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Teaching and practice of navigation in Mozambique : the impact of new technology on traditional methods

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TEACHING AND PRACTICE OF NAVIGATION IN MOZAMBIQUE:

The Impact of New Technology on Traditional Methods

By

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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.

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ABSTRACT

The dissertation is an evaluation of the current navigation teaching in Mozambique and training practices in selected maritime institutions world-wide. In the light of this, all navigation syllabuses in selected countries are identified for comparison.

It is obvious that modern technology is playing an increasingly important role in the teaching and practice of navigation globally, and therefore, the impact of technology on traditional methods as well as on the safety of navigation is discussed. Some limitations in accurately predicting the future developments of navigation technology on board ships due to its high rate of change are noted. The problem of accuracy, limitations and the current situation of some navigation equipment such as Decca, Omega, Loran-C, ARPA, GPS, INS and ECDIS are described for comparison, noting the way in which technological developments such as Differential GPS and INS are promoting safer navigation.

The STCW/78 as revised by IMO and the amendments now proposed which deal with navigation are examined with a view to evaluating their impact on standards and on technology in the country. The Navigation Control System (NACOS) developed by Atlas Electronik is described in order to elucidate the facilities offered by INS. The need for a new syllabus for the Nautical School of Mozambique is proposed to fit the changing ship technology.

The final chapter is a summary of the objectives of navigation teaching world-wide and describes the importance of resolution A.666 (16)- World-wide Navigation Systems. A proposal for the staged introduction of new simulators and equipment over the next few years in the Nautical School of Mozambique is made.

TABLE OF CONTENTS

LIST OF TABLES

ABBREVIATIONS

ALAM	Academi Laut Malaysia
AMC	Australian Maritime College
AMTA	Arab Maritime Transport Academy
ARPA	Automatic Radar Plotting Aids
AUTO WP	Automatic Waypoint
C/A	Coarse Acquisition
CDU	Chart Display Unit
CNIS	Channel Navigation Information service
CW	Continuous Wave
DGPS	Differential Global Position System
DNS	Decca Navigation System
DOP	Dilution Of Precision
ECDIS	Electronic Chart Display and Information System
ENC	Electronic Navigation Chart
ENIDH	Escola Nautica Infant D. Henriques
ENM	Escola Náutica de Moçambique
FRP	Federal Radionavigation Plan
GLA	General Lighthouse Authorities
GLONASS	Global Navigation satellite System
GPS	Global Position System
GRI	Group Repetition Interval
HDOP	Horizontal Dilution of Precision
IALA	International Association of Lighthouse Authorities
IHO	International Hydrographic Organisation
IMO	International Maritime Organisation
INMARSAT	International Maritime Satellite Organisation
INS	Integrated Navigation System

LI	Line Indicators
LOP	Line Of Position
LORAN	Long Range Navigation
MAROFF	Marine Officer
MET	Maritime education and Training
MPP	Most Probable Position
NACOS	Navigation Control System
NCC	Navigation Control Console
NINAS	Nucleus Integrated Navigation System
NORAD	Norwegian Development Authority
P-Code	Precise Code
PAD	Predicted Area of Danger
PCS	Planing and Consulting Station
PPC	Potential Point of Collision
PPS	Precise Position Service
SA	Selective Availability
SADC	Southern African Development Community
SAR	Search And Rescue
SCC	Ship Control Centre
SOLAS	Safety Of Life At Sea
SPS	Standard Position Service
STCW	Standards of Training Certification and Watchkeeping
TD	Time Difference
TSS	Traffic Separation Scheme
UERE	User Equivalent Range Error
URAs	User Range Accuracy
US DOD	United State Department of Defence
USMM	United State Merchant Marine Academy
VDU	Visual Display Unit

VLF	Very Low Frequency
VTS	Vessel Traffic Service
WGS	World Geodetic System
WWRS	World-Wide Radionavigation System

INTRODUCTION

Navigation is an important marine activity with economic benefits, but with adverse effects on the marine environment. However, it can be defined as the process of traversing from two different points safely, effectively and efficiently. The task of the navigator is to ascertain the ship's position with accuracy using all facilities available in order to avoid dangers. Carrying out this task needs good knowledge of the profession which can only be acquired through training. This makes the need for training very important. The purpose of this dissertation is therefore to evaluate the current teaching of the subject in Mozambique and the training practices in selected countries.

In essence, the research methodology adopted is empirical in nature, much data being based on class notes from the course professor, visiting experts and material from the WMU library and institutions concerned. It is supported by information gained from other sources during the field studies.

In the first chapter, the author provides a general overview concerning navigation requirements, the shipping industry and the current Mozambique nautical course including facilities and teaching methods.

The second chapter investigates the current navigational teaching and training practices in selected maritime institutions. A comparison table of current navigation syllabuses in these selected countries is made.

Following this, the third chapter examines the impact of changing technology on the safety of navigation. It discusses the problem of accuracy, limitations and the current situation of some navigation systems. Comments are made on the problem of changing technology and the requirement for a world-wide navigation system of a non military nature.

Chapter four, gives an overview of the minimum requirements of the STCW/78 as revised and the impact of changing trends in navigation on the Mozambique environment. The impact of the revised convention on standards, technology and the need for qualified instructors and the alternative certification is discussed. It identifies the requirements of the country's shipping industry.

In the fifth chapter, the paper considers the development of INS and new training needs. It describes the facilities offered by NACOS developed by Atlas Electronik. In the light of this, a proposal for a revised navigation syllabus for the navigation course in Mozambique is made.

Finally, the author concludes by making a number of recommendations on the need to ratify some IMO conventions, providing a plan for the staged introduction of new simulators and equipment over the next few years in the Nautical School of Mozambique.

CHAPTER 1

MOZAMBIQUE: A GENERAL OVERVIEW

1.1 COASTLINE

Mozambique is located in south-east Africa along the Indian ocean. The extension of its coastline is about 1600 nautical miles. The country is divided by at least 25 main rivers, all of which flow to the Indian ocean. The largest is the Zambeze, whose 820 km Mozambican section is navigable for 460 km and provides access to the interior of Africa from the eastern coast.

1.2 NAVIGATION REQUIREMENTS

Coastal navigation uses strategic lights and prominent points of coastline to obtain position. This form of navigation is quite good. One disadvantage is that the distances between the lights are too great, thus demanding extremely high light intensities and making it impossible to take bearings of at least two visible identified lighthouses at the same time.

Another serious problem is that all the sand banks, islands and reefs are some 10-20 nautical miles outside the coastline, making navigation along the coast dangerous in some areas. A lot of wrecks along the coastline provide evidence as to this statement.

The existing lights are mainly used by coastal traffic, by ships bound for Mozambican harbours, and by fishing vessels. However, the heavy traffic from the Middle East around South-Africa to Europe and America is also very dependent on the coastal lights. Therefore, the use of modern racons (radar responders) is of utmost importance if safety of navigation along the coast is to be increased.

1.2.1 Tidal regime

The tidal regimes vary between the regions and this is illustrated by data for the three major ports of the country from the South, Centre and North regions, Viz.

- Port of Maputo (south region)

  Latitude 25 59' S, longitude 32 36' E. The prevailing weather is SE to SW winds, generally light in the morning but it can reach gale force in the afternoon. The range of tide is 3.57 metres (low tide).

  There are two main channels to the port. The south channel has a depth of 9.75 metres for vessels with local knowledge. The north channel is for deeper draught vessels, the channel having a depth of 11.3 metres. The draft in the port channel is 10 meters plus the height of the tide. The width is 100 metres due to dredging of the channel.

- Port of Beira (central region)

  Latitude of 19 50' S, longitude 34 50'E. The range of tide is 6.22 metres to 7.35 metres and only vessels with draught up to 4.88 meters may enter at any time of the tide.

- Port of Nacala (north region)

  Latitude of 14 32' S, longitude 40 40' E. The port is 60 metres deep, while the range of the tide is 2-4 metres. The predominant weather from February to July is a

SE wind and from July to January it is a NE wind.

1.2.2 Pilotage needs

Although the three major ports of the country have been marked according to the International Association of Lighthouse Authority (IALA) system, pilotage is compulsory. However, apart from the major ports, there are 12 secondary ports, mostly used by national cabotage vessels. Due to sand banks that make the entrance to them hazardous, the use of pilots has been recommended.

1.3 SHIPPING INDUSTRY

Mozambique's geographical position makes it the most important country for access to the sea by most of the landlocked Southern African Development Community (SADC) member states. Therefore, the country's shipping organisations now attach great importance to the transit traffic of goods being exported to or imported from the inland countries.

Mozambique's domestic policy is to be characterised by the state involvement in the various sectors of economic activities. Thus any foreign company or ship wishing to operate in any port of Mozambique is obliged to indicate a local authorised shipping agent, who will be responsible for the ship's operations at the port and for the payment of taxes, services and possible compensations.

1.3.1 General situation in Mozambique

It is well known that the maritime activities concerned with chartering, owning ships, ships' insurance, and ships' management are much more efficient if people with sea experience were more closely involved in them. In Mozambique this role has been ignored.

Therefore, why should not one way of becoming the head of a marine school, a port manager, a ships agent, or a shipbroker be after a period of experience at sea?

The question arises due to the failure to use available personnel from the maritime field, and consequently all the maritime activities within the country are facing major difficulties as a result of which shipping activities remain inefficient.

Neither the nautical school, nor the shipping companies are successful in their activities.

The most relevant case is of the largest national company (Navique EE), with a total of 12 vessels, only four of which are operational. The Nautical School of Mozambique (Escola Nautica de Moçambique) is another relevant example of mismanagement of marine activities. Consequently, the demand for students is less thus making it impossible to run the normal academic year.

1.3.2 Infrastructure needs

The main shipping enterprises are:

- Agencia Nacional de Frete e Navegação (ANFRENA),
- Companhia Nacional de Navegação,
- Companhia Portuguesa de Transportes Maritimos,
- Empresa Moçambicana de Cargas (MOCARGO),
- Manica Freight Services sarl,
- Empresa Moçambicana de Navegação (NAVIQUE),
- Transmaritima, and

* NAVINTER.

Apart from Navique and Transmaritima, all the others are shipping agencies. Navique is the one that provides employment for the majority of national officers and ratings. The shortage of foreign going ships within the country is a big disadvantage, not only for the country but also for shipping itself because, having such foreign going ships would contribute to the upgrading of skills of marine officers thus giving a better reputation to the country. Therefore, the government should play an important role.

1.4 CURRENT MOZAMBIQUE NAUTICAL COURSE

1.4.1 Objectives of the navigation course

The navigation course of the Mozambique Nautical School is intended to provide a trainee with the navigation science and skills necessary for a future deck officer or master, complying with the Standards of Training Certification and Watchkeeping Convention (STCW/78).

1.4.2 The navigation curriculum and syllabus

The maritime curricula consist of elements of land based education and sea based training.

Course duration

The navigation course is composed in two parts called levels, viz:

First level- is to be done over two consecutive years, where students learn not only navigation but also general subjects. After this period the trainee is able to graduate in accordance with regulation II/4 of the STCW convention.

Second level- is composed of one and half years, where the teaching of technical subjects is continued. After this period of one year and half, the student is issued a certificate in accordance with regulation II/3 of the STCW convention.

Finally, after a period at sea the navigation course is concluded during the last six months and the trainee is able to graduate in accordance with regulation II/2 of the STCW convention. Moreover, during the six months, general subjects like shipping, administration, and maritime economics are taught.

Entrance requirements

To be enrolled in the navigation course, it is necessary to fulfil the following requirements, trainee must:

- Be a Mozambican
- Have reached 18 years of age
- Posses the Mozambican high school certificate
- Be physically fit, and
- Pass the written examination in maths and physics.

1.4.3 Facilities and teaching methods

Equipment and training aids play an important role in the evolution of marine training. With technology advancing very fast, it is difficult if not impossible to teach a navigation course without such equipment. Fortunately, the navigation department is well equipped to cover the actual needs. However, it is important to update equipment in the department in order to challenge the actual requirements of the new technology.

The actual equipment among others, consists of a radar simulator, and a computer based training program for 10 students. It would be of advantage if the radar simulator were upgraded into a ship handling (bridge) simulator for day and night views. Having such a simulator at school will help to close the gap between theory and practise as well as to improve the professional skills of mariners.

Concerning teaching methods, like other places in developing world, the use of a blackboard is the most important tool; However, the overhead projector and TV/Video are media that are used to support the teaching process.

1.4.4 School certificate

It is important to notice that the certificate referred to above is a school certificate that confirms the passing of the school exam. It is not to be confused with a certificate of competency that is issued by the ministry of transport.

There is a general misunderstanding of the value of marine education by the trainees, particularly regarding the level of the academic award which gives them recognition within the national education system. After three and half years at school, six month pre-sea training and one year at sea, the bachelor diploma is issued. All of this amount to five years of training at the nautical school which awards the bachelor diploma. The duration at university is also five years with an award of a masters degree. Consequently, this makes the student have a preference for the University rather than the nautical school resulting in a situation whereby the Nautical School is less recognised.

CHAPTER 2

SELECTED CURRENT MET SYSTEMS WORLD-WIDE

2.1 BACKGROUND

There are different types of MET systems around the world, each with its own policy and philosophy. Therefore, this paper will identify and investigate the current teaching of navigation in selected countries in order to examine the development and impact of new technology upon the teaching of navigation in Mozambique as well as the impact on traditional methods. For the purpose of the analysis, the selected MET systems will be divided into two groups:

1- Those MET systems which use the traditional or monovalent system (Australia, ALAM, Portugal and Egypt); and

2- Those MET systems which use the new or dual purpose system (Netherlands and USA).

However, with all MET systems there are common factors which lead to change. These factors are:

- Advances in technology which have provided shipping companies, ports and other maritime enterprises with opportunities for data access thus enabling them to be in contact with a vessel at any time;
- The risk of a ship carrying dangerous goods being involved in any accident is an important consideration, hence making the training of both shipboard personnel and shore personnel crucial. Thus the MET institutions play a very important role

in this regard.

- Advanced shipboard navigation systems and automation on ship bridges which have modified the traditional operation of ships, from the traditional monovalent system to the dual purpose or bivalent system, thus requiring the upgrading of the MET institutions; and finally,
- Changes that may occur within the society, whether economic, political or historical that have their impact upon the MET system in one way or another.

The current approach of maritime education in many countries has been to integrate the marine education system into the national education system through Academies Polytechnics, or Universities (Australia, USA, Portugal, Egypt). The main objective of the integration is to provide seafarers with an opportunity to obtain an academic degree in nautical and engineering science in addition to a professional certificate of competency. The outcome of the strategy can be seen in the increased number of enrolments in some Nautical Institutions (Australia, Portugal, Netherlands). Finally, having dealt with common aspects relating to the selected MET systems, it is relevant at this point to examine or look at each system in detail.

2.2 AUSTRALIA

The Australian Maritime College (AMC) is the Australian government's national centre for maritime and maritime related education, training, research and development. The mission of the AMC is to provide education and conduct applied research of international distinction, in keeping with the needs of the Australian maritime industry.

Therefore, the diploma of applied science (Nautical Science) provides a trainee deck officer with the academic and practical training necessary for progression from junior navigating officer to shipmaster. It incorporates the basic knowledge requirements for the certificate of competency as Second Mate and Master Class 1 within a cohesive program of studies. The diploma is designed to meet the needs of students seeking such professional qualifications, as well as providing a career path for integrated ratings who have completed the certificate in marine operations (through the Integrated Rating Course).

The Australia Maritime College provides a trainee with a mobile system through training for the industry. The AMC functions within the Australian national system of education. New courses are constantly being developed to produce graduate and post-graduate maritime specialists who can adapt to the challenges of changing and increasingly complex industries. The AMC provides 80 non-award short courses and certificate of competency preparation courses.

Course duration

A sandwich course of four years duration consisting of five academic semesters and three semesters of seagoing experience. See Appendix 1 for details of the navigation subjects.

