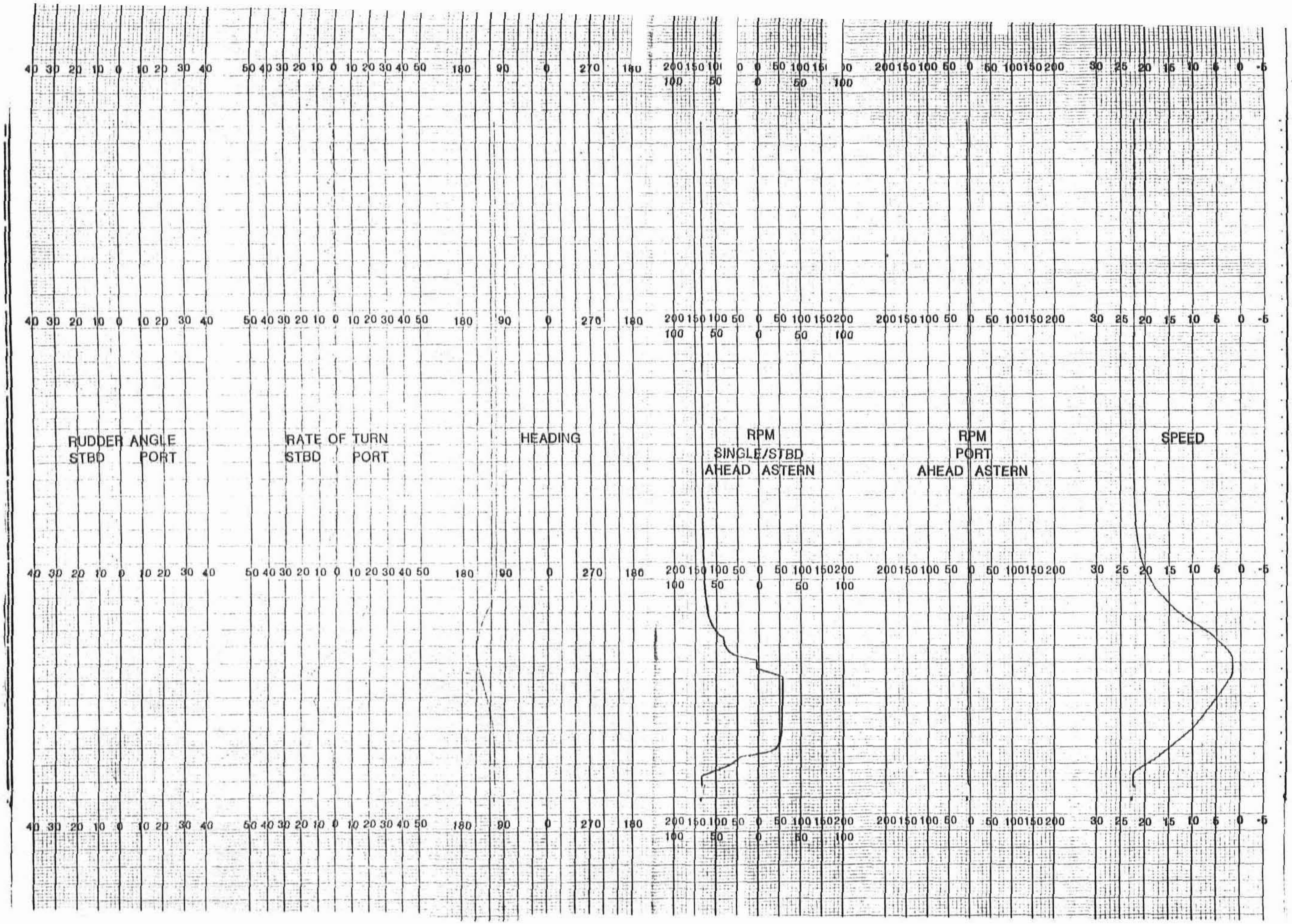
★ *Good model of own ship's manoeuvring* behaviour—*proper relation of* revs, rudder, draught, depth, lateral thrust, etc.

