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# Maritime satellite communications: its influence on maritime education & training and shipboard operations

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# MARITIME SATELLITE COMMUNICATIONS; ITS INFLUENCE ON MARITIME EDUCATION & TRAINING AND SHIPBOARD OPERATIONS

by

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

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

(Signature) ____________

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# Maritime Satellite Communications;

## Its Influence on Maritime Education & Training and Shipboard Operations

To Shahnez, my wife

*It's a safe bet that satellites will continue to be the best means of long-range communications with moving vehicles until someone makes the Earth transparent by inventing a wide-band neutrino transducer weighing less than ten thousand tons*...(Never Beyond Reach, Arthur C. Clarke)

*In the near future there will be no separation between communication by radio and radionavigation. From a technical point of view radionavigation systems are a part of radiocommunication systems*...(Maritime Radiocommunications, J.H. Mulders)

*The modern seafarer, unlike his forefathers, is able to communicate instantly, effectively and in privacy. Satellites made this high quality service possible - INMARSAT turns that possibility into reality*...(INMARSAT)

# CONTENTS

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Lalin D. de Silva
September, 1991
Malmo, Sweden.

# Preface

*It is not generally realised that, despite tremendous advances in electronics, the world's shipping is still in Morse code era. Sometimes, when conditions in the ionosphere are bad, a ship may be out of touch with land for days on end. Such break down in communication can cause hundreds of thousands of dollars and occasionally the entire ship. Even today, no ground radio station could guarantee to alert the Titanic in time...* (Never Beyond Reach, Arthur C. Clarke)

The maritime satellite communication has made a significant contribution to the improvement in safety and efficiency of commercial shipping over the last decade.

It is important to have a clear idea of what satellite communication is. It is not merely an improved ship's radio, although it is true that many users still see it that way. It is seen that Satellite communications enables a ship at sea to make use of any form of information available, whether it is a distress message or a normal commercial message to the nearest Rescue Centre /ships in the vicinity, or to an office ashore.

A number of Shipowners are now using satellite communications not only for data transfer between ship and shore but also for the monitoring and management of the vessel itself.

This dissertation exposes some of the important applications of satellite communication and maritime activities to the reader. It is not possible though to elaborate all the applications within the scope of this dissertation.

Chapter 1 is "An Introduction to Satellite Communications". It briefly describes the satellite orbits, compares terrestrial/satellite links and exposes the reader to applications with databases and data communication systems.

Chapter 2 highlights the need for a Global Maritime Distress and Safety System and shows that availability of world-wide satellite communication has vastly improved the safety of shipping.

Chapter 3 emphasizes the important role satellite communication plays with the "Integrated Bridge". A fully integrated bridge leading to a "single officer on watch" would be difficult.

Chapter 4 shows the applications and importance of shore-based operations connected to satellite communications, and as such many vessels are being monitored from ashore today.

The author wishes to express his views as to whether there is a "need for a radio officer on-board vessels in the future". The importance of the subject "Maritime Communications" is stated and a "Proposed Maritime Communications Syllabus" is drawn up in Chapter 5.

Chapter 6 contains the Conclusions.

# LIST OF ILLUSTRATIONS

# CHAPTER 1

## AN INTRODUCTION TO SATELLITE COMMUNICATIONS

### 1.1 Introduction

In 1945, the English science fiction writer Arthur C. Clarke, writing in " Wireless World" proposed a global communication system utilizing space stations orbiting the earth at the same rate as the earths' rotation.

"An artificial satellite at the correct distance from the Earth would make one revolution every twenty-four hours; it would remain stationary above the same spot and would be within optical range of nearly half the Earths' surface. Three space stations, 120 degrees of longitude apart in the correct orbit, could give television and microwave coverage to almost the entire planet."

If a satellite at a particular height above the equator moves at the correct speed, it will travel once around the earth in the same time the earth takes to complete one rotation. If it also travels in the same direction as the earths' direction of rotation it remains over the same point on the equator and it appears stationary to an observer on the ground. Thus gives rise to the expression "geostationary orbit".

### 1.2 The Satellite Orbit

A space satellite is actually an artificial moon, and its behaviour is described by the laws of celestial mechanics. These were first brought to notice by Johannes Kepler in the form of Keplers' Laws. These were modified again by Sir Isaac Newton under the Law of Gravitation and the associated Laws of Motion. These provide the basis for all the calculations involved in launching and positioning space satellites.

The reason for a satellite to remain in its orbit rather than falling to earth is that the satellite velocity, in the absence of gravity, would otherwise carry the space vehicle away from the earth, but that the acceleration due to gravity counterbalances centrifugal acceleration, allowing the satellite to remain in the orbital path. The closer the satellite is to the earth the stronger is the gravitational pull, and the faster the satellite must travel to avoid it falling to the earth.

## 1.3 Types of Orbit

### 1.3.1 Low Orbit Satellites

The low orbit satellites travel at about 15,000 miles/hour, and at this speed they circumnavigate the earth in about 1.5 hours e.g. RCA and TELSTAR satellites. They are within line-of-sight for only brief periods, and as they are also in motion relative to the earth, the earth stations have to be capable of tracking them. They have the following characteristics: height 100-300 miles, rotation period 1 1/2 hours to 2 hours approximately, time in line-of-sight of earth station 1/2 hour or less. They are of little or no use for telecommunications.

### 1.3.2 Medium Altitude Satellites

The Soviet Union makes use of inclined highly elliptical orbits, for geographical reasons, ( e.g. no point in the Soviet Union is closer to the equator except 35 degrees North). This has promoted the development of highly eccentric orbits which has acquired the name of the satellites that first exploited it "Molniya". The Molniya orbit has a period of about 12 hours, it is highly elliptical in shape and is inclined at 63.4 degrees to the equatorial plane e.g. Russian Molniya communication satellites and AT & T, TELSTAR satellites. They have the following characteristics: typical height: 300-25000 miles, typical orbital period: 12 hours, typical time in line-of-sight of USSR earth station: 9 hours.

### 1.3.3 High Orbit Satellites (Geostationary)

This satellite is positioned 35,786 km (22,500 miles) above the earth; and travels at a speed of 6,879 miles/hour. It completes its orbital journey of 264,000 km in 23 hours 56 minutes and 04 seconds, which is the rotation period of the earth. Since the orbit lies in the equatorial plane and the satellite is moving in the same direction as the earths' rotation, it appears to be stationary with respect to the earth.

It is well-known that a system of three satellites in Geostationary Orbit, each separated by 120 degrees of longitude, can receive and transmit radio signals over the entire globe except for the polar regions. A large contiguous land area as well as offshore locations can simultaneously gain access to a single satellite. The greater the height of the satellite, the larger the portion of earth which it covers; and the greater the earth coverage, the greater can be the maximum permissible distance between earth stations to guarantee simultaneous line-of-sight, and as such communication capabilities. If the satellite has a specially designed communication beam focused on these areas, then any receiving antennas within the "foot print" of the beam (the area of coverage) will receive precisely the same transmission.

### 1.3.4 The advantages of Geostationary Satellites

* as the satellite remains stationary on relative to earth the cost of sophisticated tracking equipment is avoided, minimizing the cost and complexity of the earth stations;

* the locations within the satellites area of coverage remain in line-of-sight contact, and the break in transmission, which occurs when a satellite disappears over the horizon, is avoided;

* the large coverage area, where a large number of earth stations can intercommunicate;

* a relatively small number of satellites can provide almost total global coverage;

* the satellites, apart from minor drifts, experience no motion relative to the earth station, as such there is no Doppler shift;

* it is easy to provide in orbit spare satellites, spares are also in GEO and only a small amount of energy is needed to bring one into operational service.

### 1.3.5 The disadvantages of Geostationary Satellites

* latitudes greater than 75 degrees North and South are not covered;

* compared with lower altitude orbits, more powerful rocketry and on board fuel supplies are required to achieve geostationary orbit;

* with increasing altitude the effect of earth and lunar eclipses become increasingly pronounced;

* there is always loss of radiated energy to space (Free space loss), the Free space loss increases with increasing distance;

* because of the great distance, the received signal strength, which is inversely proportional to the square of the distance, is very weak-of the order of 1 pico watt or billionth of a watt.

The multiple advantages of GEO have generated a high level of demand from existing and potential users, creating the possibility of interference between communication channels.

## 1.4 Satellite Networks

The purpose of operating a satellite in orbit is clearly to provide connections between earth stations which in turn deliver or originate various types of communication services. The application of such satellite networks are broken down into the broad categories of video, telephone, and data. There are three forms in which points on the earth are linked between each other. They are :

* point-to-point

* point-to-Multipoint

* Multipoint-to-point

### 1.4.1 Point-to-Point

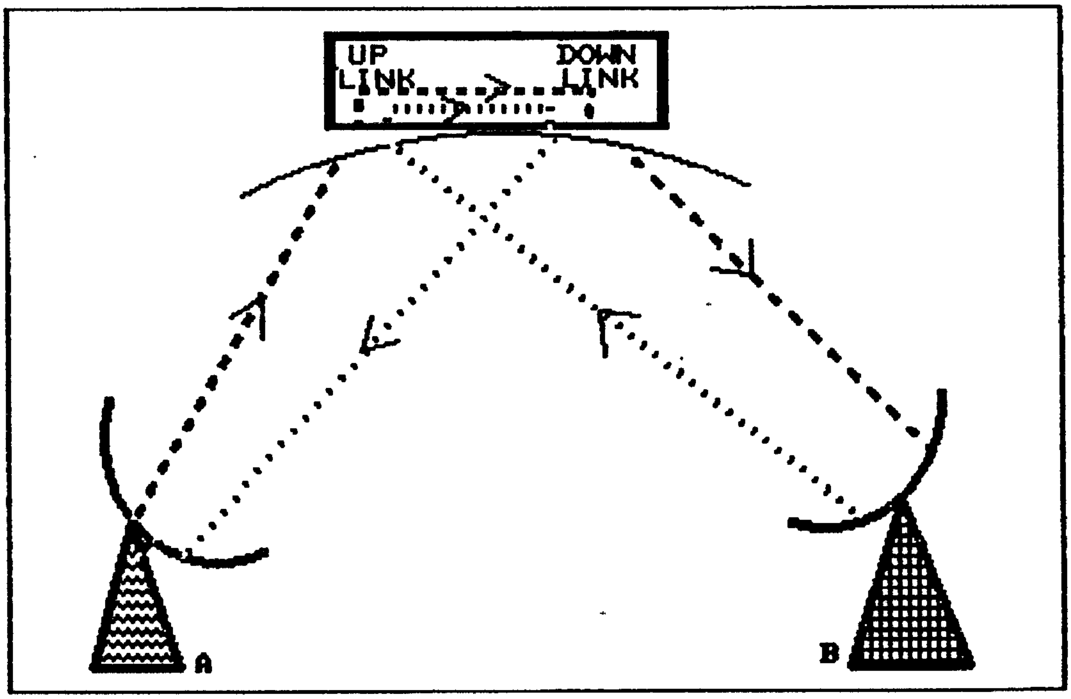


Figure 1 Point-to-Point

The simplest type of connectivity is point-to-point, with two earth stations, placed apart and both linked simultaneously to the satellites. A pair of earth stations transmit RF carriers one to another (and receive each others' carriers), creating a duplex link. The parties being served can as such talk or transmit information in both directions.

### 1.4.2 Point-to-Multipoint

Here the satellite broadcasting is accomplished with one transmitting earth station (called the uplink in common practice) and Receive Only (RO) earth stations. The satellite repeater retransmits the single RF carrier containing the information to be distributed.

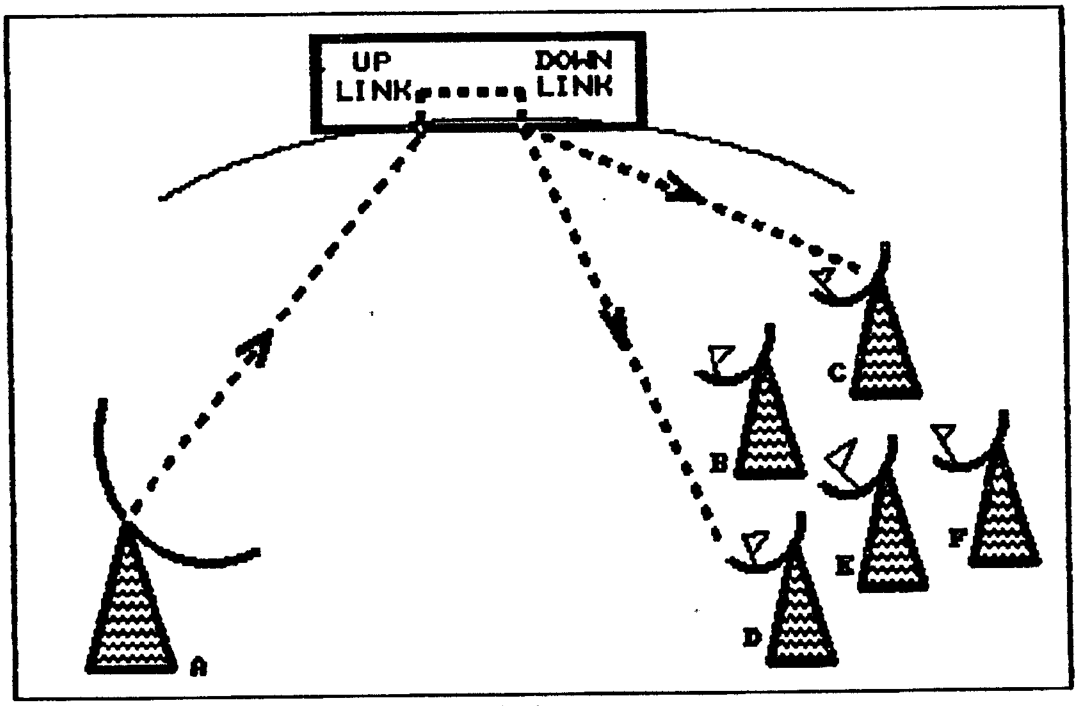

Figure 2 Point-to-Multipoint

This allows thousands of viewers to utilize the satellite transmissions (RO's) using small receiving antennas.

### 1.4.3 Multipoint-to-point

It allows the remote stations to send information back to the central station. As shown in the figure, this type of connectivity provides two-way communication as the remote stations receive the broadcast from the central station and can transmit back over the same satellite. It is different from the point-to-point network because the remote stations cannot communicate directly with one another but must do so through the central station.

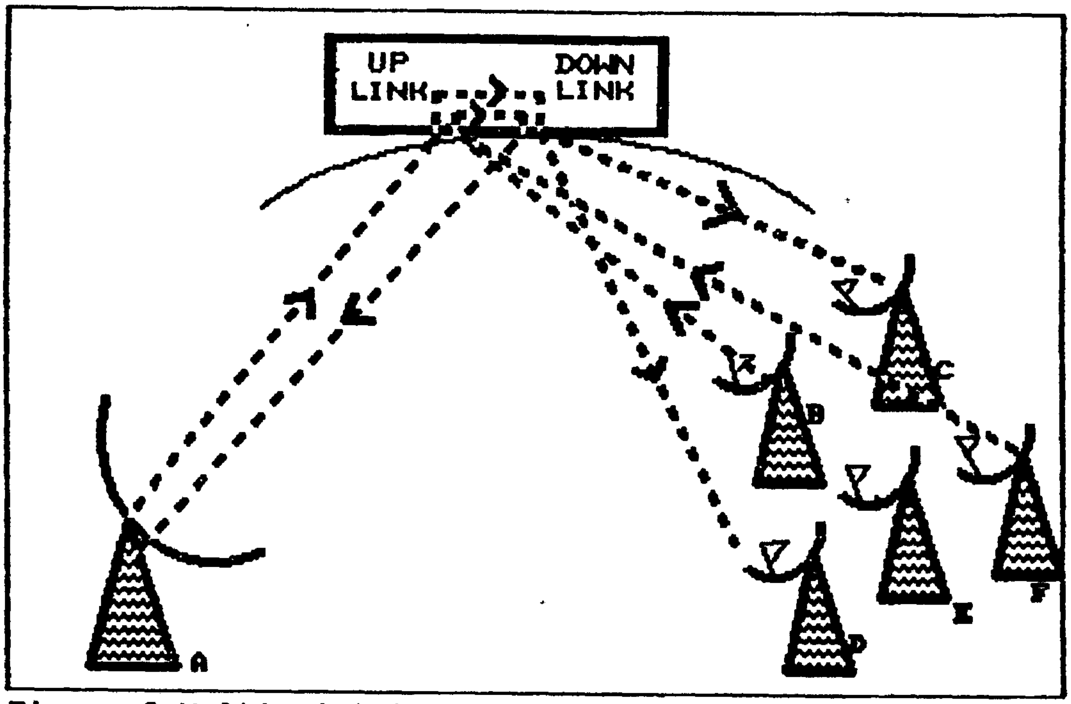

Figure 3 Multipoint-to-Point

## 1.5 The advantages over the Terrestrial Communication System

The terrestrial communication systems, which include cable and point-to-point radio, were present before satellites. They are still in use and will be around long into the future. Since technology is always advancing, satellites and terrestrial communications will improve in quality, capacity and economy. A terrestrial systems must spread out over a land mass like a highway network in order to reach the points of access in cities. The time, difficulty, and expense incured are extensive; but once established, a terrestrial infrastructure can last a life time. The satellites, on the other hand, are designed to last about seven years-twelve years in orbit due to the practical inability to service a satellite in GEO and replenish consumables (fuel, battery cells, and degraded or failed components).

In a terrestrial microwave system, radio repeaters must be positioned at intermediate points along the route to maintain line-of-sight contact. This is because microwave energy, including that on terrestrial and satellite radio links, travels in a practical straight line with a minimum of bending over or around obstacles. In the case of a long distance cable system, a different form of repeater is needed to amplify the signals and compensate for changes in cable characteristics. The cable systems (coaxial and fibre-optic) are as such probably the most costly to install and maintain and provide only for local and short distance telephone services and major uses of communication services (governments, agencies, multinational corporations, rail roads, utilities etc.) which are able to justify the expense of operating their own terrestrial cable or microwave networks. The fiber-optic cables are now being laid across the oceans. They require a fewer number of repeaters and are able to provide communications at a lower cost than via satellites.

The implementation of the ground segment of a satellite network is relatively simple, primarily because the number of physical installations is minimal. To be installed in a satellite network, a planner need only consider the sites where service is required. On the contrary terrestrial cable system requires firstly that the right of way is secured from organizations such as governments, utility companies, and rail roads. In this case hundreds or even thousands of sites must be provided with shelter and power. Once the entire system is installed and tested, all of the equipment must be maintained to assure continuous service. The terrestrial networks must deliver a multipoint connectivity by extending terrestrial links to each and every point to be served e.g. broadcast radio and TV work on a point-to-multipoint basis. These techniques are severely restricted as to range because of line-of-sight radio propagation. To extend well beyond this geographical limitation, less reliable point-to-point links must be established between the radio towers to chain the broadcasts.

The cable systems are susceptible to accidental leakage or the deterioration of the cable itself, and can take several hours or even days to repair. Thus a single buried cable or microwave system is relatively unreliable due to inevitable leakage or failure.

The reliability of satellite communication is enhanced by the fact that virtually all the ground facilities can be under the direct control of one organization. If a problem occurs with equipment or its interface with other facilities such as telephone switches or computers, the technical support personnel can easily identify and reach the trouble spot. The restoration of service can be so accomplished conveniently and quickly.

A communication satellite contains essentially 100% back-up (except for solar panels) for all of its critical subsystems to prevent catastrophic failure.

The achieving of point-to-multipoint connectivity with a terrestrial network is extremely expensive, since the cost of adding cable or microwave facilities to reach service points is roughly proportional to the number of points. In contrast to satellite broadcasting, there is usually no economy of scale in delivering broadcast information terrestrially. In using the terrestrial telephone network, data communication users find that they are forced to pay high monthly lease rates for private lines. A number of organizations such as stock brokerage houses, airlines, department store chains, oil companies, and car rental agencies, must maintain nearly continuous data links with hundreds or thousands of branch offices and stores, even though only a small amount of data is being sent to one specific site at a particular time.

## 1.6 Satellite Communications and Databases

The satellite communications via INMARSAT are now accepted and commonplace in the maritime community. It is not the only form of new technology which has become established in shipping in recent years. The other is computers, and when the two came together, they gave birth to a third, known as "telematics". It is this, the boom in available information on ship and on shore, which is showing signs of having the greatest impact on shipping in the future.

Today satellite communications is being talked about in terms as absolute as the "missing link" in achieving the rational ship. The role of the computer is information management. The collected information can be presented directly for human consideration or selected for automated response. On board ship, the available information is geographically constrained both in its sources and in its application. What it presents is determined by the available databases on board and/or the sum total of the local monitoring sensors. This means that the ship must be self-sufficient on all the data references it is likely to need and the crew members must be capable of responding effectively to all the information.

In real terms, what this has meant to date has been great strides forward in handling of engine and bunkers monitoring, of maintenance schedules and on board spares management, of cargo loading and payroll calculations. The real problem has been in collecting the software right for the job the computer has to do. In addition massive investments still have to been done in computerization of shipping companies. There are a few companies with new developments such as KBS ship of Denmark, and Black Box of Germanische Lloyd etc. who have developed such systems. It is seen that satellite communications link any ship to many shore subscribers almost anywhere in the world. As such telephone and telex are normal and are as easy to use as those in the office. This applies to facsimile too. The data transfer has a full error correction capability and is reliable for computer connection and VDU presentation.

The ship earth station can be connected to any on board equipment, either directly or through some processing or discrimination device, including a computer. This means that any on board network is fully accessible from shore. The network can gather all the conventional areas, including engine performance and condition, fuel consumption, ship speed and heading and cargo condition. It could also include navigational, weather and sea state information. It can include database information such as maintenance records, equipment condition, engine logging, supplies and crew information.

From the point of view of the ship at sea, the vessel equipped with satcoms and a computer has access to any computer-based technical information relating to equipment, including engineering drawings, currently only available via facsimile. In the shipping world there is the problem of providing up to date drawings and plans. In the majority of cases plans are not updated as plant modifications take place, which results in time wasting at a later date when reliable information is required. From the maintenance and spare parts point of view any drawings and equipment part numbers must be kept current if they are to have any meaning.

