A vision of Chinese MET in the 21st Century: the impact of new technology in the Chinese MET [maritime education and training]

Ren Ping Zhang

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WORLD MARITIME UNIVERSITY
Malmö, Sweden

A VISION OF CHINESE MET
IN THE 21ST CENTURY
- The impact of new technology on Chinese MET

By

ZHANG REN PING
The People’s Republic of China

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

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DECLARATION

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

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

Zhang Ren Ping
5 October 1998

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Title of Dissertation: A Vision of Chinese MET in the 21st Century
- The impact of new technology on Chinese MET

Degree: MSc

This dissertation is a study of the new developments in maritime technology, new educational methodology and technology, and the new standards of STCW 95. The impact upon Chinese MET is analysed in relation to these three aspects.

A general study is made of the latest developments in maritime technology and MET educational methodology. The outcome indicates that the influence of the integrated bridge systems (IBS) and the one man bridge operation (OMBO) have an effect on the shipping industry; the new MET educational methodology and technology also have a deep impact on the traditional way of education in Chinese MET institutions.

The present status of the Chinese MET has been briefly described in order to delineate or outline the advantages and limitations of the MET. The focus is placed on instructors' qualifications, revision of curricula and programmes, replacement of old and out of date equipment for training by new and up to date marine equipment, use of the simulator for training and assessment, and the inadequate knowledge of students in the English language communication.

The results were collected and evaluated in the conclusions which highlight the necessity of adapting to technology developments. A number of recommendations are also made in view of the deep impact upon Chinese MET in the 21st century.

KEYWORDS: Maritime Technology, Education Methodology, STCW 95, Chinese MET.
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LIST OF ABBREVIATIONS

AAP Adaptive Auto Pilot
AIS Automatic Identification System
ARCS Admiralty Raster Charts Service
ARPA Automatic Radar Plotting Aid
BRM Bridge Resource Management
CBA Cost-Benefit Analysis
CBT Computer-Based Training
CD-ROM Compact Disk - Read Only Memory
CGI Computer-Generated Images
COC Certificate of Competency
DE Distance Education
DGPS Differential Global Positioning System
DMC Dalian Maritime College
DMU Dalian Maritime University
ECDIS Electronic Chart Display Information System
ECS Electronic Chart System
ENC Electronic Navigation Chart
EU European Union
FSA Formal Safety Assessment
GIS Geographic Information System
GLONASS Global Navigation Satellite System
GMDSS Global Maritime Distress and Safety System
GNI Guangzhou Navigation Institute
GPS Global Positioning System
IALA International Association of Lighthouse Authorities
IBS Integrated Bridge System
IBS Integrated Bridge Systems
IHO International Hydrographic Organization
IMLA International Maritime Lecturers' Association
IMO International Maritime Organization
IRM Information Resources Management
IT Information Technology
JNI Jimei Navigation Institute
MET Maritime Education and Training
MOC Ministry of Communications
NOAA National Oceanic and Atmospheric Administration
OBT On-board Training
OECD Organisation for Economic Cooperation and Development
OJT On the Job Training
OMBO One Man Bridge Operation
<table>
<thead>
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<tr>
<td>OOW</td>
<td>Officer of the Watch</td>
</tr>
<tr>
<td>PID</td>
<td>Proportional, Integral and Derivative</td>
</tr>
<tr>
<td>QOSMC</td>
<td>Qingdao Ocean Shipping Mariners' College</td>
</tr>
<tr>
<td>RCDS</td>
<td>Raster Chart Display System</td>
</tr>
<tr>
<td>RENC</td>
<td>Regional Electronic Navigational chart co-ordination Centre</td>
</tr>
<tr>
<td>SAR</td>
<td>Search and Rescue</td>
</tr>
<tr>
<td>SMCP</td>
<td>Standard Marine Communications Phrases</td>
</tr>
<tr>
<td>SMS</td>
<td>Safety Management System</td>
</tr>
<tr>
<td>SMU</td>
<td>Shanghai Maritime University</td>
</tr>
<tr>
<td>SOLAS</td>
<td>International Convention for the Safety of Life at Sea 1974</td>
</tr>
<tr>
<td>TSS</td>
<td>Traffic Separation Schemes</td>
</tr>
<tr>
<td>VHF</td>
<td>Very High Frequency</td>
</tr>
<tr>
<td>VLCC</td>
<td>Very Large Crude Carrier</td>
</tr>
<tr>
<td>VMS</td>
<td>Voyage Management System</td>
</tr>
<tr>
<td>VTMIS</td>
<td>Vessel Traffic Management Information Service</td>
</tr>
<tr>
<td>VTS</td>
<td>Vessel Traffic Service</td>
</tr>
<tr>
<td>WTU</td>
<td>Wuhan Transportation University</td>
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<tr>
<td>WWW</td>
<td>World Wide Web</td>
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CHAPTER 1

INTRODUCTION

1.1 Objectives

The rapid development in maritime technology has had a strong impact on the shipping industry. The new maritime technology developments include radar, automatic radar plotting aids (ARPA), the global positioning system (GPS) and the differential GPS (DGPS), adaptive auto pilots (AAP), track control systems, the electronic chart display information systems (ECDIS), the integrated bridge systems (IBS), the vessel traffic services (VTS) and vessel traffic management information systems (VTMIS), the automatic identification systems (AIS), and the use of computers in navigation. The impact of the new maritime technology is on the safer operation and the more efficient maintenance of ships.

The new methodology and technology in use in maritime education and training (MET) have a significant influence on the Chinese MET system and institutions. One of the key influencing factors is the wide utilisation of multi-media for MET instruction, including distance education via Internet and e-mail. Computer based training (CBT) and the use of simulators also play a key role in MET. The use of a radar and ARPA simulator for training was made mandatory by STCW 95.
The objective of this dissertation is:

- to conduct an overview of the developments in the use of modern maritime technology in the shipping industry;
- to study how new methodology and technology in MET institutions affect Chinese MET;
- to highlight the new requirements of STCW 95;
- to examine the impact of these aspects upon the Chinese MET system and the extent to which technology is being used;
- to identify appropriate approaches by which the Chinese MET system can adapt to new development in maritime technology;
- to make proposals and recommendations for enforcement and improvement of MET standards in China.

The emphasis is placed on the expected impact of new maritime technology and new MET educational methodology upon the Chinese MET in the 21st century.

1.2 Methodology

The author researched the relevant literature in the library at World Maritime University (WMU) and analysed the information gathered. The author also studied the Chinese Government Report to the International Maritime Organization (IMO) regarding the implementation of the Convention on Standards, Training, Certification and Watchkeeping for Seafarers, 1978, as revised in 1995 (STCW 95).

A further study of the Chinese MET system was conducted with respect to its schemes, programmes, funds, equipment and facilities, and instructors.
Some contacts were made through e-mail, facsimile and ordinary mail to collect first hand information on regulations and rules set by the Chinese Government, and on the Chinese MET system.

All the information and data collected have been studied, analysed, and argued. Conclusions were made by giving analysed information with comments. The recommendations were made by addressing the imperative needs for improving the Chinese MET system.

1.3 Limitations and Omissions

This dissertation is not intended to describe the Chinese MET system to a full extent, but only for the purpose of this dissertation. In Section 5.1, the present status of the Chinese MET is briefly discussed, focusing on the aspects of instructors, students, equipment and quality assurance. Detailed information on the Chinese MET system can be found in the relevant sources available in the WMU library.
2.1 Navigation Technology and Ship Controllability

2.1.1 Navigation

2.1.1.1 Global Positioning System (GPS) and Differential GPS (DGPS)

The Global Positioning System (GPS) was originally developed by the United States Department of Defense to provide precise navigation for a wide range of military requirements including weapons targeting. In the mid-1980s it was decided to make the technology available to civilian users, the US Department of Defense decided to deliberately degrade the signals, through a process called selective availability, to deny unauthorised access to the system's full capability. Accuracy achieved under this regime is normally in the range of 50 meters.

In addition to selective availability, there is also a number of other sources of error within GPS which can influence the overall accuracy of the final positioning solution. Satellite clock errors, atmospheric delays, multi-path transmission errors and receiver clock errors are all capable of contributing to inaccuracies in GPS. However, to overcome these errors and the built-in selective availability, a GPS receiver can be
linked to a differential receiver or incorporated within its circuitry to make a continual correction. Differential GPS, as it is known, relies on the establishment of a local reference station at a precise location within the area of operation.

For wider geographical coverage the reference station can be linked to a number of other transmitter reference stations to produce a network. The GPS satellite signals are monitored at the reference station and compared to their known values, the difference being a set of correctional values. Accuracies achieved with Differential GPS are less than, or equal to, 10 meters.

An article in Safety at Sea (February, 1998, 11-13) highlighted the GPS update. For specific applications, like fast ferries which usually have no bridge wings, a real time kinematic (RTK) system can be used for precise manoeuvring. A DGPS network provides highly accurate en route navigation while the RTK system provides the sub-meter, typically down to 20 cm, accuracy needed for the dynamic positioning system to dock the large fast ferries. The equipment is part of an integrated bridge which meets the required standard.

DGPS relies on the assumption that certain types of error, which can degrade the performance and accuracy of a system, are common to all users within a given area. If the errors can be calculated at a known location their application to the measurements of other users, as a correction, will allow the removal or at least reduction of them. DGPS involves the removal of correlated systematic error between a reference receiver and a remote user (Ackroyd and Lorimer, 1994)

The application of GPS has a very wide range in the maritime sector. It is in coastal navigation where GPS has the greatest number of users. A coastal passage is
generally the most dangerous portion of any vessel's journey and the vast majority of marine casualties occur during it, the reasons are:

- a greater risk of collision due to increased traffic densities
- an increased risk of grounding either on the coastline or on off-lying obstructions

The GPS also helps enhance safe navigation in congested or coastal waters which is now mostly concerned about the management of vessel movement and the maintenance of safe distances between vessels. The objectives of traffic separation schemes include:

- to reduce the damage of head-on collision by separating opposing streams of traffic
- to reduce the danger of collision between crossing traffic and shipping following the traffic lanes
- to simplify the patterns of traffic flow in congested areas
- to organise the flow of traffic in areas of intensive off-shore activity
- to organise traffic flow to avoid areas where vessel movement is dangerous or undesirable
- to provide guidance to vessels with regard to areas where water depths are critical or uncertain
- to guide traffic clear of fishing grounds or organise traffic through them.

The GPS has also introduced dramatic changes in position and data reporting systems which are generally referred to as electronic fleet management systems (EFMS). The impact of GPS on electronic ship management systems will be in the fields of fleet voyage reporting, fleet performance analysis and voyage estimating. Such a global, continuous and reliable position fixing system offers the possibility of tracking highly dangerous or highly valuable cargoes and monitoring vessels' positions in hazardous areas. An EFMS system requires each mobile craft to be equipped with a computer.
and communications package and with a fully automated bridge. Data transfer between ship and shore should be frequent.

One of the most exciting prospects of low-cost navigation and low-cost communication on a global scale is the potential for integrated fleet management. Integrated fleet management allows more efficient use of a company's transport resources. The benefits are obvious, for example, for a company trying to arrange the sailing schedule for a vessel expecting unit cargoes from a large number of units. A low-cost position reporting system is equally useful for tracking high-value or dangerous cargoes or re-routeing land mobiles to avoid congested areas.

What will be the future development of satellite navigation systems? GPS is a part of the world-wide radio navigation system (WWRNS) which consists of satellite navigation systems and terrestrial navigation systems. WWRNS is capable of providing adequate position information within its coverage area. The satellite navigation systems include GPS and GLONASS systems. The terrestrial navigation systems include Loran-C and Chayka.

The present situation of WWRNS is that GPS became fully operational in 1995 with the accuracy of about 100 meters (95%), which is not suitable for navigation in harbour entrances or restricted waters. The US Air Force will provide at least six years notice to IMO prior to termination of GPS operations. GLONASS is operated by the Russian Space Agency and it became fully operational in 1996 with the accuracy of about 45 meters (95%). The system will provide unlimited civilian use until 2010. Both GPS and GLONASS do not have a warning of system malfunction. Decca will be phased out by 2000, the US will phase out Loran-C by 2000, but Russian Chayka will not be phasing out until 2010. In this case, IMO has been
making efforts to establish a new navigation system called Global Navigation Satellite System (GNSS).

