NEAR EAST UNIVERSITY

Faculty of Engineering

Department of Electrical and Electronic Engineering

GLOBAL MARITIME DISTRESS AND SAFETY SYSTEM

Graduation Project
EE- 400

Student: Jabra Dahdal (991589)

Supervisor: Prof. Dr. Fakhreddin Mamedov

Lefkoşa - 2001

TABLE OF CONTENTS

ACKNOWLEDGMENTS

First of all I want to thank Prof. Dr. Fakhreddien Mamedov to be my supervisor in my graduation project. It was a great thing that he accept to be my supervisor, because I know that under his guidance and his advises I will overcome all the problems and difficulties that can face me in my project. He always helps me either in study or in the university in general.

Special thanks to Assoc. Prof. Şenol Bektaş and Mr. Tayseer Al-shanableh for every thing. Really I want to say that, without your help in all the times I could not solved most of the problems. I hope the university will improve more and more under your hands.

I also want to thank Assoc. Prof. Adnan khashman, because he taught me something new in the study (neural network) and in the life by how you can make the other respecting you.

Special thanks to my mother and my single brother for moral supporting and helping me to continue my study in the university.

Finally I want to thank all my friends for supporting me all this time and helping me in the study and in the life.

LIST OF ABBREVIATIONS

IMO	International Maritime Organization
SOLAS	Safety Of Life At Sea
VHF	Very High Frequency
MF	Medium Frequency
CCIR	International Radio Consultative Committee
SAR	Sea And Rescue
ITU	International Telecommunication Union
WMO	World Meteorological Organization
IHO	International Hydrographic Organization
GMDSS	Global Maritime Distress and Safety System
MSI	Maritime Safety Information
DSC	Digital Selective Calling
ASRT	Search And Rescue Transceiver
EGC	Enhanced Group Call
ASGD	Automatic Signal Generating Device
NBDP	Narrow Band Direct Printing
HF	High Frequency
RCC	Rescue Co-ordination Center
EPIRB	Emergency Position Indicating Radio Beacon
OSC	On-Scene Commander
CSS	Co-ordinator Surface Search
CES	Coast Earth Station
SES	Ship Earth Station
OCC	Operation Control Center
DMG	Distress Message Generator
AOR-E	Atlantic Ocean Region-East
AOR-W	Atlantic Ocean Region-West
IOR	Indian Ocean Region
POR	Pacific Ocean Region
NCS	Network Co-ordination Station
VDU	Visual Display Unit

HSD	High Speed Data
PSTN	Public Switched Telephone Networks
PSDN	Public Switched Data Networks
BPSK	Binary Phase Shift Keying
TDMA	Time Division Multiple Access
FDMA	Frequency Division Multiple Access
GPS	Global Positioning System
LUT	Local User Terminal
ELT	Emergency Locator Transmitter
PLB	Personal Locator Beacon
MCC	Mission Control Center
LEOSAR	Low Earth Orbit Search And Rescue
ICAO	International Civil Aviation Organization
RF	Radio Frequency
ALC	Automatic Level Control
IF	Intermediate Frequency
CMC	COSPAS Mission Control Center
LES	Land Earth Station
WAN	Wide Area Network
ISDN	Integrated Services Digital Networks
LCD	Liquid Crystal Display
MMSI	Maritime Mobile Service Identity
WWNWS	World Wide Navigational Warning Service
IFRB	International Frequency Registration Board
INMARSAT	International Maritime Satellite System

The GMDSS is primarily a vessel-to-shore alerting system where Rescue Co-ordination Centers (RCC's) receive distress alerts from vessels and then co-ordinate an appropriate rescue response.

Vessel-to-vessel distress alerting is also a feature of GMDSS and operates in a similar way to the current distress system. GMDSS also provides Urgency, Safety and routine communications and safety information broadcasts (navigation warnings, weather forecasts and search and rescue messages etc).

GMDSS is designed to provide an automatic means of transmitting and receiving distress alerts either by using Digital Selective Calling (DSC) via conventional radio or via the INMARSAT satellite system. DSC communication is much faster and has a greater probability of reception than the existing manually operated distress system.

GMDSS also provides the facilities to send distress alerts and locating signals using EPIRBs (Emergency Position Indicating Radio Beacons).

For the foreseeable future existing distress alerting arrangements for small craft (particularly VHF Channel 16) will operate in parallel with GMDSS. However GMDSS will eventually replace it and become the sole means of initiating distress and safety communications. You must therefore carefully consider the options, which are available to you, thinking about your own needs for training and equipment to Understand and use GMDSS.

INTRODUCTION

The Global Maritime Distress and Safety System (GMDSS) has been developed by the International Maritime Organization (IMO) to replace the existing worldwide distress and safety communications system.

GMDSS is designed to provide an automatic means of transmitting and receiving distress alerts either by using Digital Selective Calling (DSC) via conventional radio or via the INMARSAT satellite system.

The main functions of this system are to provide vessel-to-shore and Vessel-to-vessel distress alerting and provide Urgency, Safety and routine communications and safety information broadcasts (navigation warnings, weather forecasts and search and rescue messages etc).

The main aim of this project is to improve the radio communication systems and to replace the existing worldwide distress and safety communications system for safety of life at sea.

The thesis consists of the introduction, six chapters and conclusion.

The chapter 1 introduces the historical view of GMDSS, the need of this system, and the main functions of GMDSS.

Chapter 2 covers the basic concept of the GMDSS and communications functions in the GMDSS.

Chapter 3 involves the INMARSAT system in the GMDSS and it services, L-band satellite EPIRBs.

Chapter 4 explains the communication systems in GMDSS, it consist of COSPAS-SARSAT system, System Performance and Operations, Operational Procedures, Digital Selective Calling (DSC) System, Search and Rescue Radar Transponders, the last section of this chapter presents Maritime Safety Information System.

Chapter 5 presents GMDSS requirement and procedures work, shore-based SAR communications network.

Chapter 6 flaws the system and studies the entire problems that faced the system and it solutions.

Conclusion presents the importance and features of this system.

CHAPTER ONE
INTRODUCTORY CONCEPTS

1.1 History

Since its establishment in 1959, the International Maritime Organization (IMO), in its efforts to enhance safety at sea by the adoption of the highest practicable standards, has sought to improve the radio communication provisions of the international convention for The Safety Of Life At Sea (SOLAS) and to exploit the advances made in radio communication technology.

The ship borne radio communication equipment prescribed by the 1960 and 1974 SOLAS conventions consisted of radio telegraph equipment for passenger ships of all sizes and cargo ships of 1,600 tons gross tonnage and upwards, as well as radiotelephone equipment for cargo ships of 300 to 1,600 tone gross tonnage. The ships so fitted, although they could receive a distress alert, could not communicate with each other, and it was not until 1984 that all ships were required to be able to communicate by means of VHF and MF radio telephone. The range of transmission on MF was only 150 miles, so for ships beyond this distance from the nearest coast station, the old system is essentially a ship- to-ship distress system.

In 1972, with the assistance of the International Radio Consultative Committee (CCIR), IMO commenced a study of maritime satellite communication, which resulted in the establishment, in 1979, of the INMERSAT organization, thus making available to shipping an international satellite communication system.

In 1973, IMO reviewed its policy on the development of the maritime distress system so as to incorporate satellite communications and foresaw the possibility of automatic alerting and transmission of maritime distress and safety information.

In 1979 the international conference on maritime search and rescue adopted the international convention on maritime search and rescue, 1979 (1979 SAR convention), the ultimate objective of which is to establish a global plan for maritime Search And Rescue (SAR) on a frame work of multilateral or bilateral agreements between developments and improve the safety of life at sea.

With the assistance of the International Telecommunication Union (ITU), CCIR, other international organization, notably the World Meteorological Organization (WMO), the International Hydrographic Organization (IHO), INMARSAT, and the COSPAS-SARSAT partners, IMO developed and proved the various equipment and techniques used in Global Maritime Distress and Safety System (GMDSS). The ITU has established the appropriate regulatory framework for the implementation of the GMDSS.

The 1983 and 1987 world administrative radio conferences for the mobile services (WARC-Mob-83 and 87) and WARC-92 adopted amendments to the ITU radio regulations which prescribe the frequencies, operational procedures and radio personnel for the GMDSS.

In 1988, the conference of contracting governments to the 1974 SOLAS convention of global maritime distress and safety system (GMDSS conference) adopted amendment to the 1974 SOLAS convention concerning radio communication for the GMDSS, together with several relevant resolution. These amendments entered in to force on 1 February 1992, and the GMDSS will be fully implemented on 1 February 1999.

- **What are the Advantages of the GMDSS Over the Current System?**

1) Provides worldwide ship to shore alerting, it is not dependent upon passing ships;
2) Simplifies radio operations, alerts may be sent by "two simple actions" ;
3) Ensures redundancy of communications, it requires two separate systems for alerting;
4) Enhances search and rescue, operations are coordinated from shore centers;
5) Minimizes unanticipated emergencies at sea, maritime safety broadcasts are included;
6) Eliminates reliance on a single person for communications, it requires at least; two licensed GMDSS radio operators and typically two maintenance methods to ensure distress communications capability at all times.

- **Are Radio Officers Still Required?**

Radio officers (trained in manual Morse code) are not part of the GMDSS regulations or system. In lieu of a single radio officer, the GMDSS regulations require at least two GMDSS radio operators and a GMDSS maintainer if the ship elects at sea repair as one of its maintenance options.

- **Functions of the GMDSS**

1) Transmitting ship to shore distress alerts (by at least two separate and
2) Independent means, each using a different radio communication service;
3) Transmitting and receiving ship to ship distress alerts;
4) Receiving shore to ship distress alerts;
5) Transmitting and receiving search and rescue coordinating communications;
6) Transmitting and receiving on-scene and bridge to bridge communications ;
7) Transmission and receipt of locating signals;
8) Receipt of maritime safety information(MSI);
9) Transmitting and receiving general radio communications to and from shore;
10) Based radio systems or networks.

CHAPTER TWO

BASIC CONCEPT OF THE GMDSS

2.1General

The basic concept of the GMDSS (shown in figure 1) is that search and rescue authorities ashore, as well as shipping in the immediate vicinity of the ship in distress, will be rapidly alerted to a distress incident so that they can assist in a co-ordinated SAR operation with the minimum delay. The system also provides urgency and safety communications and the promulgation of Maritime Safety Information (MSI) navigational and meteorological warnings and forecasts and other urgent safety information to ships. In other words, every ship is able, irrespective of the area in which it operates, to perform those communication functions which are essential for the safety of the ship it self and of other ships operating in the same area.

Figure 2.1 General concept of GMDSS

Recognizing that the different radio subsystem incorporated in the GMDSS system have individual limitations with respect to the geographical coverage and services provided, the equipment required to be carried by a ship is determined in principle by the ship's area of operation, which is designed as follows:

- Sea area A1: an area within the radio telephone coverage of at least one VHF coast station in which continuous Digital Selective Calling (DSC) alerting is available, as may be defined by contracting government;

- Sea area A2: an area, excluding sea area A1, within the radio telephone coverage of at least one MF coast station in which continuous Digital Selective Calling (DSC) alerting is available, as may be defined by contracting government;

- Sea are A3: an area excluding sea areas A1 and A2, within the coverage of an INMARSAT geostationary satellite in which continuous alerting is available; and

- Sea area A4: an area outside sea area A1, A2 and A3.

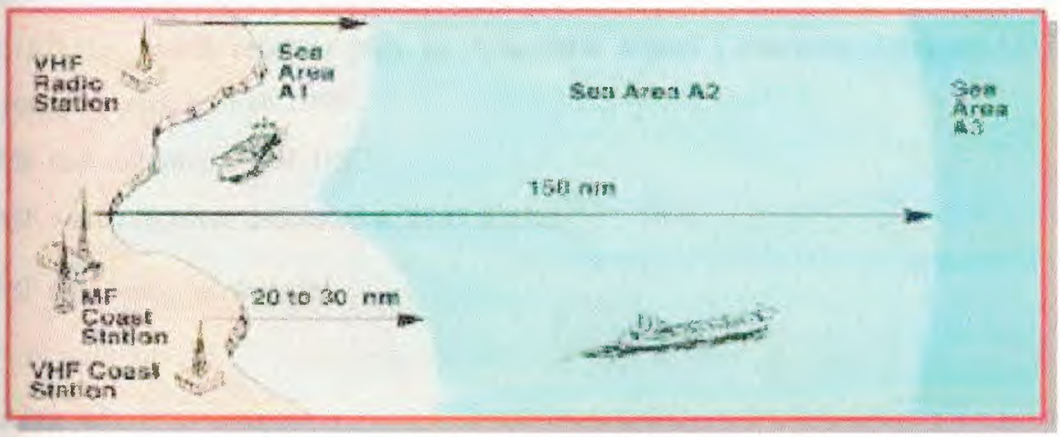

Figure 2.2 Sea areas

- **GMDSS Shipboard Equipment of Those Areas**

1. **Area A1**
   - VHF radiotelephone.
   - VHF DSC on Channel 70.
   - VHF DSC watch receiver.
   - SART (One).
   - NAVTEX receiver.
   - Enhanced Group Call (EGC) equipment Required if outside NAVTEX coverage.
   - Satellite EPIRB float free,or VHF.

- EPIRB capable of transmitting a DSC.
- Distress alert on Channel 70 VHF.
- 2182kHz watch receiver required until1st Feb 1999.

2. Area A2

- VHF radiotelephone.
- VHF DSC on Channel 70.
- VHF DSC watch receiver.
- SART (One).
- NAVTEX receiver.
- Enhanced Group Call (EGC) and Printer equipment required if outside NAVTEX coverage.
- Satellite EPIRB float free.
- 2182kHz watch receiver plus an Automatic Signal Generating Device (ASGD) required until 1st Feb 1999.
- MF radiotelephone with DSC.
- MF watch receiver dedicated to 2187.5kHz.
- MF DSC encoder/decoder.

3. Area A3

- VHF radiotelephone.
- VHF DSC on Channel 70.
- VHF DSC watch receiver.
- SART (One).
- NAVTEX receiver.
- Enhanced Group Call (EGC) and printer required if outside NAVTEX coverage.
- 406MHz EPIRB float free.
- 2182kHz watch receiver plus an Automatic Signal Generating Device (ASGD) required until 1st Feb 1999.
- MF radiotelephone with DSC.
- MF watch receiver dedicated to 2187.5 kHz.
- MF DSC encoder/decoder.

- INMARSAT MES.
- OR instead of above: MF/HF plus DSC (scanning watch receiver plus narrow band direct printing (NBDP)).