2.3 MALAYSIA

The Maritime Academy Malaysia or ALAM (acronym from its name in the national language) is the premier maritime education and training institution in Malaysia. First established in 1977 as a training centre, it was upgraded in 1981 to an academy with the award of a government charter. The primary role of the academy is to develop and enhance the knowledge and skills of maritime personnel engaged in and associated with the merchant navy as well as its related industries. Recently designated as a branch of the World Maritime University, it is fast becoming a leading institution in the region.

Courses currently offered include professional maritime and shipping courses and a wide range of specialised safety courses. Courses offered for seafarers are all in line with the International Maritime Organisation's International Convention on Standards of Training Certification and Watchkeeping (STCW/78). Thus the main areas of training and education presently undertaken by the academy are all in the traditional monovalent scheme and include: Pre-sea courses (cadets/ratings), communications, officers and the full range of nautical certification of competency from second mate to mates (Foreign going) and a master at local trade course. Appendix 2 gives more details on the subjects.

2.4 EGYPT

The Arab Maritime Transport Academy (AMTA) is a specialised educational institution for the Arab League engaged in teaching, training, research work, community service and projects. Since its inception in 1972, AMTA has been educating, training and qualifying students in all the disciplines, sciences and technologies relating to the various aspects of the maritime industry. It offers academic and professional degrees and certificates in navigation, marine engineering, electronics, computer sciences, maritime transport economics management, seamen's training and marine catering. The college of maritime studies and technology is composed of three departments:

- Department of Navigation
- Department of Sea Training
- Department of Marine Safety

Through its departments and educational and training centres, the College of Maritime Studies and Technology offers a considerable number of study programs leading to the following degrees and certificates of competency:

- B. Tech. In maritime technology (navigation), together with second mate certificate of competency; third mate/second mate certificate of competency; first mate and master certificate of competency.

However, for those students who are interested only in a sea carrier, there is another training system to follow after the 5th semester. Instead of coming back to school the student can continue his/her sea training on board any vessel (apart from the training vessel) for 12 months and then return to school for 6 months. See appendix 3 for navigation subjects.

2.5 PORTUGAL

In Portugal the ENIDH (Escola Nautica Infant D. Henrique) is the only polytechnic institution that provides education and training for merchant marine officers. From the educational training and research point of view, ENIDH is organised into three departments (Deck, Engineering, and Telecommunications), which report to a scientific council.

Presently the courses provided by ENIDH are as follows:

- There are 4 or 5 year courses, depending on the student's option. Both courses are divided into two phases.

1st phase: BSc courses- undergraduate 3 years courses

a) Deck officers

b) Marine engineering officers

c) Marine electronic telecommunications and engineering systems officers

2nd phase: Superior specialised studies course

1) <u>One year</u>- for student holding a BSc and a 2nd officer certificate.

- Marine management and technologies
- Marine machinery engineering
- Electronics of telecommunication marine systems engineering

2) <u>Two years</u>- for students graduated as BSc and possessing a 3rd officer certificate.

- Maritime and port administration and management
- Maintenance and systems control engineering

- Electronic and telecommunications systems engineering.

Upon completion of all the subjects that comprise the curricular plan of each of these courses, students are awarded a "Licenciatura" degree. See Appendix 4 for details of the navigation subjects.

2.6 NETHERLANDS

In the Netherlands, all training and education in the regular higher vocational education structure is now based on the dual purpose (bivalent) system, which in the Netherlands was christened with the rather peculiar name Maroff (short for maritime officer). Training levels in the Netherlands are three- fold for the merchant marine:

- **The Lower level**, has been producing multidiscipline-discipline ratings for some years now.
- **The middle level**, trains bivalent officers for ships of up to 6000 gross tonnage and 3000 kW engine power.
- **The higher level**, prepares the bivalent "maroffs" for ships of unrestricted size and engine power.

Years 1 and 2

These years cover basic training, specially all general and supporting subjects with as many of the job- specific subjects added as necessary to cope with a proper and useful apprenticeship year.

Year 3

This is the year at sea on board either a monovalent or bivalent merchant ship. The student is expected and required to encounter all aspects of the shipboard systems, i.e. he/she will have to work in a bivalent mode or monovalent mode depending on type of ship he finds himself on board.

Year 4

At the beginning of this year, the student can choose which subjects, technical or nautical, he/she wants to take major lectures in during year 4. See Appendix 5 for navigation subject details.

2.7 USMMA

The US Merchant Marine Academy (Kings Point) is a national institution operated by the federal government's Maritime Administration, an agency of the US Department of Transportation . The 4-year program offers a Bachelor of Science degree, a licence as Merchant Marine Officer (issued by the US Coast Guard), and a commission as Ensign in the US naval reserve.

The USMMA offer different courses such as: Marine transportation, Ship's Officer, Marine engineering systems and Dual licence. For the purpose of this evaluation the dual purpose program which is a course combining marine engineering and marine transportation studies for licensing in both specialities is the most important. This course starts in three class year as illustrated in appendix 6. The dual program is conducted by both departments of engineering and marine transportation. In this dual program students receive professional preparation as both deck and engineering officers, leading to licensing as both a third mate and third engineer, thus the graduate is qualified to serve on board in deck or engineering departments. Details of the navigation subjects are listed in Appendix 6.

2.8 GENERAL OVERVIEW OF WORLD-WIDE TEACHING OF NAVIGATION

The main objective of teaching navigation is to provide a trainee with academic knowledge and skills in order to operate a ship safely, effectively and efficiently. From the teaching point of view, navigation can be defined in different terms depending upon the objectives of the institute. For some, navigation is the process of traversing from A to B safely and efficiently. On the other hand navigation may mean traversing from A to B to C safely and efficiently, thus meaning that the trainee should be able to work ashore as well. The safety and efficiency aspects are very important considerations which oblige ship-owners to train their personnel to high standards. Therefore, the world-wide teaching of navigation will be presented in terms of the different subjects taught within these selected MET systems.

2.8.1 Coastal Navigation

Within the traditional monovalent system, in coastal navigation amongst other things, the following subjects are taught: Nautical chart, chart projection and interpolation, dead reckoning, direction measurement by magnetic and gyro compass, errors, determining the ship's position by the use of landmarks, aids to navigation including lighthouses, beacons and dead reckoning taking into account winds, tides and currents. The modern system concentrates more on teaching Electronic Chart Display and Information System (ECDIS) and the new tidal tables.

2.8.2 Offshore Navigation

There is more emphasis on celestial navigation with particular use of short method tables (Marq St. Hilare methods). In the modern system there is less instruction on sidereal hour angle, equation of time, and chronometer errors as well as less emphasis on the moon, planets and sun and the practical sextant. However, there is more interest in errors in navigation and integrated systems.

2.8.3 Electronic Navigation

In this subject there are similarities in both systems because the objectives of teaching the subject is to equip the student with the fundamental knowledge and skills needed to operate the bridge equipment. Therefore, there is more emphasis on adaptive auto-pilots, ECDIS, GPS, ARPA, Loran-C, Differential Loran-C/ GPS, weather fax, satellite communications and integrated navigation systems. On the other hand, there is less focus on Decca, Omega, Transit and Radio Direction Finder. More details on equipment will be provided in Chapter 3.

2.8.4 Bridge Equipment

As regards Bridge equipment the emphasis is on the Doppler log. However, there is less emphasis on compass adjusting. The use of a compass on board is one of the traditional methods which technology does not easily replace. Even with the advent of the gyro and auto-pilot, the compass remains on board as a backup system.

2.8.5 Navigation Safety

To improve safety at sea it is necessary to enhance the education and training of all personnel involved in the operation of ships. Therefore, the teaching of navigation safety is emphasised in the subjects discussed below.

2.8.5.1 Use of Simulators

Maritime Simulators have been used in MET institutions to develop the skills of mariners. For example, simulator training has been conducted on radar, navigation instrument and ship handling simulators for a number of years. Amongst the many tasks and skills, which can be simulated for the mariner, can be found identification- of lights, berthing/docking, turning and sailing a course, to illustrate some of the capabilities of simulators and their advantages in the teaching of navigation.

The simulator as a training tool can improve training efficiency in many different tasks. For example, full-mission simulators provide a real-time ship's/bridge and environment. All manoeuvring situations for training purposes can be simulated under real-time conditions in realistic looking environment. It is important however, that the trainee has a feeling for the situation, this means that, he/she must act as if on board, thus, the use of simulators is most appropriate for those with sea experience. Moreover, simulators can help to close the gap between the training at school and shipboard practices. Nowadays it is difficult, if not impossible, to teach navigation without such technology.

2.8.5.2 Passage Planning and Teamwork

The concept that should be taught in passage planning is knowing where the ship is in relation to danger, not the geographical position at the present moment. The most important thing is not to know where the ship is at the present moment, but where it will be during the next hour of navigation. It was observed in these selected MET systems that the teaching of passage planning has been done at the level of Mates and Masters.

2.8.5.3 Watchkeeping at Sea and in Port

There is particular attention paid to collision regulations, grounding, anchors and their uses, precautions to be taken in heavy weather and accidental damage including collision. There is more emphasis on the development of correct bridge procedures using simulators, shore operations, and the relationship between the cargo vessel and shoreside operations.

2.8.5.4 Vessel Traffic Service (VTS)

This aspect is being promoted by heavy traffic conditions and weather reporting in order to improve the safety and efficiency of traffic within a port or waterway; Therefore the teaching is concentrates on the type of facilities provided by a VTS system and its role in improving safety.

2.8.6.5 Traffic Separation Scheme (TSS)

The introduction of Traffic Separation Schemes is one of the measures adopted by IMO to improve the safety of navigation in converging areas, and in areas where the density of traffic is great or where the freedom of movement of ships is limited. An example is the Channel Navigation information service (CNIS) manages the ship movement reporting scheme (Marep). The enforcement of all the collision regulation rules, in particular rule 10 covering Traffic Separation Schemes (TSS) is the most important item covered in teaching the above subject. However, VTS is mainly designated for the control of traffic entering and leaving port confines.

2.9 A COMPARISON OF CURRENT NAVIGATION SYLLABUS IN SELECTED COUNTRIES

Despite the different systems and designations of the subjects, there are many similarities in the teaching of navigation within these selected countries (Australia, Portugal, Malaysia, Egypt, Netherlands and USMMA). The only difference lies in the titles the different subjects are given. The contact hours also differ as illustrated on table 1.

In Australia (AMC), the Command Navigation subject takes more contact time, whereas in Portugal (ENIDH) and Egypt (AMTC) more time is given to Astronomical Navigation whilst in Malaysia (ALAM) it is greatest in Principles of Navigation. There is a different approach altogether in the United States Merchant Marine Academy (USMMA) where there is a tendency to make equal the contact hours in all three navigation subjects.

Less contact hours are spent in the following subjects: Coastal navigation in Australia, Voyage planning in Portugal, Advanced navigation systems in Egypt, and Navigation laboratory in USMMA. However, in Malaysia the concept is different, all six subjects have been given the same amount of time as illustrated in table 1. In the Netherlands, the contact hours per subject is not specified, thus giving only the total hours which is 14 periods.

Finally, those countries which use the monovalent or traditional system spend more hours teaching navigation, thus increasing indeed the basic knowledge of the future seafarer. In those countries which use the bivalent or modern system, there is a tendency of reducing the contact hours in navigation. Consequently, in future those who will be trained through a modern system might lose the knowledge of basic principles of navigation. Although technology exists and is good, the Author believes that navigation is still an art which depends very much on how much knowledge is gained. It is therefore very important for a mariner to be able to explain the basic principles because it is there where the technology originated from. Hopefully, in future, mariners from traditional systems will be in position to explain basic principles being applied in modern systems.

Table 1

Navigation subjects and contact hours in selected countries

Subject	Australia	Portugal	Malaysia	Egypt	Netherlands	USMMA
Offshore navigation.	75 hours	-	7 weeks	-	-	-
Coastal navigation	40 hours	90 hours	7 weeks	54 hours	-	-
Elect.Nav System	90 hours	75 hours	-	80 hours		-
Bridge equipment nav. safety	30 hours	-	-	-	-	-
Command navigation	120 hours	-	-	-	-	-
Astronomic navigation	-	180 hours	-	90 hours	-	-
Voyage planning	-	60 hours	-	54 hours	periods	-
Geodetic navigation	-	120 hours	-	-	-	-
Practical navigation	-	-	7 weeks	-	-	-
Chartwork	-	-	7 weeks	-	-	- -
Principle. navigat.	-	-	14 weeks	72 hours	-	
Nav.Aids instruments		-	7 weeks	162 hours	periods	-
Navigation reliability.	-	-	-	54 hours	-	-
Navigation control	-	-	-	60 hours	-	-
Advance nav. syst	-	-	-	27 hours	-	-
Navigation	-	-	7 weeks	-	periods	60 hours
Nautical science	-	-	-	-	-	75 hours
Navigation law	-	-	-	-	-	60 hours
Navigation laborat.	-	-	-	-	-	60 hours
Total	355 hours	525 hours	56 weeks	653 hours	14 periods	255 hours

Source: Author

CHAPTER 3

THE IMPACT OF CHANGING TECHNOLOGY ON THE SAFETY OF NAVIGATION

3.1 DECCA SYSTEM

3.1.1 Background

The Decca navigator system is a hyperbolic navigation system arranged in chains comprising a central master and usually three outlying slaves. The four stations are arranged in pairs: Master/red slave, master/green slave and master/ purple slave. The stations transmit low frequency continuous wave (CW) signals and each pair produces a pattern of hyperbolic lines of position (LOP). These lines are overprinted on charts in corrected colour according to the pair used. The range of the system is typically 440 nautical miles by day and 240 nautical miles by night. The receiver detects the line patterns and drives three indicators (decometers) which continuously and automatically display the number of the LOPs passing through the receiver. Each decometer reading gives a numbered LOP for the specific colour and the intersection of any two LOPs on the chart gives the position of the vessel containing the receiver. (L Tetley & Calcutt P55).

The Decca system transmits continuously in the frequency range of 70 and 130 Khz. The frequencies used by Decca are related to a fundamental value "F" which is roughly 14 Khz, the exact value varying from chain to chain. The master and slave frequencies have a specified relationship to each other, thus the receiver drives a common frequency from each transmission using the process of frequency multiplication. In practice all chains operate with a fundamental frequency close to the value 14 Khz and master, red, green and purple slaves transmit on frequencies which are close to 84 Khz, 112 Khz, 127 Khz, and 70 Khz respectively; however, the actual values used depend on the chain.

3.1.2 Decca Accuracy

The accuracy of the Decca system is dependent on the position of the user with regard to the transmitting stations, the period of year, and the time of day. Because of sky-wave interface Decca is susceptible to night effect which reduces the accuracy of the system. In daylight at a distance of 240 Km the accuracy will be better than 440 metres. This figure decreases to approximately 2.4 Km at night. Within 80 Km of the master station the accuracy is approximately 25 metres by day and 190 metres at night. The Decca system user has to be aware of the following possible causes of error:

- *Fixed errors.* Due to the actual hyperbolic LOPs, computed mathematically, being distorted in practice.
- *Reception of two transmitted signals by two possible paths, the ground wave and the sky-wave*. The ground wave is the wanted path and the charts are prepared on the basis of reception via this path. Whereas, the reception of signals via the skywave is a factor which limits the range of the system to 240 nautical miles by night in the north, but less nearer the equator.
- *Weather effects.* The performance of the decometers and line indicators (LI) can be affected by snow or precipitation, thus greater care should be exercised in position

fixing by taking frequent lane checks.

3.1.3 The current situation of Decca.

The general trend is a change from Decca to Loran-C after 1997. However, there will be some parts of the world (Sweden, Denmark, Netherlands) where the Decca system is appreciated for its accuracy and low operational coats, and where it will be maintained at least until the year 2000 for coastal navigation purposes. Around Britain, Racal Decca have offered to bear the total costs of modernising the balance of the UK Decca navigation system (DNS), passing on the resultant savings to the general lighthouse authorities (GLA) in return for an extension of the maintenance contract until the year 2014.