GNSS is a satellite system which provides a world-wide position determination, time and velocity capability for multi-model use. GNSS includes user receivers, one or more satellite constellations, ground segments and a control organisation which facilitates to monitor and control the world-wide conformity of the signals processed by user receivers.

The operational requirements, as prescribed in IMO Resolution A. 860 (20) (1997), state that the future GNSS should enable shipborne equipment to provide the user with information on position, course and speed over the ground, have a data-link capability and meet the requirements for interoperability with the shipborne GMDSS equipment. The applications of GNSS are as follows:

- shipborne applications - ECDIS interface, automatic position reporting interface, GMDSS interface, high speed craft requirements, track control, docking/mooring, ship motion monitoring, voyage data recorder, ship heading and attitude indication.

- external applications - SAR, hydrographic survey, buoy positioning, fairway design and dredging.

2.1.1.2 Electronic Chart Display Information Systems (ECDIS)

Electronic chart display and information systems (ECDIS) have emerged as a new aid to maritime navigation, the use of which results in significant benefits to maritime piloting and safety. ECDIS is a real-time geographic information system capable of integrating GPS/DGPS, echo-sounder, gyrocompass, radar, and electronic chart information into one display. As an automated decision aid, ECDIS is capable of
continuously determining a vessel’s position in relation to land, charted objects, aids to navigation and unseen hazards. As a navigation system, ECDIS also displays such important information as cross-track distance, course made good, speed over ground, and time-to-go. ECDIS and other forms of electronic charts like raster chart display system (RCDS) represent an entirely new approach to the safety of maritime navigation and piloting.

ECDIS is a navigation information system which, with adequate back-up arrangements, can be accepted as complying with the up-to-date chart required by regulation V/20 of the 1974 SOLAS Convention, by displaying selected information from a system electronic navigational chart (SENC) with positional information from navigation sensors to assist the mariner in route planning and route monitoring, and by displaying additional navigation-related information if required.

Electronic navigational chart (ENC) means the database, standardised as to content, structure and format, issued for use with ECDIS on the authority of government-authorised hydrographic offices. The ENC contains all the chart necessary for safe navigation, and may contain supplementary information in addition to that contained in the paper chart which may be considered necessary for safe navigation.

The primary function of the ECDIS is to contribute to the safety of navigation. It is capable of displaying all chart information necessary for safer and more efficient navigation as well as facilitating simple and reliable updating of the electronic navigational chart, thus reducing the navigation workload of the officer of the watch. In support of ECDIS, the ECS is required to be issued on the authority of the authorised hydrographic offices and it must conform to the IHO standards, i.e. S-57-DX-90. The primary functions of the ECS are to enhance the safety of navigation and
to reduce the navigational workload of plotting compared with the paper chart. ECS is capable of displaying chart data related to the past, present and planned position.

The vector charts are more flexible in practical terms than the raster data charts as the former has possibility to display all or a part of the nautical chart as the graphical reference on a VTS display in order to keep the display from becoming too cluttered.

The rapid growth of computer technology over the past two decades has enabled a radical departure from the traditional paper chart. The ECDIS will integrate digital information, real-time environmental data, i.e. current, tide, wind etc., and the data of vessel systems into a display that is expected to improve the safety and reliability of coastal and harbour navigation. The Table 2.1 shows a comparison of raster and vector charts.

Table 2.1 Comparison of Raster and Vector Charts

<table>
<thead>
<tr>
<th>Raster (alone)</th>
<th>Vector</th>
</tr>
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<tbody>
<tr>
<td>• is cheaper to produce</td>
<td>• is smarter</td>
</tr>
<tr>
<td>• looks like a chart</td>
<td>• can look like a chart too</td>
</tr>
<tr>
<td>• can not rotate for heading up display</td>
<td>• will do flips if you want</td>
</tr>
<tr>
<td>• margin notes require scrolling</td>
<td>• margin notes at a mouse click</td>
</tr>
<tr>
<td>• zoom constrained by pixel size</td>
<td>• zoom is unconstrained</td>
</tr>
<tr>
<td>• symbols and text fixed</td>
<td>• symbols and text tailorable</td>
</tr>
<tr>
<td>• no query</td>
<td>• yes, query</td>
</tr>
<tr>
<td>• can not be decluttered</td>
<td>• declutters</td>
</tr>
</tbody>
</table>

The shortcomings of ECDIS may include:

- the growing demand for digital ENC products cannot be met in the near future at the rate of digitalisation by the officially authorised hydrographic office.
- the frequency of updates and revisions of ENC data may not catch up with the progress of the ECDIS.
A new service will be launched to broadcast official hydrographic office (HO) data to ships digitally via an Inmarsat point-to-multi point service. The data will be in the form of paper chart updates and digital tracings, initially from UK, US and Canadian HO data (Ryle, 1998).

Digital weekly Notices to Mariners data sent to a vessel at sea allows the navigation officer to update charts as the corrections come in, providing vital information regarding an area in which his ship is, or will be, navigating as soon as it is issued. This will also reduce the officer's workload when the vessel is in port, when possibly several weeks' printed Notices may be waiting for him, resulting in many hours of work to correct the ship's chart set.

On board a subscribing vessel, an decoder unit is fitted to receive the digital broadcast signal directly via Inmarsat B and M. The ship would need to have an 486 66 MHz PC with 8 Mbytes RAM and 200 Mbytes hard disc space running Windows 95 or NT, a serial interface port for connection.

2.1.1.3 Radar and ARPA

Radar technology has been developed and improved over 60 years from a prototype machine in the 30s to analogue signal processing in the early 60s, to the digital signal processing in the late 80s. The latest radar advance with overlaying display of radar picture and ECDIS has great potential in the integrated bridge system, as the situation involving encounters with other vessels can at all times be assessed within the overall context.
By integrating the functions of ARPA and ECDIS, a system would be developed to help officers of the watch to deal with complex traffic situations by giving them suggestions for avoidance routes. This system can also be used in a VTS centre.

Rolfe and Alexander (1997) discussed the issues of the overlaying radar picture with ECDIS in terms of visualisation of the information, these issues include:

- the minimisation of the quantity of information, i.e. reduction of the displayed information
- weighting of the displayed information
- clear structure of person-machine interface, distinct separation between input and output.

The real power of ECDIS lies in its capability to integrate all navigation sensors necessary for all aspects of safe piloting and manoeuvring. When ECDIS and radar/ARPA are superimposed on a single display, they provide a dual-function system that can be used both for navigation and collision avoidance. The results of the investigation showed that when ECDIS and radar/ARPA are superimposed, they form a single system that can be used both as a primary navigation system and as a primary collision avoidance system.

The benefits of ECDIS radar/ARPA integration include a synergistic improvement in navigation and collision avoidance, particularly in confined waters or during periods of reduced visibility. Also, the officer of the watch (OOW) does not have to monitor two displays at the same time. There are some factors that can cause a mismatch between ECDIS and radar, such as temporary loss of the differential correction signal of DGPS. There are also some concerns about screen clutter or information overload with a combined ECDIS radar / ARPA display.
2.1.2 Ship Identification

2.1.2.1 Vessel Traffic Service (VTS) and VTMIS

A vessel traffic service (VTS) is defined as a service implemented by a competent authority, designed to improve safety and efficiency of vessel traffic and to protect the environment. The service should have the capability to interact with the traffic and respond to traffic situations developing in the VTS area (IALA, 1993). The stated purpose of VTS is to improve the safety and efficiency of navigation, safety of life at sea and the protection of the marine environment and/or the adjacent shore area, worksites and offshore installations from possible adverse effects of maritime traffic.

The VTS has internal and external functions. Internal VTS functions include data collection and data evaluation / decision making. External VTS functions include primary traffic management functions in terms of allocation of space, routine control of vessels, and manoeuvres to avoid collisions.

VTS services may be directed at the general traffic or at individual vessels in order to aid the on-board navigational decision making to prevent the development of dangerous situations and to allow optimum use of the resources. The services available in VTS include:

- information service - positions, identities, intentions and destinations, meteorological information, visibility conditions, notices to mariners.
- navigational assistance service - course and speed made good, way-points, warnings,
- traffic organisation service - to prevent the development of dangerous situations and to provide for the safe and efficient movement of traffic within the VTS area.
• co-operation with allied services, emergency services and adjacent VTS - a supporting activity of the VTS to increase the safety and efficiency of the traffic, the protection of the environment and the effectiveness of the VTS without adding to the reporting burden of the vessel. This may be achieved through data exchange, common use of data bases and action agreement between parties.

The new development in VTS is the vessel traffic management information system (VTMIS), which is defined as a system that services a predefined region which contains a number of VTSs connected by an interactive traffic information system based on the construction of a traffic image and a part of the high seas bordering the territorial waters of coastal states.

As discussed in the proceedings of the 8th International symposium on Vessel Traffic Services (1996), the VTMIS can provide the services rendered by VTS as well as the expanded services that would result from the regional coverage of the system. VTMIS concept should take into account the potential needs for regional systems handling and making available the information related to events occurring outside the VTS area of coverage and more generally outside territorial waters.

Froese (1998) pointed out that a VTMIS gathers, evaluates and distributes vessel traffic and waterborne transport data to improve the safety and efficiency of traffic and to better protect the environment. A VTMIS supports navigation and scheduling of vessels based on sound information of the geographic, hydrographic and meteorological local conditions considering actual traffic and related circumstances in compliance with local rules and regulations.

VTMIS also provides the strategic and tactical management of waterborne resources in case of a casualty. Some important functions in the VTMIS include the automatic
identification of ships, automatic vessel tracking, data exchange via transponder, and information exchange between VTS. The technology used for VTMIS includes the AIS, ECDIS, radar, satellite communication system, telephone, facsimile, data transfer, Internet, and e-mail. VTMIS data serve:

- to provide traffic information and guidance
- to organise the traffic flow
- to plan traffic and transport resources
- for law enforcement
- for contingency planning and reactions
- for statistical evaluations

2.1.2.2 Automatic Identification System (AIS)

Modern maritime technology has made it possible to identify and track ships in directions of ships to ships, ships to shore and shore to ships. The automatic identification system (AIS) can fulfil the demands from both the mariner on the ships and shore based stations, monitoring and supervising the coast and harbours with VTS stations. It is also vital that the AIS can enhance the safety of ship as a whole.

It is clearly stated in the draft recommendation on performance standards for a universal shipborne automatic identification system that the AIS should improve the safety of navigation by assisting in the efficient navigation of ships, protection of the environment, and operation of VTS, by satisfying the following functional requirements:

- in a ship-to-ship mode for collision avoidance
- as a means for littoral States to obtain information about a ship and its cargo
- as a VTS tool, i.e. ship-to-shore (traffic management).
The information provided by the AIS should include static, dynamic, voyage related and short voyage related data. In static, IMO number, ship’s name and call sign, the length and beam, ship’s type and location of position-fixing antenna on the ship should be indicated. The dynamic data may include, inter alia, ship’s position, time in UTC, course and speed over ground, heading, navigational status, rate of turn. The voyage related data include the draught, the type of hazardous cargo, destination and ETA.

The AIS can help pilots and the master of a large ship to manoeuvre the ship in congested areas or narrow waters because AIS can look behind the bend in a channel or island and detect and identify other ships. It can predict the exact positions of meeting with other ships in a river, know where a ship is bound for, the size and draft of ships in the vicinity, and detect and identify a ferry leaving the shore bank in a river.

The AIS can also be widely used in the VTS for the high up-date rate of tracking, broadcasting and interrogating. The AIS can be employed for shore-based pilotage by improving the tracking and detection of a course change of a ship from shore.

The AIS could perform a perfect function in collision avoidance by broadcasting the identification, heading and the change in heading of ships. The widespread use of AIS can be made for route planning, short message communication in case of limited radio system capacity, mobile VTS, and one-man bridge to reduce the workload of the OOW to a considerable extent.