4. Area A4

- VHF radiotelephone.
- VHF DSC on Channel 70.
- VHF DSC watch receiver.
- SART (One).
- NAVTEX receiver.
- 406MHz EPIRB float free.
- 2182kHz watch receiver plus an Automatic Signal Generating Device (ASGD) required until 1st Feb 1999.
- MF radiotelephone with DSC/NBDP.
- Telex (NBDP).
- MF/HF scanning DSC watch receiver.

The following type of radio communications mode is the minimum complement of services that can be offered to meet GMDSS Sea Area A-4 guidelines:

Table 2.1 Radio communications mode

Frequency band	DSC alerting frequency	R/T Distress\safety traffic frequency	NBDP (broad cast) frequency
HF 4	4207.5 kHz	4125.0 kHz	4210.0 kHz
HF 6	6312.0 kHz	6215.0 kHz	6314.0 kHz
HF 8	8414.5 kHz	8291.0 kHz	8416.5 kHz
HF 12	12,577.0 kHz	12,290.0 kHz	12,579.0 kHz
HF 16	16,804.5 kHz	16,420.0 kHz	16,806.5 kHz

2.2 Communications Functions in the GMDSS

The GMDSS comprises the following communications functions as required by regulation IV/4. These functions are individually performed by the radio subsystem set out in chapter3 and 4.

2.2.1 Alerting

Distress alerting is the rapid and successful reporting of a distress incident to a unit, which can provide or co-ordinate assistance. This would be a Rescue Co-ordination Center (RCC) or another ship in the vicinity. When an alert is received by an RCC, normally via a coast station or coast earth station, the RCC will relay the alert to SAR units and to ships in the vicinity of the distress incident. A distress alert should indicate the ship's identification and the position of the distress and, where practicable, its natural and other information, which could be used for, rescue operations.

The communication arrangements under the GMDSS are designed to enable distress alerting to be performed in all three directions ship-to-shore, ship-to-ship and shore-to-ship- in all sea areas. The alerting function is based on both satellite and terrestrial means and the initial distress alert is primarily transmitted in the ship-to-shore direction. When the distress alert is transmitted by DSC on VHF, MF or HF, ships within DSC range of the ship in distress will also be alerted (ship-to-ship alerting).

A distress alert is normally initiated manually and all distress alerts are acknowledged manually. When a ship sinks, a float free satellite Emergency Position-Indicating Radio Beacon (EPIRB) is automatically activated. Ships operating exclusively in sea area A1 may, in lieu of satellite EPIRRB, use VHF EPIRBs on channel 70.

The relaying of a distress alert from an RCC to ships in the vicinity of a distress incident is made by satellite communication or by terrestrial communication using appropriate frequencies. In either case, to avoid all ships in a large sea are being alerted, an "area call" is normally transmitted so that only those ships in the vicinity of the distress incident are alerted. On receipt of a relayed distress alert, ships in the area addressed are required to establish communication with the RCC concerned to enable the assistance to be co-ordinated. Chapter 4 deals with the operational procedure and routing of the distress alert.

2.2.2 SAR Co-ordinating Communications

In general these are the communications necessary for the co-ordination of ships and aircraft participating in a search and rescue operation following a distress alert and include communication between RCCs and any "On-Scene Commander (OSC)" or "Co-ordinator Surface Search (CSS)" in the area of the distress incident.

For SAR operations messages are transmitted in both directions, as distinct from "alerting", which is generally the transmission of specific message in one direction only, and distress and safety traffic by radiotelephony and direct-printing telegraphy will normally be used for passing such a messages.

The techniques, which are available for SAR co-ordinating communications, are radiotelephony or direct-printing telegraphy or both. These communications can be carried out by terrestrial or satellite means, dependent upon the equipment fitted on the ship and the sea area in which the incident occurs.

2.2.3 On-Scene Communication

On-scene communications normally take place in the MF and VHF bands on frequencies designated for distress and safety traffic, by radiotelephony or direct-printing telegraphy. These communications between the ship in distress and assisting units relate to the prevision of assistance to the ship or the rescue of survivors. When aircraft are involved in on-scene communications they are normally able to use 3023, 4125 and 5680 kHz. In addition, SAR aircraft can be provided with equipment to communicate on 2182 kHz or 156.8 MHz or both, as well as on maritime mobile frequencies.

2.2.4 Locating

Locating is the finding of a ship/aircraft in distress or its survival craft or survivors. In the GMDSS this function is performed by means of 9 GHz SAR radar transponders *(SARTs) by the ship in distress or its survivors,* whose position is indicated when the SART is interrogated by the searching unit's 9 GHz radar. Use of the frequency 121.5 MHz in most satellite EPIRBs is provided for homing by aeronautical SAR units.

2.2.5 Promulgation of MSI

Ships need to be provided with up-to-date navigational warnings and meteorological warnings and forecasts and other urgent safety information (MSI). MSI is made available by narrow-band direct-printing telegraphy broadcasts, using forward error correction on the frequency 518 kHz (international NAVTEX service) and, for ships navigate beyond the NAVTEX coverage, by broadcast via INMARSAT Enhanced Group Call (EGC) system (known as the international safety NET system). A high seas MSI broadcast system by HF direct-printing telegraphy is under development. Details for MSI systems are given in section 3.6.

2.2.6 General Radio Communications

General radio communications in the GMDSS are those communications between ship stations and shore-based communication networks, which concern the management and operation of the ship and may have an impact on its safety. These communications can be conducted on any appropriate channel, including those used for public correspondence. Examples are orders for pilot and tug services, chart replacement, repairs, etc.

2.2.7 Bridge-to-Bridge Communications

Bridge-to-bridge communications are inter-ship safety communications conducted from the position from which the ship is normally navigated. Normally performed by VHF radiotelephony.

CHAPTER THREE

INMARSAT SYSTEM IN GMDSS

3.1 General

- **Satellite Communications**

Satellite communications are particularly important elements of the GMDSS.

The INMARSAT system which employs geostationary satellites and operates in the 1.5 and 1.6 GHz band (L band) provide ships fitted with ship earth station with a means of distress alerting and a capability for two-way communication using direct-printing telegraphy and radio telephony. L-band satellite EPIRBs are also used for distress alerting. The INMARSAT safety NET system is used as a main means to provide MSI to areas not covered by the NAVTEX system.

A polar orbiting satellite system, orbiting in the 406 MHz band using satellite EPIRBs (COSPAS-SARSAT system), provides one of the main means of distress alerting and determining the identity and position of the ship in distress or its survivors in the GMDSS.

- **Terrestrial Communications**

With terrestrial communications, DSC forms the passes of distress alerting and safety communications. Distress and safety communications following a DSC call can be performed by radiotelephony or direct-printing telegraphy or both.

- **Long-Range Service**

Use of HF provides a long-range service in both the ship-to-shore and shore-to-ship directions. In areas covered by INMARSAT it can be used as an alternative to satellite communications and out side these areas it provides the only long-range communication capability. Frequencies have been designated in the 4, 6, 8, 12 and 16 MHz bands for this service.

- **Medium-Range Service**

MF radio communications provide the medium range-service. In the ship-to-shore, ship-to-ship and shore-to-ship directions 2187.5 kHz will be used for distress alert and safety calls using DSC, and 2182 kHz will be used for distress and safety traffic by radiotelephony, including SAR co-ordinating and on-scene communications. 2174.5 kHz will be used for distress and safety traffic by direct-printing telegraphy.

- **Short-Range Service**

VHF provides short-rang service on the frequencies:

- 156.525 MHz (channel 70) for distress alert and safety calls using DSC, and
- 156.8 MHz (channel 16) for distress and safety traffic by radiotelephony, including SAR co-ordinating and on-scene communications.

There is no short-range direct-printing telegraphy service on VHF.

3.2 INMARSAT Systems

3.2.1 Introduction

INMARSAT grew out of an idea that originated within IMO in 1966. Following extensive study by IMO experts an international conference was convened which, after three sessions on 3 September 1976, unanimously adopt the convention and operating agreement on the International Maritime Satellite organization (INMARSAT). According to its convention, INMARSAT is "to make provision for the space segment necessary for improving maritime communications, there by assisting in improving distress and safety of life at sea communications".

The INMARSAT system has three major components: the space segment provided by INMARSAT, the Coast Earth Stations (CESs) provided by INMARSAT signatories and Ship Earth Stations (SESs).

The nerve center of the system is the Operations Control Center (OCC), located at INMARSAT's headquarters in the United Kingdom. The OCC is responsible for controlling the INMARSAT system operation as a whole. Operating 24 hours a day, it co-ordinates a wide range of activities. The OCC also arrange the commissioning of SESs upon application by the ship owner.

3.2.2 Safety Advantages of Satellite Services

Some of the advantages of maritime satellite communications for safety uses are:

- Satellite communications are fast, reliable and of high quality. Users are not plagued by ionospheric disturbances and crowded radio waves, which can result in delays of hours or even days when making a call with conventional radio communications.

- Satellite communications are simple and easy to use. A ship equipped with a ship earth station can send a telex or make a telephone call directly to shore or to other satcom-equipped ships as easily as if the call were being made between two offices ashore.

- Maritime satellites provide near-global coverage (to about 75 degrees of latitude), which means that a ship with a ship earth station can be virtually anywhere on the navigable waters of the world and still send a distress alert or be reached by telephone or message communications.

- A ship equipped with a ship earth station can be reached 24 hours a day.

- INMARSAT has granted access to its system by land-based ship earth stations at RCCs, in accordance with provisions in the ITU Radio Regulations, which permit SESs at RCCs to communicate with other stations of the same category for distress and safety purposes. INMARSAT-A SESs are installed at RCCs in Argentina, Bulgaria, China, Germany, Greece, Ireland, Israel and the United Kingdom. With an INMARSAT ship earth station, safety authorities have virtually instant and high-quality communications available for contacting help and co-ordinating rescue operations.

- A distress message generator (DMG) can be built into the software of ship earth stations. Some ship earth stations already have this. This feature permits a distress message, which includes ship's position, course, speed and particulars of the distress, etc., to be sent automatically, without the need to prepare the entire message at the time of the emergency.

- The INMARSAT system can accommodate additional safety features, such as automatic ship reporting at regular intervals. A ship polling system can be used so that shore authorities could obtain ship's position information automatically. Many ship earth station manufacturers already offer an interface between navigation equipment and the ship earth station, which will allow this. Information relating to the ship's heading and speed can be sent to or retrieved by authorized users on shore.

- The INMARSAT system provides business communications for ships and meets many of the requirements specified for the GMDSS and included in amendments to the SOLAS Convention. Satellite communications, with their high reliability, simple operation and ability to handle a range of operating modes, are being enthusiastically welcomed aboard ships for their business, safety and social benefits.

- Satellites bring rapid, reliable communications to the aid of the mariner, to help avoid danger and to provide a means for summoning assistance when all else fails. The ability to communicate with a vessel anywhere in the world, at any time of day, and to know that you can be advised immediately of any difficulties, should appeal to all owners and operators of ships. The ability to contact a rescue co-ordination center or technical experts ashore for immediate assistance should appeal to every seafarer.

3.2.3 Space Segment

Four satellites in geostationary orbit 36,000 km above the equator cover for ocean regions, namely AOR-E (Atlantic Ocean Region-East), AOR-W (Atlantic Ocean region-west), IOR (Indian Ocean Region) and POR (Pacific Ocean Region), and provide near-global coverage.

3.2.4 Coast Earth Stations

The CESs provide the link between the satellites and terrestrial telecommunications networks. Currently, all CESs are owned and operated by telecommunications carriers. A typical CES consists of a parabolic antenna about 11m to 14m in diameter, which is used for transmission of signals to the satellite at 6 GHz and for reception from satellite at 4 GHz. The same antenna or another dedicated antenna is used for L-band transmission (at 1.6 GHz) and reception (at 1.5 GHz) of network control signals. The type of communication service provided varies depending on the CES. Designated for each ocean area for each communication service (i.e. telephone, direct-printing telegraph, etc.) service as a Network Co-ordination Station (NCS) which assigns communication channels, on demand, to SESs and other CESs and monitors signals transmitted by these stations.

3.2.5 Ship Earth Stations

The requirements for the SESs in the GMDSS can be met by INMARSAT SESs capable of two-way communications, such as INMARSAT-A, INMARSAT-B and INMARSAT-C SESs.

3.2.6 INMARSAT-A SES

An INMARSAT-A SES consists of two parts, Above –Deck Equipment (ADE) and Below-Deck Equipment (BDE) (figure 3.1). The BDE includes a parabolic antenna, about 0.85m to 1.2m in diameter, mounted on a plate form and stabilized so that the antenna remains pointed at the satellite regardless of ship motion. It also includes a sold state L-band power amplifier, an L-band low-noise amplifier, a diplexer and a low-loss protective radome. The ADE consists of an antenna control unit; communications electronics used for transmission, reception, access control and signaling; and telephone and telex equipment.

Figure 3.1 Example of INMARSAT-A SES

The new generation of INMARSAT-A equipment currently begins produced by manufacturers is smaller and easier to use than earlier models. ADE is now available weighing less than 50 kg, making it suitable for installation in most types and sizes of vessels and yachts. Many of the current systems are modular in design and allow the addition of optional equipment such as facsimile, data and slow-scan television, etc. some BDE has a microcomputer with Visual Display Unit (VDU), alphanumeric keyboard, hard-copy printer and modem. The computer can be used to prepare telex messages with the ease of modern word-processing equipment. Messages can be composed, edited and transmitted directly from the screen or stored for later transmission. In some models, the computer memorizes the satellite's co-ordinates and CES tariffs and automatically routes the call in the most economical way.

With additional facilities, users have modified their terminals to allow automated vessel reporting. Those involved in vessel management on shore can dial the ship at any time of the day or night and automatically receive information as to its position, heading, etc., as well as data on its cargo and operation-all without disturbing or distracting the crew. A distress message generator is normally built in to a terminal (mostly a software modification) for storage of basic essential vessel information and automatic transmission in a distress situation.

3.2.7 INMARSAT-B SES

The INMARSAT-B SES is a digital complement of INMARSAT-A SES developed to replace INMARSAT-A SES equipment in the future. It provides the same communications services as an INMARSAT-A SES.

The INMARSAT satellite system provides nearly global coverage with a constellation of geostationary satellites. The original INMARSAT-A service is due to be phased out in the coming years. Its re-placement, INMARSAT-B service, offers high-quality Voice, Telex, Data and Group III fax capabilities.

INMARSAT-B service rates are significantly less than INMARSAT-A service, making it a must for customers with high-volume requirements. The high-speed data (HSD) option for the INMARSAT-B Service allows for data transfer at 56/64 kbps.