It is now possible to overcome some of the problems with updating and transmitting plans and drawings by using a system which can electronically scan and convert to digital form, the document in question. This system can rapidly convert large volumes of paper records into electronic filing systems and databases.

The master will be able to draw on dedicated maritime databases that will inform him about dangerous cargoes or update him on port information. He no longer needs to carry a library of references and regulations much of which can be out of date. He will use electronic charts, automatically updated and will have access to Notices to Mariners as soon as they are published.

It is seen that not all these databases are commercial. The US government's Defence Mapping Agency (DMA) has given the maritime community access to its Automated Notice to Mariners System (ANMS), a scheme developed to automate the considerable task of updating the DMA's published charts. The service is provided free of charge to DMA Navigation Product users and provides chart corrections, navigational warnings, information on lights, oil rig locations and bulletins on acts of piracy and terrorism.

For instance, in today's terms, shipping technology already presents a number of well established developments. These are mostly in areas already invaded by computers on their own. An elaborate computerized maintenance system installed in a tanker company enables the office to monitor the vessels progress. This keeps an eye on patterns that might be developing that could forewarn of technical or operational problems ahead. It also automatically alerts the office to requirements for new parts. It also ensures that replacement parts are where they are needed e.g. at the ship's next port of call, so that they could maintain tight liner schedules.

The result being that container ship operators are able to expedite ship turnaround considerably by means of exchange of loading data at sea. The loading computers can be linked to their ship earth station. The objective is to enable the offices in the trading route to extract the load and ballast situation of an inbound ship. They can then transmit new load details so that the calculations are complete and available on board even before the ship enters harbour.

Since cruise ships require to dispatch restaurant seating plans and supplies lists in advance of arrival and to receive newspapers and commercial information of passenger interests, these are being transmitted via computer-related means rather than hand-keyed telex. One such system is developed at Liverpool Polytechnic College in the UK, now commercialised as Mimac, provides a videotex service to ships at sea on a monthly subscription basis. In addition to a variety of data communications facilities such as messaging, ship-shore reporting and telegram forwarding, it provides port information, weather bulletins, chart corrections and new service for passenger vessels.

The mariners requiring 24 hour access to global weather information are being served by the new Electronic Data Retrieval System (EDRS), operated by Universal Weather and Aviation Incorporation of Houston, Texas. The EDRS provides standard and specialized marine meteorology and physical oceanography forecasts. These are most often used by the offshore oil exploration, and production industry and tug and tow operators, but were designed to serve any maritime venture.

All users with the need for precise astronomical and time data in support of navigation, geodesy, astronomy, space sciences and other related activities can use the US Naval Observatory's Automated Data Service (ADS). This provides status and scheduled maintenance data for the Omega, GPS, Transit and Loran navigation systems. It also offers time references and predictions and calculations for sidereal time, sunrise and sunset, time of twilight and standard time anywhere in the world. The ADS can be consulted without a specific password or identification, and users need only specify name, organization and location, in basic english.

The Institute of Shipping Economics and Logistics in Bremen, Germany has installed an electronic information and retrieval system in its Institute of Shipping Logistics information centre/library. The development started in 1986 as part of the information and documentation co-orperated for the German transport sector. The electronic storage is done with the mainframe computers of Bremen University. Since 1954 the institute collects documents relating to "maritime economics and logistics". It collects all aspects relating to shipping, ship building, ports, sea channel and water ways, traffic, transport and logistics, economy and trade. It also consists of market research, conferences, proceedings, research studies, annual report, statistics, directories, newspaper articles etc. The database "sea base" contains more than 23,000 records and covers the following:
shipping (cargo, liner, container ships etc.)
merchant fleets
seaborne trade
shipping markets
ship financing
ship building
shipping policy
port planning
port administration and management
sea canals and waterways
transport system
transport technology
logistics
safety, environmental protection
databases, automation, CAD information systems etc.

The documentation units are selected by subjects and relevance. The ISL offers on demand literature searches of current as well as other literature. All database searches are supported, by qualified library staff in accordance to the needs and specifications of customers. The ISL also offers compilation of bibliographical and statistical data. For those who want constant updating, this ISL special service automatically generates and mails the results of requested searches, each time selected files are updated. It offers full text service, and the user need not gather material himself. An on-line connections for users outside the ISL is planned for the future.

## 1.7 Modern Data Communication System

The purpose of modern data communication is to link computers and other centralized data processing facilities with remote users or with other computers. The data communication is a field in which rapid developments are taking place. Since shipping and associated operation activities increase in complexity and size, the need for efficient communication likewise increases between ship and shore, owners and authorities. The possibilities are now available for rendering the necessary communication more efficient when the cost of both equipment and transmission is being reduced. Here more communication does not necessarily mean better communication or increased efficiency. The important factors that should be taken into consideration when data transmissions are taking place are:

* quantity of data;

* requirements as regards freedom from error;

* requirements as regards transmission time;

* accessibility in all marine zones;

* routing possibilities on land;

* automatic setting-up and handling of communications;

* cost.

Quantity of Data

The quantity of data and the requirements as regards transmission time are the main factors determining the minimum speed of the data channel. The following are some of the examples:

* transmission of short messages, ETA, position etc. (few hundred characters or less);

* transmission of schemes, data concerning state etc. (few thousand characters);

* transmission of seismic data (several million characters).

It is important to ascertain which transmission speed is technically feasible and economically viable.

Freedom from Errors

The degree to which error correction should be approached varies according to requirements. In some cases the discovery of an error means a retransmission. This is only possible if the data being transfered can be recalled from the source. Presently users are required to use error correction units, hardware add-ons, or they have to prepare their own protocols to protect data communication against transmission of errors.

## Requirements as regards Transmission Time

The INMARSAT system has several types of services which can be used for data communication. Here some are operative services throughout all marine zones while others are still in the experimental stage.

* Low speed data rate (50 bps)

* Medium speed data rate (300 -2400 bps)

* High speed data rate (50k bps)

## Accessibility in all Marine Zones

The existence of the service in all marine zones will be an absolute requirement for ships which voyage world-wide. In addition, good interference free data transmission is essential, and as such the preference for satellite links.

## Routing Possibilities on Land

The maximum speeds available on traditional land lines restricts the end use to 2400 bps. The modern ISDN networka can provide 9600 bps and higher.

## Automatic Setting-up and Handling of Communications

This is necessary because a typical factor in shipping is that there is such a great time difference between the position of the vessel and that of the shipping office that none of the office hours coincide.

Cost

The cost[1] aspect plays a decisive part in the choice of the system. The expenditure must remain in proportion to the savings and a compromise will often be accepted depending on the degree of automation required and and the data speed necessary.

### 1.7.1 Low Speed Data

When there is a modest quantity of data e.g.less than one page of text, telex is usually the most suitable method of transmission. The advantage of telex is that it is an established international standard. The communication can be automatically set-up both from ship-to-shore and from shore-to-ship from a large number of countries and the investment involved in connecting up data machines, monitoring equipment or navigation equipment is comparatively reasonable. Frequently, the connecting of the equipment is only required at one end (e.g. connection of navigation receivers on board) to enable the system to be used. The telex network has error correction facilities.

### 1.7.2 Medium Speed Data

Here use is made of a telephony channel, established in the same way as an ordinary telephone communication. In practice, the transmission speed ranges 1200-1400 bps. For the purpose of maritime communication this speed is sufficient.

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[1] The requirement of speed/quantity of data etc. depends on the user, e.g. a container vessel/bulk carrier would require a slow speed and a nominal amount of data to be sent as compared with a seismic vessel/scientific research vessel which would require a very high speed data transfer as well as a vast quantity of data.

Since it is the telephony channel that is used for the transmission, via all coastal earth stations and can be routed over the entire world. The use of the system requires an ordinary data modem of the same type as used on land between the data machines and the telephone line of the satellite terminal. The data communication via telephone channels can be set-up at any time without a prior order and the charge is the same as for ordinary telephone communications.

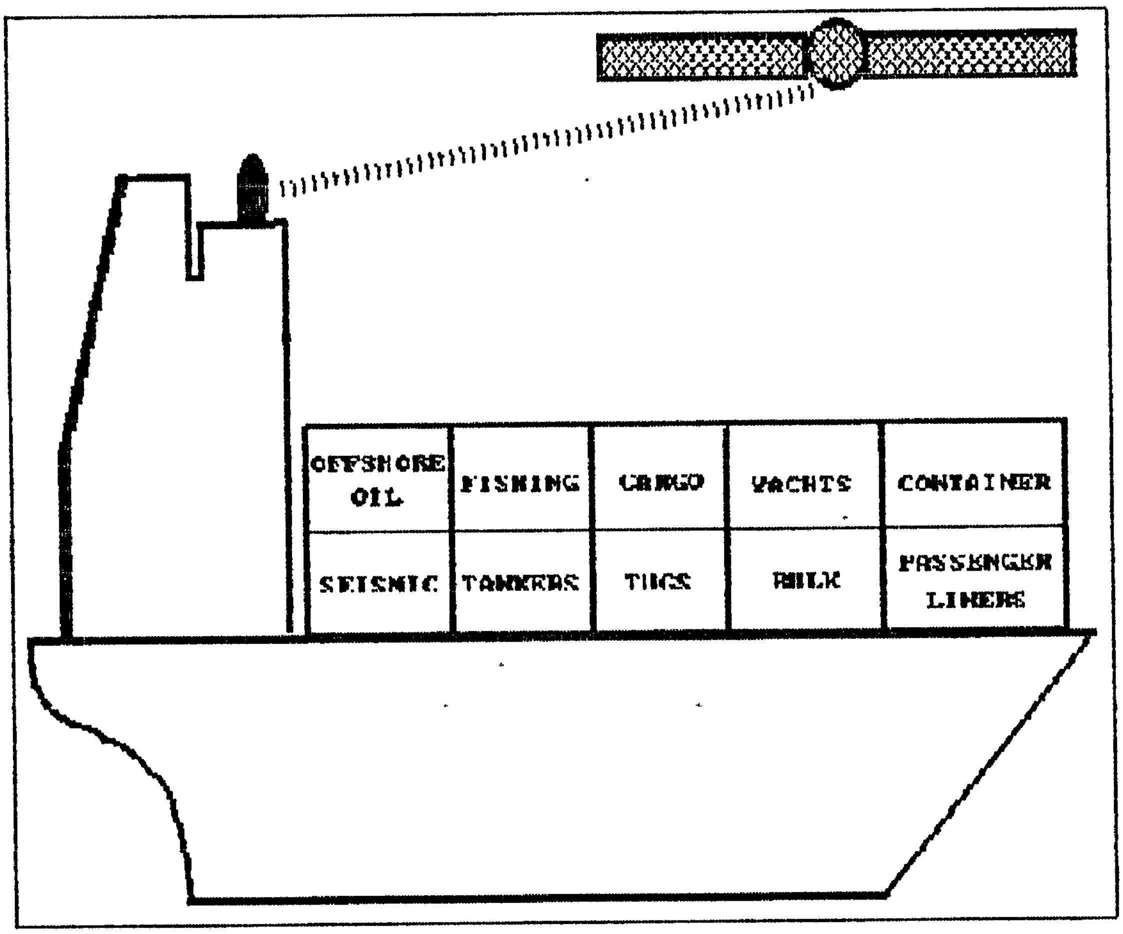


Figure 4 User Groups

### 1.7.3 High Speed Data

In the INMARSAT system this is a special type of data channel. The speed is 56 K.bit/sec in the ship-shore direction, and in the shore-ship direction a telephone channel is set-up which can be used as a control channel for error correction. The system requires a special modem in the ship's terminal and in the coastal earth station. Presently there are only a few users who employ the service for the transmission of seismic data. The service has to be ordered in advance and the setting-up of the communication is a manual process, both in the ship's terminal and at the coastal earth station.

A duplex automatic 64 Kbs service will be available via INMARSAT from the middle of 1992. This service will also utilize new ISDN land lines to/from the Coast Earth Station and the end user.

## 1.8 MARINET System

The Marinet system is one of several message switching and data transmission systems specifically built and optimised for use over radio and satellite circuits where noise and extensive propagation delays are a problem. The Marinet system uses a sophisticated full duplex modem connection and a specialized communications protocol which has been shown in practice to achieve cost savings in the region of 70% to 85% when compared with standard mediums. The advantages of such a system are:

* according to Marinet, transmission rates of 180,000 characters per minute can be achieved over good quality voice grade circuits, compared with 200 characters per minute from telex, which is very favourable;

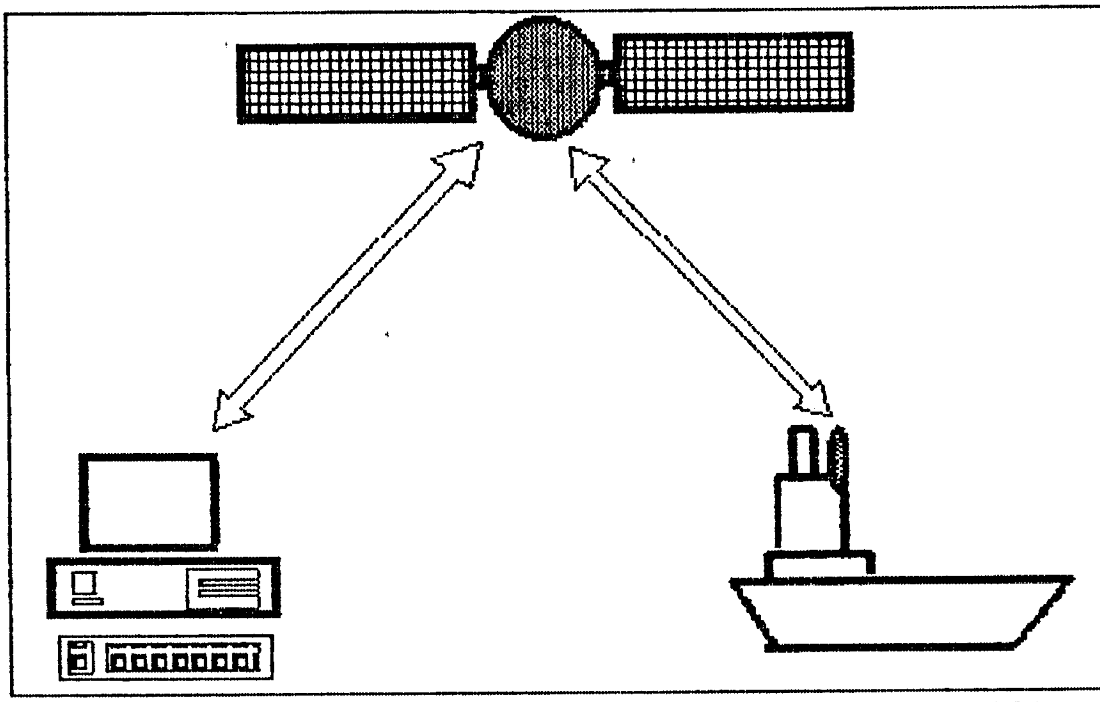

Figure 5 MARINET : Computer Communications via Satellite

* the transmissions are transparent messages and files that may contain data in any form, text files, data files, spreadsheet files or executable program files;

* it can be interfaced to public and private networks such as telex, fax, RS 232 networks, local area networks, Ethernet, mini and main frame computer networks;

* it can act as a front end communications processor to any other system;

* it is a single system capable of handling all communications, text, data, telex, and fax;

* it introduces the opportunity to increase efficiency, and any file or data ashore can be transfered to the ship's computer, and data on board can be input

directly to the office system, and it is in addition capable of operating in an unattended mode;

* the data can be compressed to less than 70 percent of the original text.

The examples of data that can be sent:

* passenger or cargo manifests

* charter parties

* bills of lading

* ship performance data

* purchasing/inventory information

* payroll

* news for your ship's press

* text or word processing documents

* financial and spreadsheet data

# CHAPTER 2

## SATELLITE COMMUNICATIONS AND SAFETY OF SHIPPING

### 2.1 The Terrestrial Safety Radio Communications

Before the invention and development of radio signals for the transmission of messages, telecommunication between distant points was entirely a telegraphic system which depended on cables and wires between the point of transmission and the point of reception. These methods as such could not be used to communicate with ships. Once a vessel left sight of land she was as such being cut off from all contact with other places at sea and on land. Samuel F.B. Morse invented the electric telegraph and devised a unique code consisting of dots and dashes representing the alphabet and decimal numbers. He also experimented with submarine cable telegraphy. The morse code was for a long period the sole wireless communication language.

The invention of radio by Guglielmo Marconi in 1895, and the development of the technology of wireless communications by several other scientists started a new era in telecommunications and maritime communications in particular.

Although radio had a revolutionary and welcome effect on communications at sea, it has always suffered from a number of inherent shortcomings, that no amount of development will ever cure. These first became clear when radio began to be applied to communications on land. The terrestrial radio systems developed quickly. During peace time the neighbouring countries enjoyed the facility of communications, It though represented a grave stategic disadvantage in war. The result being that most countries threw themselves into the development of point-to-point radio services, characterized by land stations with tremendous power and huge antenna systems.

There was a rapid development of world-wide maritime medium and high frequency radio systems. These could not be applied on board ships due to the limitation of power and designing of antennas. Due to the relatively low strength of the signal from the ship, together with the distance and effects of radio propagation of natural phenomena contributed in communication by such methods being slightly unreliable.

A majority of all merchant ships above 1599 GRT carry a radio officer on board. As per SOLAS and ITU conferences an eight hour watch period is mainly for safety and distress communications. During the 16 hour off-watch period no communications is done except for listening for automatic telegraph and telephone alarm. These arrangements are inadequate for modern business communications. The result, was that ships never became part of the day-to-day operations of their shore-side head offices.

The traditional ship-to-shore communication methods have included continuous wave (CW), morse code, radio-teletype/telex, RTX, high frequency voice (HF), and single side band. Sometimes CW and RTX are the only communication paths available.

The difficulties which were to be dealt with were:

* commercial rivalry was to be prevented as this could have a harmful impact on maritime safety;

* misuse of radio could lead to severe and dangerous situations;

* as the early transmitters had a very wide band width, two operators using these transmitters could severely hamper each others messages, including distress messages, within large areas.

To prevent such situations many countries got together and held conferences to avoid difficulties and to adapt certain rules and regulations. From the year 1903 to date many such conferences were organized and the result this had on maritime safety communications was amongst these:

* coast radio stations were obliged to receive and transmit telegrams coming from or destined for ships at sea;

* radio stations were linked to the international telegraph network;

* absolute priority was to be given to all distress messages;

* radio interference was to be avoided as much as possible;

* certain ships were required to maintain a permanent radio watch, which became compulsory after the disaster of the "TITANIC" (e.g. large passenger ships);

* adoption of SOS as the international distress call;

* ships carrying more than 50 passengers were required to be equipped with a radio installation having a range of at least 100 nautical miles;

* an obligation for ships receiving a distress call to go to the assistance of the ship concerned and to give the master of a ship in distress the right to request the

services of any ship;

* watchkeeping for ships fitted with radio telegraphic automatic alarm;

* larger passenger ships to be fitted with life boats equipped with radio equipment, references were made to the Radio Regulations adopted by the International Telecommunication Union (ITU);

* carriage of a radio telegraph installation became mandatory for all passenger ships and for cargo ships of 1600 GRT and above;

* maintenance of adequate radio watches, and proper equipment to be carried;

* the radio telegraph and telephony rules and regulations were ammended regularly as per ITU standards and were published.

### 2.1.1 The drawbacks of Terrestrial Safety Radio Communications

Until the 1970's ships on the high seas had only terrestrial radio capabilities available to meet their communication needs. The ships communication was dependent upon ionospheric propagation for long distance communications and ground wave propagation for medium distances. The terrestrial communications suffer from the changes of the ionosphere, atmospheric interference etc. These handicaps are due to the physical phenomena in the ionosphere and atmosphere and technology can do little to change them.

The present safety system as defined by the SOLAS convention of 1974 requires vessels above 1600 gross tonnage to have morse radio telegraphy on 500 KHz and for all ships above 300 gross tonnage to have radio telephony on 2182 KHz and a continuous listening watch on 156.8 MHz.

The drawbacks of terrestrial radio communications can be summarized as follows:

* the number of radio frequencies available for long distance communications is physically limited and cannot be increased;

* the successful receipt of a radio message, even a distress message depends on the propagation characteristics, the geographical location of ships, time of day and season;

* in many parts of the world the density of shipping is low and the number of coastal radio stations limited, as a result, it may under certain conditions be impossible for a ship in distress to alert other ships or coast radio stations and as such assistance may be delayed for many hours or even days;

* as the range for radio telegraphy on 500 KHz is only 100-500 nautical miles, the system depends mainly on ship-to-ship communications;

* the effectiveness of the system depends on the availability of someone to receive, hear and act on a distress signal, as such the radio officer has to keep a specified watch at all times, and the duty officer must be listening to the distress channels, (in addition radio telegraph alarm on 500 KHz is used when the radio officer is off-watch);

* as morse telegraphy on 500 KHz is used in all cargo ships of and above 1600 gross tonnage there is a need for a morse qualified radio officer;

* it is totally dependent on human operation and if for any reason the radio officer is injured or killed there could be great difficulties;

* there are difficulties in initiating and co-ordinating SAR activities when ships use different communication methods e.g. radio telegraph, radio telephone and VHF.

Under the present system vessels of less than 1600 gross tonnage do not have to carry the full compliment of expensive communications equipment mandatory for ships above 1600 gross tonnage. They do not have to carry a radio officer, or to maintain a listening watch on 500 KHz. From a safety point of view this situation is dangerous as well as contrary to the popular belief that small ships do not stay within sight of land. The ships of a few hundred tonnes are trading all over the world, often in more dangerous navigating conditions as VLCCs and giant bulk carriers, and face the same weather conditions.

## 2.2 Maritime Satellite Communications

It was as far back as in February, 1966 that the IMO's maritime safety committee decided to study the operational requirements for a satellite communications system to be used for maritime purposes.

The main reasons for establishing such a system were:

* to improve distress, urgency and safety communications;

* to limit the overcrowding of medium frequency (MF) and high frequency (HF) bands;

* to improve reliability, quality and speed of safety radio communications;

* to provide a world-wide coverage.

After much preparatory work and many conferences, in 1976 the convention on the International Maritime Satellite Organization (INMARSAT) was adopted.

The convention entered into force in 1979 and INMARSAT became operational in February, 1982 when it took over the system operated by MARISAT, an American system which had pioneered the use of satellites for merchant shipping.