Who wants AIS? Coastal states are responsible for traffic separation schemes and routeing areas in their territorial waters which require compulsory compliance by those who use them and coastal states need to monitor 'areas to be avoided'. The AIS
will be used by the coastal states who are responsible for traffic separation schemes and routeing areas in their territorial waters, and by those who use the traffic separation schemes (TSSs).

Monitoring and identifying from shore will result in a greater compliance with TSSs and routeing measures from ships that use them. It is highly possible that accidents in coastal areas can be avoided if the ship is identified, and the ship is therefore advised by VHF to take proper measures provided that there exist no language difficulties.

It has been argued that accidents in coastal areas can be avoided if ships in coastal areas can be avoided if they are identified. This may be true in some cases but a shore station that has identified a ship can only advise actions over the VHF. This may or may not be understood because of language problems.

If a ship is equipped with an AIS this would enable the OOW to be the first one to benefit to get a better situational awareness. With an AIS, it has been argued that, if the OOW knows the name of the other ships, he will make contact with them and sometimes agree on actions contradictory to the COLREGs. This may be true, but it is known that contact can be made without knowing exactly to whom they are speaking.

AIS would improve safety and solve the limitations of radar, an AIS can:

- look behind the bend in a channel or behind an island in an archipelago to detect the presence of other ships and identify them
- predict the exact positions of meeting with other ships in a river or in the archipelago to avoid meeting in a narrow river bend.
- know where and to which harbour a ship is bound for
- know the size and draft of ships in the vicinity
• detect a change in heading as soon as undertaken by other ships
• detect and identify a ferry leaving the shore bank in a river
• identify fixed obstacles, like oil rigs, ship wrecks, dangerous to shipping
• identify slowly moving targets, like log rafts, sounding arrays, unable to make rapid evasive actions

AIS also plays an essential role in anti-collision. Radar has been the primary means for preventing collisions at sea in restricted visibility. With a broadcast AIS the identification, heading and the change in heading could be determined with a high update rate and solve some of the limitations in a radar.

2.1.3 Ship Control

2.1.3.1 Adaptive Auto Pilot (AAP)

The adaptive auto pilot is so designed that the ship can make the course steering more accurate taking into account the drag of the rudder angle and the ambient conditions, e.g. weather, wind, currents and tide. The AAP makes use of the proportional, integral and derivative (PID) controls forming the PID autopilot systems which are widely used on board merchant ships. The autopilot is primarily used for steering the ship on long ocean passages, which eases the quartermaster's workload.

The AAP could certainly reduce the possibility of ship's wandering as it can monitor and keep the track of the course made good, this consequently increases the accountability of the course keeping as well as to ensure the safety of navigation. Modern ships are manned with fewer crews and one man bridge has come into reality, the AAP therefore could function more efficiently in a way that it helps to minimise the number of crew without threatening the safety of navigation. Whenever the ships
transit canals, approach channels, pass straits, the quartermaster should be called in the bridge to steer the ship manually instead, in which case, human errors might be brought in to generate potential risks.

2.1.3.2 Track Control Systems

The objectives of track control systems with their sources of position, heading and speed data are intended to keep a ship automatically on a pre-planned track over ground under various conditions and within the limits related to the ship's manoeuvrability. The systems can be applied on board ships of maximum speed of 30 knots with maximum rate of turn not in excess of 600 degrees per minute, it is applicable to the straight tracks.

The operational requirements of the system include the functions in steering the ship to or along a sequence of waypoints, change of waypoints, position monitoring, course change and confirmation, overriding function, heading monitoring and control. The visual and sound alarms are also required to warn the officer of the watch when a failure of the system or a deviation beyond the pre-set limit takes place. In modern ships, the track control systems may be integrated in the electronic navigation chart system, GPS, Loran-C or other navigational equipment to enhance the safety of navigation. The officer may pre-plan the way-points for a certain voyage to increase the safe navigation by using track control system.

2.1.3.3 Computers in Navigation

The maritime industry is changing in a steady and positive manner and there can be no turning back. The application of computer technology has a profound influence on the entire shipping sector. The increasing need for fast and effective transfer and handling
of documentations has created a good environment for the shipping industry to make the computer more user-friendly.

Computers are present in every field of the shipping industry including vessel operation and management, voyage planning, maintenance scheduling, communications, engine room controls.

The full advantage of the latest IT developments in the shipping sector lies in the fact that the use of IT can increase the efficiency of shipping operations and reduce the time spent on labour intensive work, it therefore ensures the safer navigation and operation of ships.

Computer management applications are allowing data to be exchanged between applications and used for in-depth fleet-wide analysis.

An article in Compuship (1997, December, 22-23) stated that the November 1997 IMO Assembly rubber-stamped a requirement that, after July 1st 1999, all new and existing bulk carriers more than 150 m in length should have a loading instrument. The instrument must be type-approved before being installed on board ship. Type-approval is a key competitive issue among the manufacturers. Computers are widely utilised on board ships. The application of computers may include those for ship control and monitoring, and administration systems. Ship control and monitoring include integrated bridge system, engine control and monitoring, ballast control, condition monitoring, fire detection. The administration applications cover maintenance purchasing system, reporting system, load calculation, performance evaluation, operational database, document database, weather routeing.
2.2 Information Technology (IT) in Shipping

A frequently cited definition of information is 'that which reduces uncertainty' (Feeney and Grieves, 1994). Information technology (IT) is a term commonly used to cover the range of technologies used for the transfer of information, in particular to computers, digital electronics, and telecommunications (Crystal, 1990).

Information technology (IT) provides data to support decision making. But data is not information, and information is not knowledge. Hence, it is necessary to translate data into information to provide the knowledge needed for action. Information technology (IT) in use for ship operations can improve competitiveness through development of new operating concepts and information systems in shipping companies, in close cooperation with equipment suppliers, classification societies and authorities.

The latest innovations in computer technology and the use of satellite communication systems give the opportunity to improve vessel operation and maintenance. The major challenges include integration of resources and competence aboard, in the shipowner's office and in the supporting industries to improve the operation and maintenance of the ship, and meet demands for safe operation and pollution prevention. Information technology offers a means for producing ship documentation in an interactive electronic way. This will contribute to an increased quality of the documentation itself and to updating when changes are made.

The impact of IT on shipping operations is really beyond what people can imagine. IT plays a key role, as commented by Compuship (December 1997, 10-11), in information exchange and decision support, performance evaluation, qualification and training of officers, new and flexible organisational structures, and services support.
IT may also bring certain changes in people's minds in terms of processing work and improving decision making.

The initial information analysis is essential. The information transferred and processed between ship and shore or between ships must be analysed for its accuracy, timeliness, reliability and relevance at three levels: operational, managerial and strategic. The degree of quality of information may range from low to high. High quality information will have significant impact on the strategic planning. The scope of information integration may also be extended beyond the shipping company itself. The challenge now is to find out what adds to the value of decision making, which is produced by smart thinking, not by tons of data without any added-value.

Appropriate approaches to IT can enhance the effective operation of the fleet. A wise approach may involve the use of standard equipment using compatible software, all of which must be type-approved. A non-standard approach to IT may sometimes cause a disastrous impact. Ships of Canada Steamship Lines were full of mismatched equipment and inefficient and sometimes unreliable software. The multi-platform network made effective technical support almost impossible (Compuship, April/May, 1998, 20).

Storey (1998) reports that there are two types of standards under development in the maritime industry: standards to enable data to be shared between various companies and organisations electronically in a common format, and standards designed to ensure that vessel operational information can be readily collected, stored and transmitted.

IT may also have certain limitation in terms of non-standard approach to hardware and software, which could cause a disastrous impact. For decision making at strategic and
managerial levels, it is quite essential to ensure that the information is accurate, reliable and relevant. The information may come from different sources, the accurate and reliable information should be from the competent authority.

2.3 Impact on Ship Operations

2.3.1 Integrated Bridge System (IBS)

An integrated bridge system (IBS) is defined as a combination of systems which are interconnected in order to allow centralised access to sensor information or command / control from work stations with the aim of increasing safe and efficient ship's management by suitably qualified personnel. IBS should support systems performing two or more of the following operations:

- passage execution
- communication
- machinery control
- loading, discharging and cargo control
- safety and security

IBS is required to meet several criteria, the fundamental ergonomic requirements include:

- Input devices - minimal user actions, feedback, operation of controls, functional grouping, layout compatible, labelling controls.
- Information display - simplicity, display necessary data, consistent presentation, display important and frequently used information, meaningful abbreviation, use of icons, VDU resolution.
• User system interaction - consistent, standard procedures, logical ordering of menu.

Tasks by navigation and manoeuvring workstations include observing all vessels and targets, recognising dangerous situations, deciding on collision avoidance action, checking own speed and course, keeping/changing own course/speed, checking own position, handling own internal communication on board, handling communication ship/ship and ship/shore, acknowledging watch alarm.

Equipment used in IBS includes radar/ARPA, ECDIS, auto visual position indicator, information of position fixing system, information of AIS, heading/track control, controls for main engine, controls for main rudder, controls for thruster, indications of revolution, speed, rudder angle, rate of turn and gyro. From the author’s point of view, IBS is still in the experiment stage, as not all design functions can be utilised until the training and expert level of the officer of the watch allows it, the system lacking validation under busy operation conditions.

It is the multi-function bridge workstation that uses the latest advances in flat-panel display technology. The system uses high-resolution flat-panel colour display screens, the workstation's compact design makes it suitable for any bridge size, and the electronics are remotely mounted to save space, reduce heat and minimise electronic interference on the bridge. It integrates inputs from radar/ARPA, ECDIS, autopilot, GPS, gyrocompass, speed log, echo sounder, engine monitoring systems, shipboard IT systems and other devices for presentation on multi-function display screens. The combination of advanced flat-panel technology and multi-function displays will reduce the number of separate consoles and workstations required for the current generation of integrated bridge systems.
2.3.2 One Man Bridge Operation (OMBO)

The technology needed to create a fully automated ship is either in place or will be on the market shortly. Navigation equipment is obviously at the heart of an automated ship, but engine controls, machinery maintenance monitoring systems, hull integrity instruments and other sensing equipment are no less important. The latter provides an indication of excessive strains on ships' structures.

GPS systems have made it possible to locate ships within 100 or so meters of their actual position, but in busy waterways this is not accurate enough. DGPS has narrowed the accuracy of the position down to around five meters although an even greater accuracy can be achieved. ECDIS is seen as the most appropriate instrument for unmanned ships due to their ability to view the own ship's position in relation to charted hazards. Transmitted chart correction services will enable unmanned ships to keep up-to-date with the latest information.

Fig. 2.1 Management of Shipowner and Operator

(Source : Mottram, 1998b)
The European Union (EU) research project on the collision avoidance advice system (CAAS) has shown that the utilisation of redundancy will be a key element in fully automated ships with the focus on control systems, machinery, electronics and steering gear (Thomas, 1997).

It is also arguable that one man bridge operation could be an optimum solution as 80% of accidents are said to have occurred due to human error. A report (Lloyd's List Press November 10, 1997) indicated that a ship had run on to the rocky island after the watchkeeping chief officer had fallen asleep in the pilot chair on the bridge. The officer would not be the first to find himself in such a state, but this was compounded by the fact that the "dead-man's alarm", which the owners had thoughtfully provided to ensure a watchkeeper's alertness, was not activated, nor was any human lookout, who should have been available to provide for additional watchkeeping.

Such a casualty ought to provide those who oppose the implementation of One Man Bridge Operations (OMBO) with valuable ammunition to fire at those who would like to see lookouts dispensed with. Risk management demands that OMBO is rejected, once and for all, and that ships are properly manned for safer navigation.