3.2.8 INMARSAT-C SES

INMARSAT-C SESs are small, lightweight terminals designed for two-way message communication (figure3.2). INMARSAT-C SESs can not be used for radiotelephone communications; they operate at 600 bit/s and provide access to the international telex/teletex networks, electronic mail services and computer databases. This low-powered terminal with its Omni directional antenna and lightweight is a practical solution for installation on the smallest of vessels, there by bringing the benefits of satellite communications within the reach of all mariners. It will enlarge the user community by providing equal access to exiting and emerging satellite services to all seafarers.

Figure 3.2 Example of INMARSAT-C SES

Additionally, an INMARSAT-C SES can serve as a back-up for an INMARSAT-A SES on large ships and also fulfill potentially vital role as a fixed or table transmitter/receiver for use on board ship or in survival craft. The Omni directional antenna characteristics are particularly valuable for a vessel in distress as the SES continues to operate even when the vessel is listing severely. As with the INMARSAT-A SES, a distress message generator can be included in the terminal software for storage of basic essential vessel information and automatic transmission in a distress situation.

3.2.9 Enhanced Group Calls Receiver

The INMARSAT EGC receiver is a dedicated piece of equipment for the reception of information by INMARSAT EGC service. It has been designed to enable automatic continuous watch on international safety NET MSI broadcasts and commercial INMARSAT fleet NET messages, such as superscription to news services, etc. An EGC capability can be added to INMARSAT-A, INMARSAT-B and INMARSAT-C SESs or it can be stand-alone receiver with its own antenna.

An EGC receiver is required in the GMDSS for all ships, which processed beyond coverage of the international NAVTEX service.

3.3 INMARSAT Services

1. Ship-to-Shore Distress Alerting

The INMARSAT system provides priority access to satellite communications channels in emergency situations. Each SES is capable of initiating a "request" message with distress priority (INMARSAT priority-3 call). Any "request" message with a distress priority indication is automatically recognized at the CES and a satellite channel is instantly assigned. If all satellite channels happen to be busy, one of them will be preempted and allocated to the SES, which initiated the distress priority call. The processing of such calls is completely automatic and does not involve any human intervention. The CES personnel, however, are notified of the reception and passing through of a distress priority message by audio-visual alarms.

To ensure the correct treatment of distress priority request, the NCS in each ocean region automatically monitors the processing of such calls by all other CESs in that region. In the event that any anomalies in processing are detected, the NCS will take appropriate action to establish the end-to-end connection. In addition, the monitoring NCS also checks the CES identity contain in the distress priority message and automatically accept the call if an identity of a non-operational CES has been detected (which any happen due to operator error a board the vessel in distress).

The distress priority applies not only with respect to satellite channels but also to the automatic routeing of the call to the appropriate RCC. Each CES in the system is required to provide reliable communication interconnection with an RCC; these national RCCs are known as associated RCCs. The means of CES-RCC interconnection may vary from country to country and include the use of dedicated lines or public switched networks. Thus, any distress priority request message received at the CES is automatically processed and passed to the associated RCC. Some CESs, due to national consideration, pass distress priority message to special operators, who are responsible for the subsequent routeing of the call to the appropriate RCC, or provide an option which allows the ship board operator to contact any RCC when a satellite channel has been assigned on the distress priority basis.

The initiation of a distress priority message in most SESs is made simple for ship crewmembers by provision of a "distress button" or code in the SES. On activation of this button, the equipment instantaneously transmits a distress priority message. This single operation, a push of the "distress button", provides automatic, direct and assured connection to a component rescue authority, there by avoiding the need for the SES operator to select or key the telex or telephone number of the RCC and eliminating possible human error. The establishment of this end-to-end connection, begin completely automatic and on a priority basis, takes only a few seconds.

INMARSAT has issued technical guidelines to manufacturers for a Distress Message Generator (DMG), which consist of SES soft ware to transmit automatically, after the connection has been established, the distress message in a standardized format that provides information on the vessel's identification, its position and the particular emergency.

The procedure described above is the primary means of ship-to-shore distress alerting in the INMARSAT system. It should be noted, however, that INMARSAT SES-equipped ships can also contact any RCC of their choice by following the calling procedure for routine calls. In this case, the complete international telephone/telex number has to be selected.

A major benefit of the INMARSAT distress priority is that it eliminates the need for dedicated frequencies to be allocated for distress and safety communications. Distress messages made through the INMARSAT distress priority system are sent through the general communication channels on an absolute priority basis to ensure an immediate connection.

2. Shore-to-Ship Distress Alerting

Shore-to-ship alerting to groups of ships with INMARSAT-A, INMARSAT-B or INMARSAT-C SESs but without INMARSAT safety NET capability can be performed in the following modes:

1. "All ships call"-calls to ships in the ocean region concerned. It should be noted, however, that due to the large coverage zones of geostationary satellite such alerting is not very efficient, although it maybe justified under exceptional circumstances.

2. "Geographical area calls"-calls to ship navigation in a defined geographical area. Each satellite coverage region is subdivided in to smaller areas, and the bounders of these areas are based on NAVAREAs each having a unique two-digit area code. SESs will automatically recognize and accept geographical area calls only if the correct code has been input by the SES operator; the system requires the periodic manual input of appropriate area cods; or

3. "Group calls to selected ships"-this service is provided by number of CESs in the operator- assisted mode and allows alerting of a predetermined group of vessels. This service could be very useful for alerting, for example, SAR units.

As long as they are not engaged in traffic, SESs accept all incoming messages without any differentiation of priority.

3. Shore-to-Ship Distress Alerting Through the INMARSAT Safety System

The EGC receiver can be an integral part of a SES or a completely separate unit and it ensures a very high probability of receiving shore-to-ship distress alert messages. When a distress priority message is received, an audible alarm will sound and it can only be reset manually.

Accessing the INMARSAT safety NET service by RCCs requires arrangement similar to those needed for shore-to-ship distress alerting to a standard SES. Those

6. Promulgation of MSI (via INMARSAT Safety NET Services)

In the INMARSAT system, promulgation of MSI is performed by means of the INMARSAT safety NET system. Although an INMARSAT-A, INMARSAT-B or INMARSAT-C SES can receive the safety NET broad casts, if uninterrupted receipt of important MSI is required when the SES is engaged for other communications, then it is essential to have a dedicated EGC reception capability for such broad casts. Alternatively, an EGC receiver can be installed as a separate unit.

7. General Radio Communications

The INMARSAT system provides ships at sea with the same types and quality of modern communications as are available a shore. The capability for direct-dial, automatic connection without delay using high-quality multi-mode communications is provided by SES. Tele printers, VDUs and telephone sets, as well as facsimile machines and data equipment can serve as peripheral equipment to SESs.

The quality and availability of general radio communications offered by the INMARSAT system permit ship's master to rapidly consult and seek assistance on any matter, whether of a safety or commercial nature. High-quality general communications are therefore a valuable asset to safety at sea as well as the efficient operation of the ship.

The following are examples of INMARSAT services:

- Direct-printing telegraphy.
- Telephony.
- Data communications.
- Facsimile.
- Slow-scan television.
- Automatic data collection from ships.

3.4 L-band satellite EPIRBs

L-band satellite EPIRBs operating through the INMARSAT system can be used a means of alerting by ships operating in sea areas A1, A2 and A3 as an alternative to 406 MHz satellite EPIRBs.

The basic concept of the INMARSAT L-band satellite EPIRBs system is shown in figure 3.3. The distress signal transmitted from the float-free satellite EPIRBs on the dedicated channel in the 1.6 GHz frequency (L-band) is relayed by an INMARSAT satellite to CESs equipped with the appropriate receiver and processor equipment.

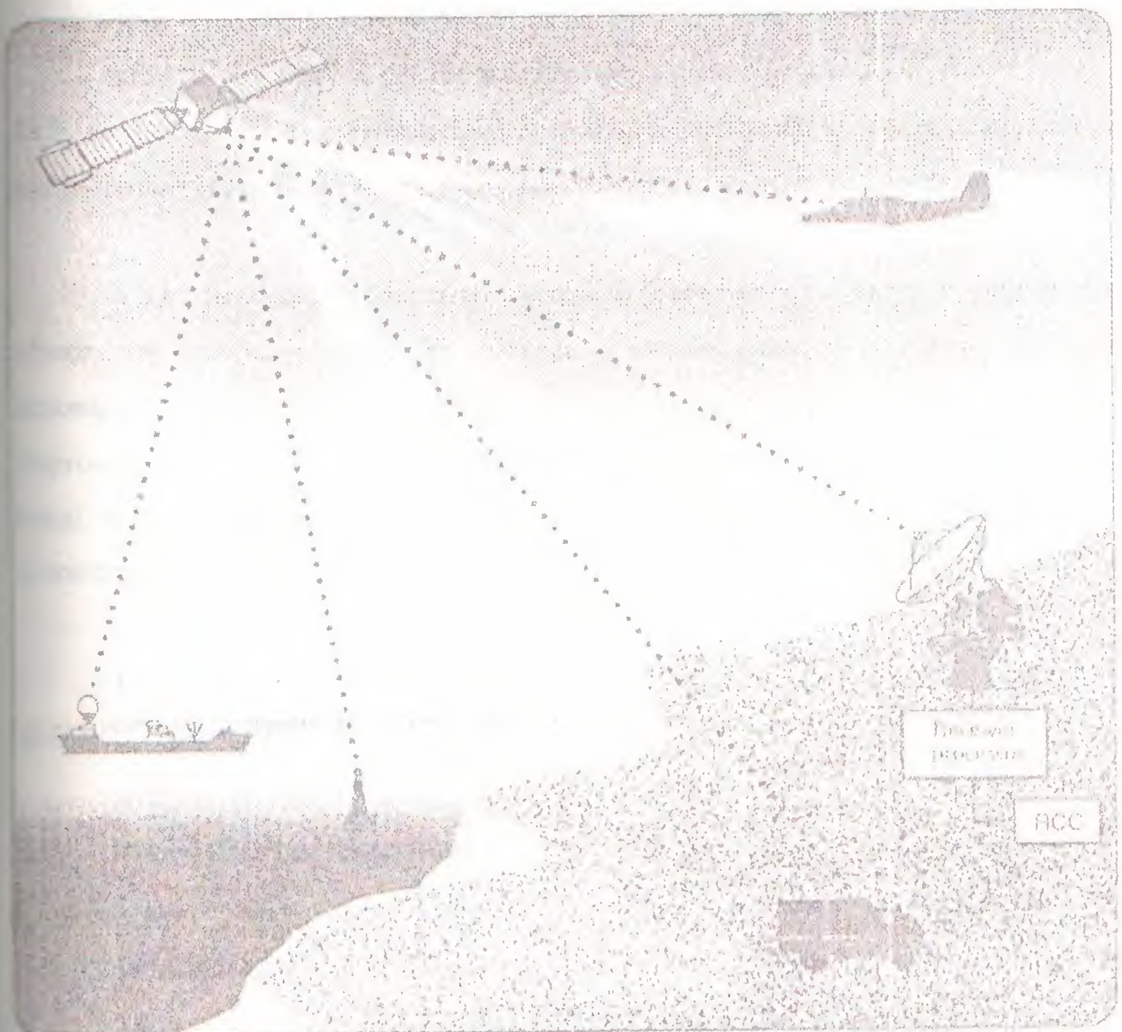

Figure 3.3 Basic concept of the L-band satellite EPIRB system

The L-band satellite EPIRB provides for rapid distress alerting (in the order of 10 minutes with 1W output power radiated by an EPIRB). Coverage up to ±70° latitude, 20 simultaneous alert within 10-minute time frame and the possibility of manual or automatic entry and update of position information to the satellite EPIRB. The satellite EPIRB can be activated either manually or automatically, by a floating free from the sinking ship.

After activation, the satellite EPIRB transmits the distress message containing the ship station identity, position information and additional information, which could be used to facilitate rescue. The transmission is repeated on a pre-selected duty cycle. Additionally, unless an integrated electronic position- fixing device is included which provides position updates, a built-in 9 GHz SART is activated for locating purposes.

After begin relayed by the satellite, the distress signal is down-converted at the CES to the specified intermediate frequency to be transferred to the computer-aided multi-channel receiver for satellite EPIRB identification and message decoding.

After the signal channels are identified, they are assigned to processor channels where the incoming signal plus noise is superimposed in the memory. Having accomplished the necessary number of superposition which results in 2~3 dB improvement of signal-to noise ratio for every frame, the memory is read out and the usual processors, such as bit and frame synchronization, evaluation of the error-correcting code and the message print-out, are performed.

The distress message is then forwarded to an associated RCC for appropriate action.

3.5 Sea 6003 Specifications

- **General**

INMARSAT T/A: TA-04-060-04. Meets or exceeds all current and proposed specifications for the INMARSAT-C Network and SOLAS/GMDSS requirements, including CN114, IMO A.807 (19), IEC 1097-4, IEC 945, EEC EMC and CE Mark. FCC ID: BZ6SEA6003

- **Protocol**

Message transmission and reception with IA-5, ITA-2, and binary transfer to/from the following destinations: Telex, PSTN (telephone and fax modems), PSDN (X.25 network), EGC message reception with automatic geographical area selection, polling and data reporting with automatic transmission of position reports down to 1 per minute, special access codes, DNID messaging, program unreserved data reporting, preassigned data reporting, SOLAS distress calling facilities (GMDSS). Transmit message size: Max 32 Kbytes. Receive storage: 106 Kbytes.

Languages Available: English, Cyrillic, French and Spanish

- **Transceiver**

Transmit Frequency: 1626.5 to 1660.5 MHz.

Receive Frequency: 1525.0 to 1559.0 MHz.

GPS Frequency: 1575.42 MHz.

Channel Spacing: 5/2.5/1.25 kHz.

Modulation: 1200 symbols/sec BPSK.

Ambiguity Resolution: Unique Word.

Coding: R 1/2 K = 7 convolutional code. (Interleaved code symbols RX).

Data Rate: 600 bit/sec.

RX Frame Length: 8.64 seconds.

TX Signaling Access Mode: Slotted ALOHA.

TX Message Channel: TDMA & FDMA, interleaved code symbol.

Antenna Interface: Standard 50-Ohm female TNC-connector.

GPS (Optional): 8 channel, 1-second update rate, 15 m RMS accuracy (100 m with S/A)

Terminal Interface: Serial EIA-232-E DTE, CCITT Rec. V.24/28, 110-38400 Baud IA-5 code, DB-9F connector.

Printer Interface: Standard parallel IEEE 1284, Centronics, DB-25F connector.

I/O Interface: NMEA 0183 version 2.1, ArcNet 2.5 Mbit, Remote Alarm, DB-15F.

System Setup: Flash EEPROM programming from operator terminal.

Solid State Storage: 256 Kbytes SRAM, 512 Kbytes Flash.

DC Power Source: 10 to 32 V floating DC.

RX: 4.8/90 W Rx/Tx with GPS module.

Ambient Temperature: - 25°C to 55°C operating, - 40°C to 80°C storage.

