1 AN INTRODUCTION TO THE GMDSS SYSTEM

1.1 HISTORY

Radio was first used to save lives at sea in 1899. Subsequently, it has helped to rescue tens of thousands of people and become the key element of maritime search and rescue systems.

Since then, numerous technological advances have been made. However, until the introduction of the GMDSS in 1992, the way in which a message from a ship in distress was sent had changed very little from those early days; namely a radio operator sending a message by morse code or radiotelephone and hoping that another ship or shore station within range would hear the call and respond.

The GMDSS introduced new technology which completely transformed maritime radiocommunications. The system enables a distress alert to be transmitted and received automatically over long range, with significantly higher reliability.

1.2 FUNCTION REQUIREMENTS

The GMDSS provides every ship, while at sea, the following basic communication functions:

- transmitting ship-to-shore distress alerts (by at least two separate and independent methods)
- receiving shore-to-ship distress alerts
- transmitting and receiving ship-to-ship distress alerts
- transmitting and receiving search and rescue coordinating communications
- transmitting and receiving on-scene communications
- transmitting and receiving signals for locating
- transmitting and receiving maritime safety information
- transmitting and receiving general communications
- transmitting and receiving bridge-to-bridge communications.

1.3 BASIC CONCEPT OF THE GMDSS

Figure 1 gives a simplified overview of the GMDSS system.

1.3.1 Equipment carriage

A major difference between the GMDSS and the previous wireless telegraphy (W/T) and radio telephony (R/T) systems is that the equipment to be carried by a ship should be determined by its area of operation, rather than by its size.

1.3.2 Search and rescue

The GMDSS uses modern technology including satellite communications and digital selective calling techniques in the MF, HF and VHF bands (the latter known as terrestrial systems) enabling a distress alert to be transmitted and received automatically over short and long distances.

The system allows search and rescue authorities ashore, as well as shipping in the vicinity of the ship in distress, to be rapidly alerted to a distress incident so that they can assist in a coordinated search and rescue operation with the minimum of delay.

1.3.3 Maritime Safety Information

Additionally, the GMDSS provides for urgency and safety communications and the dissemination of maritime safety information (MSI) (navigational and meteorological information) to ships. Two systems are used for broadcasting MSI.

They are provided specifically to serve the requirements of Chapter IV of the 1974 SOLAS Convention, as amended, in the areas covered by these systems:

- NAVTEX — which uses MF radio to provide coastal warnings
- SafetyNET — which uses Inmarsat satellites to provide coverage from about 76 degrees north to 76 degrees south latitude.

In addition, some national meteorological services may issue warnings and forecasts for transmission by using HF narrow band direct printing (NBDP).