Table 2.2 Pros and Cons of OMBO

<table>
<thead>
<tr>
<th>Advantages of OMBO</th>
<th>Disadvantages of OMBO</th>
</tr>
</thead>
<tbody>
<tr>
<td>low crew cost</td>
<td>increased shore based maintenance</td>
</tr>
<tr>
<td>increased ship utilisation</td>
<td>increased capital equipment</td>
</tr>
<tr>
<td>ease of recruitment</td>
<td>training more complex and costly</td>
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<tr>
<td>greater job challenge</td>
<td>need high reliability</td>
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<tr>
<td>better job satisfaction</td>
<td>increased workloads</td>
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<tr>
<td>increased pay and prestige</td>
<td>reduced maintenance on board capability</td>
</tr>
<tr>
<td>improved teamwork</td>
<td>lack of manpower in emergence</td>
</tr>
<tr>
<td>more flexible workforce</td>
<td>more risk and fear of change,</td>
</tr>
</tbody>
</table>

26
Human error is roundly blamed for around 80% of maritime accidents. If poor legislation, equipment design and maintenance are also taken into account, then 96%. It is believed that using a five goal strategy - know more, train more, do more, offer more and co-operate more - can improve mariners' performance and so reduce the risk of accidents. Correct bridge design, ergonomics and the right equipment are crucial to obtaining OMBO notation. OMBO has both advantages and disadvantages (Muirhead, 1998).

The IMO provided a guideline concerning the ship bridge outlay and ergonomics.

![Diagram of Function Areas - Interrelation of Workstations]

2.3.3 Impact on Ship Maintenance

The development and use of new technology will certainly affect the shipping industry and will change it. One of the changes is the simulator in terms of virtual reality (VR), which uses a software database to create the real environment and real sensation. In this sense, the simulator will be finally replaced by virtual reality. When
it will be quite common, the officer of the watch will not be allowed to work on board ship if he/she has not attended the virtual reality training course in ship operations.

Technology change will also affect the standardisation of software, it needs to be standardised more in commercial aspects and technical aspects. Communication between shore and ship requires a standard format to be followed by both parties.

Maintenance has many definitions, usually related to the technical process itself. Maintenance is a measure taken to reduce the consequence and likelihood of failure, i.e. it is and always has been a risk control measure. Two aspects of ship maintenance need to be taken into account, one is the 'reliability', the other is the 'prediction'. Reliability of equipment depends very much on the design, prediction is more concerned with the maintenance of equipment. It is the manufacturer who can diagnose and predict the potential failure of equipment and send in advance spare parts to replace those with potential fault.

IT will certainly play a big part in shipping operation. Maritime education and training will improve gradually but not overnight. With regards to economical impact, it must take into account the manning of ships. A large container ship can theoretically be manned minimally with 6 people, but practically it needs 9-11 people. Why? three kinds of risks should be considered (Mottram, 1998a):

- inherent design risk - the risk existing during the design of the ship. This risk must be reduced.
- active risk - ship officers must be very well educated and trained with excellent practical hands-on experience.
- procedural risk - a risk in routine operational procedure.
The ship maintenance usually is not done on board. The annual maintenance will be done in accordance with the requirements of a classification society, the maintenance will also be conducted by manufacturers or their authorised agents.

What is the situation in the airline industry regarding maintenance? The questions often asked by groups of experts include: Is there any risk? If yes, what will happen? Will the equipment fail? If so, what will be the result? How can problem be solved? The airline industry tends to focus on the risk and reliability of the equipment. The author believes that the new technology will change the present situation in ship maintenance. It will be the risk-based approach that will be the dominant ship maintenance strategy.

The need for risk based maintenance exists. Hazards are present in all business sectors due to factors such as human error, environmental extremes and equipment failure. Safety risks are those that affect the health of individuals. Environmental risks are those that cause pollution or impact on the health of flora and fauna. Commercial risks are those that affect direct costs associated with loss of business and repair, and also indirect costs associated with plant degradation, consequential damage, loss of prestige, fines, penalties, increased insurance.

Child (1997, 101-109) analysed the risk management process and pointed out that the risk targets should be set and the hazards identified. The risk and consequence should also be assessed to evaluate the acceptability of the risks with respect to targets, fairness, cost balance. The control measures should also be established to reduce the risk of hazards to an acceptable level. A regime should be established to monitor the key factors that could lead to major incidents in order to validate initial assumptions and promote continuous risk reduction.
There are a range of measures that can be adopted to control risk:
1) one can simply accept the risk and ensure that training and competency are able to manage the consequences of an incident (e.g. disaster management).
2) one can try to eliminate the risk through redesign, changed operations, etc.
3) one can reduce the likelihood of occurrence through increased reliability and availability, reduced operations, more benign environment, etc.
4) one can reduce the consequences of the incident by acquiring advanced warning or introducing protective systems
5) one can look to transfer the risk (at a cost) through insurance or subcontract.

The most important part of the risk based maintenance loop is performance monitoring.

Fig. 2.3 Risk Based Maintenance
(Source: Child, 1997)
CHAPTER 3

MET AND NEW EDUCATIONAL METHODOLOGIES AND TECHNOLOGY

'Scholars who are worth anything never know... what bitter study means. They merely love books and read...'. Linyutang (1895-1976)

3.1 IT and the Role of the Internet

3.1.1 Information Technology in MET

Information technology has been widely used in shipping operations, which in consequence has led to the fact that operators both on board and ashore must be very well trained in computing techniques, computer operations, software utilisation, and information analysis. MET institutions should have a closer collaboration with shipping companies to find out what is essential for training IT-orientated seafarers to the STCW 95 requirements.

What knowledge and skills will be required for future maritime officers to operate the high-tech ship? Can MET institutions realise the potential threat that IT may bring to the pace of education and training to meet modern technology development? (Muirhead, 1998c)

The use of computing facilities, CD-ROMs, Internet, electronic mail, and PC networks has been penetrating into the education sector with far more influence on traditional education methods. MET institutions should therefore modify the programme objectives with more rational teaching methodologies applicable to both academic staff and students.
The common issue for IT in MET may include the lack of training programmes for the trainer in the first place, the lack of sufficient funds for IT equipment and software, and appropriate training programmes for students.

3.1.2 The Role of the Internet

The Internet is a global network of networks made possible by common protocols for information exchange. The World Wide Web (WWW) acts like a globally distributed hypermedia system, providing a standard for structuring applications as hypertext documents that can be published on the Internet.

Computer-based telecommunications are developing at breakneck speeds, and new products and services are quickly supplanted by more powerful options. Computer-based telecommunications using the Internet provides teachers and students with unparalleled educational benefits and information resources. There is a great variety of learning projects available on the Internet, including simulation. Dyrli (1996, 57) pointed out that exchanging ideas and project results with distant education classes motivates students strongly, enhances their communications skills, and especially when the collaboration involves international participants, increases their geographic competence and cultural understanding.

The Internet is and will be changing the way by which MET is conducted. A foreseeable effect is the change of concept from lecturer-centred to learner-centred environment. The Internet can also provide redundant information, thus the processing of valid information becomes essential in MET. The Internet plays an important role in MET lecturing and learning.

3.2 Multi-Media for the Classroom

3.2.1 Multi-Media Instruction

As a Chinese proverb goes 'I hear and I forget, I see and I remember, I do and I understand.'
A medium is defined by Webster’s (1991) as an intervening agency, means or instrument, by which something is conveyed or accomplished. The term multimedia was introduced in the 1960s to describe the combined use of several media, such as films, video, and music; today, multimedia has become closely associated with the computer-controlled, instructional delivery systems.

Why does multimedia play a key role in classroom education? This relates to the importance of the senses in learning. Poole (1995, 325) commented that vision is recognised as the most powerful data acquisition device for the brain. Visual displays of information encourage a diversity of individual viewer styles and rates of editing, personalising, reasoning, and understanding. Unlike speech, visual displays are simultaneously a wideband and a perceiver-controllable channel.

The traditional chalkboard is unlikely to be replaced by technology, it has rather been improved by technology. The common term used for teaching aids is audio-visual aids; this includes video cassette recorders (VCR) and high-resolution monitors.

A multi-media system thus differs from a basic computer system in that it adds to the computer-based learning experience the dimension of computer-controlled integration of images, full motion pictures and sound for purposes of teacher/student interaction. A multimedia system includes all the components of a basic computer system - the multimedia computer itself with a monitor, a printer, scanner, digital camera, overhead projector for computer. The computer is connected with the server which has access to the Internet.

3.2.2 The Role of Multi-Media

Multi-media technology can be used as resources and tools for learning, to support a variety of learning settings, for information dissemination and retrieval and information retrieval from the WWW resource based learning.

One of the most powerful uses of multi-media is to immerse the user in a learning environment, the key to this approach is achieving the imaginative engagement of the
learner. The ultimate expression of simulation is full virtual reality (VR), which is potentially one of the most powerful media for educational systems.

Virtual reality (VR) is defined as something 'which is not real, but may be considered to be real while using it. VR has three broad layers, namely social, cognitive, and sensory. Most VR systems are concerned with the sensory layer. The classic paradigm is the head mounted display and data glove, the aim being to create the illusion of immersion in a different sensory world. The greatest educational focus in VR at the moment is in training complex physical skills.

How effective is multi-media in education and training? Consider the characteristics of human perception. Perception is not a passive process of reflecting the external world but is a highly active and constructive process involving the interaction of two sources of information: information from the senses, and accumulated knowledge stored in memory. Perception is a patterned, active, and selective system.

How can more features be added to multi-media? Animation adds impact to a presentation. The visual impact of animation should be harnessed to serve the learning objectives. There are several types of animation including moving objects across the screen, user controlled movement of objects, bitmap flipping and full animation files.

A multimedia system may require the use of speech, music or special sound effects. The use of digital sound may be divided into two distinct categories namely the use of speech, and the use of music and sound effects. In order to incorporate digital video into a multimedia learning environment four steps need to be taken:

- create or locate the source material
- capture the video in digital form
- edit the video
- integrate the video into a multimedia authoring environment

All projects have to deal with the functions of analysis, design, evaluation and implementation as follows:

- what is the overall management framework of the project?
- how is the specification of the system to be represented?
• how are design ideas captured and communicated?
• what is the role of evaluation in project development and delivery?
• which parallel activities in design and development can be identified so that the group can work more effectively?
• how is the project to be signed off and delivered?

3.3 Distance Education and Learning Methodologies

3.3.1 Distance Education and Learning

Open university and distance education and learning are introduced due to the rapid developments in technology, and especially the Internet. The newer technologies certainly offer the possibility of any course delivered at any time, anywhere, the potential for truly international courses, fully inter-cultural, with students and teachers drawn from all over the world. The technology brings greater learning effectiveness, more learner-centred approaches, and better quality of interaction.

3.3.2 Use of New Technologies in Distance Education and Learning

The wise use of technology can allow, according to Bates (1997, 93-109), the following advantages:
• to improve access to education and training
• to improve the quality of learning
• to reduce the costs of education
• to improve the cost-effectiveness of education

Distance learners need an on-line help service that covers both technical and academic issues. Different kinds of students require different kinds of service, even though they may be using similar technologies. Technologies that students can access at any time, sometimes called asynchronous technologies, provide more flexible access. Asynchronous technologies include computer conferencing, the World Wide Web, and CD-ROM, but it is worth noting that print, audio-cassettes and video-cassettes are also asynchronous technologies.
3.3.3 Distance Education and Learning for MET

New technologies require new kinds of educational organisation that can fully exploit the potential of new information technologies. New technologies also threaten dedicated MET institutions. As MET is a peculiar field with diversified approaches, it is expected that distance education and training will be one of the most effective methods for MET institutions.

Distance education for MET needs flexible delivery in respect of utilising multi-media. The option may include print, audio tape, video tape, computer disc, compact disc (CD). The technologies available for distance education and learning include radio, T.V., computer, Internet, e-mail, video conferencing, teleconferencing. Flexible delivery is the appropriate mix of media and technology.

The appropriate use of distance education can satisfy individual demands. Distance education is most applicable when students cannot attend on-campus study, when students want to study at a reduced rate. The appropriate mix of delivery is still print, with other media acting as supporting means to print.

