1998

The development of training and practice of navigation for advanced ships : application to merchant marine training centre programmes in Thailand

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WORLD MARITIME UNIVERSITY

Malmö, Sweden

THE DEVELOPMENT OF TRAINING AND PRACTICE OF NAVIGATION FOR ADVANCED SHIPS

Application to Merchant Marine Training Centre programmes in Thailand

By

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Thailand

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

MASTER OF SCIENCE

in

MARITIME EDUCATION AND TRAINING (NAUTICAL)

1998

DECLARATION

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

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

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ACKNOWLEDGEMENTS

For the successful completion of this dissertation, I am indebted to many individuals and organizations who have contributed in different ways.

I owe a large debt of gratitude to the Royal Thai Government and the office of the Civil Service Commission for granting me the scholarship, leading me to the successful completion of the two year post graduate course at the World Maritime University. Special thanks also goes to the Royal Thai Embassy in Sweden for supporting me during the period of study.

My sincerest appreciation to Lt.Jg. Wit Worakupt, former Director-General of Harbour Department and Lt. Vinai Chueysupakatu, Director of the Merchant Marine Training Centre for supporting and providing me with the opportunity for professional development. My sincere thanks also to Mr. Sukin Rattanasathein for encouraging me to attend this course.

I am extremely grateful to my course professor Peter Muirhead for his untiring supervision and professional guidance throughout the preparation of this dissertation and the period of two years study. I am also deeply indebted to the teaching staff of the World Maritime University, to all visiting professors, from whose profound knowledge I have gained and to the various organizations and institutions that I visited during my field studies.

Special thanks go to all staff of the World Maritime University for their help and assistance in many ways during my study. Particularly I wish to extend sincere thanks to the English lecturer, Inger Sund Battista and all library staff for their valuable contributions to the success of this work.

Finally, loving thanks to my wife, Netrnapa Tingmai for her encouragement, understanding and overwhelming support during the study period, without whom nothing is possible. I am also grateful to my parents and my sisters for bringing me the inspiration. My appreciation also goes to all whom I have not been able to mention in this paper.

Dedication: In memory of my grandmother

ABSTRACT

Title of Dissertation: **The Development of Training and Practice of Navigation for Advanced Ships: Application to Merchant Marine Training Centre programmes in Thailand**

Degree: **MSc**

This dissertation is a study of an advanced ship, focusing on the training needs for a navigation officer by taking into consideration technological advances, operational factors and human factors.

A short overview is given of current and future trends, and developments in modern technology in shipping including an advanced bridge in the form of an integrated bridge system. The role of the navigator, bridge operational procedures and conditions, and training needs are examined, taking into account manning and technological change that have taken place.

The required knowledge, skills and attitude for an operator of advanced ships are identified. The importance of Bridge Resource Management training is also discussed. The factors influencing the operation of the advanced ship under the concept of one man bridge operations are investigated. The results are evaluated to further improve the safe and efficient operation of an advanced ship.

Proposals and recommendations are made to improve the training programmes, technology and operations for advanced ships and to update the navigation training programme at the Merchant Marine Training Centre (MMTC). A number of recommendations are also made concerning the need for further study and investigation in the subject.

KEYWORDS: Advanced ship, Integrated Bridge System , One Man Bridge Operation, Technology, Training, Navigation

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LIST OF ABBREVIATION

AIS	Automatic Identification System
APP	Adaptive Auto-Pilot
ARPA	Automatic Radar Plotting Aids
BRM	Bridge Resource Management
CAL	Computer Aided Learning
CBT	Computer-based Training
COLREGs	International regulation for preventing collision at sea, 1972
COMOSS	Modernization of the Seafarers' System, Japan
DGPS	Differential Global Positioning System
DNV	Det Norske Veritus
DSC	Digital Selective Calling
DWT	Dead Weight Tonnage
ECDIS	Electronic Chart Display and Information System
EGC	Enhanced Group Calling
ENC	Electronic Navigation Chart
ETA	Estimated Time of Arrival
GLONASS	Global Navigation Satellite System
GMDSS	Global Maritime Distress and Safety System
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
IALA	International Association of Lighthouse Authorities
IBS	Integrated Bridge System
INMARSAT	International Maritime Satellite Organisation
INS	Integrated Navigation System
IMO	International Maritime Organisation
LANs	Local Area Network system

LEO	Low earth-orbiting satellites
MARPOL	International Convention for the prevention of Pollution from Ships, 1973, protocol 1978.
MASSTER	Maritime Standardised Simulator Training Exercises Register project
MMTC	Merchant Marine Training Centre, Thailand
MPP	Most Probable Position
MSC	Maritime Safety Committee
MSI	Maritime Safety Information
NACOS	Navigation Control System
NAV	Safety of Navigation sub-committee
NELS	Northwest European Loran-C system
NIS	Norwegian International Ship register
NTSB	National Transport Safety Board, U.S Coast Guard
OMBO	One Man Bridge Operation
P&I	Protection & Idemnity Club
RCDS	Raster Chart Display System
RNC	Raster Navigation Chart
ROTI	Rate of Turn Indicator
SCC	Ship Control Center
SOLAS	International Convention for the Safety of Life at Sea
SPS	Standard Positioning Service
STCW	International Convention on Standards of Training, Certification and Watchkeeping for Seafarers, 1978, as amended in 1995
TDMA	Time Division Multiple Access
TEU	Twenty equivalent unit
VMS	Voyage Management System
WWRNS	World-Wide Radionavigation System

CHAPTER 1

Introduction

1 Introduction

The demand for more cost effective operation of ships to increase the competitiveness in the international sea transport market and the increasing international focus on safety and pollution prevention, is the main driving force in the research and development of new technology of navigation and improved ship concepts. The latest innovations in computer technology and use of satellite communication systems open new possibilities to greatly enhance the efficiency and safety of ship operations.

Further, many efforts have been made to reduce manning on board by utilising automation and sophisticated technology. This has led to the introduction of the so called "advanced ship" under the concept of Integrated Bridge System (IBS) and One Man Bridge Operation (OMBO). As a result, more shipboard functions are allocated to the bridge and are expected to be handled by a single man on the watch in addition to his navigation tasks. These functions are greatly supported with the aid of a number of complicated computer systems.

With the rapid change of technology in the shipping world, it is obvious that the traditional procedures for navigation and other shipboard functions will be enormously affected. The role and function of a bridge operator will also be tremendously changed.

The author believes that the training and practice of navigation for an advanced ship need to be developed and updated in order to be compatible with the contemporary technical environment. Hence it is important to carefully examine what training is required for a navigator to be able to operate the advanced ship safely, efficiently and effectively. The author also strongly believes that there is an urgent need to update the training programme at the Merchant Marine Training Centre (MMTC) in Thailand to enable the Thai navigators to cope with the technological navigation changes.

The dissertation is part of the component required by the World Maritime University for the award of the MSc. degree in MET; therefore, the author decided to concentrate the present study on this field which is expected to contribute to the development of the world maritime education and training and particularly in Thailand.

The objective of the study

- To examine the current and future trends and development of advanced technology.
- To examine the impact of advanced technology upon bridge operational procedures and the role of a navigation officer.
- To investigate the factors influencing the safe and efficient operation of advanced ships under the concept of one man bridge operation.
- To examine and identify the training needs for an operator of advanced ships
- To consider the need to update navigation training programmes and to utilize modern technology to assist in training at MMTC.
- To make proposals and recommendations to improve and develop the training programme for an advanced ship's operator and to introduce a new navigation scheme to the Merchant Marine Training Centre.

Research method

The methodologies used to carry out the research of this study are as follows:

- a library literature search was made of recent publications, technical journals, books, conference papers, research and projects report, information via internet.
- valuable lectures delivered at World Maritime University by both resident and visiting professors.
- field trips to maritime institutions, organizations and industries in Germany, Norway, the United Kingdom and France.
- interviews and discussions with various visiting professors and experienced professional persons in this field.
- the antecedent academic and professional experience of the author gained prior to his enrolment at WMU, basically as a merchant marine officer, harbour inspector, nautical lecturer, co-ordinator of short courses and as an officer of a training ship.

Difficulties and limitations

- not having own experiences of the operation of advanced ships equipped with an integrated bridge system
- not having enough time to visit an advanced ship and to interview or discuss with the navigation officers.

The author believes that an opportunity to visit or to sail onboard an advanced ship and to gain more experiences from the integrated bridge simulator would have allowed this study to develop further.

CHAPTER 2

Current and future trends in the development of modern technology in the shipping industry

2.1 Introduction

During recent years there has been significant development of several advanced technologies in the shipping industry. Therefore, in this Chapter, the latest developments and their future trends will be described, particularly in the area of navigation systems, communications systems and ship control systems. In addition, comment on future pathways for navigation and performance of the navigator will also be discussed.

2.2 Navigation Systems

Bridge technology has recently been improved in many respects, namely: position fixing systems, traffic observation systems and ship handling systems.

2.2.1 Position fixing systems

Presently, two state-owned military-controlled global positioning satellite systems are offered for civilian use, free of charge, namely: Global Positioning System (GPS) and Global Navigation Satellite System (GLONASS). Both systems have been recognized by IMO as a component of the World-Wide Radionavigation System (WWRNS) for navigation use in other waters in accordance with the requirements of the Annex to resolution A.815(19).

Since the Global Positioning System (GPS) (which is operated by the US military), became fully operational in 1995, the standard positioning service (SPS) has been made available for civilian use. This provides 100 metres accuracy at the 95% level. The development of GPS has been extremely rapid during the past few years. More precise equipment is still being developed for a range of marine uses. The receiver can now operate on less than 10 metres accuracy or even down to centimetre accuracy by means of differential correction techniques known as Differential Global Positioning System (DGPS).

DGPS relies on the correctional values which are transmitted from a local reference station to mobile receivers within the area of operation in order to correct error signals received from satellites. Wide area DGPS is also being developed in the United States and Europe by using differential correction signals from recent Inmarsat III satellites.

GLONASS, which is managed by the Russian Federation Government, has been fully operational since 1996 with an accuracy of 45 metres (95%). Integrated receivers are also being developed to combine signals from GPS/GLONASS.

According to IMO Resolution A.860(20), adopted on 27 November 1997, both the GPS and GLONASS are expected to be available until at least the year 2010; the United States has promised to provide at least six years' notice prior to termination of GPS operation. However, the future Global Navigation Satellite System (GNSS) is currently being considered by IMO in order to supplement the existing systems. Much attention has been paid, as specified by IMO resolution A.860(20), on: Accuracy, Integrity of the system, Availability, Reliability, Coverage of service, Position fix update rate and Service capacity (see table 2.1).

Table 2.1 List of Minimum Maritime User Requirements For a Future GNSS

Parameter	Requirement
Accuracy of the system at the position of the receiving antenna -absolute accuracy -repeatable accuracy	 ≤ 10 m (95%) ≤ 14 m (95%)
Integrity of the system -time to alarm -threshold valve	 ≤ 10 s ≤ 25 m
Availability of service -threshold value	> 99.8 % (30 days) Unintended interruptions should not exceed 3 s
Reliability of service	≥ 99.97% (1 Year)
Coverage of service	world-wide
Fix (update) rate of the system	at least once every 2 s
Service capacity	Unlimited

Source: IMO document-Resolution A.860(20): Maritime policy for a future Global Navigation Satellite System (GNSS), 1997.

For the recent development of terrestrial radionavigation systems, as reported by IMO (NAV42/7/9, 1996), the Northwest European Loran-C System (NELS) is being established by the agreement of five European countries namely France, Germany, Ireland, the Netherlands and Norway, with the purpose to complement the US military-controlled GPS system. The NELS will cover from northern Norway to the east coast of Canada, including the North Sea and the Bay of Biscay. The civil-controlled LORAN-C and LORAN-C/CHAYKA networks are also being set up in the Far East.

On the other hand, some existing systems are expected to be terminated. DECCA will be phased out in many countries by the year 2000. The US-controlled LORAN-C networks are under consideration for phasing out by the year 2000 and the Russian Federation-controlled CHAYKA network is expected to terminate after the year 2010. OMEGA was recently phased out in 1997.

2.2.2. Traffic observation systems

Over the past few years the electronic chart has emerged as a very promising aid to mariners. Today, two different types of systems have been developed: a Raster Chart Display System (RCDS), which is used for displaying a raster navigation chart (RNC). RNC is derived from the scanning of paper chart. It is by no means just an electronically stored photograph of the paper chart. After having serious controversy for a number of years, RCDS has been finally approved by IMO for officially using on board (NAV44,1998).

The other system is Electronic Chart Display and Information System (ECDIS). ECDIS is used for displaying an electronic navigational chart (ENC) or a vector chart. ENC is derived from vector databases which are formed by digitizing features as points, lines and polygons with descriptive information tied to the feature.

ECDIS is accepted as equivalent to the paper charts required by Regulation V/20 of SOLAS 1974. The performance standard for ECDIS has been set up by IMO (A.817(19), 1996). This has a lot of new features added which can greatly enhance safe and efficient navigation, as follows:

- Own ship's position can be added to the chart in true motion.
- The radar/ARPA image can be overlaid on the ECDIS display.
- ECDIS also provides supplementary information such as sailing directions, list of lights, tide, buoy.
- ECDIS can be selected by the navigator to show just the vital information for safe navigation
- The electronic chart can be displayed in the different scales (zooming).
- Chart updates (notice to mariners) can be done automatically in several ways such as diskette, CD-ROM or via satellite.

It is obvious that ECDIS is a real time, automated decision aid when combined with accurate position fixing systems such as GPS/DGPS and superimposed with Radar/ARPA, which enables ECDIS to continuously determine a vessel's position in relation to land, charted objects and surrounding environment and to facilitate the determination of the appropriate course of action to avoid collision. Furthermore, it has the capability of providing audio and visual warnings to the mariner of real and potential dangers in time to take corrective action such as off track alarm, crossing the ship's safety contour alarm and entering dangerous or prohibited area alarm.

ECDIS is regarded as the key element for the implementation of many of the emerging bridge technologies particularly integrated navigation and bridge systems more details of which will be discussed in a later chapter.

Due to rapid development in technology, microprocessors and software technology are now used in Radar/ARPA systems, Auto pilot, Doppler log and other bridge systems that would contribute to improved operation of ships in terms of performance, economic efficiency and safety.

Many modern Radar/ARPA are now offered with advanced digitized video processing to ensure clutter suppression, especially at short ranges where performance is of particular importance and capable of automatic tracking up to 50 targets. The increase of antenna rpm rate has been introduced to allow rapid picture update. Moreover, the advanced touch screen technology is employed in Sperry Radar/ARPA, which allows the user to operate the system by the touch of a finger.

2.2.3 Ship handling systems

The modern type of automatic steering system or autopilot system known as "Adaptive Auto-Pilot" (APP) has been developed to increase the efficiency and accuracy of steering by adding a digital control system (microcomputer) containing ship's characteristic and environment effects data; thus, enabling steering control to be optimised. Calcutt and Tetley (1991) comment that the APP has been produced to improve fuel economy and maintain safe pilotage where minimized course-track error is required.

As the size and draught of ships have been dramatically increasing, greater difficulty in manoeuvring has been encountered by the navigator. It is essential that the accurate speed of a ship is known for the purpose of safe handling. Today, the Doppler log is made available for measuring the ship's speed with high precision, together with the development of the Rate of Turn Indicator (ROTI) which is designed to indicate the rate of change of a ship's heading in degrees per minute or second. From the experience of the author, the combined use of Doppler log and ROTI are very effective tools for controlling a turn especially in confined waters.

2.3 Communications systems

2.3.1 Present and future prospects of maritime communications

The tremendous revolution in maritime communications was sparked by IMO's introduction of the Global Maritime Distress and Safety System (GMDSS) that entered into force from 1 February 1992 and will be fully implemented on 1 February 1999.

The equipment required by GMDSS forms the major part of a ship radio station with the capability of handling several new kinds of communications. GMDSS will therefore not only change and improve distress and safety communications for shipping worldwide, but will also have a very strong impact on both commercial and social communication on board. Commercial communications will be faster and more reliable in both the ship to shore and the shore to ship directions and the increased utilization of satellite communications and digital selective calling (DSC) enables a ship to be operated more safely and efficiently and enables personnel on board to keep in touch with the world outside.

Many shipowners today are looking at GMDSS as the basic requirement for their vessels' communication capabilities and are then looking further to decide what is needed in addition to the GMDSS equipment in order to enhance the communication between their vessels and offices.

2.3.2 Recent developments in maritime satellite communications

As is widely known, the International Maritime Satellite Organization (Inmarsat) plays a crucial role in GMDSS. A ship fitted with a satellite communications facility acts as a ship earth station operating within the Inmarsat communications network and has the capability of two-way communications with any point on the globe covered by Inmarsat satellites through various land earth stations.

The recently launched new generation of Inmarsat-3 satellites is eight times more powerful than the previous generation of Inmarsat-2 satellites and provides the extra capacity and concentrated spot beam power needed for expanding the range of mobile multi-media services. A key feature of the Inmarsat-3 satellites is their ability to focus power on particular areas of high traffic. Recent advanced services have been made available in cellular system such as Internet, E-mail. Higher data speeds for mobile multimedia applications enabling more capable office connectivity, broadcast audio and video will be available early in 1999 (Lloyd's list,1998, 5). Inmarsat's third generation also supports a navigation capability designed to enhance the accuracy, availability and integrity of GPS and GNSS.

The recent introduction of low earth-orbiting satellites ('little LEOs') marks a new phase in low cost communications technology in the shipping industry, being exploited by various companies for data communications services. The latest emergence of the other LEO satellites ('big LEOs') offers the first hand-held satphones by iradium system (starting this September 1998). Its effect will be enormous and will completely revolutionise communications at sea. Seafarers with a simple hand-held phone will be able to make a phone call to anywhere in the world at relative low cost and with a convenience.

Other satellites such as Globalstar, Odyssey and ICO will be ready in service over the next 2 years. A further development called the Teledesic system (internet in the sky) will use 288 satellites that will allow seafarers to roam the Internet (Muirhead, 1998).

The utilization of satellites for maritime communications and information technology (IT) can be summarised as follows:

(A) Safe navigational aspect

As mentioned earlier Inmarsat forms the important element of the GMDSS. Inmarsat provides ships fitted with satellite communications equipment with a means of distress alerting and a capability for two-way communications using direct-printing telegraph and radiotelephone. Maritime safety information (MSI), including navigational warnings and meteorological warning and forecasts and other urgent safety information, is made available for ships by broadcasts via the Inmarsat enhanced group calling (EGC) system known as "the international SafetyNET system". (Wortham, 1997).

During the last five years, there has been a technical revolution in the weather routeing business. Several commercial companies are now able to transmit the weather forecast data to their client vessels via satellite. The data then can be downloaded to the vessel's computer within 3 minutes allowing the master to decide the best route for a ship to take with timely weather information.

(B) Commercial aspects

As stated by Favre in Oceanvoice (1996,17) :

> Merchant vessels as fully featured floating offices, equipped with integrated onboard computer and communications networks, inter-connected into corporate, regulatory and associated land-based office systems are not an option, they are destined to become a necessary fact of shipping life.

The growth in ship/shore communications infrastructure is emerging to become a vital management tool in the shipping world. The proliferation of advanced computer hardware/software and use of satellite communications systems provide an effective information technology on board which are utilised for remote monitoring vessels and cargo in real time from the shore and improve vessel operation and maintenance by increasing closer co-operation with equipment suppliers, classification societies and other authorities concerned (i.e vessel traffic service, maritime safety authority).