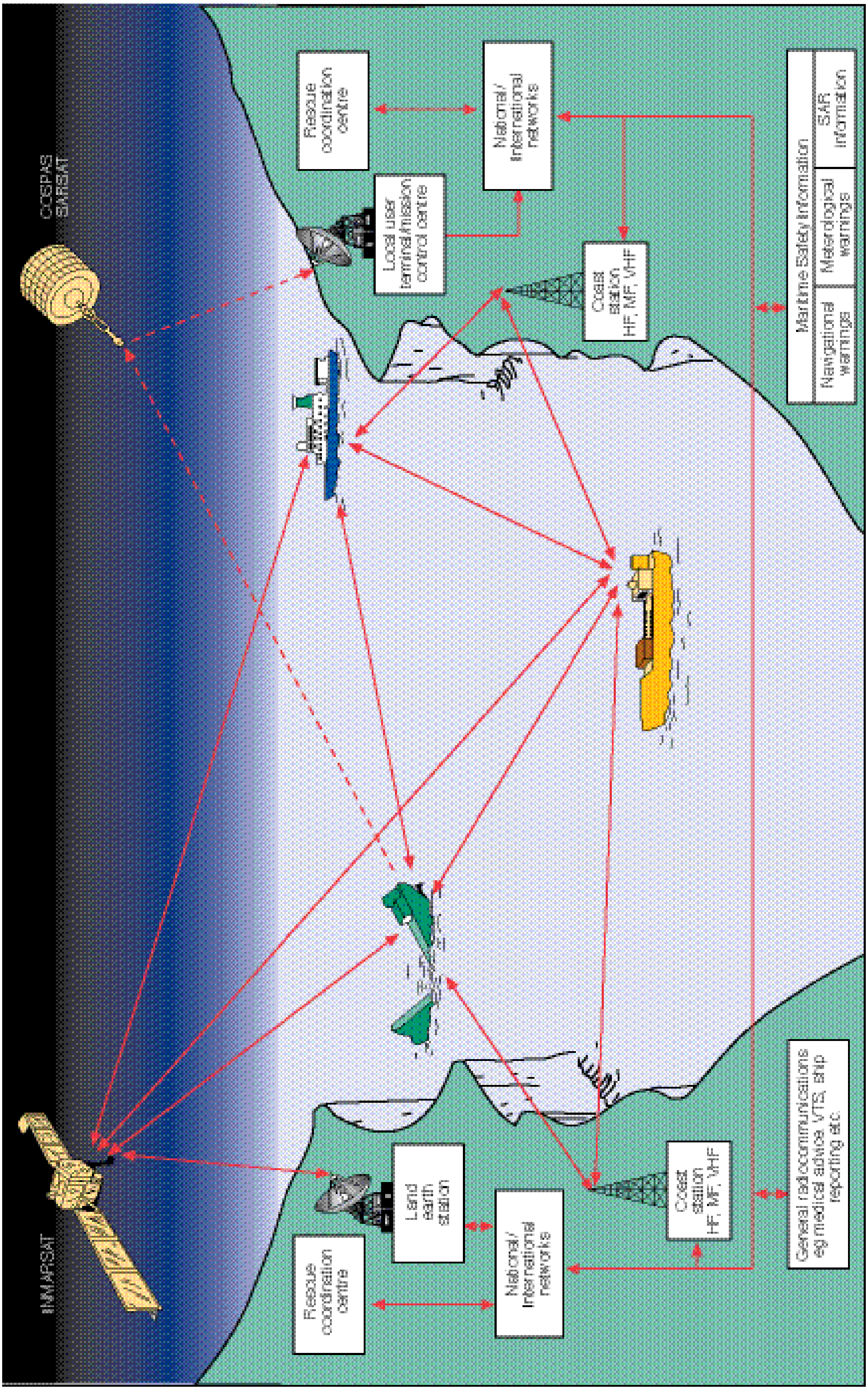

Figure 1 — The Global Maritime Distress and Safety System (GMDSS) - simplified overview

1.4 AREAS OF OPERATION UNDER THE GMDSS

Due to the different radio systems incorporated into the GMDSS having individual limitations with respect to range and service provided, the equipment required to be carried by a ship is determined by the ship's area of operation, rather than by its size. The GMDSS has divided the world's oceans into four distinct areas. All ships are required to carry equipment appropriate to the sea area or areas in which they operate.

1.4.1 GMDSS operational areas

Sea Area A1	within the radiotelephone coverage of at least one VHF coast station in which continuous VHF DSC alerting is available (approx. 20-30 nm)
Sea Area A2	within the radiotelephone coverage of at least one MF coast station in which continuous MF DSC alerting is available (within approx. 100 nm) (excluding Sea Area A1)
Sea Area A3	within the coverage area of an Inmarsat geostationary satellite in which continuous alerting is available (approx. between 76° N and S) (excluding Sea Areas A1 and A2)
Sea Area A4	the remaining sea areas outside areas A1, A2 and A3 (basically, the polar regions)

The Australian Government has designated its surrounding waters as GMDSS Sea Area A3 (see www.amsa.gov.au for more details). The only exception to this designation is the Antarctic waters south of approximately 76° S (dependent on longitude) which are Sea Area A4.

There are discussions at IMO that may result in redefining Sea Areas A3 and A4 based on satellite coverage of systems other than Inmarsat, if such systems are approved for use within the GMDSS. This is not expected to come into force for several years.

1.5 THE GMDSS MASTER PLAN

The IMO, a specialised agency of the United Nations, regularly publishes a list of planned and operational GMDSS shore based communications facilities available worldwide. This document is referred to as the GMDSS Master Plan.

1.6 INTRODUCTION OF GMDSS

The International Convention for the Safety of Life At Sea (SOLAS) contains a set of international regulations and standards governing all aspects of merchant ship operations. The convention has been ratified by all major maritime nations which operate through the IMO.

Amendments to the 1974 SOLAS Convention concerning radiocommunications for the GMDSS were published in 1989 and entered into force on 1 February 1992.

All ships over 300 gross tonnage (GT) on international voyages, and hence subject to the 1974 SOLAS Convention, have been required to comply with the carriage requirements of the GMDSS since 1 February 1999.

1.6.1 Relevant conventions and legislation

The carriage requirements for ships subject to the SOLAS Convention are contained in Chapter IV of SOLAS with Australian requirements provided in *Marine Order 27 (Safety of navigation and radio equipment) 2016*. Some requirements (eg for SAR locating devices) are also contained in:

- Chapter III of SOLAS
- the International Life-Saving Appliance (LSA) Code
- the High Speed Craft (HSC) Code.

The carriage requirements for both SOLAS (GMDSS compliant) ships and non-SOLAS (GMDSS compatible) vessels are designed to ensure the vessel can meet the functional requirements of the GMDSS relevant to that vessel and its operating area/s.