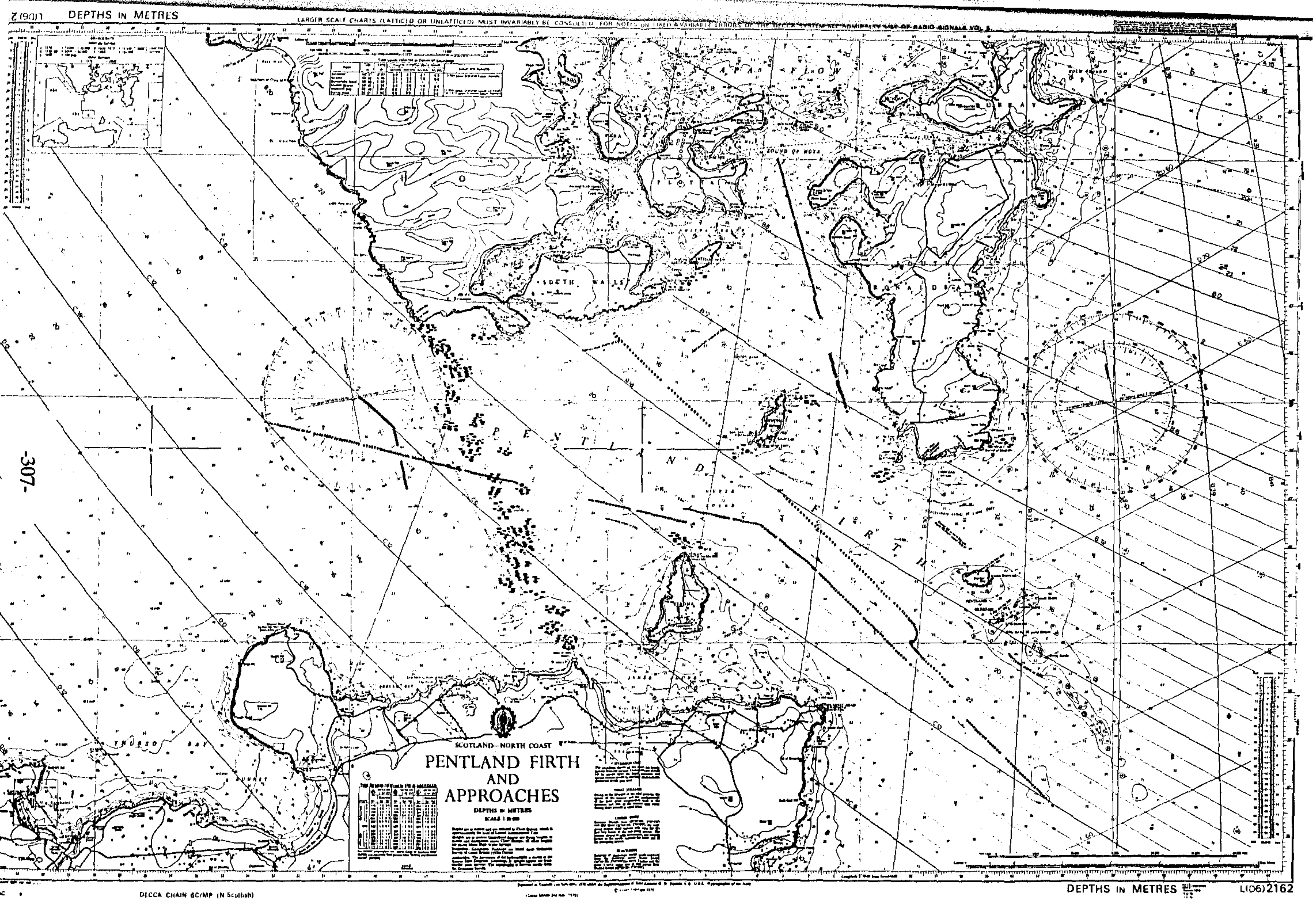
★ Exercise areas can be changed in minutes.

★ Visibility can be changed as required.

★ High degree of realism.

★ Design based on trials with experienced Masters and Pilots.


RUDDER ANGLE
STBD PORT
RATE OF TURN
STBD PORT
HEADING
RPM
SINGLE/STBD
AHEAD ASTERN
RPM
PORT
AHEAD ASTERN
SPEED


L(D6)2 DEPTHS IN METRES
LARGER SCALE CHARTS (LATTICED OR UNLATTICED) MUST INVARIABLY BE CONSULTED. FOR NOTES ON FIXED & VARIABLE ERRORS OF THE DECCA SYSTEM SEE ADMIRALTY LIST OF RADIO SIGNALS VOL 5
SCAPA FLOW
SOUND OF HOXA
SOUTH RONALDSAY
SOUTH WALLS
PENTLAND FIRTH
THURSO BAY
SCOTLAND—NORTH COAST
PENTLAND FIRTH
AND
APPROACHES
DEPTHS IN METRES
DECCA CHAIN 6C/MP (N Scottish)
DEPTHS IN METRES
L(D6)2162