(C) Educational and recreational aspects

The nature of seafarers' working lives has changed so much in recent years with longer tours of duty, smaller crews and quicker turn around times in port such that their isolation from the rest of the world and society has increased. Fortunately, the Internet and E-mail can now be accessed from ships at sea via satellite, which enables seafarers to be in contact with the outside world and have up to date news.
There are also potential benefits for at-sea training and education by distant learning. Shipping companies should realise that access to Internet for education can improve crew's skill and knowledge and access to Internet for entertainment can keep the crew happy which will contribute to safer operation of a ship.

Satellite communication is still relatively expensive to use, however the costs have been coming down and will continue to decrease as the medium is increasingly used in the near future.

2.3.3 Automatic Identification System (AIS)

There is currently much interest at IMO in a new navigation aid known as the Automatic Identification System (AIS). The concept is that a vessel will carry a transponder which is capable of providing and receiving information automatically to or from authority (e.g. vessel traffic service), other ships and other sources. As specified in the IMO performance standards for AIS (NAV/43/WP.2,1997), such information will include vessel name, type, position, course, heading, speed, intentions, navigational status, ship's draught, cargo type and short safety related message.

The primary aim of AIS is to improve ship-to-ship communication for collision avoidance aspect and ship-to-shore communication for efficient managing and monitoring traffic aspect with the minimum involvement of ship's personnel.

Currently, as reported in the article of Fairplay solution (October 1997, 6) four systems of AIS being developed are GP&C Sweden's 4S transponder, Digital Selective Calling (DSC) equipment favoured by the UK, a high speed DSC system proposed by the US and a Time Division Multiple Access (TDMA) system, developed in South Africa .

AIS can be superimposed on the Radar display and ECDIS which will enhance the capability of the navigator in traffic monitoring. AIS has a high possibility of tracking and identifying other ships which are hidden from radar view and displaying details on the Radar or ECDIS. Undoubtedly, the AIS will also solve the inherent problem with all radars, by detecting smaller ships or fishing boats fitted with AIS, in sea-clutter and in heavy rain. It can be said that AIS is dramatically improving the communication quality between ship to shore and ship to ship.

2.4 Ship Control Systems

With the present advancements in technology, it is possible that a ship can be controlled automatically on a pre-planned route without human interference, except only for course change acknowledgments.

With the availability of various high accuracy and efficiency navigation aids on the bridge supported by increased integration and automation, the navigator today is able to carry out voyage planning, monitoring and execution effectively and simply. Once the voyage plan has been created, it can be presented on the ECDIS which, interfaced with position sensing equipment such as GPS/DGPS and other navigation sensors, allows the navigation computer to compare the actual progress versus the plan while the ship is underway. It can calculate for instance, off-track errors, heading-to-steer, distance to go, estimated time of arrival (ETA).

Once such information is known, the next logical step is to allow the ship to be piloted by the so called *Track control system.* Its basic principle is that the system sends commands to the autopilot to keep the ship on a pre-planned track under various conditions and within the limits related to the ship's manoeuvrability. Before arriving at any wheel over point near the waypoints, the system will alert the operator to confirm the course change, then the turn will be executed automatically according to the pre-planned track. The speed of the ship can also be controlled automatically by means of an interface with the engine automation system which can ensure that the ship arrives on schedule and with optimum fuel consumption.

2.5 Future pathways for navigation and performance of the navigator

Traditionally, navigation has been seen as an *art* which heavily depends on personal skill; today this concept is changing to one that accepts that navigation is the application of *science*, the present nautical environment being heavily based on a number of automation based decision making aids for ship navigation and piloting. Today's navigator is provided with sufficient accuracy and real-time navigation information through an electronic display, which in earlier times was very much reliant on his subjective and intuitive perceptions.

In the changing technological world of today, it is apparent that the traditional procedures for navigation and ship-handling will be affected and need to be improved upon in order to be compatible with the contemporary technical environment. The factors influencing change to the role of master and watchkeeper can be summarized in the figure below:

Technological Advances

- **Design, Size, Speed of ship**
- **Automation**
- **Navigation accuracy**
- **Satellite communication**
- **Reliability of equipment & machinery**
- **New materials for maintenance**
- **Port/ship cargo handling facility**
- **Increased traffic control**
- **Faster port turn around**

Changing roles & skills

- **Communication & Computing**
- **Data information processing**
- **Smaller crew-multi skilling**
- **Less time for on board training**
- **Traditional seamanship skills?**
- **Handling emergency procedures**
- **New training needs ?**

Figure 2.2 Technical advances-Changing roles&skills

Therefore, the performance and skills of the navigator in the future will be:

- Multi-skilled and cross disciplined background

- Process controller and tasks supervisor
- Increased decision making role

The so-called *advanced ship* under the concept of the Integrated Bridge System (IBS) and the One Man Bridge Operation (OMBO) is of great interest to everyone in the marine community because it promises safer ship operations by relieving the navigator from some of the tedious routine tasks and is more cost-effective by reducing the manning. There seems to be a contradiction between increased safety and reduced manning at the same time, but the potential way to achieve such a goal is by the utilization of advanced technology and computers. However many questions might arise as follows:

- Can modern technology really be used to compromise between safety and economic factors?
- To what extent will advanced technology and computers be used onboard and how will they replace the mariner's functions?
- Will it be fully reliable?
- How do we deal with the smaller crew size, organization and functions onboard?
- Will the navigator be overloaded?
- What skills and training are needed to improve the capability of the crew to be suitable for the new technical environment?

These questions create challenges to anyone who is involved in the shipping industry.

CHAPTER 3

Advanced bridge system and one man bridge operation concept

3.1 Introduction

With the large number of navigational aids provided on the bridge today, the requirement to make the information available easier to assimilate and use effectively is pushing the trend to consolidate displays. Such consolidation is thought to free the watch officer's time and attention so that more attention can be focused on safe and efficient navigation.

As a result, integrated navigation systems have been developed to satisfy such demand. Further, the traditional role of the bridge, dedicated to the navigation of a ship has changed. It is now the operational center for navigational and supervisory tasks aboard ship, incorporating controls and monitors for all essential vessel functions, which aim to be operated by only one man on the bridge. For this reason, the purpose of this Chapter is to examine the functionality and capability the advanced bridge offers today and the development of reducing manning level towards the introduction of one man bridge operation concept.

3.2 Advanced bridge system

3.2.1 Integrated System

The heart of the advanced bridge concept lies on the integration and automation. The term *Integration* can be classified into two systems namely: *Integrated Navigation System (INS)* and *Integrated Bridge System (IBS).* It can be said that the INS is the core sub-system of the IBS. The functional relationship between INS and IBS can be expressed in diagrammatic form as shown in Figure 3.1.

The basic concept of the *Integrated Navigation System (INS) or Horizontal Integration* can be defined as two or more electronic navigation aids combined together in a manner which produces a single set of navigation data. The integrated navigation system can be developed from a small to a large system depending on a wide range of electronic navigation aids available (see Appendix 1). The heart of the system is the central process which manages all of the operations and centralises data from a variety of sensors.

For the *Integrated Bridge System (IBS) or Vertical Integration,* it combines together, in addition to INS, other vital shipboard functions to be controlled and monitored from the bridge (see Appendix 2). To consider the whole concept of the advanced bridge, bridge design and layout are also included./

3.2.2 Basic integrated bridge functionality

The central function of an integrated bridge system (IBS) is to improve the efficiency of the navigator by enhanced co-ordination and presentation of information and display the combined information through a single control. The principle advantage to the navigator is improved flow and presentation of data, allowing better navigational control and reputedly, a reduced workload.

The most important functional capabilities of the integrated bridge which are different from traditional bridge designs are summarized in Table 3.2.

The key product for integrated bridge system is the *voyage management station (VMS).* It is a real-time status, advisory and control system designed for a central location in the bridge conning area. Designed to monitor all of the navigation and environmental sensors on the integrated bridge and to execute voyage plans, it is intended to be the primary operator interface to the navigation system while the ship is underway (Denham,1993, 281). The other is *the navigation workstation* which is a planning and data entry station usually located in the chart table area. The two primary functions of the navigation workstation are creating and editing (digitizing) electronic navigational charts and preparing the voyage plan.

All functions as contained in Table 3.2 are the fundamental functions around which all integrated bridge systems are designed. However, in a highly competitive market, each manufacturer has put his effort to develop his own product to attract customers by extending integration and automation levels and improving bridge design and layout.

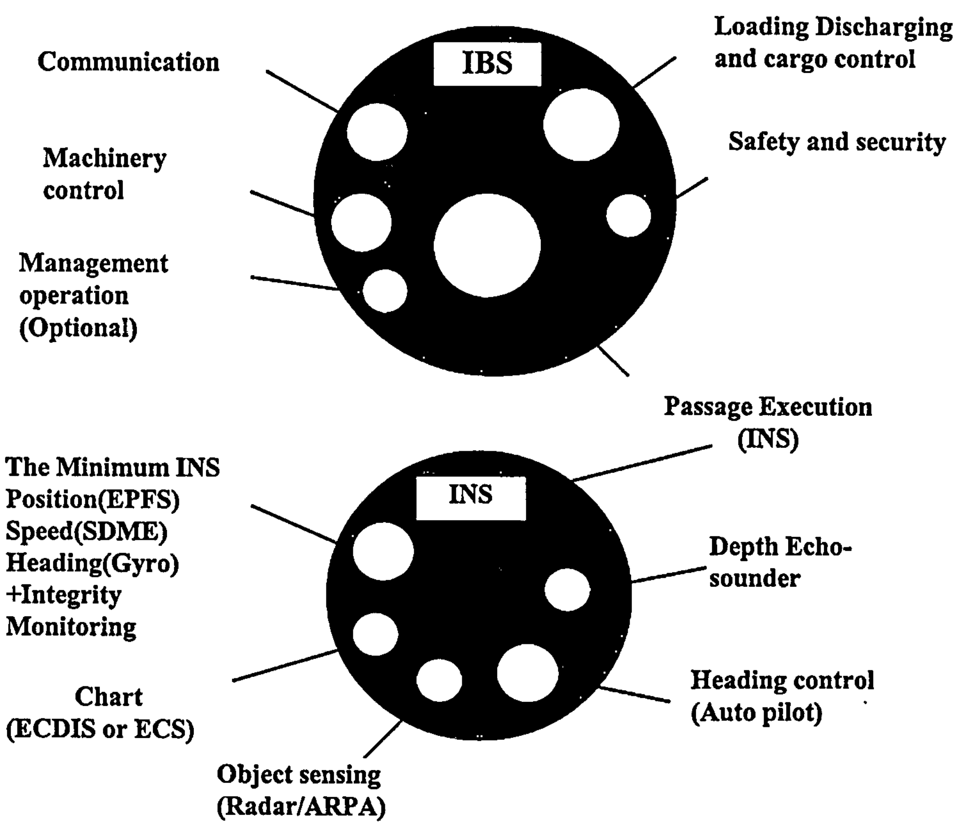

Figure 3.1 Functional relationship between INS and IBS

Source: IMO document, NAV 43/7/2, 1998

Table 3.2 Basic fuctional capabilities of Integrated bridge system

TITLE	FUNCTION
Automatic data collection and distribution	The capability to collect and distribute data from navigational and environmental sensors automatically without human intervention. Navigational information: geographic position from variety of position sensing equipment such as a GPS, Loran-c, Decca, etc; Heading from the gyro compass, radar; Speed from speed log, the radars or the position center. Other types of sensor data such as depth data and engine room data
Graphical data display	Once all the data has been collected, the first and most important task is to present it to the operators in a timely fashion, in a form that they can most readily assimilate.
Automatic data logging	The integrated bridge system can automatically log information such as position, heading, speed, wind speed and direction, navigation mode, and time. The data can be logged either to magnetic storage media, to a printer, or both. Data log files may be automatically sent via a satellite communicator (SATCOM) to home office
Automatic data reduction	The collected navigation sensor data can be correlated and filtered using Kalman techniques to develop a best estimate of position, heading and speed.
Voyage planning and monitoring	Computers can simplify many of the computational details of voyage planning: computing track headings, estimated times of arrival (ETAs) to waypoints, computing great circle routes, etc. The track of an electronically recorded voyage plan can be automatically overlaid on electronic chart to show the planned route. Once underway, it is easy to see the ship's position with respect to the plan, and the navigation computers can compare the actual progress with the plan.
Ship control:	Since the voyage plan represents the desired position of the vessel as a function of time, and the actual position is also known, the next logical step is to allow the navigation computer to pilot the vessel, sending commands to the autopilot and the engine controls to keep the ship on track and on schedule

Source: Denham, 1993, page277-280

3.2.3 Recent developments in integrated bridge systems

This part of the chapter looks at the way in which one of the leading manufacturers of marine electronic systems has developed advanced bridge systems to satisfy the requirements of vessels in the 21st century.

In 1985, a German company, STN Atlas Elektronik, installed the first fully integrated navigation system known as NACOS system (Navigation Control System). It has recently introduced a new generation of integrated bridge systems so called *Ship Control Center (SCC),* featuring a series of standard configurations tailor-made for the specific requirements of different classes of ships in different trades.

The *Ship Control Center* is special designed for one man on watch by the integration of all vital shipboard functions to the central point. SCC now includes the latest NACOS generation 3 (NACOS 65-3) integrated package, which comprises among other things an electronic chart (ECDIS), chart digitizer, radar/ARPA, auto pilot, nautical information display, Geamar 200 ISL machinery monitoring and control system and a multi-pilot. Multi-pilot is the key element, which is capable of performing various functions, including displaying overlaying of ECDIS and Radar/ARPA.

Multi-pilot facilitates voyage planning and simultaneously monitors and controls all the basic ship handling functions, including collision avoidance decision-making aids and automatic track control. It also provides conning displays for necessary navigation and manoeuvring data. Other systems included in SCC package are automatic power supply, remote control of the propulsion engines, ship management system, monitoring and control (cargo, ballast) and integrated communications system with GMDSS compliance (DEBEG 3020).

With a capability of automatic track keeping of the NACOS 65-3 system, STN ATLAS claimed that *Grand Princess*, 300 m long and extending more than 40 m above water level, can be kept on course to within half a ship's breadth even when strong winds prevail during navigation in confined areas (Lloyd's list Maritime Asia, 1998, 54)

It can be concluded that the integrated bridge system today is designed to support the tasks for one man watch operation with the following elements:

- Graphically supported route planning
- Radar-controlled and bottom-stabilized automatic track control
- Integrated nautical information display of all the important process data
- Electronic chart with integrated radar/ARPA function
- Control and monitoring of ship operation

3.2.4 Bridge design and lay-out

Bridge design has changed dramatically in recent years. Many of the new developments have been modeled on aircraft practice as a *cockpit* (see Appendix 3). Indeed, the word 'cockpit' is often used to describe the modern compact layout, where all the controls and instruments can be reached from a seated position. By locating the officer of the watch in one position, he is able to monitor continuously not only the electronic navigation situation, but also the multitude of alarms which protect the machinery and the operation of the vessel and, at the same time, maintain a visual look-out.

It should be noted that the enhanced performance and safety, which can be achieved by installation of excellent instruments, may be lost if they are not located in logical and strategic places on a well planned and designed bridge.

3.3 One man bridge operation (OMBO)

3.3.1 The development of manning reduction towards one man bridge operation concept

During the last two decades many attempts have been made to reduce crew costs, particularly in Europe and Japan. A number of projects were carried out with the objective of reducing manning levels by utilising automation and new technology. Some of the manning projects are briefly described as follows:

Manning projects in Germany

In the late 1970s, the German ship of the future project was initiated. Its primary objective was to produce advanced ship designs with low manning requirements. The first two container ships the *Norasia Samantha* and her sister ship the *Norasia Susan* (27,600 dwt,1,550TEU) were delivered at the end of 1985 with a manning level of 17 including 6 multi-purpose licensed ratings. In 1989, the *Bonn Express,* a container ship of 34,800 dwt operated by Hapag-Lloyd was introduced into service with a crew of 15, using a high degree of automation incorporating newly developed equipment. Later, Hapag Lloyd operated 7 container ships, each manned with a crew of 14 as indicated in Table 3.3.

Table 3.3 German ship of the future project

Rank	Number
Master	1
Ship officers(dual-qualified)	4
Radio officer	1
Bosun	1
Multi-purpose rating	4
Cook/Steward	3
Total	14

Source: Olofsson, 1993

Manning projects in Denmark

The Danish Ministry of Industry initiated a project called "project ship" in 1986. The original target was to design a number of ships which could be safely run by a crew of six. The composition of this crew could typically be:

Table 3.4 Danish project ship

Rank	Number
Master	1
Deck officers	2
Chief engineer	1
General purpose rating	2
Total	6

Source: Olofsson, 1993

The shipping company J.Lauritzen A/S had built 4 reefers. The first vessel was the *Ditlev Lauritzen* of 16,600 dwt, delivered in 1990 with a crew of 9 (extended by a first engineer, a cook-steward and a messman). The limited size of crew necessitated a new approach to a number of operations, for example the process of alongside which traditionally requires six or seven men. By placing a remote control position on the ship's side only one man was required for mooring operation. In addition, the ships were designed to operate under one man on the bridge. Finally, a minimum safe-manning level, comprising a crew of 7, has been made permanent for the four Lauritzen reefers.

Manning projects in Japan

In 1979 the committee on the Modernization of the Seafarers' System (COMOSS) was organized to conduct an investigation about the manning levels and the changing pattern of shipboard functions. The initial experiments were succeeded by a carefully planned sequence of steps towards *a new hypothetical image of seafarers.* The goal was to remove the departmental distinctions, with the substitution of a shipboard management team. Each of the stages was initially split into an experimental stage and a verification stage and the different levels were divided as below:

Table 3.5 Janpanese modernization of the seafarers' system

STAGE	CREW NUMBER	COMMENCED YEAR
A	18	1981
B	16	1982
C	14	1986

Source: Olofsson, 1993

In January 1987, a concept called the Pioneer ship was introduced. Seven ships were selected to function with a crew of 11.

Table 3.6 Pioneer ship concept

RANK	NUMBER
Master	1
Chief engineer	1
Radio operator	1
Watch officers(dual watch)	4
Dual purpose crews	3
Cook-steward	1
Total	11

Source: Olofsson, 1993

During the 1980s a project called "Intelligent ship" was conducted, completing its second six-year research phase in late 1994. Its aim was the development of a highly reliable machinery plant, super automated navigation systems and high-technology equipment for reliable and safe operation. These have all been coupled to satellite communications systems through an artificial intelligence programme, known as the *captain expert system* which ultimately aims at a totally unmanned ship.

<u>Manning projects in Norway</u>

In 1982, "the ship of the future" project was begun. The objectives of this project were to improve the efficiency, productivity and competitiveness of Norwegian shipowners by the use of new technology. This project has been carried out in the building of several reduced crew vessels. After a trial period of operation, a safe manning level of 14 was set. A ship 2000 project was also begun which is directed towards ships being operated by a single watchkeeper. In 1987, the introduction of the Norwegian International Ship register (NIS) allowed for Norwegian ships to recruit their crews from low-wage countries. Thus, the use of Norwegian crews on board Norwegian ships has become of less interest.

Manning projects in Sweden

In 1987, the manning project was conducted on the container-ro/ro ship *Companion Express* (51600 dwt) with a crew of 12, including:

Table 3.7 Swedish manning project

RANK	NUMBER
Master	1
Officers (3)	3
Chief engineer	1
Engineers (2)	2
GP-ratings/deck (3)	3
GP-rating/engine (1)	1
Cook-steward (1)	1
Total	12

Source: Companion express,1988

It was reported that the result of such a project was very satisfactory and could have led to a permanent arrangement. However, disagreements with the Swedish seamen's union required the ship to carry a crew of 15 members (extended with a messman and two GP-ratings).