New developments in receiver capabilities enable the system to be operated from two chains simultaneously, selecting from them the best angle of cut. The Decca display can show latitude, longitude, course and distance to one of a series of presented waypoints. The Mark 53 navigator is the latest Decca receiver, comprising four separate channels for the continuous reception of master and slave transmission signals. Receiver operation is normally automatic but a manual override facility is provided. Chain section is achieved automatically. An automatic waypoint may be established by passing a single button (AUTO WP) which allows the position of the craft to be determined at any instant. In future, the development of hybrid receivers such as Decca/ Loran-C is expected to join the already existing Racal Decca MK53 G combined Decca/ GPS receiver.

3.2 LORAN-C SYSTEM

3.2.1 Background

Loran-C is an acronym for Long Range Navigation. It is an electronic system of land based transmitters broadcasting lower frequency pulsed signals that enable ships and aircraft to determine their position. The system is operated by the US coastguard. The original system, known as Loran-A, has now been superseded by an improved version known as Loran-C. However, the basic principles of both systems are the same. (Tetley & Calcutt, 1991, p83).

The Russian Federation operates a similar system called "Tchaika" which will not be described in this thesis due to its similarities to Loran-C.

The frequency transmission of all Loran-C stations is 100 Khz. The system is also used for timing. The Loran-C system uses a chain of three to five land-based transmitting stations. One station is designated the Master (M) and the other stations are referred to as secondary stations (W), (X), (Y), and (Z). The interval between the pulse transmissions for a particular chain or group of stations is known as the group repetition interval (GRI) and is used to identify or designate the chain.

The Loran-C information can be displayed in two forms:

a) *Time difference (TD).* Two signals displayed simultaneously. This is an older system where special charts (lattice charts) is required. Some of the lattice charts are normal navigational charts with a lattice overlay printed on them. Others are plotting charts where the position obtained has to be transferred to the navigational chart; or

b) *Latitude and Longitude*. In this case the information can be plotted using the normal way on a standard navigation chart.

3.2.2 Loran-C Accuracy

Among many factors, variation in signal propagation velocity, contamination of the ground-wave by the sky-wave and the position of the vessel relative to master and slaves are factors that influence the accuracy of Loran-C. Loran-C gives an absolute accuracy of 0.25 miles (463 metres) or better depending upon the receiver. Both repeatable and relative accuracy range between 0.097 miles (18 metres) and 0.05

miles (90 metres).The Loran-C system can also be used in the range-range (Rho-Rho) mode of navigation and accurate position data can be obtained with only two stations. Rho-Rho requires that the user has a very precise clock. This mode is rarely used because of the high cost of the equipment.

3.2.3 Loran-C Current Situation

In the US Loran-C is expected to continue in operation at least until year 2005. Future changes in Loran-C are not expected. All the US department of defence (DOD) service plans call for phase-out of Loran-C in favour of GPS.
However, in Europe possible expansion of Loran-C coverage is expected. The future will most probably be that each country with transmitters on its territory takes over the financial costs of the system. In addition, agreement has been reached between the USA and Russia on a joint Loran-C/ Tchaika chain in the Bering Sea area of the North Pacific. This came into operation in 1995.

Therefore, if the self support of local operational costs and the local agreements are to be implemented the question from the author is whether those developing countries (Egypt, Saudi-Arabia and China) which operate the so called local mini-chains will be able to afford the costs of the system. If these countries are not able to maintain the system because of the costs involved, what effect will it have for the traditional user. Although the GPS is available, the Loran-C is necessary as a back up in those developed countries where the system will remain. The decision of self financing it will be seen as the "price of technology" among those developing countries which will not be able to afford the costs.

3.2.4 Differential Loran-C

Differential Loran-C is a position fixing system used to reduce the position errors of the receiver over a limited area such as a harbour approach. It has been found that it may result in considerable improvement of accuracy. In fact differential Loran-C increases the receiver accuracy to between 8 and 20 metres. However, it is important to notice that only those errors which are correlated can be reduced. Noise in receiver is an example of un-correlated error which is not reduced by differential Loran-C.

3.3 OMEGA SYSTEM

3.3.1 Background

Omega is a very low frequency (VLF) system using frequencies in the band 10 Khz and 14 Khz. It is a continuous, world-wide, internationally-operated, ground-based navigation system. The Omega system consists of eight widely separated transmitting stations in seven different countries.

Omega utilises continuous wave (CW) phase comparison of signal transmission from pairs of stations. The stations transmit time-shared signals on four frequencies, in the following order: 10.2 Khz, 11.33 Khz, 13.6 Khz, and 11.05 Khz. In addition to these common frequencies, each station transmits a unique frequency to aid station identification and to enhance receiver performance. These transmissions are essentially synchronised among 8 stations, for which the US Coast Guard and Japanese Maritime safety agency are carrying on special duty of Omega synchronisation.

3.3.2 Omega Accuracy

The system was designed to provide a predictable accuracy of 4M. However, this accuracy depends on location of the user, station pairs, time of day, and type of equipment used.

3.3.3 Current Situation of Omega

The future of Omega is also dependent on the impact of GPS. However, the US does not expect to end Omega operations before the year 1997, but this is highly dependent upon continued participation of the six partners nations (Norway, Liberia, France, Argentina, Australia and Japan).

3.3.4 Differential Omega

Differential Omega is a position-Fixing system giving accuracy in the ranges from 0.3 miles at 50 miles from the transmitting station to 1 mile at 500 miles. The system is provided by an alarm in case of no transmission of correction, no correct reception of signal, no updating for the last 6 minutes and failure in 8 Hz sub-carrier transmitting the integral part of the correction. As regards coverage, at present, there are 22 differential Omega transmitting stations. These are located along the north Atlantic coast of France and in Indonesia.

3.3.5 Decca, Loran-C, Omega Systems Comparison

Unlike Decca and Loran-C navigation systems, there are no "chains" in the Omega system, but eight transmitting stations provide world-wide coverage working in pairs (any station being able to pair with any other station). Omega provides continuous world-wide position fixing, but accuracy for coastal navigation and docking can prove inadequate. Meanwhile Decca and Loran-C are suitable for coastal navigation in certain regions covered by the chains at a coverage range of 240 NM- Decca, and 1200 NM- Loran-C. As regards accuracy, Decca provides an accuracy of less than 0.25 NM (463 m). Loran-C provides an accuracy of 0.25 which can be modified with Differential Loran-C for a level of 5-10 metres. Likewise Omega system provides an accuracy of between 1-3 NM (1852-5556 metres). With Differential Omega this accuracy can be increased to 8-20 metres.

The Federal Radionavigation Plan (FRP) suggests that in coastal waters, position accuracy of 0.25 NM is required. In fact, the requirement of precise position is great in the coastal zone up to 50 NM from land, where there is a need to provide an accurate navigation system to ensure safety of navigation and to avoid environmental disasters. Decca and Loran-C meet this requirement of 0.25 NM as suggested by FRP. However, if Differential Omega is to be used, the Omega system also can meet the requirement of FRP, thus enabling the system to be feasible for coastal navigation as well. However, only those regions which have Differential Omega can benefit from this advantage offered by Omega. For further details of the three systems refer to table 2.

Table 2

Decca , Loran-C, Omega systems comparison

SYSTEM	DECCA	LORAN-C	OMEGA
PRINCIPLES	Phase Comparison	Pulse/time difference	Phase comparison time difference
COVERAGE (RANGE)	240 NM	1200 NM	World-wide
POSITION LINES	Hyperbolic	Hyperbolic	Hyperbolic (Range circles)
TRANSMISSION FREQUENCY	70 - 130 Khz	100 Khz	10 - 14 Khz
EMISSION TYPE	Interrupted continuous wave (CW)	Pulse Modulated Continuous Wave	Time Shared Continuous Wave
DATA FORMAT	Analogue "Clock" Display giving Decca lane ref. (Lat./Long)	Automatic time, Difference display (some Lat./Long)	Omega station pair and lane number (some Lat./Long)
POSITION FIX	Apply corrections, plot on special lattice chart	Plot on special plotting or lattice chart	Plot on special plotting or lattice chart
TIME FOR FIX	1 minute	1 minute	1 minute
TYPICAL ACCURACY	< 0.25 NM	0.25 NM	1 - 3 NM
24 HOURS CONTINUOUS AVAILABILITY	Yes	Yes	Yes
ALL WEATHER AVAILABILITY	Skywave problems at limits of coverage	Skywave problems at limits coverage	Modal interference close to station, polar cap absorption, sudden ionosphere disturbance
TYPICAL COST	£1500	> £ 5000 for highest accuracy	£ 6000

Source: Tetley & Calcut (1991). The Navigation Control Manual (Second edition)

3.4 GLOBAL POSITION SYSTEM (GPS)

3.4.1 Principles

The Global Position System (GPS) is a space-based, radio positioning, navigation and time-transfer system which enables land, sea and air users to determine a three-dimensional position, velocity and time, continuously, anywhere in the world in all weather. GPS is made up of the three following segments:

1. **The Control segment**. It is responsible for the maintenance and control of the system. It includes a number of monitor stations and ground antennas located throughout the world. The monitor stations use GPS receivers to track all satellites in view, and thereby accumulate ranging data from the satellite signals. The information obtained from the monitor stations is processed at the master control station (MCS) to determine the satellite orbits, and to update the navigation message of each satellite. The updated information is transmitted to the satellites through the ground antennas, which is also used for transmitting and receiving satellite control information. In essence, the control segment is responsible for the daily control of the system.

2. **The Space Segment**. This is the most important part of the GPS system. It contains the satellites and signals they emit. Each satellite is equipped with 3 high precision atomic clocks (Oscillators), two of which are spares, and these clocks are used to produce two highly stable radio frequencies for the transmission of the positioning signal. Each satellite broadcasts 2 positioning codes: The C/A or Coarse Acquisition code and a P or Precise code. Both P and C/A codes are provided for civilian use. However, the P code has been designed in such a way that the US Department of Defence can degrade it at anytime to a secret code known only by military personnel. Therefore, the position based on the C/A code is known as the SPS or Standard positioning service and the position obtained

through P code is known as the PPS or Precise Positioning service.

3. <u>The User Segment</u>. It consists of antennas and receivers which will provide positioning and navigation data to the user. The user segment is made up of all military and civilian personnel who have a need for an accurate position. In essence, the user segment of the GPS system includes all the elements required to successfully utilise the signal being broadcasted from the satellites.

3.4.2 GPS Position Theory

The GPS position theory is based on two fundamental observations: Pseudo-Range- which is the radio travel time between the satellite and receiver expressed in metres. This is obtained by decoding the P or C/A code which contains a Snapshot of the satellite clock at the time of transmission. This is compared to a receiver clock at the time of reception, thus giving a time distance/distance measurement. The second one is Phase-Observable which has some limitations to its use. Therefore, accurate GPS measurements are dependent on the precise transfer of time between the three segments, it being the responsibility of the ground/control segment to maintain a common time based on all the satellites as well as providing accurate data as to their position in space at all times.

The satellite geometry is presented to the user by a factor known as the dilution of precision (DOP). The dilution of precision figures are therefore used to access the potential positioning quality of a certain satellite constellation and to provide the best user geometry. Horizontal Dilution Of Precision (HDOP) is used for two dimensional fixes, while Position Dilution Of Precision (PDOP) is used for a three dimensional fixes. For the purpose of marine navigation HDOP figures are actually used. The UERE or User Equivalent Range Error is another GPS acronym and is the means by which the DOP can be assessed in position accuracy terms. UERE figures are also known as User Range Accuracy (URAs). The UERE figure is part of the broadcast ephemeris message of each satellite and a performance figure in metres, of the satellite as seen by the control segment. Therefore, if a satellite is working well it is usually allocated a UERE figure of between three to five metres. Figures of worse than 10 metres usually indicate some problems with the control. When used with DOP, the UERE provides a feel for positioning accuracy of the system at a particular time.

3.4.3 GPS Accuracy

Great care is necessary when assessing the accuracy of any system as it is a function of many different sources such as the user to station geometry, the noise characteristics, and frequency. With GPS there is a new consideration which is the deliberate degradation of the system for military purposes. This is known as Selective Availability (SA) which will be discussed further in this chapter. GPS uses the World Geodetic System (WGS 84) and through data transformation will permit co-ordinates to be transformed between WGS 84 and most of the major local data in the world.

The GPS provides two services for position determination: The Precise Position Service (PPS) which provides predictable positioning accuracy of 17.8 metres (2dRMS) horizontally. The Standards Positioning Service (SPS) provides a lower level accuracy than the PPS and is made available to civil, commercial and other users. The current policy of the US Department of Defence is to provide the SPS at an accuracy of 100 metres (2dRMS) horizontally. This accuracy is suitable for offshore navigation, thus making GPS the most required navigation system in the world.

3.4.4 Selective Availability (SA)

The GPS was originally designed for military use with limited availability for civilian users. The original intention was to make the Precise code (P-code) available for military purposes, while the Coarse Acquisition code (C/A code) was for general use with the expected accuracy to be not better than 100 metres. However, when the capabilities of C/A code were tested the accuracy achieved was found to be closer to 20-30 metres level. Hence the introduction of an accuracy denial method known as Selective Availability (SA).

In essence, selective availability is a technique by which the US Department of Defence restricts the accuracy of the GPS. Under SA the accuracy is 100 metres (2dRMS). However, all military receivers will be equipped with special decoding devices to overcome Selective Availability. Moreover, the limitation of accuracy to civilian users can be achieved in two ways; by degrading the broadcast orbital parameters and by dithering the frequency of the broadcast C/A code.

3.4.5 GPS Limitations

There is no doubt that GPS is a very good system. However, the fact of it being operated by military authorities and used without any payment creates some limitations to the user. Such limitations include:

- **Selective Availability**. The issue of SA is one of the major problems of the GPS. With GPS there is no warning to navigators in case of system malfunction. This means that the US department of defence can switch off or alter the system to a convenient position at any time. This situation happened during the Gulf conflict. Moreover, in case of maintenance of any satellite the military authority can take out a satellite without warning to the civil users. This is because other countries have no influence on the operation of the system. It seems to be that Differential GPS is a good solution to the SA, but in fact, certain types of SA cannot be removable by DGPS such as the introduction of a high rate Clock Jitter onto the code transmission, thereby reducing the resolution.

- **The GPS and the problem of present-day charts**. The problem of chart accuracy is so critical because not all navigation charts are referenced to the World Geodetic System (WGS 84) as GPS. This situation causes many errors in the position, although most GPS receivers carry out the transformation of WGS-84 to most local datum, the problem of chart accuracy remains. For example, at present there are few coastal and harbour charts that meet the accuracy necessary to use GPS confidently.

- **The GPS and Coastal navigation.** The GPS is a feasible system for offshore navigation providing efficiency and safety. However, in coastal navigation where it has the greatest number of users the accuracy is inadequate. The requirement of an accurate system in coastal and narrow channels is necessary because most accidents happen due to traffic density. Therefore, the use of Radar/ARPA or other conventional systems such as Decca and Loran-C can play the most important role in this regards, as also the use of Echo-Sounder can be required.

3.4.6 Differential Global Position System (DGPS)

Differential GPS is a precise system used to recover the GPS accuracy degraded by SA. Although not all Selective Availability can be recovered by DGPS, the system provides a local level accuracy close to 5 metres. The DGPS stations are located at a surveyed area and calculate the range errors associated with the satellites. The Differential corrections can be communicated by suitable link to local GPS receivers, where they can be used to modify the calculations made in the receivers.

DGPS allows the operating authority to enforce their own levels of quality control and repeatability. Because of the accuracy level provided by DGPS its Maritime application will not be limited solely to navigation. In search and rescue (SAR), time will be reduced; the identification of ships on a VTS for instance will became very unambiguous and fast. The monitoring and replacement of buoys in channels will become more effective and easy to install and be a less time consuming operations.