The advantages were that shipping had a communications system reserved solely for its purposes.

The other advantages of this system over terrestrial radio communications are:

* instant alerting and communication with ships in cases of distress or emergency and as such improving and facilitating search and rescue operations;

* issuing safety and urgency messages;

* automatic reporting of ship positions;

* automatic navigational warning.

The trend in maritime communications are very strongly towards satellite communications for speed, accuracy and reliability. The only system currently available to the

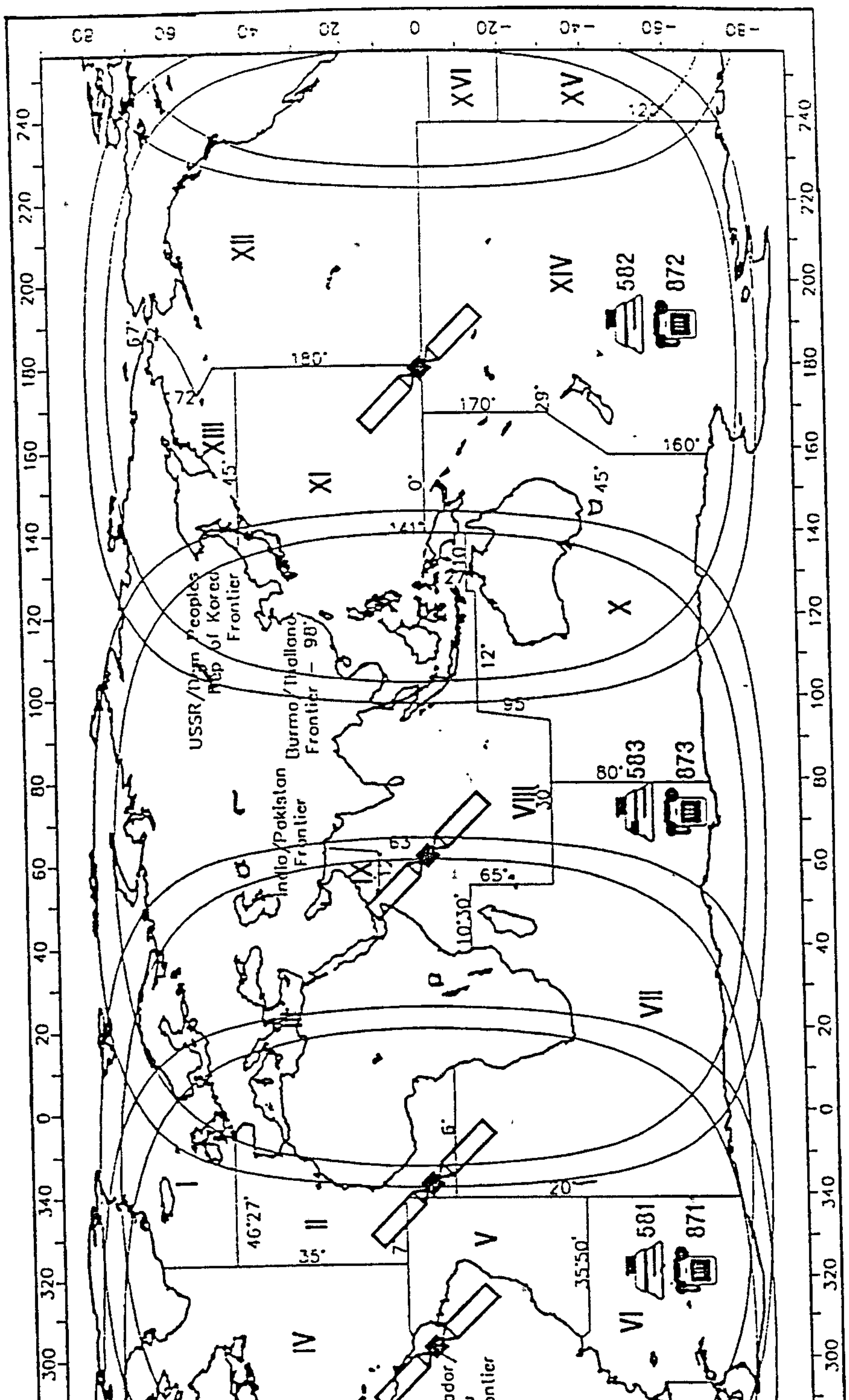


Figure 6 INMARSAT Satellite System on Four Ocean Reagons

civil sector is operated by INMARSAT, and covers the whole earth between 75 degrees North and 75 degrees South.

INMARSAT satellite system is based on four ocean regions. (Refer figure 6). These are at:

Atlantic Ocean Region East (AORE)

Indian Ocean Region (IOR)

Pacific Ocean Region(POR)

Atlantic Ocean Region West (AORW).

A second generation of satellites are now being launched by INMARSAT. These are claimed to be the world's most advanced mobile communication satellites, and are able to handle 250 simultaneous telephone calls.

From 1995, INMARSAT will launch their third generation satellites (INMARSAT 3) which will have ten times the effective capacity of the INMARSAT 2 satellites.

## 2.3 Global Maritime Distress and Safety System

It is with the above in mind and noting the major technological advances in radio communications that the International Maritime Organization (IMO) member governments decided to develop a new distress and safety system called "Global Maritime Distress and Safety System" with implementation to commence in 1992.

The GMDSS is expected to enter into force under the SOLAS conventions tacit acceptance procedure on 1st February, 1992. The new system will be introduced in stages between 1992 and 1999. It will take into account technological advances such as satellite communications, automatic transmitters and receivers and result in the gradual phasing out of morse radio telegraphy. It is a largely automated system which for a considerable part will use INMARSAT satellites for rapid and reliable communications, overlong ranges, almost irrespective of meteorological and ionospheric conditions. It will ensure that shore-based search and rescue units and vessels in the vicinity are quickly alerted and rescue operations are carried out more effectively. The GMDSS passed a major milestone when the International Telecommunications Union (ITU) approved the necessary changes to radio regulations at the 1987 World Administrative Radio Conference for the Mobile Services (WARC-Mob 87) in Geneva. The GMDSS will be a mix of terrestrial and satellite communication links and will provide for:

* ship-to-shore, shore-to-ship and ship-to-ship alerting;

* transmitting and receiving search and rescue co-ordinating and optimum communications;

* transmitting and receiving on-scene communications;

* transmitting and receiving signals for locating Emergency Position Indication Radio Beacons (EPIRB), Search and Rescue Transponders (SART's) etc.;

* transmitting and receiving navigational and meteorological warnings and urgent information.

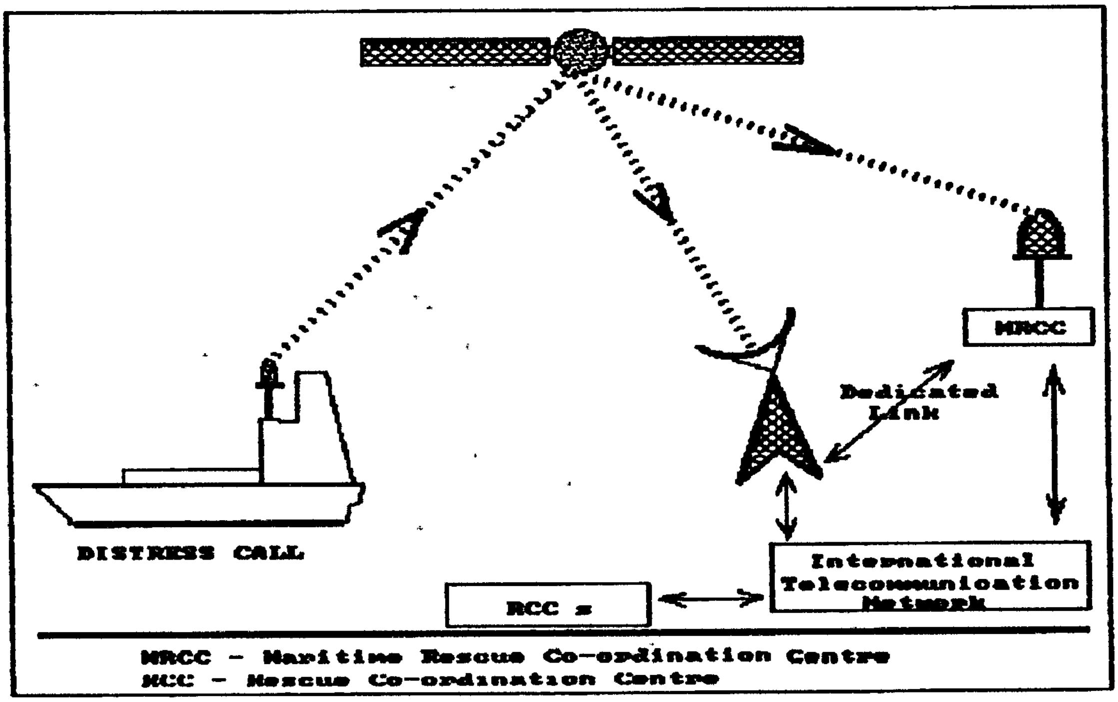

Figure 7 Distress Message Relay

### 2.3.1 GMDSS Sea Areas

Under the GMDSS regulations the required communication equipment will not be dependent upon the size of the vessel but on the trading areas.

Area A1. Within the coverage of shore-based VHF stations. This area generally extends out to 20 to 30 miles.

Area A2. Within the coverage of Medium Frequency coast radio stations (excluding A1 areas). This is the area extending to about 100 miles.

Area A3. Within the coverage of geostationary satellite excluding areas A1 and A2. This is generally the area accepted as being up to 70 degrees North and South.

Area A4. The Area outside the coverage of the geostationary satellites, namely the polar regions.

2.3.2 GMDSS Equipment

The equipment required to be carried in a specific trading area will be selected from those given below: (Refer figure 8).

1. VHF radio station capable of voice and digital selective communications

2. MF radio station capable of voice and DSC communications

3. MF/HF radio station capable of voice, DSC and direct printing communications

4. NAVTEX receiver

5. INMARSAT ship earth station (SES)

   INMARSAT A terminal

   INMARSAT C terminal

6. Satellite Emergency Position Indicating Radio Beacon (EPIRB)

7. VHF EPIRB

Additionally for survival craft equipment:

8. Search and Rescue transponder( SART)

9. Portable VHF equipment (two sets)

10. VHF homing transmitter

Distress links can either go through:

* Terrestrial links

* Copas Sarsat system

* INMARSAT links

In case of an emergency message via the INMARSAT System, the distress alert, is initiated by either a "distress button" or a code on the Ship Earth Station. The distress priority is immediately recognised by the CES and a channel will be instantly assigned. In the event that all channels at that time are busy then a channel will be initiated for other communication and allocated to the Ship Earth Station. This process is intended to be automated and will not require any human involvement. The distress call will be automatically routed to a rescue co-ordinating centre (RCC). Each CES within INMARSAT system must have reliable telephone and telex interconnections with the RCC. The RCC will alert its SAR units on land and retransmit the call to vessels known to be in the area of the vessel in distress by either Digital Selective Calling, Narrow Band Direct Printing or INMARSAT satellite.

| SEA AREAS \ EQUIPMENT | VHF | | | | MSI | | | EPIRB | | | | MF | | | | HF | | | | SES | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | DSC ch.70 | DSC WATCH RX | Com ch.6,13,16 | Gen. Com. | NAVTEX | EGC | HF | 406 MHz | L-BAND | VHF ch.70 | SART | DSC on 2187,5 KHz. | DSC watch RX | R/T on 2182 KHz. | R/T or NBDP | DSC on HF- FREQ'S | DSC watch RX | R/T | NBDP(TOR) | Standard A | Standard C | 2182 watch RX | 2-tone alarm gen. | VHF portables |
| A1 | * | * | * | * | ☐ | ⊙ | ⊙ | ⊕ | ⊕ | ⊕ | * | | | | | | | | | | | | | * |
| A1+A2 | ☐ | ☐ | * | | ☐ | ⊙ | ⊙ | ⊕ | ⊕ | | * | * | * | * | ⊗ | | | ⊗ | ⊗ | ⊗ | ⊗ | * | * | * |
| A1+A2+A3 (SES OPTION) | ☐ | ☐ | * | | ☐ | ⊙ | ⊙ | ⊕ | ⊕ | | * | * | * | * | | | | | | ◬ | ◬ | * | * | * |
| A1+A2+A3 (HF OPTION) | ☐ | ☐ | * | | ☐ | ⊙ | ⊙ | ⊕ | ⊕ | | * | * | * | * | | * | * | ⦸ | ⦸ | ⊕ | ⊕ | * | * | * |
| A1+A2+A3+A4 | ☐ | ☐ | * | | ☐ | | * | * | | | * | * | * | * | ⦸ | * | * | ⦸ | ⦸ | | | * | * | * |

* MANDATORY
☐ MANDATORY IF SERVICE IS AVAIBLE
⊙ ONE OF THE MARKED EQUIPMENT IS MANDATORY — ⊙ MSI
⊗ ONE OF THE MARKED EQUIPMENT IS MANDATORY — ⊗ GENERAL COMMUNICATIONS
⊕ ONE OF THE MARKED EQUIPMENT IS MANDATORY — ⊕ DISTRESS ALERT
◬ ONE OF THE MARKED EQUIPMENT IS MANDATORY — ◬ DISTRESS ALERT & GENERAL COMMUNICATIONS
⦸ ONE OF THE MARKED EQUIPMENT IS MANDATORY — ⦸ GENERAL COMMUNICATIONS EITHER R/T OR NBDP

Figure 8 GMDSS Matrix

### 2.3.3 L-Band EPIRBS

The L-band EPIRBs can be used in A1, A2, and A3. They operate on 1.6 GHz through the INMARSAT geostationary satellites, and are so designed that they may be automatically activated or manually activated. The vessels last position could be entered manually or connected to a position determining device. It has a output of about 1 watt and is effective in its coverage area of up to 70 degrees latitude N or S. It will give a quick alerting (about 2 minutes) and will give 20 alerts within a 10 minute interval, and will transmit a distress message containing the ship station identity, the last position and any other information which may help the rescue. It may also carry a 9 GHz radar transponder.

## 2.4 COSPAS-SARSAT System

This is a satellite aided search and rescue system designed to locate distress beacons transmitting on the frequencies of 121.5 MHz and 406 MHz. It is intended to serve all organizations in the world with responsibility for search and rescue operations whether a distress occurs at sea, in the air or on land.

The COSPASS-SARSAT EPIRB operates on 121.5 MHz frequency and 406 MHz. It uses low altitude polar orbit satellites and complete global coverage is obtained. The position of the EPIRB is calculated by observed Doppler shifts and relayed to the closest Rescue Co-ordination Centre. As this system provides global coverage IMO has decided that carriage is to be mandatory in the GMDSS system. It is only the vessels trading in the areas A1, A2, and A3 who can replace the 406 MH EPIRB with an L-band device.

### 2.4.1 The advantages and disadvantages of COSPAS-SARSAT System

**Advantages of the system:**

* provides a position fix of the EPIRB;

* provides a full global coverage;

* COSPAS-SARSAT EPIRBs are quite small and relatively cheap, and can be used on small crafts.

**Disadvantages of the system:**

* polar orbit satellite pass with intervals which can have lengths of more than one hour;

* the four countries operating this system operate on an "understanding" basis. The future and the cost of the system has not been determined by them.

## 2.5 Maritime Safety Information

The Marine Safety Information is defined as the co-ordinated service of navigational and meteorological warnings, and alerts.

It represents vital information which the master of a ship is required to receive under the provisions of chapters 1V and V of the Safety of Life at Sea Conventions(SOLAS).

It is compulsory for the nations and ships to broadcast messages relating to marine hazards, and obligation is placed upon masters to report such hazards.

There are three separate kinds of information dealt with in the SOLAS Convention:

* Meteorological Services;
* Search and Rescue information;
* Hazards to navigation. (This is handled by the World-Wide Navigational Warning Service WWNWS).

The WWNWS extends to:

collect, exchange and collate navigational safety information;

broadcast messages in a way that can be received and understood by all mariners;

control the huge amount of raw information so that the mariner is not overloaded with irrevelent information.

To achieve this, three types of radio navigational warnings have been established, each designed to serve the needs of the mariner in a particular location by exploiting the characteristics of the radio networks he will be using.

Firstly are Navarea warnings, which are broadcasted by high frequency using morse code.

Secondly and more common are the coastal warnings. These are usually the most important warnings, and broadcasts use voice communications, both MF and VHF.

Thirdly the local warning which may be issued by port authorities and sometimes coast guards, for broadcasting by VHF voice only.

The central theme of the Global Maritime Distress and Safety System (GMDSS) is setting-up of a world-wide search and rescue plan, and establishing communication networks to support this plan. While it is vital to be able to save lives in a distress situation, it is even more important to prevent mariners needing to use these search and rescue services. It was for this reason that member states co-operated within the International Hydrographic Organization (IHO) and the World Meteorological Organization (WMO), under the umbrella of the IMO, to develop a new communication system which is designed to deliver safety-related information to the mariner in a clear, efficient and cost effective way. The IMO has decided that beginning in 1991, an increasing number, and eventually all ships over 300 tons, shall be required to be capable of automatically receiving scheduled and unscheduled broadcasts from the shore of navigational and meteorological warnings and urgent information by direct printing. This is achieved by:

Navtex;

Safety-NET of Enhanced Group Call (EGC).

### 2.5.1 Navtex

The Navtex operates on 518 KHz and provides navigational, meteorological warnings as well as other urgent messages related to marine safety. Depending on the transmission power, it covers areas up to about 400 miles offshore which is normally its coverage under normal propagation conditions (coastal regions). The mutual interference between stations is prevented by limiting the power output and by time sharing of the transmissions. The time sharing is done by dividing an area into four main groups. Here each group has six transmitters and each would be allocated

10 minutes of transmission time every four hours. Within the allocated transmission time stations would broadcast the following:

Navigational warnings

Meteorological warnings

Ice reports

Search and Rescue information

Meteorological forecasts

Pilot Service messages

Decca messages

Loran messages

Omega messages

Satnav messages

Other electronic navaids messages

Other navigational warnings

Special Services

The ship equipment is relatively simple and inexpensive, and can filter out duplicated or irrelevant messages. In the case where time allows, transmission of warnings in an alternative language, takes place.

The range limitations which are imposed on the Navtex transmitters make the system unsuitable for providing information in the oceans, and there will be many areas of the world's coastline where Navtex will not be provided, (e.g. stretches of the coast of Africa). Due to this, IMO has led the search for a further system capable of providing broadcasts over all navigable waters of the globe. After examining several possibilities it became clear that satellite communications could be the most effective answer to this problem, and the global coverage of the INMARSAT satellites provides the best solution available in a single system.

### 2.5.2 SafetyNET

**Enhanced Group Call System (EGC)**

The enhanced group call (EGC) allows INMARSAT to provide a global shore-to-ship message broadcast service to pre-selected groups of ships in both fixed and different geographical areas. An example of this will be for NAVAREA or meteorological forecast areas. The advantage is that ships will have the same facility as with the terrestrial communication system with the collective callsign facility. The Ship Earth Stations are addressed on the basis of:

* Individual unique ID.

* Group IDs.

* Pre-assigned geographical areas.

* Temporary geographical areas.

It is common to regard this SafetyNET as a world-wide satellite Navtex service, although it has a number of wider applications. The receiver may look like almost a Navtex receiver, and will only require an omnidirectional aerial which is very small. These receivers have already demonstrated the reliability of the SafetyNet service. The results of such trials have been able to convince the IMO to adopt SafetyNet for the transmission of Marine Safety Information to areas not covered by Navtex. This will mean that after implementation of the GMDSS every ship will be able to receive Marine Safety Information.

The satellite communication distress alert service is at its highest level of availability and is very efficient. The system is constantly and systematically monitored. The records show a 99.913% availability of the system.

## 2.6 SATCOM - Its role on Vessel Traffic Services

The primary aim of a VTS is "to assist, and possibly enhance the safe and timely passage of ships through and within the VTS area of interest".

As per the European Economic Community "COST 301" programme which is a research project on VTS, the objectives of a VTS are:

* Assistance to safety of life at sea;

* Contributing to safety of navigation;

* Reducing hazards to ships and other marine property;

* Assisting in the containment of danger and pollution arising from escape substances from ships or other sources;

* Assistance to emergency services to ships;

* Co-ordination and operation of search and rescue services;

* Assistance to ports and associated services e.g. pilots, tugs;

* Monitoring of IMO traffic separation schemes;

* Co-operation with law enforcement agencies, e.g. police, customs etc.

The VTS should include the acquisition of data on all fixed and mobile targets within the area of interest on a continuous basis. This data should contain information on position, course and speed, intentions and identifications of all those targets.

As with the introduction of GMDSS it would be wise to match the communication equipment carried on ships with VTS equipment on shore. This equipment being able to transceive:

* Voice communication by VHF, MF, HF and SATCOM;

* Data broadcast by DSC, NAVTEX, SATCOM (Enhanced Group Call);

* Possible future VTS communication system;

* Data over VHF and video text, either by VHF or SATCOM, for shore-ship-shore applications.

The benefit of such a system would be:

* Continuous real time position reporting would add to safety;

* Uninterrupted ship-to-shore, shore-to-ship communication;

* Advice and warnings could be sent directly by video text using satellites;

* Real time transmission of weather information;

* Reducing the navigator and VTS operator work-load.

The secondary messages could be sent by video text and the leaving of voice communication as a minimum for the safe navigation of the vessel, information regarding the ship's particulars, last port of call, carriage of dangerous goods etc. could be sent via SATCOM data transfer directly to the shore VTS.

# CHAPTER 3

## SATELLITE COMMUNICATIONS AND INTEGRATED SHIP OPERATIONS

A variety of systems have been developed under various projects to modernize merchant ships served by a reduced number of crew. The navigation, machinery, ship and cargo handling systems in these ships are controlled and monitored from the navigation bridge in an integrated manner.

The trends towards the expanded modernization of shipboard installations and equipment to be supervised by fewer crew are obviously pointing to the ultimate goal of "one-man control from the bridge", or "single officer on watch".

It is evident that in order to achieve a "single officer on watch" an integrated bridge is a necessicity. It is beyond the scope of this chapter to elaborate the details of an integrated bridge. I will be concentrating on the important role satellite communication plays in achieving the integrated bridge and the "single officer on watch".