1.7 FUNCTIONAL REQUIREMENTS

There are two types of ships/vessels that carry GMDSS equipment:

- SOLAS (GMDSS compliant) ships which are required to carry the equipment under the SOLAS Convention
- non-SOLAS (GMDSS compatible) vessels, which are not subject the SOLAS Convention, but are required to carry GMDSS equipment under commonwealth legislation.

1.7.1 Functional requirements for GMDSS compliant ships

The functional requirements for GMDSS compliant ships (ships to which the SOLAS Convention applies) are contained in Chapter IV, Regulation 4 of the SOLAS Convention. This regulation requires that every ship, to which the regulation applies, and while at sea, shall be capable of:

- transmitting ship-to-shore distress alerts by at least two separate and independent means, each using a different radiocommunication service
- receiving shore-to-ship distress alerts
- transmitting and receiving ship-to-ship distress alerts
- transmitting and receiving search and rescue coordinating communications
- transmitting and receiving on-scene communications
- transmitting and receiving locating signals
- receiving MSI
- transmitting and receiving general radio-communications relating to the management and operation of the ship
- transmitting and receiving bridge-to-bridge communications.

1.7.2 Functional requirements for GMDSS compatible vessels

The functional requirements for GMDSS compatible vessels (vessels to which the SOLAS Convention does not apply) are contained in Schedule 3 of *Marine Order 27 (Safety of navigation and radio equipment) 2016*. This regulation requires that every vessel, to which the regulation applies, and while at sea, shall be capable of providing for the safety of the vessel with the ability to:

- perform ship-to-shore distress alerting by two independent means
- transmit ship-to-ship distress alerting
- transmit and receive on-scene communications, including appropriate SAR coordinating communications
- transmit locating signals
- receive MSI.

The installation on the vessel must be capable of assisting other vessels in distress, particularly the ability to:

- receive shore-to-ship distress alerting
- receive ship-to-ship distress alerting.

2 GENERAL PRINCIPLES AND FEATURES OF THE MARITIME MOBILE SERVICE

2.1 PRIORITIES OF COMMUNICATIONS IN THE MARITIME MOBILE SERVICE

Article 53 of the International Telecommunication Union Radio Regulations states that all stations in the maritime mobile (terrestrial radio) and the maritime mobile satellite service shall be capable of offering four levels of priority in the following order:

2.1.1 Distress communications

A distress message indicates that a mobile unit or person is threatened by grave and imminent danger and requires immediate assistance.

A distress message has absolute priority over all other communications.

Distress calls transmitted by radiotelephony are prefixed by the spoken word MAYDAY sent three times. Subsequent messages are preceded by the word MAYDAY once only (refer to section 16.7.2).

A distress message is often preceded by a distress alert using DSC.

2.1.2 Urgency communications

An urgency message indicates that the calling station has a very urgent message concerning the safety of a mobile unit or person.

An urgency message has priority over all other communications, excepting distress.

Urgency messages transmitted via radiotelephony are prefixed by the words PAN PAN sent three times.

An urgency message is often preceded by an urgency Alert using DSC.

2.1.3 Safety communications

A safety message indicates that the calling station has an important navigational or meteorological warning to transmit.

A safety message has priority over all other communications, excepting distress and urgency.

Safety messages sent via radiotelephony are prefixed by the word SECURITE sent three times.

A safety message can be preceded by a safety alert using DSC.

2.1.4 Other (routine/public) correspondence

A routine message is one not covered by the previous categories. Public correspondence communications are those which are used to convey routine information between persons on board ships and those ashore through the public telecommunications network. Examples of public correspondence communications are: telephone, fax, email and data messages.

2.2 TYPES OF STATIONS IN THE MARITIME MOBILE SERVICE

2.2.1 Ship stations

A ship station is a radio station established on board a ship for communications with stations ashore and other ship stations.

2.2.2 Coastal radio stations

A coast radio station is a radio station established on land for the purpose of communicating with ships at sea.

In Australia there are typically two types of coast radio stations:

- Major coast station — a station whose major function is the provision of SAR communications on behalf of AMSA, the transmission of weather reports and navigation warnings and watchkeeping on GMDSS distress channels. There are two major coast stations in Australia, located at Wiluna (Western Australia) and Charleville (Queensland). Both are remote controlled from JRCC Australia in Canberra
- Limited coast station — a station operated by volunteer marine rescue organisations and state/territory governments.

2.2.3 Port operations stations

Port operations stations are established for the operational control of ships in and around ports and harbours. A vessel traffic service (VTS) can operate within port areas, and can be guided in their operation by with IMO Resolution A.857 (20) (Guidelines on Vessel Traffic Services).

2.2.4 Aircraft stations

Ship stations communicate with aircraft stations during search and rescue operations on designated frequencies.

2.2.5 Joint Rescue Coordination Centre (JRCC)

The Australian JRCC (referred to as JRCC Australia) is located in Canberra and operated by AMSA. The JRCC coordinates search and rescue operations for ships and aircraft and the promulgation of navigation warning information (referred to as MSI). It is also the mission control centre for the Cospas-Sarsat system (discussed later). The JRCC is connected by various communications links to coast radio stations, land earth stations (LESs) and other search and rescue organisations.