3.3.2 Present and future trends in reduced manning levels

The above discussed manning projects have provided evidence that it is possible to operate a large ocean-going vessel with a crew of less than 14. The integration of the crew into one department instead of the traditional deck and engine division and the increased use of automation and remote control systems have greatly contributed to reduced manning levels. This has led to the creation of a "one man bridge operation" concept where a single officer on watch is supervising functions such as navigation, communication, cargo and engine operations simultaneously, whereas these would once have each been handled by a separate officer. Further manning reductions have led to research trials of "24 hour one-man bridge operations" which are being intensively conducted by Denmark, Germany, the Netherlands and Sweden.

The issue of manning with regard to safety of manning, skills of crew, fitness and shipboard management has now become an increasingly important factor in the regulation of ship both by international convention and national law. Consider the following for example:

- The STCW Convention 1978 as amended in 1995. Safety of manning, certification and fitness and rest period for person who performs watchkeeping duty .
- The International Safety Management code (Chapter IX of the SOLAS Convention; safety of manning and skill of crew)
- SOLAS (Reg V/13 to ensure that ships are "sufficiently and efficiently manned")
- The US Oil Pollution Act 1990 (OPA90) (Manning and management of the ship both ashore and afloat)
- International Convention on Seafarers' Hours of Work and the Manning of Ships (ILO Convention No. 180 will enter into force in the near future)

Even though the appropriate minimum safety manning is still the responsibility of the flag state, however the total manning of the ship is certainly of concern to everybody involved with safe and efficient ship operations. It should be borne in mind that to reduce manning, is not only to be achieved in operational economy, but operational safety must also be met and the condition of crew life at sea must also not be overlooked.

To further reduce crew size on future ships in order to achieve such aims, the following influencing factors, as commented by Muirhead (1992), should be taken into account:

- Technological development
- Automation
- Equipment reliability
- Maintenance procedures and techniques
- Emergency situations procedures
- Human resource skills and capabilities
- Operational needs of the trade

However, the attempt to utilize the new technology to operate ships more cost-effectively with reduced manning and to meet the safety standard and environment protection creates challenges to anyone who is involved in or contributes to the planning, designing, building, operating and training. The questions thus should be asked *What will be an optimum manning level for rational ship operation ?* and *Where do the reductions end?* Seeking answers to these questions will continue. (see the manning development chart in Appendix 4)

3.3.3 One man bridge operation concept

(A) Legal considerations

Traditionally, to sail a ship from one port to another port, the bridge had to be manned by at least 3 men, namely: officer of the watch, helmsman and lookout in order to perform safe navigation for the entire voyage. Since Radar/ARPA and Autopilot have been widely used on the bridge, the presence of helmsman and lookout are no longer required at all times on the bridge during a normal period of the watch. Furthermore, a highly automated ship of today makes it possible to run a ship with only one man on the bridge throughout a voyage (see Appendix.5)

Considering the legal aspect, bridge manning and watchkeeping requirements have to conform with the following regulations:

- International Convention on Standards of Training, Certification and Watchkeeping for seafarers, 1978, as amended in 1995 (STCW 95)- in paragraph 15 of section A-VIII/2 -states that "the officer of the watch may be the sole lookout in daylight (in certain conditions). This means that sole look out is permitted in daylight under certain circumstances with regard to, among other things, weather, visibility and traffic density conditions but in the period of darkness, in all cases, additional lookout should be provided. Paragraph 16 of A-VIII/2 also contains the list of factors to be taken into account in determining the composition of bridge watchkeeping (see Appendix 6).
- International Regulations for Preventing Collisions at sea 1972- Rule 5 (Look-out) states that 'Every vessel shall at all times maintain a proper lookout by sight and hearing as well as all available means appropriate in the prevailing circumstance and conditions so as to make full appraisal of the situation and of risk of collision'.
- International Convention for Safety of Life at Sea, 1974-Regulation 13 of chapter 5 states that 'all ships shall be sufficiently and efficiently manned'.
- International Maritime Organization Assembly-Resolution A.481(XII): Principles of safe manning, in Annex 2 (Bridge watchkeeping) states that 'the bridge watch should consist of at least one officer qualified to take charge of a navigational watch and at least one qualified or experienced seaman, provided that the watch complies with the regulation VIII/2 of STCW 95'.

According to the existing regulations as mentioned above, solo watchkeeping is permitted only in daylight under certain conditions and does not allow, in all cases, for solo watchkeeping at night. So the concept of a 24-hour-one-man-bridge operation has not yet been legally approved. However, a great deal of research and various trials have been intensively conducted in order to verify that solo lookout at night is safely practicable.

(B) Operational considerations

Prior to implementing the one man bridge operation during day and night, the scope of the concept needs to be clearly defined with respect to the operational and environmental conditions a single man watchkeeping will be allowed to be posted on the bridge. In the view of the author, taking into account existing regulations and future prospective the scope of one man bridge operation concept may be divided into 3 stages as follows:

Stage 1. One man bridge operation (OMBO) permitted under existing regulations

Period	OMBO	Limitation
Daylight	yes	under favourable navigational conditions in open sea and comply with Section A-VIII/2, paragraph 15 and 16 of STCW 95
Darkness	No	-

Stage 2 One man bridge operation (OMBO) 24 hour concept under trial

Period	OMBO	Limitation
Daylight	yes	under favourable navigational conditions in open sea and comply with Section A-VIII/2, paragraph 15 and 16 of STCW 95
Darkness	yes	under favourable navigational conditions in open sea and comply with Section A-VIII/2, paragraph 15 and 16 of STCW 95

Stage 3. Full concept of one man bridge operation 24 hours (berth to berth)

Period	OMBO	limitation
Daylight	yes	comply with section A-VIII/2, paragraph 15 and 16 of STCW 95 but regardless of weather, visibility and traffic conditions
Darkness	yes	comply with section A-VIII/2, paragraph 15 and 16 of STCW 95 but regardless of weather, visibility and traffic conditions

The scope of the 24-hour-one-man-bridge operation under trial falls into Stage 2 (see above) in which solo watchkeeping is not to be conducted or is to be terminated under some exceptional conditions as stated in the IMO provisional guidelines

(MSC/Circ.566) for a trail of a solo look-out in the periods of darkness (based on Section A-VIII/2, part 3-1, paragraph 15-16 of the STCW Code, see Appendix 6). However. it may not be acceptable to step into stage 3 at the present, but it may be possible in the future.

As the scope of the operational and environmental conditions of this concept has already been discussed, the next step is to describe the definition of the concept. The definition of one man bridge operation concept can be summarized as follows:

- There is no look-out either on the bridge, or on standby, in the period of normal watch conditions.
- There is no helmsman available for manual steering of the vessel in the period of normal watch conditions.
- There is no other officer available to assist in navigation or collision avoidance during normal watch conditions.
- A Backup navigator (normally the Master) is provided when assistance is requested by the officer of the watch if the situation becomes unsafe.
- Extension of functions- Due to the transformation of the traditional bridge to a ship operation centre all monitoring and control actions associated with engine room functions, communications functions, cargo functions, ballast control and ship safety functions can be carried out on the bridge. Therefore, the responsibility for monitoring these systems, responding to events and alarms would fall to a single man on the bridge in addition to watchkeeping tasks (see Appendix 7).

These conditions above apply to both daylight and darkness periods for the 24 hour one man bridge operation concept.

With extra functions, it would appear that the officer of the watch will be provided with a great deal of information, or in other words, increased information workload (see Appendix 8). This effect is that the role of the bridge operator approaches a 'supervisory controller'. The operator's function is to monitor systems under automatic control during periods of normal operation and take executive action during abnormal conditions to restore normal operating status.

In conclusion, the increase in shipboard functions allocated on the bridge and combined with look-out functions are expected to be handled by a single man on the watch in addition to his navigation tasks regardless of day and night period. However this challenge needs to be carefully examined and seriously investigated with regard to the environmental work place (i.e. bridge layout, instrumentation arrangement, level of control equipment and instrumentation) and importantly, human factor (safe and healthy operational procedures) prior to full implementation being adopted in order to ensure the safety and efficiency of such practice are met.

3.4 High technology versus increased risk

It is not necessarily true to say that advanced technology always increases safety. In some cases, it might degrade rather than enhance the safety if introduced without proper consideration. As commented by Froese (1994, 21) that:

> The increase use of electronic methods leads to dangers resulting from an excessive variety of functions, loss of system understanding, loss of competence, and inadequate overcoming of malfunctions in complex systems.

A further comment by Lee, D. J. (1996) stated that:

> Technological advances do not always meet the goals of enhanced safety and efficiency promised by developers. Two trends in shipboard technology are particularly disconcerting:
>
> (1) remote monitoring of complex systems erodes situation awareness

(2) the proliferation of computer-based systems that unnecessarily complicate shipboard operations.

It can be said that the more a technology is progressing, the more sophisticated and complicated instruments and systems become, which might lead to the appearance of new types of accidents. Therefore, any advanced technological equipment should be carefully analysed in the process of design and trial prior to being adopted on board. The seafarers need also to be effectively trained to cope with new technology.

CHAPTER 4

One man bridge operation (24 hours):
Feasibility, Safety & Efficiency considerations

4.1 Introduction

The technical and operational requirements for one man bridge operations caused considerable debate at the IMO sub-committee. Criticisms have been focused on the matters of solo watchkeeping in the period of darkness (without additional look-out) and the increased workload of the navigational watchkeeping officer affecting safe ship operation.

Much effort had been made to seek the answer to the question *Is it safe to sail a ship without a special lookout and only one watchkeeping officer on the bridge, during the night?* Consequently, the question was developed to *Can a single watchkeeping officer on a highly automated bridge, whether by day or night, safely perform all his lookout and additional functions (communication, controlling and supervising tasks) besides his navigational task?* Due to the new challenging question, countries conducting trials have heavily invested in technologies and seriously studied the human factors in bridge operations in order to find out the positive answer to this question.

4.2 Factors to be considered for OMBO (24 hours)

To evaluate that the officer of the navigational watch could safely perform his duties alone on the advanced bridge during day and night, the following factors are examined and discussed:

4.2.1. Human factor

(A) Workload

It is apparent that the workload on a modern ship is shifting from a physical to a mental load in which the officer of the watch increases his decision making role. The effect of automating much of the information collection and processing concerned with the navigation and anti-collision functions during severe navigation conditions, could be seen as increasing the bridge operator's activities. Addition of extra responsibilities in conjunction with controlling other ship systems can also be seen as increasing the job of the officer on watch. It is a fact that regardless of automation and the assistance of computer technology, the human element will always be a decisive factor.

Therefore, the question should be asked *What are the mental processes when a single officer of the watch is supervising various functions simultaneously?* This is very relevant in critical conditions where the officer of the watch needs adequate information in order to make the right decision.

It is interesting to look at the results of the research conducted in Germany by using a simulator. The outcomes indicated that the navigational watchkeeping officer on the advanced bridge experienced less workload than on a conventional bridge. It is also stated that time of day did not have any noticeable effect on workload (NAV36/INF.4, 1989). Other simulation trials carried out by Norway compared the performance of narrow water navigation on a conventional bridge manned by traditional bridge personnel with a one man operated bridge. The results indicate that the watchkeepers considered the one-man bridge reduced the difficulty in performing the task by approximately 30% and the workload by approximately 45% (NAV 36/INF.4, 1989).

However, the trials conducted by Germany to investigate the task performance and workload of navigators during a sea watch both day and night, by interviewing 489 navigation officers, reported that 36% of those interviewed felt keeping a proper look out in addition to other duties was sometimes difficult. Comparing the workload between day and night it was found that about 26% of those interviewed think workload at night is somewhat higher than by day (MSC 69/INF.6, 1998).

It can be concluded that the issue of workload, as reported by the results of such trials, obviously shows that the workload on the advanced bridge has been considerably reduced compared with the conventional bridge. It should be noted that such reduced workload is made on a physical state but may not apply to the mental state. Thus, the question of mental workload needs to be examined further. Time factor does not have much effect on the workload. The night condition may have little effect on the increase of the workload.

(B) Solo lookout at night

The analysis of the average estimates of time used by the officer of the watch during one man bridge operation trial conducted by Norway found the following:

Time used on lookout 88%

Time used on other tasks 12%

This means that the relative load of all the other tasks is estimated to about 12%, leaving 88% of the time available for lookout. It is further stated that even during such interruptions, the distraction time from the traditional lookout function would seldom exceed 1 minute (MSC.55/INF.5, 1988). The results of trials conducted by Germany also point out that on an average, non lookout functions took altogether 38.1 minutes per navigational watch, i.e. about 16%. The maximum duration of an interruption of lookout duties was 9 minutes, the average duration 1.4 minutes (MSC 69/INF.6). However, from this result, it is argued that a continuous lookout, as required by Rule 5-Lookout of COLREGS 72 (International regulation for preventing collision at sea 1972) is not being maintained.

However, it is a fact that even when there are two persons on the bridge, it does not always necessarily mean that the look-out function is fully continuously maintained or that it is any safer than a bridge manned by a single person. It much depends on how alert they are, and how seriously each of them takes their job. In some cases, it might happen that one relying on the other may lead to a mishap if the other is not aware of the fact that he/she is being relied on. Sometimes the lookout is certainly not given clear instructions as to his/her duties, and this is considered to be the main negative contributory cause.

This is supported by the strong view of Denmark after 7 years of trial experiences (MSC 69/21/6, 1998) which stated that safe navigation of a ship depends on the bridge at all times being manned by a qualified and alert officer. It can be said that it does not depend on how the bridge is manned but it rather depends on how the bridge watch is performed.

(C) Measures used to support a solo lookout

Under one man bridge operation, the absence of a rating lookout can be compensated by a bridge safety alarm system, a qualified backup officer (Master) and the Radar/ARPA. The effectiveness of a bridge safety alarm system is to keep the officer of the watch alert and to call a backup, if the officer of the watch fails to act or need assistance.

It is logical to bringing a qualified officer as additional support to the officer of the watch because in most cases when assistance is needed for unusual watchkeeping tasks caused by external or internal events, the requirements for such support are, however, on a qualification level that cannot be expected of a rating. Therefore, it can be said that if the solo watchkeeper at night cannot handle the situation alone, only the master or other qualified officer at night can act as a suitable backup to provide immediate and qualified assistance.

Further evidence has been given by the German Institute of Ship Operation, Maritime Transport and Simulation from the results of formal safety risk assessment The determination of risks covering the following hazards levels were classified.

Table 4.1 Classification of hazards level

LEVEL	ACTION
1	Perception of a change within the sea area being observed;
2	Assessment of the change with respect to a possible hazard;
3	Development of a solution strategy to eliminate the hazard;
4	Application of the selected problem solution strategy;
5	Requesting support from the master; and
6	Final management of the problem jointly with the master.

Source: IMO document : MSC 69/21/7, 1998

It states that the rating as an additional lookout is only relevant at the first hazard level (see Table 4.1 above). It is evident that the rating lookout does not support the officer of the watch effectively in any of the other hazard levels. If the officer of the watch cannot manage any escalating situation alone, then he will require support from someone with at least the same qualifications.

However the question then to be considered is *Can the backup officer arriving on the bridge when called by the sole watchkeeper or by an alarm be considered immediately available taking into account the time it takes to wake up, proceed to the bridge and adjust to night-vision?* So the availability of assistance to be summoned immediately to the bridge when necessary is significant.

Although the result of the trials conducted by Germany (MSC 69/INF.6,1998) reported that the master was available an average 2 minutes after being called, the fact should be noted of how long he would take to adjust to night vision, to get familiar with the internal and external situation and how prompt in performing the task after arriving on the bridge that may need additional time.

(D) Fatigue and loneliness

It is generally acknowledged that fatigue is prevalent within the maritime industry, where long periods of overtime are the norm. Moreover, long periods of service, typically one year, without relief can only further contribute to fatigue. The reduction in manning levels on vessels is also likely affected.

According to IMO A.772(18), Fatigue results in the degradation of human performance, the slowing down of physical and mental reflexes and/or the impairment of the ability to make rational judgments. Human fatigue can be defined as a combination of physical and mental exhaustion. The factors that influence the shipboard crew fatigue are:

- Inadequate rest and excessive workload; quick port turn around, navigating in congested waters and low level of automation.
- Adverse environmental factors; noise, vibration, temperature and ship motion Other psychological factors; changing of social pattern, loneliness, monotony and dissatisfaction with the change of workplace.

Take into consideration a single-man watchkeeping at night, if he is fatigued, he will fall asleep very easily Although the deadman alarm is equipped to keep the officer of the watch awake, *will the fatigued man really stay awake to press the button and efficiently perform his tasks ?*

The lesson to be learned from two accidents in 1995, which both occurred in Australian Barrier Reef waters when ships stranded with nobody awake on the bridge (Bimco bullentin, 1996, 3) are worthly of notice.

The first incidents involved the officer of the watch, sitting in the pilot chair in the wheelhouse remaining conscious enough to cancel the alarm at pre-selected intervals, but not sufficiently awake to call his relief or the pilot in time to prevent the ship from stranding.

The other case, which similarly and fortunately did not result in pollution or damage to either the vessel or the reef, involved the sole watchkeeper leaving the bridge to collect some cigarettes, falling asleep in his cabin, and leaving the ship to steam through the night for some 4-5 hours before her stranding roughly woke all hands.

In respect of loneliness or monotony of the solo watchkeeper in night conditions,. The result of the investigation carried out by Germany indicated that about 38% of the interviewed navigators feel being alone as a solo watchkeeper increases their watchfulness and only 9% of those interviewed found being alone during solo watchkeeping mentally stressful (MSC69/INF.6, 1998).

In order to control shipboard fatigue, one has to control the following three basic mechanisms that affect it, namely:

- the number of hours worked;
- the ability to get regular or uninterrupted sleep, and
- exposure to stressful conditions, both psychological and physical.

In introducing an international measure to eliminate the fatigue factor, IMO established watch arrangement requirements and minimum mandatory rest periods for watchkeepers and strict enforcement by both flag and port states. Under Regulation VIII/1 of the STCW 95 it requires that each administration, 'for the purpose of preventing fatigue', shall 'establish and enforce' rest periods for watchkeeping personnel. It requires, in addition, that duties are organized in a manner which ensures that all watches are 'sufficiently rested and otherwise fit for duty'.

All parties involved in ship operations should be alert to the factors as discussed above which can contribute to fatigue, and should take them into account when making decisions on ship operations.

4.2.2 Technological factor

(A) Reliability

One man bridge operation requires highly reliable technologies. The degree of reliability of modern technology available today has increased markedly. However, it should be noted that there will be no problem for a brand new ship in which all equipment still fits. But *what happens when the ship gets old ? Will the technology still be operating to an acceptable level of reliability ?* When the ship ages and is passed on down to second and third owners, who may not have the same highly trained crews? *Can the one man bridge operation and the same manning level be justified on this ship?* and *Who will be trained to carry out critical maintenance and fix problems on board ships at sea?*

It should also be realised that as the technical reliability of system components and the level of automation increases, the occasions where the human operator is required to intervene as executive controller become fewer and fewer. However, the faults and conditions during these occasions seem to be more and more serious and also more difficult to foresee. *How can the officer handle this situation?*

(B) Bridge alarm systems

Bridge alarm systems play a crucial role in the contribution of safeguard for one man bridge operation. As specified in the provisional guidelines on the conduct of solo watchkeeping trials at night (MSC/Circ.566,1991) the bridge alarm system is composed of:

- Bridge safety alarm system: to periodically verify the presence and alertness of the officer of the watch, the alarm will be released according to the setting-interval.
- Collision warning system: in order to safeguard against the risk of collision when any floating objects may come into a collision course, the alarm will be released.
- Grounding and off-track warning system; in order to safeguard against the risk of grounding, the alarm will be released when the ship's position is at a given distance from the planned track
- Alarm transfer system : to call back-up navigator or master when a proper acknowledgment of any alarms has not been made by officer on watch

However, prior to adopting the bridge safety alarm system the following aspects should be taken into consideration:

- The optimum setting-intervals at which the bridge safety alarm would require acknowledgment.
- The level of tone and volume of alarm and the location where the alarm and acknowledgment devices should be placed.
- Likelihood of interference with the performance of routine watchkeeping duties.