### 3.1 Integrated Bridge

According to the dictionary, to integrate a system is to make it complete by linking the parts of a system. Ship-wide data networks can allow access to independent systems in various parts of the ship from a single place. A distinction of the integrated systems should be that it processes data (and as such combines shipboard functions) automatically. An integrated system simplifies manual operations, but if it entirely replaces the operator it should be termed "automatic".

An integrated bridge combines various components used in navigation, propulsion, cargo control, ship management and communication. This system enables the navigator to intervene in the vital functions of navigation, ship handling and engine room equipment on board, without even leaving his seat. In addition at the same time and in the same comfortable position, he can fulfil a bridge function in the communication on board and world-wide, with people and means of communication, on land and sea. It is seen that from such an integrated bridge it is possible for one navigator to control and operate the ship in an efficient, versatile, ergonomic and above all, in a safe manner. The "single officer on watch" is now able to give his undivided attention to supervising and maintaining safety during the voyage and to take action or make adjustments as necessary.

### 3.1.2 The Developments

In the 1960's Sperry and Norcontrol, pioneered the concept of an Integrated Bridge System.

IBM, Hitachi, Iotron and Decca followed and since then Krupp Atlas Electronic, Racal, JRC, Radio Holland, Mitsuibishi etc. have designed Integrated Bridge Systems, often supported by research institutes. Since then several studies have been performed in maritime oriented countries to further develop the "Bridge or Ship of the Future".

It is from 1963 to 1983 that the automated ship of the first generation evolved gradually, and the major was obtained, being the elimination of watchkeeping in the engine room. This small evolution was due to:

* increased reliability of automation equipment;

* the introduction of more modern technology as was being used ashore, modular components, integrated circuits,an extension of the automation program on the up to date vessels.

Since technically, most of the information data was produced from analogue to digital converter (ADC). Some systems though based on computer application were beginning to be fitted on board vessels. These were the monitoring system of the diesel engine parameters, satellite navigation and other navigation systems, integrated navigation systems, loading indicating systems covering stability, stress, fatigue potential and cargo monitoring etc.

Nevertheless, these systems did not communicate together, since they were developed separately, with no idea of homogeneity. Although they improved knowledge about the operative systems, they were not integrated into the overall ship operation automation, with the exception of integrated navigational systems. In other words shipborne computer aided systems did not co-operate, each system was isolated, as such giving poor possibilities of optimisation. One of the main technical causes of non-progress during 1964-1983 was the limited means of telecommunication which only permitted a small amount of traffic between ships, companies, customers, and shore standing databases. As a result, the marine computers, could not exchange any message with those of the company, keeping the vessel isolated when at sea. Here progress would involve incorporating the vessel in real time within the whole fleet management system.

### 3.1.3 The advantages of an Integrated Bridge

* improved operating efficiency, consistent with safety and reliability;

* better information processing on the bridge, both to enhance operator judgement, and to improve the overall control of business performance;

* better control in the shore office;

* optimum life time cost of the installation.

## 3.2 The Fully Integrated Information System (Intelligent Ship)

The increase in computing power and telecommunication services now offer the opportunity to integrate many aspects of automated ship operation. The possible entities covering machinery, navigation, shipboard and ballast, telecommunication and office automation are linked together, which offers improvements in ship operating efficiency and safety. This is mainly due to:

* micro-computer development;

* local area network spreadout;

* development of the international standards of computer interconnection: I.S.O. Basic Reference Model, I.E.C., I.E.E.E.;

* multiplication of the telecom tools, telex; international networks, satellites (300 new satellites are expected within the next 10 years);

* spectacular technology progress of information processing systems;

* corresponding increase in reliability, of components;

* increasing extent of the available program libraries;

* drastic price cut slumps in all of the above matters.

This makes all the automated systems co-operate, which consists of propulsion plant, cargo and ship handling, management, navigation, administration and business data processing. The integrated system would co-ordinate all the actions in using and managing the information flow circulating all over the ship.

The computers are to be so interconnected as to fit the large needs of a modern vessel considered as a whole and integrated into the shipping company organization. The computer systems (hardware and software) so structured, constitute the so-called Information System.

These systems have already been developed e.g. Knowledge Based Systems (KBBS SHIP Project of the Danish Maritime Institute). These combine artificial intelligence techniques (including operational analysis methods) and interfaces with sensors of on board systems.

The information system is shared into six conceptual elements called functional entities:

navigation

ship operating and voyage management

ship load and ballast

telecommunication

ship management

machinery monitoring and diagnostic maintenance system

For optimal operation of a ship it has to draw on all its systems available on board, and as such there is a need for integration of concepts and data communication. Here satellite data communication will have a profound effect on future developments.

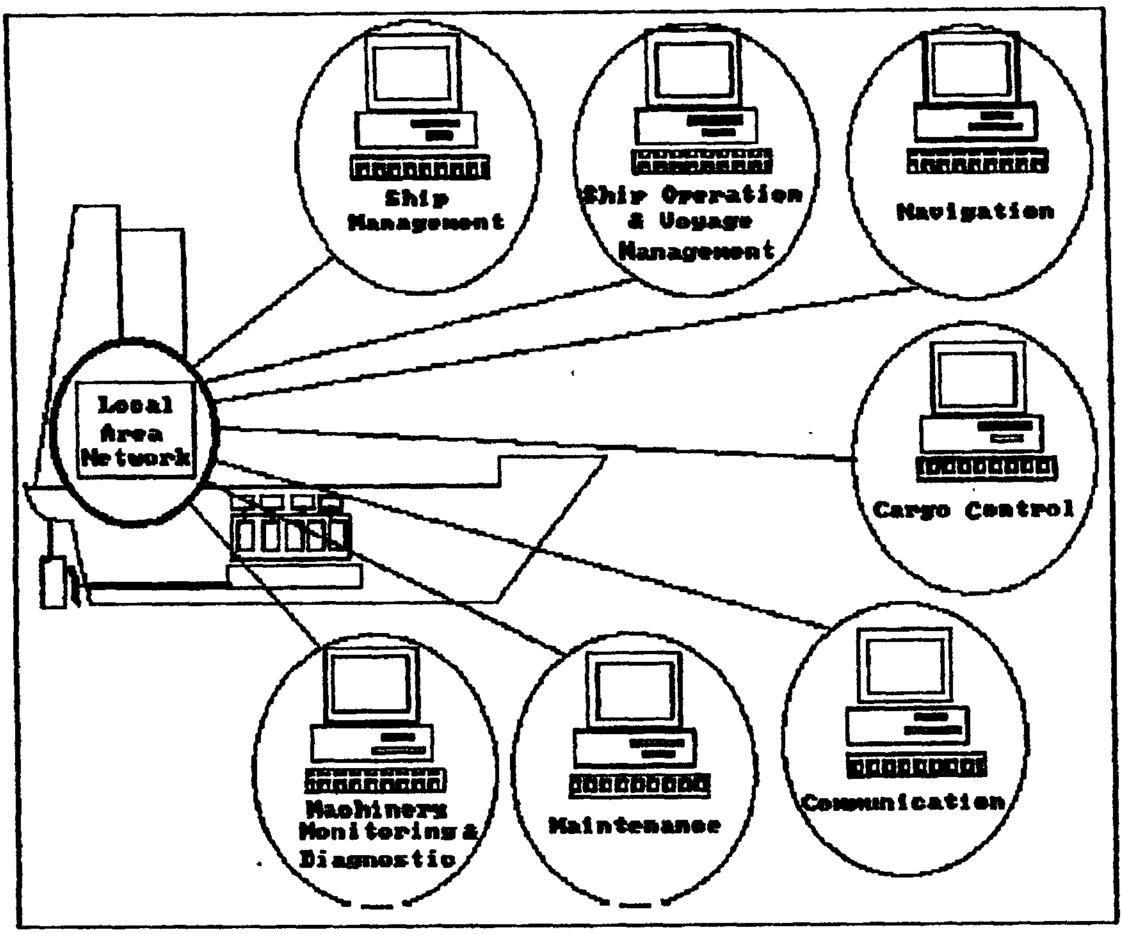


Figure 9 Fully Integrated Information System (INTELLIGENT SHIP)

### 3.2.1 Navigation

The multiplication of instruments on navigating bridges requires the operators to collect, and evaluate more and more information.

The computers and satellite communications have already introduced some aids to these tasks:

* to collect navigational and environmental information;

* to process and shape this data for possible use by the other entities or by the officers.

The advanced electronic navigation systems will play a pivotal role in future ship operations. These systems will provide centralized vessel control and will include a combination of the ship's position/status, radar, and chart information. The future DR/Loran C/GPS combination is well suited to an integrated bridge system, since it provides automatically the best position fix available. In addition a:

* Rasterscan Radar, with built-in ARPA

* Gyrocompass

* Dual Axis Speed Log

* Adaptive auto pilot

all of which are necessary for an integrated bridge system. This data is used directly by the Navigation System.

Chart Corrections via Satellites

The electronic chart display systems will comprise a major component of these advanced navigation systems. It is imperative that the database feeding the electronic chart system be maintained up to date. A chart that is not up to date with the latest correction information may be interpreted as being up to date by the mariner and could reduce the level of navigational safety.

Here communication plays an essential element on these vessels. The information on a chart is forever being corrected and updated and the key to such electronic updating is the satellite viability as a medium for sending chart corrections. There are many companies that have developed various methods of correcting charts via satellite links. One of the pioneers in this field "Disc Navigation System" used by the "Seatrans Project"[1] is described below.

The chart corrections are generated at the Norwegian Hydrographic Service which is originating from the Norwegian Notices to Mariners, which is at a shore-based centre. Here each correction is entered manually to the modified part of the chart database using a software package developed by the NHS and running on a Personal Computer. A second software package is developed to sift through the database automatically every 10 minutes, to identify new corrections, put them in message format and send them by telex to an INMARSAT coast earth station. The

[1]The "Seatrans Project" is a follow up to the "North Sea Project" which carried out first practical demonstrations at sea of a variety of Electronic Chart Display System (ECDIS) using Electronic Chart Data Base (ECDB) in 1987-88.
The "Seatrans Projects" practical sea trials were completed during september, 1990.One of the objectives of the project was to;
"Explore automatic transmission of chart corrections using recommended maritime satellite communications".

CES, sends the corrections via satellite to the ship, where they are received by the Ship Earth Station. These are fitted so that it automatically recognizes incoming chart corrections and transfers them, via a local area network aboard the ship, to the Disc Navigation System, which then updates the charts in its own database. When the system is fully operational, the corrections will be sent by INMARSAT satellite link using EGC facility.

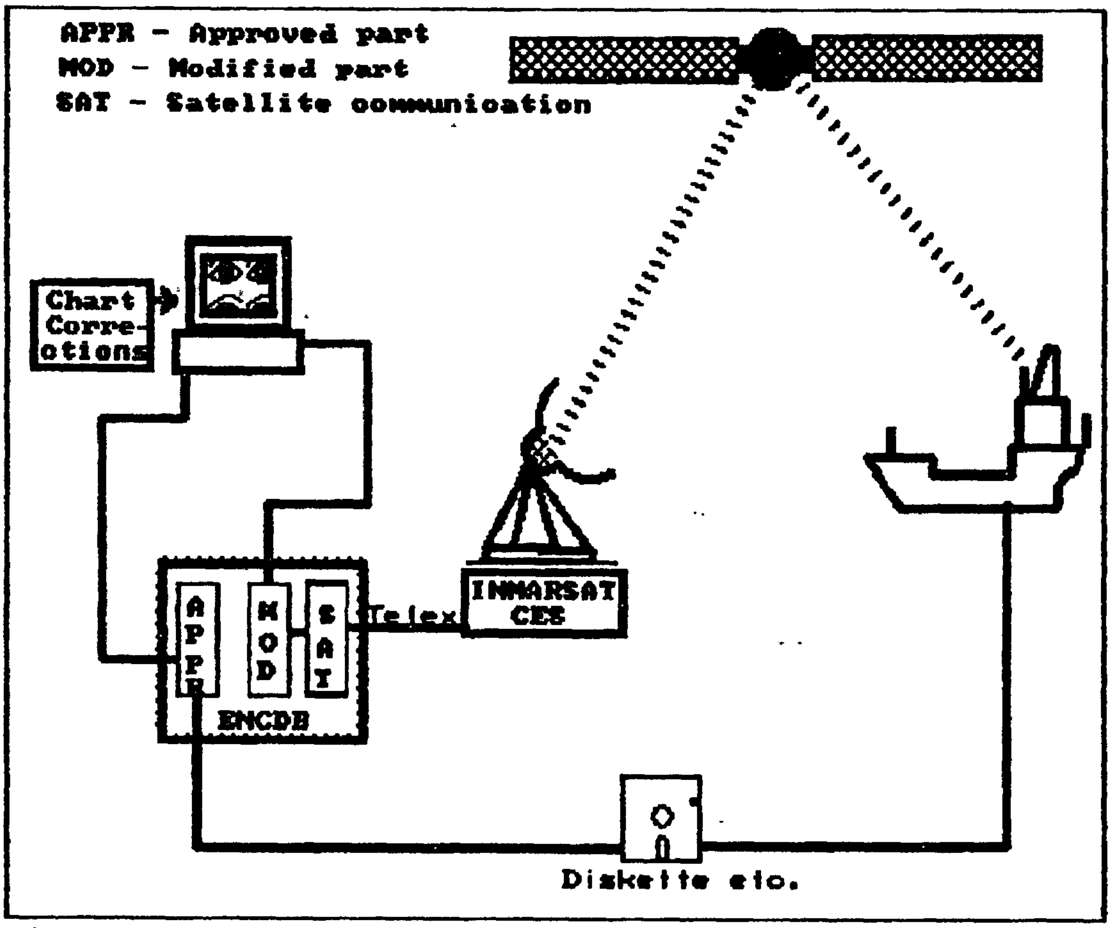

Figure 10 Chart Corrections Via Satellite

The types of chart corrections that could be sent via INMARSAT C:

* general chart correction messages broadcasted to all vessels;

* retransmission of a specific chart correction message requested by a vessel to compensate for lost updates;

* broadcast a historical account of all chart corrections registered for a cell upon request from a vessel;

* broadcast historical account of all chart corrections within a time period, upon request from a vessel.

Position Determination using INMARSAT Satellites

The INMARSAT has confirmed its intention to supply a navigational payload on its third generation satellites, which will be launched in 1995. The navigation payload , will be a dedicated equipment package on the satellite, which will transmit signals in the same frequency band as the navigation signals and will be similar to those of US Global Positioning System (GPS). The wideband navigation signal would employ modulation and coding similar to the GPS and Glonass Systems, and would be receivable on very slightly modified GPS or GPS/Glonass receivers. This will provide one or more additional pseudo range measurements for the GPS receiver, in enhancing the position determining solution and also providing an important level of reduncy.

In the near future a Geostationary navigation as well as a communication system will be developed by INMARSAT. Many navigation users also require communications, and combining the two functions in one system is expected to be less expensive than having two independent, interconnected systems.

### Integrity Monitoring

These space crafts will relay integrity information on GPS navigation signals, as well as those from the Soviet Glonass satellite navigation system. This will permit GPS and Glonass users to verify the integrity of the system's position determination capability. This facility will be particularly important for applications where extreme accuracy and reliability is paramount, such as vessel traffic system.

### Differential Corrections via Satellites

It is possible to relay GPS and Glonass differential corrections via INMARSAT satellite link. The satellite transmission is particularly well suited when the users of the corrections may be operating over a wide geographic area. A number of tests have shown that the corrections can be valid for upto 500 km from the reference. The satellite link also offers data rates much higher than the 50 bits/s which are sent presently by the terrestrial link.

### 3.2.2 Ship and Voyage Management

The optimisation of ship operation plays a major role in today's shipping industry with its sensitive balance between operating cost and freight income. The voyage management plays an important role in an integrated ship.

The object is to conduct the vessel and to fulfill requirements of the voyage as ordered by the shipping department of the company in the most profitable and safe manner.

If supplied with the main route data such as destination, estimated time of departure, estimated time of arrival, and other charter contract related data, the upper planning level of the voyage management will generate an initial route considering the relevant data such as weather scenario, ocean current, vessel characteristics, loading conditions, charter requirements, and sea keeping criteria. The initial route may also be selected from a database of previous routes for the same voyage or may be specified by the user. All the initial routes as such selected are analysed by the route optimiser which determines the optimal route nearest to each initial route, while still maintaining the specified ETA and respecting all the specified criteria as well as restrictions given by the other entities.

The long term reliable and detailed wave and weather forecasts are of paramount importance for this optimisation and the system is designed to utilize satellite transmitted digital weather data which will be fed directly into the on board computer system. The optimised route will thereafter be checked against the electronic sea chart and if accepted, the user will transfer the route data to the ship's autopilot.

The system is designed to supervise the voyage and raise an alarm in case progress along the route deviates from the plan, or fuel consumption is larger than predicted.

When the voyage management is implemented on a new vessel, a vessel response database is set-up on the basis of model test results and theoretical calculations. The updating of the database will be performed by monitoring the ship response and performance during voyages. As such the reliability of the voyage management will improve as it is being used. In addition, this facility may be used to detect deterioration of ship performance and indicate hull fouling, propeller damage etc.

It will also manage the parameters of the voyage as ordered by the shipping department of the company under the most profitable and safe conditions. It collects all available parameters which are of technical, economical, or logistic interest with a view to increasing productivity. For this, it computes expenses and revenues of each possible solution, as such making financial estimates and guiding the operator to select the best planning of dates, courses, and order of ports of call, in view of the best profit expected from the voyage. The entity proposes to the ship staff an optimum parameter combination, allowing the vessel to remain on schedule in respect of crew, cargo and equipment safety, under the most economical conditions.

The long term schedule including course selection is achieved by considering the available marine environment statistical data and records (charts, currents, tidetable, meteorological data etc.) as provided by Navigation.

The following data is considered to be strictly useful for route planning:

* wind direction /wind speed, fetch and duration;

* currents;

* speed losses of the ship in wave field;

* maximum allowable heel angles, pitch and roll accelerations.

The voyage management offers the following:

* optimal voyage planning based on forecasts on wind, waves, current and depth;

* "just in time" operation with minimum fuel consumption for ships on a fixed schedule;

* optimal steaming, considering the freight market and the bunker prices, for ships with an open time of arrival;

* optimisation of trim and propulsion parameters whenever needed;

* technical performance monitoring of hull and machinery;

* enables performance trimming;

* actual economic efficiency of the main machinery;

* additional frictional resistance of the hull due to fouling;

* the total performance of the ship to be used for voyage planning and optimisation.

On-line Voyage Management
(Refer figure 10).

Presently, the weather data concerning wind and waves is limited and is only received every three days at the most. This has to be manually done by the ship operator. On the other hand, if this data is input through INMARSAT, (which is planned for the near future) an automatic decision can be made to meet the actual ship operating conditions. It would also be possible to detect the route requiring the minimum navigation time to the destination or the minimum fuel oil consumption for one round voyage.

It is apparent that the effectiveness of the above mentioned depends to a large extent on the reliability of weather data. The input of actual forecasting data through INMARSAT, rapidly raises the practical use of this techniques.

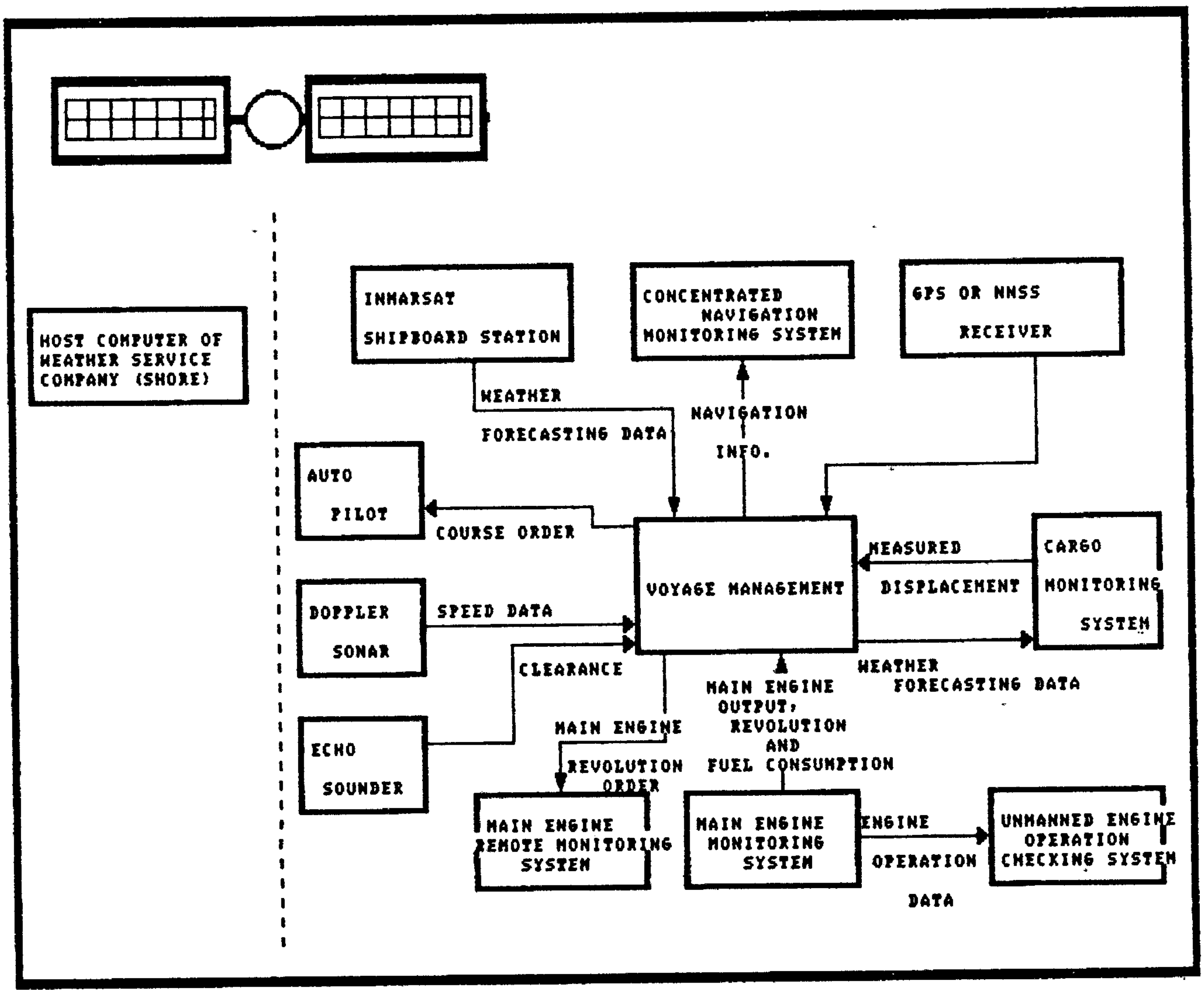


Figure 11 On-Line Voyage Management

### 3.2.3 Ship Load and Ballast

This entity offers the ship's staff and the company head office some facilities, helping to improve the management of:

* transport capacity and schedule, earning time;

* voyage fuel expense;

* protection of hull structure, ship stability, and cargo monitoring.