Electronic Unit Mounting: Flange mounting, vertical or horizontal.

Compass Safe Distance: 0.5 m.

- **General Antenna Specifications**

Type:

INMARSAT-C/GPS Omni directional, RHC polarized, G/T -23db/K, EIRP 14 dBW at 5° elevation. Coverage +90° to -15° elevation.

Ambient Temperature: - 35°C to 55°C operating, - 40°C to 80°C storage.

Relative Humidity: 95% non-condensing at 40°C.

Precipitation Up to 5 cm/hour, droplet size 0.5 to 4.5 mm.

Wind: Up to 200 km/h.

Ice: Up to 25 mm.

Vibration Operational: Random 5-20 Hz 0.005 g^2/Hz, 20-150 Hz -3dB/Oct. (1.0g rms.).

Vibration Survival: Random 5-20 Hz 0.05 g^2/Hz, 20-150 Hz -3dB/Oct. (1.7g rms.).

Shock: Half-Sine 20g/11ms.

Standard Capacity Antenna

Interface: Female TNC Connector.

Solar Radiation: 1200 W/m^2 max flux density.

Max. Transmission Length: 10 Kbytes.

Mounting: Roof. Standard 1.5" tube.

Heavy Capacity Antenna (Optional)

Interface: N Connector.

Solar Radiation: Infrared, 500W/m^2.

Max. Transmission Length: 32 Kbytes.

Mounting: Roof. Standard 1.5"tube.

CHAPTER FOUR
COMMUNICATIONS SYSTEMS

4.1 COSPAS-SARSAT System

4.1.1 Introduction

The COSPAS-SARSAT system is a satellite-aided SAR system designed to locate distress beacons transmitting on the frequencies 121.5 MHz or 406 MHz. It is intended to serve all organizations in the world with responsibility for SAR operations whether a distress occurs at sea, in the air or in the land.

COSPAS-SARSAT is a joint international satellite-aided SAR system, established by organizations in Canada, France, the United States and the former USSR.

The COSPAS-SARSAT system has demon started that the detection and location of distress signals can be facilitated by global monitoring based on low-altitude satellites in near- polar orbits. It has been used successfully in a large number of SAR operations worldwide.

Unless, as an alternative, a ship is provided with an L-band satellite EPIRB, the carriage of a float-free satellite EPIRB operating on the frequency 406 MHz in the COSPAS-SARSAT system is mandatory on all SOLAS ships.

4.1.2 General Concept of the System

The basic COSPAS-SARSAT system concept is given in figure (4.2). There are at present three types of satellite beacons, namely Emergency Locator Transmitter (ELTs) (air borne), EPIRBs (maritime) and Personal Locator Beacons (PLBs) (land). These beacons transmit signals that are located by COSPAS-SARSAT polar-orbiting satellites equipped with a suitable receivers/processors. The signals are then relayed to a ground receiving station, called a Local User Terminal (LUT), which process the signals to determine the beacon location. An alert is then relayed, together with location data and other information, via a Mission Control Center (MCC), either to a national RCC, to another MCC or to the appropriate SAR authority to initiate SAR activities.

Doppler shift (using the relative motion between the satellite and the beacon) is used to locate the beacons. The carrier frequency transmitted by the beacon is reasonably stable during the period of mutual beacon-satellite visibility. The frequencies currently in use are 121.5 MHz (international aeronautical emergency frequency) and 406.025 MHz. The 406 MHz beacons are more sophisticated than the 121.5 MHz beacons because of the inclusion of identification codes in the messages, but complexity is kept to a minimum. To optimize Doppler location, a low-altitude near-polar orbit is used. The low altitude results in a low up link power requirement, a pronounced Doppler shift, and short interval between successive passes. The near-polar orbit results in complete world coverage over a period of time.

The Doppler location concept provides two positions for each beacon: the true position and its mirror image relative to the satellite ground track. This ambiguity is resolved by calculations that take into account the earth's rotation. If the beacon frequency stability is good enough, as with MHz beacons 406 MHz beacons, which are designed for this purpose, the true solution is determined over a single pass. In the case of 121.5 beacons, the ambiguity is resolved by the results of the second pass if the first attempt is unsuccessful. The improved performance of 406 MHz satellite EPIRBs is the reason these devices were selected for the GMDSS.

Figure 4.1 COSPAS-SARSAT satellites

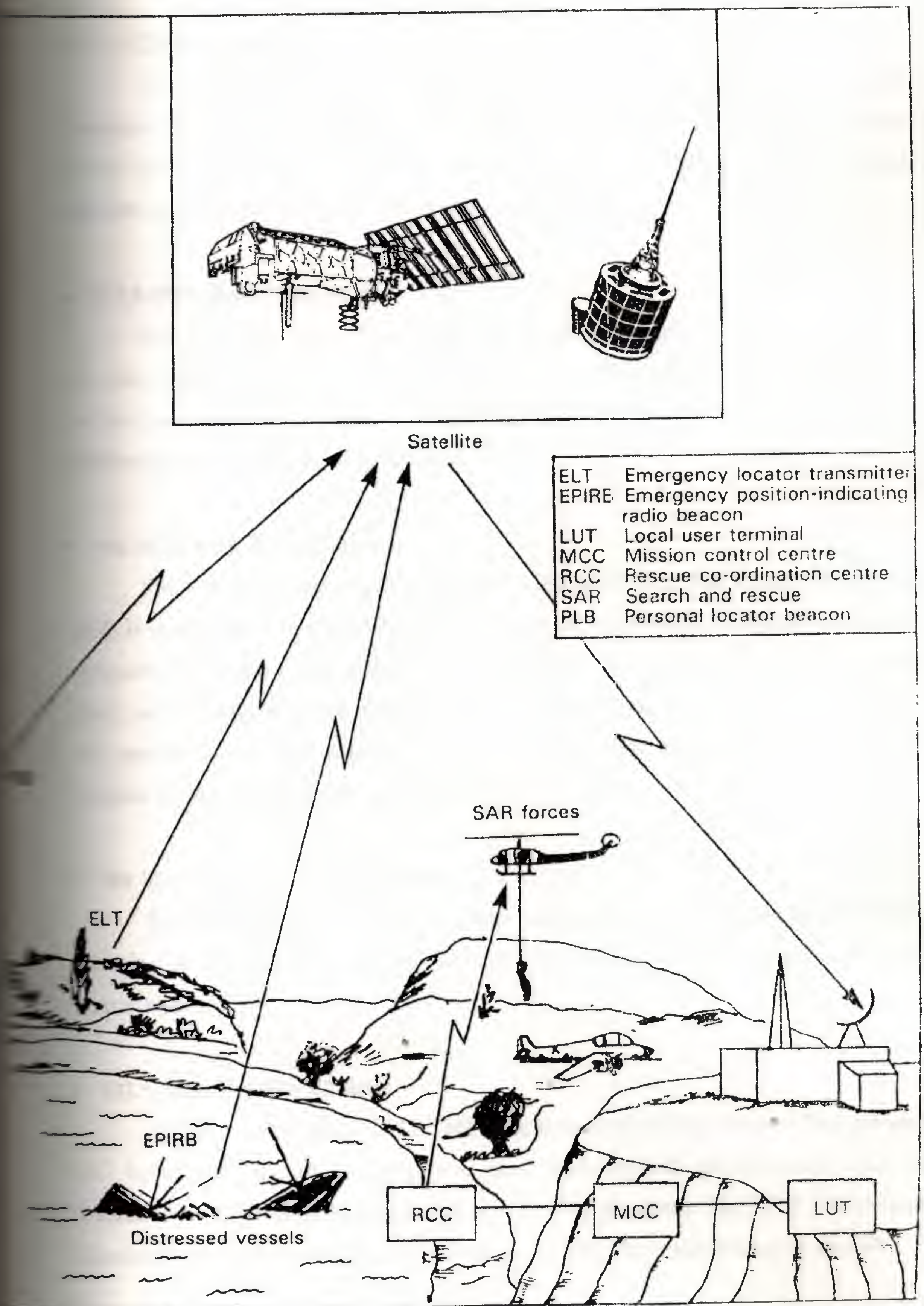

Figure 4.2 Basic concept of COSPAS-SARSAT system

4.1.3 Coverage Modes

The COSPAS-SARSAT system implements two coverage modes for the detection and location of beacons, namely the real-time mode and the global coverage mode. Both the 121.5 and 406 MHz systems operate in the real-time mode, while only the 406 MHz system operates in the global coverage mode.

- **121.5 MHz Real-Time Mode**

In this mode, an LUT and EPIRBs must be in the same view of the satellite for the 121.5 MHz EPIRB signal to be relayed by a repeater on board the satellite directly to the ground, where it is received and processed. For this reason, world-wide real-time mode coverage is unlikely to be achieved.

- **406 MHz Real-Time Mode**

Once the satellite receives the 406 MHz satellite EPIRB signals, the Doppler shift is measured and the beacon digital data, which include ship's identification, etc., recovered from the beacon signal. This information is time-tagged, formatted as digital data, and transferred to the downlink repeater for real-time transmission to any LUT in the satellite views. The data are simultaneously stored in the on-board memory of the satellite for later transmission in the global coverage mode.

- **406 MHz Global Coverage Mode**

The 406 MHz system provides global coverage by storing data on board for later dumping and reception by LUTs. Each satellite EPIRB can therefore be located by all operating LUTs.

- **121.5 MHz Satellite EPIRBs**

EPIRBs operating on 121.5 MHz are already in widespread use. They are used on board light aircraft and ships and must meet national specifications based on International Civil Aviation Organization (ICAO) standards. The 121.5 MHz beacon signals also provide for homing by SAR units and over flight monitoring by aircraft.

- **406 MHz Satellite EPIRBs**

The development of 406 MHz satellite EPIRB (figure 3.5) has been under taken to overcome certain shortcomings of 121.5 MHz system. The new EPIRBs were specifically designed for satellite detection and Doppler location and include the following features:

- Improved location accuracy and ambiguity resolution;
- Increased system capacity, i.e. a greater number of beacons transmitting simultaneously in the field of view of a satellite can be processed;
- Global coverage;
- Unique identification of each beacon; and
- Inclusion of distress information.

The 406 MHz satellite EPIRBs transmit a 5 W radio frequency (RF) burst of approximately 0.5 second duration every 50 seconds. Improved frequency stability ensures improved location accuracy, while the high peak power increase the probability of detection. The low duty cycle provides good multiple-access capability with a system capacity of 90 activated beacons simultaneously in view of the satellite, and low mean power consumption.

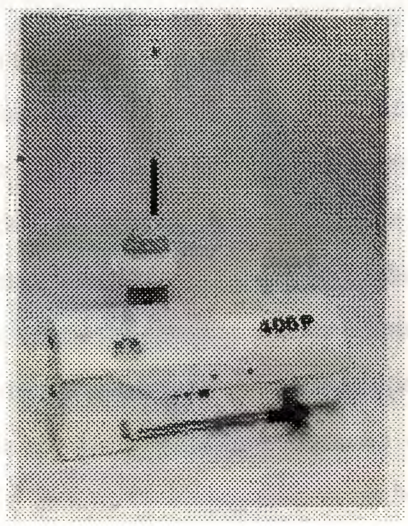

Figure 4.3 Example of 406 MHz COSPAS-SARSAT satellite EPIRB

An important feature of the new satellite EPIRBs is the inclusion of a digitally encoded message, which may provide such information as the country of origin of the unit in distress, identification of the vessel or aircraft, nature of distress and, in addition, for satellite EPIRBs coded in accordance with the maritime location protocol, the ship's position as determined by it navigation equipment.

Most satellite EPIRBs are, as recommended, dual-frequency 121.5/406 MHz beacons, through the inclusion of the frequency 121.5 MHz is not mandatory. This enables suitable SAR units to home in on the 121.5 transmission and permits over flight monitoring by aircraft. This type of homing facility, if provided, is indicated to the rescue authorities by the message. As SARTs have limited range of operation (5 nautical miles), consideration is being given to requiring all maritime satellite EPIRBs to operate on the frequencies 121.5 MHz and 406 MHz.

Depending on the type of beacon (maritime, airborne or land), beacons can be activated either manually or automatically.

4.1.4 COSPAS-SARSAT Low Earth Orbit Search and Rescue (LEOSAR) System

COSPAS-SARSAT has demonstrated that the detection and location of 406 MHz and 121.5 MHz distress beacon signals can be greatly facilitated by global monitoring based on low-altitude spacecraft in near-polar orbits. Complete, yet non-continuous coverage of the Earth is achieved using simple emergency beacons operating on 406 MHz to signal a distress. The non-continuous aspect of the coverage occurs because the polar orbiting satellites can only view a portion of the earth at any given time. Consequently the System cannot produce distress alerts until the satellite is in a position where it can see the distress beacon. However, since the satellite onboard 406 MHz processor includes a memory module, the satellite is able to store distress beacon information and rebroadcast it when the satellite comes within view of a LUT, thereby providing global coverage. With the older type of beacons operating at 121.5 MHz, the system coverage is neither global nor continuous because detection of the distress depends on the availability of a ground receiving station in the satellite field of view at the same time that the satellite receives the beacon signal.

As described above, a single satellite, circling the earth around the poles, eventually views the entire Earth surface. The "orbital plane", or path of the satellite, remains fixed, while the earth rotates underneath it. At most, it takes only one half rotation of the Earth (i.e. 12 hours) for any location to pass under the orbital plane. With a second satellite, having an orbital plane at right angles to the first, only one quarter of a rotation is required, or 6 hours maximum. Similarly, as more satellites orbit the Earth in different planes, the waiting time is further reduced. The COSPAS-SARSAT System design constellation is four satellites, which provide a typical waiting time of less than one hour at mid-latitudes.

The LEOSAR system calculates the location of distress events using Doppler processing techniques. Doppler processing is based upon the principle that the frequency of the distress beacon, as "heard" by the satellite instrument, is affected by the relative velocity of the satellite with respect to the beacon. By monitoring the change of the beacon frequency of the received beacon signal and knowing the exact position of the satellite, the LUT is able to calculate the location of the beacon.