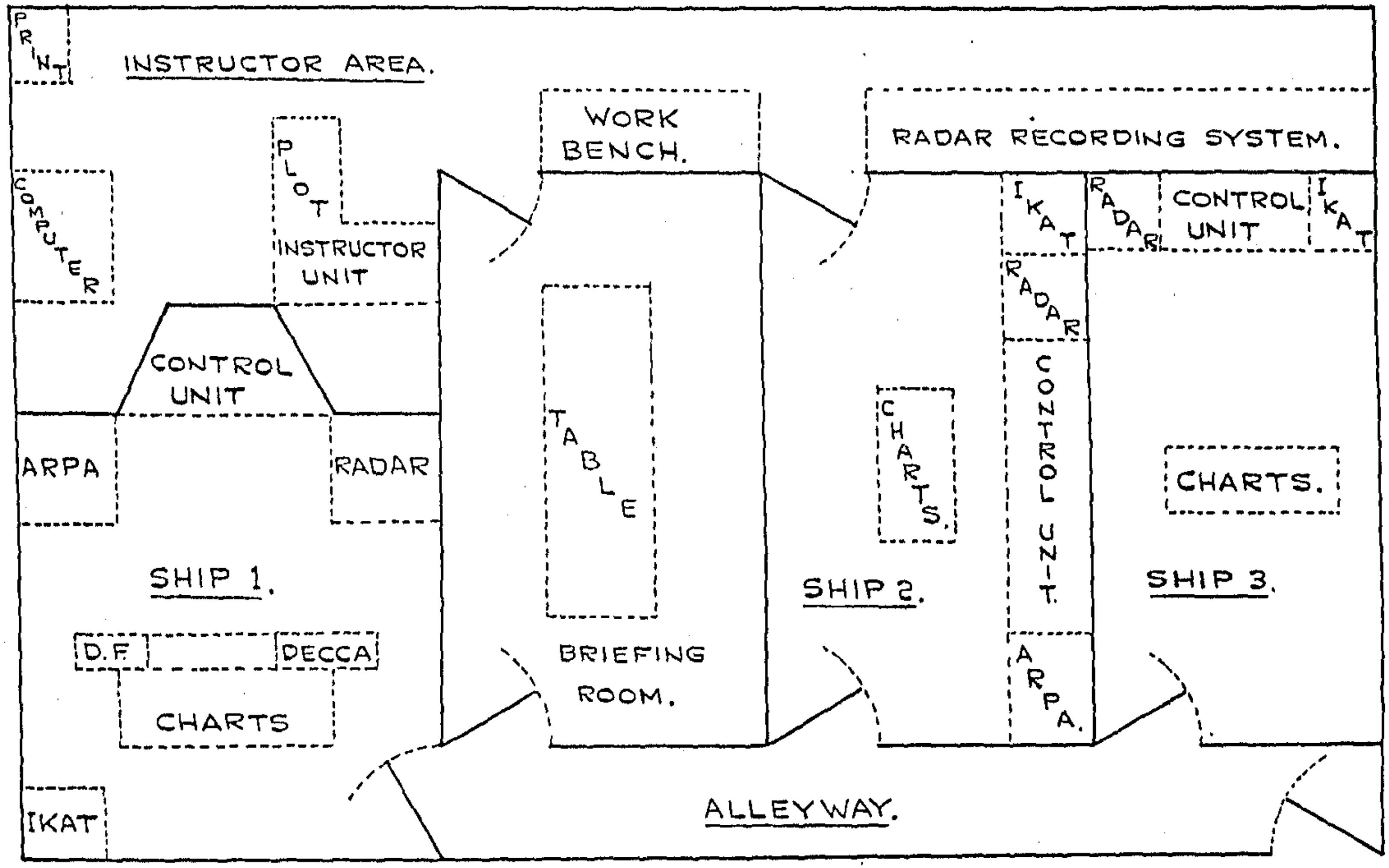
APPENDIX VI

Liverpool Polytechnic

The following page provides the following information:

- Floor plan of the radar simulation installation. (Bole, 1983:104).

  (Own Ship 1 has visuals).


PRINT
INSTRUCTOR AREA.
WORK BENCH.
RADAR RECORDING SYSTEM.
COMPUTER
PLOT
INSTRUCTOR UNIT
CONTROL UNIT
IKAT
RADAR
CONTROL UNIT
IKAT
RADAR
ARPA
RADAR
TABLE
CHARTS.
CONTROL UNIT.
CHARTS.
SHIP 1.
SHIP 2.
SHIP 3.
D.F.
DECCA
CHARTS
BRIEFING ROOM.
ARPA.
IKAT
ALLEYWAY.

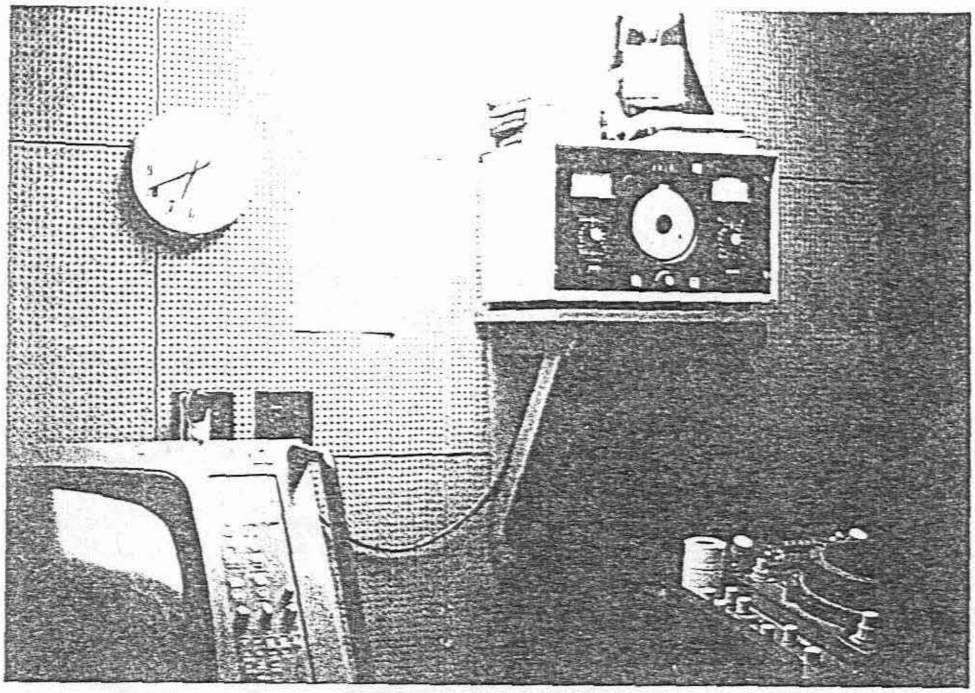
APPENDIX VII

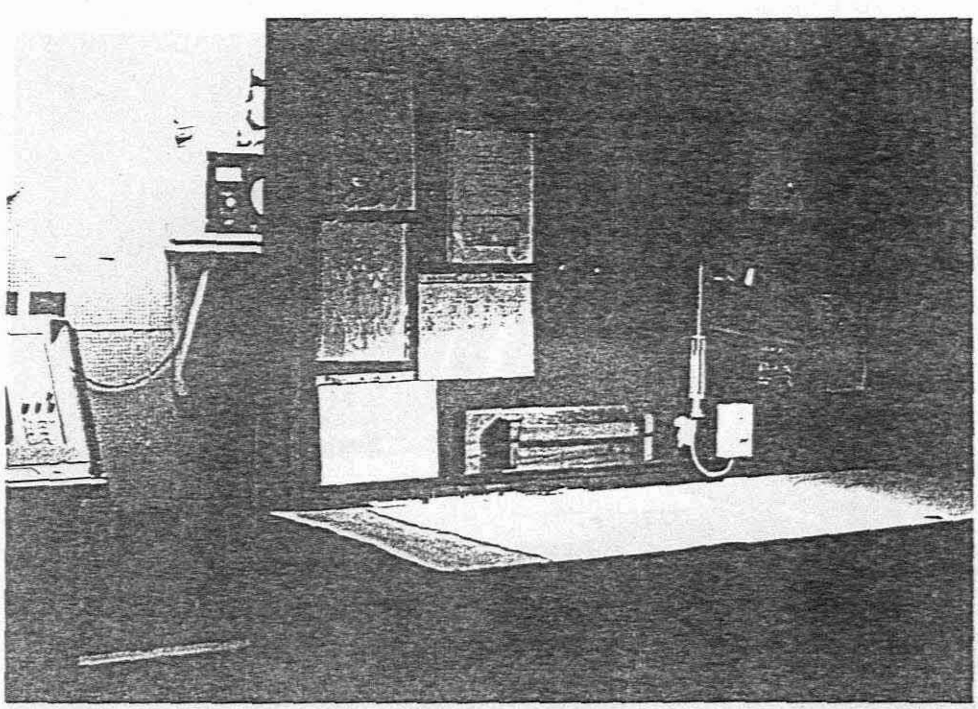
Cape Technikon, General Botha Campus, Cape Town