By having duplex communication between the ship and ashore the vessel can be operated more efficiently. e.g.:

* cargo schedule (assignment of the right cargoes to the right stowage location, right voyage);

* optimum load stowage according to commercial energy saving, stability and navigation criteria;

* proposal for sequences of loading and of ballasting pattern before each part and during the voyage;

* fast transmission of the loading plan to the vessel where the ships officers could plan the vessel more efficiently with minimum restows (which is very useful on container vessels);

* automatic tracking of containers;

* an auxiliary software can be implemented at the company computer centre to survey the development of the risk of hull fracture, for this it will analyse the hull stress records made on board and compute the remaining potential of fatigue (e.g. by using software similar to SEFACO system developed by Bureau Veritas).

### 3.2.4 Ship Management

The object of this entity is to streamline and reduce paper work and to improve both the administrative management and the link with the company head office:

* the navigation, machinery and cargo log books will be automatically prepared using all available data; meteorological, nautical, machinery parameters etc. all collected data will be memorized and duly processed with a view to editing the voyage technical report;

* it will provide, when requested, a wider range of information to ship's officers e.g. operational procedures and other relevant operational requirements on the international, statutory classification regulations applicable to particular ships etc.;

* all the statutory surveys either for classification purpose or for the national authorities, will be stored and maintained e.g. all the regulations from Lloyds Register's Rules, IMO's, SOLAS, MARPOL, National Port Regulations etc.

### 3.2.5 Telecommunication

In order to increase the ship's productivity necessitates an increase in the communication capacity with shore. This will enable the ship and the company to exchange a lot of information about machinery maintenance, trouble-shooting, investigation, paperwork, route programming, economical data etc. The telecom entity gives that possibility. It also gives the possibility to shift parts of the work from the ship to the company office or reciprocally to delegate an increased part of the responsibilities to the ship staff.

It is apparent that satellite communications is the best solution for integrated ship operations. It can offer high data flow, everywhere, as well as short access time and good transmission safety. The urgent data may be sent immediately, or alternatively it can be stored for economic batch transfer when either the vessel or the shore office initiates a call. It can give in addition the best facility of private communication in maintaining the confidential aspect.

This unit is an INMARSAT A, Class 1, Ship Earth Station, providing global, two-way telephone, telex and data links between ship and shore. It is advisable to have a dual ID option (two telephone numbers), which permits segregation of voice and data communications. The first telephone number can be placed on permenent standby, to send and receive data files automatically, without the need to establish voice communication first. The second telephone number may be used for other communications by voice or telex as required. By connecting it to a Data Communications module, messeges could be compressed and sent automatically over satellite voice channels.

As with computerization becoming more and more widespread in international transport, it has been obvious for some time that there would be considerable advantages in exchanging trade and transport data by electronic means. This could help to reduce administrative overheads, facilitate the flow of goods, shorten waiting times at ports and maximize the efficient use of transport facilities. The Facilitation Committee of the International Maritime Organization (IMO) has developed and adopted the FAL Convention, which recommends the use of 6 standardized FAL forms by shipping and shore authorities. These forms include an IMO General Declaration, Cargo Declaration, Ship Stores Declaration, Crew's Effects Declaration, Crew List and Passenger List (which are mainly aimed for Port Authorities, like Customs, which require many different documents to clear passengers and cargo). These six IMO FAL forms contain all the necessary and essential data elements to construct Electronic Data Interchange (EDI) messages.

### 3.2.6 Machinery Monitoring and Diagnostics

This entity watches the behaviour of all the vessel's installations. Any significant change in the healthy condition of a major component is automatically reported and whenever it requires urgent crew intervention, the entity dispatches an appropriate alarm to those concerned.

It also informs the shipmanager of the following:

* if the present voyage plan is inconsistent e.g. the current available propulsive power is less than the current planned propulsive power;

* if the present maintenance plan is inconsistent (as it does not cover all failed components);

* monitoring the rate of rise of all important parameters ashore and tripping an alarm in case of any abnormal increase (or decrease);

* checking their credibility to the values set by the shore superintendent for maximum performance;

* monitoring of the ship's position at fixed times and obtaining the necessary data such as position, speed, rpm, ETA etc. which could be done completely unattended, identify defect components in the engine room installation, supplemented with remedy/repair suggestions;

* prediction of consequences from the current set of defective components, in terms of safety consequences and in operational consequences (vessel manoeuvrability); identify work around suggestions to the current set of defective components.

The ship's engine components such as fresh water cooling systems, sea water cooling systems, auxiliary engines etc. are connected to sensors. The instant values of these sensors are continuously monitored, and a diagnosis is triggered when one of these values enters a pre-defined state.

The diagnostic process follows the following steps:

* diagnosis starts at the lowest level, and continues up in the modelling hierarchy;

* at each level, the diagnostic conclusion is based on local knowledge;

* the higher layers in the hierarchy determines the consequences of lower level defects.

## Remote Monitoring

In such a system, monitoring of the sensors are also done by a group of experts who are continuously monitoring the engine parameters from a laboratory. The experts are from the manufacturers of the main engine and auxiliary engines, and they have all the details of the engine e.g. test bed condition, delivery test run reports etc. WÄRTSILÄ DIESEL have developed such an expert system called FAKS (Fault Avoidance Knowledge Based System) which is an on-line system connected to the vessel through the satellite link. (Refer figure 12).

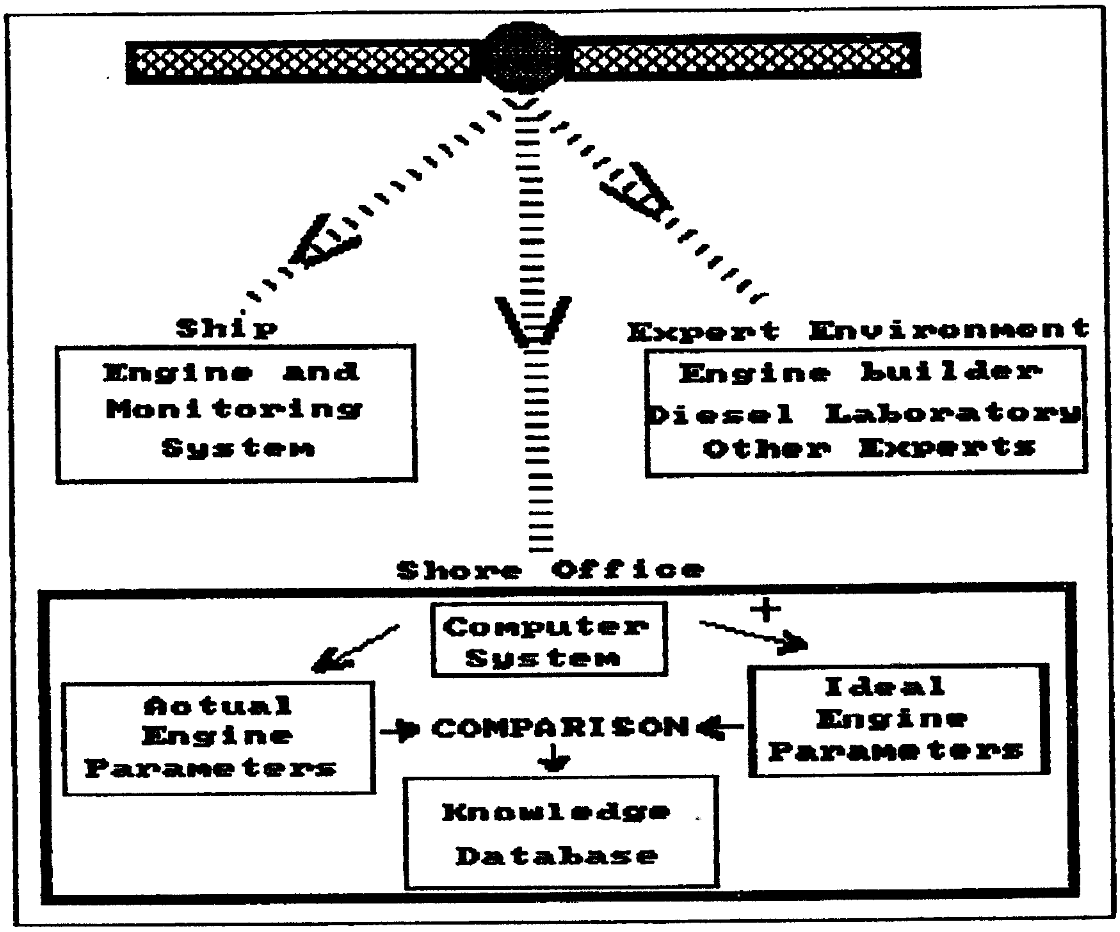

Figure 12 Remote Monitoring/Diagnostics

### 3.2.7 Maintenance System

This entity will provide a maintenance plan maximizing ship availability and minimizing maintenance costs. It will make good use of resources, and comply with various constraints that affect maintenance. The results will be made available to other entities, including the planned times of maintenance, and the expected completion times of maintenance activities.

The maintenance system is built to be used by chief engineers. They should be able to specify periods over which the system should plan maintenance, and it will allow the chief engineers to create, edit and display maintenance plans, including the ability to explore hypothetical alternatives.

The functions found in such a system:

* takes into account spares information and provides an integrated stock control system;

* maintain a record of maintenance carried out on machinery and components;

* support engineers in the reporting of maintenance work carried out;

* support the scheduling of maintenance on a 5 yearly basis down to a daily level;

* support the use of machinery condition data when constructing (or supporting the construction of) the maintenance schedule;

* provides additional information such as cost, cargo location, port restriction, ship motions, and charter contract details;

* provides condition information such as fuel quality.

# CHAPTER 4

## SATELLITE COMMUNICATIONS AND SHORE-BASED OPERATIONS

### 4.1 Fleet Management

If a shipowner wants to stay in the shipping business for a considerably long period of time in today's competitive environment, then he has very little choice but to invest in some sort of computerized vessel monitoring system, whether it be a comparatively simple engine monitoring device or an automatic polling system, covering everything from spare parts to cargo status.

The position and data reporting are not new concepts. Since the advent of marine radio, ships have been able to inform the head office of their position, estimated time of arrival, and other necessary information. In the opposite direction, the shipmanager has been able to give commercial instructions as regards the ports of call, berthing arrangements, crew changes, and bunkering details.

During the last two decades, this traditional relationship has been undergoing a change with more and more of the ship's management functions being undertaken from ashore. The main reasons for this change are:

* the pressure for decreased manning levels, particularly amongst the fleets of the industrialised nations, has meant an increased work-load for those officers and crew remaining, and it has been necessary, both in the interests of efficiency and safety, to transfer some of the decision making and general ship management functions ashore;

* the introduction of secure, high capacity, global satellite communications links in the 1970s and 1980s has made such transfer of responsibility on a day-to-day basis technically feasible;

* prices of networking systems for microcomputers are falling almost daily;

* an increased use of data based tools at the offices.

In order to be an efficient monitoring system it is absolutely necessary to have a accurate and reliable positioning system. These positioning systems have already being developed e.g. the Global Positioning System by USA and Glonass of USSR. It is with such a global, continuous and reliable position fixing systems that the possibility of continuously tracking a ship over the entire navigable globe is possible. This makes implications for tracking highly dangerous or highly valuable cargoes, and for monitoring the vessels' positions in hazardous areas. In addition besides the owner there may be large number of different organizations which may be interested in obtaining the ship's latest position including coast guard and environmental agencies, underwriters, brokers and agents.

### 4.1.1 INMARSAT Position Reporting and Surveillance Service

This service is intended for land mobile and maritime users, and will provide a cost effective transfer of position reports (with or without ancillary data) from mobiles including ships to fleet headquarters. The position report messages can be:

transmitted at regular intervals;

transmitted at the discretion of the ship's staff;

activated by polling from the fleet headquarters.

The message consists of upto three packages of information. The first package contains standard information such as the position of the vessel, identification, and estimated time of arrival (ETA) of the vessel at its intended destination. The two remaining packets are used at the discretion of the operator, and he decides the content.

The position of the vessel can be determined by any navigation sensor (such as GPS, Loran C, Decca, Transit, etc.) which will be interfaced to the Standard C of the vessel. (An integrated communications and navigation terminal, based on INMARSAT C and GPS, could provide this facility). They also have similar system descriptions, with the divisions between ground, earth and user segments. Here both provide global coverage, and even have similar operating frequencies).

The communication link between the coast earth station (CES) and shore-based station may consist of a packet switched data network (PSDN), circuit switched data network (CSDN), public switched telephone network (PTSN) for voice band data or telex.

In such a position reporting may only be used at infrequent intervals (perhaps once a day). The vessels may use only the basic position format. The output of the ship operator could be something as simple as a telex printout when the vessels send their position reports. The position could be entered manually.

### 4.1.2 On Board Automatic Data Reporting System (ODARS)

The situation where the shipowner may want more information than a position report, such as:

an extract of the daily bridge log;

distance run;

fuel consumption;

wind direction and sea state etc.;

speed;

course;

position;

cargo conditions;

engine performance etc.

The vessel could be displayed in real time on a map on the screen at the ship operator's office. Since world-wide coverage is essential GPS interfaced with Standard C is the ideal choice for the vessel. The position reports and messages are stored in a database where it could be examined by the ship operator.

### 4.1.3 Electronic Fleet Management System

This is the ultimate in data-transmission, and processing. In the present day environment the move towards reduction in manning will demand reliable display and manipulation of data some of which is presently held ashore.

As with a fully automated ship, data transfer between ship and ashore would be frequent. The more the automation, the more information is required onshore to analyse performance, efficiency and safety. An INMARSAT A or M could be used instead, as two-way data messaging service is needed. The frequency of data transfer will determine the frequency at which the vessel's position must be determined and an electronic position fixing system becomes an obvious requirement. The functions of an EFMS could be extended to cover all aspects of fleet management, including fleet performance monitoring, spare parts management, fleet preventive maintainance programs, fleet payrolls and personnel management.

The need for some of these aspects to be monitored ashore are shown below.

## 4.2 The need for Computerized Planned Maintenance System

All seafarers have been practising maintenance for years. In earlier days ships were mostly controlled manually and automation was rarely used, and maintainance was more transparent than today and crew numbers were substantially high.

It was not logical and necessary to have an on board maintenance system in older days and people once joined the vessel continued to stay on the vessel for a longer period and often came back to the same ship. The ships were staying longer at ports and on board, maintenance of the main engine and other equipment was conducted in an efficient manner of providing satisfactory operation.

It is a fact that a piece of machinery or equipment is more likely to break down the more it is being used. The break down by its very nature can happen almost at any time and anywhere. These failures which could not be repaired led to the loss of lives or the vessel. To avoid that large MTBF's, the redundancy of the equipment should be provided for and also a well managed preventive maintenance system should be carried out. It is with computerized planned maintenance that the situation can be controlled by having the equipment maintained at pre-determined intervals, taking into account past history, checking that the spares are available, and printing the work orders.

## 4.3 Control of Spare Parts

In ordering spare parts for the ship the purchase order passes through many hands from watchkeeping engineer to the chief engineer, captain, radio officer, purchasing manager, marine superintendent, spare parts company, customs, and ship agent.

The chances of making an error when sending such a message through so many links is large and the time involved is enormous compared with modern communication methods.

In a computerized system, the type of the component, with the reference number, is entered into the system and the spare parts are linked to this component with the proper name and manufacturer's reference number. This requisition is linked to the component, generated and produced by the computer, and the same numbering system is also available in the office where the purchase order is generated. In this there are hardly any chances of making an error and the case of a wrong part arriving on the vessel is eliminated in this system.

A computer system provides accuracy. Once the number is entered correctly, it goes from ship to supplier without alteration to component name, type, serial number and correct part name and number.

This system has many advantages:

* it can quickly calculate the number of spares used;
* it can easily produce inventory checks;
* it can easily find or display a requisition/purchase order;
* it can list outstanding purchase orders;
* it can read old listings for components;
* it can list history of failure of break downs, written between specific dates;
* it provides simpler means of transmitting information to the head office.

It can produce statistics for:

* MTBF, MTTR,;
* time spent on planned maintenance for each component/ group/system;
* costs of maintenance.

### 4.4 Document Management

The advent of computers into the office environment has not necessarily reduced the paper work-load, even though it has enabled data collection, analysis and distribution to be handled more effectively and faster than before. In the shipping world the provision of up to date drawings and plans is an ever present problem. In the majority of cases the plans are not updated as plant modifications take place, with resulting time wasting at a later date when reliable information is required. Thus from the maintenance and spare parts point of view any drawings and equipment part numbers must be kept current if they are to have any meaning.

It is now possible to overcome some of the problems with updating and transmitting plans and drawings by using a system which can electronically scan and convert to digital form, the document in question. This system can rapidly convert large volumes of paper records into electronic filing systems and databases.

The main component of such a system is a digital scanner. It scans the document in an electronic beam in a series of parallel sweeps. Here each picture results in one scan line of 7,200 side by side black and white dots known as pixels. The pixels are collected into 16-bit words and sent by interface cableing to the work station at a rate of 2 million pixels per second (an A0 size document can be scanned and transferred to disc in about 20 seconds). The time includes data compression which produces a balanced and uninterrupted data flow. The data is collected onto a hard disc where it is available for use by the operator.

Once on disc the data can be stored, either by disc storage or by magnetic tape, retrieved, displayed, edited or transmitted. To assist in these tasks a high resolution screen, with provision to zoom in for close-up views of any part of a drawing, an editing tablet and a hard copy printer are added. There is interfacing with a modem for external communications. By linking with the office management through satellite communications a very efficient maintenace, spare parts control, dockings and damage reports etc. could be carried out.

The advantages of such a system:

* the document can be electronically edited, indexed and retrieved;

* the document can be transmitted over conventional telecommunication facilities;

* the document can be merged with computer generated text and graphics;

* the document becomes easier to index and file.

## 4.5 Photo Transmission via Satellite

The still and moving video is one of the most exciting applications of computers since the invention of word processing. While it took more than 10 years for communications and local area networks to become an important complement to word processing, it took only a few months to grasp the importance of being able not only to create images, but also to communicate with images.

As with today's existing products, you can display live moving video on the screen of computers. The video signal coming from a video camera can be manipulated by the computer as ordinary graphics. One can zoom, re-size, rotate pictures, change colours, create contrasts, or even use special effects. The most important of these being that one can save one frame as a file, compress it to reduce its size, and transmit it via an ordinary modem to the office ashore where it can be incorporated into any desk top publishing software.

The INMARSAT A terminal can also be used to handle transmission of still pictures from the field to any office. Here different manufacturers with world-wide support now offer a wide range of analogue and digital portable equipment for transmitting, receiving and processing high resolution colour photographs in less than five minutes. In this respect INMARSAT is currently evaluating new technologies. Many tests have been conducted and extremely positive results have been produced.

One of the major issues has been the transmission cost, and INMARSAT has been investigating into image compression techniques. A colour picture ( of 256 different colours) can easily occupy 500 Kilobytes of hard disk space. A newly developed image compression technique can reduce this compression rate from 2:1 up to 100:1 with some resolution losses for higher compression rates. The 500 kilobyte picture can easily be compressed to a 50 kilobyte size. As with a 9600 bps modem and the suitable modem, this will take less than 90 seconds to be sent via satellite.

## Applications on Vessels

As with regard to repairs on board, the chief engineers can transmit photos of damaged equipment to manufacturers /marine superintendents etc. and seek technical assistance as and when required. They can in addition monitor the live repair being carried out on board. Although this may seem an expensive way by the image compression technique, the satellite communication cost could be cut drastically.

The underwater repairs and hull inspection could be carried out and monitored from the shippng office.

The cruise vesels can receive pictures from press agencies and print them in the ship's daily newspaper.

The fisheries experts aboard scientific vessels can receive aerial photographs to help them to asses plankton concentrations, fish migration paths, pollution levels, etc.

The maritime insurance brokers can receive photos of marine casualty and promptly process claims.

## 4.6 Voyage Planning

This is a computerized data base system which is being used by ship operating managers, agencies and charterers.

It gathers information from different subject areas, and evaluates their individual worth, and provides optimal advice. There is information from the weather router, bunker broker or port agent, on likely weather, oil prices, or port costs before deciding on his voyage, or whether to use that router, broker or agent (e.g. World Ports from BIMCO). The data to be handled are great and has to be continuously updated. (This is usually done by satellite link e.g. port information, bunkering prices etc.). This has led to the creation of "one stop marine data base" holding a wide variety of marine industry related information under one on-line data base service roof.

The tramp operator unlike the liner operator has very little information on particulars of that area which may be little or unknown to him. After discharging his vessel he is faced with several options on where to direct his vessel, possibly involving a "positioning voyage" to reach a port where he can load cargo. He must then do a voyage plan for each option to determine his best strategy. The key figure the tramp operator will calculate is the "opportunity cost" or the cost giving a vessel the opportunity of loading a particular cargo. The methods of calculating this figure vary, as for calculating optimum, or economic speed (the speed at which a ship should proceed to gain maximum economic advantage with regard to fuel consumption, cargo opportunity etc.). Those who are largely interested are the ones whose vessels are on voyage charter rather than the ones who are under time charter.

### 4.6.1 Voyage Planning Requirement

A large amount of data has to be stored. These have to be stored in different computers and in different formats for a variety of reasons, which has little to do with the task of planning a voyage. Some of the data is fairly static in nature e.g. historical weather data, whilst the other is dynamic e.g. bunker prices. It is required to extract the relevant data from these sources into some standard form, then deliver it to the users at remote locations e.g. charterers offices and ships, enabling the users to effectively have at their command a very large up to the minute database at their local site.

* the user should have the opportunity to amend any data obtained from its data store and presented on screen.