It is essential to know that there are several discrete skills required to produce suitable distance education material. These skills include:

- technical knowledge
- ability to write in a user friendly manner
- instructional design skills
- ability to edit
- layout/design skills

What are the costs and benefits associated with distance education? The costs may be high in development, but low in delivery of the courses. The benefits are to allow students the flexibility to study at their own pace, to reduce costs of individual students in aspect of travel, loss of income, also to take advantage of a variety of media increasing positive learning outcomes.
What will be the role and functions of MET lecturers in the future? As technology advances are being widely used in education, virtual or cyber universities have been opened up, the role and functions of lecturers will change accordingly. No less work will be assigned to lecturers, but the lecturer will focus more on new curriculum design for better teaching effectiveness in terms of electronic versions of study materials, and lecturers will get more involved in the learning process.

3.4 Computing and Simulation

3.4.1 Computing and Networks

Today multimedia applications are being developed primarily for stand-alone systems, where one user interacts with one computer, drawing from materials stored on a local device, such as a CD-ROM or video disc player. Advances in technology suggest a fundamentally different type of application, wherein many users will communicate with one another over a network of computers, drawing upon comparatively vast resources distributed across the network. Academic institutions are able to link computer laboratories and individual computers by computing networks to form a virtual reality teaching environment and let people meet in an information network.

Computing networks in MET have an effective application. Computing networks can be utilised in computer based training (CBT) for MET by setting up a CBT network which consists of an instructor's station, supported by a number of student stations. Each student station can run different training programs to perform the individually required task. Several student stations can also run the same program at the same time to enhance teamwork capability.

3.4.2 Marine Simulation

Mitropoulos (1996) pointed out in an IMLA Conference that the irony of the situation was that the collision might not have happened, had the ships not navigated under radar. These kinds of accidents came to be known as radar-assisted collisions.
Marine simulation training has been developed to such a level that it helps enhance competence of seafarers. The ship simulator can be categorised as follows:

- **category I - full mission.** Capable of simulating full visual navigation bridge operations including the capability for advanced manoeuvring and pilotage training in restricted waters.
- **category II - multi task.** Capable of simulating full visual navigation bridge operations but excluding the capability for advanced manoeuvring in restricted waters.
- **category III - limited task.** Capable of simulating an environment for limited (instrument or blind) navigation and collision avoidance (e.g. radar simulator with no visuals)
- **category IV - special task.** Capable of simulating particular bridge instruments or limited navigation manoeuvres but with the operator located outside the environment (e.g. a desk top simulator using computer graphics to simulate a birds eye view of the operating area).

Source: Cross (1998)

Simulation has been used to train mariners since the 1960s. Simulation application for trainees may include training in:

- knowledge of the International Regulations for Preventing Collisions at Sea (COLREGs)
- radar operation
- navigation techniques
- electronic navigation systems
- automatic radar plotting aids (ARPA)
- global maritime distress and safety system (GMDSS)
- passage planning
- bridge watchkeeping
- bridge resource management (BRM)
- emergency procedures
- shiphandling
- vessel traffic service (VTS)
- search and rescue (SAR)
Some problems of effectiveness of simulator-based training exist. There are two issues to be examined when evaluating the performance of simulator based training namely transfer of the training and gaps in knowledge and performance. The following factors can influence the transfer:

- the quality of training programme
- the quality, competence and credibility of the instructor
- the level of experience and aptitude of the trainee
- instructor and trainee attitudes to the simulator
- the effects of team or individual training
- the attitude of senior personnel
- organisational factors in the work place
- commitment of the organisation to the training objectives
- commercial pressures
- ongoing training
- refresher training
- failure to validate the training

Simulation can be used to support vicarious experience in real or imagined worlds. In task based simulation the user interacts with the simulation environment to achieve some effect or goal. The idea of task based simulation is developed to identify a number of problems that may limit the effectiveness of task based reasoning.

The navigation system makes extensive use of video to create a realistic training environment for learning navigation skills. This aims to integrate the three aspects of knowledge, theory and experience, by presenting the theoretical components of navigation in the context of a simulated experience.

The development of multimedia technology has opened up rich possibilities for learning based on 'virtual' experience. Simulation can support both exploration and task based learning. There is a danger of becoming beguiled by the technology. It must be asked how effective is a particular simulation in promoting learning, and what is learned well through simulation.
Virtual reality (VR) is characterised by the illusion of participation in a synthetic environment rather than external observation of such an environment. VR relies on three-dimensional (3D), stereoscopic, head-tracking displays, hand/body tracking and binaural sound. VR is an immersive, multi-sensory experience (Earnshaw et al, 1993).

The use of full VR for learning has been more rare, and the central question from an educational perspective must remain - how is learning better promoted using this technology? One of the most exciting possibilities is the creation of new imaginative worlds. How to structure and promote learning is the key question. The technology, no matter how wonderful, simply provides the materials that require shaping by a deep understanding of the nature of learning.

Simulators have both advantages and disadvantages (Muirhead, 1998b):

<table>
<thead>
<tr>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>highly effective form of training</td>
<td>capital equipment costs high</td>
</tr>
<tr>
<td>training costs can be reduced</td>
<td>experienced instructors needed</td>
</tr>
<tr>
<td>safety risks eliminated</td>
<td>skilled maintenance support needed</td>
</tr>
<tr>
<td>effective skill based training medium</td>
<td>system limitations</td>
</tr>
<tr>
<td>exercise flexibility</td>
<td></td>
</tr>
<tr>
<td>assessment medium</td>
<td></td>
</tr>
</tbody>
</table>

3.5 New Approaches to Competence in MET

3.5.1 Bridge Resource Management

Bridge resource management (BRM) is the effective utilisation of all available resources - hardware, software, and liveware (human resources) - to achieve a safe, efficient voyage (Pols, 1997, 99). Bridge resource management is all about making the best use of resources on the bridge. It includes not only the crew but also the navigation equipment with its software. Bridge resource management requires ship officers to anticipate the unexpected, particularly in extreme conditions. Bridge resource management also requires a right attitude that the bridge team should have.
The right attitude can be established through consistent practice of bridge resource management and by attending on-board training as well as training ashore.

As stated in 'Tokyo report urges new tanker rules' (1997) in which the VLCC Diamond Grace scraped the bottom and leaked oil on July 2 1997 in Tokyo Bay, the three key points featured in the report are the drafting of a voyage plan, the introduction of navigational aid equipment and the implementation of a bridge resource management training programme. The report concluded that ship officers need to have more training in bridge resource management.

3.5.2 Dual Purpose Education

The high technology ship installed with a workstation on the bridge and engine control room enables one person to efficiently navigate, monitor marine traffic and manoeuvre the ship in normal conditions. The high-tech ship is usually equipped with a bridge safety system that can verify if the officer of the watch is present and can also set alerts of safe guarding, off-track and system monitoring.

The need for training multi-purpose officers becomes necessary as merchant ships are built with more and more sophisticated technologies, which in consequence results in the role-players' responsibilities being re-assigned.

Shipowners certainly like to have their ships manned with the least number of crew in order to reduce the manning cost. Ratings and junior officers with multiple skills will be more competitive. The alternative certification as described by Morrison (1997, 158) is aimed at allowing 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, particularly during periods of intense ship calls at a series of near-neighbouring ports.

The education and training of candidates for alternative certificates must be in compliance with those requirements of STCW 95 regarding both navigational and engine watches. The training should also be carried out at three levels of management, operation and support. The training of alternative certificate candidates does not
necessarily mean the simple addition of the training programmes for navigational and engine watches. Multi-skill training needs an appropriate and applicable programme with an emphasis placed on multiple skills.

3.5.3 On-board Training and Assessment

The ISM Code requires, amongst many other provisions, that:

- each ship is manned with qualified, certificated and medically fit seafarers in accordance with national and international requirements.
- the company should establish and maintain procedures for identifying any training which may be required in support of the safety management system (SMS) and ensure that such training is provided for all personnel concerned.

Source: ISM Code, Sections 6.2, 6.5

Holder (1996) is of the view that emphasis of shipboard training should be placed on:

- familiarising crew members with the ship and equipment
- implementing safe procedures for routine operations including prevention of pollution
- providing EMERGENCY RESPONSE TRAINING
- encouraging career development for all crew members (records of sea training and assessment 'on the job' are more important under the revised STCW).

Installation of computers on board ships allows the use of interactive training aids. Cadets will be able to e-mail their efforts to college and receive advice or additional practice material at the push of a button.

On-board training (OBT) may have a negative side. The major disadvantage of OBT is that it also passes on possible bad habits of the experienced personnel.
CHAPTER 4

NEW STANDARDS OF STCW 95

The International Convention on Standards of Training, Certification and Watchkeeping for Seafarers, 1978, as amended in 1995 (STCW 95) became necessary in order to clarify the standards of competence required, introduce qualification requirements for trainers and assessors, provide mechanisms for enforcement of its provisions and allow greater flexibility in the assignment of functions on board ships and thus broaden the career opportunities of seafarers (IMO, 1996, Foreword).

STCW 95 is widely regarded as one of the most important new set of rules contributing to improved maritime safety, especially when viewed together with the ISM Code. STCW 95 is intended to bring the training of seafarers into the modern era and ensure common international standards. It is a great change affecting the whole maritime community. Its success is dependent upon governments, owners and regulatory bodies all adopting common interpretations and enforcement mechanisms.

4.1 STCW 95 Requirements

The International Maritime Organization (IMO) initiated the amendments to STCW 78, followed which the regulations and resolutions were adopted in 1995 by the Conference of Parties to the 1978 STCW Convention. STCW 95 has a vital impact on maritime education and training (MET) for maritime countries. One of the challenges to MET institutes is whether they have sufficient qualified and experienced academic staff to fulfil the requirements of STCW 95 with complete effect. STCW 95 aims at setting out verification and control mechanisms, and at achieving uniform implementation, application and enforcement of STCW 95 on a global basis.
STCW 95 is aimed at raising the overall level of seafarers' competence on a global scale. It sets global and mandatory standards for the following:

- the professional competence of seafarers, especially officers
- the education, training and certification of seafarers, including the requirement of a mandatory program of education and training for all masters, officers and radio operators
- the responsibilities of MET institutions, maritime administrations and the shipping industry in meeting these standards

Requirements and changes in STCW 95 include, among other provisions:

- approval of training and assessment
- qualification of instructors, supervisors and assessors
- in-service / on-board training
- simulator trainer and assessor standards
- assessment of competence
- functional approach - seven functions
- assessment methods
- mandatory use of Radar/ARPA simulators for training

The competence concept in STCW 95 is the key point which is by definition the ability to perform to the standards expected in employment. Competency based assessment is defined as:

the level of proficiency to be achieved for the proper performance of functions on board ship in accordance with internationally agreed criteria (as specified in the STCW Code), incorporating prescribed standards or levels of knowledge, understanding and demonstrated skill (IMO, 1996, A-I/6).

Competence based qualification is a statement of competence that incorporates assessment of skills, knowledge and understanding, and an ability to apply skills, knowledge and understanding to the proper performance of tasks, duties and responsibilities aboard ship. The key feature of a competence-based system is the way the tasks and skills are defined in terms of outcomes to be achieved rather than pure knowledge to be gained.
Maritime education and training shall be subject to approval by the Administration. As required by STCW 95 that Parties are required to ensure that the aims and objectives of simulator-based training are defined within an overall training programme with the emphasis on objectives and tasks relating as closely as possible to shipboard practices. Code A-I/6 refers to training and assessment. In regard to onboard training, approval by the Administration is clearly required also under I/11, II/1, III/1, V/1, V/2, A-VI/1 and A-VI/2 of the code.

4.2 Quality Assurance and Instructors' Qualifications

In STCW 95, the quality standards systems mean 'fitness for purpose' and 'compliance with claimed objectives'. The quality standards are defined in the STCW 95 (B-II/1 para. 14), under which all training, assessment of competence, certification, endorsement and revalidation activities are 'continuously monitored through a quality systems standard to ensure achievement of defined objectives, including those concerning the qualifications and experience of instructors and assessors.'

MET institutions are required to meet the quality standards in respects of quality assurance, faculty staff qualifications, and updated programme provision. Qualifications and experience of instructors and assessors are prescribed in STCW 95. The element in auditing MET institutions includes, inter alia, the following:

- the entrance level of students
- the number of students
- curriculum and syllabus for each course
- equipment related to learning objectives
- instructors' qualifications related to subject
- examination requirement and system for assessment

STCW 95 stresses the competence based assessment. The form of assessment covers three points, namely assessment at entry, assessment during study, and formal assessment for certificates of competency. The competence implies skills to specified
standards, relevant knowledge and understanding, ability to use skills and apply knowledge and understanding to the performance of relevant tasks.