3.4.7 GLONASS Overview

The GLONASS is an acronym from Global Navigation Satellite system, and is a space-based radio navigation positioning system operated by the Russian Federation. GLONASS is a similar system to GPS and it has the same potential user community and has an advantage over GPS of not using Selective Availability (SA) as GPS does, and it provides an accuracy of less than 100 metres. The user establishes position by measuring the time of arrival of received signals from at least three satellites and calculates the distances to the satellites. Therefore, the development of the GLONASS system is expected to attract more attention because this system is the only domestic

radionavigation designed to make uninterrupted, precise navigation for air, marine and land mobile vehicles on a global scale.

3.4.8 GPS/ GLONASS Systems Comparison

GPS and GLONASS have many characteristics in common as can be seen in table 3. The frequency band for GPS and GLONASS systems are close enough so that users may receive the signal of both systems using a common antenna and common signal. One remark should be that GPS uses the World Geodetic System (WGS 84), while GLONASS uses the SGS 85. This differences may give rise to errors in navigation determinations when jointly operating the systems. Another difference is in the time reference used by both systems. GPS uses Universal Time Co-ordinate (UTC), while GLONASS is based on Moscow time.

Table 3

GPS /GLONASS Comparison

SYSTEM	GPS	GLONASS
SIGNAL CHARACTERISTICS	L1:1575.42 L2: 1227.6	L1: 1597-161 L2 1240-1260
FREQUENCY BAND	MHZ	MHZ
BANDWIDTH	L 120.46 Mhz & L2 2.046 MHz	-
MINIMUM SIGNAL LEVEL	L1 163 dbw & L2 160 dbw	-
EMISSION TYPE	24 MOGID	-
RADIATED POWER	L1 40 w & L2 10 w	-
AVAILABILITY	Expected approach 100%	100%
ACCURACY (2DRMS)		
PREDICTABLE	100 metres	100 metres
REPEATABLE	100 metres	-
COVERAGE	Global	Global
AMBIGUITY	None	None
FIX DIMENSIONS	3	3
FIX RATE	Continuous	1/s
CAPACITY	Unlimited	Unlimited
INTEGRITY	YES AFTERWARDS	-

Source: NAVGUIDE December 1993

3.5 ECDIS

3.5.1 Principles

ECDIS is an acronym from Electronic Chart Display and Information System. As the name suggests ECDIS is a navigation information system through which the user can display stored hydrographic information and actual navigation information in an interactive way according to his needs. The ECDIS provides a real time position where a mariner no longer needs to take bearings so they can be plotted on the paper charts. In fact, this process of taking bearings and plot them to a navigation chart is time consuming and is liable to several sources of errors; moreover, the position plotted refers a past event, this being dangerous in restricted waters. Therefore, the ECDIS will give a new dimension to a navigation where navigators will no longer require hundreds of paper charts on board as well as the hand plotting of ship's position will not be necessary. Thus the traditional process of combining sea chart and radar picture mentally will be overcomed with the use of ECDIS, where all the essential navigation information will be displayed in an one screen. This information will consists of ownship's position, other ship's position, hazards to navigation and environmental data. However, the traditional paper chart will remain on board as back-up for ECDIS, because ECDIS uses electronics and electronics can fail. Moreover, the carrying of paper charts on board is required by SOLAS convention regulation V/20.

The ECDIS is to be used in conjunction with radar (synthetic information and raster-scan type) and other navigation equipment like GPS in such a way that the systems will complement each other and interact in order to achieve a higher degree of safety.

3.5.2 Display of Information on ECDIS

According to IMO/IHO harmonisation group on ECDIS, information to be displayed during route planning and route monitoring should be subdivided into the following three categories:

1. **<u>Display base</u>**- permanently retained on the ECDIS display consisting of coastline (high water); own ship's safety contour; indication of isolated underwater dangers of depths less than the safety contour which lie within the safe waters defined by the safety contour; indication of isolated dangers which lie within the safety waters defined by the safety contour such as bridges, overhead wires; the inclusion of buoys and beacons whether or not these are being used as aids to navigation; traffic routing systems; scale, range, orientation and display mode; unit of depth and height.

2. **<u>Standard Display</u>**- to be displayed when the chart is first displayed on ECDIS, consisting of a display base; drying line; indication of fixed and floating aids to navigation; boundaries of fairway, channels; visual radar conspicuous features; prohibited and restricted areas; chart scale boundaries; and indication of cautionary notes.

3. **<u>All Other Information</u>**. All other information displayed individually on demand, for example: Spot soundings; submarine cables and pipelines; ferry routes; details of all isolated dangers; details of aids to navigation; contents of cautionary notes; ENC edition date; geodetic datum; magnetic variation; graticule and place names.

However, for safety reasons the display base cannot be suppressed by the user. In case of too much clutter on the display, the navigator can run to the standard set by a single push button. The ECDIS provides alarms and warning of impending dangers. Due to high technology used on ECDIS the need for training is crucial so that the navigator will be able to select the sophisticated information offered by the system. In essence the most important information displayed by ECDIS is that of; the actual position; actual water depth for chart comparison; navigation marks and limiting danger lines; menu/trackball control for data call up or "Overlay"; environment; track performance and performance alert. This all information will be displayed in a high-resolution colour screen display.

3.5.3 ECDIS Limitations

Likewise other navigation systems, and apart from its advantages upon the paper charts, ECDIS has some limitations, these are;

- Position fixing. Position fixing of highest accuracy is required on ECDIS. It is unlikely to say that the ECDIS position is hardly dependent on other navigation systems such as GPS. It is well known that GPS has its limitations such as the issue of Selective Availability (SA). The SA will therefore affect the position accuracy of ECDIS, and the question of the author is how safe is the system. Moreover, ECDIS is not a SOLAS requirement, therefore used by limited number of navigators mostly those from developed countries.

- Display of Information. If ECDIS is to display all the information contained in a paper chart, then the display will result in a confusing clutter. It is said that ECDIS must display essential information which is essential, but the fact is, what is an essential information can be confused to a navigator when it appears on a screen

- Navigational Data base. Like a paper chart, ECDIS must present all the sea areas of the world, including contents and symbols of the navigational data. The main problem is that, to create a world-wide accepted data base is a difficult issue. At present moment those countries that issue ECDIS operate in a regional data base which is not official. If an unofficial data is to be used, the navigator must be informed of the limitations of their ECDIS in order to avoid accidents on board ships. Appendix 7 illustrate an ECDIS display.

3.6 AUTOMATIC RADAR PLOTTING AIDS (ARPA)

3.6.1 Principles

The availability of data from ARPA is of utmost importance in the safe navigation of vessels, mostly when they approach near coastal waters, and when navigating at night or under bad weather conditions and dense traffic. To use an ARPA successfully, it is necessary to have an ability to relate the echoes displayed to the information shown on the paper chart and an understanding of the level of performance and accuracy which can be achieved under given circumstances.

The ARPA's display may be a separate or integral part of the ship's radar. When it is a separate stand-alone ARPA, it has to be interfaced to a variety of existing equipment. This is however not the ideal solution and nowadays, ARPA's are fitted with as integral part of the radar and the ARPA data can be displayed on the some screen as the conventional radar data. The advantage of this integration is that the radar and ARPA data are readily comparable. The integration is also feasible to the manufacturers because a single one can design, test, and install the system that is not possible with the separate system where it is required one manufacturer for each system radar and ARPA. ARPA is an IMO requirement. The IMO resolution A 422 (XI) Performance Standards for Automatic Radar Plotting Aids (ARPA) deals with the system and it consists of the following items: Introduction; Definitions; Performance Standards and three Annexes. Further, under Chapter V of the IMO-SOLAS convention (1974) as amended to 1983, depending on the type of ships there is a requirement to carry radar and ARPA on board.

Besides these facilities required by IMO, ARPA is provided with additional facilities such as additional alarms and warnings; automatic ground-stabilisation; navigational lines and maps; the potential point of collision (PPC); and the predicted area of danger (PAD). These all feature to increase safety.

3.6.2 Target Tracking

The ARPA should be able to automatically track, process, simultaneously display and continuously update the information on at least:

1. Twenty targets, if automatic acquisition is provided, whether automatically or manually acquired.

2. Ten targets, if only manual acquisition is provided.

It has been suggested that 10 to 20 tracking channels might be insufficient in heavy traffic but from practical experience it has been found that ship's officers can quickly identify the targets which need to be tracked and acquire them. (Although at times there will be some 40 plus targets on the screen, not all of them will need to be Tracked). In fact, it has been found that an excess of vectors can produce "ARPA clutter" and be counter productive. (Bole & Dineley, 1992 p200).

In the process of tracking targets it is important to distinguish from amongst others the following:

- **Target Loss**. The ARPA is required to track an acquired target which is clearly distinguishable on the display for 5 out of 10 consecutive scans. If for some reason, a response from a tracked target is not received on a particular scan, the ARPA must not immediately declare the target lost.

- **Target swop**. This happens when two targets respond within the tracking gate at the same time. Therefore, when this happens, the trucker can become confused and the vector may transfer to the wrong target. To minimise this problem, the gate should be made as small as possible, and the movement of target should be predicted.

- **Tracking history**. This is another feature on the process of tracking targets which enables an observer to check whether a particular target has moved in the recent past, possibly at the time the observer was away from the display. This knowledge will help him to make quick decisions in what the target is likely to do in future.

3.6.3 ARPA Errors and Limitations

Errors on the ARPA screen will affect decision making of the navigator. Therefore, it is necessary for the navigator to know the level of accuracy and limitations of the system and the errors that can be expected. ARPA errors can be grouped in three groups: Errors which are generated in the radar installation itself; errors which may be due to inaccuracies during processing of the radar data; and errors in interpretation of the displayed data. One remark should be that ARPA is a kind of integrated system where errors in the radar, gyro-compass and log which supply data to the system will result in errors in the output data. This is one of the ARPA's limitation.

3.7 INTEGRATED NAVIGATION SYSTEMS (INS)

3.7.1 The concept of Integrated Navigation System

The concept of INS seems to be new, but in fact, it has been known in a simple form since the 1960s when the radar was integrated with gyro. The only new thing about it is the way it has been developed up-to the present times. From the previous sections of this chapter, different navigation systems were described. Besides, ECDIS and ARPA, most of them were set-up to stand alone, although they perform their function correctly the need for a single system which can perform all functions of the single system is necessary to increase safety of navigation. Integrated Navigation Systems can be a better solution. In essence, Integrated Navigation System is a combination of two or more systems in order to provide a system having the advantages of the combination thus giving one resulting navigation data. An INS may comprise the following elements: Central computer; Doppler log; Satellite receiver; Decca navigator; Gyro-compass, Omega receiver; Loran-C; Radar; Anti-collision display; data selected (keyboard) and Data display.

With INS the navigator can overcome the problem of various systems indicating different positions at the same time. Further, this situation of identifying the Most Probable Position (MPP) is even worse when there are more data being displayed making it necessary to use sophisticated mathematical techniques using a computer. However, it is necessary at this stage, to describe how the integration is done within the central processor through the "Kalman Filter" which is the heart of an INS. In fact, the "Kalman filter" is a computer software program which cleans the weighting of all navigation systems which are part of an INS in order to get the Most Probable Position (MPP). It is based on its knowledge of the random errors of each system. The filter ensures that navigation data is "cleaned up" so that the best possible estimate of position, speed and heading are available to the navigator.

3.7.2 Developments on INS

According to Tetley & Calcutt (1995) pp 244-245 the growth towards a total integrated Navigation System is following a predictable format as stated as:

- A position fixing system with additional facilities for computing navigational parameters such as waipoints- a modern microprocessor based satellite navigation receiver with both gyro and log interfaces, falls into this category. Limited facilities are available to enable the device to be used for navigation calculations. This type of apparatus is limited by the possible long time span between acceptable fixes.

- A position fixing system as previously described plus data from a hyperbolic system. This apparatus is the first true attempt at integration. Both satellite navigation and Omega or Loran-C data are under the control of a central microprocessor. Gyro and speed log data are also interfaced to enable the equipment to navigate by dead reckoning between fixes.
- The previous system plus additional memory and a full keyboard. Additional

microprocessor memory could be utilised for voyage calculations, or loading and stability calculations.

- The previous system plus ARPA interface. Data extracted from a radar system can be displayed on a Visual Display Unit (VDU) and either automatically or manually acted upon to prevent dangerous situation accuring. The navigator is able to operate “trial manoeuvres” as part of a limited system programming operation.

The development of INS has been done mostly by the manufacturers, being necessary to indicate some of them which are the pioneer in this development.

STN ATLAS ELECTRONIC. The latest development from this manufacturer is a version called NACOS 45-2 which comprises the following equipment: Radarpilot (radar/ARPA with integrated adaptive trackpilot); Navigation control console (NCC); Multipilot (Integration of: Radarpilot, ECDIS, NCC); and planning and consulting station (PCS-LAN/PCS- ECDIS). Details of the NACOS system in chapter 5.

SPERRY MARINE. The new version 2100 VMS-VT employs PC electronics with versatile window-based application software. It includes complete ECDIS capability which is compliant with IMO requirements.

KELVIN HUGHES. Integrated navigation development from Kelvin Hughes centres on its NUCLEUS 26000 ARPA, NINAS 2 (Nucleus Integrated Navigation Systems) and CDU2 (Chart Display Unit).

RACAL DECCA MARINE. It is developing a system called MIRANS 4000A which consists of bridge systems each of which consist of two of the new bridge master 340 ARPA radar inter-switched to X-band and S-band antenna.

3.7.3 Limitations of INS

If there is a navigation system which provides absolute safety navigation, this system might be the Integrated Navigation System. However, there are some limitations within the system. The navigator who operates an INS ship loses the feel for the real situation. There is no doubt that the system is more accurate than other systems, but the problem is how easily can the navigator detect when the system goes wrong. The need for a navigator to adapt is another issue which is mostly dependent on the level of training and experience that the navigator might have.

4.8 NEW TECHNOLOGY AND THE SAFETY OF NAVIGATION

In spite of the campaign by manufacturers of its usefulness, the new technology does not provide the solution to all maritime position fixing problems. It is important to remember that ships have been navigated successfully for centuries and traditional methods still have their place and role to play in modern times. Further, before all these modern technologies arrived on the scene, the navigator was able to get the accuracy of his position thus making the voyage safely to different points.

The better use of the new technology is very dependent on how well the navigator has been trained. Hence the safety of navigation depends on the navigator's quality of training, no matter how good the equipment is.

From all the systems which have been described previously, the author believes that Decca, Omega, ARPA and INS provide safety for navigation, though they have their limitations. ECDIS, has been advertised to contribute to safety but it does not provide the level of safety it ought to, as long as it depends on GPS. This is because ECDIS is the only system which provides a real time position. The question is, "what will happen to a navigator using ECDIS if the Selective Availability is switched-off suddenly".

Nowadays, the safety of navigation is in the "hands" of the US due to the user friendly and accuracy offered by the GPS. However, it is a fact that the system is being operated by a single country, and being military controlled it is dangerous for the safety of navigation. Therefore, the joint GPS/ GLONASS and the idea of the INMARSAT to launch a satellite for navigation could be a better solution, thus it is necessary for IMO to encourage this development, because navigation can affect public safety as well.

In fact, IMO has adopted the resolution A.666 (16) - World-Wide Radionavigation System. The resolution provides mechanisms for a world-wide navigation system to provide ships with navigational position-fixing throughout the world. One remark is that IMO should not adopt a radionavigation system without the consent of the government or organisation which is operating the system. This means that, although the resolution establish mechanisms, IMO is still dependent on the countries which provide the operations of the system.