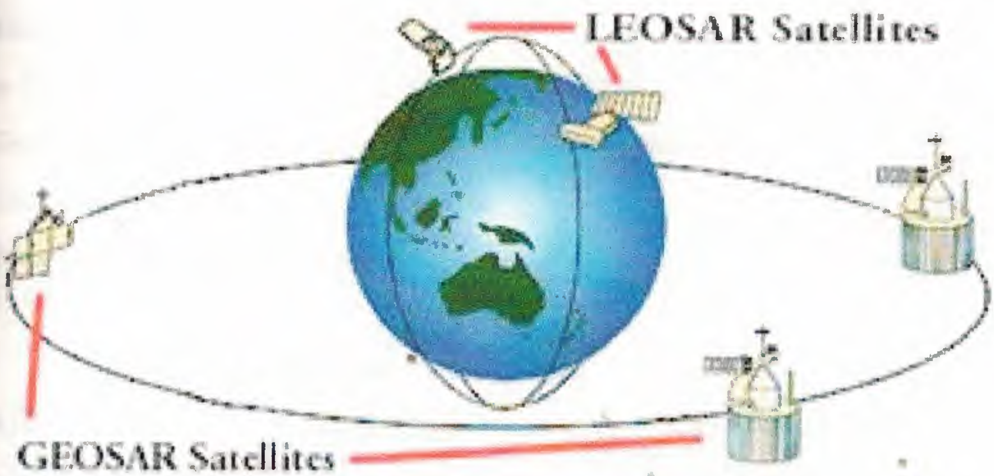

Figure 4.4 LEOSAR satellites

4.1.5 Space Segment

The SAR instrumentation on board the COSPAS and SARSAT satellites operates in the following modes:

- Real-time mode: 121.5 repeater;
- Real-time mode: 406.025 MHz data processing and downlink; and
- Global coverage mode: 406.025 MHz stored data transmission.

The equipment in the board the satellite consists of the following basic sub-assemblies:

- 121.5 MHz receiver;
- 406.025 MHz receiver/processor and memory unit; and
- 1544.5 MHz downlink transmitter.

- **121.5 MHz Receiver**

This unit has a bandwidth of 25 kHz. Automatic Level Control (ALC) is provided to maintain a constant output level.

- **406.025 MHz Receiver/ Processor**

The functions of the receiver/processor are as follows:

- Demodulating the digital messages received from beacons;
- Measuring the received frequency; and
- Time-tagging the measurement.

All these data included in the output signal frame are modulated for down linking to LUTs. The signal frame is transmitted at 2,400 Bits/second in the real time mode and also stored in memory for later transmission by the global coverage mode. In the global coverage mode, the on-board memory is dumped in the same format and at the same bit rate as real-time data. LUTs thus directly receive the stored beacon messages acquired during an entire orbital revolution. If a new beacon signal is received during the stored memory dump, the dump is interrupted so that the signal can be processed and the resultant message interleaved with the stored data. Appropriate flag bits indicate whether the data are real-time or stored and the time at which full playback of the stored data was accomplished.

- **1544.5 MHz Downlink Transmitter**

The 1544.5 MHz downlink transmitter accepts input from the 406 MHz receiver/processor and receiver(s) operating on the other COSPAS-SARSAT band(s) (121.5 MHz and 243 MHz), adjusts the relative power level in accordance with ground command, phase modulates low-frequency carrier with the composite signal, multiplies the frequency to produce 1544.5 MHz, amplifiers the power level and drive the satellite downlink antenna.

4.1.6 Local User Terminals and Mission Control Centers

The configuration and capabilities of each LUT vary to meet specific requirements of countries, but the COSPAS and SARSAT satellite downlink signal formats ensure interoperability between the various satellite and all LUTs meeting COSPAS-SARSAT specifications.

There are tow types of LUTs, those, which process 121.5 MHz, and 406 MHz signals and those, which process 406 MHz, signals only.

Figure 4.5 is block diagram of typical COSPAS-SARSAT LUT. The antenna and receiving system pick up the signal, which is down-converted to an intermediate frequency (IF) and linearity demodulated to produce the composite baseband spectrum, which is filtered and separated into the various bands of interest. As the signal is received, the processing of each band is accomplished according to the specific capabilities of the LUT. The option for LUT configuration incorporating analogue tape recorders provides a back-up mode in the event of processor failure.

For the 121.5 MHz signal, each transmission is detected and the Doppler shift is calculated. A beacon location is then determined using these data. All 406 MHz data received from the satellite memory on each pass can be processed within a few minutes of pass completion.

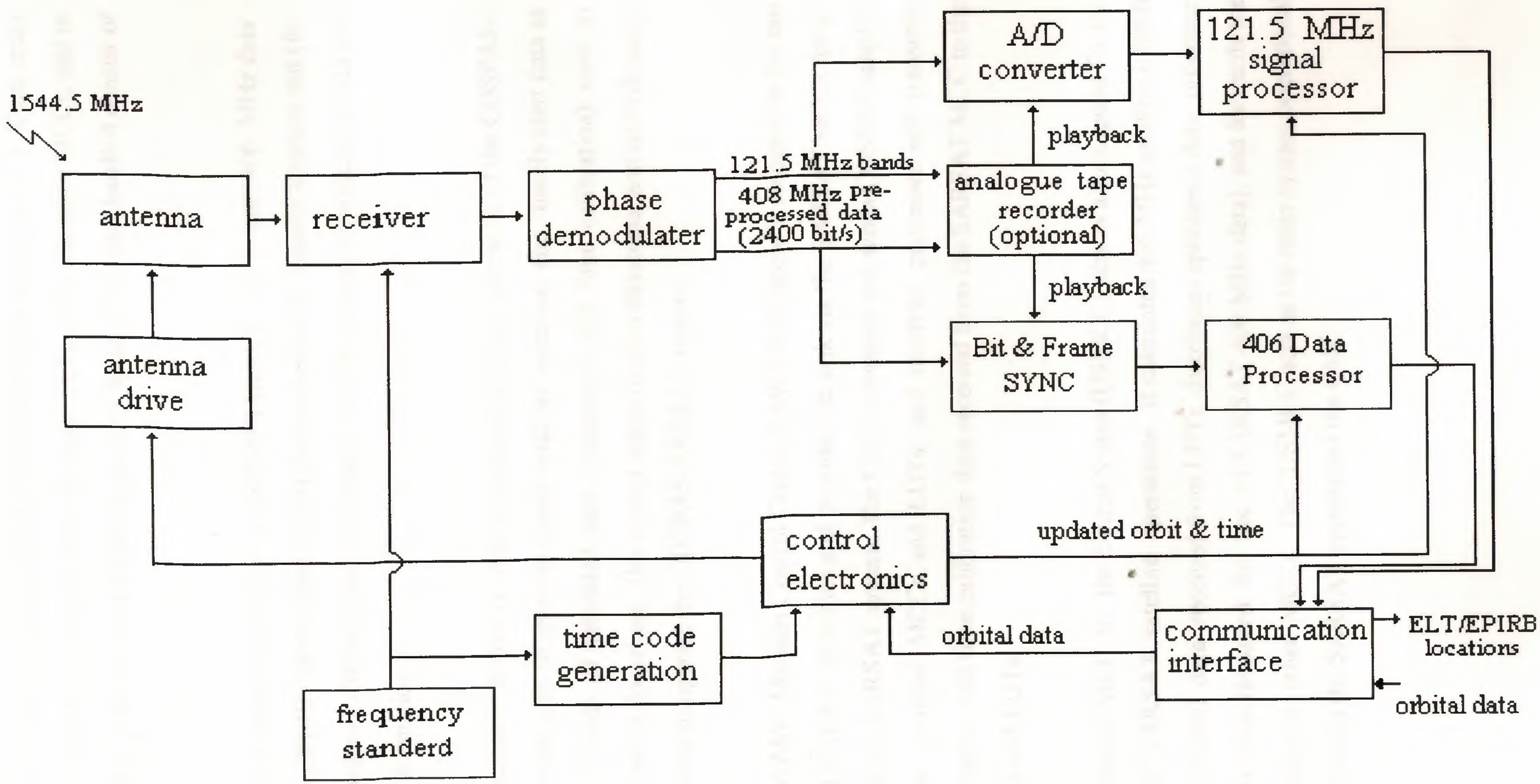

Figure 4.5 Example of COSPAS-SARSAT LUT functional block diagram

MCCs have been set up in each country operating at lest on LUT. Their main functions are to collect, store and sort the data from LUTs and other MCCs, and to provide such data to SAR networks (see figure 4.6). Most of the data handled consist of the following:

1. Alert data is the generic term for COSPAS-SARSAT 121.5 and 406 MHz data derived from EPIRB information. Alert data comprise the beacon location and (for 406 MHz satellite EPIRBs) other information such as beacon identification data and other coded information.

2. System information is primarily used to maintain efficient operation of the COSPAS-SARSAT system and to provide users with as accurate and timely alert data as possible. It consists of tabulated data (ephemeris and time calibration) used to determined beacon locations, the current status of all subsystems, and co-ordination message required to operate the COSPAS-SARSAT system.

The COSPAS Mission Control Center (CMC) in Moscow is responsible for co-ordinating all COSPAS activities and provides the link via the SARSAT MCCs for all interaction with the SARSAT system. The CMC computes and sends COSPAS satellite ephemeris data to other MCCs and LUTs, and receives, processes and transmits SARSAT ephemeris and time calibration data received from the SARSAT MCC to the COSPAS MCCs and LUTs.

A designated MCC in the United States (USMCC) acts as a focal point for the co-ordination of SARSAT satellite operations. It calculates 406 MHz satellite EPIRB locations using stored data received from LUTs, distributes ephemeris data, processes time calibration data (required for use of SARSAT 406 MHz data), and forwards the appropriate results to other MCCs. The USMCC acts as the main system operational contact point between the SARSAT system and the CMC.

2. EPIRB detection probability for the 406 MHz satellite EPIRB is defined as the probability of detecting and decoding at least four individual message bursts during a single satellite pass so that a Doppler curve-set estimate can be generated by the LUT. At 121.5 MHz, EPIRB location probability is defined as the probability of location during a satellite pass above 10° elevation with respect to the beacon. EPIRB location probability relates to the two solutions ("true" and "mirror") and not to a single unambiguous result.

3. EPIRB location error is defined as the difference between the location calculated by the system using measured Doppler frequencies and the actual location.

4. Ambiguity resolution probability is defined as the ability of the system to select the "true" rather than the "mirror" location.

5. Capacity is defined as the numbers of EPIRBs in common view of the spacecraft, which the system can process simultaneously.

6. Notification time is the period from activation of an EPIRB (i.e. first transmission) to reception of a valid alert message by the appropriate RCC.

Performance of the COSPAS-SARSAT system

The system performance characteristics are given in table 4.1.

Note: performance at 121.5 MHz is highly sensitive to EPIRB spectral characteristics. The values given below were confirmed by statistical analysis of over 5,000 beacons during the development and experiment phase.

Table 4.1 system performance characteristics

Characteristic	121.5 MHz	406 MHz
Detection probability	(not applicable)	0.98
Location probability	0.9	0.9
Location accuracy	17.2 km	90% within 5 km
Ambiguity resolution	0.73	0.96
Capacity	10	90

1. Coverage: the 12.1 MHz system operates in real-time only, while the 406 MHz system operates in both real-time and global modes. The overall coverage is provided by the COSPAS-SARSAT system in real-time mode is determined by the number and positions of LUTs, each covering an area with a radius of approximately 2,500 km. In the global coverage mode using 406 MHz satellite EPIRBs, complete world coverage is achieved.

2. Notification time depends on the following parameters:
   - Satellite constellation;
   - LUT configuration;
   - Beacon location relative to an LUT;
   - Beacon latitude; and
   - Ground communication network.

4.3 Operational Procedures

This section provides a description of alert data and system information and general description of data flow.

4.3.1 Alert Data

Alert data users are defined as those responsible for SAR operations; system information users are primarily organizations with technical responsibility for the COSPAS-SARSAT system (MCCs, LUT operators, and managers of ground segment facilities).

Alert data are of two types: coded beacon-generated messages and LUT/MCC-generated alert messages. Signals transmitted by activated EPIRBs provide the initial input, which triggers the generation of alert messages. Once the incoming coded EPIRB message has been received and processed by the LUTs, the alert data are forwarded to the national MCC for distribution.

Each MCC distributes alert data according to its own requirements and procedures to any country within its service area, which has greed to accept such data. These data are given to SAR authorities so that immediate SAR action can be taken. Additionally, any MCC receiving alert data relating to an EPIRB within another MCCs service area or elsewhere in the world relays that information to the appropriate MCC or SAR authority.

4.3.2 System information

The term system information covers five types of system messages- ephemeris messages, time calibration messages, telemetry data, satellite command and c0-ordination messages:

- Ephemeris or orbits vector information is used to acquire and track the satellite and to compute EPIRB positions.
- Spacecraft time calibration is vital for the accurate determination of EPIRB locations.
- Telemetry data provides for information on the status of the on-board SAR instruments.
- Satellite command messages are transmitted on up link during the post-launch checkout procedure to correct faults or out-of-limit conditions.
- Co-ordination messages are used to communicate general information required for COSPAS-SARSAT system operation.

4.3.3 Message Formats

Messages between MCCs are sent specific format permitting automatic processing and retransmission, while messages between their LUTs are formatted in accordance with national requirements. Standard message formats are used to transmit alert data to RCCs outsides the COSPAS-SARSAT system.

4.3.4 Communication Network

Each MCC transfer alert data and system information to ground system elements within its service area according to communications network requirements and procedures

- **How the global area network works**

Take a TV crew's video package as an example:

First, software running on the notebook PC takes the output from the digital video and compresses it to a more manageable size.

The resulting compressed file is then transferred from the notebook to the mobile satellite unit, which transmits it as a stream of digital information over the INMARSAT satellite network to the nearest land earth station (LES). At the LES it joins the telecoms operator's ISDN backbone network. From there, it can:

- Travel across the TV company's private wide area network (WAN)
- Be sent across the public ISDN network, or
- Pass through the Internet, perhaps to the broadcast company's password-protected web site.

Whichever route the message is sent, it takes just a few minutes for the file to arrive at the newsroom computer on the other side of the world. There, it is decompressed and ready for use in the next broadcast .

The latest breakthrough in INMARSAT's growing range of mobile e-communications. All in a notebook-sized package weighing about 4kgs. With 20 years' experience in leading-edge mobile satellite technology, trust INMARSAT to keep you networked everywhere business takes you.