Competence based assessment is defined in Code B of the STCW 95 (B-II/1 17), noting that there are five types of evidence about candidates competence given:

• direct observation of work activities (including seagoing service)
• skills/proficiency/competency tests
• projects and assignments
• evidence from previous experience
• written, oral or computer-based questioning techniques

Assessment methods both ashore and on board may include any of the following:

• practical exam
• project work
• oral exam
• written exam (open and closed, multi-choice, matching, true or false)
• video-based assessment
• computer-based assessment
• interactive video incorporating assessment
• audio tapes, photographs, slides

The qualifications of trainers and assessors are one of the key requirements. A-I/6 of STCW Code defines in-service training requirements as follows:

• any person conducting in-service training of a seafarer shall
  1. have an appreciation of the training programme and an understanding of the specific training objectives for the particular type of training being conducted;
  2. be qualified in the task for which training is being conducted.
• any person responsible for the supervision of in-service training shall have a full understanding of the training programme.
• any person conducting in-service assessment of competence shall have an appropriate level of knowledge, be qualified in the task, have received appropriate guidance, and have gained practical assessment experience.
MET institutions need both an internal quality assessment and an external quality audit in order to:

- find out and overcome shortcomings in course programs, curriculum and teaching activities
- evaluate the level of quality of students knowledge and skill
- examine the quality of staff with qualifications and experience
- evaluate the feedback of educational quality from the maritime industry
- improve teaching methods and techniques for higher quality
- ensure the capability of maritime institutions to meet quality requirements

Quality assurance should be conducted in relation to:

- the determination and implementation of the quality policy
- a quality system with an organisational structure, responsibility, procedures and resources
- the necessary activity for effective quality control
- the planned and systematic quality assurance reviews
- the periodical external quality audit

The audit team should finally draw up an audit report covering:

- audit procedure used
- briefing of all observations of the education, training, management and quality assurance
- summary of the education quality with conclusion and recommendations.

4.3 Use of Simulators

STCW 95 only makes the use of simulators mandatory for radar and ARPA training. Performance standards for radar and ARPA simulation are laid down in Part A of the Code and must be met by all new simulators after 1 February 2002.

Performance standards shall be complied with in respect of all mandatory simulator-based training, any assessment of competency by simulator and any demonstration of continued proficiency. Performance standards for simulators have several
requirements in aspects of training and assessment of competence. Training objectives and procedures and assessment procedures are also set up accordingly, the prime criterion in assessment procedures is that a candidate demonstrates the ability to carry out a task safely and effectively to the satisfaction of the assessor. The new challenge facing maritime institutions is that not only will they have to consider the capabilities of a simulator facility to meet course training objectives, but they will also have to consider how to use the simulator for assessment of performance. Moreover, they are obligated to see to it that instructors and assessors are properly trained, qualified and experienced.

According to Muirhead (1998b), there were about 800 simulators in use world-wide by the end of 1997, and the number is increasing. It may be argued whether these simulators can meet relevant performance standards; whether instructors and assessors are properly qualified and experienced; if simulators are being used for competency purposes and if simulator courses are to be relevant and effective within the overall training programme.

The availability of simulators used for maritime training requires higher priority. The methodology of simulator training and the qualification of trainers are essential in the first place. The simulator assessment has to be criterion referenced. The trainees' performance should be assessed with reference to performance standards to achieve the objectives of the training program. Due attention should also be paid to the following aspects when teaching teachers:

- respect the teacher
- acknowledge the learner's experience
- admit teacher's content mastery at a reasonable level
- teacher honesty and the element of trust
- pay attention to learning objectives of the learner
- be prepared for challenge.

4.4 Challenges to Chinese MET

The successful implementation of the STCW 95 can be achieved by an objective assessment. The aim of all MET institutions should be to ensure that sufficient,
reliable and verifiable evidence is available to enable a properly qualified assessor to be satisfied that a candidate has the ability to perform effectively at the appropriate level and function in accordance with the standards. There are four areas in which Chinese MET institutions will need to make substantial changes if they are to meet effectively the requirements of STCW 95:

- professional staffing
- academic curriculum
- teaching facilities and technology
- quality standards system

With the implementation of STCW 95, the Chinese MET institutions are facing challenges. The new challenge will include:

- quality standards system in MET institutions
- qualification of instructors and assessors
- teaching programmes and curricula
- simulator upgrading to the standards required
- competence based skill training and assessment
- adaptation to new technology

One of the greatest difficulties facing Chinese MET institutions is training the trainers. When teaching other teachers, it is important that the teacher have content mastery in the field being taught. The focus, aims and objectives of a course for teachers are also very important. Larsson (1994, 113) stated that if one wished to do something, learn how to do it, once learned, create change by teaching others; to maximise the amount of change, teach teachers. How do shipowners respond to STCW 95? Some shipowners take a little persuading. The white list is driving governments to take STCW 95 seriously. Owners and managers have to spend large amounts of their training budgets on focused upgrading of often only basically trained officers.

In meeting the new technological opportunities and challenges China needs a set of principles for maritime education and training. This should guide the country in how best to exploit the technological opportunities available.
Fig. 4.1 MET and Certification

(Source: Regulations on Examination, Assessment and Certification for Seafarers, 1997)
Chinese shipping companies want to have more Chinese seafarers employed by European owners; as pointed out by Osler (1998, 1) that Chinese crew is cheaper than a crew made up of European officers and south east Asian rating. However, some European manning agents believe that even at the cheaper price, many owners will still be reticent to use Chinese manpower, arguing that serious question marks remain over quality and bureaucratic management style.

The problems can be considered in two aspects. One is the salary scale of the Chinese seafarers which is not paid in full compliance with the international practice. The other is the quality or qualification of Chinese seafarers. For the latter issue, the Maritime Safety Administration in China has set up several regulations and a legal scheme to enforce the requirements of STCW 95. The whole process for a qualified seafarer to get a certificate of competence (COC) issued is given in figure 4.1.
In this chapter, the results of Chapters 2, 3 and 4 are summarised by stressing the impact of new maritime technology in ship navigation, MET educational methodology and technology, and the new standards of STCW 95 upon the Chinese MET in the 21st century. The entire present status of the Chinese MET system has been considered, but is only explained to the extent required for this dissertation (refer to section 1.3).

5.1 Present Status of Chinese MET and its Environment

Laubstein (1997) pointed out that maritime education and training (MET) refers to the formal, institutional education and training of officers as well as shore-based administrators, managers and educators in the maritime sector. The Chinese MET has broader scope, covering in addition the education of engineers in electronics, computer science, automation and social science in the maritime field.

5.1.1 Present Status of Chinese MET

Chinese MET is under the jurisdiction of the Ministry of Communications (MOC). There are currently seven MET institutions: Dalian Maritime University (DMU), Shanghai Maritime University (SMU), Jimei Navigation Institute (JNI), Wuhan Transportation University (WTU), Qingdao Ocean Shipping Mariners' College (QOSMC), Guangzhou Navigation Institute (GNI), and Maritime College of Ningbo
University. Another 20 maritime technical schools are also involved in training seafarers. There are about 4,000 academic staff engaged in MET, among whom are 1,000 professors and associate professors and 1,200 lecturers. The annual intake of students at MET institutes is approximately 2,000; an additional 2,000 students are enrolled in maritime technical schools every year.

![Diagram of MOC and MET Institutes]

Fig. 5.1 Relations of MOC and MET Institutes

The Chinese MET system presently consists of three levels:

1) higher education
   - postgraduate (Master of science and doctoral degree)
   - undergraduate (Bachelor degree in addition to marine diploma)

2) vocational education
   - technical school education

3) continuous professional development
   - continuous professional development
   - upgrade training for certificate of competence

Most MET institutions in China are preparing to establish a quality standard system. Dalian Maritime University (DMU) was audited by Det Norske Veritas (DNV) and issued an ISO 9001 certificate in June 1998. Qingdao Ocean Shipping Mariners'
College has passed the audit of a quality standard by DNV. Shanghai Maritime University (SMU) has also passed the audit of quality system by the DNV with the ISO 9001 certificate being issued. Other MET universities and colleges are ready to submit the documentation for a quality standard system to the Maritime Safety Administration, who will organise the independent audit and approval.

As people are involved in the process of the change, some fear also exists among certain academic staff who are either reluctant or resistant to the change. It is therefore essential for MET institutions to establish a better policy with greater motivation to encourage the staff to meet the challenge, to keep the assets to the best utilisation of the intelligent resources. The average age of the teaching staff at DMU is shown in Table 5.1, which indicates that the professors are aged.

<table>
<thead>
<tr>
<th>Title</th>
<th>Average Age</th>
</tr>
</thead>
<tbody>
<tr>
<td>Professor</td>
<td>56.4</td>
</tr>
<tr>
<td>Associate Professor</td>
<td>43.3</td>
</tr>
<tr>
<td>Lecturer</td>
<td>32.1</td>
</tr>
<tr>
<td>Assistant Lecturer</td>
<td>28</td>
</tr>
<tr>
<td><strong>Average Age</strong></td>
<td><strong>39.5</strong></td>
</tr>
</tbody>
</table>

(Source: DMU, 1998)

The training facilities, equipment and simulators in MET institutions are summarised in Table 5.2.

<table>
<thead>
<tr>
<th>MET Institute</th>
<th>Radar</th>
<th>ARPA</th>
<th>Nav. Aids</th>
<th>Cargo Handling</th>
<th>Ship Handling</th>
<th>GMDSS</th>
<th>E/R Sim.</th>
<th>T/S</th>
</tr>
</thead>
<tbody>
<tr>
<td>DMU</td>
<td>√</td>
<td>√</td>
<td>√</td>
<td>√</td>
<td>√</td>
<td>√</td>
<td>N/A</td>
<td>√</td>
</tr>
<tr>
<td>SMU</td>
<td>√</td>
<td>√</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>√</td>
</tr>
<tr>
<td>JNI</td>
<td>√</td>
<td>√</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>√</td>
<td>N/A</td>
<td>√</td>
</tr>
<tr>
<td>WTU</td>
<td>√</td>
<td>√</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>√</td>
<td>√</td>
<td>N/A</td>
</tr>
<tr>
<td>QOSMC</td>
<td>√</td>
<td>√</td>
<td>N/A</td>
<td>√</td>
<td>N/A</td>
<td>√</td>
<td>N/A</td>
<td>√</td>
</tr>
<tr>
<td>DMC</td>
<td>N/A</td>
<td>N/A</td>
<td>√</td>
<td>N/A</td>
<td>N/A</td>
<td>√</td>
<td>N/A</td>
<td>√</td>
</tr>
</tbody>
</table>

Legend:
MET = maritime education and training
ARPA = automatic radar plotting aids
GMDSS = global maritime distress and safety system
E/R = engine room
T/S = training ship
N/A = not available
The following MET institutions have been approved by the Administration as meeting STCW 95 standards:

- Dalian Maritime University (DMU)
- Shanghai Maritime University (SMU)
- Jimei Navigation Institute (JNI)
- Wuhan Transportation University (WTU)
- Qingdao Ocean Shipping Mariners' College (QOSMC)
- Dalian Maritime College (DMC)
- Dalian Seafarers' Training Centre, MOC
- Shanghai Seafarers' Training Centre, MOC

5.1.2 Chinese MET Environment

The MET environment comprises two parts, i.e. the wider environment - the trade and society, and the closer environment - industry and administration.

Zade (1996, 37-44) is of the view that the wider environment has the primary influence on MET. The wider environment of MET consists of international trade and the national society. Developments in international sea trade impact on the national sea trade and the national economy, whilst developments in national society impact on the value system, attitude and behaviour of the individual.