In the developed world the policy is to reduce manning in favour of high technology, and less use of traditional methods of navigation such as the celestial navigation. It is a fact that technology cannot in any way replace man. Moreover technology expects one to forget the basics and this is dangerous. What will happen if the electronics fail in a situation of reduced manning and less knowledge of the basics. Therefore, to increase safety in navigation, the back-up might not only be other electronic navigation systems, but also the traditional and non electronic systems of positioning the ship such as celestial navigation. One might argue that these processes of taking bearings are too slow but when there is an emergency situation the slower can be useful.

CHAPTER 4

MINIMUM REQUIREMENTS OF THE STCW/78 & THE IMPACT OF CHANGING TRENDS IN NAVIGATION ON THE MOZAMBIQUE ENVIRONMENT

4.1 Background

The revision of the STCW/78 developed by IMO is one of the most important current developments for the shipping industry in general. The amendments now proposed would improve the effectiveness of the STCW convention in raising global standards and will provide a flexible framework for the training and certification of seafarers in the future. However, this is mostly dependent on good co-operation between governments which are parties to the convention.

The inclusion of a new chapter VIII which deals with standards regarding watchkeeping is relevant to the navigator. Principles to be observed during the watch are clearly described as well as the fitness for duty. The revised convention will have the following structure:

- Articles
- Annex to the Convention
- Chapter I Standards Regarding General Provisions (15 regulations)
- Chapter II Standards Regarding the Master and Deck Department (4 regulations)
- Chapter III Standards Regarding the Engine Department (4 regulations)
- Chapter IV Standards Regarding Radiocommunication and Radio personnel (2 regulations)

- Chapter V Special Training Requirements for Personnel on certain types of Ship (2 regulations)
- Chapter VI Standards Regarding Emergency, Occupational safety, Medical care and Survival Functions (4 regulations)
- Chapter VII Standards Regarding Alternative Certification (3 regulations)
- Chapter VIII Standards regarding Watchkeeping (2 regulations)

4.1.1 Impact on Standards

The convention provisions represent practicable standards which can be achieved in all parts of the world. The successful implementation of these standards depend on the states which are part of the convention. The revised convention is provided by annexes with specifications of these standards of competence for the three levels of competence: Management, operational and support level. These standards are laid down within the convention as illustrated on table 4. With the tables provided by the revised convention the evaluation and certification of seafarers is made easy.

Table 4 represents part of the specification of minimum standards of competence for officers in charge of a navigational level. From column 2 of the table there is a note which says:

ECDIS systems are considered to be included under the term "Charts".

The fact is that the carriage of ECDIS on board ships is not an IMO requirement. Moreover, the specification standards of ECDIS are not stablished yet. For this reasons it is premature to include ECDIS under the term chart in the convention, unless the ECDIS standards are laid down.

Another consideration is made in the use of radar and ARPA to maintain safety of navigation. From table A-II/1 which is not provided in this work it says:

Training and assessment in the use of ARPA is not required for those who serve exclusively on ships not fitted with ARPA. This limitation shall be reflected in the endorsement issued to the seafarer concerned.

At the operational level, seafarers are supposed to have a broad knowledge and skills to serve in any type of ships. It can happen that today an officer is serving on a ship without ARPA, but in the next position the officer may be required to serve on board ships with ARPA.

Therefore, training and assessment in the use of ARPA should be required for all seafarers trained in navigation; otherwise in some developing countries where there are no ships fitted with ARPA, the training on ARPA will not be necessary due to the above statement. The officer will have to undertake a recognised 2 day ARPA course in such circumstances as it is today. Colleges, if wise, will include it in their programs.

Appropriate mechanisms to ensure that the convention's standards are properly enforced are established by IMO through regulation A-I/7 dealing with the Communication of Information. Under this regulation, parties are required to provide to the secretary general within a time period of twelve (12) months a report on the steps it has taken to give the convention full and complete effect. Under the revised convention the Maritime Safety Committee is given power to evaluate whether the information which has been given to IMO by the country demonstrates that full and complete effect is given to the provisions of the convention.

This is very encouraging for those countries having difficulty in implementing the convention. In Mozambique, if the information on the difficulties being encountered to implement the convention is well provided to the IMO, regulation A-I/7 can indeed create new opportunities for the country to implement the convention requirements properly.

Table 4

Function: Navigation at the operational level

Column 1	Column 2	Column 3	Column 4
COMPETENCE	KNOWLEDGE, UNDERSTANDING AND PROFICIENCY	METHODS FOR DEMONSTRATING COMPETENCE	CRITERIA FOR EVALUATING COMPETENCE
Plan and conduct a passage and determine position	***Celestial Navigation*** Ability to use celestial bodies to determine the ship's position ***Terrestrial and Coastal Navigation*** Ability to determine the ship's position by use of: .1 landmarks .2 aids to navigation, including lighthouses, beacons and buoys .3 dead reckoning taking into account winds, tides, currents and estimated speed Thorough knowledge of and ability to use navigational charts and publications, such as sailing directions, tide tables, notices to mariners, radio navigational warning and ship's routing information NOTE: ECDIS systems are considered to be included under the term "charts"	Examination and assessment of evidence obtained from one or more of the following: .1 approved in-service experience .2 approved training ship experience .3 approved simulator training, where appropriate approved laboratory equipment training : chart catalogues, charts, navigational cations, radio navigational warnings, t, azimuth mirror, electronic navigation equipment, echo sounding equipment, compass	The information obtained from navigational charts and publications is relevant, interpreted correctly and properly applied. All potential navigational hazards are accurately identified The primary method of fixing the ship's position is the most appropriate to the prevailing circumstances and conditions The position determined within the limits of acceptable instrument/system errors The reliability of the information obtained from the primary method of position fixing is checked at appropriate intervals Calculations and measurements of navigational information are accurate The charts selected are the largest scale suitable for the area of navigation and charts and publications are corrected in accordance with the latest information available

Source: (STCW.6/Circ.1 24 July 1995)

4.1.2 Impact of Technology

Technology has been the major cause of the STCW/78 revision, being necessary to adjust the traditional methods of training and navigation to meet the actual needs of new ships. Under the revised STCW convention the use of Radar and ARPA training by simulators in Maritime Institutions is made mandatory. The use of simulators is also encouraged, but any simulator used in the training of seafarers or in evaluating their skills or competence would be required to meet general performance standards. The question is whether these standards will be such as to be afforded by all institutions. For those developing countries where the use of simulators is still at the very first stage, it will be difficult to satisfy this requirement, but this can be achieved through co-operation between developed and developing countries as supported by IMO.

4.1.3 Alternative certification and The Future Approach to Navigation

The traditional form of certification under the provisions of chapters II, III, and IV of STCW/78 has been changed. The standards of competence are grouped in seven functions: Navigation; Cargo handling; Controlling the operations of the ship and care for persons on board; Marine and control engineering; electrical and electronic engineering and machinery; Maintenance of ships and communications. On the basis of these functions, standards of competence will be established hence the alternative certification is made easier and will be issued at three levels of responsibility:

1. <u>Management level.</u> This cover those tasks and levels of responsibility performed by the master and chief mate and those performed by the chief and second engineering officers. These functions at the management level are identified in the specification of competence tables for the relevant certificates in chapters II and III.

2. <u>Operational level</u>. This relates to those tasks and levels of responsibility performed by the officers of the navigation and engineering watches and are similarly identified

in the relevant specification of competence tables.

3. Support level. This covers those levels of responsibility performed by ratings forming part of a watch or performing other functions identified under chapter VI.

The alternative form of certification will allow those parties that wish to, to issue alternative certificates, although the use of these provisions is not compulsory. It is important to clarify that alternative certification does not mean that parties will issue lower standard certificates. The competency required for alternative certificates will be based on the corresponding competencies specified in chapters, II and III. The functions concerned will be prescribed in appropriate tables, according to the level concerned.

As regards navigation, specification of minimum standards of competence for officers in charge of a navigational watch of ships of 500 gross tonnage or more are specified for the three levels of competence. The specification of these minimum standards will facilitate the administration to conduct the appropriate examination of seafarers, thus avoiding the improvisation of examinations.

4.1.4 Qualification of instructors and Assessors

The influence an instructor has on education and training cannot be ignored within an institution. Under the revised STCW/78 it is made mandatory that lecturers, instructors and assessors be appropriately qualified and have relevant experience. The need for qualified instructors will encourage or even oblige those institutions where the training and updating of instructors is not seen as a priority, to see that staff upgrade their knowledge and skills. In fact, the impact of a qualified and experienced instructor and his/her attitude towards the student is of great importance and will contribute to the reputation of the institution.

4.1.5 New Codes

The revised STCW/78 convention includes two new codes:

Code A Mandatory requirements. It is made mandatory by cross references contained in the regulations of the Annex;

Code B Guidelines. This contains guidelines of a non-mandatory nature on the implementation, interpretation, application and enforcement of the convention.

4.2 IDENTIFICATION OF THE REQUIREMENTS OF THE MOZAMBIQUE SHIPPING INDUSTRY

2.2.1 Background

With Mozambique having a coastline of about 1600 nautical miles and a strategic geographical location in the region, it is obvious that shipping activities should play an important role for the development of the country's economy. The economy of a country cannot improve without increasing the facilities of transportation, particularly those of the sea, being relatively inexpensive.

Marine activities are only recognised when the times are hard. As an example, during the war period, ships were the major mode of transportation of goods and passengers to all different parts of the country. The importance of national cabotage policy was noted during that period. Nowadays, the role of ships has been largely ignored and the national cabotage tends to die slowly, despite the excellent conditions possessed by the country to develop marine activities, taking into account the length of the coast, the existence of 11 cabotage operational ports and 3 international Ports and navigable rivers and lakes.

The human element is also an important factor for the country's development. The Mozambican government in co-operation with NORAD has been training marine personnel inside the country and abroad. However, the integration of such qualified personnel has been to a large extent inadequate. People with marine background have been ignored within the shipping industry. Marine Officers are not given due recognition in the industry. The major concept is that marine officers are strictly to be employed on board ships only. This is not a wrong approach, but for a country with a lack of qualified personnel ashore, it is important to have people with seafaring background. The need for qualified personnel became obvious when the grounding of "Katina-P" occurred in May 1992, where the investigation was conducted on the basis of "good faith," rather than on a basis of technical knowledge. The role of the government should be to ensure that the required qualified personnel for onboard and onshore is available when needed to avoid the method of "trial and error" when decisions are to be made.

The objective of the navigation course is to train competent and qualified officers in nautical science in order to perform its activities where required. In this regard the government has made a good effort and all vessels under the Mozambican flag are manned by local officers up to the highest level of certification. This effort might not be seen as unique because this is only the beginning. Ships are already manned by national officers and therefore, it is necessary to upgrade the knowledge of some of these officers. Upgrading will enable them to acquire enough knowledge to face the actual challenges of today's needs of high technology as required in ships and other activities within the scope of the merchant marine such as marine security, marine surveyors, marine environment and marine administration.

It can be said that most benefits from the sea can only be achieved through having knowledge of its secrets and laws. It is necessary to create mechanisms to ensure that information related to shipping developments should be available within the country's marine libraries. This will allow those interested in doing research to develop their activities properly. Moreover, the development of the Mozambique shipping industry is greatly dependent on the ability of the government to integrate those who have a seafarer's background within the industry.

The ratification of some IMO conventions is important for the country. The most important for the time being are:

- Safety of Life at Sea (SOLAS/74);
- International convention for the Prevention of Pollution from Ships (MARPOL/73-78) mostly the following annexes;

  - Annex I- regulations for the Prevention of Pollution by Oil,

  - Annex II- regulations for the control of pollution by Noxious Liquid Substances in Bulk

  - Annex-IV Regulations for the Prevention of Pollution by Sewage from Ships,

  - Annex V- Regulations for the Prevention of Pollution by Garbage;
- International convention on civil liability for oil pollution damage (CLC);
- International convention on the Establishment of an international Fund for Compensation for Oil Pollution Damage (Fund).

These conventions are of great importance for the time being. Besides SOLAS, all mentioned conventions deal mainly with protection of the marine environment. Some efforts are therefore being made by the government to ratify some of these conventions. In fact, the marine environment is very important to the economy of the country as it relies heavily on tourism and fisheries. The latter would be adversely affected by any incident along the coast, thus causing a large impact not only on the marine environment but also on the society in general and the coastal cities in particular.

4.2.2 The Need For Staff Training

Safety of life at sea and efficiency of ships can only be achieved through a good system of education and training. This is only possible with well trained instructors or lecturers. The STCW/78 as revised requires that instructors are to be qualified and have relevant experience. As regards staff training, the nautical school has been conducting a good program to train its staff abroad. The World Maritime University (WMU) Malmö-Sweden, Escola Nautica Infante D.Henrique (ENIDH) Portugal, Brazil and London are places where staff have been trained. Other training programs such as the training of specialists are to be observed in future for certain subjects in navigation to ensure that the required staff for the school is available to satisfy the changing industry. Moreover qualified staff is required to relieve the expatriate teachers.

An institution will perform well if it has qualified staff. No matter how sophisticated the equipment it has, such equipment can only be useful or operational if the lecturers or instructors are well qualified. It must borne in mind that navigation technology is constantly changing and therefore, upgrading and refresher courses are important for the staff. The Nautical School must encourage and facilitate the professional development of staff. The training program amongst other things must be able to:

- Allow staff to obtain practical experience on board foreign going ships;
- Provide opportunities for staff to prepare themselves for technological changes and create opportunities for research and other studies.
- Enable staff to prepare and be equipped for greater responsibilities which are usually associated with career advancement.

Besides the requirements for training, staff need to be motivated and one form of motivating them is observing the aforesaid training programs.

4.2.3 The Need For Revision Of The Mozambique MET System

> "It should be borne in mind that there is nothing more difficult to handle, more doubtful of success, and more dangerous to carry through than initiating a new system.
>
> The innovator makes enemies of all those who prospered under the old order, and only lukewarm support is forthcoming from those who would prosper

under the new. Their support is lukewarm partly from fear of their adversaries, who have the existing laws on their side, and partly because men are generally incredulous, never really trusting new things unless they have tested them by experience" (Muirhead, P 1995 class-notes).

Maritime Education and Training has been changed dramatically due to advances in technology. With Japan developing the "Intelligent Ship," Germany the "Ship of the Future" and the European Community promoting the "Efficient Ship," it is time to revise the Mozambique MET system to cope with the actual requirements.

One might say that advances in technology will not affect the Mozambican shipping industry due to its intention of maintaining cabotage. The issue is that there are many types of ships which ply the country's waters and ports. An accident on the coast may happen and it will be necessary to conduct an investigation or rescue operations. For this reason it is necessary to be aware of the latest advances of navigation technology. Officers trained in Mozambique are not supposed to serve only in the country as it was during the time of country's strong politics. Furthermore, a few officers have even succeeding signing on foreign flag ships in high rank positions. The maritime directorate should encourage Mozambican officers to sign on under other foreign flags, thus exploiting new opportunities. This will help to attract more students to the marine school. The success of these officers abroad is strongly dependent upon the clear regulation of certification within the marine directorate, because so far the rules of certification within the country are not clearly interpreted as recommended in the STCW/78 convention to which the country is a signatory. The STCW/78 as revised will however, play an important role in this regard if it is to be interpreted properly.

As far as the navigation subjects are concerned, changes within the curriculum should be those of reducing the amount of time spent on astronomical navigation and giving more time to Electronic Navigation Systems. Particular attention must be in the limitations and accuracy of these navigation systems. An understanding of how to use them and how they can mislead is the most important message to be given to the students.

4.2.4 *Cost Implications of Equipment and the Financial Situation of the Mozambique MET System*

According to the present scheme of deck training, it takes ten years of education and sea service before a captain can be licensed. It is therefore expensive to train a marine officer in developing countries like Mozambique because of the high costs of operating a nautical institution. To train a deck officer, apart from the basic education, good equipment like Radar and Simulators is important. These equipment make the cost per student high. For a country where maritime activities are not given top priority, it is difficult to afford the costs of such equipment. The only form in which the institution can benefit from such equipment is through a Bi-lateral co-operation with other developed countries. So far NORAD is the one which supports the Nautical School in this regard. However, the financial support from NORAD is expected to end by 1995 and if this happens, the future of the School is to a large extent uncertain, because the local budget support from the government is not sufficient. Therefore, those parties which benefit from MET such as shipping companies and other entities should play an important role in order to provide financial support for the school to survive.