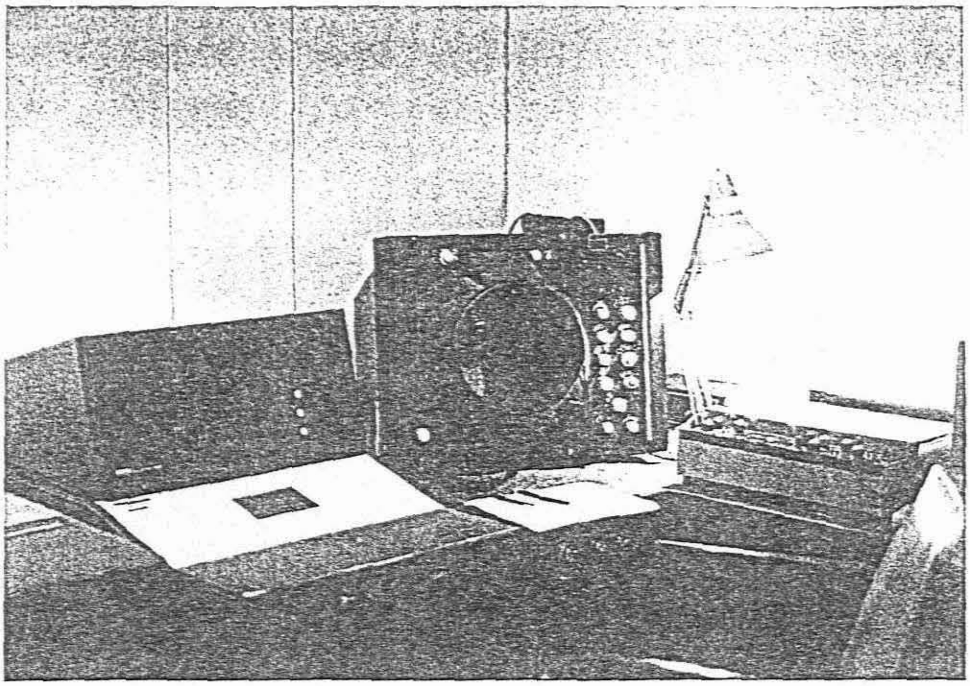
The following pages provide the following information:

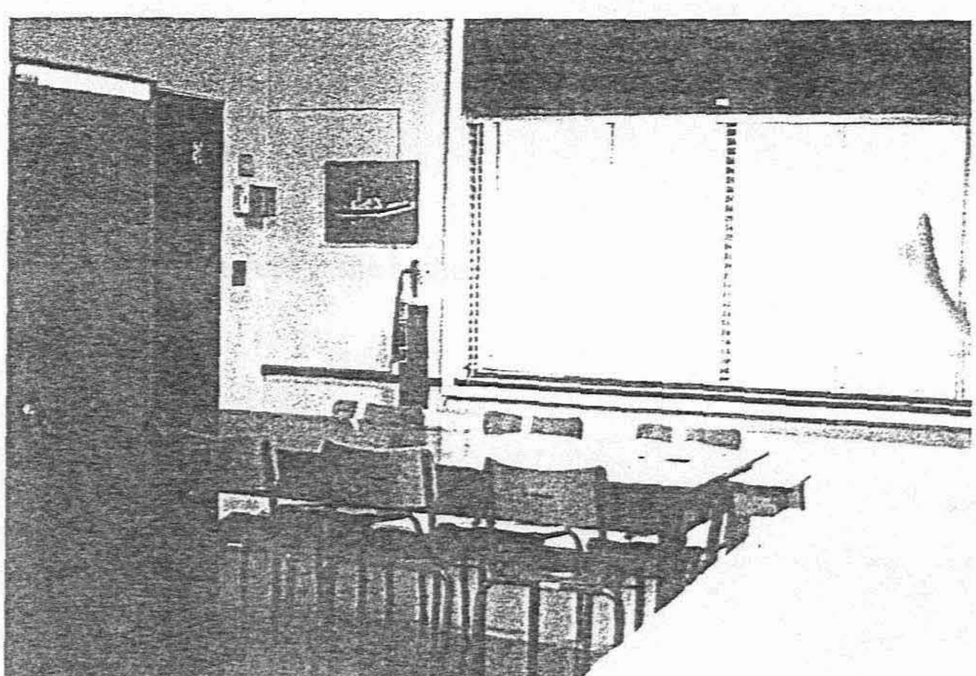
- Inside one of the smaller cubicles of the radar simulation facility.
- The chartroom just outside of the same cubicle.
- The control console of the bridge of own ship 1.
- Chart table and navigation instruments of own ship 1.
- Control station.
- Debriefing area.

(photography: the author).