Because it is satellite based, INMARSAT's Global Area Network can extend your company's IT reaches anywhere and everywhere, on any continent. And because it embodies the latest in 64kbps ISDN and IP technology the connection can be seamless and on-line for as long as it's needed

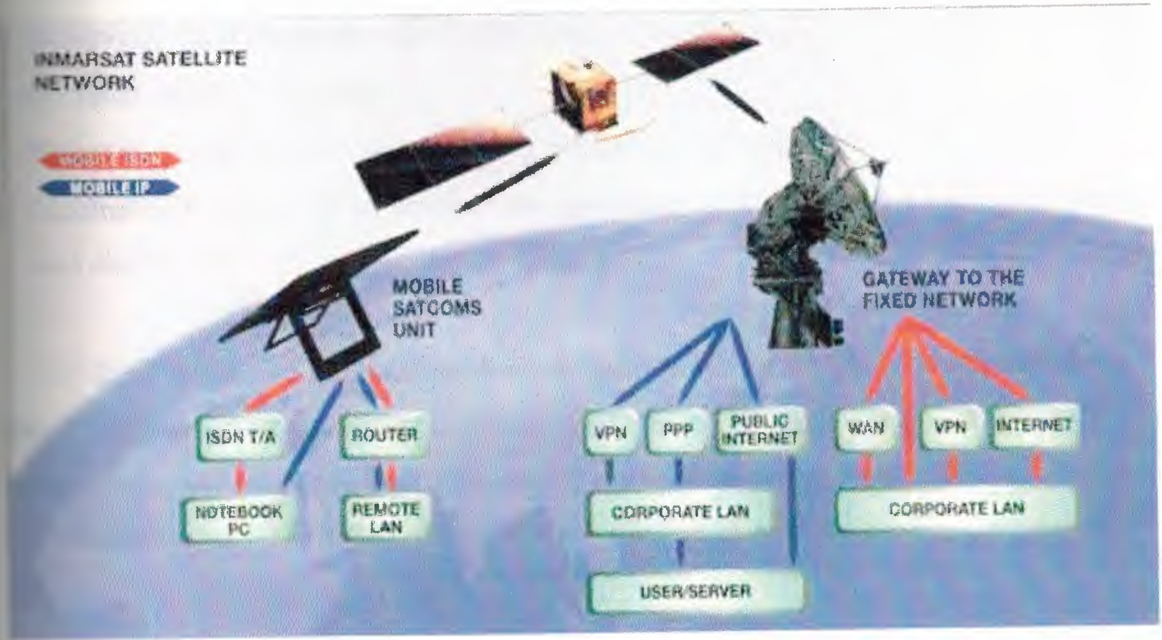

Figure 4.7 Communication network

The three common elements are:

The INMARSAT satellite network: The gateway to a fixed network: The Mobile Satcoms Unit (MSU)

4.4Digital Selective Calling (DSC) System

4.4.1 Introduction

Digital Selective Calling (DSC) is an integral part of the GMDSS and is used for transmitting distress alerts from ships and for transmitting the associated acknowledgment from coast stations. It is also used by ships and coast stations for relaying distress alerts and for other urgency and safety calls. Trials of DSC systems were co-ordinated by the CCIR Interim Working party 8/10 during 1982-1986 and included tests of the HF, MF and VHF DSC systems.

4.4.2 Advantages of Digital Selective Calling

A DSC-equipped VHF radio has all the features of your current VHF radio. In addition, it lets you participate in GMDSS and provides you with these convenient, safety-oriented features:

- Includes a capability to send automatic distress alerts
- Achieves greater range for distress alerts and other DSC calls
- Operates similar to a phone
- Makes direct ship-to-ship calls avoiding calling channel congestion
- Automatically alerts to incoming calls including notice of sudden storm warnings and distress alerts.

DSC makes a VHF radio work more like a telephone. It allows boaters to send a digital call directly to another DSC-equipped vessel or shore station, much like a person-to-person telephone call. Channel 70 has been set aside as the VHF/DSC digital call channel. Once the DSC call has been confirmed, both parties are automatically switched to a working voice channel.

4.4.3 Basic Description of DSC

- **Technical characteristics**

The system is a synchronous system using a ten-unit error-detecting code. The information in the call is presented as a sequence of seven-unit binary combinations.

The classes of emission, frequency shifts and modulation rates are as follows:

- FIB or J2B 170 Hz 100 baud for use on HF and MF channels. When frequency-shift keying is effected by applying audio signals to the input of single-side band *transmitters (J2B), the center of the audio-frequency spectrum offered to the transmitter is 1700 Hz.*
- Frequency modulation with a pre-emphasis of 6 dB/octave with frequency –shift of the modulating sub-carrier for use on VHF channels:
  - The frequency-shift is between 1300 Hz and 2100 Hz, the sub-carrier being at *1700;*

- The frequency tolerance of the 1300 Hz and 2100 Hz tons is ±10Hz;
- The modulation rate is 1,200 baud; and
- The modulation index is 2.0 ± 10%.

4.4.4 Operational Procedures

CCIR gives operational procedures of the DSC system. The content of a DSC call includes the numerical address of the station (or stations) to which the call is transmitted, the self-identification of the transmitting station and a message which contains several fields of information indicating the purpose of the call.

Various types of DSC calls are available, being either distress and safety-related calls or "commercial" calls (to indicate that a commercial communication, e.g. a telephony or telegraphy call, etc., is required). In the case of VHF, automatic connection to the public network can also be established through suitably equipped coast stations.

The receipt of a DSC call by a receiving station is accompanied by a suitable display or printout of the address, the self-identification of the transmitting station and the content of the DSC message, together with an audible or visual alarm or both for certain categories of calls (e.g. for distress and safety related calls).

The transmission speed of a DSC call is 100 baud on MF and HF and 1,200 baud on VHF. Error-correction coding is included involving the transmission of each character twice, together with an overall message-check character. The duration of a single DSC call varies between 6.2 and 7.2 seconds on MF and HF or 0.45 and 0.63 seconds on VHF depending on the type of DSC call transmitted.

For distress and safety operations simplex frequencies are used, there being one frequency in the MF band, five in the HF bands and one in the VHF band. For commercial operation at MF and HF paired frequencies are used, but at VHF the simplex channel 70 is used for both distress and safety and commercial calling.

In order to increase the probability of a DSC distress relay being received it is repeated several times to form a distress call attempt. On MF and HF two types of distress call attempts may be used, either a single frequency call attempt (five consecutive DSC distress calls in one frequency) or a multi-frequency call attempt (up to six consecutive DSC distress calls dispersed over any of the six DSC distress frequencies- one on MF and five on HF). On VHF only a single-frequency call attempt is used since there is only one VHF DSC frequency (channel 70). VHF and MF/HF distress calls may be transmitted simultaneously.

The various distress and safety-related calls by DSC are itemized below, together with a description of the content of the message for each type of call. In addition to the message content, each DSC call also contains other information, which is not displayed to the receiving station but which is used to ensure the technical integrity of the DSC system.

- **Distress Call (Alert)**

DSC distress calls are transmitted by a ship in distress and will be received by all suitably equipped ships and coast stations within propagation range of the radio frequency used.

A DSC distress call contains various items of information including the self-identification of the ship in distress, which will be displayed to the receiving station. This information will either be automatically included in the transmitted DSC distress call or will be inserted by the operator prior to transmission. When time does not permit the insertion of any information, "default" information will be included automatically.

- **Distress Acknowledgment**

Distress acknowledgments by DSC are normally transmitted manually by coast stations in response to a DSC distress call on the same frequency as the distress call was received. However, a distress alert may be acknowledged by ship stations when they believe that no coast station is likely to be able to acknowledge it. In this case, the acknowledgment is made by radiotelephony on the associated radiotelephone distress and safety traffic frequency.

- **Distress Relay**

DSC distress relays are transmitted in the following two situations:

1. By a coast station to alert ships in the area of a distress incident. Such a relay transmission would be addressed, as appropriate, to all ships, to a selected group of ships or to a specific ship.

2. By a ship station to an appropriate coast station if it received a DSC distress call on a HF frequency and it was not acknowledged by a coast station within 3 minutes.

The distress relay is transmitted as either single-frequency or multi-frequency call attempt.

If a ship receives a DSC distress relay addressed to a ships in a particular geographical area, then the display or print-out and alarm will not be activated if geographical co-ordinates inserted manually or by navigational interface into the receiving ship station's DSC equipment processor lie outside the addressed geographical area.

- **DSC Distress Call Repetition and Acknowledgment Transmissions**

If no distress acknowledgment is received in response to a DSC distress call transmission, then the ship in distress may repeat the DSC distress call attempt (on different DSC distress frequency if desired) after a delay of between 3.5 and 4.5 minutes from the beginning of the initial call. This allows time for any acknowledgment to be received.

A coast station receiving a DSC distress call on MF or HF should transmit a DSC distress acknowledgment after a minimum delay of 1 minute after receipt of the distress call, normally within a maximum delay of 2,75 minutes. On VHF a DSC distress acknowledgment should be transmitted as soon as practicable.

- **Reception of DSC Calls**

All DSC distress-related calls transmitted on MF and HF contain, at the beginning of each single call, a 200-bit 100-baud (i.e. 2 seconds) dot pattern to allow the use of scanning receivers on board ships. When used, a scanning receiver should be set to scan only the desired DSC distress frequencies, i.e. selected from the one MF frequency and the five HF frequencies.

It is important to ensure that, where a scanning receiver is used, all selected frequencies are scanned within 2 seconds, and the dwell time on each frequency should be adequate to allow detection of the dot pattern. The scan should only stop on detection of a 100-baud dot pattern. It is advisable that cost stations are able to receive more than one DSC distress-related call simultaneously on different frequencies, and scanning receivers should therefore not be used at coast stations.

4.4.5 DSC Ship Borne Equipment

Figure 4.8 shows examples of a DSC control unit, which, together with suitable VHF or MF/HF radio equipment, provides a complete ship borne radio system for automatic or manual operation within the DSC system for use in the maritime mobile services.

Figure 4.8 Examples of a DSC control unit

The unit consists of a modem and signal coder/decoder for producing DSC signals; it also contains a central processor unit for creating the different call formats, etc.

In addition, the unit includes an interface sub-unit, enabling automatic channel control of the connected VHF radio equipment, hard-copy printing of messages, and data collection from, for example, the navigational equipment on board the ship.

The unit also contains an audio alarm giving an acoustic alarm when a DSC message is received.

The information contained in the received DSC message is decoded and displayed on the front panel LCD display. This information maybe stored in an internal memory.

When receiving DSC messages other than a distress, urgency and safety call, to control unit provides for an automatic transmission acknowledging the call received.

Transmission of distress call by VHF DSC from the ship in distress can be initiated by simply pushing the distress button on the front panel of the control unit. The control unit also provides a function for including additional information concerning the distress situation in the distress message. Once initiated, the distress call is automatically repeated at intervals of about 4 minutes until acknowledged by another station or interrupted manually.

By using the keypad on the front panel of the control unit, the operator can compose different types of DSC message. In the case of VHF, the operator may, for individual DSC messages to a coast station, include the message the telephone number of the land subscriber, thus providing for the use of semi-automatic VHF systems expected to be implemented t coast stations in the future.

The control unit includes an internal register enabling the operator to store, for example, identity numbers of the coast stations with which the ship often operates. Also, telephone numbers of land subscribers may be stored in the register. These facilities make it possible for the operator to use abbreviated forms when composing DSC messages to coast situations.

- **Why Should I Register My DSC Radio?**

To use DSC, you must obtain a Maritime Mobile Service Identity (MMSI) number. MMSI acts as your unique maritime "phone number" used by search and rescue authorities to identify you and by other boaters that wish to call you. When you obtain an MMSI, you will be asked for certain information about you and your boat. This information is included in a national search and rescue database that the Coast Guard will use to locate and identify you in an emergency.

4.4.6 What is an MMSI?

Under GMDSS every vessel has it's own unique Maritime Mobile Service Identity (MMSI). An MMSI is composed of nine digits. A vessel MMSI is built into the DSC equipment and is not user-changeable. If a DSC unit is moved to another vessel, or the vessel is sold, a technician must re-program the MMSI.

MMSI's can also be assigned to a group of vessels. This can prove invaluable, for example, to fishing fleets and shipping lines to keep in touch with other vessels within that group. A call made to a group rather than an individual MMSI will alert all vessels within that group.

The Maritime mobile Access & Retrieval System maintained by the International Telecommunication Union is a searchable database, which can be used to identify a vessel or coast stations MMSI number. The database is updated on a weekly basis.

- **MMSI Format**

The first three non-zero digits of an MMSI number are used to distinguish the country of origin. Leading zero's are used to distinguish between vessels (no leading zero's), vessel groups (one leading zero), and coast stations (two leading zeros).

- **Example:**

- *232777777UK registered vessel*
- 023266666Group of UK registered vessels
- 002325555Coast Radio Station

- Typical Australian merchant vessel MMSI – 503001000 Where:
503is the Australian MID; and
01000is the individual ship number

- Coast Station MMSI – 005030001 where:
503is the Australian MID; and
0001is the individual Coast Station number

4.5 Search and Rescue Radar Transponders

4.5.1 Introduction

Search And Rescue Radar Transponders (SARTs) are the main means in the GMDSS for locating ships in distress or their survival craft, and their carriage on board ships is mandatory. The SART operates in the 9 GHz frequency band and generates a series of response signals on begin interrogated by an ordinary 9 GHz ship borne radar or suitable airborne radar. No modification is needed to a ship's radar equipment for detecting SART signals. SARTs can be either portable, for use on board ship or carrying in to any survival craft, installed on the ship and in each survival craft, or so as to operate after floating free from the sinking ship (figure 4.9). They may also be incorporated into a float-free satellite EPIRB.

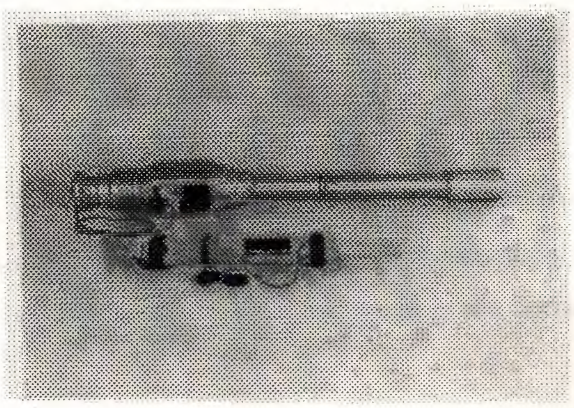

Figure 4.9 Search and rescue radar transponder

4.5.2 Operational and Technical Characteristics

The SART can be activated manually or automatically when placed in to the water so that it will thereafter respond when interrogated.

When activated in a distress situation SART respond to radar interrogation by transmitting a swept frequency signal which generates a line of blip code (figure4.10) on radar screen out word from the SART's position along its line of bearing. This unique radar signal is easily recognize on the radar screen and the rescue vessel (an aircraft, if equipped with suitable radar) can detected survivors even in poor visibility or at night.

Figure 4.10 SART blip code on radar screen

The SART provides a visual or audible indication of its correct operation and will also inform survivals when it is interrogated by a radar.

The SART will have sufficient battery capacity to operate in the stana-by condition for 96 hours and will be able to operate under ambient temperatures of –20° C to +55° C.

The vertical polar diagram of the antenna and hydrodynamic characteristics of the device will permit the SART to respond to radars under heavy swell conditions. SART transmission is substantially Omni-directional in the horizontal plane.