Moreover, the alarms must meet three criteria to be effective, namely enable the operator to detect the warning, to interpret the warning and take appropriate action. The alarm should be compatible with the situation and the kind of danger its indicate, and those to be warned must be instructed on what subsequent action is most appropriate according to the condition of the area in which they work.

(C) Ergonomic bridge design and equipment

The bridge or so called 'workstation' for one man bridge operations should be designed and arranged to enable efficient operation by one person and also allowing more than one person (when necessary) to perform navigational duties and other functions allocated to the bridge related to the safety of the ship. All relevant instrumentation should be easily accessible from the workstation to facilitate the ability of the officer of the watch to maintain a visual look-out and other navigational functions. Account should also be taken of the ergonomic standards and man/machine interface which can contribute to safe operation and relieve the officer of the navigational watch of routine work.

In addition, attention should also be given to the lighting on the bridge that may have an impact on the performance of the watchkeeping officer. The IMO guideline for the conduct of trials on solo watchkeeping at night (MSC/Circ.566,1991) defines that 'the lighting required on the bridge should be designed so as not to impair the night vision of the officer on watch'. Moreover, the lighting required in access ways to the bridge should also be designed so as not to impair the night vision of the back-up navigator.

4.2.3 Operational factor

The operational factor is vital for one man bridge operations. No matter how sophisticated equipment placed on board is, if the operational procedure is poor, the safety then cannot be achieved. The operational factor can be considered in two aspects namely: operational conditions and operational procedures.

- Operational conditions concerns the circumstances under which the one man bridge operations can safely be implemented. The prerequisites and/or operational conditions are based on Section A-VIII/2, part 3-1, paragraph 15 of the STCW Code A (see Appendix 6). If such conditions are not being met, the conduct of one man watchkeeping must not be commenced or must be terminated.
- Operational procedures concerns how an organization is operated in order to ensure that the human element is taken fully into consideration. The instruction

and operational procedures should be clearly written. It is the responsibility of the company and master to ensure that effective bridge procedures are maintained for instance:

(I) All watchkeeping officers should be carefully instructed in the circumstances under which assistance should be called

(II) The master should ensure that the watchkeeper is adequately rested and fit for duty and not impaired by fatigue.

(III) The officer of the watch should ensure that all essential bridge instrumentation is functioning properly and is in use during the watch, including bridge safety alarm system.

(IV) All duties to be performed outside the scope of the watch should be distributed evenly among all watchkeeping officers

(V) A back up officer arrangement is properly made and takes full account of time required to arrive on the bridge and to adjust the night vision.

It should be noted that the operational procedures should be constructed to motivate a solo watchkeeper to perform his duties in a safe manner rather than to increase the stress. Moreover, it is necessary to ensure that such procedures contribute to minimizing human failure.

4.3 Conclusion

To operate a ship with one man on the bridge during day and night would be feasible, safe and efficient, in regard to the above discussed factors being fully taken into consideration (see also Appendix 9), and also provided that proper measures are being taken to improve as follows:

- improved training both basic and periodic follow-up training
- improved competence and sense of responsibility of marine officer
- improved instrumentation, layout and arrangement of the control functions on the bridge

- the introduction and familiarization of new and better technology and technical aids
- improved and more reliable alarm systems
- improved operational bridge procedure
- the introduction of measures to overcome monotony, loneliness and fatigue
- improved qualified backup officer

In addition the duration of watches and service contract may need to be discussed further. The analysis of training needs must also be carefully examined as well as the change of mariner's attitude to adapt with the new technological and operational environment. The bridge technology also needs further development.

CHAPTER 5

Training needs and Integrated function analysis

5.1 Training needs

With the increased capability of high technology, it would appear that the role of the navigator in the near future will become less directed towards executing the ship's handling and the ship's operation, but his role will be mainly monitoring, decision-making, supervisory, remedialing emergency situations and rectifying the faults. As mentioned previously, the navigation officer has his hands full with responsibility for shipboard functions: navigation, engine, cargo, ballast, alarm system. These functions are greatly supported with the aid of complicated computer systems and a number of "black boxes". The difference in functions on a traditional ship and an advanced ship are explained in the following diagram.

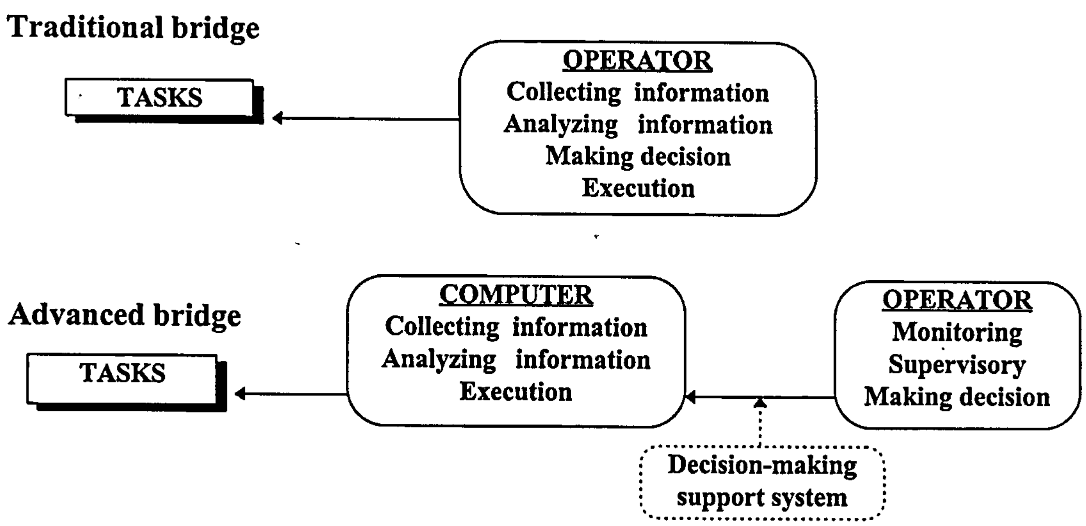

Figure 5.1 Difference in functions on Traditional bridge & Advanced bridge

With the tremendous change in the bridge operator's role, it is therefore important for a bridge operator to fully understand the contents and characteristics of the new system and have the capability to perform the tasks effectively, efficiently and safely. Undoubtedly, to be compatible with the contemporary technical environment, new training is needed.

Prior to identifying the training needs, it is important to understand what is meant by "training". In the view of the author, the most suitable definition to describe training is:

> Training is the systematic development of attitudes, knowledge and skills required by an individual in order to perform adequately a given task or job (Stammers and Patrick, 1975).

It is obviously seen that training comprises attitudes, knowledge and skills. Thus, the following questions will be asked: *Which knowledge, skills and attitude will be required for operating advanced ship, and how do we create them ?*

By closely examining the performance of the navigation officer on the advanced ship, the following issues should be taken into consideration in order to identify training needs:

- By introducing IBS as a support system for the human operator, the required navigational ability will change. The system carries out many parts of the tasks of which a watch officer is currently in charge. To be able to understand the system's characteristics is an important requisite ability.
- It is necessary to understand the effect sensor errors have on integrated bridge system processing and to make a correct judgment due to the information analysed by the system which is collected by various sensors. Therefore , the analysis results provided by the system depend on the measurement

characteristics of the sensors. An operators must be able to cope with this problem.

- Many functions of the system have to be understood: which function to use in which situation under various conditions. Correct understanding of the function and adaptation to manoeuvring is necessary as well as appropriate selection of the function.
- With the increased information workload, the operator should know clearly the distinction between what information is vital and what is not necessary, to effectively maintain safe navigation. The operator should also know where such vital information is available when the system fails.
- With the increase in number of 'black box', it is essential to know the input/output data of the system, its the reliability and limitation and how to correct the output data.

- When the system suddenly develops a fault, the operator must be able to discover the error in time to correct it.
- With the number of alarms on the bridge, an operator must be able to understand what is happening in the system when there is an alarm and identify whether or not it influences the safety of navigation and prioritise reaction to the alarms.
- The operator must have capability to compensate for the parts where the system is inferior whenever necessary as well as to fully use the system function. The operator should not over rely on the electronic screen, but he should be aware of what is happening in the real situation outside the windows. Sometimes the objects which could be recognised by operators through visual observation , can not be recognised or detected by the system, probably due to the small size of the object or the limitation of the system itself

- ♦ With the proliferation of computer and network systems, to effectively and efficiently work with this environment basic knowledge of computer, hardware, software, processing characteristic and local network system (LAN) is required.
- ♦ The attitude of the ship's officer needs to be developed to adapt with the change of the environmental workplace and willingness to work as a team and to communicate and to improvise even under stress.

Therefore, the following identified knowledge, skills and attitudes are needed for a ship's operator of an advanced ship equipped with integrated bridge system (IBS) in addition to those required for conventional ship operations.

Required knowledge of integrated bridge system

- Principle of IBS- processing characteristics of IBS must be understood. It is necessary to understand the method in order to evaluate results of the processing by an operator himself. The following items as recommended by Kobayashi (1996) must be understood in order to know the processing done by a machine system.
  - ♦ Processing characteristics: the information from each sensor has the specific characteristics concerning errors. It is required to know the procedure of data processing and the effect of sensor errors which affects the processing results.
  - ♦ Data processing: The method of data processing changes depending on the manoeuvring objective. Therefore , an operator has to know what kind of sensor data is selected, how to process the data and by what evaluation method the result is obtained. An operator also has to understand the control law in the shiphandling mode in order to know how to realize the ship motion by the system.
- Display characteristics: understand the display characteristic of the system in order to build up the ability to get information and use it correctly. In case of

graphic style display, it is necessary to consider the accuracy and the resolution of CRT.

- IBS operation- understand the main functions of the system , understand the construction and contents of each functional menu, appropriate selection of support items from the given menu, understanding of support items and utilization of them, understanding of the characteristics of IBS errors and knowledge of maintenance and management of data-base.
- Training for emergencies. In case of system break down, an operator must be able to understand alarm information, diagnose the fault, repair system troubles and compensate the lack of functions. If the fault can not be remedied on board, an operator should be able to provide an accurate statement on its nature to the manufacturer or shore technician and to have it repaired.

<u>**Required knowledge of computer system**</u>

- Computer system- the processing characteristics of the computer, knowledge about the computer which carries out a main function of the system, hardware of IBS, local-area-network (LAN) connecting to various sensors, software management of each function and the total system.

<u>**Other training needs**</u>

- Bridge resource management- ability to use all available resources on the bridge, positive attitudes towards communication, co-ordination, leadership, standard procedure, situational awareness and judgment and decision making

After the knowledge is gained, the following skills and attitudes are required.

<u>**Required skills**</u>

- ♦ Supervising other ship board functions skill: engine, safety system, etc.
- ♦ Engineering skills at operational level

- Fault diagnosis skills
- Managerial resource skills
- Ability to select and make use of available information
- Capability of familiarization with the complex system and use its manual or plan in an effective way

Required attitudes

- Willingness to communicate
- Willingness to cooperate and to work as a team
- Flexibility and reliability

In conclusion, as ships become more automated, there is a requirement to train personnel to higher educational levels in order to face today's technology. The ship's operator must be able to understand a ship as a whole or total system. The aim of the training should be to give the person sufficient insight into the system, to enable him to handle the system safely and to go on learning by experience during actual operations.

5.2 Bridge Resource Management (BRM)

> The overall training objective for the future must be: to motivate ship's officer/pilots to change their behavior to good resource management practices during everyday operations. This includes understanding of the importance of good management and team work and willingness to change behavior. The use of common terminology must also be emphasized" (Hederstrom, 1992)

5.2.1 BRM: Why is it needed?

Over the years, it has been stressed that the human element is the major contributing factor to maritime casualties in about 80% of the cases. Much effort has been made in technical improvements, stricter regulations and training development to reduce the accidents. However, recent marine accidents have occurred involving many ships equipped with technologically advanced navigation equipment and manned by well-trained and experienced mariners. It is evident that application of new technology and providing skills training for shipboard personnel is not sufficient to improve safety, while the number of accidents caused by human error continues to increase.

A great deal of research and various investigations conducted by, among others, the United Kingdom Protection & Indemnity Club (U.K P&I Club), the U.S Coast Guard, the National Transport Safety Board (NTSB), and Det Norske Veritas came to a common conclusion that the majority of accidents have been caused by 'management errors' while lack of competence is actually a minor reason for accidents (Johnson, 1993). As the evidence shown in Figure 4.2, DNV reported that 71 percent of ship grounding incidents are caused by bridge management errors. It also pinpointed four key causes of accidents as follows (Beech, 1994, 36):

- Failure to communicate intent and plans
- A preoccupation with minor technical problems
- A failure to delegate tasks and assign responsibilities
- A failure to detect and correct deviations from standard operating procedures.

Therefore, mariners must be trained how to use and co-ordinate all the resources available to increase safety and efficiency. Moreover, mariners need to have the right attitudes and they need to be able to adapt to the new changing environmental workplace. Therefore, a new type of training programme is needed to achieve such aims. That is the reason why 'Bridge Resource Management' training programme was developed.

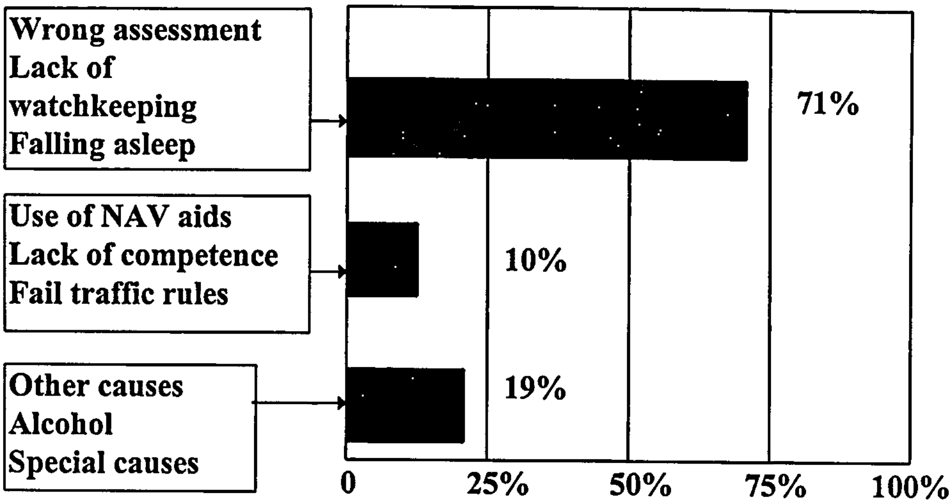

Figure 5.2 Causes of Grounding

Source: Safety at Sea International, March 1994, page 37

5.2.2 The BRM training programme

BRM is a training programme for ships' officers, engineers and pilots, based on knowledge and experience from the airline industry, to support a change of attitudes and increased knowledge about managing human and technical resources in the maritime environment. BRM was developed with the cooperation of the SAS flight academy and seven maritime organizations in 1993.

Generally speaking, its aim is to minimize the risk of human error by creating positive attitudes towards communication, co-ordination, leadership, situational awareness and standard operating procedures.

The BRM programme conducted by SAS flight academy is based on the followings 12 modules:

- Attitudes & management skills
- Cultural awareness
- Communication & Briefings
- Challenge & Response

- Short term strategy
- Authority & Assertiveness
- Management style
- Workload
- state of the Bridge
- Human involvement in errors
- Judgment & Decision making
- Emergencies & Leadership

Each consists of a study unit on human relations. The key element of transferring tools are; interactive video drama, computer-based training (CBT), group discussions, real life case studies.

After completion of 12 modules and workshops, it is followed by a practical exercise in a ship's handling simulator to allow participants to practise their improved management skills

BRM programmes are being widely adopted in many countries, including Sweden, the United States, Norway, Australia, Denmark, Germany and the United Kingdom. It is apparent that 'Bridge Resource Management (BRM)' will be a significant tool for reducing the number of accidents caused by human error. As a matter of fact human error can not be eliminated, but it can be minimized and BRM thus is a solution.

5.3 Integrated function analysis: Functional approach

The issue of the impetus to reduce crew number and the availability of sophisticated technologies in shipping today has been discussed. The impact of these factors have changed many operational practices and the shipboard organization. The outcome has been the abolishment of the separation between deck and engine department by integrating the functions from both disciplines. The General-Purpose crew was born and followed by integration at officer's level, the so called 'Bivalent or Dual watch officer'.

The initial approach was made by the French in the early 1960s, by introducing the bivalent officer who was fully trained in both deck and engineering disciplines. Later during the 1980s, the need for cross-discipline training of seafarers became more and more in vogue because of the increasing sophistication of ships. In response to these needs a number of countries, particularly in Europe, have modified their traditional training system to offer broader skills training.

With these concerns, the new chapter VII -Alternative certificate of the revised STCW 95 has been introduced. The new chapter VII will allow parties to this convention, at their discretion, to issue certificates to persons who have met requirements in crossing disciplines of deck and engine functions.

The purpose of the alternative certification is to allow greater flexibility in the assignment of duties on board ship so that better use may be made of all crew members and workloads more evenly distributed. This led to the introduction of the 'functional approach' in which the shipboard functions are classified into 7 functions and three levels of responsibility (the standard of competence of each function is specified in the table of Chapter II, III, IV of STCW 95 code-A).

The following three levels of responsibility (Section A-I/1, STCW 95) are as follows:

- Management level: the overall responsibility for the proper performance of all functions or of certain specified functions on board
- Operational level: dealing with technical operations such as navigational or engineering watch

- Support level: dealing with basic maintenance of the ship and machinery other than responsibilities for management and operation

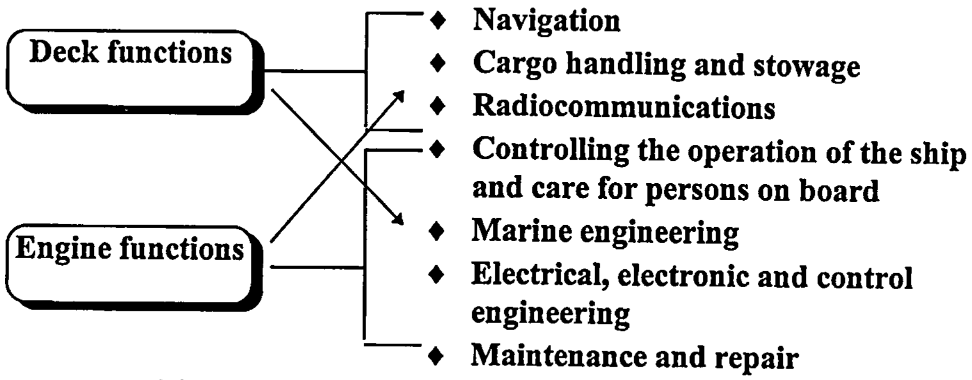

Figure 5.3 Functional approach (crossing discipline)

Source: IMO: STCW 1978 Convention (amendment 1995), Code A, page 3

A functional approach is a competency-based or skill-based approach. It assesses the more obvious aspects of the cognitive domain relating to the recall or recognition of knowledge such as basic theory, technology of operating ships and technical skills. It also assesses the less obvious aspects of the affective and psychomotor domain relating to skills such as full application of knowledge and being competent in a changing situation. It can be said that it focuses on the outcomes rather than on the learning process. It is obvious that the introduction of the functional approach will facilitate to establish a global standard of competency for seafarers effectively and efficiently.