2.3 FREQUENCIES AND FREQUENCY BANDS

2.3.1 Frequency and wavelength

The number of times that the alternating current in a radio wave performs its complete cycle per second is known as its frequency. The international unit of measurement of frequency is the hertz (symbol = Hz).

The wavelength of a radio wave is the distance between two successive positive peaks of two cycles. Wavelength is inversely proportional to frequency, ie as the frequency of a radio wave increases, the wavelength decreases, and vice-versa.

The wavelength of a radio wave is determined by the formula:

> Wavelength (λ) = velocity in metres (m) per second (s) divided by frequency in hertz (Hz).

The velocity of a radio wave is a constant 300 000 000 m per second.

2.3.2 Units of frequency

Units of frequency are:

The kilohertz (kHz) = 1 000 hertz

The megahertz (MHz) = 1 000 000 hertz

The gigahertz (GHz) = 1 000 000 000 hertz.

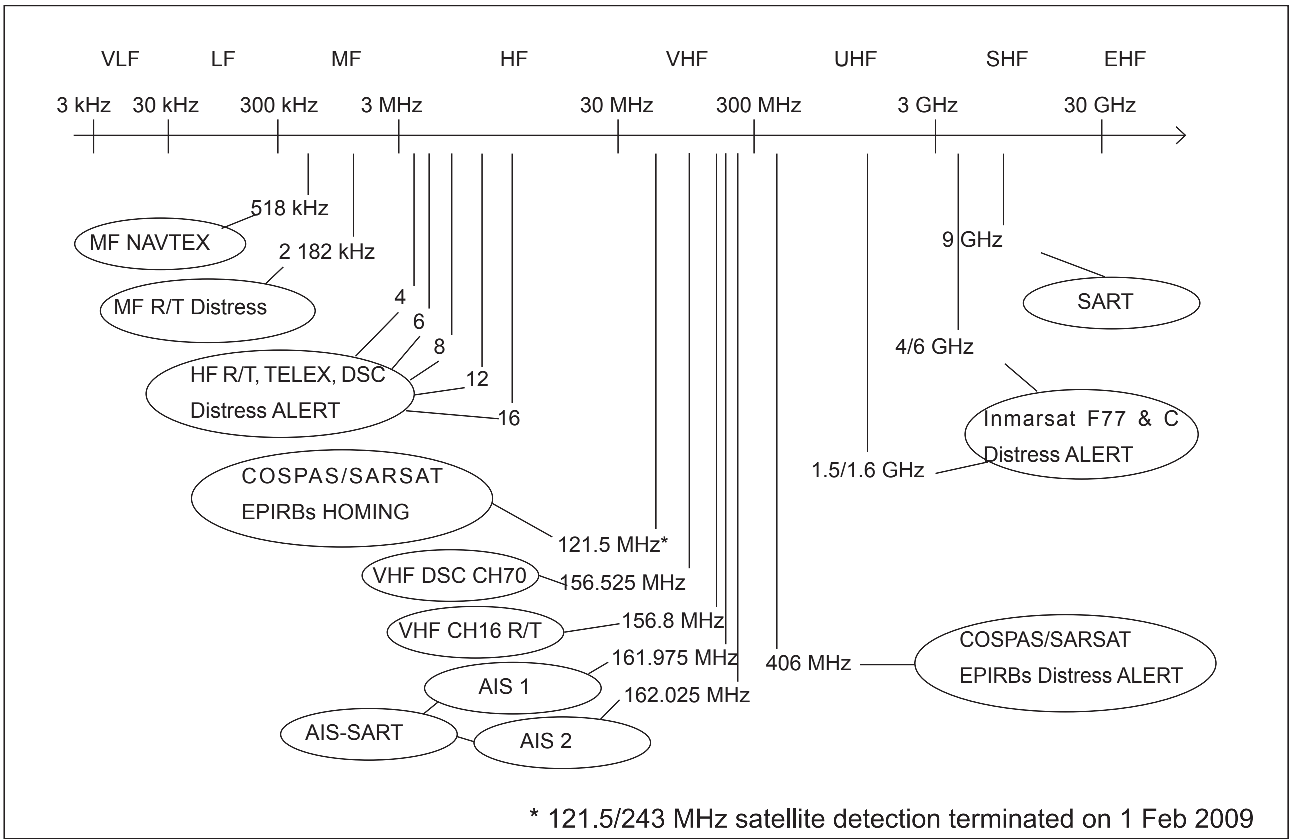

Figure 2 — ITU radio frequency bands and GMDSS usage

2.3.3 Sub-division of the radio frequency spectrum

The radio frequency spectrum is sub-divided into eight bands, as follows:

Very low frequencies	(VLF)	3 to 30 kHz
Low frequencies	(LF)	30 to 300 kHz
Medium frequencies	(MF)	300 to 3 000 kHz
High frequencies	(HF)	3 to 30 MHz
Very high frequencies	(VHF)	30 to 300 MHz
Ultra high frequencies	(UHF)	300 to 3 000 MHz
Super high frequencies	(SHF)	3 to 30 GHz
Extra high frequencies	(EHF)	30 to 300 GHz

2.4 FREQUENCIES ALLOCATED TO THE MARITIME SERVICES

2.4.1 Allocations

The ITU has allocated various bands of frequencies throughout the radio frequency spectrum to the maritime mobile service and the maritime mobile satellite service.