* the user permitted to enter any other voyage and operating cost which were not automatically included, and also freight or charter party rates.

This could realistically provide an optimum voyage plan, and quantify profit/loss over the whole voyage (including the positioning voyage).

## 4.7 FleetNET

The FleetNET is an enhanced group call (EGC) service capability via INMARSAT that enables message or information transmissions to be received by a number of selected ships simultaneously.

It as well as being an important communications tool for fleet operations, also provides the facility for commercial news, sports, information and database services to be distributed to groups of maritime subscribers. Here FleetNET operates round the clock, taking advantage of the unique ability of INMARSAT's global satellite communications system to transmit information world-wide, in the certain knowledge that messages will be received whatever atmospheric conditions prevail.

### 4.7.1 How FleetNET works

The FleetNET messages are sent to a coast earth station using either telex or electronic mail. The earth station then transmits the information, via satellite, at 600 bit/sec. The special address codes ensure that messages are received and automatically displayed/printed only by the designated vessels. The FleetNET also allows for repetition of messages, where required. The frequency and number of repeat transmissions is at the discretion of the message originator, although the receiver will print messages once only, automatically suppressing any repeated messages. The messages can be sent in all the international alphabets and languages.

### 4.7.2 Equipment

The FleetNET operates through low cost, easily installed on board equipment. The INMARSAT's new Standard C terminals display/print FleetNET messages automatically. The existing Standard of a ship earth stations can be modified to provide this capability. For vessels with no other satcoms requirement, simple receive only units will be available.

### 4.7.3 The advantages of FleetNET:

* can be transmitted in any international alphabet or language;

* can be broadcast to any ocean region, to selected ships, to a fleet, or to all ships via a coast earth station;

* sending a message is as simple as sending a telex or electronic mail using store and forward techniques, where messages will be transmitted by the coast earth station according to their priority e.g. distress, urgency, safety and routine (commercial correspondence);

* can be used to update databases installed aboard ships and a single message sent to all ships operated by the same ship management company, and in addition update shipboard databases containing information on manufacturers, ship chandlers, currency rates, immigration procedures etc.

## 4.8 Integrating Ship and Shore : The Ultimate in Maritime Communications

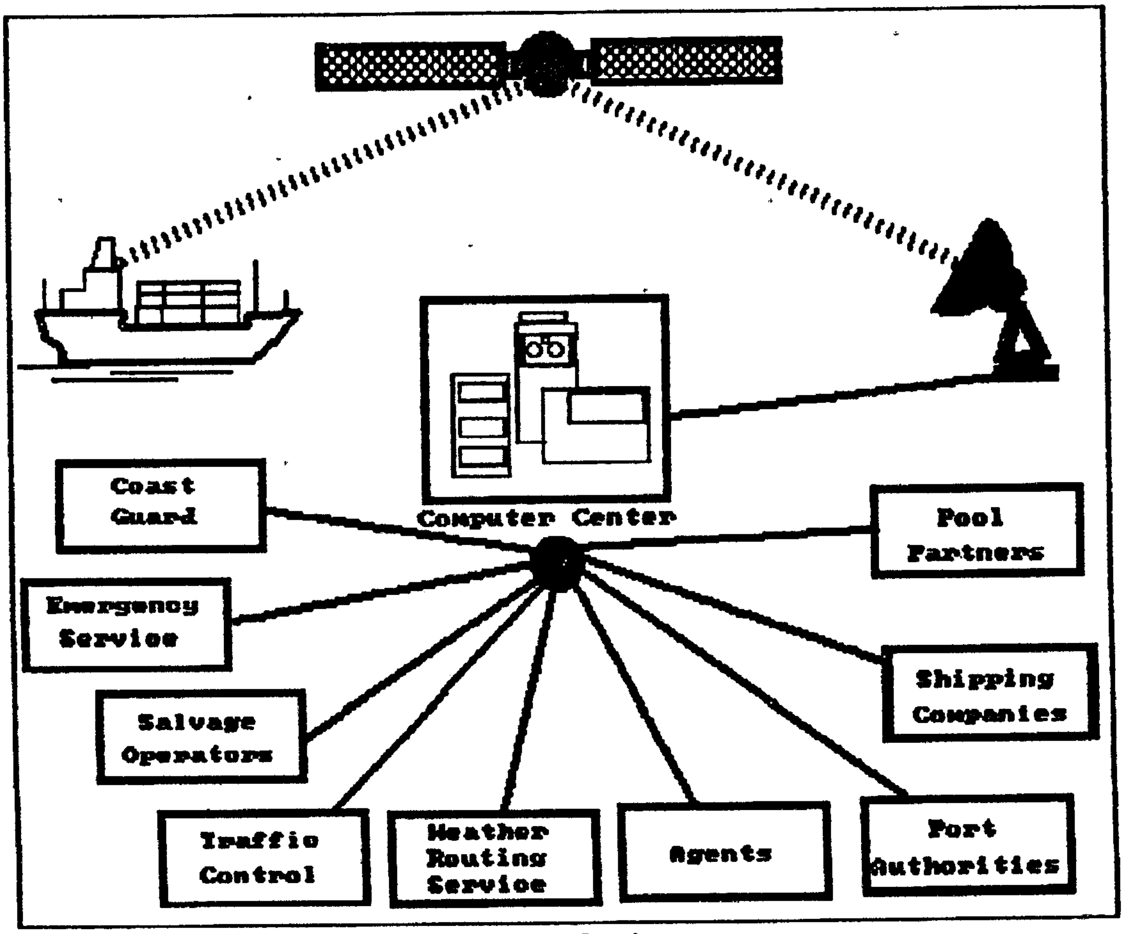

Figure 13 Integrating Ship and Shore

The principle behind this system is to extend all the well-known ship and office automation tasks by a communication interface which would allow transparent and automatic exchange and distribution of data (at the user level). This allows both the ship and the office users to treat their common subsystems as though they were installed locally, within a single site.

The system which is mentioned here was developed by Czechoslovak Ocean Shipping Company (COS) and is designed to operate with INMARSAT satellite communications covering operations both aboard ship and on shore. It is a complex and user friendly program, that enables ship operators on board to prepare text messages and send them via INMARSAT and landlines PSTN network, together with data files, to the head office (or any other shore office). On having received a call, the office system recognizes the ship code and password and switches to the appropriate mailbox. (There should be a round-the-clock standby computer at the shore office, answering ship calls). Then the vessel sends her text/data files, afterwhich she will receive text/data from the office. To have the maximum cost efficiency all redundant operations are put outside the paid period.

This means that:

* all operational text messages are converted into and processed as electronic mail i.e., they are tagged with appropriate headers and delivered to the RX mail boxes of the addressee;

* all subsystems like those for reporting, cargo planning, crew payrolls, spares control which have regular ties between ship and the office, are programmed in a way that allows, automatic "exporting" and "importing" of coded files suitable for satellite transmission;

* the satellite transmission itself takes place automatically (fully unattended or attended only at the ship side) and the highest efficiency, employing the most up to date file compression techniques, and as such file transfer is normally accomplished in a maximum of two calls per working day.

Databases and Programmes at Ship Side:

* Loading calculations (Draft survey, Trimming tables, Loading and Discharging for desired trim);

* Ship Stress/Stability Programs (cargomaster, taskmaster), assit the chief officer in planning time and hardware necessary to achieve an optimised lashing dangerous cargo planning, which ensures that safety rules and regulations regarding dangerous cargo are enforced, adequately segregated can be tracked at a keystroke, and in addition the position of specific containers;

* Ship Operating Reporting System, where all standard information can be held on the ship database, such as procurement rules, currency rates, recommended ship chandlers, address books, medical information etc. and a single group call to all ships will update the content of their databases;

* Communication Program;

* Nav Charts Tracking System;

* Provisions Control/book keeping;

* Stock/Spares Control, monitor the stock position, track spare parts, indicate frequency of use, show items which should be ordered and the value of the stock;

* Crew Payroll/Staff Records, such as holiday plans, sick leave, premiums, benefits and compute compensation for overtime;

* IMO Crewlist and Custom Forms, here the rules change quite often making compliance very difficult and with

such a system new requirements can be passed to ships in a few hours;

* Simulate damages on the vessel, making the crew better prepared to face hazardous situations;

* Notices to Mariners, these are already available from on-line databases, such as Navinfonet from Defence Mapping Agency (USA) and Norweigian Hydrographic department and can be updated every day, making navigation safer for all.

Databases and Programmes at Office Side:

* Universal Communication Support, for telex, fax, (INMARSAT links to ships), providing for despatching, checking/correcting and retrieving messages from all desktop PCs;

* Ship Management System, for all office users showing planned employment, crew and their changes, sending mail and supplies to ships and the agents data;

* Distance Table;

* World Ports by BIMCO;

* Database System covering, Reporting System, Agents Lists, Crewlists, Stock/Spares Control;

* Exchange Rates, which is updated automatically from the State bank;

* Market Analysis and Brokers Support, which is a full set of spreadsheets based on Lotus 1-2-3;

* Payrolls, Book Keeping and Personal Records, forming a complete internal accounting system.

### 4.8.1 The Benefits

The resulting benefits are enormous for both the ship and office users, as a result of the availability of a universal interface for all end users: the end user follows only one procedure in handling programs and messages, disregarding whether the party with whom he is communicating is in another shore office or a ship.

This system changes the very nature of communications for users both on shore and aboard ship. The office user, previously obliged to limit, for example, his technical instructions to several lines of telex messages or even several words of short wave cable, finds that he can now even send several pages of text directly from his desk top PC. Similarly, the ship sends fully or semi-automatically created daily operational reports, which are sorted and stored at the office database. Here each ship correspondent or superintendent at the office can access these reports or final statistics at a touch of his keyboard.

There are many communication packages available on the market, which utilize the INMARSAT voice band channel with such efficiency that it could send all the following into a 90 second interval.

The identification which consists of:

* modem synchronizing overhead;

* sending ship password, recognizing it and switching it to the right mailbox at the office.

Data from ship-to-shore:

* one operational daily report ( 350 B);

* complete crew payroll (5 kB);

* 1 set of loading data (4 kB);

* about 2 full A4 pages (65 characters * 60 lines) of text messages.

Data from shore-to ship:

* full exchange rates table (2kB);

* about 2 full A4 pages (65 characters * 60 lines) of text messages.

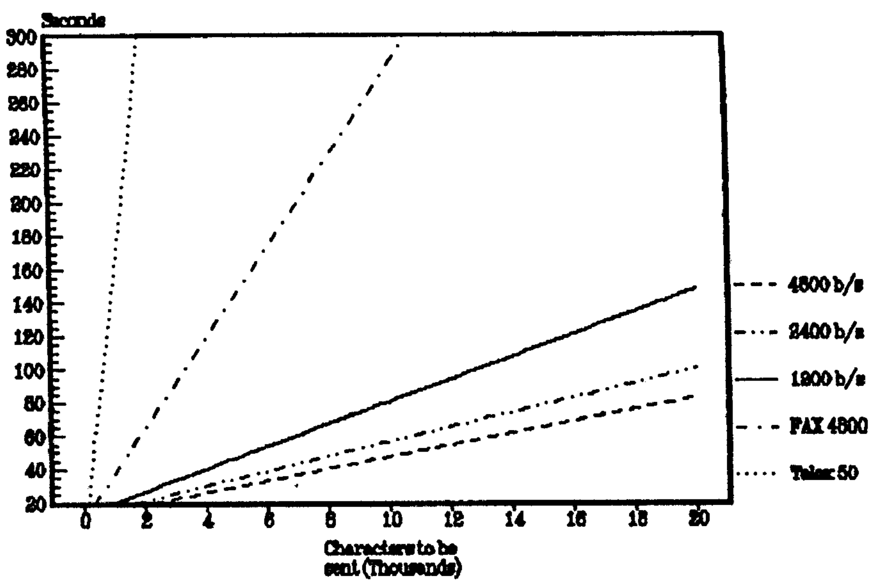


Figure 14 DATA/FAX/TELEX Compared

All this could be accomplished at a rate of 2400 b/s or 4800 b/s. In taking into account the usual phone rates which is of US$8.00 per minute, the 90 second call costs about US $12.00. It is seen that for the same price a ship can send only about 15 lines of satellite telex or only 17-20 words of short wave radiotelegram.

In considering the average operational calls per ship is 90 seconds the cost for communication for a ship per month is 12 * 30 = US$360 per month.

| PROTOCOL | SECONDS TRANSMISSION TIME | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1200 b/s | | | 2400 b/s | | | 4800 b/s | | | TLX | FAX |
| COMPRESS (%) | 30 | 60 | 85 | 30 | 60 | 85 | 30 | 60 | 85 | 0 | 0 |
| BYTES SENT | | | | | | | | | | | |
| 0 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 24 | 32 |
| 250 | 22 | 22 | 22 | 22 | 22 | 22 | 21 | 21 | 21 | 62 | 37 |
| 500 | 23 | 23 | 23 | 22 | 22 | 22 | 22 | 22 | 22 | 99 | 42 |
| 750 | 24 | 23 | 23 | 22 | 22 | 22 | 22 | 22 | 22 | 137 | 47 |
| 1000 | 26 | 24 | 23 | 23 | 23 | 22 | 22 | 22 | 22 | 174 | 52 |
| 2000 | 32 | 27 | 24 | 26 | 24 | 23 | 25 | 23 | 22 | 324 | 72 |
| 3000 | 37 | 30 | 24 | 29 | 26 | 24 | 27 | 24 | 22 | 474 | 92 |
| 4000 | 42 | 32 | 25 | 32 | 27 | 24 | 28 | 25 | 22 | 625 | 112 |
| 5000 | 47 | 35 | 26 | 34 | 29 | 25 | 30 | 26 | 22 | 775 | 132 |
| 7500 | 60 | 42 | 29 | 41 | 32 | 25 | 34 | 28 | 23 | 1150 | 182 |
| 10000 | 73 | 49 | 31 | 48 | 36 | 27 | 39 | 30 | 23 | 1526 | 232 |
| 12500 | 86 | 57 | 34 | 55 | 39 | 28 | 43 | 32 | 24 | 1901 | 282 |
| 15000 | 99 | 64 | 36 | 61 | 43 | 29 | 47 | 35 | 25 | 2276 | 332 |
| 20000 | 124 | 77 | 41 | 73 | 50 | 32 | 55 | 40 | 27 | 3027 | 432 |

Figure 15 METHODS OF DATA COMPRESSION - ADVANTAGES OVER FAX/TELEX

Above listed results in seconds are based on measurements executed over the INMARSAT Satellite network, including the path through the international public telephone network. The telefax 9600 b/s is not listed because of bad performance and quality when using a telefax with a speed of 9600 b/s over the INMARSAT system.

Source: SAIT MARINE COMMUNICATIONS

# CHAPTER 5

## MARITIME EDUCATION AND SATELLITE COMMUNICATIONS FOR SHIPS OFFICERS

### 5.1 The Present Maritime Education and Training System for Radio Personnel

The present maritime distress and safety system is based on mandatory human watchkeeping on the international distress frequency 500 KHz. It is mainly a terrestrial communication system.

The existing requirements for training radio personnel are contained in:

* Articles 55 and 56 of the Radio Regulations (RR);

* Chapter 1V of the International Convention on Standard of Training Certification and Watchkeeping for seafarers (STCW), 1978.

The requirements for ships to carry a radio officer or radiotelephone operator are contained in regulations 6 and 7 of the old Chapter 1V of 1974 SOLAS Convention as follows:

* Regulations 6(a) requires each ship fitted with a radiotelegraph station to carry at least one radio officer and, if the ship is not fitted with a radiotelegraph auto-alarm, to listen continuously on the radiotelephone frequency by means of a radio officer using headphones or a loud speaker; implying that at least three radio officers are present on long voyages. The passenger ships fitted with an auto alarm carrying more than 250 passengers on voyages exceeding

16 hours are required to carry at least two radio officers;

* Regulation 7 requires ships to carry one radiotelephone operator if between 300 and 500 tons gross tonnage and two radiotelephone operators if between 500 and 1600 gross tonnage.

The Radio Regulations specify four categories of radiotelegraph operator certificates:

* the radiocommunication operator's general certificate

* the first-class radiotelegraph operator's certificate

* the second-class radiotelegraph operator's certificate

* the radiotelegraph operator's special certificate

The two types of Radiotelephone operator's certificates are:

* the radiotelephone operator's general certificate

* the restricted radiotelephone operator's certificate

Presently there is a considerable difference in the training requirements for radiotelegraph and radiotelephone operator's, particularily regarding training duration. The basic training of radiotelegraph operators is of between twelve months and two years depending on the level of electronics and maintenance ability to be achieved and the types and number of equipment for which maintenance skills are needed (e.g. the radar maintenance certificate course is of three and half to four months duration if the examination is passed on the first attempt). A total of approximately six months of the basic training is generally needed to obtain the essential minimum standard of ability in morse radiotelegraphy.

The training for the radiotelephone operator's general certificate is of between one and two weeks duration and that for restricted radiotelephone operator's certificate is of about five days duration.

## 5.2 Training for GMDSS Radio Operators

The Global Maritime Distress and Safety System (GMDSS) which will be implemented by 1st February, 1992 and will come into force in 1999 is an automated system based largely on a mixture of satellite and terrestrial communications. The decision to discontinue the use of morse telegraphy in the GMDSS meant that the most important function of the existing radio officers would cease once GMDSS equipment and similar commercial equipment were fitted. The other important functions of the radio officer are maintenance of the radio equipment to ensure that it is continuously available for use, running the radio station, keeping records and if he is qualified the maintenance of radar, radio navigational aids and other electronic equipment[3].

The question of maintenance of GMDSS equipment however is not decided upon. The opposing arguments are:

* to include maintenance requirements in the SOLAS Convention so that the GMDSS radio operator is capable of ensuring on board maintenance, and availability of equipment at all times for distress and safety purposes

[3] Training in the GMDSS-Captain J.L. Thompson Head, Navigation Section, IMO - a paper presented on IMO regional seminar and workshop on the GMDSS, at WMU, Dalien, China, on 31st August-4th September, 1991.

and it will be mandatory to carry a radio operator with suitable electronic maintenance qualifications.

* the inclusion of maintenance requirements is unnecessary as the need to maintain radiocommunication availability and the method of ensuring such availability should be left to the discretion of the administration, in the same manner as manning requirements are left to their discretion by SOLAS regulations V/13 for all ships officers and ratings.

Due to growing pressures from shipowners who intend to keep the crew level to a minimum, some traditional maritime nations have conducted trials[4] by not employing a radio officer to perform the traditional communication services. These results have been carried out on a number of ships each fitted with additional equipment so that each radio installation was near as practicable to the proposed GMDSS carriage requirements which included the following:

* a full compliment of 1974 SOLAS radiocommunication equipment;

* a radio telegraph auto alarm;

* a tape recorder electrically connected to the radio telegraph auto alarm;

* an INMARSAT ship earth station;

* a NAVTEX receiver;

* an on board call system for the radio officer (the on

[4] The trials conducted by the Department of Transport of the United Kingdom commenced in December 1985 for a period of twelve months. (Maritime Communications and Control 26th-28th October, 1988).

board call system enabled the radio officer to be rapidly contacted when absent from the office during normal watchkeeping hours).

The outcome of these trials have indicated that:

a) no distress and urgency communications had been subject to any delay in transmissions, retransmissions or acknowledgement as a direct result of relieving the radio officer from the 500 KHz radio telegraph watch were it can be stated with confidence that the safety of these ships was not in any way degraded;

b) by cross-checking the ships' log sheets with other documented international distress incident records, no distress alert or urgency call from ships in the near vicinity of any of the trial ships had failed to be received on board during the complete trial period.

In order for ships to be exempted to carry a radio officer the following conditions should be met:
(Refer figure 16)

* The radio installations on board should comply to the standards set by the GMDSS carriage requirements;

* A strict maintenance requirement will need to be compiled to ensure the availability and smooth operation of GMDSS facilities, as well as all other communication equipment (refer appendix 1 for regulations concerning the availability of communication equipment in the GMDSS).

As per IMO GMDSS Conference for the maintenance requirements, the following conditions should be met:

## Guidelines to sail with or without Radio officer

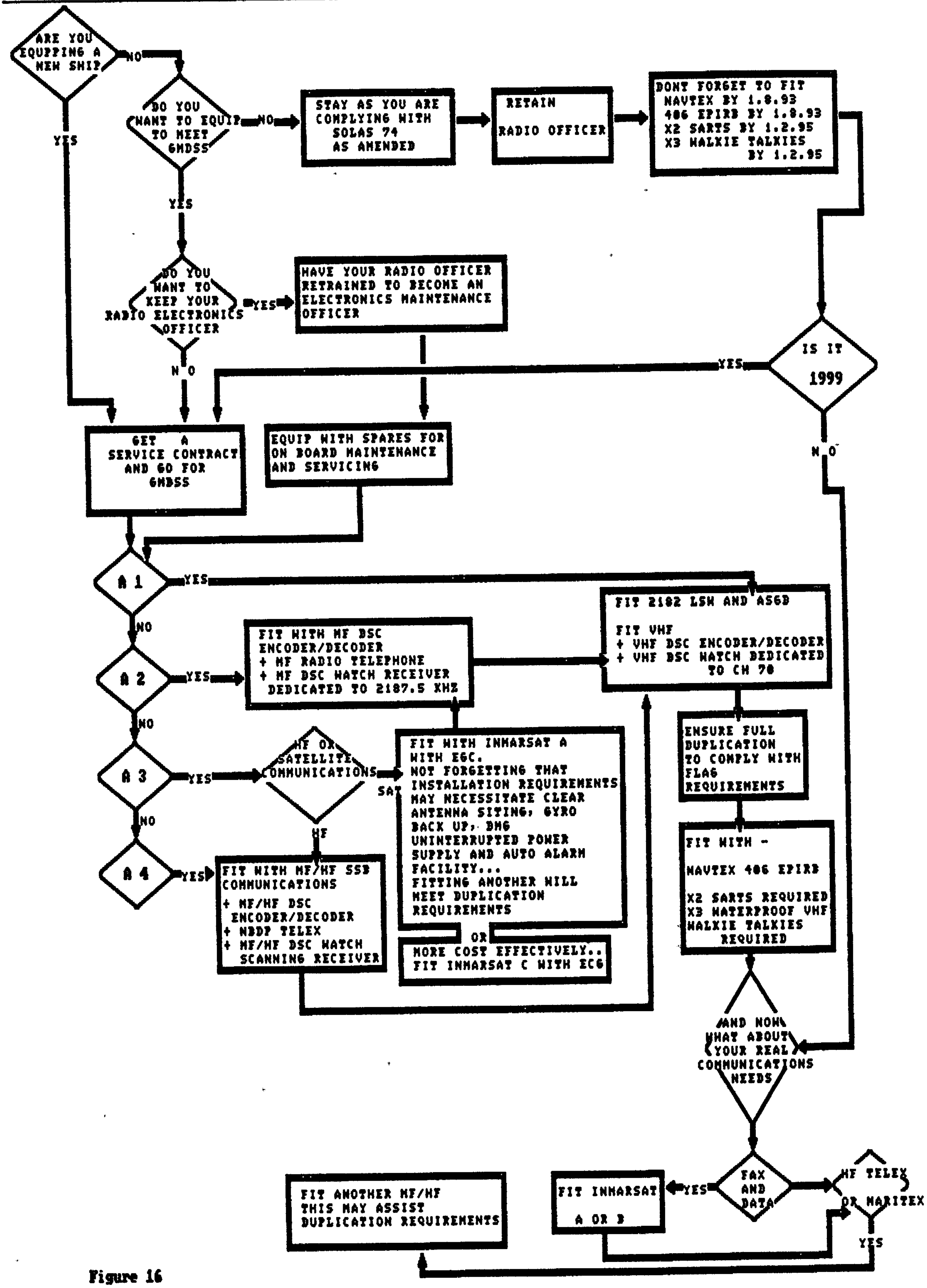


Figure 16

* On ships engaged on voyages in sea areas A1 and A2 areas, the availability shall be ensured by using such methods as duplication of equipment, shore-based maintenance[5] or at-sea electronic maintenance capability, or a combination of these, as may be approved by the administration.