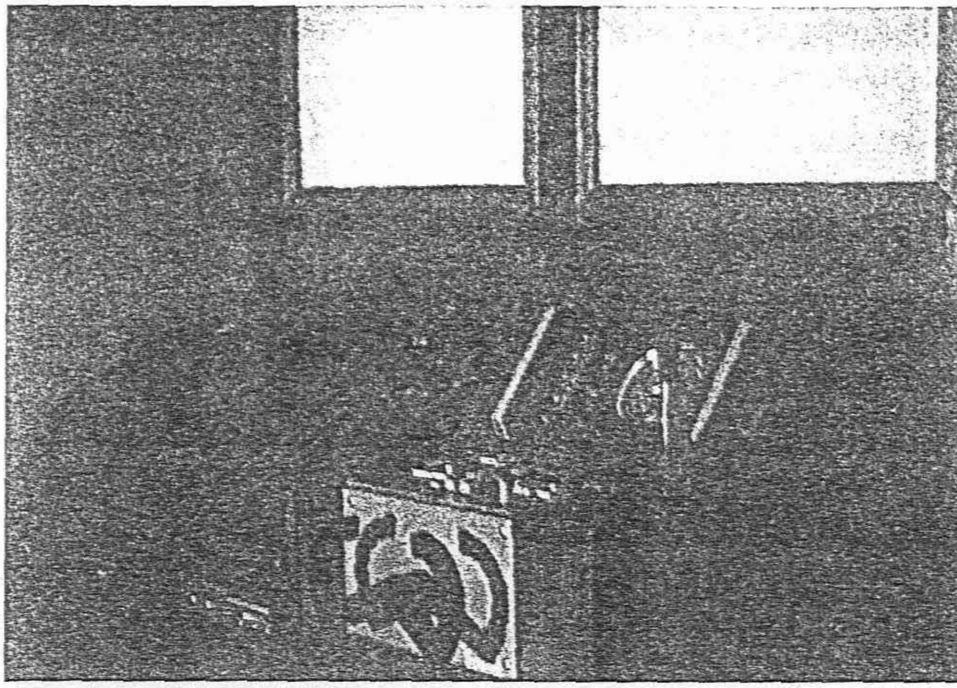
APPENDIX VIII

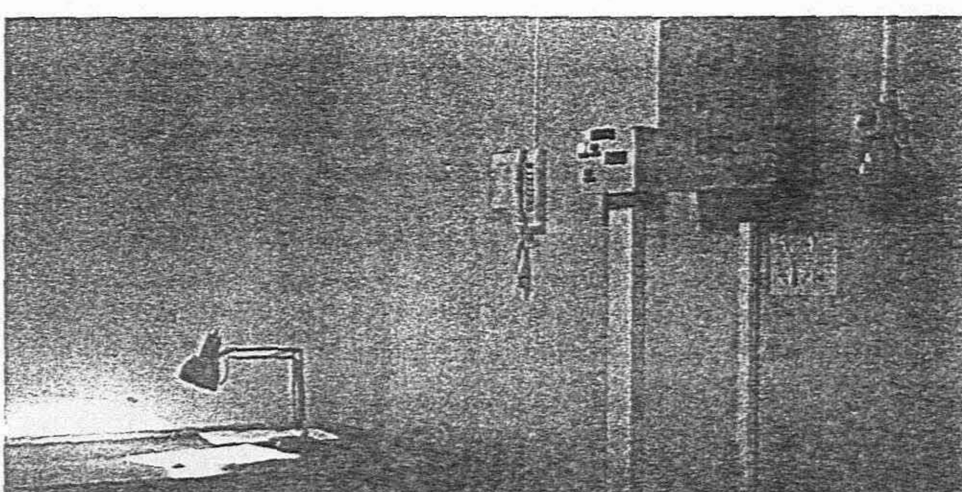
Training Centre for Seamen, Cape Town

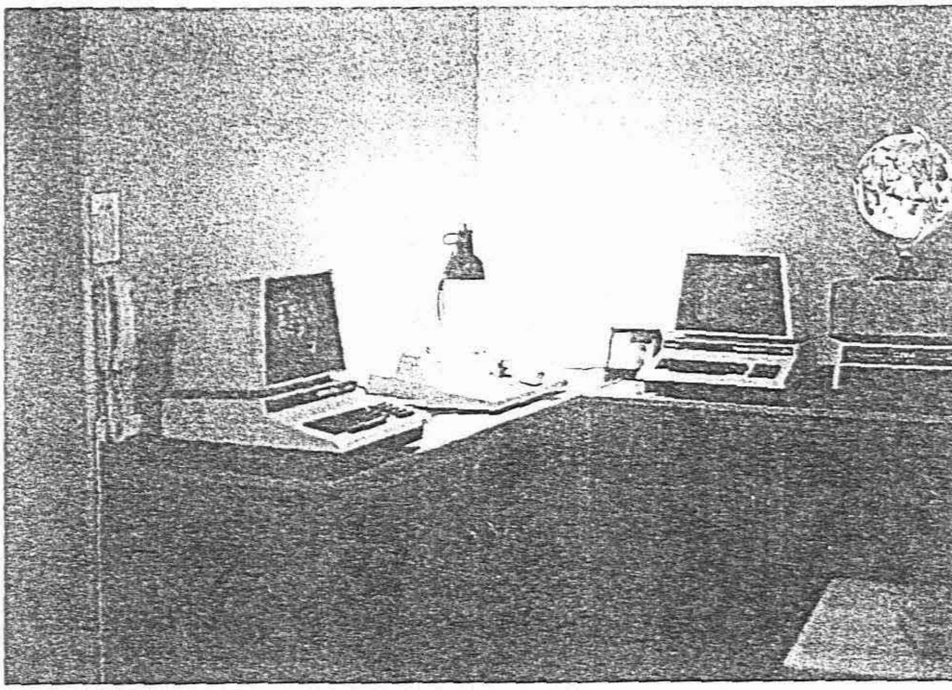
The following pages provide the following information:

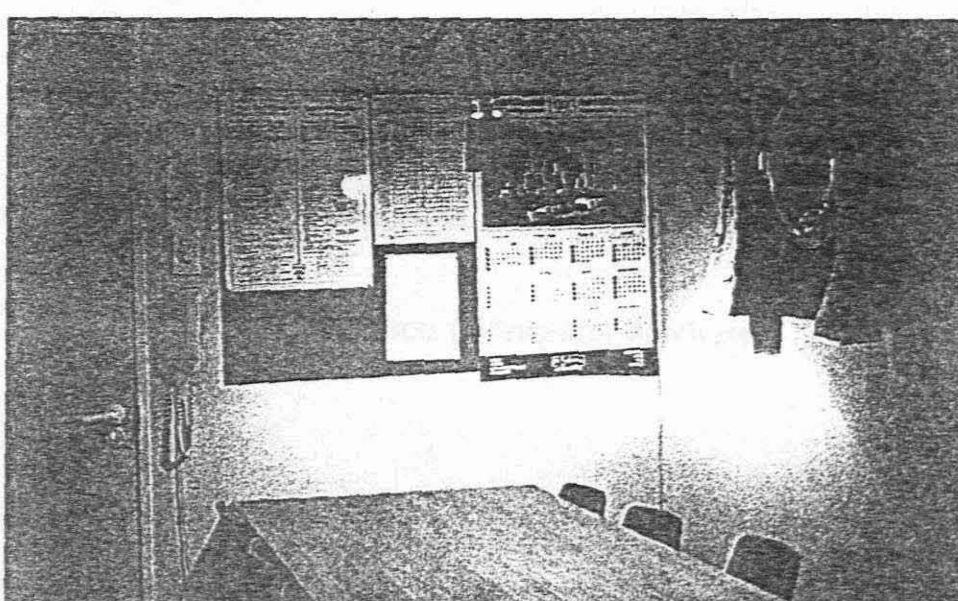
- Bridge console, own ship 1.
- Chartroom, own ship 1.
- Control centre.
- Debriefing area.

(Photography: the author).









APPENDIX IX

Miscellany

The following pages provide the following information:

- Link Trainer. (Bonanni, 1991:7).
- F-16 jet part task trainer. (Bonanni, 1991:14).
- Flight simulation in session. (Marine Safety International Brochure).
- A typical layout of a well planned radar and whole-task ship simulation facility. (Norcontrol Brochure).
- Typical Bridge simulation. (Norcontrol Brochure).
- Typical Control Station. (Norcontrol Brochure).