Tables A-II and A-III, Code A of the revised STCW78 Convention contain the standards of competence for each function and also provide specifications for training programmes related to each function. This would give a challenging opportunity to maritime training institutions to modularize their courses by offering programs in the form of functions (seven functions). It would offer greater opportunity for seafarers to obtain fundamental conceptualized knowledge and ability for a multi-skilled, flexible and adaptable workforce. It is also more flexible in allowing seafarers to update individual knowledge and skills with the rapid technical change in ship operation and management.

Importantly, it also satisfies the needs of the shipowner in designing an alternative shipboard organization structure. The example of a new shipboard organization which was developed by Hapag-Lloyd is given in the Appendix 10 .

The development will continue. Further integration of functions will take place at officer's level. As quantity is reduced, quality must be increased. It would appear that the organization of the future will be a mix of highly multi-skilled officers, supported by a number of skilled technicians and a multi-purpose crew. It is important that the MET institutions, particularly in developing countries, should be aware of this situation and prepare for future changes.

CHAPTER 6

A proposal for development of education and training at MMTC

6.1 Background

The growth of the Thai maritime industry has dramatically increased over the past decade. The Thai shipping fleet increased its capacity from 648,773 DWT in 1986 to 2.2 million DWT in 1996 (Office of the maritime promotion commission,1997). The large expansion of sea ports on the south eastern coast of Thailand has been continuously developed, followed by investments in various businesses related to maritime activities such as shipyards, ship and cargo survey, marine equipment suppliers, shipping agents and freight forwarders.

As the shipping industry increases, manpower supply has to keep pace. This falls into the responsibility of the Merchant Marine Training Centre (MMTC), which was established in 1972. MMTC is a national institution operated by the Harbour Department, an agency of the Ministry of Transport and Communication. MMTC is the only institution in Thailand that provides education and training for merchant marine officers.

Presently the courses provided by MMTC are: officer deck/engine cadet course (5-years), rating course (15 weeks), special engine cadet course (3-years) and most specialised safety courses as required by the revised STCW78 Convention. All courses offered for seafarers fully comply with the revised STCW78 Convention. The main areas of training and education presently undertaken by the institution are all in the traditional monovalent scheme.

6.2 Present deck officer curriculum

The current approach of maritime education in many countries has been to integrate the marine education system into the national education system through universities. The main objective of the integration is to provide seafarers with an opportunity to obtain an academic degree in nautical and engineering science in addition to a professional certificate of competency in order to attract young people to a seafaring career and provide opportunity for higher education and mobility of a professional career.

For this reason, MMTC introduced a new curriculum for the officer course in 1997 (see Appendix 11). This programme includes all the required subjects (to be included in a bachelor's degree) which fully satisfy the national requirements set by the Ministry of Universities. All the requirements of the revised STCW78 Convention are also completely satisfied in this set-up. The students graduating from this system are entitled to receive a bachelor's degree in nautical science plus a second mate certificate.

The course structure is as follows:

- Total 5 years duration. The academic set up is on a semester basis. Each year is composed of two semesters, and each semester is about 18 weeks in length.
- The first 2 years of institutional based theoretical training including practical training on board the training vessel (15 days for each year)-covers the requirements for officer in charge of navigational watch (in accordance with Code A- II/1, STCW95).
- 1.5 years of apprenticeship on board a cargo vessel
- The final 1.5 years of institutional based theoretical training, including practical training on board the training vessel (15 days) covers the requirement for masters and chief mates (in accordance with Code A- II/2, STCW95).

6.3 Training facilities available for deck officer training

A number of training facilities and technology have been installed and provided in MMTC. Some of the main training facilities are as follows:

- Two training ships:

  M/V Visudsakorn, 1089 grt equipped with stand alone navigation equipment and full range of GMDSS system, capacity 60 cadets

  M/V Phayuharak 131.26 grt capacity 16 cadets (mainly used for training rating level in coastal voyage)

- Radar/ARPA simulator with 3 ownships
- GMDSS simulator 3 operator consoles
- Loading calculator 2 sets
- Cargo oil handling simulator-CBT 2 sets
- Gyro compass model consist of master compass, Gyrosphere cut away model
- Hull construction cut away model
- Computer laboratory 30 units and computer Network-LAN system 2 rings
- Video cassettes (Videotel)

However, a shiphandling simulator and other useful computer based training software for navigation have not been made available at MMTC yet.

6.4 The need for revision of navigation scheme

Modern technology is all around our environment, and for this reason there is pressure to combine these new aids together with the human element and prepare for the changes. Therefore, the institution has to be aware of the latest advances of navigation technology and keep improving, updating and upgrading the existing education and training programme in order to equip trainees with a practical reality of current and new trends of navigation systems.

The main objective of teaching navigation is to provide a trainee with academic knowledge, skills and positive attitude in order to operate a ship safely, effectively and efficiently. Therefore, the revision of the programme is not only made on the syllabus but also includes the use of more efficient ways of teaching, the use of efficient training facilities, and very importantly the need of high commitment from the instructors.

The scopes of revision of the present program are as follows:

- Decreasing the amount of time in some subjects that may no longer need to be covered to the same level of detail as they were before, such as celestial navigation, Omega, Decca and radio direction finder and adding new subjects on electronic navigation systems which are of great importance.
- Particular attention must be paid to the limitations and accuracy of the navigation systems. An understanding of how to use them, how they can mislead and how to correct them is the most important message to be given to the students.
- More emphasis on passage planning, bridge procedure, teamwork and the ability to use or co-ordinate all available resources on the bridge effectively, efficiently and safely.
- Introduction of the efficient way of teaching and encourage use of simulator, computer based training (CBT) and computer assisted learning (CAL), VDO, model and other media to attract the students' attention and for acquiring certain skills more quickly and effectively.

6.5 A proposed new navigation scheme

The proposal for revision will be made on three main existing subjects namely: Navigation, Watchkeeping and Shiphandling due to the fact that all existing subjects were designed on the basis of IMO model course 7.01 master and chief mate and 7.03 officer of navigational watch (published in 1991). As stressed previously, because of the fast change of technology in shipping, there is a need to reshape seafarers who will be competent to cope with the new trends, by updating the training programme.

In order to allow the proposed navigation syllabus to be easily implemented and harmonized with the present curriculum, which was recently introduced in 1997, the revision will not be made on the change of the total number of contact hours for each subject and the title of subjects and modules. The revision will mainly be focused on the syllabus and reallocation of the number of contact hours for some modules. The proposed navigation schemes are as follows:

Navigation Subject

Module: Navigation 1-Terrestrial Navigation
Teaching schedule: First Year -Semester 1 (54 hours, 3 hours per week)

Proposal
1. Definition of earth: great circle, spherical angles, earth's pole, equator meridian , latitude and longitude, nautical mile, cable and the knot 2. Charts: Chart projection, mercator chart, use of a chart catalogue, corrections and notice to mariners 3. Datums: rotation of the earth around its axis, gyro course, compass course 4. Compass corrections: deviation, variation 5. Distance: distance between two positions on a mercator chart 6. Position lines and positions: determine ship's position by use of land mark, aids to navigation including lighthouses, beacons, buoys and dead-reckoning 7. Sailings: parallel sailing, plane sailing, mercator sailing, great circle sailing

Remark: For further experience, the students will do more practice during sea training on board training vessel "Visudsakorn" (15 days) after completion of this semester.

Module: Navigation 2-Terrestrial Navigation
Teaching schedule: First Year -Semester 2 (54 hours, 3 hours per week)

Proposal
1. Chart work exercises: lays off true course between two positions, finds the distance and calculate speed, set, rate drift, leeway, course made good and course to steer. 2. Information from Charts, lists of lights and other publications; symbols and abbreviations on a chart, characteristics and range of lights, IALA bouyage system, sailing direction, ocean passages for the world, basic theory of tides,

simple passage planning and execution 4. Keeping a log; lists of rules, regulations and common practice regarding keeping a log 5. Ship's routing system and traffic separation scheme, narrow channel water

Remark: For further experience, the students will do more practice during sea training on board training vessel "Visudsakorn" (15 days) after completion of semester 4.

Module: Navigation 3- Celestial Navigation

Teaching schedule: Second Year -Semester 3 (54 hours, 3 hours per week)

Proposal
1. Solar system, celestial sphere and its co-ordinates, hour angle 2. Sextant and altitude corrections 3. Time and equation of time, nautical almanac 4. Rising and setting and identification of star, position fixing 5. Errors of compasses-azimuths, amplitude

Remark: For further experience, the students will do more practice during sea practical training on board training vessel (semester four) and the assignment will be given to the students during sea practical training on board merchant ships (18 months) (Semester 5-6-7)

Module: Navigation 4- Navigation Instruments

Teaching schedule: Second Year -Semester 3 (36 hours, 2 hours per week)

Proposal
1. Magnetism of the earth and the ship's deviation, magnetic compass, gyro compass 2. Principles, limitations and source of errors of navigational sensors and equipment, including the following: echo sounder, doppler speed log, rate of turn indicator, adaptive automatic pilot, rudder angle indicator

Module: Navigation 5- Electronic Navigational aids

Teaching schedule: Second Year -Semester 4 (54 hours, 3 hours per week)

Proposal
1. Basic principles of hyperbolic position fixing systems 2. Principles, operation, working knowledge, accuracy and possible errors and correction of the following instruments; Loran-C, radio direction-finders, satellite navigation system; GPS/DGPS, electronic chart system 3. Most probable position (MPP) analysis, areas of probability, cocked hat, diamond errors, ellipse of probability 4. Basic concept of integrated navigation system; data input, processing and presentation 5. Basic concept of automated bridge system; integrated bridge system

Module: Navigation 6- Electronic Navigational aids
Teaching schedule: Second Year -Semester 4 (36 hours, 2 hours per week)

Proposal
1. Principles, operation and limitation of Radar and automatic plotting aids (ARPA) 2. IMO performance standard for Radar/ARPA 3. The overlay of ARPA and ECDIS, basic concept of AIS

Remark: Radar/ARPA simulator is used for practical training, ECDIS is also required.

Module: Navigation 7- Passage planning
Teaching schedule: Fourth year -Semester 8 (54 hours, 3 hours per week)

Proposal
1. Introduction to passage planning 2. Types of passage plan; ocean, coastal, landfall, pilotage water, contingency 3. Appraisal: appraisal checklist, publications, the chart, navigations aids, tides, operational status of the vessel, meteorological information 4. Making the plan: marking the chart, pilotage waters 5. The contingency plan: diversion, reduced progress, changed conditions, emergencies

Remark: Shiphandling simulator is required for practical training

Module: Navigation 8- Navigation control
Teaching schedule: Fifth year -Semester 10 (36 hours, 2 hours per week)

Proposal
1. Execution of the passage plan:; monitoring progress, minor adjustments to the plan 2. Reacting to changed circumstance: implementing the contingency plan, reappraisal, replanning 3. Collision avoidance: clear visibility, restricted visibility 4. Distress, search and rescue: responding to the distress message, co-ordinating search and rescue 5. Vessel traffic service: functions of vessel traffic services, communications, informations service, ship reporting system.

Remark: Shiphandling simulator is required for practical training

Watchkeeping Subject

Module: Watchkeeping 1
Teaching schedule: First Year -Semester 2 (36 hours, 2 hours per week)

Proposal
Content, application and intent of COLREGs 72: Part A- general, Part B-steering and sailing rules, Part C-lights and shapes and Part-D sound and light signals

Module: Wactkeeping 2

Teaching schedule: Second Year -Semester 3 (36 hours, 2 hours per week)

Proposal
1.Annexes of the COLREGs 72 2. Lesson learned from actual collision 3. Keeping a watch in port: under normal circumstance and when carrying out hazardous cargo 4. Prevention of pollution: MARPOL 73/78, oil record book , reporting of incidents

Module: Watchkeeping 3

Teaching schedule: Fourth Year -Semester 8 (36 hours, 2 hours per week)

Proposal
1. Bridge procedure: keeping a safe navigational watch, principles to be observed in keeping a navigational watch as set out in regulation VIII/2 of STCW 1978 (amendment 1995) 2. Bridge teamwork procedure; bridge organization, master/officer relationship, navigating with a pilot on board, basic concept of bridge resource management

Remark : Shiphandling simulator is required for practical training and further practical training will be carried out onboard the training vessel during the sea training period after completion of semester 9.

<u>**Shiphandling Subject**</u>

Module: Shiphandling 1

Teaching schedule: Second Year -Semester 4 (36 hours, 2 hours per week)

Proposal
1. The effects of various deadweights, draughts, trim, speed and under-keel clearance on turning circles and stopping distances 2. Effect of wind and current on ship handling 3. Manoeuvres for the rescue of a man overboard 4. Squat and shallow-water and similar effects 5. Proper procedures for anchoring and mooring

Remark: Shiphandling simulator is required for practical exercise.

Module: Shiphandling 2

Teaching schedule: Fifth Year -Semester 9 (36 hours, 2 hours per week)

Proposal
1. Berthing and unberthing under various conditions of wind and tide, with or without tugs 2. Management and handling of ships in heavy weather; avoid roll resonance and quartering sea

3. Manoeuvring in traffic separation schemes, communications, use and operation of full range of bridge equipment and electronic navigational aids.

Remark: Shiphandling simulator is required for practical training

6.6 Effective use of Radar/ARPA simulator

It is apparent that the Radar/ARPA simulator in MMTC has not been used effectively for the maximum benefits. The fact is that it is mainly used for training in the radar observer and radar simulator courses which are conducted about seven times a year (seven weeks per year) for external participants. Rarely is the simulator utilised for support in navigation subjects. Therefore, for economic and effective training purposes, the maximum use of the simulator is recommended. The instructors should budget their lecture time for practical training on the simulator rather than spend most of the time on the whiteboard.

Another important issue is that there is a need to develop and improve the present radar observer and radar simulator course offered by MMTC. The Radar/ARPA simulator is nowadays a mandatory training tool in a maritime institution and the training and assessment procedures as well as the qualification of simulator instructors are required by the revised STCW 78 Convention.

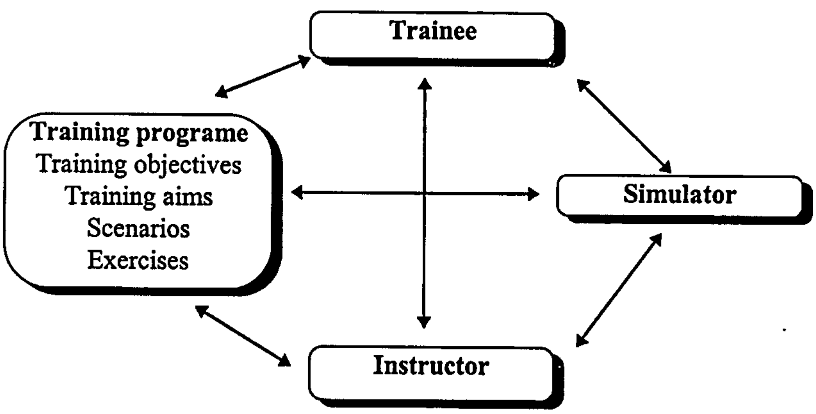

Figure 5.1 Relationship of four elements in a simulation training

Source: Lemburg, 1998

Simulation training can be considered as consisting of four elements which show an intensive interaction through the training in a simulator (see Figure 5.1). The figure shows that the four elements are dependent on each other. Any changes to one of the elements will influence the other. They are interlinked and highly dependent on each other. It is often said that the instructor is the most important component in ensuring the effectiveness of simulator training.

Therefore, for the time being the need to improve radar/ARPA simulator training in MMTC can be focused on 2 aspects, namely the instructor and the training programme.

(a) The instructor : According to STCW 95, code A, Section A-I/6 requires that the simulator instructor must have received guidance in instructional techniques for the use of the simulator and have gained operational experience in the use of the simulator. In addition in Section A-I/12 paragraph 1 requires that the simulator instructor has to use the simulator in the most appropriate way to produce a level of realism appropriate to training objectives and to control, monitor and record exercises for effective debriefing or assessment, define training programmes and training objectives on the basis of shipboard tasks and practices.

The following is a summary of proposed instructor's qualifications which is contained in Annex F of Task 46, WP 4 of MASSTER project (Maritime Standardised Simulator Training Exercises Register, 1998) which can be used as a guideline for improving the skills of the simulator instructors at MMTC.

<u>The instructor and assessor in relation to simulator facility</u>

The instructor has to

- be able to use the equipment installed in the simulator for training.
- understand and use the simulator in the field of training objectives the simulator is installed for.

- know the limits of the simulator and of simulation in detail and in general for conducting an effective training.
- use all means of the simulator to produce a level of realism appropriate to the training objectives.
- use all means available for an effective briefing, monitoring, recording and debriefing.
- use all means available for an evaluation and assessment

The assessor has to

- know the training objectives the simulator is installed for.
- know the limits of the simulator and simulation.
- be able to use all means available for assessment.

<u>Instructor and assessor in relation to the training programme</u>

The instructor has to be able

- to detect training requirements.
- to define training objectives according to shipboard tasks and practices.
- to define the training programme.
- to prepare the relevant scenarios/exercises.
- to conduct training.
- to carry out an effective briefing, monitoring, recording, debriefing by all means. available for the control of the achieved results in regard to the training requirements, objectives and the training programme.

The assessor has to

- know the training objectives and the training programme.
- be capable of using the relevant assessment criteria.

Instructor and assessor in relation to the trainee

The instructor has to be able

- to motivate the trainee.
- to produce a positive learning atmosphere.
- to communicate in a clear and understandable way.
- supervise in a constructive and helpful manner.
- to show a certain amount of enthusiasm for the training.

The assessor has to

- be able to give information about the assessment criteria understandable to the trainee.
- be able to inform about the assessment results in a clear and understandable manner.

(b) Training programme, exercises and scenarios: the exercises and scenarios used in the training programme at MMTC need to be reviewed, evaluated and properly documented. For this purpose, it is worth applying the guidelines for designing and evaluating a simulator exercise, which was recommended by Cross (1998) to MMTC. The guideline consists of nine steps as follows:

Step 1. Introduction: to know the capability and limitation of the simulator

Step 2. Special learning objectives: specify what the students must be able to do after the training.

Step 3. Duration of exercise: specify the time for: simulator familiarisation, briefing, simulator training, debriefing, discussion and possible evaluation.

Step 4. Number of students per instructor: student:instructor will vary per exercise level, exercise stage in a programme and experience of the trainees, 4:1 or 6:1 should be feasible.

Step 5. Special instruction for the instructor: the instructor guidance is a technique whereby relevant information concerning the appropriate procedures is provided to the trainees during the training exercise on the simulator.

Step 6. Special instructions to the students: the exercise given to the trainee should be as specific as possible.

Step 7. Status: specify the initial condition or status of the simulator at the time the exercise will commence.

Step 8. Debriefing: debriefing after the exercise is of great importance in order to acquire knowledge about the effect of the exercise. The following questions can be considered for the debriefing:

Was the situation realistic enough?

Was the situation correctly understood?

Were the aims and objectives correct?

Were the actions taken correctly?

Were the procedures carried out correctly?

Were the results of the actions as expected?