4.6 Maritime Safety Information System

4.6.1 Introduction

The world-wide Navigational Warning Service (WWNWS) was established by IMO and IHO for the purpose of co-ordinating the transmission of navigational warnings to ships in co-ordinated geographical areas (NAVAREAs).

Radio systems to be used internationally for the promulgation of MSI in the GMDSS and for which requirement have been included in SOLAS are:

- the international NAVTEX system;
- the INMARSAT safety NET system; and
- HF Narrow-Band Direct-Printing (NBDP) which may be used to augment these systems (under development).

The HF Morse telegraphy system, which is currently used for broadcasts of NAVAREA warnings, will be superseded by the above automated systems during the implementation periods of the GMDSS.

4.6.2 The International NAVTEX System

This system is an international direct-printing service for promulgation of MSI in the English language, pertaining to coastal waters up to about 400 miles off shore. Unlike NAVAREA warnings, which are tailored for international sea commerce on or near main shipping lanes, NAVTEX carries information relevant to all sizes and types of vessels within a region established for this service. It also carries routine meteorological forecasts and warnings and other urgent safety information to ships. A selective message-rejection feature of the receiver allows the mariner to receive only that safety information pertinent to his requirements.

Procedures to be followed by Administrations and the International Frequency Registration Board (IFRB) for co-ordination of the planned used of the frequency 518 kHz in the international NAVTEX system are contained in RR article 14A.

The existing NAVAREAs are used as region for planning and co-ordination of the international NAVTEX service. To assist such planning and advise IMO on the progress and on solutions to problems of system expansion, IMO has established the NAVTEX co-ordinating panel, which reports to the IMO sub-committee on radio communications.

- **Frequency of Operation**

The NAVTEX system has been allocated three broadcast frequencies:

518kHz – the main NAVTEX channel

490kHz – used for broadcasts in local languages (i.e.: Non-English)

4209.5kHz – allocated for NAVTEX broadcasts in tropical areas – not used at the moment.

In real terms, 518 kHz is the only NAVTEX channel used – this means that all broadcasts from stations within the same NAVAREA must be coordinated on a time sharing basis to eliminate interference.

In addition, power outputs from each station are adjusted to control the range of each broadcast. This is particularly important during night-time hours, as Medium Frequencies tend to travel further after dark.

NAVTEX is a single-frequency broadcast system; the frequency 518 kHz is used for this purpose. Mutual interference will be avoided by limiting the transmitter power to that necessary for coverage of the assigned area and by co-ordinating the broadcast schedules. MSI on the international NAVTEX service is broadcast in English.

- **NAVTEX Message Format**

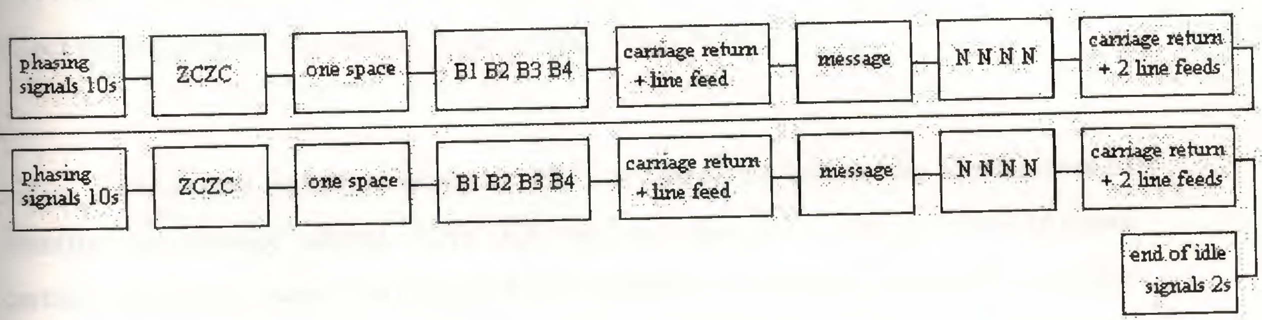

Figure 4.11 NAVTEX message format

In which:

ZCZC defines the end of the phasing period,

The B1 character is a letter (A-Z) identifying the transmitter coverage area,

The B2 character is a letter (A-Z) for each type of message.

B3B4 is a two-character serial number for each message, starting with 01 except in special cases where the serial number 00 is used.

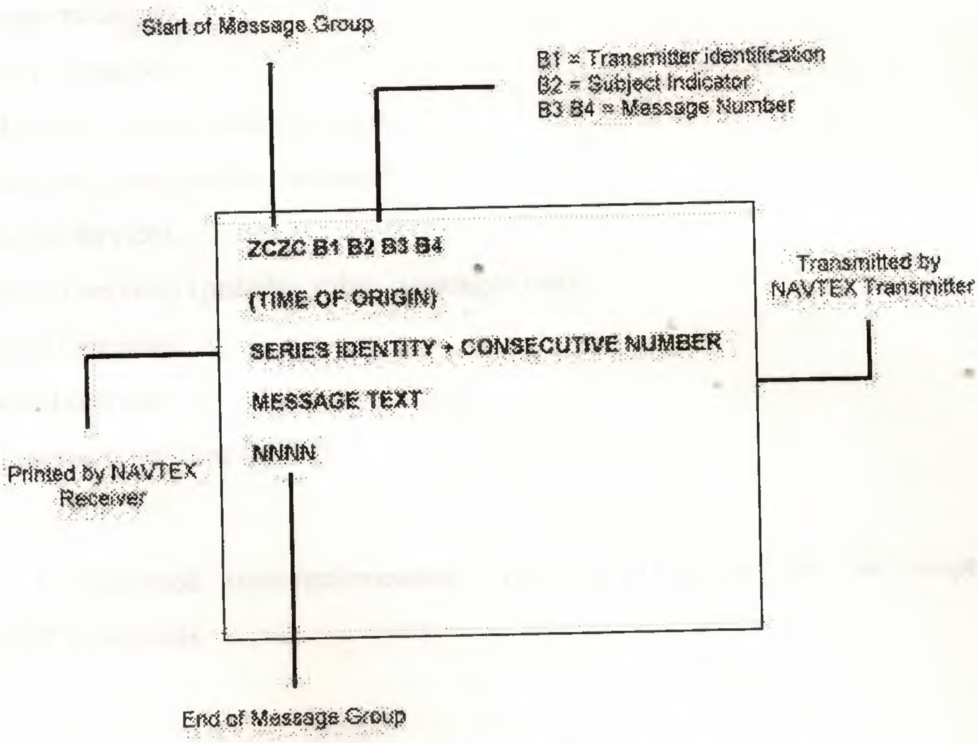

Figure 4.12 NAVTEX message block diagram

The transmitter identification character (B1) is a single letter allocated to each NAVTEX shore station transmitter. NAVTEX receivers allow the operator to accept or reject messages from any station, based on this single letter code.

The subject indicator character (B2) is also single letter code, which serves to identify the message subject. NAVTEX receivers also allow the operator to reject certain messages based on the subject indicator character. However, messages concerning Navigational Warnings, Meteorological Warnings, and Search And Rescue information can not be rejected.

Subject indicator characters assigned to the NAVTEX system are as follows:

A - Navigational warnings.

B - Meteorological warnings.

C - Ice reports.

D - Search and rescue information.

E - Meteorological forecasts.

F - Pilot service messages.

G - Decca messages.

H - Loran messages.

I - Omega messages.

J - Satnav messages.

K - Other electronic navaid messages.

L - Additional navigational messages.

V - Special services.

W - Special services (possible other languages use).

X - Special services.

Y- Special services.

Z - No message on hand (QRU).

A dedicated receiver/processor (figure 4.13) is used for the reception of NAVTEX broadcasts.

Figure 4.13 Example of NAVTEX receiver

4.6.3 Enhanced Group Call System

The Enhanced Group Call (EGC) (Safety NET) system, which was developed by INMARSAT, enables the provision of unique global automated service capable of addressing messages to pre-determined groups of ships or all vessels in both fixed and variable geographical areas.

The system is able to meet requirements of broadcasting global, regional or local navigational warnings, meteorological warnings and forecasts and shore-to-ship distress alerts to any region within INMARSAT satellite coverage. In addition to coverage the mid-ocean areas, the safety NET system can also provide an automated service in coastal waters where it may not be feasible to establish the NAVTEX service or where shipping density is too low to warrant its implementation.

A particularly useful feature is the ability to direct a call to a given geographical area. The area may be fixed, as in the case of a NAVAREA or weather forecast area, or it may be uniquely defined. This is useful for messages, such as a local storm warning or a shore-to-ship distress alert, for which it is inappropriate to alert all ships in the satellite coverage area.

Safety NET messages originate from registered information providers anywhere in the world and are broadcast to the appropriate ocean region via a CES. Messages are transmitted by the CES according to their priority, e.g. distress, urgency, safety and routine.

A board ship, safety NET messages will be received either via a dedicated receiver or via an optional receiver integrated in INMARSAT SES equipment. Upon reception of messages of distress or urgency category, aural and visual alarms are activated and they can only be reset manually.

IMO has established an international safety NET co-ordinating panel for the purpose of co-ordinating the development and the use of the international safety NET system for promulgating MSI.

CHAPTER FIVE

GMDSS REQUIREMENT AND PROCEDURES WORK

5.1 GMDSS Equipment Carriage Requirements

All the ships, to which the 1974 SOLAS convention, as amended in 1988, applies, are required to carry the GMDSS radio equipment, depending on the sea areas in which they operate.

One of two basic principles on which the GMDSS carriage requirement is based is a functional requirement to answer the capability of transmitting ship-to-shore distress alerts by at least two separate and independent means. The capability of performing other communications functions is also required.

Carriage requirements for GMDSS radio equipment can be summarized as follows:

- Sea area A1 ships will carry VHF equipment and either a satellite EPIRB or a VHF EPIRB;
- Sea area A2 ships will carry VHF and MF equipment and a satellite EPIRB;
- Sea area A3 ships will carry VHF, MF and satellite EPIRB and either HF or satellite communication equipment;
- Sea area A4 ships will carry VHF, MF and HF equipment and satellite EPIRB; and
- All ships will carry equipment for receiving MSI broadcasts.

The 1974 SOLAS convention, is amended in 1988, sets out the time frame for installing the GMDSS radio equipment, taking in to account system amortization, operational continuity, personal training, etc. to this and, the following transitional approach for the implementation of the GMDSS is given:

- All ships constructed after 1 February 1992 to be fitted with a radar transponder and two-way VHF radar telephone apparatus for survival craft;

- All ships to be fitted a NAVTEX receiver and a satellite EPIRB by 1 August 1993;

- All ships constructed before 1 February 1992 to be fitted with a radar transponder and two-way VHF radar telephones apparatus for survival craft by 1 February 1995;

- All ships constructed after 1 February 1995 to comply with all the appropriate requirements for the GMDSS;

- All ships to be fitted with at least one radar capably of operating in the 9 GHz band by 1 February 1995; and

- All ships to comply with the appropriate requirements for the GMDSS by 1 February 1999.

Ships which are not required to comply with the 1974 SOLAS convention are recommended to comply with the guide lines for the participation of non-convention ships in the GMDSS.

Amendments to the following instruments are under consideration by IMO for their compatibility with the GMDSS:

- Torremolions international convention for the safety of fishing vessels 1977;
- Code for the construction and equipment of mobile off shore drilling units;
- Code of safety dynamically supported craft;
- FAO/ILO/IMO code of safety for fisher men and fishing vessels; and
- FAO/ILO/IMO voluntary guide lines for the design, construction and equipment of small fishing vessels.

- **Power Supply Requirements**

GMDSS equipment is required to be powered from three sources of supply:

- Ship's normal alternators/generators;
- Ship's emergency alternator/generator (if fitted); and
- A dedicated radio battery supply.

The batteries are required to have a capacity to power the equipment for 1 hour on ships with an emergency generator, and 6 hours on ships not fitted with an emergency generator.

The batteries must be charged by an automatic charger, which is also required to be powered from the main and emergency generators.

Changeover from AC to battery supply must be automatic and effected in such a way that any data held by the equipment is not corrupted (i.e. "no break").

5.2 How do GMDSS Radio Procedures Work?

The difference between current procedures and GMDSS is that DSC is used to transmit the initial call. For example, currently you would initiate the call on Channel 16 to agree a working channel, whereas the GMDSS procedure would send a DSC call on Channel 70 containing the proposed voice-working channel. Once the other station has accepted the call then it can respond directly on the working channel.

If you are in distress, a DSC Distress Alert should be sent before the MAYDAY procedure. This Distress Alert will activate all alarms in any DSC radios within range and alert any radio operators to listen on the distress working channel (i.e. for VHF – Channel 16) for the subsequent MAYDAY call. The DSC alert contains your identification number and should contain a valid position (preferably as an automatic input from your navigation receive.

5.3 Shore-Based SAR Communication Network and Operation

To exploit the full advantages of globally integrated satellite and terrestrial communications, the GMDSS necessitates the establishment of an efficient communication network between RCCs. This will consist of interconnecting links between RCCs in accordance with arrangements made by IMO in support of the 1979 SAR Convention. In addition, each RCC will need rapid and effective communication links with its associated coast stations, INMARSAT CESs and COSPAS-SARSAT MCCs.

The interconnecting links between RCCs will usually be implemented using the public switched networks or dedicated circuits. Some RCCs, particularly those not having sufficient to access to the public switched networks, may use an INMARSAT SES to assist in the rapid exchange of distress and safety information between RCCs.

The communications network for the future system and associated SAR procedures will be flexible enough to satisfy many levels of international SAR co-ordination from the ideal of ocean areas where a SAR plan is operational, through many variations in the designation of Search and Rescue Regions (SRR) and provision of SAR facilities, to the worst cases where no responsibility has been assumed for, nor facilities provided in, a specific area.

SAR action in response to any distress situation will be achieved through co-operation among SAR administrations, which are able to provide assistance.

The shore station nearest to the reported distress position should, whenever possible, acknowledge the alert. Other shore stations receiving the alert should acknowledge it if the nearest station does not appear to respond. The shore station, which acknowledges the alert, must establish and maintain communications with the ship in distress until relieved of this duty.

The first RCC, which is the RCC affiliated with the shore station which first acknowledged the alert, should assume responsibility for all subsequent co-ordination of

SAR measures unless and until that responsibility is accepted by another RCC which is in a better position to assist.

If it is not at once clear which RCC has become the first RCC because more than one shore station has acknowledged the alert, the RCCs concerned should, as soon as possible, agree which is to become the first RCC so that the incident is responded to promptly. Follow-up action by the first RCC to co-ordinate SAR activities or to refer action to a more suitable RCC should also be carried out promptly.

A flow-chart for communications and procedures illustrating the action to be taken by the first RCC, is given in figure 5.1.