CHAPTER 5

INTEGRATED NAVIGATION SYSTEMS (INS) AND NEW TRAINING NEEDS

The possibility offered by new technology to operate ships effectively with reduced manning and the high competition in shipping create challenges to anyone who is directly or indirectly involved in training. Therefore, it is an obligation of the education and training authorities and maritime training centres to produce ship personnel with adequate competence to carry out the various functions on board, as long as safety is of special concern to all countries involved in shipping.

The INS offers more accurate and continuous position-fixing systems and automatic track-keeping which reduces the workload of the navigator. The task to be carried out by the watch officer has been changed and nowadays it requires new working routines and knowledge requirements, as well as new technical requirements necessary for the officer to operate a ship, thus demanding huge changes in the manner of training officers. Changes in methods of operating ships require new procedures. Nowadays the navigation information of ship's position is offered "FREE" to the navigator. Therefore, it is most important for a navigator to be able to evaluate the information offered and to use all capabilities of the systems for safety and efficient operation of the ship. To achieve this, the training is the most important tool and for this reason it is necessary at this point to describe some of the capabilities offered by INS.

5.1 THE NACOS SYSTEM

NACOS is an acronym for Navigation Control Systems. The NACOS series is developed by STN Atlas Electronik. The heart of a basic NACOS assembly is an automatic radar-controlled track pilot. This enables a ship to be steered along pre-determined tracks of selectable width. Route planning and monitoring of the ship's track is done by radar display. All essential information is presented on an integrated navigation display and with the use of positioning methods, it has been possible to navigate some of the most difficult routes in the world. There are many capabilities offered by NACOS, according to STN Atlas Electronic. This is described as follows:

Ship Control Centre (SCC): It is a kind of integrated bridge which offers important tasks of shiphandling through good ergonomic bridge design, and by the integration of all necessary displays and operating elements in modular consoles, making the ship's bridge easy to use. SCC provides all consoles with the same overall height of 1100 mm. The system is designed as a workplace for a seated operator, but it is therefore feasible for use by an operator standing up when the ship is berthing or docking. The SCC is provided with the following display of information:

- Voyage Planning. Planned routes and radar maps are transmitted automatically to all radar units and to the track control system. This means that various planning stations permit comprehensive graphical and numerical voyage planning including the processing and storage of routes. Appendix 8 shows a voyage planning display.

- Automatic Track Control. This is one of the important features in modern navigation. In fact, the integrated track control system TRACKPILOT allows directional control on the planned route of the voyage in accordance with a pre-defined compass course, on a pre-defined set track including drift or bottomstabilised sailing. The course is displayed on the radar screen and the automatic track can be controlled by direct joystick. Appendix 9.

- Nautical Information Display. This display shows all data necessary for ship-handling. The information consist of: ship's position, course, speed, drift, water depth, weather, rudder angle, rate of turn, deviations from the set course and track, route planning and the most important data of the engines as illustrated in appendix 10.

- Collision Avoidance. The system uses high resolution rasterscan radar units to ensure reliable avoidance of collisions. Moreover, with the aid of the track control system and the geographical reference of the radar image, ship-handling is made easier.

- Electronic Chart with Radar. The technology of overlaying ECDIS and ARPA leads to a new generation of nautical unit which is known as the MULTIPILOT. Therefore, the direct comparison of the radar and chart information on the display increases the safety of navigation, facilitates collision avoidance and ship's position refers to a present time. The process of acquiring position by ECDIS is explained in chapter 3 of this thesis.

- Sensors. The system is provided with a three-axis Doppler log, DGPS position sensor and other high precision measuring devices to ensure reliable data regarding speed, course, and position.

- Communication. The modular design of SCC makes it possible to adapt the radio equipment to fit sea areas A2 to A4, and permits higher transmitting power and additional duplex telephony. The integration of additional INMARSAT systems is also possible, since the world-wide introduction of the Global Maritime Distress and Safety System (GMDSS).

- Ship Management. This displays information for ship management for planning and organisation concerning stability, and longitudinal strength of the ship during loading and unloading.

- Monitoring and Control. The integrated ship control system is the central point for data from the areas of cargo, ship-handling and nautical information.

- Remote Control of the Propulsion Engines. The automatic remote control system for marine diesel engines ensures low stress starting and run-up of the propulsion system. Critical revolution rates and limitations when the ship is sailing in bad weather or is moving astern are taken into account .

- Automatic Power Supply. This system monitors and protects the diesel engines and generators of the ship's main by automatically connecting and disconnecting the units as required. The display is shown in appendix 11.

These are some of the information facilities that can be found in modern bridges. Without knowledge or sufficient training, the display shown in the appendices can be seen as having too much clutter, but in fact useful and important navigation information is displayed. The most important aspect is that the mariner is required to have sufficient knowledge to evaluate the data.

Apart from the navigation information, the NACOS bridge shows the valid information related to engine and radiocommunication. A multiskilled officer is required to evaluate such information provided and it can be concluded from this that modern forms of training must lead to a dual or polyvalent training program as explained in chapter 2.

5.2 A PROPOSED NAVIGATION SYLLABUS FOR THE NAVIGATION COURSE IN MOZAMBIQUE

5.2.1 Immediate Needs

As ships become more automated, there is a requirement to train personnel to higher educational levels in order to face today's technology. Modern ships are fitted with sophisticated panels which provide data, and it is most important for a mariner to be able to interpret such data. While at school, the student must be accustomed to computers. The use of the existing facilities at school is important.

Having a shortage of ships equipped with modern technology in the country, it is important to have such facilities of computers and simulators to be used to maximum advantage, thus complying with the revised STCW/78 convention. Indeed, the simulator has become an accepted term in nautical schools and ship handling simulators have been established in a number of countries, which though expensive, are good teaching tools and are required in today's teaching, as explained in chapter 2.

Modern technology is all around our environment, and for this reason we need to be able to combine these new aids together with the human element and prepare ourselves for the changes. It is necessary to take an advantage of new technology and have a suitable syllabus for the curriculum. For the time being, the updating of the present program will consist of decreasing the amount of time in some subjects such as celestial navigation and adding new subjects on electronic navigation systems which are of great importance.

The objective is to improve the present education and training to equip trainees with a practical reality of present and future navigation systems. However, in achieving the high level of knowledge in navigation, it must be accepted that other more traditional subjects like celestial navigation may no longer need to be covered to the same level of detail as it was before.

It is perhaps one of the major omissions of the present syllabus that, in covering a range of subjects, it fails to give to the student adequate guidance as to those parts of the syllabus that will be of everyday importance when on board modern ships. For this reason, with the view of where are we now and considering today's changes, the navigation syllabus will consist of the following:

NAVIGATION I

Principles of navigation: Definitions, great circles, spherical angles, earth's poles, equator and radians, latitude and longitude, nautical mile, cable and the knot, chart projection, mercator chart, correction and notice to mariners, rotation of the earth around its axis, gyro course, compass course, compass correction, deviation and variation, distances between two positions on a mercator chart.
Duration: 45 hours

Navigation Instruments: the earth's magnetism and ship's deviation, the theory of simple magnetism, magnetic field, binnacles and correcting devices, permanent magnetism, induced magnetism, the gyro compass, free gyroscope, rudder angle indicator, rate of turn indicator, adaptive automatic pilot, speed log and 3-axis doppler logs.
Duration: 45 hours

Coastal navigation: Ability to determine ship's position by means of: landmarks, aids to navigation including lighthouses, beacons and buoys, problems of grounding and passing over shoals, evaluation of the height of lighthouses, chartwork and the earth and co-ordinates.

Duration: 45 hours

Celestial Navigation: Celestial sphere and its co-ordinates, the apparent day and annual motion of sun, sidereal time, the moon, the stellar family, identification of the stars, the sextant, rising and setting, twilight, altitude corrections.

Duration: 30 hours

NAVIGATION II

Navigation reliability: Errors of observations as applied to marine navigation, navigation systems, practical application of navigation errors- IMO performance standards for navigation equipment.

Duration: 30 hours

Electronic Navigation System 1(ENS): Principles of operation and working knowledge of Decca, Loran-C, and Omega, including knowledge of causes of errors, lane identification methods, radar and ARPA- statutory requirements.

Duration: 60 hours

Celestial Navigation 2: Meridian passage of the heavenly bodies, polaris observation, simultaneous sights, compass errors by amplitude methods, preparation for star sights.

Duration: 45 hours

NAVIGATION III

Passage Planning: Description of the route, tides and currents. Sailing directions, symbols and abbreviations in charts, international buoyage system, use of list of lights, Atlas and ocean passage for the world, manoeuvring characteristics, voyage plan relative to meteorological information and bridge procedures.

Duration: 45 hours

Navigational Control: Distress search and rescue procedures, bridge team procedure, communications, collision avoidance and VTS.

Duration: 30 hours

Electronic Navigation System 2 (ENS): Navigation errors, the Most probable Position (MPP) analysis, GPS, Navstar, radio direction finding, sonar navigation, Integrated navigation Systems, ECDIS, areas of probability, cocked hat, diamond errors, ellipse of probability.

Duration: 60 hours

NAVIGATION IV

Command navigation: selection of anchorage, bridge procedures at sea, in harbour and whilst berthing or anchoring, interpretation and use of meteorological information and aids including the use of radar in collision avoidance. Decision making processes.

Duration: 60 hours

Simulators: Radar, ARPA and shiphandling simulator

Duration: 45 hours

5.2.2 Future Needs

Although the syllabus has been proposed, it does not mean that the changes will be done dramatically. It is necessary to realise that when a system has been organised and developed over many years, there is always a resistance to change. Particularly if such changes are sudden and dramatic. There is no doubt that a gradual approach to change would achieve a wider approval and support than a sudden one.

It is therefore, necessary to upgrade the existing facilities at the school including the installation of radar and ARPA simulators as well as a shiphandling simulator later. These are the future needs, to take full advantages of the opportunities offered by the technologically advanced vessels of the future. Therefore, the curriculum should be structured using the proposed syllabus. For the successful implementation of the proposed syllabus, it is necessary to review and investigate not only education and training but also the system of certification of competency within the country. Even if the main training program is complete, seafarers would be required to return to college at appropriate periods for updating.

However, for the nautical school of Mozambique, time is critical and any change in the curriculum structure must be initiated within the coming years so that when the revised STCW/78 convention enter into force in 1 February 1997, at least, well trained instructors are available to carry out the activities efficiently.

CHAPTER 6

CONCLUSIONS AND RECOMMENDATIONS

6.1 CONCLUSIONS

Considering all the data provided, it can be concluded that:

1. Nowadays the teaching of navigation is based on simulators due to the technology of today's ships. The practice of navigation is therefore dependent on such technology.

2. Despite the different systems of education, methods of teaching and the form that navigation is designated, the main objective of teaching of navigation is to provide a trainee with knowledge and skills in order to operate a ship safely, effectively and efficiently. Nowadays, the teaching of navigation is not needed only in the operation of the equipment, but in understanding when to use them and their limitations.

3. Those countries which use the monovalent or traditional system of training spend more hours teaching navigation than those countries which use the bivalent or modern system. Consequently in the modern system the student is likely to ignore the knowledge of basic principles of navigation such as taking a ship's position by mean of celestial navigation. This is mostly evident in those countries of Europe

where ships are equipped with high technology equipment and they rely heavily on technology.

4. As regards accuracy for position fixing, the Federal Radionavigation Plan (FRP) suggests that in coastal waters, position accuracy of 0.25 NM is required. This requirement is great in the coastal zone up to 50 NM from land where there is a need to provide an accurate position to ensure safety of navigation. Decca and Loran-C systems meet this requirement of 0.25 NM as suggested by FRP. Omega system can meet this requirement using Differentials.

5. With the use of Differentials, navigation systems like Omega and Loran-C can provide position accuracy of less than 0.25 NM, thus increasing the safety of navigation. This technology of Differentials is applied to GPS and it increases the accuracy to about 10 metres. Despite the limitations, Decca, Omega, Loran-C, ARPA, and INS are systems which the navigator can rely on. However, ECDIS as long as it depends on GPS, the level of accuracy is doubtful due to problems of selective availability as explained previously in chapter 3.

6. The fact that GPS is operated by a single country and military controlled is dangerous for the safety of navigation. Therefore, the joint GPS/ GLONASS system coupled with the idea of INMARSAT launching satellites for civil navigation could be a better solution. On the other hand, IMO has adopted the resolution A.666 (16)- World-wide Radionavigation System. This resolution provides mechanisms for a world-wide navigation system to provide ships with navigational position-fixing throughout the world without restrictions.

7. The revised STCW/78 in its Code A-I/12 Standards Governing the Use of Simulators, says that the use of radar and ARPA training by simulators in maritime institutions is made mandatory. The use of other simulators is encouraged, but any

simulator used in the training of seafarers or in evaluating their skills or competence under part A of the code would be required to meet general performance standards. Under the code A-I/6 Training and Assessment, it is made mandatory that lecturers, instructors and assessors be appropriately qualified and have relevant experience.

8. In practising navigation, it is easy to abandon the basics in favour of the new, but the combination of both will ensure the highest safety and efficient operation of ships. Moreover, the safety of navigation depends on the navigator's quality of training, no matter how good the equipment is.

9. Navigation is an important marine activity with economic benefits but with adverse effect on the environment. Most environmental impacts from navigation results from accidents, which in most cases occur in the coastal area. For adequate protection of the marine environment, it is evident that the country must ratify some IMO conventions. The most important conventions to be ratified for the time being are:

- Safety of Life at Sea (SOLAS/74)
- International Convention for the Prevention of Pollution from ships (MARPOL/73) mostly annexes (I, II, IV, V)
- International Convention for the Prevention on Establishment of an International Fund for Compensation for Oil pollution Damage (FUND).
- International Convention on Civil Liability for Oil Pollution Damage (CLC)

10. For the success of the Nautical School of Mozambique, a professional development program of instructors must be provided. Such program amongst other things must be able to:

- Allow staff to obtain practical experience on board foreign going ships,

- provide opportunities for research and advanced studies in other developed institutions, apart from the World Maritime University.

11. The training policy in the country must take account of the uncertain nature of the future of our industry and therefore it must be careful about change. To cope with new technology the retraining or upgrading of graduates should be done. The syllabus which provides seafarers with good basic skills and knowledge and understanding about new technology are the essential foundations to enable them to cope with changing technology.

6.2 RECOMMENDATIONS

In the light of the foregoing conclusions it is recommended that:

1. The Government ratify the IMO conventions identified above.

2. The Nautical School of Mozambique establish a professional development training program for its instructors.

3. The country's maritime directorate facilitate national officers to sign on under other foreign flags to increase their job mobility, since shipping is of international concern.

4. Those parties which benefit from the graduates of the school such as shipping companies and other entities provide financial funds to assist in purchasing navigation training equipment previously identified.

5. The following staged introduction of new simulators and equipment over the next few years be undertaken to enable the ENM, to meet the demands of new technology, taking into account new international requirements in the future.

EQUIPMENT	STAGE	YEAR
GPS/ Loran-C	I	1996
Radar/ARPA Simulator	II	1997
GMDSS	III	1999
ECDIS	IV	2000
Shiphandling Simulator	V	2002

6. That navigation software programs OOW, PORTSIM and MARINER be purchased

7. The present syllabus be updated as suggested in chapter 5 in order to meet the actual needs of high technology on board ships.

8. As electronic equipment have been developed, the reliability of components increases, and the chance of total system failure decreases. However, if such a failure does occur, it will be necessary for the officer to navigate by the traditional methods of compass and sextant. The teaching of traditional methods continue to be offered in ENM curriculum for the purpose of the world-wide employment prospect of graduates.