The bands and their uses are detailed in Figure 2.

2.4.2 Simplex and duplex channels

All HF and all VHF marine frequencies are arranged in a channelised format.

Channels are designated as either:

Simplex — operating method in which transmission is made possible alternatively in each direction of a telecommunication channel, for example by means of manual switching

Duplex — operating method in which transmission is possible simultaneously in both directions of a telecommunication channel.

2.4.3 Simplex operation

A simplex system (figure 3) allows only one station to transmit at any one time. Communications equipment designed for simplex operation uses one antenna, which is connected to either the transmitter or the receiver through a change-over relay or switch.

Channels used for distress and calling purposes are always operated in simplex mode, so that all stations can hear all others using the frequency.

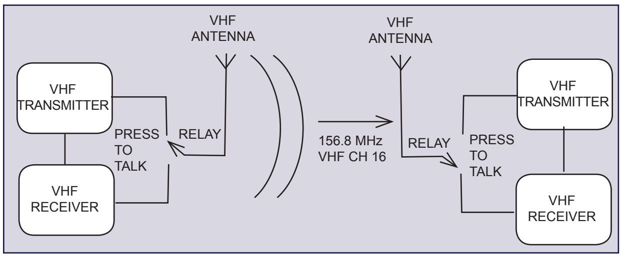

Figure 3 — Simplex operation

2.4.4 Duplex operation

Communications equipment designed for duplex operation (figure 4) allows simultaneous transmission and reception on two different frequencies through the use of either two widely spaced antennas or one antenna connected to the transmitter and receiver through special combining and filtering circuitry.

Duplex channels are normally used for public correspondence purposes (ie radio telephone calls). Each duplex channel comprises two separate frequencies; one for transmit and one for receive.

Duplex operation allows radiotelephone calls to and from suitably equipped ships and coast radio stations to be conducted in the same way as telephone calls made over the conventional land telephone system — ie both parties can speak and be heard at the same time.

Only two stations can use a duplex channel at any one time.

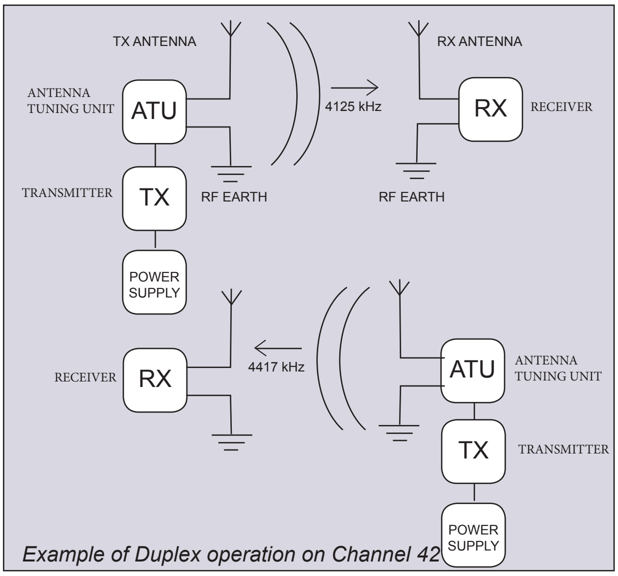

Figure 4 — Duplex operation

2.4.5 Semi-duplex operation

Communications equipment that does not have the facility for simultaneous transmission and reception often operates in semi-duplex mode — ie a method which is simplex operation at one end of the circuit and duplex operation at the other.

2.4.6 HF radiotelephone channel plan

The HF radiotelephone channel plan is described in Appendix 17 of the ITU Radio Regulations, and reproduced in the Manual for use by the Maritime Mobile and Maritime Mobile-Satellite Services (carried by every GMDSS ship).

The plan allocates a series of channels for duplex operation, and a series of channels for simplex (inter-ship) operation. Duplex channels are always referred to by their channel number. This channel number is comprised of three or four digits, the first one or two representing the frequency band (4, 6, 8, 12, 16, 22 and 26 MHz), and the last two representing the actual channel number, ie channel 403 is the third channel in the 4 MHz band, and channel 1602 is the second channel in the 16 MHz band.