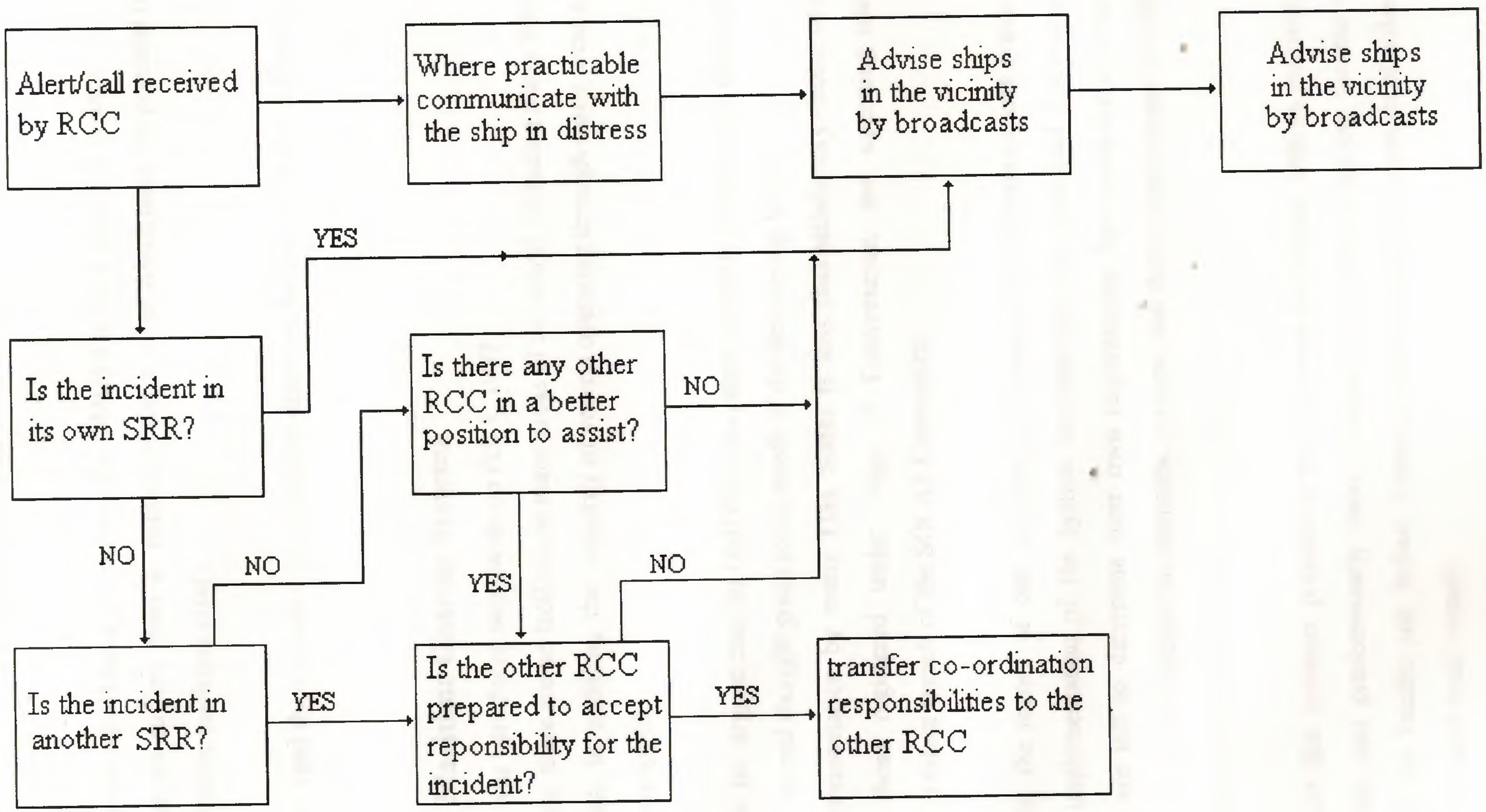

Figure 5.1 Action by the "first RCC"

CHAPTER SIX

FLAWS IN THE SYSTEM

Despite what some would have you believe the GMDSS is NOT a perfect system.

The system suffers from a number of flaws, all of which have the potential to seriously undermine maritime safety.

The problems (and their possible solutions) are discussed below and in the following 2 sections.

6.1 Two Maritime Distress Systems

The GMDSS was introduced worldwide on Feb 1, 1999.

To date, there are no facilities in many areas of the world, including many South Pacific nations. In addition, the majority of vessels operating through many areas are not GMDSS equipped.

It can be argued that the GMDSS is a system primarily designed for developed nations, with no real thought given to the needs of the developing world. GMDSS implementation by many Flag States is less than satisfactory - some ships, particularly those registered under Flags of Convenience, are operating under exemptions, in direct breach of the SOLAS Convention.

Whilst the theory of one universal global maritime communications system is sound, the implementation of the system has been less than successful. For example, Flag States are left to determine their own requirements for vessels not covered by SOLAS - i.e.: those engaged on domestic voyages, and those vessels under 300 GRT, engaged on an international voyage.

Whilst this solution presents no real problems for Europe, with its multitude of coast stations, and predominantly short voyages, it is next to useless for the vast expanses of the Pacific and Indian Oceans, where voyages of thousands of miles are undertaken by quite small vessels.

The result is that, in many parts of the world, there are two separate maritime safety communication systems running in parallel.

Some nations are even maintaining their Morse code services on 500 kHz.

Whilst IMO have extended the requirement for merchant vessels to maintain channel 16 VHF watch keeping until 2005, they have not continued the medium range compatibility provisions that existed between GMDSS and non-GMDSS vessels on 2 MHz under the pre-GMDSS system.

What this means is that there are no direct communications available between GMDSS and non-GMDSS vessels outside of VHF range (about 20 nautical miles). A merchant ship can therefore sail by a small vessel in distress, and vice-versa.

The GMDSS pundits would have us believe that the shore based GMDSS infrastructure will solve this problem by relaying ship-shore alerts from GMDSS vessels to their non-equipped counterparts.

Again, this is fine in theory for Europe, but what if there is no GMDSS-compatible shore infrastructure in place?

How are the alerts to be received, and then re-broadcast on non-GMDSS systems? Alerts go unheard, and people die.

The problem is exacerbated by the separation of commercial and distress/safety functions brought about by the GMDSS.

Under the pre-GMDSS Morse and Radiotelephone systems, the distress and safety services provided by Coast Radio Stations were subsidized to a certain extent by revenue from commercial traffic (i.e.: telegrams and telephone calls).

The GMDSS has transferred the great majority of the world's maritime commercial traffic to INMARSAT (satellite) systems.

Accordingly, many Coast Radio Stations are now forced to rely directly on funding from their Governments and SAR agencies. Unfortunately, some developing countries have precious little revenue to allocate to Coast Radio Networks.

Even Coast Stations in developed countries are feeling the effects of the GMDSS - many of the world's major Coast Radio Stations have closed or severely rationalized their services.

Some countries are now providing SAR-related services only from their stations.

What is being done?

To their credit, the IMO and the ITU are acting on the problem of GMDSS shore infrastructure in developing nations.

The IMO are developing a regional SAR fund to assist in the development of GMDSS shore stations, and the ITU have sent technical experts to many regions to design GMDSS facilities.

Unfortunately, these initiatives may not come into effect for some time.

6.2 The False Alert Problem

- **The DSC mess**

The GMDSS DSC system, particularly on HF, is plagued by an appallingly high false alert rate - in excess of 99.5%.

Of the 1200 DSC alerts received by Australian Coast Radio Stations in 1998/9, only 2 were genuine.

This situation has reached critical levels, to the point that there is talk of discontinuing DSC.

The root of the problem is that there is no real central operational and administrative authority to oversee the DSC system - the operation of DSC systems on vessels is effectively managed/regulated by individual Flag States.

The INMARSAT system used to suffer from a false alert rate approaching that of DSC – INMARSAT instituted a strong and well managed program to combat the problem, with the result that the INMARSAT false alert rate has dropped to negligible levels.

The situation has reached the point that DSC has become an impediment to safety at sea.

- **Equipment complexity**

Much of the DSC equipment available today is far too complex to operate. In addition, the operating routines vary significantly from brand to brand, such that a user trained on one type of equipment will have considerable difficulty operating another.

DSC controller operation is complicated by the inclusion of many (unnecessary) commercial functions - DSC controllers can be used to make automatic telephone calls via suitably equipped HF Coast Stations. Unfortunately, there are very few, if any, Coast Stations that offer this service.

Many controllers are equipped with small display screens - this makes operation very difficult. There was a move some time ago at IMO* to mandate a minimum DSC display screen size of 4 lines by 64 characters per line.

This recommendation was modified to require that a minimum of 160 characters be displayed in two or more lines. These modifications have taken effect for all new equipment fitted to ships as from 1 January 2000.

The modifications also mandate connection of a GPS and also the provision of an alarm to indicate that no position data is received from the GPS or, in the case of manual input, the position information is over 4 hours old. Any position information not updated for more than 23½ hours is also required to be erased from the system.

A complete copy of the new IMO requirements may be viewed here, or downloaded here in doc format.

There is nothing in the IMO performance standards to prevent manufacturers using a Personal Computer type system for DSC, i.e.: one with a large display screen - however none have been produced, probably because of cost.

However, all is not lost - some manufacturers are producing simple to use DSC systems, with large display screens.
It is hoped that this trend will spread.

- **False alerts**

Equipment complexity is leading to an unprecedented number of false alerts being transmitted.

The majority of these are caused by human error, however some have been known to be deliberately sent out of ignorance by system installers - they program in a bogus MMSI, and just push the distress button to see if the system works.

Such alerts are relatively easy to spot - the position is often suspect (12.34s 123.45e, for example), and the MMSI is often equally dubious (123456789, 111111111, 222222222, etc).

Can the system be too effective?
HF DSC's effectiveness and worldwide range is leading to its downfall.

Alerts are often received from stations quite literally on the other side of the world. It is not uncommon to receive a 12 MHz DSC alert from the North Sea in the South Pacific.

Whilst this is quite interesting from a technical perspective, it is a complete waste of time from a SAR viewpoint.

Compare the DSC system with INMARSAT - with INMARSAT, alerts are directed straight to the RCC - surrounding ships are only alerted via a carefully controlled re-broadcast from the RCC.

Although HF DSC is designed for ship-shore alerting, it operates in a broadcast mode - all ships monitoring the frequency receive the call, and all are therefore able to relay it.

- **Users are too enthusiastic.**

The ITU operational guidelines for HF DSC require that, basically, a vessel receiving a HF DSC alert is to immediately set watch on the corresponding R/T or NBDP channel for the band in which the DSC alert was received and await communications from the vessel in distress.

However, this is not happening - vessels are relaying HF DSC alerts indiscriminately.

Ironically, the original distress alert being relayed is, in itself, probably false. This is leading to serious congestion of the DSC channels - to the point that the original alert has become so corrupted that it appears a Coast Station is in distress!

Unfortunately, DSC is becoming an end in itself, rather than a simple alerting mechanism.

Many ships fail to adequately consider the information in a received alert before relaying - an alert from a ship with an obviously false MMSI (such as 123456789) should not be relayed.

Perusal of the international MID list reveals that the following MID numbers are not allocated:

000 123 111 222 333 444 777 888 999

It is very difficult for a ship's operator to change his/her DSC system's MMSI at sea, so one can safety assume that MMSI's with the above MID's must be bogus.

Users receiving a DSC distress alert from a vessel with a MMSI starting with any of these MID's can therefore IGNORE the alert - it can not be genuine.

Misplaced enthusiasm does not stop at the shoreline either.... Many Coast Radio Stations are also guilty of jumping in too quickly and relaying or acknowledging alerts that are clearly out of their area.

6.3 Solutions

Solutions

So, how do we come to terms with the HF DSC fiasco?

A lot of the problem can be overcome by ships directing relays to specific coast stations, and by Coast Stations using the geographic addressing capability of the system.

A ship receiving a HF DSC alert must:

1. WAIT and LISTEN on the corresponding radiotelephone or NBDP channel in the band in which the DSC alert was received.

2. If no communications can be heard from the ship in distress, and/or the ship in distress continues to send alerts, then the alert should be relayed to the nearest Coast Station - NOT TO ALL SHIPS.

Coast stations receiving a HF DSC alert out of their area must wait for a closer station to respond, rather than jumping in first.

DSC distress alert relays from Coast Stations should be addressed to a Geographic area around the distressed vessel's position, in the same way as an INMARSAT EGC message, not just broadcast to all ships.

Further, Coast Stations receiving a DSC alert from a bogus MMSI should not relay the alert, only acknowledge it to stop the offending equipment from sending any more.

(DSC distress acknowledgment messages automatically terminate the transmission of DSC distress alerts).

These simple steps will go a long way to improving the current chaotic situation with HF DSC.

The IMO has finally released DSC flow charts to serve as a simple guide for shipboard users. A link to these charts may be found at the bottom of the DSC page.

Whilst the charts are not as clear and simple as they might be, at least they are a step in the right direction.

CONCLUSION

The GMDSS is a system put in place internationally to enable rapid alerting of a marine distress situation to take place. This in turn enables search and rescue proceedings to be implemented with the minimum of time lost. The system involves the use of one or more methods of communication including Digital Selective Calling (DSC), Emergency Position Indicating Radio Beacons (EPIRBS), Search and Rescue Transponders (SARTS) as well as voice radiotelephone and INMARSAT communications.

From the 1st February 1999, GMDSS was fully implemented. From this date also the MF/HF radiotelegraphy (Morse code) service in Australia came to an end after 87 years of valuable and dedicated service.

Maritime Communications Stations operate on the HF GMDSS frequencies and broadcast weather reports and navigational warnings at scheduled times.

The basic concept of the GMDSS is that search and rescue authorities ashore, as well as shipping in the immediate vicinity of the ship, or persons, in distress, will be rapidly alerted to a distress incident so they can assist in a co-ordinated search and rescue operation with the minimum delay.

The system also provides for urgency and safety communications and the promulgation of maritime safety information (navigational and meteorological warnings and forecasts and other urgent safety information).

In other words, every ship is able, irrespective of the area in which it operates, to perform those communication functions, which are essential for the safety of the ship it self and of other ships operating in the same area.

REFERENCES

[1] GMDSS Hand Book Part One and Part Two, International Maritime Organization (IMO), 1997.

[2] Sue Fletcher ,Reeds VHF DSC Handbook, Thomas Reed,1997.

[3] ENG. Abed Alhamed Abed Alassem, GMDSS, Arab Academy For Science And Technology College Of Maritime Transport And Technology, 1995.

[4] Michael Gale, VHF GMDSS Handbook, Fernhurst, 1998.

[5] GMDSS Concept, http://www.gmdss.com.au.

[6] INMARSAT system, http://coastradio.tripod.com/gmdss.htm.