APPENDIX 1

Navigation Syllabus (Australia)

Year 2, semester 1
Offshore Navigation 1
Shape of the earth, common approximations used in navigation. Geoid, ellipsoid and the relationship between them; geometry of the sphere; the sailing; the measurement of time, the use of UTC, local, Greenwich, standards and zone times; nautical almanac; altitude corrections; meridian passage of celestial bodies; rising and setting; astronomical position lines.
Duration: 60 hours

Coastal Navigation
General principles of navigation and position fixing; the mariner's chart and its properties; introduction to tides; allowances for observational errors; allowances for environmental factors.
Duration: 40 hours.

Electronic Navigation Systems (ENS)
Time determination and measurement, use of radio waves in position fixing, effects of atmospheric and ionosphere factors, propagation characteristics; principles of operation and working knowledge of Decca navigator, Loran-C and Omega system, including knowledge of causes of errors, lane identification methods; principles and operation of GPS navstar satellite navigation system, including knowledge of the causes of errors and calculated position rejections and typical accuracy of the system; operation and principles of radio direction finder, calibration of direction finder and statutory requirements; Radar and ARPA.
Duration: 90 Hours.

Bridge equipment & Navigation safety
Limitations and source of errors of navigational sensors, instruments and aids including the following: Logs, echo sounders, rate of turn gyros, bearing instruments, sextant and chronometers. Contents and application of the international regulations covering the safety of navigation; operation and use of VHF; principles and operations guidance for deck officers in charge of a watch in ports.
Duration: 30 Hours

Year 3, Semester 2
Offshore Navigation 2
The overall concepts of the practice of using traditional methods. To finalise celestial navigation techniques after sea experience.
Duration: 15 Hours

Command navigation 1
Detection and compensation of systematic and random errors in position fixing by any method; area of probability, cocked hat, diamond errors, ellipse of probability; interpretation and use of navigation charts and publications; developments in electronic charts and their advantages and disadvantages; voyage planning; selection of anchorage; search and rescue and rescue procedures; bridge procedures at sea, in harbour, and whilst berthing or anchoring; interpretation and use of meteorological information and aids including the use of radar in collision avoidance.
Duration: 60 Hours

Year 4, Semester 2

Command Navigation 2
Incidents at sea; manoeuvring solutions to collision avoidance problems; the use of communications for navigational safety; the impact of VTS upon navigational safety, marine reporting systems; the use of radar simulators and ARPA; the use and operation of full range of bridge equipment and electronic navigational aids; the use of simulators in collision avoidance; passage planning; principles of keeping a safe navigation and bridge teamwork procedures.
Duration: 60 Hours.

Source: (AMC, Handbook 1995)

APPENDIX 2

Course and Navigation syllabus (Malaysia)

3rd Mate preparatory course

Practical navigation & Chart work
Knowledge of parallel and plan sailing formula, use of transverse tables for solving parallel sailing problems, plan sailing problems; Mercator sailing formula; use of the nautical almanac; obtain LMT of the meridian passage of star; sextant altitude; zenith distance of the body; co-latitude; polar distance; Marcq. St Hilaire method. The use of star charts; different types of position lines; error of the magnetic compass or gyro compass.

Chartwork
Symbols and abbreviations on a chart; position line and position circle; true magnetic and compass north; set, rate, drift and leeway; principles of passage planning; general theory of tides.
Duration: 14 Weeks.

2nd Mate Preparatory course

Principles of Navigation
Shape of the earth and ability to define: Great circle, small circle, spherical angles and triangles; equator and meridians; rhumb line ; Mercator chart; general astronomy; celestial sphere; daily motion, rational horizon, zenith and nadir; sextant altitude; observed latitude of sun and moon; civil, nautical and astronomical twilight's; equation of time; position line theory; meridian altitudes; operation of satellite navigation system; position fixing in radar hyperbolic system; free gyroscope.
Duration: 14 weeks

1st Mate Preparatory course

Ocean and Offshore Navigation
Rhumb line navigation; true bearing of sun, moon, stars and planets given dead reckoning position; great circle sailing and its advantages; sextant altitude correction; true altitude of the circumpolar star; local hour angle at any heaven body given GMT; principles of marine radar; principles of hyperbolic lines of position; principles of Decca, Loran-c, and Omega systems; the consol system, radio direction finder; fixed and variable errors; principles of the supersonic echo sounder; satellite navigator.
Duration: 7 weeks

Coastal navigation
Relationship between compass, magnetic, true and gyro courses and bearings; planning the passage; limitations of electronic aids e.g. Radar, radio direction finder,

Duration: 7 weeks
Master Foreign Going preparation course

Navigation
Principles of weather routeing for ocean passages keeping in view climatic conditions; planning a coastal voyage; traffic separation zones and inshore traffic zones; search and rescue operations; navigating a ship in heavy weather; sailing directions, anchoring and manoeuvring in port; interpretation and use of navigational aids available on ships.
Duration: 7 weeks

Navigation Aids and Instruments
Knowledge of terrestrial magnetism including earth's magnetic field, variation, angle of dip, vertical and horizontal components of earth's magnetic field, isoclinic, isodynamic charts; properties of a free gyroscope; gyro compass; automatic pilot; principles and characteristics of marine radar; principle of hyperbolic position fixing systems; use of Decca navigator system; fixed errors, variable errors associated with Decca navigator system; operational use of Loran-C and Omega; operation, use, errors and limitation of ARPA; principles of Radio direction finding; Transit navigation system; operation of echo sounder system and steam logs; electromagnetic logs.

Duration: 7 weeks

APPENDIX 3

Navigation Syllabus (Egypt)

Year 1, Semester 1

Principles of Navigation
Definitions, great circles, spherical angles, earth's poles, equator and meridians; latitude and longitude; nautical mile, cable and the knot; chart projection, mercator charts; corrections and notice to mariners; rotation of the earth around its axis; gyro course; compass course, compass correction; deviation and variation; position line ; distance between two positions on a mercator chart.
Duration: 72 Hours

Year 1, Semester 2

Navigational instruments
Heading speed and distance instrument. The magnetic of the earth and ship's deviation; the theory of simple magnetic, magnetic field, variation, compass needle, disturbing forces; the magnetic compass; binnacles and correcting devices, deviation; permanent magnetism; induced magnetism; the gyro compass, free gyroscope, undamped and damped gyrocompass; course recorder; rudder angle indicator; rate of turn indicator; automatic pilot and speed logs.
Duration: 162 Hours

Year 2, Semester 3

Coastal navigation (chart work and tidal)
Types of marine navigation; the earth and co-ordinates; the nautical chart, chart projections, and interpolation; dead reckoning; direction measurement by magnetic and gyro compass; errors; ability of determining ship's position by means of: landmarks, aids to navigation, including lighthouses, beacons and buoys; problems of grounding and passing over shoals; evaluation of the height of lighthouses.
Duration: 54 Hours

Astronomical Navigation 1
Celestial sphere and its co-ordinates, the apparent day and annual motion of sun; the astronomical triangle p2x; the solar, sidereal time; the moon, the stellar family; identification of the stars; the sextant; rising and setting, twilight; altitude corrections.
Duration: 45 Hours

Year 2, Semester 4

Planning the passage at sea
Choosing the route; ship's routing and traffic separation schemes; tidal stream and current; leeway effect; navigation in thick weather; anchorage and mooring; navigation in channel and narrow waters.
Duration: 54 Hours

Astronomical Navigation 2
Rising, setting and twilight; meridian passage of the heavenly bodies; Polaris observation; simultaneous sights, two sights with long run in between; compass errors by amplitude methods; preparation for star sights.
Duration: 45 Hours

Year 3, Semester 6

Navigation reliability
Errors of observation as applied to marine navigation; navigation systems; visual propagation methods and error propagation in radio navigational systems; practical application of navigational errors- IMO performance standards for navigational equipment.
Duration: 54 Hours

Electronic Navigation System (ENS)
Basic principles of Radio Direction-Finder and echo-sounder, principles of Decca navigation system and receivers used on board. Description of basic Omega system. Principles of Satellite navigation system. Principles of marine radar plotting and operation of radar for self-plotting.
Duration: 80 Hours

Navigational Control
Navigation systems comparisons; passage planning; distress search and rescue; bridge operation and bridge team procedure; communications; execution of the passage plan; collision avoidance; VTS.
Duration: 60 Hours

Year 4, semester 7

Advanced navigation systems
Future safety of navigation; GPS; Integrated Navigation System; electronic charts and radar integration; integrated bridge system; future of radio marine navigation system.
Duration: 27 Hours
Degree and Certificate
B. Tech. In Navigation and 2nd mate

APPENDIX 4

Navigation Syllabus (Portugal)
Year 2

Astronomical Navigation
Nautical astronomy , transformation of co-ordinates, the earth movement, apparent and medium co-ordinates, the solar system, twilight, planets, moon, sun, stars, time and its measurements, astronomic ephemerid, altitude correction, the sextant, astronomic line of position, errors in sight position, utilisation of isolated sight position, simultaneous sight positions and errors in azimuth determination.
Duration: 180 Hours

Year 3

Voyage Planning
Description of the route, tides and currents, magnetic and auto pilots
Duration: 60 Hours

Coastal Navigation
Marine traffic control including VTS and its role in navigation safety; navigation in narrow channel, the effect of squat, marine publications and documents for the safety at sea.
Duration: 90 Hours

Electronic Navigation System
Navigation errors, the most probable position (MPP) analysis, radar and ARPA, Decca, Omega, and Loran-c systems, GPS Navstar, Radio direction finding, Sonar navigation, Integrated Navigation Systems.
Duration: 75 Hours

Degree: BSc in Navigation

Phase 2 (Superior Specialised Course)

Geodetic knowledge
Geodetic knowledge, the earth ellipsoid, the hyperbolic navigation, satellite navigation, calculations in navigation.
Duration: 120 Hours
Degree: "Licenciatura"
Source: (ENADH Handouts 1988)

APPENDIX 5

Navigation Syllabus (Netherlands)

Year 1 and 2

Navigation

Practical navigation based on the use of pocket calculator; knowledge of the accuracy of various navigational methods. Subjects: Spherical earth; co-ordinates and directions; course and bearing computation/reductions; mercator chart; sailing directions; dead reckoning and course distance calculation along rhumbline; great circle; radar bearing; parallel index tracking; tidal movements; position by means of Decca, Loran-C, Satellites; radio bearings; astronomical subjects; motion of earth, moon, planets and lunar phases; use of nautical almanac; time and time correction; chronometer error; compasses error and astronomical position finding.

Navigational Instruments and Systems

Principles, operation, applicability, accuracy and possible errors and corrections of the following instruments: Azimuth instruments, sextant, chronometers, magnetic compass, gyro compass, speed logs, Radar, Decca, Loran-C, Satnav, Radio direction finder and Integrated Navigation Systems.

Passage Planning and Execution

Effects of vessel type and cargo; sailing directions; symbols and abbreviations in charts; international buoyage system; use of list of lights, pilots, current atlas and ocean passages for the world; plotting courses in dangerous waters; manoeuvring characteristics; chartwork; voyage plan relative to meteorological information and bridge procedures.

Duration: Year 1- 5 periods
Year 2- 9 periods
Total: 14 periods

Source: (Nautical College: "Willem Barentsz" Terschelling)

APPENDIX 6

Navigation Syllabus (USMMA)

Forth Class Year

Nautical Science 3
An introduction to celestial navigation, the celestial sphere, celestial lines of position, time; sextant; azimuth and procedures in the practical application of celestial navigation; electronic navigation, lines of position and synoptic meteorology and marine weather observations.
Duration: 75 hours

Introduction to Navigation and Law
Concepts and theories of piloting terrestrial navigation along with their practical applications; terrestrial co-ordinates; nautical charts; navigation publications; piloting; navigation aids; compasses and sailing; practical chartwork laboratory; introduction to use of electronic navigational aids and international regulations for preventing collision at sea.
Duration: 60 hours

Third Class Year

Navigation 1
Advanced piloting, sailing including great circle, magnetic theory, and compass adjustment; current sailing; chart projections, the nautical chart, twilight phenomena, star identification.
Duration: 30 hours

First Class Year

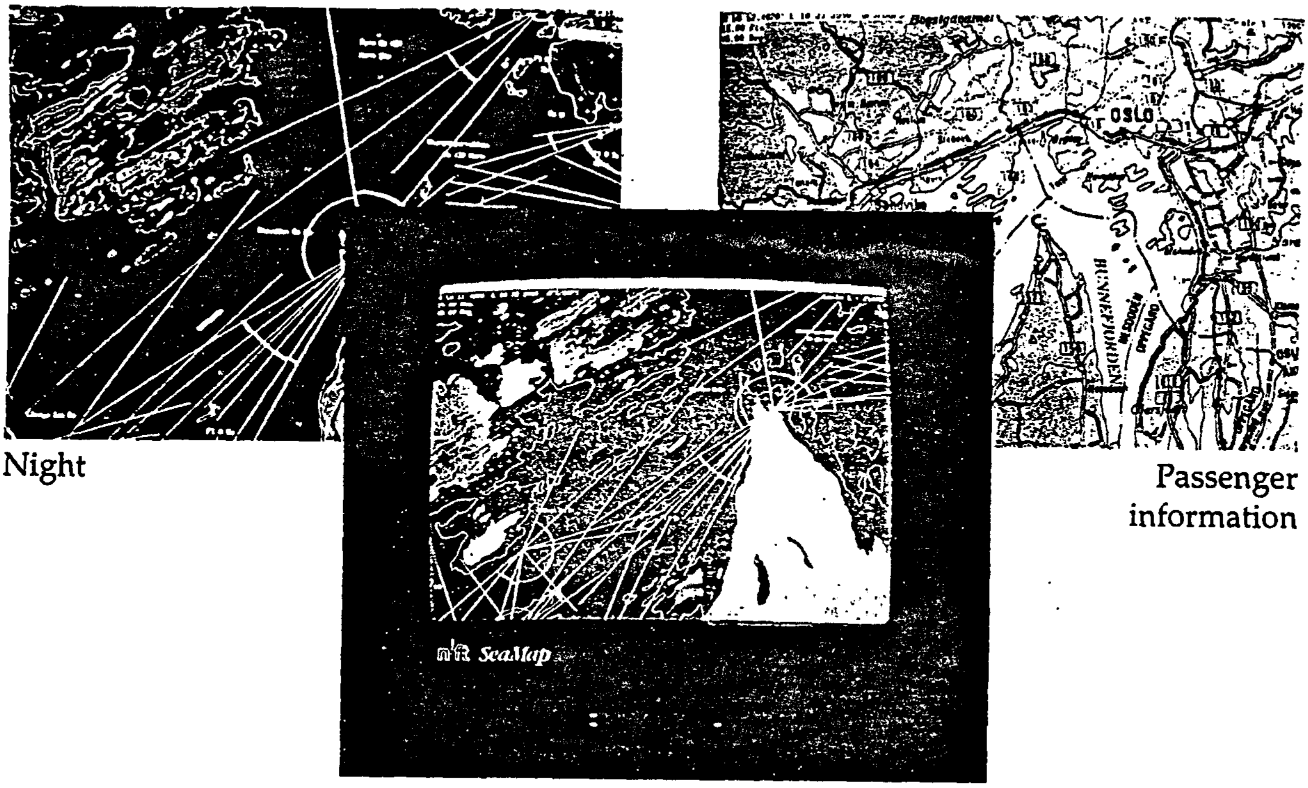
Navigation 2
Celestial navigation theory, nautical astronomy, ocean currents, tides and tidal currents; analysis of lines of position
Duration: 30 hours

Navigation Laboratory
Practical applications of the mathematics of navigation: Deviation tables, bearings, sailing, rising and setting phenomena, compass error, meridian transit, vertical angles, tide and tidal current calculations.
Duration: 60 hours a week.