Appendix 17 of the Radio Regulations lists both simplex and duplex channels available in the 4 to 26 MHz range. As a result of the introduction of the GMDSS and the move to satellite based communications methods, these sub-bands have become under utilised. With full international agreement new digital technologies are expected to be introduced into these bands. Each country is allocated a number of channels from each band for use by its coast and ship stations.

2.4.7 VHF radiotelephone channel plan

The VHF channel plan is described in Appendix 18 of the ITU Radio Regulations, and reproduced in the Manual for use by the Maritime Mobile and Maritime Mobile-Satellite Services (carried by every ship using the GMDSS) and in Appendix 10 of this handbook. The Radio Regulations, Appendix 18 was updated at ITU WRC-15. While the GMDSS channels are unchanged, new single-frequency channels have been created and more flexibility exists for new digital channels. Additionally, new channels for the testing of new technologies have been provided. Some of these changes came into force from 1 January 2017 and others from 1 January 2019. Administrations are evaluating how the new channels are to be used locally. There are some regional variations for the new digital channels. The remarks below refer to the new channel plan.

A total of 68 VHF channels are available in the VHF channel plan. Of these, at least 65 are expected to be selectable by the user, but additional channels could be available depending on manufacturers programming, as various notes in Appendix 18 of the Radio Regulations allow for a number of channels to be operated in either simplex or duplex mode.

Two channels are exclusively for AIS (AIS 1 and AIS 2) and one is exclusively for DSC (channel 70). Each simplex and duplex channel is assigned a specific purpose by the ITU. However, while the entire list is contained within the Manual for use by the Maritime Mobile and Maritime Mobile-Satellite Services specifically note the following:

Channel 06: may be employed for communication between ship stations and aircraft stations engaged in coordinated SAR operations. Ship stations should avoid interference on this channel.

Note: Channel 06 is also used in Australia and other countries for port operations, pilotage, tugs, and VTS.

Channel 13: is designated worldwide as a navigation safety communication channel primarily for inter-ship navigation safety communications.

Channel 16: may only be employed for distress, urgency, safety and calling.

Channels 15 and 17: may be used for on board communications provided the radiated power does not exceed 1 W (low power setting) and such communications are permitted in the waters of the coastal state in which the ship is operating.

Channel 70: is used for DSC for distress, safety and calling.

Channels 75 and 76: should be restricted to navigation related communications and as these channels are located in the band either side of channel 16 (Appendix 10 of this handbook). Measures should be taken to minimise the risk of harmful interference on that channel such as using low power (1 W). At WRC-12 it was agreed that these channels shall also be used to enhance the satellite detection of AIS transmissions from ships. AIS Class A and Class B transceivers fitted with this capability will automatically transmit a special AIS message 27 which can be detected by satellite, alternatively on channels 75 and 76 (at 12.5 watts) every three minutes, when outside VHF coverage of a terrestrial AIS base station. These transmissions are not expected to cause interference to channel 16.

The frequencies of 161.975 MHz and 162.025 MHz are known as AIS 1 and AIS 2 respectively and are used exclusively for AIS.

Each administration determines their own individual channel allocations based on the ITU guidelines. The VHF band is extensively used by vessels, coastal, limited coastal and port operations stations world-wide.

2.4.8 Four digit channel numbering

The channel plan now includes four digit channel numbering for certain channels. It is based on Recommendation ITU-R M.1084-4 Annex 4. This adds the 10 prefix to a single frequency channel number if a two frequency channel is operated in single frequency mode using the ship transmit (lower) frequency. Alternatively, the 20 prefix is added to a single frequency channel number if a two frequency channel is operated in single frequency mode using coast station (higher) frequency.

Channel 2006, introduced at WRC-15, has been designated for experimental use for future applications or systems (eg new AIS applications, man overboard systems, etc.) — if authorised by Administrations. At present no equipment can monitor this channel, but new equipment may. The eventual usage of this channel is yet to be determined.

2.4.9 HF NBDP (radio telex) channel plan

The HF Narrow Band Direct Printing (NBDP — also known as radio telex) channel plan is described in Appendix 17, Section III of the ITU Radio Regulations.

Commercial HF NBDP channels are assigned in a similar fashion to duplex radiotelephone channels. Each channel consists of two frequencies, one for the ship and one for the coast station.

WRC-12 has reduced the number of commercial NBDP and morse code channels as these modes are now rarely used. The channels are now used for digital data modes.

While NBDP or TOR (telex over radio) has been in sharp decline over a number of years as a commercial service a new method of text communications has been developed using the same spectrum. This new system which allows the use of email over the terrestrial (HF) bands has been developed as a global network, but does not form part of the GMDSS.

2.4.10 GMDSS distress and safety frequencies

The ITU has allocated simplex (ie single frequency) frequencies in the MF, the VHF and each of the HF maritime bands exclusively for distress and safety purposes. These frequencies are protected by international agreement and any transmission capable of causing harmful interference to distress and safety signals is prohibited.