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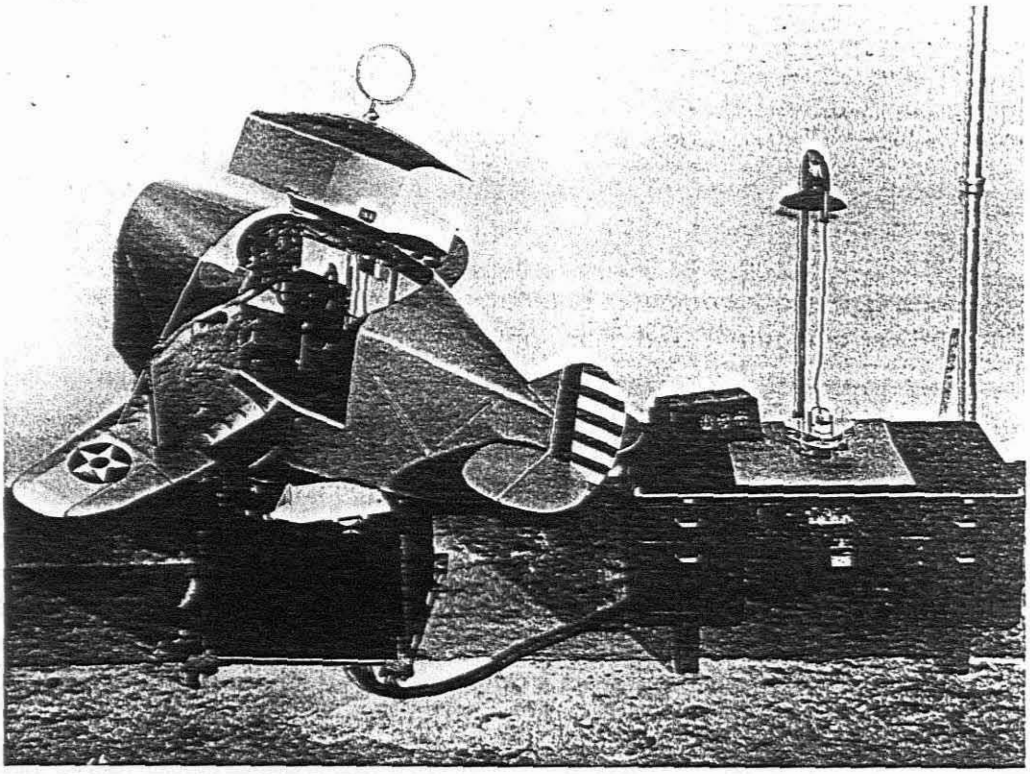
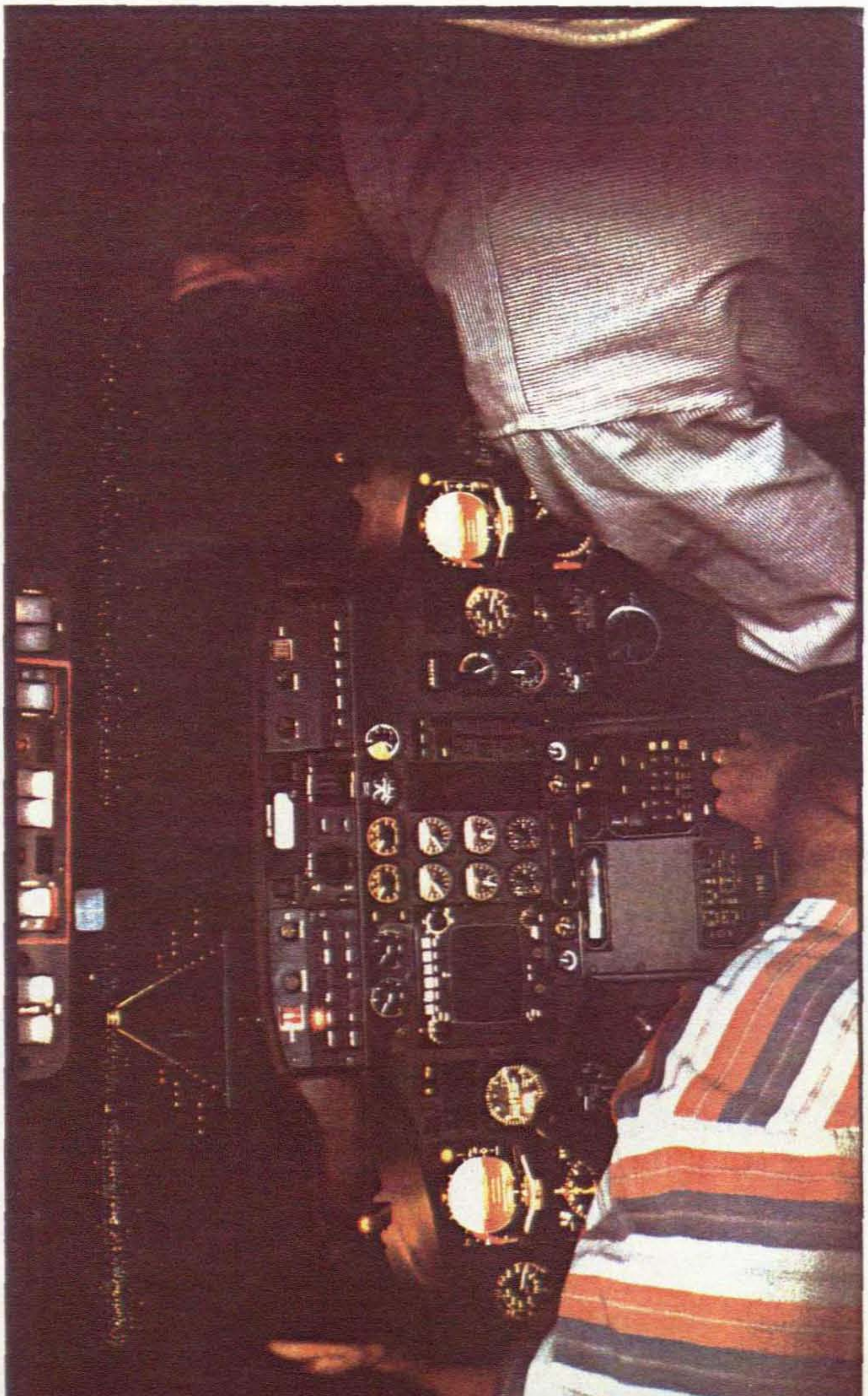
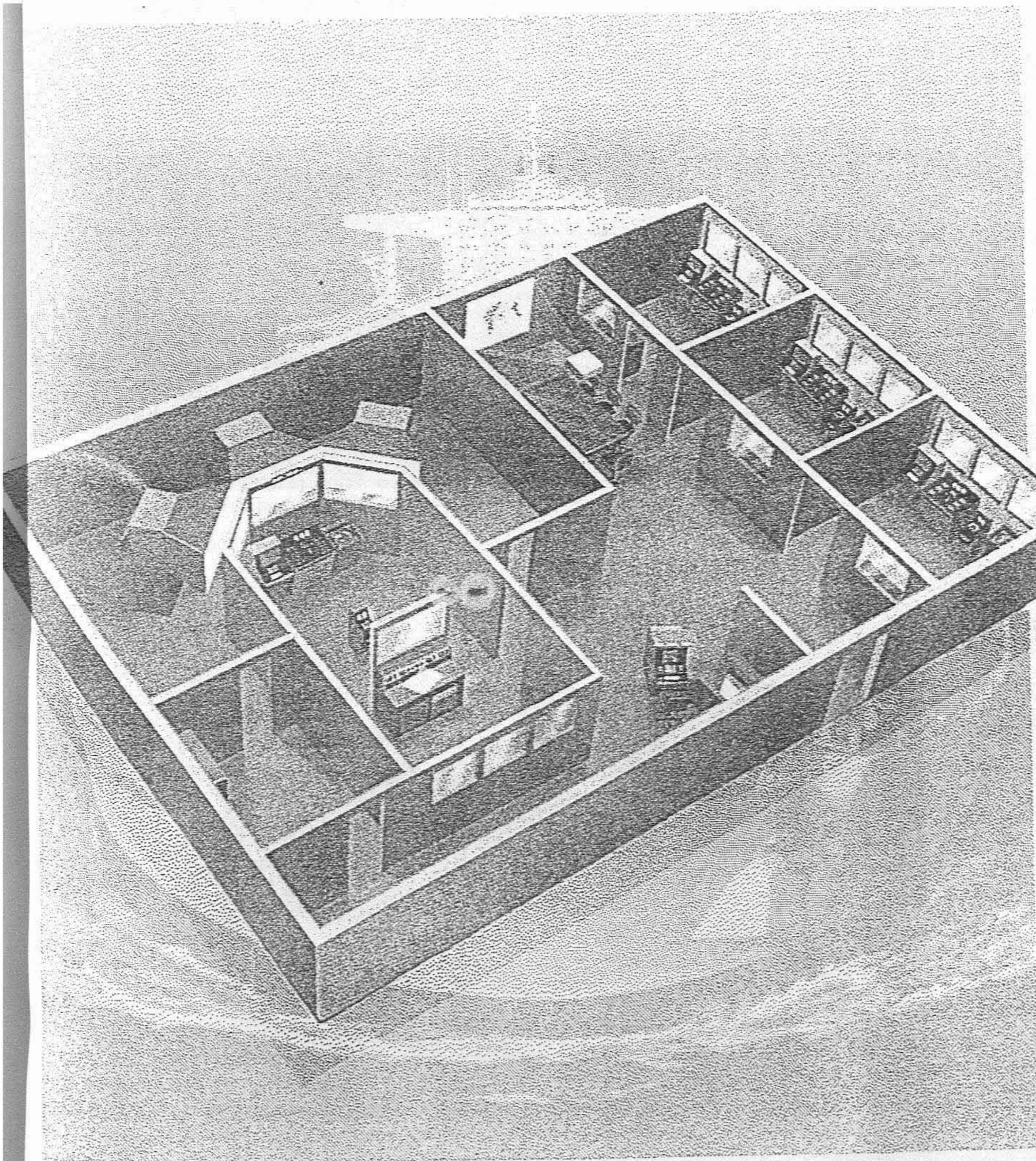