A report by UNCTAD (1997) indicated that world output increased in 1996 by 2.8 per cent over 1995. World seaborne trade reached a new record high of 4.76 billion tons. The overall seaborne trade in 1997 was to reach 4.9 billion tons. The world merchant fleet expanded to 758.2 million dwt at the end of 1996.

The closer environment, which consists of national industry and administration, also has an important influence on MET. Zade (1996) also pointed out that national MET is influenced by the requirements of shipping companies, by maritime administrations and, normally at least, by MET institutes. Shipping companies prefer MET graduates to operate their ships, while maritime administrations want MET graduates meeting international (STCW 95) and national requirements. MET institutes are normally in a
subordinate role in relation to the Maritime Safety Administration and see themselves as executors of industry and government wishes.

International seaborne trade and national society are influenced by the increasing use of computers and IT in the following ways:

- the increased use of advanced technology on ships, in shipping companies, in port approaches and ports and in MET has resulted in change that has had and is having a considerable impact on MET, the requirements from it and the provisions for it.
- the increased use of advanced technology on ships has led to a reduction in the number of crew.
- the increased use of advanced technology in shipping companies has facilitated communications with the ship.
- the increased use of advanced technology in port approaches in the form of VTS has weakened the ship master’s independence or decision.
- the increased use of advanced technology in MET, mainly in the form of simulators, has improved the quality and effectiveness of training. Technology in use on board ship has also had an impact on MET syllabuses. The black box approach to important subjects in MET syllabuses has led to a stronger emphasis on data interpretation and evaluation.

In summary, the increased use of advanced technology in the maritime sector has resulted in a shift from physical requirements to psychophysical and psychological ones. It has also resulted in a facilitation of communication and has helped shipping companies to adapt to the requirements of a global market.

The Chinese MET institutions may face the issues as follows:

- younger lecturers may leave the MET institution as the policy and environment are not so attractive and thus they are less motivated.
- MET institutions must reduce education and training costs, with the use of increasingly costly equipment as simulators.
- MET institutions should cope with increased effectiveness, better service and intensified involvement.
- the majority of officers will leave the sea, they will transfer from ship to shore.
Both technical skills and managerial knowledge and leadership qualifications should be included in the MET curricula in order to keep trainees abreast of the latest knowledge, traditional navigation subjects have to be reduced. The International Maritime Organization (IMO), the International Convention on the Safety of Life at Sea (SOLAS), and the International Convention for the Prevention of Pollution from Ships (MARPOL) should also be introduced into the curricula at MET institutions. The new requirements by STCW 95 can only be met by staff at MET institutes who are both willing and able. The willingness can be doubtful, the ability is not always existent.

5.2 Adaptation to New Technology

Technology advances have an essential impact on the shipping industry, which demands that qualified and competent personnel operate the high technology vessel. MET is consequently required to adapt to the new technology and to educate and train the trainees to become qualified and competent officers. Chinese MET institutions therefore should anticipate what will be happening in the 21st century in terms of technology.

The technology revolution seems destined to transform modern civilisation. Revolutionary innovation is now occurring in all scientific and technological fields. This wave of unprecedented change is driven primarily by advances in information technology. However, advances in IT have led to more than an information revolution; we are witnessing a technology revolution.

Much to the concern of maritime transport, the emerging technologies include:

- maritime transport
- environment
- information technology in computers namely, hardware, software, communications and information services

A wave of major technological advances seems likely to arrive during the next three decades. The four information technology fields - computer hardware, computer
software, communications, and information services - appear to lead this wave of innovation by about five years. Information technology serves as the principal factor now driving the technology revolution.

Hatal et al, (1997, 20) have predicted that in the first decade of the twenty first century (2001-2010), the information revolution should mature, producing major advances in all fields. Multimedia interconnectivity will allow people to interact seamlessly across diverse information media and geographic borders. Education, entertainment and commerce will enter a new era of electronic access. Alternative forms of energy, environmental management, transportation will also seriously begin to alter lifestyles.

Adapting to new technology requires both hard and soft environment. Zade (1996) further stated that equipment and facilities are the hard environment, training the trainer is the soft environment. MET institutions may be equipped with the latest technology advances if they have sufficient budget for them, but the challenge is how to train the instructor or trainer to a higher level of required new technological knowledge required, so that he or she can train others.

The latest technological advances that have had an impact upon the maritime industry are information technology (IT), GPS/DGPS, ECDIS, integrated bridge system (IBS), VTS/VTMIS and AIS. MET institutions should be prepared to meet all these technology challenges by updating instructors' knowledge, upgrading laboratory facilities, and keeping textbooks and handouts up to date.

The new technologies that influence MET methodologies include IT, multi-media, Internet and e-mail, computers, and simulation. Distance education may be used to help instruct students by means of computer technology and satellite communications. Issues arising from the above are whether these latest technologies can be utilised to the full effectiveness, and whether instructors/trainers can be trained in time to the required level in order to train students.
Technological revolutions have brought a lot of changes and opportunities to society. New technology advances also bring opportunities to the maritime industry as well as MET. The opportunities for Chinese MET in terms of technology may be:

- upgrading of knowledge for instructors
- attraction of young people as MET instructors
- investment of new equipment
- investment of new laboratory instruments
- set up of computer laboratories capable of accessing the Internet
- simulators with upgradable software for both navigation and engineering
- research and development of software for computer-based training
- intensive competition among MET institutions and instructors
- more competent and qualified students

5.3 Adaptation to New Educational Methodologies

5.3.1 New Educational Methods

STCW 95 set up competence-based training requirements. This challenges the traditional MET educational methods and also provides opportunities for Chinese MET institutions. Computer-based learning packages will bring more effectiveness to MET.

The major developments in the 21st century will be computer-based training (CBT) and assessment. One of the major advantages in training is the possibility of turning book 'still' pictures into dynamic presentations, but the greatest advantage to trainees is that they can monitor the progress of the training session as it proceeds and receive advice on repeats or remedial learning.

Computer-based assessment will complement computer-based learning in MET. In addition to self-assessment to help trainees test their own knowledge, computers can be used for formal on-board assessment, and to meet some requirements of STCW 95. The two most important ways are testing of underpinning knowledge and understanding, and demonstrating skills using simulation programmes.
5.3.2 Distance Education

Distance education for MET may be utilised where appropriate. China has vast coastal areas wherein maritime activities are focused. It is worth thinking ahead whether distance education is appropriate to MET, and who will benefit from it.

The 21st century will see many changes resulting from new technology. All new technology development will certainly influence the education sector and maritime education and training. Campuses with walls may be considered old-fashioned and the off-campus concept will be more reasonable. Distance education may enhance MET quality in terms of on-board training. In a wider sense, shipping companies will gain more benefits when their seafarers and cadets can get access to distance education on board ships.

Lewarn (1998) emphasised that the following points should be considered when conducting distance education:

- good quality material able to be updated and upgraded
- good communications with students to enhance success
- speedy response to inquiries and requests
- rapid turnaround times for assignments and examinations
- good system of administration
- good partners for development and delivery
- not to become driven by technology

Technology will take on a greater role in the provision of distance education programmes. The development and delivery of distance education is in transition and has an exciting future.

MET institutions need to make greater use of distance education technology to take full advantage of the flexible mode of delivery. Getting involved in the flexible delivery of distance education is to meet the MET challenge in the next century.
5.3.3 On-board Training

As required by STCW 95, on-board training or in-service training is a part of MET. The key components in a seafarer’s self-development plan ought to be appraise, plan, explore, implement and review. This development is a circular process.

- appraise - strengths and weaknesses, identify skills, abilities, future goals
- plan - strategic plan, set time scale
- explore - all possible sources of help
- implement - getting on with learning and self-development process
- review - evaluate, record the skills and abilities, adjust strategic plan if necessary

The responsibilities that MET colleges and training centres should assume are as follows:

- they will need to change their training systems to comply with the new requirements. The programmes will have to be changed and up-dated effective 1 August 1998. Revalidation is needed within a five year period.
- most of the knowledge required for certification will remain the same, but the focus is on competence. The courses will need to have been reviewed to ensure that the training outcomes are linked to the competence required by the Convention, and require the correct and intelligent application of all the associated knowledge, proficiency and skills.
- close co-operation is needed between shore-based maritime education and training and training on board before issuing a Certificate of Competency (COC).

The positive potential of multi-media and CBT applications on board are:

- assessment for entry into, and progression on, training programmes
- remedial teaching (filling the gaps) possibly linked to TV instruction
- ship familiarisation
- teaching maritime English, particularly in listening and speaking
- training for special shipboard operations
- understanding some shipboard management techniques
- safety awareness, and desk-top safety exercises
- teaching/revising some underpinning knowledge for certificates of competency
• self assessment and part of the formal assessment for certificates of competency, refresher and up-dating training.

5.3.4 Training for Multi-National Manning

Bringing together people from different races, backgrounds, etc. and with different points of view results in a new understanding of how to solve problems. In a multinational environment as exists on mixed manned ships, the environment plays a crucial role in the way people may go about their various tasks and so exhibit required skills and competency.

Although training is needed, more initiative has to come at the strategic and managerial levels if organisations are to be engaged in mixed manning. Structured on-board training programmes should be provided and given more emphasis. Planning for training at all three levels, strategic, managerial and operational, is required in order to improve competency levels on mixed manned ships.

The advanced technology now existing on ships has created an environment in which the performance of the workforce has become a function of education and training. This is still to be recognised by management of multi-culture manning in the shipping industry.

5.4 Adaptation to New Standards of STCW 95

STCW 95 was adopted in 1995 and entered into force on 1 February 1997. The Chinese Government has taken an proactive initiative in implementing the Convention. The report on implementing STCW 95 was submitted to the IMO by the Chinese government in late 1997. A special committee set up by the Ministry of Communications (MOC) has made a series of reforms in MET curricula, teaching programmes, modules and updating text books for all MET institutions in order to cope with the requirements of STCW 95.
The implementation and enforcement of STCW 95 require that the Maritime Safety Administration and MET institutions take all possible steps to fully comply with the requirements of the Convention. The major areas required by the STCW 95 include:

- the quality assurance system in place
- qualification of academic staff
- revision of curricula and programme
- replacement of the old and out of date equipment for training purposes
- state of the art simulator in place with appropriate upgradable programmes for training and assessment purposes.

STCW 95 mandates the use of radar and ARPA simulators. Simulator instructors must be trained to use the simulator before starting to train students. The instructor training course includes basic, general, specific, advanced and technical training. Instructor qualifications are also required. A qualified simulator instructor should possess at least the same general knowledge as the trainees have, hold at least the same qualifications as the trainees, be experienced in teaching techniques, and be highly motivated. The instructor can be evaluated by determining his/her ability to:

- establish training objectives
- develop an exercise
- conduct a training session
- transfer concepts and knowledge
- utilise various teaching techniques effectively
- monitor and supervise trainees
- conduct proper briefing and debriefing sessions
- identify students requiring extra guidance
- motivate the trainees
- create the right learning atmosphere
- perform training sessions in a professional way

It may not be easy for some Chinese MET institutions to fully implement the STCW 95. Certain measures can be taken by MET institutions to adapt to new approaches and standards of STCW 95 by breaking some deadlocks in human minds. Full compliance with STCW 95 requirements can ensure future success in terms of qualified and competent ship officers.
5.5 Opportunities for Chinese MET

The Chinese MET has advantages in terms of its legal regime, institution scale and academic staff. The centralised government system helps monitor and control the Chinese MET on the national scale. The Chinese government has taken initiatives to ensure the complete and effective implementation of STCW 95 by setting up legal regimes in the first place. A series of steps have been taken by the Administration, the most important one is the submission of the Government report to IMO for the implementation of STCW 95, which is the first IMO convention that requires action in the first place by Governments, not by shipowners, this is particularly important but often overlooked.

China takes its responsibilities as an IMO member state very seriously. It was therefore no surprise that China was one of the first countries to submit its proposals for 'white list' status, and that all concerned expect China to pass with flying colours. This is because China really has taken the revision to heart and changed its training methods, syllabus and examinations accordingly. Some people say that this is easy for a country like China which has a high level of government involvement and a strongly centralised administration. This is still a point of contention; not all Chinese people would agree that the process was easy, but it has been done (Bennett, 1998, 42).