What were the results of alternative action?

Were the aims and objectives reached?

Step 9. Evaluation: evaluation should be divided into various components: effectiveness of exercise, quality of exercise, trainee's achievement, exercise within programme, programme as a whole.

The evaluation of the effectiveness of the exercise and the quality of the exercise will come from the debriefing and from the students' scoring. The evaluation of a training programme can be done by means of a number of questions, written and a kind of questionnaire form at the end of the course.

The exercises and scenarios should be well documented and written in a structured format which can be easily understood and is accessible. This format should include the title and consecutive number, references to existing training objectives, the estimated duration of the exercise, the objectives to be reached, the prerequisites expected from the student, the training materials and initial condition of the simulator. The information about the briefing, the expected from the student action, the instructor actions to be taken, debriefing points and evaluation notes should also be mentioned. One of the good examples of such format as prepared by the Institute of Shipoperation, Maritime Transport and Simulation in Germany is given in Appendix 12.

6.7 The need for staff training

The shortage of qualified instructors is one of the greatest problems of MMTC. Another problem is the lack of staff development and training. Under the revised STCW 78 Convention it is made mandatory that lecturers, instructors and assessors be appropriately qualified and have relevant experience. Therefore, training and updating knowledge and expertise of instructors should be seen as a priority at MMTC. Besides the requirements for training, the staff also need to be motivated and should possess the sense of interest and commitment to their tasks and responsibilities. MMTC must encourage and facilitate the professional development of staff in various forms, amongst other things as follows:

- Establish instructor training course (IMO model course 6.09 training course for instructor) for the MMTC' s staff.
- Allow staff to sail on board various types of cargo ships at intervals in order to refresh their skills and keep up to date with the changing trends in the real shipping world.
- Provide opportunities and scholarships for staff to continue higher education, to attend short courses, seminars or workshops whether in the country or abroad and encourage or fund the staff to conduct research or other studies.

6.8 Future roles of MMTC in the Thai maritime industry

To strengthen the Thai maritime industry, the investment is not only made for technology and infrastructure but must also be made for research, training and education. In this regard, MMTC as a unique maritime institution in the country should play a significant role in contributing to the development of the Thai's capabilities and competitiveness in the maritime field such as ship operations, construction and repair, shipping management, port management, trading and safety. MMTC's roles should be improved and be more active as follows:

- anticipate and fulfill the needs of the Thai maritime industry for maritime and maritime related education and training, research and development
- increase the role of the institution in research, development and consultancy in shipping matters and publish reading materials on shipping and related subjects.
- closer liaison with the maritime industries will enable the institution to respond readily of demand.
- new courses must be constantly developed to produce graduate maritime specialists who can adapt to the challenge of changing and increasingly complex industries.

To achieve the development of the Thai maritime industry, the Thai government is advised to pay more attention and give priority to the development of MMTC. Importantly, funds should be allocated to MMTC for staff development, facilities and research.

CHAPTER 7

Conclusions and Recommendations

According to the result of the study and investigation in this dissertation, it is the author's point of view that the following conclusions and recommendations highlight the important issues in the development of training and the improvement of the safety and efficiency of an advanced ship of today and the future. The recommendations are also given for the development of education and training programmes in MMTC and the improvement of its role in the Thai maritime industry.

7.1 General conclusions

The general overview of the current trend of an advanced ship equipped fully with modern technology is summarized as follows:

- More accuracy, reliability and efficiency of navigational aids.
- More efficiency and effectiveness of communication, with increased use of satellite communication technology and increased use of information technology.
- Increased degree of integration, automation and computerised decision-making aids.
- More operations are concentrated on the bridge.
- Larger size, smaller crew and quick port turn around.
- Increased integration of shipboard functions, multi-skilled crew and one man bridge operation.

It is obvious that technological advances are having a great impact on the way in which a ship is to be operated and managed. As the bridge becomes an operational centre for all vital shipboard functions in addition to navigation tasks, the aim is for the bridge to be operated by only a single man on the bridge. These functions are mostly carried out by a number of complicated automatic systems. The operator's functions will be mainly to monitor systems under automatic control and take initial action to rectify the fault. The new roles of a bridge operator can be concluded as follows:

- Process controller and task supervisor
- Increased responsibility and decision making roles
- Increased information workload
- Shifting from a physical to a mental load
- Multi-skilled background

Therefore, a bridge operator needs to be trained in such a way that he/she must be able to adapt to the new changing environmental workplace and have the capability to perform the tasks effectively, efficiently and safely. Thus new training needs to be thoroughly examined. The required knowledge, skills and attitudes should be clearly identified and related to the actual tasks and technology on board. The aim of the training should provide him/her with sufficient knowledge of the characteristics of the system, to enable him to handle the system safely and to go on learning by experience during actual operations.

To achieve such aim, the co-operation between institutions, manufacturers and shipping companies needs to be improved (see Figure 7.1). As a large part of the equipment consists of new technology. Therefore the manufacturer of the equipment will have to accept a lager responsibility for the training than before. Not only how to operate, but also, there must be a detailed description of its working principles and where it can go wrong. Shipping company should provide clear informations on;

functions of the personnel on board, shipboard operational conditions and procedures and level of technology used on board to the institution to enable the training programme to be designed in response to the actual job on board. The outcomes will benefit to all parties concerned; manufacturers will improve the quality of their product to satisfy their customers and users, institutions will delivery effective training programme, shipping companies will happy with their well- trained crew.

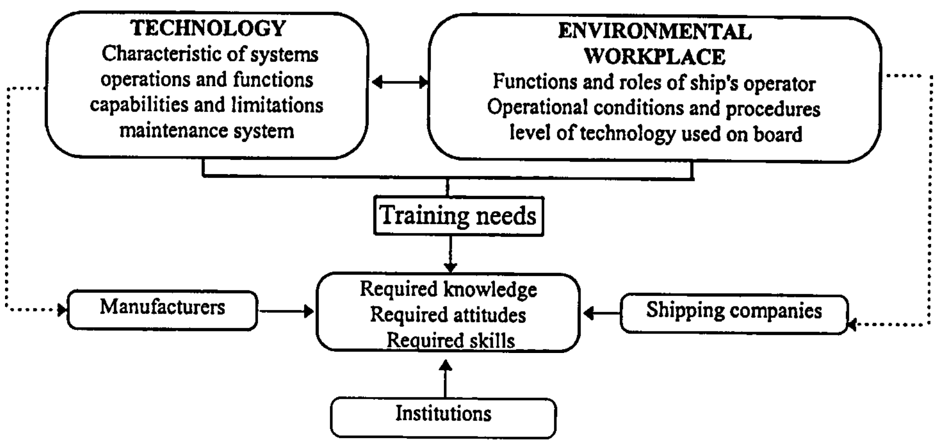

Figure 7.1 Closer co-operation need

In the light of technology, one should be aware that the use of technological advances do not always meet the goal of safety due to the fact that some weakness areas have been found and need to be further improved and developed. The technological performance of equipment, including reliability and accuracy will be defined in performance standards approved nationally and internationally. In contrast, an overall 'ergonomic performance' metric remains ambiguous. A number of areas may be addressed such as standardization of controls and symbols, ergonomics of controls and symbols, ergonomics of the interface design, all of which will clearly impact on the ease of use and effectiveness of an integrated bridge system as the ship control and management centre. Very importantly, it should be borne in mind that all electronic systems have a potential risk of failure.

In addition, the author strongly believes that technology can not completely replace human beings. Therefore, to increase safety in navigation, the backup might not only be other electronic navigation systems, but also some essential traditional navigation methods are needed to be preserved in case the electronics fail.

7.2 Conclusions for MMTC

Considering the present and future trend in the development of the maritime education and training programme in MMTC in order to provide the maximum benefits for the Thai seafarers and the Thai shipping industry, three mains factors need to be improved, namely training programmes, staff skills and training facilities (as discussed in the detail in Chapter 6). The most urgently needed training facility, for the time being, is a shiphandling simulator, which is now recognised by maritime institutions worldwide as an cost-effective, non-risk and efficient training tool, in having such a tool at MMTC will help to close the gap between theory and practice as well as to improve the professional skills of Thai seafarers. Other than used in a teaching of a navigation programme, a shiphandling simulator can be utilized for many training purposed and activities, among other things; bridge resource management, shiphandling simulator course, search and rescue, pilotage training and vessel traffic service.

The roles of MMTC should be more active in the areas of research and development project to enhance the strengtheness of Thai shipping fleet. For instance, look at the present status of Thai merchant fleet which has an average age of 20 years with an average manning level of 30 (office of maritime promotion commission, 1996). This challenges the Thai shipping fleet and MMTC to decrease the number of personnel onboard in order to become more competitive in the international market by using newer ship equipped with more sophisticated technology and multi-skilled crew.

7.3 General recommendations

In the view of the foregoing remarks and conclusions, the author makes the following recommendations:

- Closer co-operation between institutions, manufacturers and shipping companies is needed to develop the effective training programme for the operators of advanced ships of today and the future.
- The detail of syllabus and training methodology for integrated bridge operator should be further examined and incorporated in IMO model course.
- With regard to bridge resource management (BRM) training, it is recommended that the following steps should be taken:
  - ♦ Set up a standard BRM curriculum in the form of an IMO model course
  - ♦ Incorporate BRM training as one of the requirements for a ship's officer certificate
  - ♦ Shipowners and maritime institutions to be urged to support and implement BRM training within their organizations.
- To avoid excessive fatigue, the one man bridge operation vessel should be manned at least by a master and three qualified officers. The duration of the watches and service contracts need to be examined further.
- There is a need to further investigate the effect on the mental processes when a single officer of the watch is supervising various functions simultaneously. Particularly, in critical conditions where the officer of the watch needs adequate information in order to make the right decision.
- Further research should also be conducted to introduce measures to overcome monotony and loneliness.
- Manufacturers of marine electronic equipment should initiate the evaluation process at an early stage of the design phase of the user interface in order to allow for possible modifications suggested by the results of the test. Manufacturers should evaluate the user interface of their equipment from the view point of ship operators.

- It is suggested that simulator trials or even laboratory tests, be conducted independently of the design team, for example, by experienced navigators or maritime lecturers who will produce useful results for both designers and prospective end users.
- Effort should be made to bring about the standardization of each unit, total integrated system and bridge design and layout, so that the risk of human error could be reduced by standardizing user interfaces and cockpit layout.

7.4 Recommendations for MMTC

The following recommendations are put forward to indicate the directions needed to be taken in the near future in order to improve and develop maritime education and training in Thailand and most importantly, for the maximum benefits of the Thai maritime industry.

- The present navigation syllabus should be updated as proposed in chapter 6 in order to enable Thai seafarers to cope with technological changes.
- MMTC should establish a professional development training program for its instructors including simulator instructors as suggested in Chapter 6.
- MMTC should be more active, aggressive and resourceful in order to create a good relationship between shipping industries and other bodies concerned.
- Modern technologies and teaching methodologies should be introduced to MMTC; Computer Aided Learning (CAL), Information Technology (Internet, E-mail) in order to enhance the students's skills relating to many aspects of ship operations and equip them with computing skills and information technology skills.
- The radar/ARPA simulator training course should be improved in both the instructor skills and its programme.
- There is an urgent need to upgrade the radar/ARPA simulator into a shiphandling simulator fitted with a visual capability and an integrated navigation system.

- The Government should establish a fund for staff training, conducting research and updating and providing training facilities.
- It is recommended that a study on the potential reduction of manning levels onboard the Thai fleet should be conducted with the close co-operation between MMTC and Thai shipping companies to examine the application of technology on board, shipboard functions and organization structure and training needs. It is suggested that at the initial stage, a study should focus on the possibility of integrated functions at rating level and then proceed to the officer level at the next stage.

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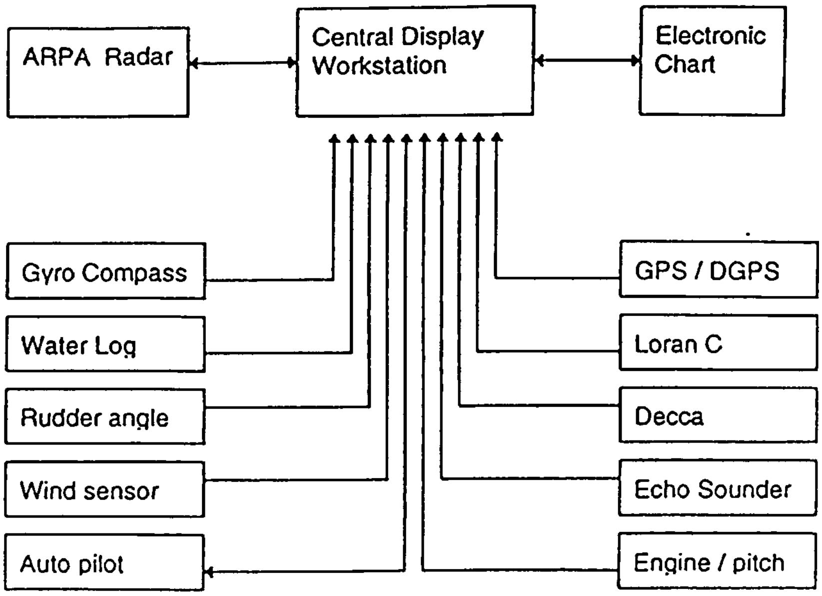
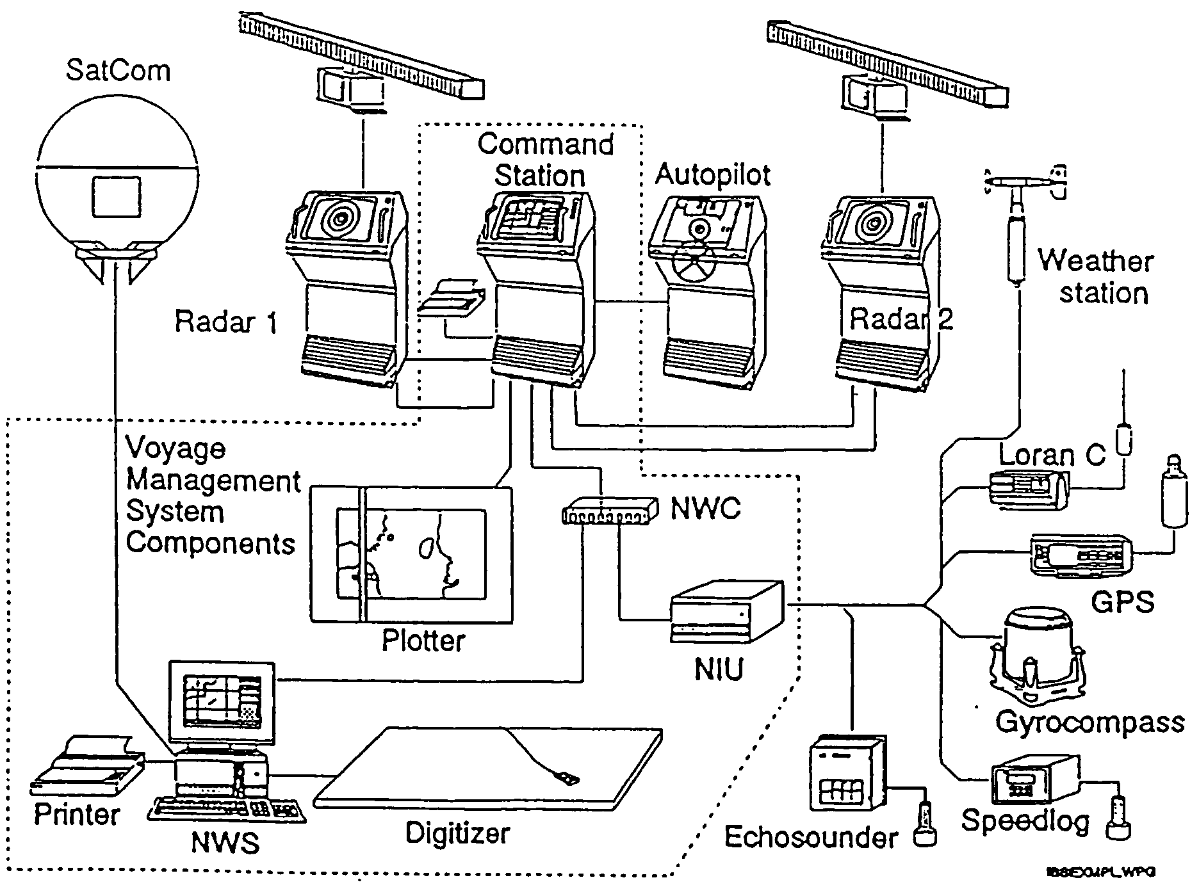
APPENDIX 1

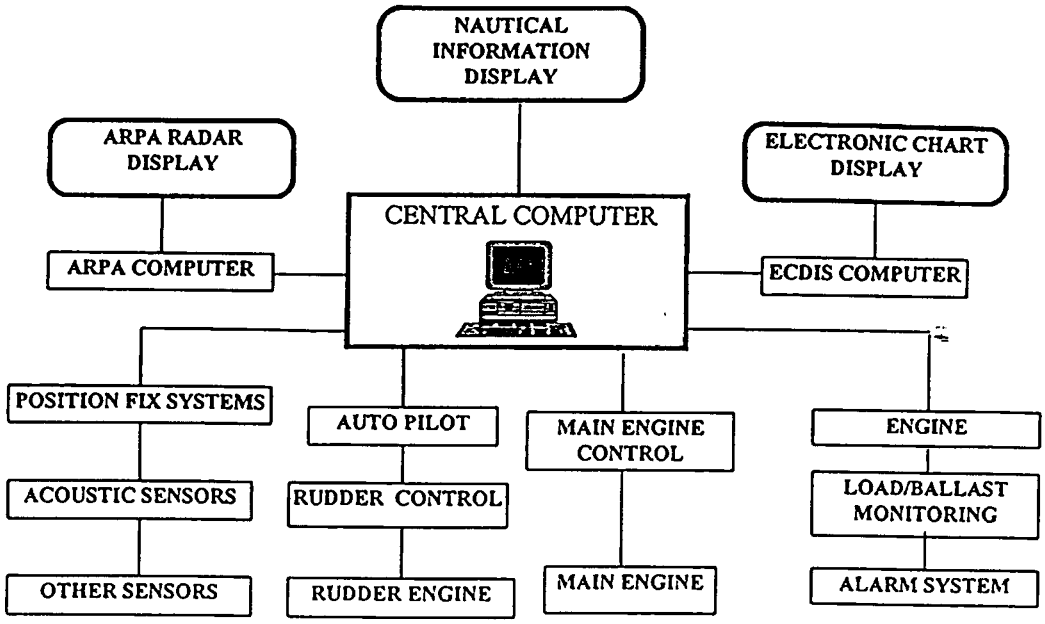


Integrated Navigation System components
Source: Safety at sea, 1997, page 29

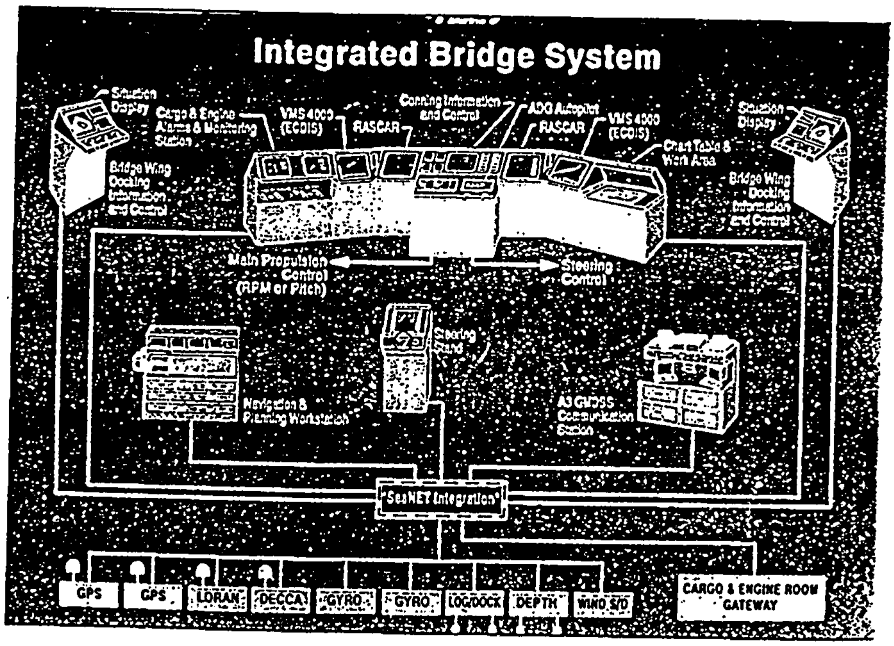


An example of a medium-sized integrated navigation system
Source: Denham, E., 1993, page 279