2.5 CHARACTERISTICS OF FREQUENCIES

2.5.1 Introduction to radio propagation

The way in which energy in the form of radio signals propagates, or travels from one point on the surface of the earth to another, or from the surface of the earth to a communications satellite in orbit around the earth, depends upon the radio frequency used.

Each item of maritime radiocommunication equipment is designed to operate on a particular band of radio frequencies. The nature of the propagation of those radio frequencies determines the range or distance over which communication can be established. This in turn greatly influences the use to which the particular radiocommunication equipment is put.

2.5.2 Electromagnetic waves

Radio frequency energy generated by a transmitter is radiated from an antenna connected to the transmitter. The antenna is specially designed for use on a particular band of frequencies. The radiated radio frequency energy travels away from the antenna in the form of an electromagnetic (EM) wave. Visible light is one form of electromagnetic wave energy.

The antenna may be designed to radiate EM waves omni-directionally (in all directions). Alternatively the radiated EM wave may be formed into a narrow beam by the antenna, which must then be directed in a particular direction in order to establish communication, (eg some Inmarsat equipment employs this type of antenna).

2.5.3 Ground wave and sky wave propagation

Radio waves will radiate from the antenna as:

Surface waves or ground waves — which travel over the earth's surface. The distance over which they will travel is determined by their radio frequency. Very low frequencies (VLF) will travel thousands of km while ultra high frequencies (UHF) travel only a few km. At VHF and UHF frequencies, apart from their gain, it is mainly the height of the transmitting and receiving antenna that determine the range over which communication can be conducted.

Sky waves — are radiated upwards at all angles from the antenna until they reach the ionosphere. The ionosphere is a layer of ionised particles that lies between 50 and 500 km above the earth's surface. At high frequencies (HF) the radio wave is refracted by the ionosphere and returns to the earth's surface having travelled over thousands of kilometres. Long distance terrestrial communication using HF is conducted in this way. At VHF, UHF and SHF, sky waves are not refracted to any great extent and travel through the ionosphere into space, thus enabling communications via satellite to be conducted.

The propagation of ground waves and sky waves is depicted in Figure 5.

2.5.4 Ionospheric propagation

The upper atmosphere surrounding the earth suffers high levels of ultraviolet and X-ray radiation from the sun which causes the gas molecules of the atmosphere to ionise or become electrically charged.

These charged ions form into regions of particular density namely:

Region (or Layer)	Approx Altitude
F2	> 210 km
F1	140 – 210 km
E	90 – 140 km
D	50 – 90 km

The D region absorbs radio frequencies around 2 MHz during daytime. At night the ionization level of the D region reduces and does not absorb the radio energy at 2 MHz. Therefore radio signals around 2 MHz travel longer distances at night, reflected by the ionosphere.

HF propagation is totally influenced and controlled by the changing state of the ionosphere.

Radio propagation conditions will vary by the hour due to magnetic storms and flares generated by the sun. Complete radio blackouts can occur, especially at high latitudes.

2.5.5 Radio propagation at MF and HF

At medium and high frequencies, reliable use can be made of both the ground and sky wave energy components allowing communications over short and long ranges.

MF/HF marine radio equipment will always offer the operator a selection of frequencies in different bands eg 2 182 kHz in the 2 MHz band, 4 125 kHz in the 4 MHz band, 12 290 kHz in the 12 MHz band, etc. This allows the operator to select a frequency which will be suitable for the distance over which communications are required, the time of day and the season.

The general rule for frequency selection is to use the lower frequencies when close to the required station and higher frequencies when further away. During hours of darkness, a frequency lower than that necessary during the day is more likely to achieve the same result.

Less interference from distant stations will be experienced on the lower frequencies. However, in tropical waters high static levels may make communications difficult or impossible at times.

A very approximate guide to the use of MF/HF frequencies is:

- use 2 MHz band frequencies for communicating with stations within 50 to 150 nautical miles, day or night (Note: much greater range is possible at night on 2 MHz)