The seven MET institutions in China play key roles in pioneering Chinese MET towards the 21st century and beyond. Most MET institutions provide fundamental maritime education, while Dalian Maritime University, Shanghai Maritime University and Wuhan University of Transportation Technology and Science offer doctoral and master of science programmes. The strength of Chinese MET may generally include the long history and experience in MET, sound and competent management systems, adequately qualified academic staff, direct involvement in the shipping industry, and availability of advanced training facilities. The capable academic staff at MET institutions are the real assets of Chinese MET in terms of scientific research, education, instruction, and training.
It is apparent that the Chinese MET system has, on the whole, lagged behind the move towards higher standards which have been occurring in other fields of post-secondary and higher education. Limitations exist in the Chinese MET system. One may take a look at the whole system at three levels, i.e. at the national level, at the institution level and at the individual level.

The Chinese government may not give top priority and full support to MET as it is only a branch of the national higher education. This implies that the policy may not be perfect and that the MET and State financial support may not be sufficient. MET institutions may be faced with some limitations which can be seen as follows:

- lack of qualified academic staff - staff in MET institutions should be qualified in both theoretical knowledge and sea experience. Not many Chinese MET staff hold appropriate certificates of competence (COC). The percentage of staff holding COC against non-sea experience is less than 30%, this figure should be increased.
- less attractive environment - the hard and soft environment. The hard environment refers to the policy, the modern experimental instruments and instructional facilities available. The soft environment refers to what can be facilitated to achieve the aims of scientific research and education to reach a higher level.
- lack of computers and simulators - more computer networks should be available, navigation and engine simulators should be developed in the next few years.
- curricula to be revised and/or to expanded - in order to meet the requirements of STCW 95.
- lack of funds - governmental funding is not sufficient.
- failure in English proficiency teaching - new technology should be used in maritime English instruction by using Internet, CD-ROM, and multi-media
- old equipment - some laboratory equipment has been in use for over 15 years; old models and frequent breakdown of equipment decrease teaching effectiveness.

Implementing multi-media and computer-based training (CBT) in today's environment requires imagination, faith and financial backing. Programmes are quite expensive to develop and to revise.
Some potential threats exist on how to attract and keep MET academic staff. The problems may be in one of the following forms:

- the attraction and keeping of MET assets - these can be affected by the hard and soft environment.
- fear of change - academic staff are reluctant to adapt to the change in educational technology and methodology, some are even resistant to the change. The phenomenon exists more among older staff.

Chinese MET has certain weaknesses. The weakness can be categorised as follows:

- qualified staff - qualified teaching staff with doctorate degrees and/or master mariner or chief engineer are needed.
- course programmes - some courses need revising as insufficient simulator based training and competence-based training are available; some short courses are not available; international exchange programme for MET information should be established.
- equipment and facilities for training - radar/ARPA simulators are out of date; no shiphandling simulator is available in most MET institutions; modern training facilities and equipment are not enough; no training vessels are available in some MET institutions.
- English proficiency - students lack proficiency in English language, particularly in speaking and listening; English publications and text books are not enough in the library.

The 21st century will bring more challenges for Chinese MET. The challenges include:

- the impact of new technology and market economy on MET
- curriculum revision and updating that should be made to adapt to the newer requirements.
- better chance only for qualified graduates of maritime institutions in the competent market of manpower.
- change of the instruction mode from the traditional way to the technology orientated by utilising newer technology like multi-media.
- the chance and challenge for Chinese seafarers supply market from increasingly international seafarers’ demand.
• intensive competitiveness in the maritime sector resulting in decentralisation of administration downward MET institutions.

The Chinese MET system will maintain its present three level infrastructure in the near future, however the emphasis will be placed on quality assurance, organisational reform and enhancement of its internationally recognised reputation. The strategies that the Chinese MET should seek to meet the challenges should include:
• an increase in maritime education investment
• more funds available for investment in the new technology in MET
• cost benefit analysis for effective use of financial resources
• establishment of quality assurance with internal and external evaluation
• set up of training programme for MET instructors
• MET management

What will the world look like in 2010? As Holder (1997) put it, economic geography will not have changed much. The world may still be affected by conflict, famine, poverty and pollution. It will be an integrated world in terms of cultural and trade barriers, and shipping will be an international service with international financing and staffing. Much more emphasis will be placed upon the quality of the people who serve in it. Both the wider and closer MET environment in the 21st century will lead the Chinese MET to a brighter future. One may wonder where to start and how to achieve the goal, but one thing is certain, it must start from a position of promise.

International conventions like STCW 95 and the ISM Code ensure the legal development in Chinese MET and the need to commitment to the full implementation of these international requirements. It will therefore enhance the overall improvement in Chinese MET competence and quality by the government’s commitment to the full implementation of the STCW 95.

In the new era of Chinese MET, current curricula and standards must reflect the information society; students at MET institutions should not be filled with facts, instead they should be provided with a framework of knowledge plus the skills required to access information quickly and efficiently.
CHAPTER 6

CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

The objective of this dissertation has been to conduct an overview of developments in the use of modern maritime technology in the shipping industry; to study how new technology and educational methodology affect Chinese MET; to highlight the new requirements of STCW 95; and to examine their impact upon Chinese MET.

The overview in Chapter 1 indicated that maritime technology advances have a profound impact upon the ship operations and shipping industry. Competent seafarers will play a key role in operating ships safely and efficiently. MET institutions play a fundamental role in producing competent ship officers to operate high-tech vessels in a safer and more efficient manner.

Modern technology that influences the shipping industry includes:

- electronic chart display information systems (ECDIS)
- global positioning systems (GPS) and Differential GPS (DGPS)
- integrated bridge systems (IBS)
- vessel traffic services (VTS) and VTMIS
- automatic identification systems (AIS)

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computers and workstations

This study revealed that the developments in economy, society, and technology world-wide have a long term impact upon maritime education and training (MET), and that the international and national regulations have a short term impact on MET. The deep impact of technology on MET is, among others, a result of the increasing use of the following factors:

- information technology
- multi-media in MET
- computers
- CD-ROM
- Internet and e-mail
- digital overhead projector
- simulation and simulators
- video conferencing
- distance education
- onboard training

China is one of the top 10 shipping nations in the world. Its container fleet ranks 5th in the world. China is also one of the major seafarer suppliers in the world, China will most probably be the dominant supplier of seafarer in the 21st century. Manning has now become an increasingly important factor in the regulation of ships both by international conventions and national law, for example, STCW 95, ISM Code, SOLAS, and Regulations on examination, assessment and certification of competence for seafarers of the People's Republic of China respectively.

The Chinese Government has established a legal regime and comprehensive policies for enhancing maritime education and training standards. The Administration has
been aware that the seafarers’ possession of appropriate qualifications and experience are all factors which are expected to reduce incidences due to human error.

The Chinese MET has great advantages. The centralised government provides powerful support in terms of policy and finance. Being an IMO member state, China has submitted its official report to IMO on implementing STCW 95. Three MET institutions have obtained an internationally recognised quality standards certificates issued by the Norwegian classification society (DNV); the others are getting ready for establishing quality assurance systems. All the MET environment is for the Chinese MET in terms of society, economy, technology, and statute. The contents of curricula in MET institutions are generally compliant with the requirements of STCW 95, and some of the curricula go beyond the minimum requirements of the STCW 95.

The Chinese MET, however, has limitations. The Chinese MET institutions can not be fully funded by the government. Most academic staff at MET institutions are well qualified and have good theoretical knowledge; however, more staff is needed with appropriate certificates of competence (COC) as well as shipboard experience is needed. Not many staff are able to attend seminars and conferences because of insufficient funds. The MET institutions also have an insufficient number of simulators and a lack of computers with access to the Internet. Some equipment used for training is old models with frequent malfunctions occurring during training; most of the old equipment needs to be replaced with the newest and latest models.

Certain short courses in most MET institutions have not been in place. These short courses include:

- Specialised advanced course on oil tankers
- Advanced chemical tanker and liquefied gas tanker
• Advanced fire fighting training
• Ro-Ro passenger ship training

The practical skills and operational capability in the students at MET institutions need to be enhanced by using new equipment and simulators for training. Another greater problem with Chinese MET is the failure to adequately conduct the programmes for maritime English proficiency. The majority of Chinese officers are incapable of communicating fluently by using English as the international working language.

The challenges to Chinese MET may bring even harder tasks to complete, and the opportunities resulting from the challenge can offer far more chances than what can be anticipated. A bright future in the maritime manning market for China will motivate and promote Chinese MET to catch-up on the English language required in a multi-national crew market. The majority of crews are mixed and this is neither new nor surprising. Mixed crews may present a variety of problems, and foremost among them is language. The use of English for inter-ship communication, as well as for communication with shore-based personnel such as the pilots, ship's agents and others, has greater significance than the use of any other language. The ship must be able to communicate externally in a language that can be understood. IMO is pressed to review the difficulties of inadequate communication between crew members and to set new language standards for communication between all officers and crew. Furthermore, it should be ensured that crew members are as sensitive to the safe operation of the vessel in port as they are at sea.
6.2 Recommendations

New Technology in Ship Navigation

1. Funds should be found to purchase the latest model of bridge equipment for MET institutions for training purposes. Both trainers and students can benefit from using the latest equipment.

2. Old malfunctioning equipment should be replaced by the newest and latest models; and more state of the art simulators should be used in developing skills and assessment.

3. A mechanism should be established by the MET institution to retrain and update instructors with the latest knowledge in navigation, IBS, ECDIS, GPS/DGPS, computer and Internet.

New Methodology and Technology for MET

1. MET institutions should establish a mechanism and policy to invite experienced master mariners as visiting professors who will give lectures or seminars at a time of the year convenient for them.

2. Some curricula need updating and revising to meet the requirements of technology development in the maritime industry.

3. Investment in equipment and simulators should be limited, and funds for research and the development of software for computer based training and simulators should be increased.
4. The updating of instructors' knowledge should be conducted at frequent intervals. As highly advanced technology develops at an increasing speed, it is essential that teachers at MET institutions keep up with the latest advances and developments in maritime technology. This could be achieved by requiring teachers to attend continuing education and/or short training courses every two years. Younger teachers should also be encouraged to take certain teaching and administrative responsibility.

5. MET staff should be encouraged to attend seminars and conferences in order to keep abreast of the latest developments in related fields.

6. All the advanced maritime technologies should be reflected in textbooks in order to keep students' knowledge up-to-date. This also requires that textbooks should be revised and updated accordingly.

7. The curricula in MET institutions should include basic science instruction, function approach instruction, quality assurance, bridge resource management instruction by multi-media, computer-based training, simulation training, and learner-centred instruction.

New Requirements of STCW 95

1. The appropriate legal system has been established to implement the STCW 95. It is the Maritime Safety Administration that should place more effort on the outcome of the implementation by assessing, and reviewing the whole process. Quality assurance system should be established; a scheme of competence based training and assessment should be in place.
2. Chinese MET institutions should have close collaboration with shipping companies to know better what is required in the manning market. The basic questions that MET institutions and shipping companies may ask should include: 'What type of person is needed as seafarer?', 'What knowledge and skills are required for the future seafarer?', 'Where are these seafarers to come from?', and 'How to keep them?'. Trained and competent seafarers are needed to man the Chinese and world fleet now and in the future.

3. A personality test aimed at discovering whether the applicant's personality has the required stress-resistance mechanisms to fulfil the role required at sea is being applied. This new concept has a potential influence on the curriculum design at MET institutions. STCW 78 required knowledge-based training while STCW 95 requires competence-based training; yet no provision has been made for the personality training, which is in fact a market demand. MET institutions should also follow the market to meet its demand.

4. The average age of academic staff should be less than what is indicated in Table 5.1, in which the average age of associate professors is too high, and that of professors is even higher. It may be reasonable to have the average age of both professors and associate professors five years younger than the figure shown.

5. Advanced training courses should be opened up. Native English speaking teachers should be employed to improve students' English proficiency. Libraries should be supplied with the newest English text books and journals. More academic staff with both theoretical knowledge and shipboard experience should be employed.
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