Source: (USMMA Handbook 1994/95)

APPENDIX 7

ECDIS Display



Night

Passenger information

A complete navigation console with colour monitor located on the bridge and any number of TV monitors in passengers areas

FACHHOCHSCHULE HAMBURG

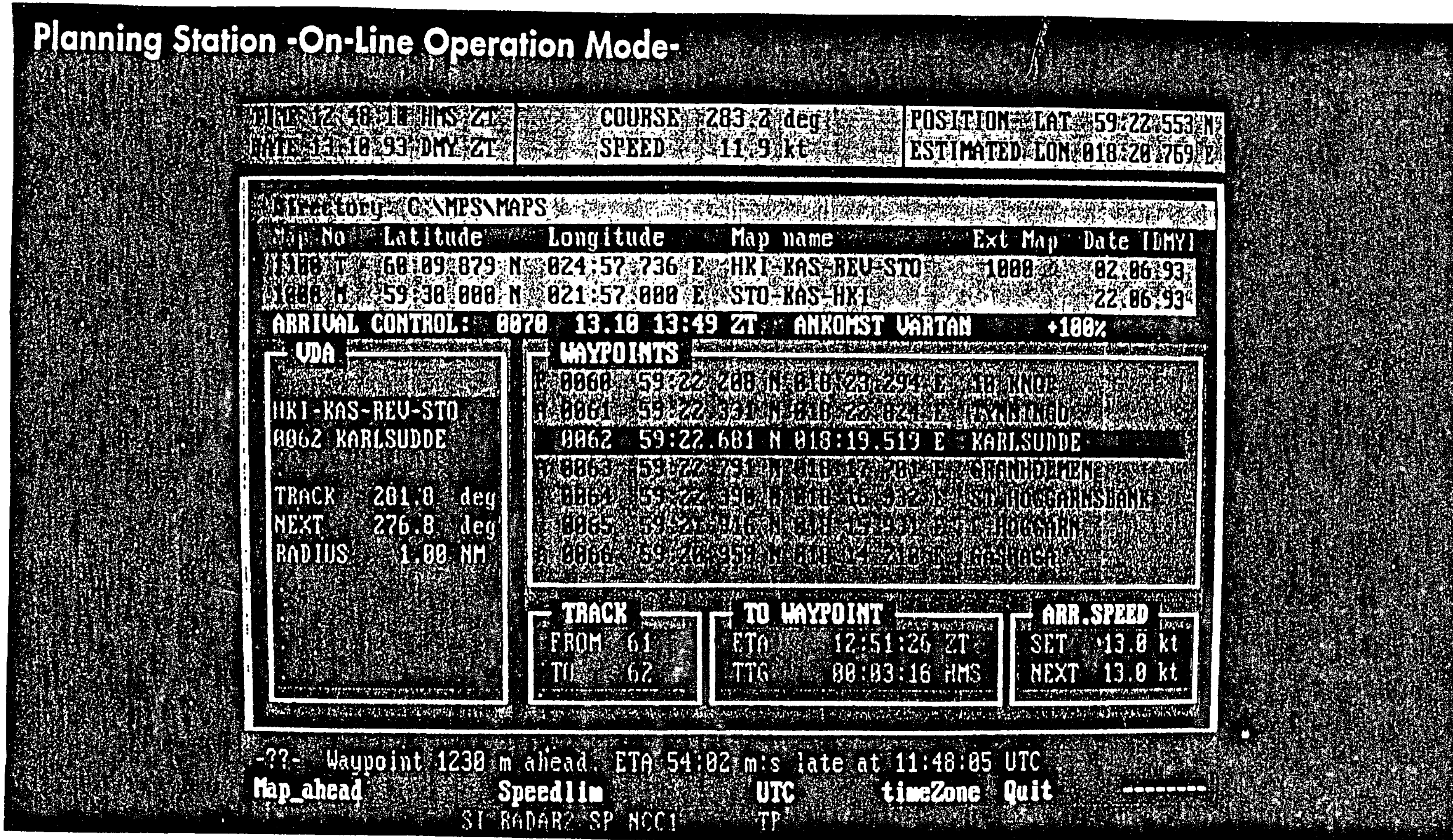
FACHBEREICH SEEFAHRT
SCHIFFSFÜHRUNGS- UND
SIMULATIONSANLAGE

SCHOOL OF MARITIME STUDIES
SHIPHANDLING AND SIMULATION
FACILITY

Radar-Überlagerung auf einem "Electronic Chart Display and Information System" (ECDIS)
Tagdarstellung

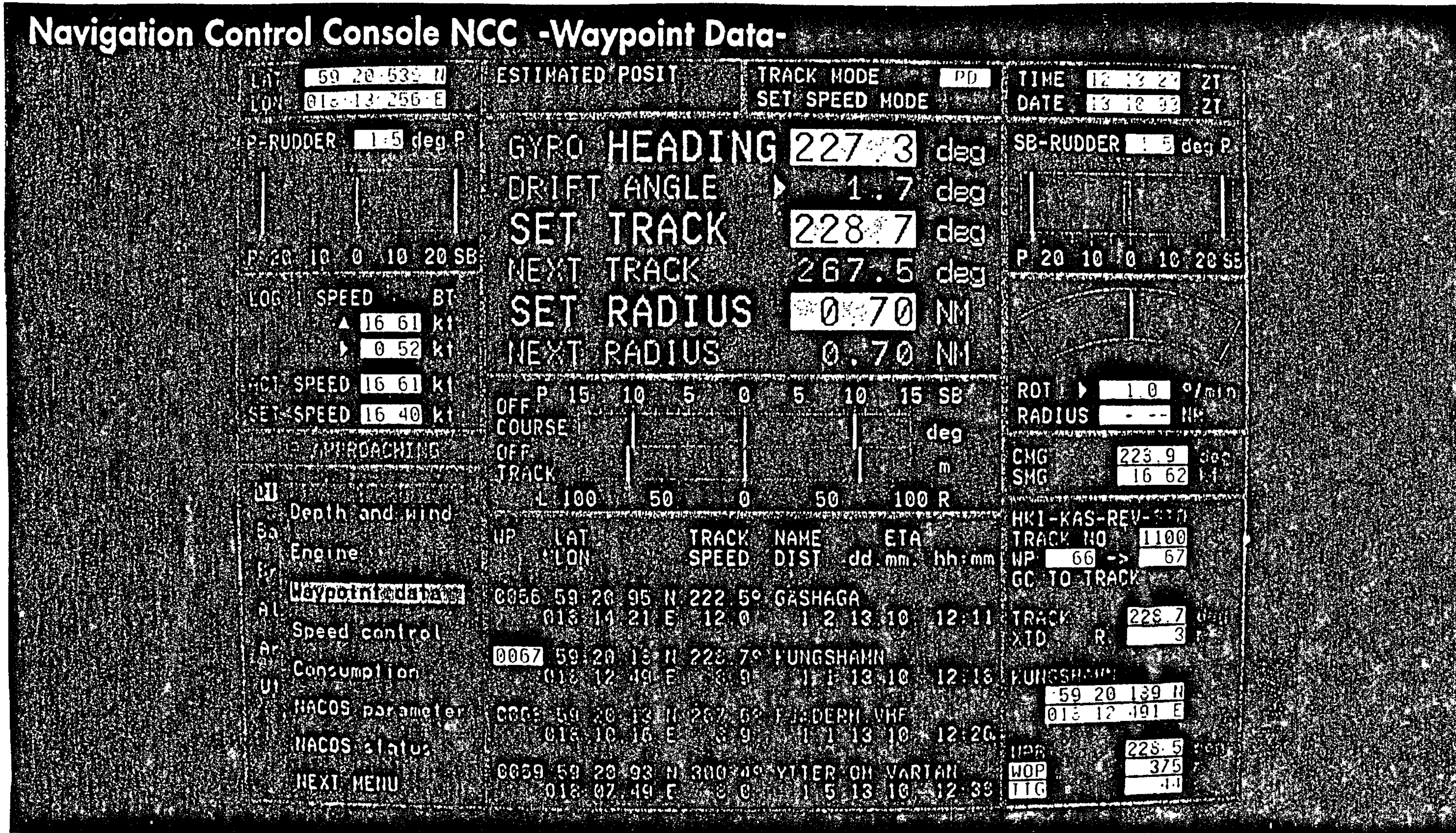
APPENDIX 8

Voyage Planning Display



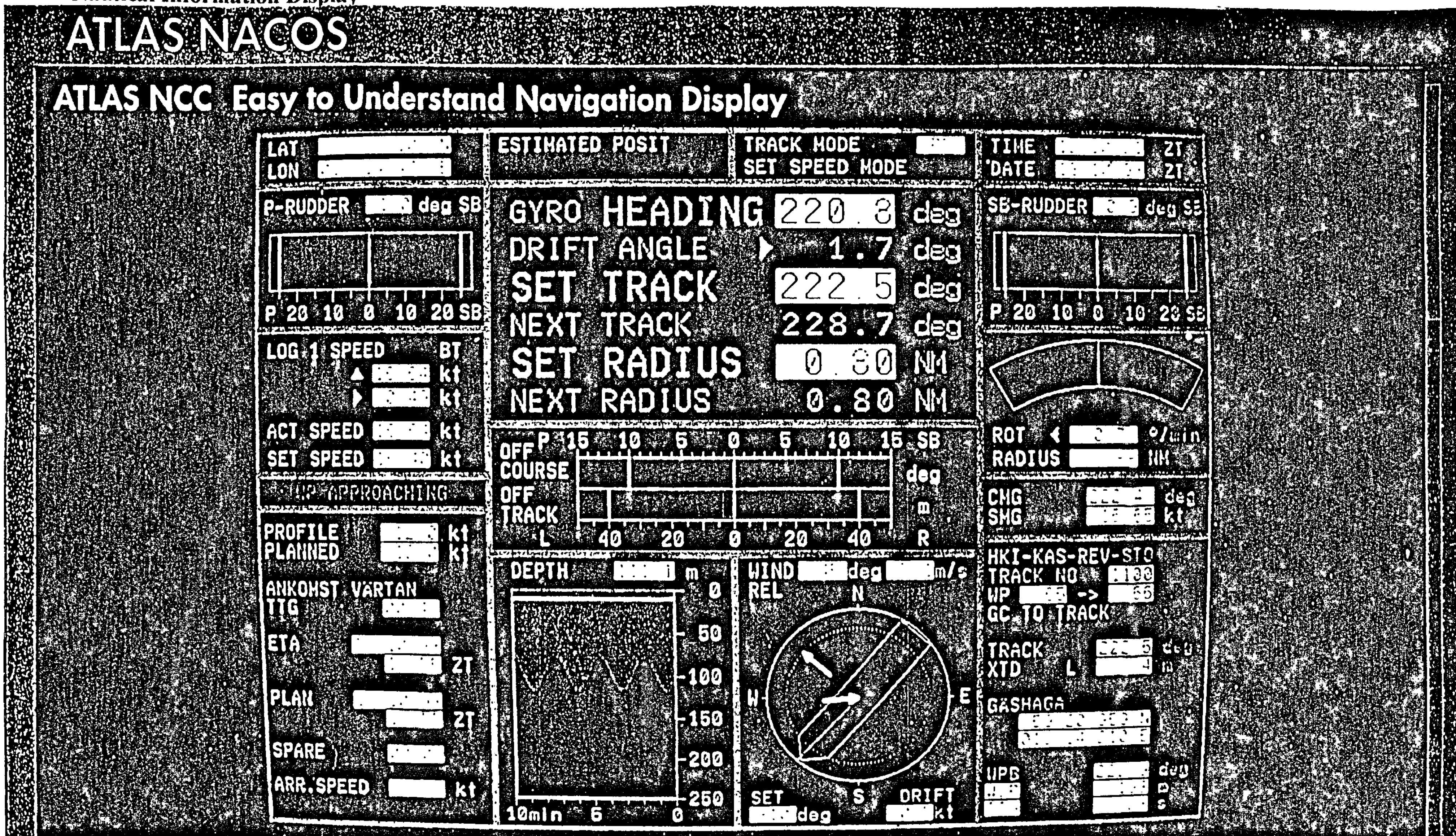
APPENDIX 9

Automatic Track Control



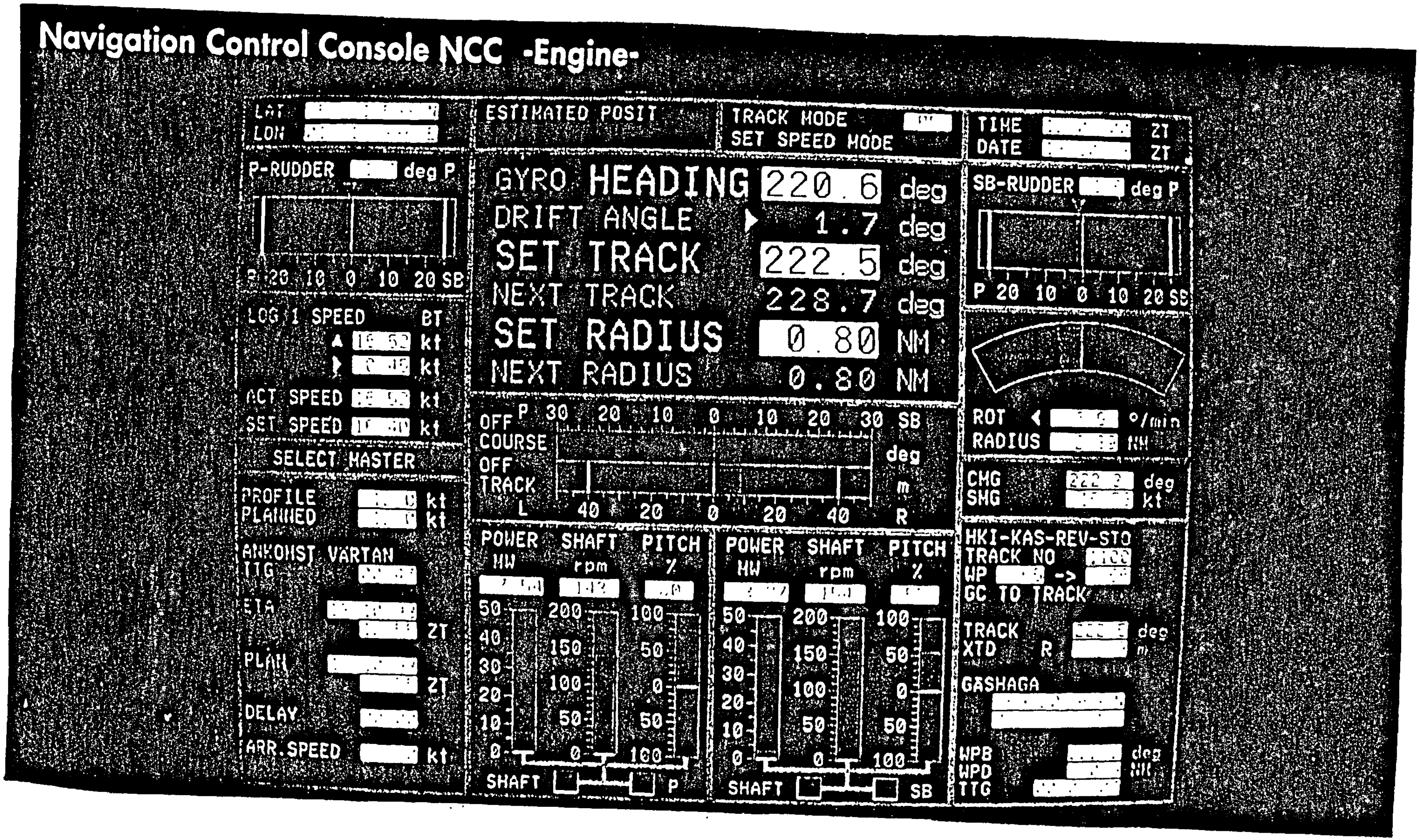
APPENDIX 10

Nautical Information Display



APPENDIX 11

NACOS Engine Display



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