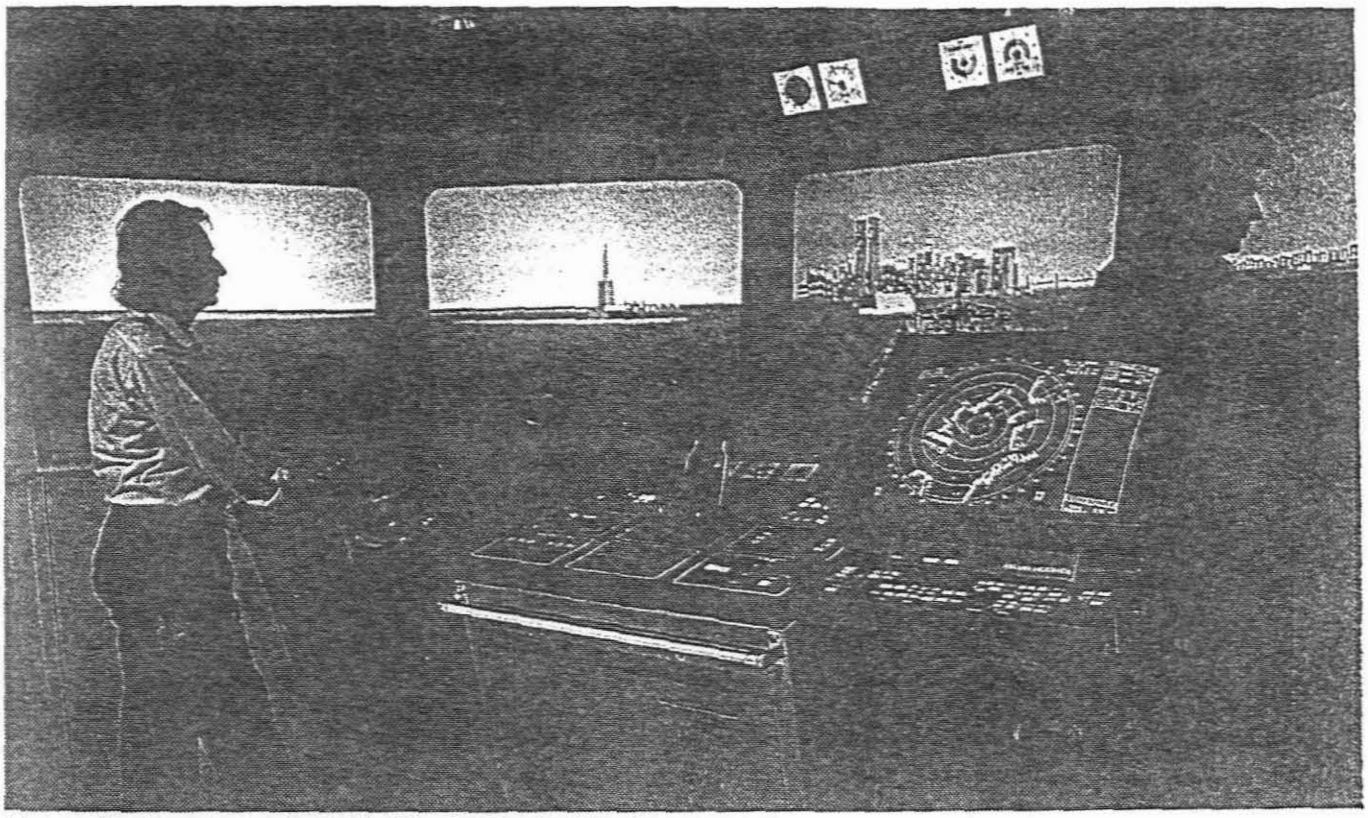
Link Trainer

F-16 PTT

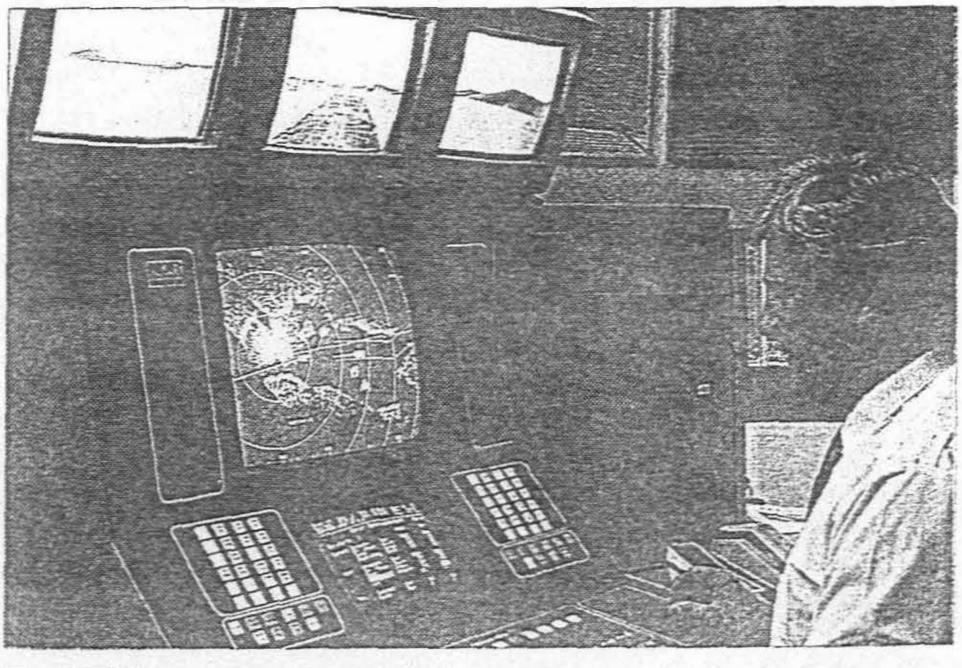




We offer a number of facility planning services to make sure your simulator fits your training requirements.



Mate and look-out preparing for docking in New York harbour.



Typical instructor stations