APPENDIX 2

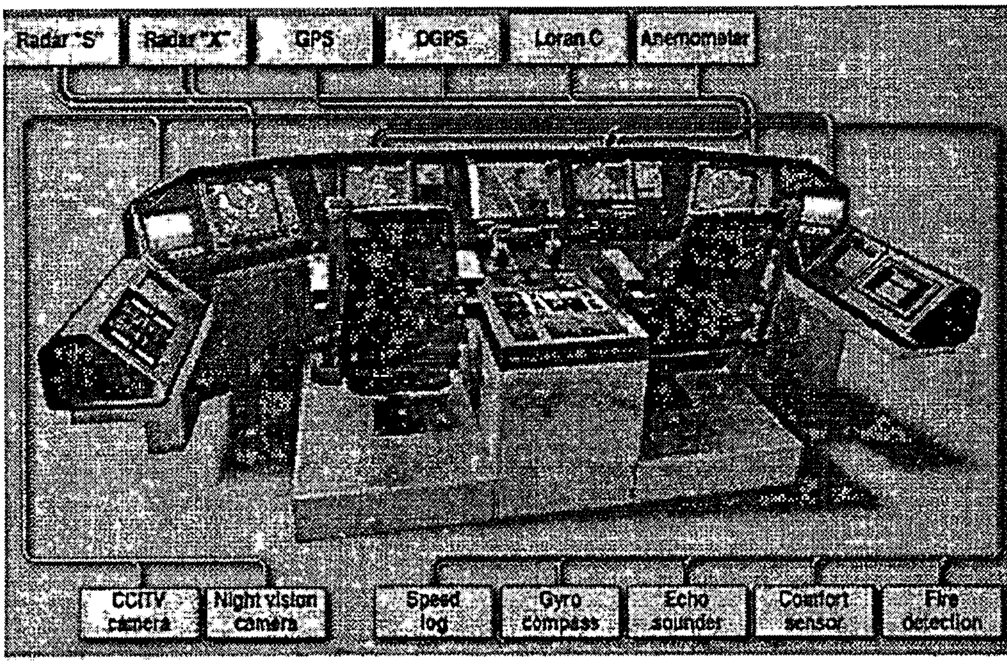


Integrated Bridge System architecture



Integrated bridge System diagram
Source: Marine Log, May 1993, page 48

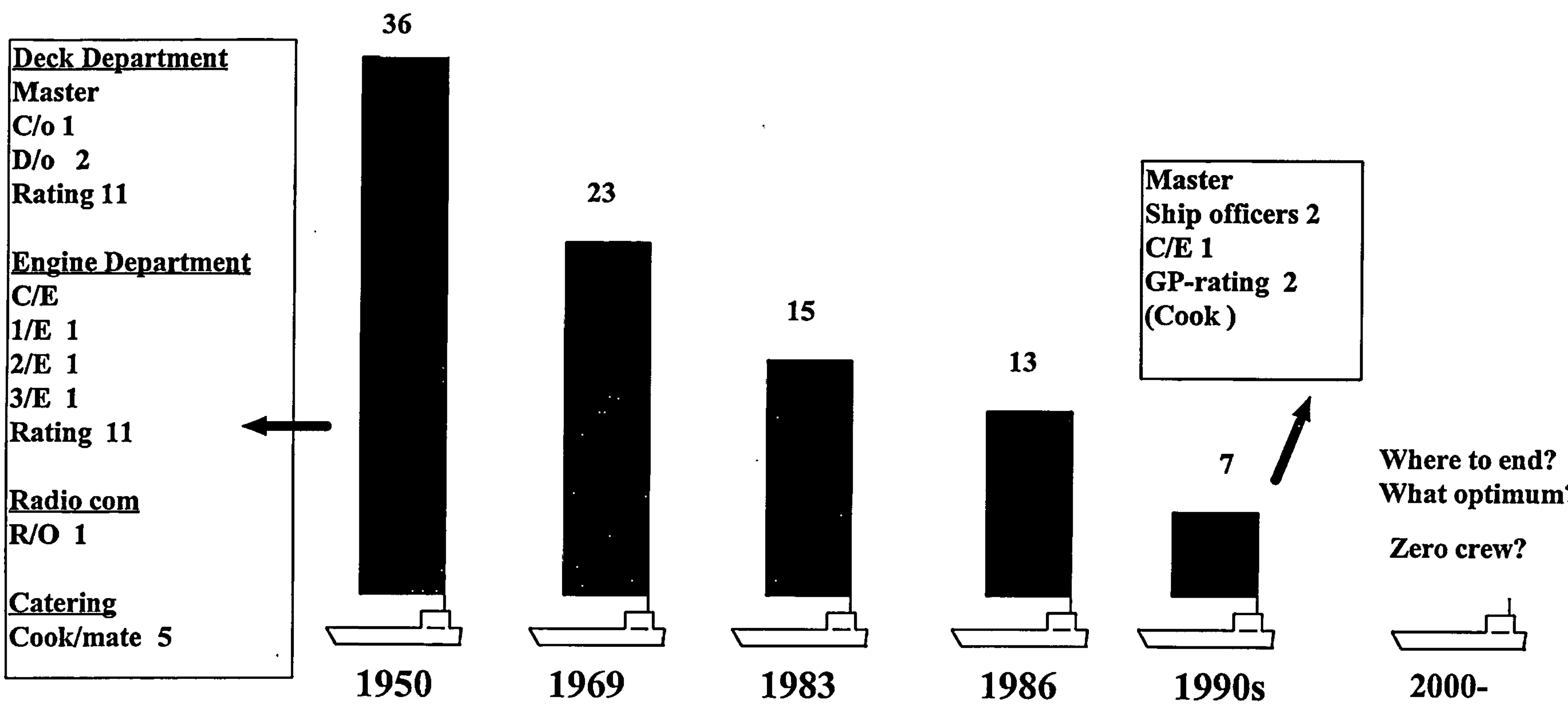
APPENDIX 3



Sea cockpit
Source :Norcontrol, 1997

APPENDIX 4

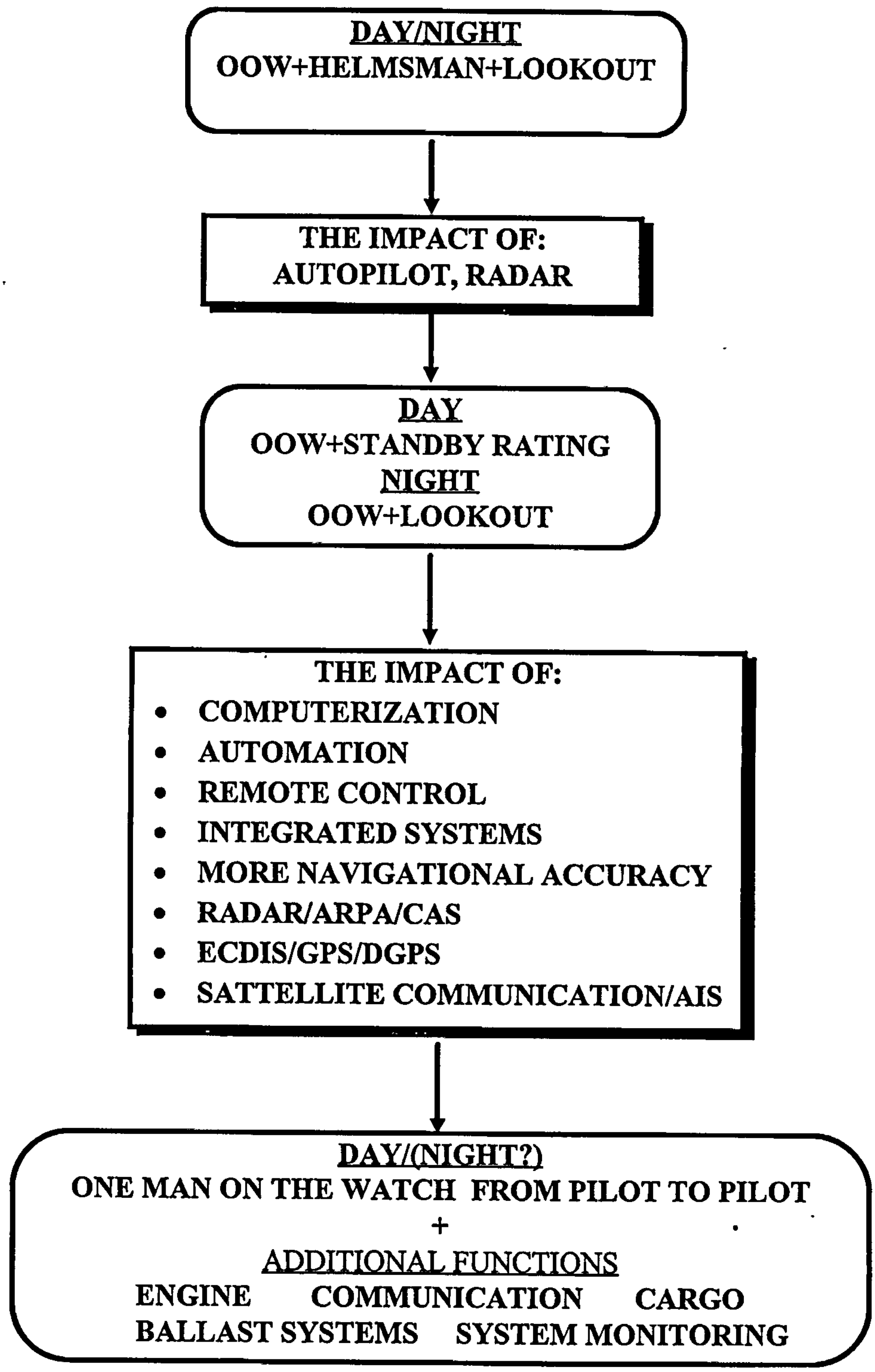
MANNING DEVELOPMENT



Modified from: Det Norske Veritus (DNV): Rules for nautical safety:one man bridge operation

APPENDIX 5

EVOLUTION OF BRIDGE MANNING



APPENDIX 6

STCW Code A, Section A-VIII/2 part 3-1-Principles to be observed in keeping a navigational watch

Part 3-1 Principles to be observed in keeping a navigational watch

12 The officer in charge of the navigational watch is the master's representative and is primarily responsible at all times for the safe navigation of the ship and for complying with the International Regulations for Preventing Collisions at Sea, 1972.

Look-out

13 A proper look-out shall be maintained at all times in compliance with rule 5 of the International Regulations for Preventing Collisions at Sea, 1972. and shall serve the purpose of:

.1 maintaining a continuous state of vigilance by sight and hearing as well as by all other available means, with regard to any significant change in the operating environment;

.2 fully appraising the situation and the risk of collision, stranding and other dangers to navigation; and

.3 detecting ships or aircraft in distress, shipwrecked persons, wrecks, debris and other hazards to safe navigation.

14 The look-out must be able to give full attention to the keeping of a proper look-out and no other duties shall be undertaken or assigned which could interfere with that tasks.

15 The duties of the look-out and helmsperson are separate and the helmsperson shall not be considered to be the look-out while steering, except in small ships where an unobstructed all-round view is provided at the steering position and there is no impairment of night vision or other impediment to the keeping of a proper look-out. The officer in charge of the navigational watch may be the sole look-out in daylight provided that on each such occasions:

.1 the situation has been carefully assessed and it has been established without doubt that it is safe to do so;

.2 full account has been taken of all relevant factors, including, but not limited to:
- state of weather,
- visibility,
- traffic density,
- proximity of dangers to navigation, and
- the attention necessary when navigating in or near traffic separation schemes; and

.3 assistance is immediately available to be summoned to the bridge when any change in the situation so requires.

16 In determining that the composition of the navigational watch is adequate to ensure that a proper look-out can continuously be maintained, the master shall take into account all relevant factors, including those described in this section of the Code, as well as the following factors:

.1 visibility, state of weather and sea;

.2 traffic density, and other activities occurring in the sea in which the vessel is navigating;

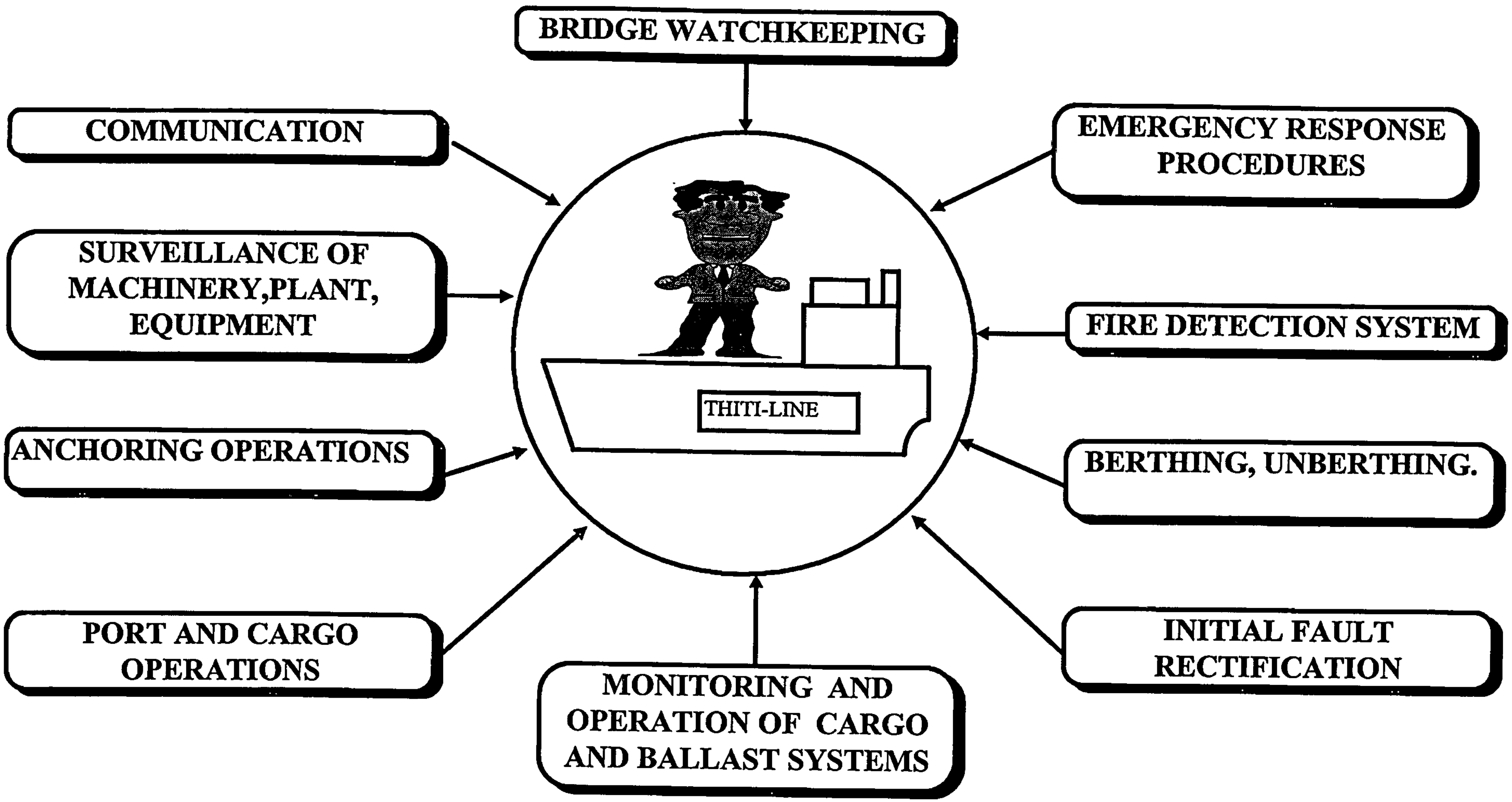
.3 the attention necessary when navigating in or near traffic separation schemes or other routeing measures;

.4 the additional workload caused by the nature of the ship's functions, immediate operating requirements and anticipated manoeuvres;
.5 the fitness for duty of any crew members on call who are assigned as members of the watch;
.6 knowledge of and confidence in the professional competence of the ship's officers and crew;
.7 the experience of each officer of the navigational watch, and the familiarity of that officer with the ship's equipment, procedures, and manoeuvring capability;
.8 activities taking place on board the ship at any particular time, including radiocommunication activities, and the availability of assistance to be summoned immediately to the bridge when necessary;
.9 the operational status of bridge instrumentation and controls, including alarm systems;
.10 rudder and propeller control and ship manoeuvring characteristics;
.11 the size of the ship and the field of vision available from the conning position;
.12 the configuration of the bridge, to the extent such configuration might inhibit a member of the watch from detecting by sight or hearing any external development; and
.13 any other relevant standard, procedure or guidance relating to watchkeeping arrangements and fitness for duty which has been adopted by the Organization.