* On ships engaged on voyages in sea areas A3 and A4, the availability shall be ensured by using a combination of at least two methods such as duplication of equipment, shore-based maintenance or at-sea electronic maintenance capability, or a combination of these, as may be approved by the administration, taking into account the recommendations of the organisation.

Shore-based Maintenance

Presently there are few reputed shore-based companies which offer dedicated shore-based maintenance services.
They offer the following:

* services in all major marine centres;

* highly trained maintenance engineers on 24 hour, seven day a week services;

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[5] As per report submitted by the International Confederation of Free Trade Unions (ICFTU) to the Maritime Safety Commitee of IMO on radiocommunications the following certificates are needed to enhance the availability of the equipment.At-sea radio electronic maintenance: They should be the holder of either a Radio Electronic Certificate or have an "equivalent at-sea electronic maintenance qualifications", as may be approved by the administration taking into account the recommendations of the organization, on the training of such personnel.

Shore-based maintenance: They should be qualified at least to the standard of the Radio Electronic Certificate First Class and have the required Operator's qualification. Additionally they should have had extensive sea service where they were responsible for at-sea maintenance and practical operation of GMDSS equipment.

These are particularly for ships not carrying a properly certificated maintainer. The maintenance and fault clearing on GMDSS equipment could well be "attempted" by personnel without adequate qualifications, which could result in further damage or an improper job causing it to break down when most needed.

* attractive lease rental arrangements;

* lease plus maintenance arrangements;
(to remove the financial burden of the shipowner)

* special buy-back schemes on selected equipments.

Additionally on training:

* training for maintenance and repair for all radio and electronic officers and other officer grades;

* operational training for ships officers.

## 5.3 Present GMDSS Certificates

The latest ammendments on training of radio personnel (GMDSS) (MSC 59/33, annex 23) which is expected to be adopted by 17th assembly in November, contain five different recommendations for training of radio operators to obtain five different certificates.

These certificates are:

* General Operators Certificate

* Restricted Operators Certificate

* First-Class Radio Electronic Certificate

* Second-Class Radio Electronic Certificate

* Maintenance of the GMDSS installations aboard ships Certificate

On the basis of these recommendations it should be possible with the necessary education arrangements for issue of the different certificates to be developed nationally. This has already taken place in some countries for the General Operators Certificates and many others should have their training courses in the future.

## 5.4 The need for a Maritime Radiocommunication Course

Presently, the arguments about recruitment, education, and training necessary for a radio operator on board a ship vary. The specialized expertise and training is always a problem for developing countries, bearing in mind that it takes a long time to teach persons the necessary high standards required to carry out at-sea electronic maintenance compared with that taken to train ordinary radio operators.

The training of electronic officers is in addition very costly and is of at least three years of academic studies. Since electronic technology is constantly advancing, such training programmes for electronic personnel is under continuous review. As such highly trained electronic officers will be in great demand ashore and it is very unlikely that they would continue their career at sea for prolonged periods.

In the foreseeable future safe manning of a ship on the high seas will be carried out by three qualified bridge watchkeeping officers. The future bridge watchkeeping officers will also be engaged in communication procedures and maintenance of these equipments.

This is mainly due to:

* less or no manual chart corrections;

* less or no manual corrections of other Nautical publications such as list of lights, sailing directions etc;

* less manual cargo planning work;

* less ship maintenance and planning work etc. (refer chapter 3 on Full Integrated Information System);

* less manual navigation calculations and route planning.

It is with respect to maintenance, that the author is of the view that:

* shore-based maintenance is the most appropriate one for vessels trading in Area 1 and Area 2 (e.g. North sea and Baltic Sea trade) and taking into account of the "Maintainance Non-Availability Period" (MNAP).

* shore-based maintenance, and duplication of equipment depending on the MNAP for vessels trading in Area 3 and Area 4.

This is supported by the facts that modern communication systems are very reliable and Mean Time Between Failures (MTBF's) in the future will further increase.

The features of modern systems are:

* Maintenance-ease: where systems are much more reliable than in the past and include built-in-test-equipment (BITE) and monitoring facilities which can reduce fault isolation time (increase MTBF) and it is also feasible

to design a system which is extremely reliable and can be regarded as maintenance-free during its normal operating life (theoretically, no maintenance is required). Here the design and development costs will be very high for such systems.

* Maintenance-friendly: where the system would adopt a plug-in modular replacement approach;

* Fault-tolerant: where systems fault tolerant features would include critical function redundancy such that no failure within the system could jeopardize its safe and efficient operation;

* Remote diagnosis: where maintenance could be further enhanced. In order to achieve this a good communication system and a world-wide support service from the manufacturer together with carriage of spares are necessary. (refer chapter 3)

In order to operate and maintain such systems, ships would require personnel with good background knowledge of marine electronics, computers and control engineering. Although special training for maintenance would not be required, familiarization with the principles and functioning of the main subsystems would be desirable.

It is also a fact that GMDSS is a basic requirement which will not cover all the communication needed on a ship. As shown in chapter 2 GMDSS is specially designed to deal with safety, search and rescue and does not necessarily take into consideration the commercial communication needs of the shipowners.

There are at present, two GMDSS operational certificates and their primary functions are: (as per MSC 59/33 on training of radio personnel).

General Operators Certificate

* A detailed practical knowledge of the operation in all GMDSS subsystems and equipment;

* The ability to send and receive correctly by radiotelephone and direct printing;

* A detailed knowledge of the regulations applying to radiocommunications and knowledge of those SOLAS regulations relating to radio;

* A sufficient knowledge of one of the working languages of the union both in speech and in writing.

Restricted Operators Certificate

* A practical knowledge of the operation of those GMDSS subsystems which are required for A1 ships;

* The ability to send and receive correctly by radiotelephone;

* A knowledge of the regulations applying to radiotelephony communications, specifically those relating to safety;

* An elementary knowledge of one of the working languages of the union, both in speech and writing. The administration may waive this requirement in defined areas.

It can be clearly seen that the above operators certificates represent only the minimum requirements and do not include the practice of first-line maintenance (e.g. basic fault finding and repairing, basic maintainence procedures, both preventive and corrective for GMDSS communication equipment and for radionavigation equipment etc.).

The author firmly believes that future ships officers should be trained to a level higher than present GMDSS Operators Certificate as follows:

(1) The operation on all communication equipments including equipments on GMDSS carriage rules as well as practical fault finding and maintenance as follows:

Knowledge to perform functional checks on and if necessary, to replace modular components of

SATCOM equipment

Emergency Position Indicating Radiobeacons (EPIRBs)

VHF equipment

Electronic navigation systems

(2) An adequate theoretical knowledge of electricity, radio and electronics as well as the theoretical knowledge of radiocommunication systems.

In taking all the above views into consideration the author suggests a special course which is termed "Maritime Radio Communications" to be mandatory for all ship operators.

| 5.5 Proposed Maritime Radio Communication Course |
|---|
| **Course** MARITIME RADIO COMMUNICATIONS |
| **Objective**<br>To give all officers leading up to ship's masters basic knowledge of methods of communication used at sea.<br>To understand and use efficiently communication equipments on board.<br>Ability to trace minor faults, rectify them and to read simple diagrams. |
| **Subject requirements**<br>Prior to following this course all officers should have detail knowledge of theory in electricity, electronics, radio techniques and control engineering. This is essential to understand the functions of fault diagnosis and repair of the equipment. (This is covered in their four year academic study period). |
| **Part A Training of Morse code and Basic Radio Telephony knowledge** |
| .1 - knowledge of the morse code.<br>.2 - knowledge of the use of the "International Code of Signals".<br>.3 - use of the Aldis signalling lamp and daylight signalling mirrors.<br>.4 - basic knowledge of Transmitters/Receivers and their capability.<br>.5 - basic knowledge of frequency bands and how to use them effectively.<br>.6 - knowledge of traffic methods - simplex, duplex and to use them. |
| **2 - Antennas** |
| .1 - knowledge on antennas and their construction.<br>.2 - constructing an emergency antenna in such a situation.<br>.3 - use of antennas without the instruction booklet.<br>.4 - knowledge, methods and the principles, of installations of antennas. |

| 3 - **Fault Diagnosis** |
| --- |
| .1 - should be able to read diagrams.<br>.2 - check for voltages on radio equipment.<br>.3 - measurement of voltages with instruments reading for the correct value.<br>.4 - understand the causes of the faults.<br>.5 - repair minor faults, fuses etc.<br>.6 - knowledge and ability for maintenance of electronic equipment on board ships.<br>.7 - read circuit diagrams, flow charts, trouble-shooting.<br>.8 - knowledge of principles and practical methods of preventive maintenance.<br>.9 - knowledge on recharging batteries, accessories etc.<br>.10 - ability to report to any service organizations regarding the location of the fault and to apply their instructions in repairing it. |
| 4 - **Emergency and Safety Traffic** |
| .1 - knowledge of emergency and safety traffic.<br>.2 - limitations of using radio telex.<br>.3 - radar transponders and their uses, operating procedure.<br>.4 - knowledge about life boat, survival craft radio equipment written information regarding signals of emergency and safety rules and regulations.<br>.5 - specify the distress and safety frequencies/ channels allocated in the MF and VHF bands, their purpose and permissible class of emission. |
| 5 - **Station handling** |
| .1 - read and understand publications of different stations. |
| 6 - **Sea Radio Traffic** |
| .1 - knowledge of sea radio traffic in an effective way.<br>.2 - within a 10 minutes period should be able to contact a coast and ship station by telephone, telex.<br>.3 - knowledge of english, ability to effectively communicate orally and in writing, by satisfactory completion of all written tests and communications exercises leading to the issue of a certificate.<br>.4 - ability to transmit/receive messages in a simulator.<br>.5 - radio medical systems and procedures. |

| |
|---|
| **Part B Advance course in Radio Communications including Radio Telex and Satellite Communications** |
| **7- MARITEX (HF) AND OTHER RADIO COMMUNICATIONS** |
| **Theory**<br>.1 - theoretical knowledge of electricity, radio and electronics as well as the theoretical knowledge of the radiocommunications systems.<br><br>.2 - theoretical knowledge as well as principles of radio navigation equipment.<br><br>Practicals<br>.1 - should be able to use Maritex Radio Telex in an effective way.<br>.2 - ability to transmit messages direct through automatic unmanned stations.<br>.3 - contact coast stations in a convenient and effective way.<br>.4 - message preparation and sending.<br>.5 - maritex practice on PC and other radio telex systems. |
| **8 - Satellite communication** |
| **Theory**<br>.1 - knowledge of the general principles and basic factors necessary for safe and efficient use of all the subsystems and equipment required in the GMDSS (note 2)<br>MF/ HF/VHF transmitters and receivers using telephony and NBDP<br>DSC encoder/decoder<br>INMARSAT ship earth stations (note 3)<br>COSPAS-SARSAT EPIRBs (note 4)<br>radar transponders<br>NAVTEX receivers<br>.2 - knowledge of the use, operation and service areas of the GMDSS subsystems, including satellite system characteristics, navigational and meteorological warning systems. |
| **9 - Documentation and Regulations** |
| .1 - regarding the SOLAS Convention, INMARSAT Regulations and Radio Regulation pertaining to:<br>.1.1 distress, urgency and safety radiocommunications.<br>.1.2 prevention of unauthorized transmissions. |

| |
|---|
| .1.3 avoiding harmful interference, particularly with distress and safety traffic. |
| **10 - Watchkeeping and procedures** |
| .1 - to prevent harmful interference in the GMDSS subsystems.<br>.2 - radio communications traffic, particularly concerning distress, urgency and safety procedures.<br>.3 - choice of appropriate frequencies for optimum frequencies for communications.<br>.4 - ship position reporting systems and procedures, radio medical systems and procedures.<br>.5 - to describe the general procedures to be followed when setting-up, conducting and terminating communication links using NBDP, Radiotelephone. |
| **11 - Practical Knowledge** |
| .1 - safe operation of all GMDSS communications equipment.<br>.2 - keyboard skills, ability to use a QWERTY keyboard to communicate over a direct printing telegraphy circuit using, where appropriate, recognized standard abbreviations and commonly used service codes (note 5).<br>.3 - antenna adjustment and re-alignment.<br>.4 - use of radio life-saving appliances.<br>.5 - use of emergency position indicating radio beacons (EPIRBs).<br>.6 - receiver and transmitter adjustment for the appropriate mode of operation, including digital selective calling.<br>.7 - thorough knowledge of satellite communication equipments on board.<br>.8 - communication procedures and discipline to prevent harmful interference in the GMDSS sub system.<br>.9 - knowledge of using a teleprinter with memory including methods of written messages, charging them and transmitting them to the desired station knowledge of sending telephone, telex messages via satcom.<br>.10 - practical knowledge to perform functional checks on and if necessary to replace modular components of GMDSS equipments (note 6).<br>.11 - training with satellite communication simulator exercises in the following (note 7):<br>off-line message preparation;<br>antenna positioning exercises; |

fault finding and trouble-shooting;
message switching;
fax/data transmissions;
distress call training;
system log.

.12 - communication between ships, and ashore search and rescue methods.

## NOTES AND REFERENCES

1. To satisfy the needs of SOLAS and morse telegraphy during the transition period. On full implementation of GMDSS there will be no requirement for morse telegraphy, but narrow band direct printing will take its place.

2. Includes knowledge necessary to choose the most appropriate system or frequency band for a given communications link.

3. Specific equipment knowledge will not be required and questions will be confined to system knowledge and procedures contained in the INMARSAT Users Handbook.

4. Basic knowledge of purpose and systems will be required. Reference: IMO publications Global Maritime Distress and Safety System.

5. Familiarity with the QWERTY keyboard should be sufficient to allow sufficient operating speed.

6. Functional checks as well as if necessary to replace modular components of:

(1) digital selective calling equipment;

(2) emergency position indicating radiobeacons (EPIRBs);

(3) radiotelephone equipments.

7. Training in "satellite communication simulator" is essential. A detailed description is provided in chapter 5.6

**Course Syllabus**

The administration has the authority of issuing regulations concerning a course syllabus.

**Examinations and Certificates**

The courses are conducted by the navigation schools under the authority of the National Board of Universities and Colleges. The administration maintains its supervisory role by participating in the examinations.

The certificates for the above are issued by the administration. The requirements for obtaining this certificate, are based on the amendments to the Radio regulations (ITU) and the SOLAS-convention (IMO), and the amendments to the STCW convention.

On completion of Part A and Part B, a written and a practical test is held.

To obtain the complete certificate of "Maritime Communications" all three parts must be completed together with the training in the Satellite Communication Simulator. This is equivalent to the "General Operator's Certificate". It is not possible to sit for Part B without completing Part A.

### Validity of the Certificates

The certificates are valid for a period of five years after which they could be renewed by having an oral test. The officer is required to show a minimum of one years sailing time within the five years. Failure to have this requirement would lead to the cancellation of the certificate.

### Duration

Part A consists of ten working days of theory and practicals in the radio laboratory. Part B consists of seven working days of theory, and practicals (including practicals in the satellite communication simulator).

## 5.6 The need for Satellte Communication Simulator Training

It is understood that satellite communications plays a major part in increasing the operating efficiency of most types of shipping.

One of the principal characteristics of the maritime satellite communications is its easiness to use. Here satellite communication has also proved to be of high quality, efficient and reliable than the conventional communications.

The satellite communication equipment is so designed that it could be easily operated by an unskilled person. To understand how to operate the system and to make use of its full capabilities a number of companies have developed a satellite communication simulator.

The advantages of such a system over learning by live station are:

* To learn the handling of satellite communication through a live ship earth station is be very expensive (e.g.call charges).

* A live ship earth station could only be used by one student at a time and many useful hours could be lost when teaching a large number of students, and several terminals would have to be bought, which requires a very high capital cost.

* Some simulators could be transported outside its teaching institute, where many shipowners, operators would find it cheaper to bring the simulator and the instructors to their premises rather than to send them to the institute.

* It enables the students to learn correct operational procedures in a controlled environment with instructors being present.

* It allows a person to experience critical operational situations which they may never encounter, even over a long period of time in service and the simulator will allow personnel a far wider range of operations in a relatively short space of time which in turn will increase the effectiveness of such training.

It should be realized that the traditional methods, such as lectures, visual aids, exercises etc. are not substitutes for the real experience gained at sea.

The main functions in such a simulator are:

* Message preparation;

* Message transmission;

* Message reception;

* Handling of distress communications;

* Exercises in antenna positioning (only in INMARSAT A,B);

* Learning to use the equipment correctly;

* Learning to use the INMARSAT system cost effectively.

## 5.7 Satellite Communication Simulator

It is a complete training system which is totally integrated and operating within its own environment. All the current INMARSAT features, Standard A and Standard C are included as well as additional enhancements that are expected to become operational within the next few years. Any Coast Earth Stations (CES) or Network Co-ordinating Stations (NCS) that are currently in use or planned by INMARSAT may be incorporated within the simulator. It can be used for both telex and speech communications.

### 5.7.1 Types of Satellite Communication Simulators

There are three main different versions of satellite communication simulators in the market today. The United Kingdom firm, Inpro, devised the Worlds'first satellite communications simulator. It was installed at the nautical college Leith, near Edinburgh, Scotland. It was fairly basic when compared with to todays standards and since then Inpro has gone on to develop the technology and the latest model is now operating in two Finnish nautical colleges, and at a college in Varna, Bulgaria. It is being marketed world-wide by Radio Holland.

The other two are from Marac Electronics, which is Piraeus-based firm, in Greece and Jeppesen which was developed in Norway.

The three products are distinctly different while they are all trying to do very similar jobs. All are based on IBM compatible machines but Inpro's device is available only with dedicated hardware. The Marac offers the option of software either alone or with hardware and Jeppesen is offering just software alone. The Inpro and Marac systems use an instructor's station and Jeppesen is a self-teaching aid. They all have in common the essential features required by the Inmarsat Standard A system definition manual, from which the Ship Earth Station manufacturers develop their own products, and the ability to vary many of the parameters that affect usage.

### 5.7.2 Satellite Communication Simulator Description

The Inpro system is described below

#### Instructors Console

The heart of the system is the instructor's console to which can be connected from four to thirty student simulator Ship Earth Stations (SES), which can be located up to one kilometre from the instructor, connected by a single cable. If necessary, SES terminals may also be placed further away and connected to the instructor's console via modems and the telephone system. The instructors console consists of a sophisticated 16 bit computer with keyboard and two video display units (VDU). The messages to or from the instructor can be stored, and also logs for any session.

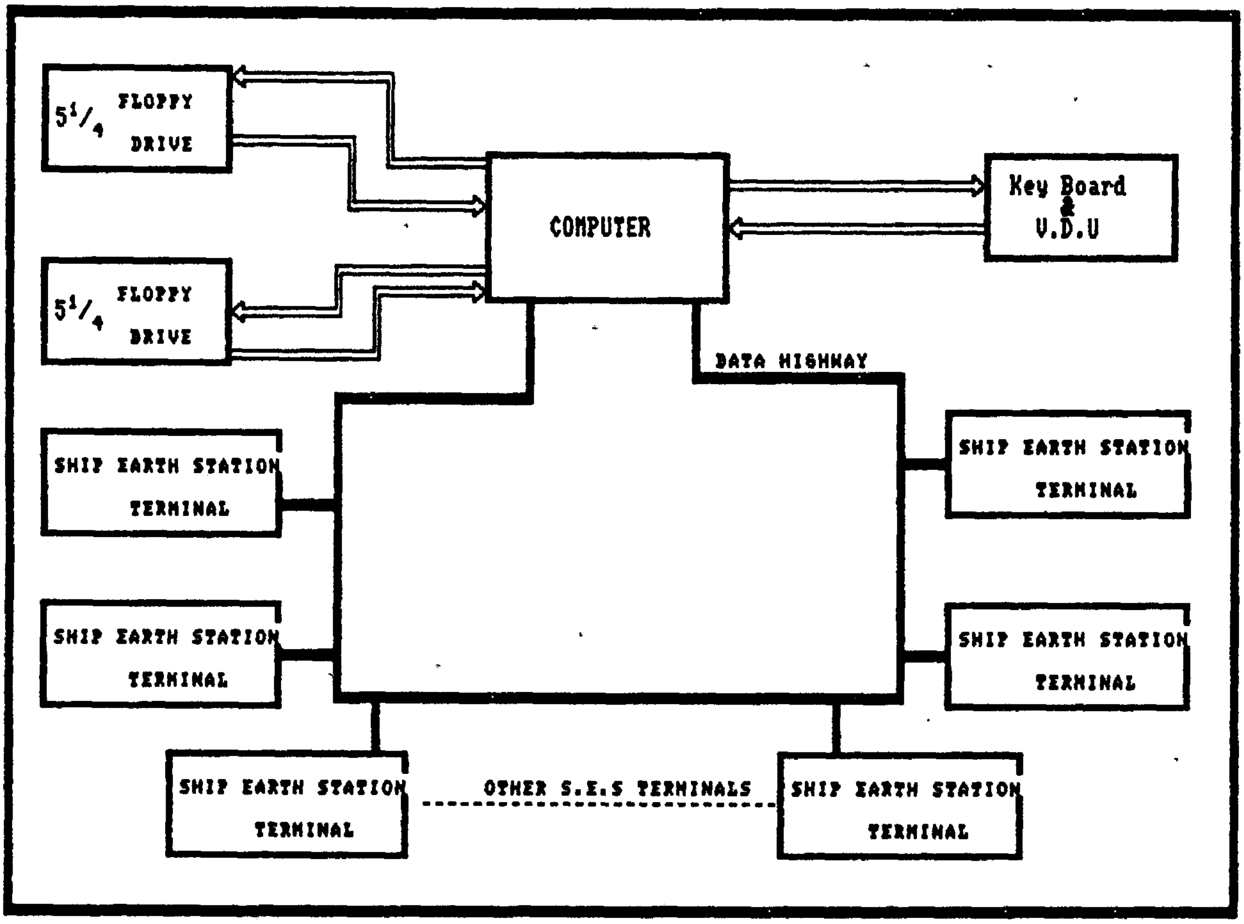


**Figure 17** Satellite Communication Simulator

The instructor can control how the complete system functions by changing operational characteristics of the network e.g.satellite position, queueing limits, coast station facilities, sun outages etc. A world map in colour shows satellites, ship and coast earth stations and pull-down windows enable details of Ships, Coast Earth Stations and satellites to be read and altered as required. The instructor can artificially position the terminal at any latitude and longitude which can also simulate the effects of different atmospheric conditions on the reception and transmission of signals. A printer is available for each Ship Earth Station terminal.