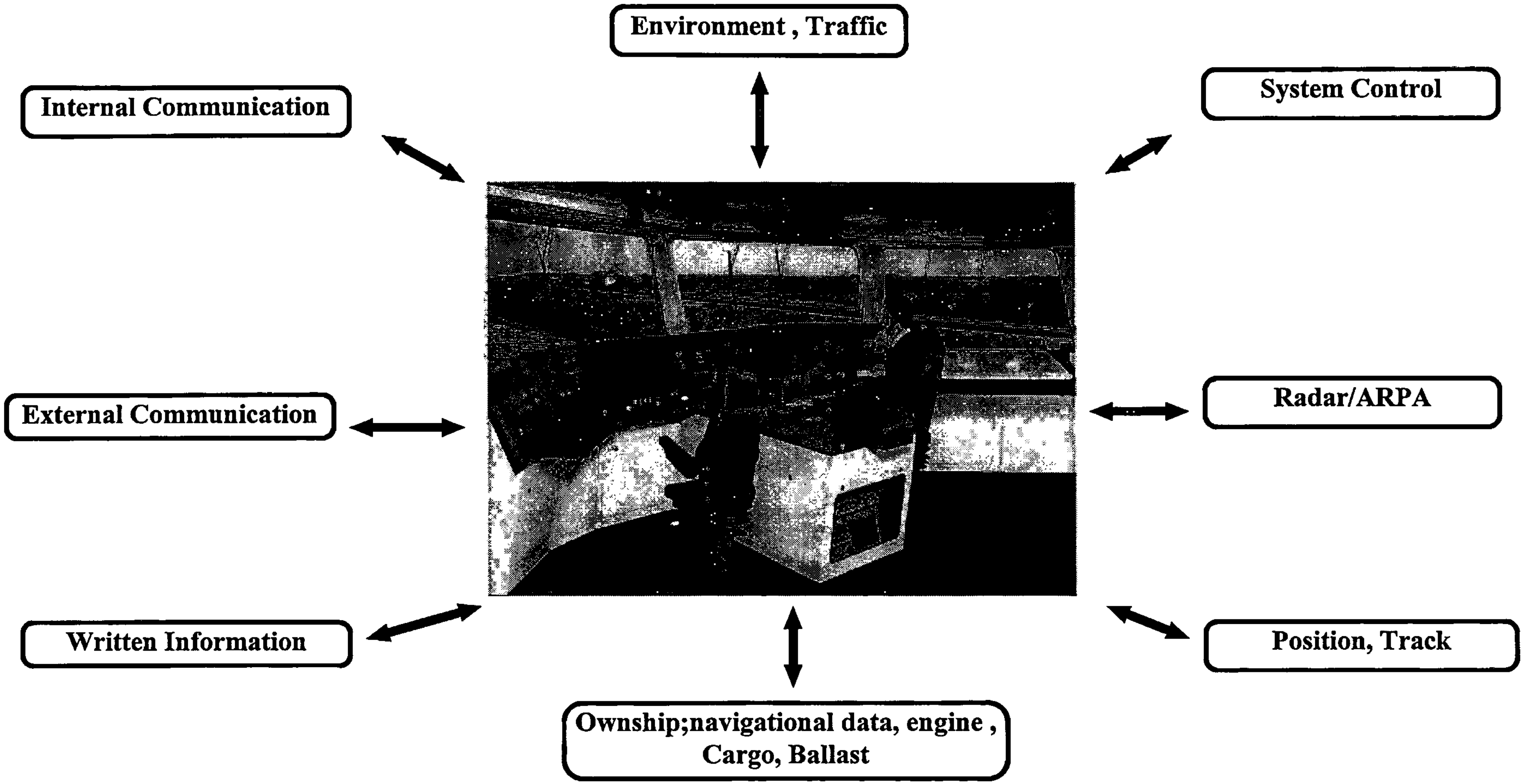
Source: Extract from International Convention on Standards of Training, Certification and Watchkeeping for Seafarers, 1978, as amended in 1995, page 141-143

APPENDIX 7

ONE MAN BRIDGE OPERATION' S FUNCTIONS



APPENDIX 8
Flow of information during watch



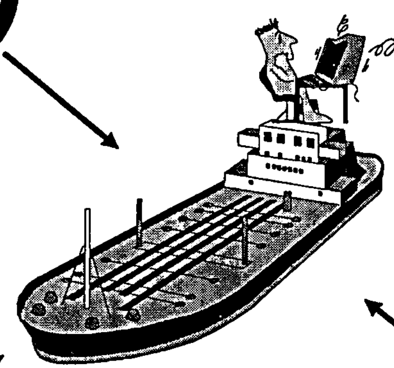
Picture from Norcontrol,1998

APPENDIX 9

ONE MAN BRIDGE OPERATION :FACTORS TO BE CONSIDERED

Operational conditions
(Section A-VIII/2 , paragraph 15 of STCW 95)
Open sea
Good weather
Clear visibility
Low volume of traffice
No hazard to navigation along anticipated route
etc.

Technology
Reliability
Bridge safety alarm system
Bridge design and instrument
Automated/integrated bridge system
Ergonomic and man/machine interface



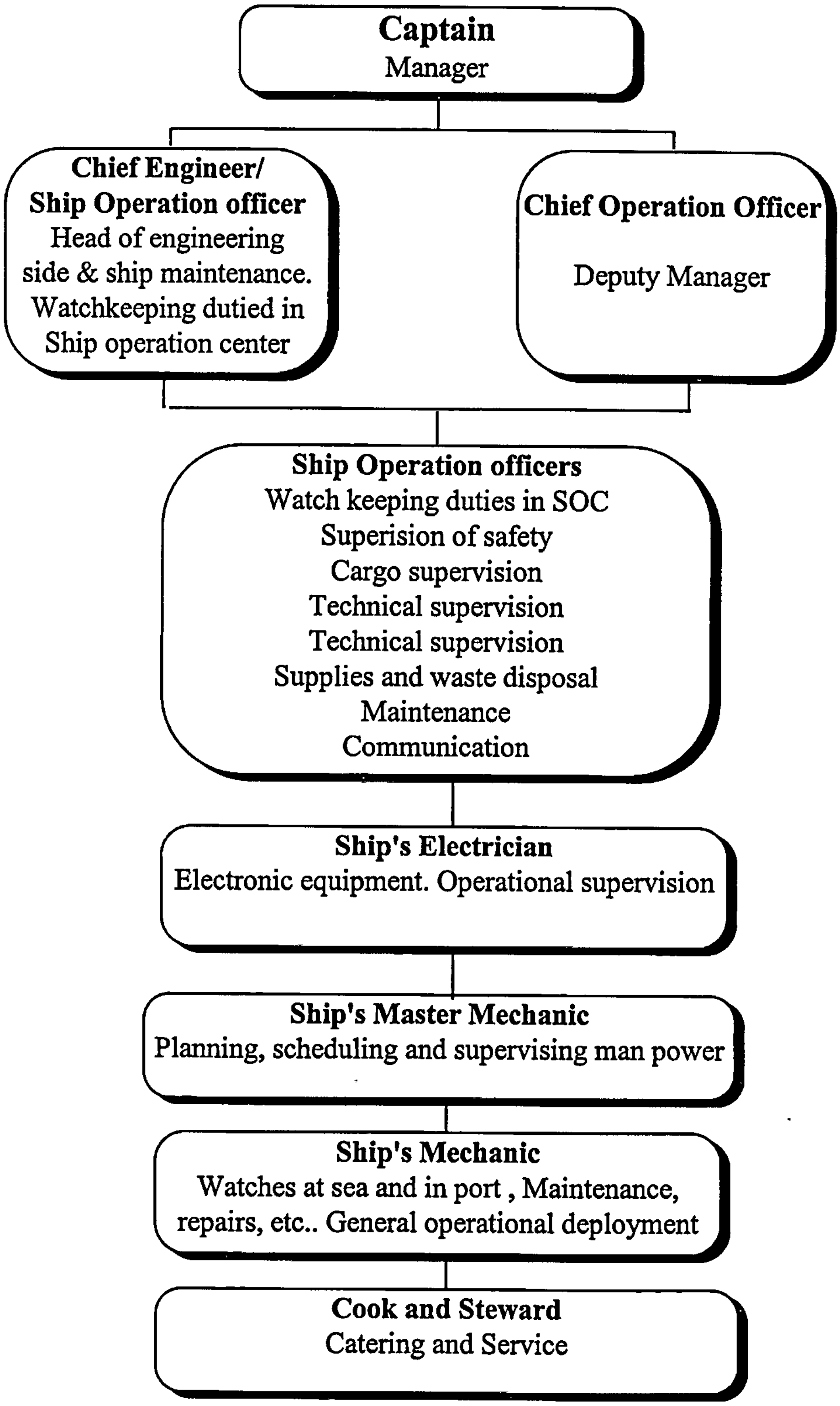
Operational procedure

Back up officer arrangment
Effective bridge procedure

Human factor
Fatigue
Attitude
Monotony and loneliness
Physical and Mental fitness
Competency and training needs

APPENDIX 10

Crew and Organizational Structure
MV"Hannover Express" Year built 1991. TEU 4,407.
52,600 DWT, 15 Crews. Hapag-Lloyd



Source: Hapag Lloyd report, 1993

APPENDIX 11

Nautical curriculum in MMTC, Thailand Total 5 years (18 weeks/semester)

Groups	Subjects	No. hours	credits
A. General study			
Linguistic	English	342	14
	Thai langauge skill	36	2
Anthropology	Ethics	36	2
	Information services and study fundamental	36	2
	Man and Aesthe	36	2
	Psychology and human relations	36	2
Sciology	Economics	36	2
	Instructor Course	18	1
	Introduction to Jurisprudence	36	2
	Organisation and Management	36	2
	Political Sciences	36	2
Physical education	Physical education	144	4
B. Specialised study			
Specialised subjects	Chemistry	108	4
	Calculus	162	9
	Computer and information processing	42	3
	Physics	108	7
	Elementary Statistic	54	3
Majors subjects	Automatic and control	36	2
	Cargo handling and stowage	144	8
	Communications (include GMDSS for GOC certificate)	144	8
	Electrical engineering	36	2
	Electronics engineering	90	3
	Emergency procedures	36	2
	Fundamental Engineering workshop	54	1
	Maritime Law	144	8
	Meteorology and Oceanography	108	6
	Navigation	378	21
	Ship business	72	4
	Ship construction	270	15
	Ship handling	72	4
	Ship power plants	72	4
	Seamanship	72	4
	Watchkeeping	108	6
C. Optional subjects	Students are required to choose any other subjects to gain 3 credits		3
D. Practical training			
Practical sea training	on-board training (cargo ship)	18 months	-
	on-board training (training ship)	45 days	-
Professional Training	Fire prevention and fire fighting course	3 days	-
	Medical first aid course	2 days	-
	Personal survival course	3 days	-
	Personal safety and social responsibilities course	3 days	-
	Survival craft, rescue boat course	5 days	-
	Medical care on board ship course	4 days	-
	Radar/ARPA simulator course	5 days	-
	Advanced fire fighting course	5 days	-
	Total		164

APPENDIX 12

Simulator training scenario format

Prepared by

The Institute of Shipoperation, Maritime Transport and Simulation

Hamburg, Germany

TRAINING SCENARIO

CROSSING GERMAN BIGHT

(Main SIT-ID ISS_7001)

Training Objectives
- Quality Assurance
- Bridge Resource Management

Training Subjects
- NACOS-Training
- ECDIS-Training
- Collision Avoidance
- Standing a Watch

DocID: MR\SIL_SCE\SIL_7001_2.WPD
Last Update... : Nov 13, 1997

SCENARIO DIRECTORY

TASKS

Conning a vessel in an area with multi direction traffic, Radar interpretation, collision avoidance

RUN DESCRIPTION SCENARIO 7001

At the start of the run MV SUSAN is located about 1.5 nm south of the *LANBY "Jade/Weser"*. The vessel is bound for Hamburg. During the first part of the voyage the Inner German Bight must be passed, where a lot of crossing traffic must be expected as well as vessels sailing in the same direc.tion.

THE BRIDGETEAM SHOULD BE FORCED TO OBSERVE AND TO PLOT CAREFULLY NOT ONLY ALL THE TRAFFIC COMING FROM STARBOARD BUT AS WELL AS ALL TRAFFIC COMING FROM PORT.

It is intended, that only the **vessel #3.1** will be all the time in unchanged bearing and will not give way for the ownship. All other vessels should follow the rules of the road.

All vessels on starboard side of the ownship are used to enforce the bridgeteam to concentrate on this side.

If the bridgeteam makes passing/traffic arrangement, **all vessels but #3.1** agree on any rational passing arrangement.

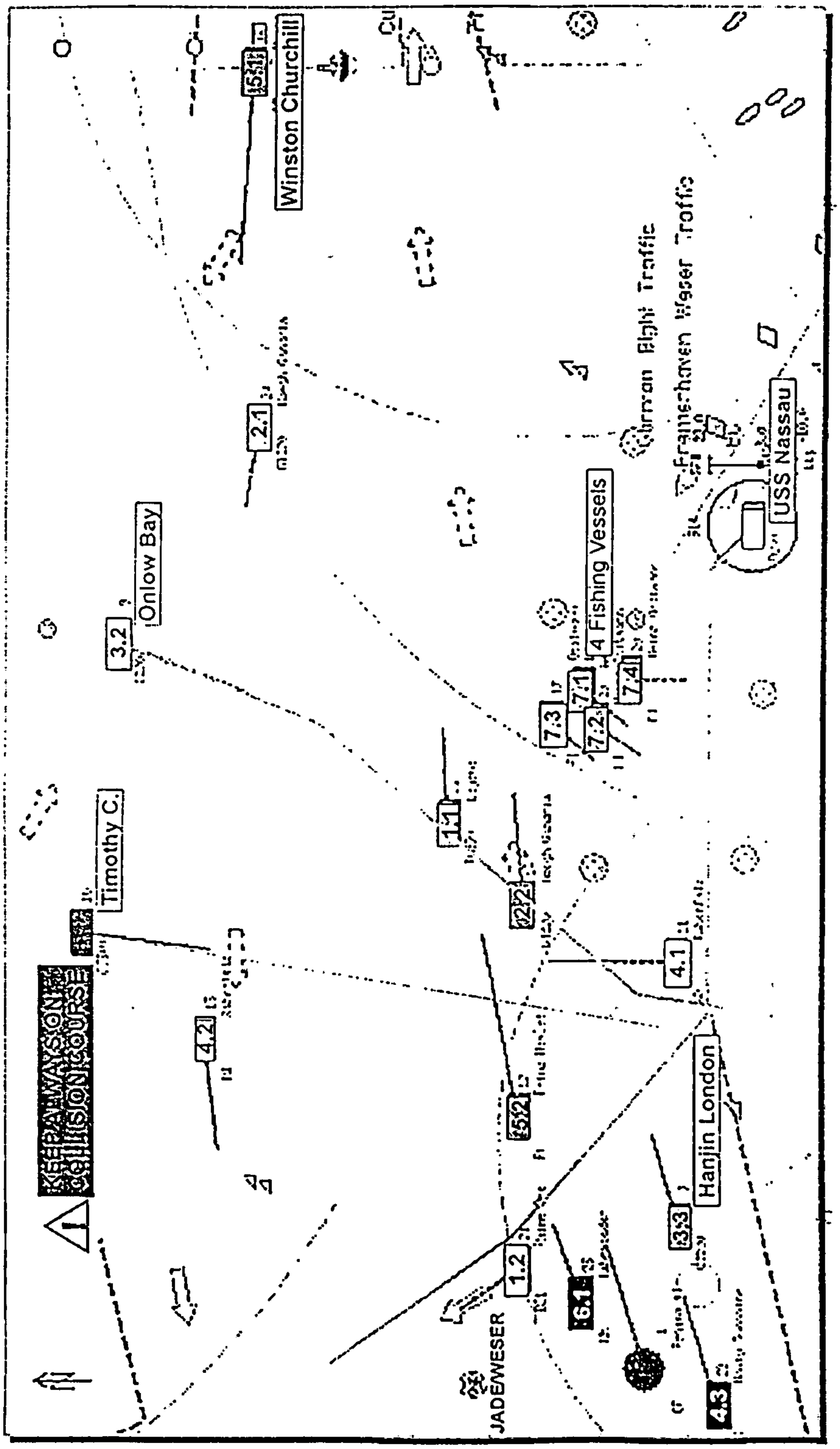
ATTENTION

In case of traffic arrangements the instructor should carefully observe and check the plausibility of the called vessel. In case of inaccurate position, bearing, distance etc. a wrong vessel may answer according to the actual situation.

In such a case the bridge team can be considerable distracted by permanent VHF-Communication.

In the final phase, approximately 10 minutes before a possible collision with vessel #3.1 **VTS-German Bight** should intervene by calling vessel #3.1 on VHF-Channels 16/80 to draw its attention to the danger of collision.

SCENARIO DIRECTORY



SCENARIO DIRECTORY

GENERAL INSTRUCTIONS

The vessels in the scenario should follow the courses shown in the attached chart.

The instructor should absolutely pay attention to avoid collision courses with all vessels from starboard and ship #3.2. Only ship #3.1 should maintain a course which may lead to a collision.

SHIP 3.1 (TIMOTY C.)

This vessel is bound for the Weser-Pilot and should cause the critical situation by not giving way to the ownship. Furthermore the vessel should not reply on any calls byVHF

SHIP 3.2 (ONLOW BAY)

This vessel approaches the Weser-Pilot. This vessel should give way to the ownship at a distance of about 3 nm.

SHIP 3.3 (HANJIN LONDON)

This vessel is sailing on nearly the same course as the ownship. The speed should be adjusted in a way that this ship is always a bit slower than the ownship. If necessary, the course may be carefully changed more northerly to confine the available space for the ownship on starboard side.

SHIP 8.4 (USS NASSAU)

This aircraft carrier is about to speed up (see COM-1) and approaching the precautionary area. The vessel should be routed on courses which lead to a situation in the final phase of the run, that the vessel is just behind the ownship to prevent the ownship to make a complete turning circle.

FISHING BOATS 7.1 - 7.4

The four trawlers are fishing in formation and sailing at slow speed with southerly courses.

All other vessels in the scenario are unimportant and may sail with its initial speed and headng.

SCENARIO DIRECTORY

BRIDGE SETUP

Compass/Steering Mode	: 78°	NACOS	
Engine Order	: EOT_1 -> 80RPM		EOT_2 -> 80RPM
Rudder Pumps	: #1 -> ON	#2 -> ON	
DSC	: ON		
NAUTOPLOT	: OFF (Chart...: INT 1452)		
FAX	: ON		

NACOS-SYSTEM

Multipilot_1

Mode	:	MASTER	RADAR		Trackmode
Radar	:	RM NorthUp	3nm	GPS	LOG1
Chart	:	Own (inactive)			
Conning	:	Open Sea (inactive)			

Multipilot_2

Mode	:	SLAVE	RADAR		
Radar	:	RM NorthUp	6nm	GPS	LOG1
Chart	:	Own (inactive)			
Conning	:	Open Sea			

Chartpilot

Ship	:	FE_Europa
Maps	:	ISS7001M
Tracks	:	ISS7001T
System Track	:	ISS7001T

GENDIS-1	:	GPS-Receiver (User-1)
GENDIS-2	:	RPM-Indicator (Engine-1/Engine-2)

SOUNDER	:	ON	
Alarmsettings	:	↘ 30 Meter	↗ 15 Meter

VHF

Settings	:	#1	Channel 80	(dual watch)
		#2	Channel 63	

SCENARIO DIRECTORY

GENERAL SETUP

Required stations : INCO1 INCO2 DEBRIEF
BRIDGE as OS-ALL

SIT-File-Identification : ISS_7001

Short Description : Crossing German Bight_MR

VESSEL CONFIGURATION

SIMULATION				SCENARIO		
SC	SIM-TYPE	STATION	M-Nu.	ID	TYPE OF VESSEL	NAME
FE	OS-All	BRIDGE	2088		Cruise Liner (EUROPA)	SUSAN
TA	Traffic	INCO		1.1	Tanker	LAGENA
TA	Traffic	INCO		1.2	Bulkcarrier	RHINE ORE
GT	Traffic	INCO		2.2	Gastanker	WORLD GAS
CD	Traffic	INCO		3.1	Container_200	TIMOTHY C.
CD	Traffic	INCO		3.2	Container_300	ONLOW BAY
CD	Traffic	INCO		3.3	Container_300	HANJIN LONDON
RO	Traffic	INCO		4.1	RoRo	RABENFELS
RO	Traffic	INCO		4.3	RoRo	VILLE DE BREST
FA	Traffic	INCO		5.2	Ferry	NORDLAND
KM	Traffic	INCO		6.1	Coaster	IJMUIDEN
WS	Traffic	INCO		10.1	Aircraftcarrier	USS NASSAU
Vessels not shown in this list can be loaded anyway from the SIT-file without changes						

MALFUNCTIONS

GPS

Unhealthy Satellites : #22
USERPDOP : 10

DSC-MESSAGES (needed)

Vessel #3.1 : All Ships >VESSEL NOT UNDER CONTROL<

FAX-MESSAGES (needed)

Weather Report : Nil
Port Informations : Nil