The instructor has the ability to set sea state (with high seas including some lags in signal strength). The instructor can also switch in an explanation of a problem a student may be facing. Probably the most valuable asset is the ability to select services offered by individual CESs, making it possible both to familiarize students with the real world and to alter it to reflect additions and sun outages.

The complete system is run from the instructors console. A colour graphics display screen is used to show how the system is operating at any time through the use of maps with symbolic overlays. The"pull-down" windows are used by the instructor to change any system operations. A second (monochrome) display screen allows the instructor to communicate in telex mode and to show systems message.

The instructor position automatically simulates the following functions simultaneously.

* **All Coast Earth Stations (CES)**
  The instructor can configure up to 30 CES stations each with different operational facilities.

* **All Satellite Positions**
  In addition to the main satellite associated with each ocean area there are also two standby satellites for each ocean area which can be configured by the instructor.

* **Any Terrestrial Telex/Telephone Number or SES Number**
  The country code routings are incorporated for automatic simulated connections. A current list of approximately 8000 valid SES numbers is also maintained by the system for immmediate call-up/verification.

* **Short Code Selection**
  The current range of short code selections are automatically incorporated for selection if required.

* **Diversion Procedures**
  The nominated CES stations can offer diversion routings under "distress" priority.

* **Standard C**
  The message switching facilities are incorporated consistent with Standard C operation.

* **Enhanced Group Calls (EGC)**
  All ocean area calls, national calls and fleet calls can be automatically transmitted under the timing control of the instructor. The message texts can also be varied.

* **System Management**
  The connection limits and queueing limits on the network can be imposed with automatic de-queuing.

* **System Log**
  A log file is maintained showing all network activity in real-time. This facility is useful for "billing" simulation

In addition to the automatic operation, the instructor can annualy select the following facilities:

* **Relocation of SES Terminals**
  The student terminals can be placed at specific latitude and longitude positions.

* **Conversation Mode**
  The instructor can respond to, or initiate, both telex and telephony calls with specific SES terminals.

The instructors position offers all facilities simultaneously and at all times. If a facility is requested for by a student that needs a response then "recorded responses" are generated.

Equipment at the Instructors position:

IBM PC compatible computer complete with;

Satcom network card;

Second EGA facility;

Colour display;

Second monochrome display;

Data on 8000 valid SES terminals;

20 MByte hard disk;

80 column dot matrix printer;

Telephone unit plus handset;

Terminal for connection of Fax machine.

## Student Terminals

Here each student position comprises a sel-contained "intelligent" terminal to allow for message preparation as well as for normal telex, voice communications.

The students using the Ship Earth Station terminals will rehearse all the procedures they will later use at sea, such as full simulation of the INMARSAT system, procedure sending and receiving messages by telex or speech, SOS call diversions, enhanced group calls, short code selection, including the aerial positioning techniques needed to connect with the INMARSAT network.

The student position has equipment similar to that found on any ship, whatever Ship Earth Station hardware is used. The student may operate in offline mode for the preparation of messages for future transmission, there being storage available of up to nine files of 2,000 characters each. A distress message facility is also included.

### 5.7.3 Distress Call Training

A special red key is found to generate a distress call. The distress call is generated within 10-seconds of activation of this key. The enhanced Group Calls can be received and messages directed by the student to screen, printer or storage as required.

The telex communications operate on a simulated 50 bauds around the network. The actual (hidden) transmission speed is 4800 bauds using ASCII character set. The communication protocol is master/slave (with the instructors position as "master"). The buffering facilities at all terminals coupled with the increased transmission speed ensure that the effect is to show real time communications at the simulated 50 bauds.

The printing facilities are available at all terminals. In the instructors position this can be dedicated either to the real system log or to provide a copy of the instructors status /messaging screen. In the students position the printer can be redirected to display the incoming EGC messages while the terminal is in off-line mode, or for printing out any other recorded or stored texts.

The telephony mode uses simulated tone dialling with the standard INMARSAT response tones for "busy", "unavailable" etc. A slave "SOS" button is incorporated into each SES telephone keypad.

### 5.7.4 Facilities offered by the Terminals:

* **Off-line Message Preparation**
  Up to ten seperate message texts can be prepared. Additionally, provision is made for a distress message texts to be prepared.

* **Distress Message Generator (DMG)**
  The distress message can be automatically transmitted at intervals after an "SOS" request by the student.

* **Antenna Positioning Exercises**
  There are two modes are available (controlled by the instructor). The mode "manual" requires the student to calculate the azimuth and elevation of the antenna before the satellite TDM signal is detected. The mode "auto" will position the antenna automatically for the student. (This is not necessary for INMARSAT C).

* **Fault Finding and Trouble-shooting**

* **Conversation Mode**
  Once a student connection has been established with a selected Coast Earth Station then telex and/or telephony conversation mode is possible (full duplex simulation).

* **Message Switching**
  The previously prepared messages can be recalled for transmission either as part of a INMARSAT A connection or in INMARSAT C mode.

* Enhanced Group Call(EGC)
  A "listening channel" is maintained for EGC calls which are valid for the Ship Earth Terminal (fleet and national numbers for each Ship Earth Station terminal are controlled by the instructor position).

* Options: Fax/Data Transmission
  If required the simulator can be modified for use with fax/ data transmissions.

Ship Earth Station Simulator consisting of;

Monochrome monitor

Keyboard

System unit

Telephone unit plus handset

Printer

Terminal for connection of FAX machine

# CHAPTER 6

## Conclusions

*Not so long ago there was a distinct gap between maritime communication and navigation which reflected in the separate functions and services on board of ships and ashore for these purposes. With modern developments in maritime radiocommunication systems the separation between radiocommunication and radionavigation is vanishing rapidly. This can be easily verified by recent developments in the Electronic Chart, Enhanced group call, GMDSS, Black Box.* ...(Maritime Radiocommunications, J.H. Mulders)

In the future telegraphy will be replaced by VHF, L-band and 406 MHz beacons which every ship will be required to carry. The beacons will be INMARSAT L-band EPIRBs incorporating GPS/GLONASS chips which will allow them to process, satellite position data. The beacons' transmissions relayed by INMARSAT and COSPAS-SARSAT satellite supporting the Global Maritime Distress and Safety System will permit immediate and precise location of vessels in distress. The result will be a great increase in the efficiency of the search and rescue services, in terms of both lives saved and the duration and cost of SAR operations.

The ship of the future will call for fewer highly trained, personnel on board. They will require detailed information, both locally and distantly acquired to carry out their tasks efficiently.

A vessel equipped with satellite communications and a computer has access to any computer based technical information relating to equipment, including engineering drawings, which are currently only available via facsimile. The ship operator has access to shore-based services such as payroll, inventory control, maintenance and repair, accounting and financial, purchasing and billing, and most recently desk top publishing. The functioning of the ships systems can be monitored remotely, permitting maintenance schedules and spares purchasing.

In the near future satellite communications could provide the means whereby very effective academic links could be maintained between the seafarer and the maritime academy. The seafarer could be tutored and his academic progress monitored while he is at sea, irrespective of where the ship is. This development of maritime education by distance learning through satellite communications would be of great benefit to the international shipping industry, to seafarers themselves, and for all involved in maritime education and training.

Presently INMARSAT is planning a world-wide navigation and communication system using geostationary satellites for the dual functions. The system which is still in the experimental stage basically could be an "active radio determination satellite service", where the user transmits a signal to the satellite system and the position is calculated by the operator's central computing facility. The positioning data can then be relayed back to the user or to any other location.

It is seen that many manufacturers of maritime communications equipment now employ the latest technologies in micro-electronics in their circuit design. This increasing applications of micro electronics systems aboard ships has led operators to answer many questions regarding MTBF of the equipment, the maintenance of such systems, the carriage of adequate spares, and the most important being who will carry out the maintenance or fault finding and what training is required to perform such a task.

The developed countries with modern rationalized ships will solely rely on shore-based maintenance and the duplication of equipments to enhance the availability of the equipment. The shore-based maintenance will be from reputed manufacturers who have qualified service engineers placed world-wide.

The specially trained maintainers who would also be qualified electronic engineers would require a long training period and in addition be too costly to be employed by the company. These highly skilled engineers are in great demand ashore and it is highly unlikely that they will go to sea for a long period of time. In view of this it is highly unlikely that the three technical courses as recommended by the IMO GMDSS Conference will be acomplished by future ship operators.

The developing countries mainly with less sophisticated vessels, and equipment will for the time being train and employ radio/electronic officers whose wages would be less than the developed countries counterparts. It is when the GMDSS becomes fully enforced in 1999 such maintenance /repairs will be carried out either by radio/electronic officers or shore-based maintenance engineers depending upon the administration. The shore-based maintenance will be encouraged by reputed manufacturers by placing equipments as well as service engineers (or leasing the equipment and having qualified maintainers on contractual basis to remove the financial burden of a shipowner to a certain extent).

The author firmly believes that in the future (as argued in Chapter 5) shore-based maintenance and duplication of equipments will be the best future solution for ship operators. It is better rather than limiting the skills only to operate (as recommended in the present GMDSS operators syllabus), basic fault finding and repairing skills of all communication equipments, electronic navigation equipments etc. must be taught to all ship's operators.

In order to understand/maintain maritime communication equipment, and use them economically "Satellite Communication

Simulator" training should be made mandatory to all ship operators.

Finally the main items of this conclusion are mentioned once more.

* The maintenance of communications and electronic equipment on board will be done mainly by shore-based maintenance involving reputed companies which have service departments world-wide. These companies offer leasing of the GMDSS communication equipment as well as a service contract for maintaining the equipment. This takes the strain off working and borrowed capital, and provides a flexible means of equipping the ships.

* The "Maritime Communications Courses" should be given for all ship operators to be familiar with all communications equipment/operating procedures to use the equipment efficiently and cost effectively. In addition technical skills on basic fault finding and repairs should also be developed. This course will cover more than the present "General Operator's Certificate" course given in many countries to operate GMDSS equipment.

## APPENDIX 1

### REGULATIONS CONCERNING AVAILABILITY OF COMMUNICATIONS EQUIPMENT IN THE GMDSS REVISIONS TO THE SAFETY OF LIFE AT SEA CONVENTION

1. Equipment shall be so designed that the main units can be replaced readily, without elaborate recalibration or re-adjustment.

2. Where applicable, equipment shall be so constructed and installed that it is readily accessible for inspection and on board maintenance purposes.

3. Adequate information shall be provided to enable the equipment to be properly operated and maintained taking into account the recommendations of the Organization.

4. Adequate tools and spares shall be provided to enable the equipment to be maintained.

5. The administration shall ensure that radio equipment required by this chapter is maintained to provide the availability of the functional requirements specified in regulations 4 and to meet the recommended performance standards of such equipment.

6. On ships engaged on voyages in sea areas A1 and A2, the availability shall be ensured by using such methods as duplication of equipment, shore-based maintenance or at sea electronic maintenance capability, or a combination of these, as may be approved by the administration.

7. On ships engaged on voyages in sea areas A3 and A4, the availability shall be ensured by using a combination of at least two methods such as duplication of equipment,

shore-based maintenance or at least at-sea electronic maintenance capability, as may be approved by the administration, taking into account the recommendations of the organization.

8. While all reasonable steps shall be taken to maintain the equipment in efficient working order to ensure compliance with the functional requirements specified in regulation 4, malfunction of the equipment for providing the general radiocommunications required by regulation 4.8 shall not be considered as making a ship unseaworthy or as a reason for delaying the ship in ports where repair facilities are not readily available, provided the ship is capable of performing all distress and safety functions.

# APPENDIX 2

## GMDSS

The Global Maritime Distress Safety System is being introduced by the IMO (International Maritime Organization).

The objective is to automate and improve emergency communications for the world's shipping industry.

Modern electronics and satellite communications will play a vital role in increasing safety at sea and co-ordinating rescue operations.

GMDSS is basically designed to deal with safety, search and rescue and does not necessarily take into consideration of commercial communication needs.

### Dates of Implementation

1. From 1st February, 1992, till February, 1999 ships could either comply with GMDSS or SOLAS 74.

2. From 1st August, 1993 all ship's require EPIRBS and NAVTEX. These must be carried by 1st AUGUST 1993.

3. All ships built after February, 1995 must comply with all GMDSS regulations.

4. All ships must comply with GMDSS regulations by 1st February 1999.

Equipments required

The equipments that need to comply with GMDSS regulations will depend on the area in which the ship operates and the specific interpretation of the country under whose flag it sails.

Those areas have been defined into four operating zones:

A1 20 - 30 Miles from land, and within range of shore-based VHF

A2 100 Miles from shore and within range of shore-based MF

A3 Within Coverage of the INMARSAT Satellite System

A4 All other areas outside A1, A2, and A3

**Area A1 : All ships must carry**

A. VHF RADIO TELEPHONE
B. VHF DSC ON CHANNEL 70 AND PRINTER
C. VHF DSC WATCH RECEIVER
D. SART MINIMUM OF TWO
E. NAVTEX
F. EGC (Enhanced Group Call)

If outside Navtex coverage

G. 406 EPIRB
H. VHF (WATERPROOF) WALKIE TALKIES
Two required by ships under 500grt
Three required by ships over 500grt
I. 2182 WATCH RX (Until 1st February 1999)

**AREA A2:** All ships must carry

A. VHF RADIO TELEPHONE
B. VHF DSC ON CHANNEL 70 AND PRINTER
C. VHF DSC WATCH RECEIVER
D. SART MINIMUM OF TWO
E. NAVTEX
F. EGC (Enhanced Group Call)

If outside Navtex coverage

G. 406 EPIRB
H. VHF (WATERPROOF) WALKIE TALKIES
Two required by ships under 500grt
Three required by ships over 500grt
I. 2182 WATCH RX (Until 1st February 1999)
J. MF RADIO TELEPHONE WITH DSC RX AND CONTROLLER
K. MF WATCH RECEIVER DEDICATED TO 2187.5 kHz
L. AUTOMATIC DIRECTION FINDER 2182 kHz
(HOMING DEVICE)
M. MF DSC ENCODER/DECODER

**AREA A3:** All ships must carry

A. VHF RADIO TELEPHONE
B. VHF DSC ON CHANNEL 70 AND PRINTER
C. VHF DSC WATCH RECEIVER
D. SART MINIMUM OF TWO
E. NAVTEX
F. EGC (Enhanced Group Call)

If outside Navtex coverage

G. 406 EPIRB
H. VHF (WATERPROOF) WALKIE TALKIES
Two required by ships under 500grt
Three required by ships over 500grt

I. 2182 WATCH RX (Until 1st February 1999)

J. MF RADIO TELEPHONE WITH DSC RX AND CONTROLLER

K. MF WATCH RECEIVER DEDICATED TO 2187.5 kHz

L. AUTOMATIC DIRECTION FINDER 2182 kHz (HOMING DEVICE)

M. MF DSC ENCODER/DECODER

PLUS EITHER

N. TWO INMARSAT A SATCOMS

OR...

O. TWO INMARSAT C SATCOMS

OR...

N/O. A COMBINATION OF INMARSAT A AND C

OR...

N. INMARSAT A

P. MF/HF RADIO TELEPHONE

Q. TELEX (NBDP)

OR...

O. INMARSAT C

P. MF/HF RADIO TELEPHONE

Q. TELEX (NBDP) To enhance duplication

OR...

P. TWO MF/HF RADIO TELEPHONE WITH DSC RECEIVER AND CONTROLLER FOR HF

**AREA 4: all ships must carry**

A. VHF RADIO TELEPHONE

B. VHF DSC ON CHANNEL 70 AND PRINTER

C. VHF DSC WATCH RECEIVER

D. SART MINIMUM OF TWO

E. NAVTEX

G. 406 EPIRB

H. VHF (WATERPROOF) WALKIE TALKIES
Two required by ships under 500grt
three required by ships over 500grt

I. 2182 WATCH RX + ASGD (Until 1st February 1999)

L. AUTOMATIC DIRECTION FINDER 2182 kHz
(HOMING DEVICE)

P. TWO MF/HF RADIO TELEPHONES WITH DSC

Q. TELEX (NBDP)

R. MF/HF SCANNING DSC WATCH RECEIVER

# KEY WORDS AND ACRONYMS

**AOR:** Atlantic Ocean Region which is covered by two geostationary satellites by INMARSAT.

**Apogee:** Point at which an orbit is furthest away from the Earth.

**Attenuation:** Absorption of electromagnetic waves by air resulting in loss of signal strength.

**Baud:** Units of information or modulation per second.

**BER:** Bit error rate. Number of error bits in a message of pre-determined lengths.

**bits/sec:** Number of binary digits transmitted per second

**C-band:** Frequency band used for satellite - earth station links in mobile satellites communications systems (about 6 GHz).

**C/N:** Carrier-to-noise ratio.

**Cospas-Sarsat:** International satellite based emergency alerting and locating system.

**CCIR:** International Telephone and Telegraph Consultative Committee.

**Differential GPS:** Highly accurate positioning service based on the use of a real time communications link with a remote monitor station at a known location.

**DSC:** Digital Selective Calling. Message transmission system to selected users.

EGC: Enhanced Group Call Method by which a group of ships sailing may be contacted at the same time.

ELT: Emergency Locator Transmitter Airborne distress beacon.

EPIRB: Emergency Position Indicating Radio Beacon. Maritime equivalent of ELT.

Error rate: Ratio of incorrectly received to correctly received signal elements.

Frequency: Number of cycles completed each second by a waveform.

FleetNEt: EGC based system permitting shipowners to broadcast to same or all of their vessels.

Gain: Ratio of output to input power.

Glonass: Global Navigation Satellite System - Soviet equivalent of United States GPS.

GMDSS: Global Maritime Distress and Safety System.

GPS: Global Positioning System - Advanced satellite navigation system by ranging, for US Defence Department and civilian use. A continuous service is expected to be available before the end of 1993.

GEO: Geostationary Earth Orbit.

Geostationary orbit: Circular, 35,786km - high orbit in the plane of the equator. A satellite moving from west to east in this orbit has no apparent motion with respect to the surface of the Earth.

Hz: Hertz. 1Hz = one wave cycle per second.

IMO: International Maritime Organization.

ITU: International Telecommunications Union.

L-band: Freqency band around 1.5 GHz used for links between satellites and mobile users.

VHF: Very High Frequency.

Ionospheric refraction: Changes in direction of signal propagation due to interaction with free electrons in the ionosphere.

Loran-C: Terrestrial EM long range navigation system (100KHz).

MCC: Mission control centre. In Cospas-Sarsat. Analyses distress signals and tasks appropriate RCC.

MF: Medium - frequency. 300KHz-3MHz radio frequency band used for terrestrial telecommunications.

Modulation: Process by which intelligence is imposed on a carrier wave.

Multipath: Effect produced by the reception of reflected as well as electromagnetic waves.

Navtex: Direct received Radio broadcasts of maritime safety-related information.

NBDP: Narrow band direct printing.

Noise: Unwanted signal or disturbance.

**Payload:** Those systems in a satellite that are used to perform its primary role.

**Perigee:** Point at which an orbit is closest to the Earth.

**Polling:** Process in which communication is initiated by a main processor calling a number of remote input devices

**PSDN:** Packet Switched Data Network.

**Priority 3:** INMARSAT designation for distress calls. Priority 3 calls have precedence over all other traffic.

**Uplink:** Communications link from earth station to satellite.

**RCC:** Rescue co-ordination centre. Responsible for tactical direction of search and rescue forces.

**RF:** Radio-frequency. Refers to those electromagnetic frequencies used for radio transmissions.

**RDSS:** Radio determination Satellite System - combining position fixing with messaging facilities.

**SafetyNET:** EGC - based system for dissemination of maritime safety information.

**SART:** Search and Rescue Transponder. 9GHz transponder which responds when interrogated by a radar, indicating its position.

**INMARSAT-A:** Current basic standard for ship earth stations.

**INMARSAT-C:** New compact ship earth station designed for use in smaller vessels. Low-speed data only.

**SOLAS:** Safety of Life at Sea.

**Transponder:** Unit of communications equipment on stellite, comprising receive antenna, receiver, channel filters, amplifies, output filters and transmit antenna.

**Tropospheric refraction:** Changes in the direction propagation as the signal passes the earth's troposphere.

**WARC:** World Administrative Radio Conference. Creates the regulations governing the use of the radio wavebands of the electromagnetic spectrum.

**Wavelength:** Distance between successive peaks in a waveform.

**WMO:** World Meteorological Organization.

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