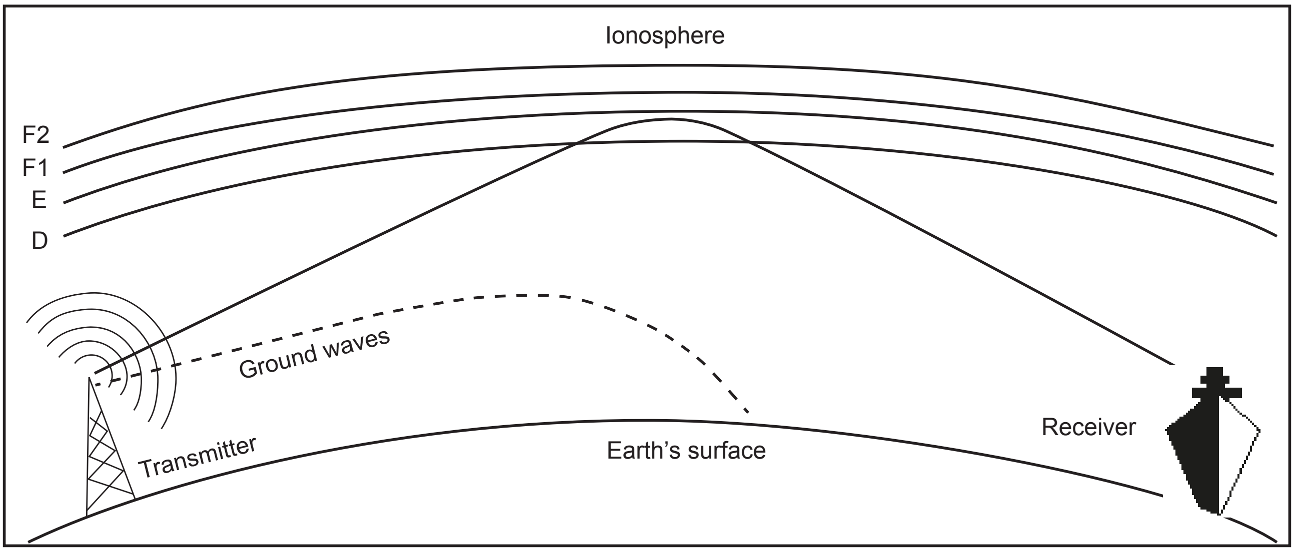

Figure 5 — Propagation of ground waves and sky waves

- use 4 MHz band frequencies for daytime communications with stations at distances greater than 60 nautical miles; or if no response to calls on 2 MHz, and for night-time communications when 2 MHz is unsatisfactory
- use 6 MHz band frequencies for daytime communications when 4 MHz is unsatisfactory, and at night when 2 MHz and 4 MHz are unsatisfactory
- use frequencies in the 8, 12, 16 and 22 MHz bands to provide progressively greater communications distances and when distance prevents the satisfactory use of the lower frequencies.

The correct selection is the lowest frequency that will provide satisfactory communications with the wanted station. However, this is often a matter of experience gained by listening to different stations operating over different ranges rather than textbook knowledge.

Additional guidance in respect of the appropriate HF frequency to employ for communications with Australian maritime communications stations is provided by the Australian Government's (Bureau of Meteorology) IPS Client Support System which is available on line at: www.sws.bom.gov.au (then select 'Products & Services' then select 'AMSA' under 'Client Support').

This system provides hourly frequency coverage charts, referred to as hourly area prediction (HAPs) charts, for both the AMSA HF stations at Wiluna (WA) and Charleville (QLD) to facilitate HF frequency selection for ship-to-shore communication.

2.5.5.1 Maximum usable frequency (MUF)

This is the maximum (ie highest) usable frequency which is reflected by the ionosphere over any particular path. It depends on time of day, time of year, latitude of sending and receiving stations and the stage of the sunspot cycle. In general the strongest signals occur using frequencies just below the MUF, for a particular path distance and layer involved. The greatest electron density in a given layer of the ionosphere reflects the MUF, and any higher frequency will penetrate the ionosphere completely and not be reflected. MUFs are higher when the sunspot number is high.

2.5.5.2 Optimum traffic frequency (OTF)

The MUF at night will be about half the daytime value for a given path. Long range communications at night can be quite reliable at lower frequencies. The MUF is generally higher during the summer than in winter. The first choice of a working frequency for sustained reliability would be around 85 percent of the MUF. The optimum traffic frequency (OTF) is a term used for an optimal frequency which takes the above factors into account.

2.5.6 Radio propagation at VHF and UHF

Under normal conditions there is no reflection of VHF radio energy from the ionosphere. Consequently, VHF communications must be conducted by ground wave and are therefore effective for short ranges only.

As a general rule, the range achievable from VHF communications is approximately 10 — 20 percent further than visual line of sight. UHF offers slightly less range. The greater the heights of the transmitting and receiving antennas, the greater the range achieved at UHF and VHF.

Under certain atmospheric conditions, particularly during the summer months, a phenomenon called ducting occurs, which causes refraction of VHF/ UHF signals in the atmosphere thereby allowing communications over many hundreds or even thousands of kilometres. Communications under these conditions are highly unreliable and must be taken into consideration when making decisions about the suitability of VHF/UHF marine radio equipment for a given application.

2.6 COMPONENT PARTS OF MARINE RADIO EQUIPMENT

2.6.1 The major parts of radio equipment

Marine radio equipment, whether operating in the VHF or MF/HF bands, is made up of three main sections:

- the antenna or aerial
- the transmitter and the receiver
- the power supply.

Each part is dependent on the other. A fault in any one of the parts will not allow the equipment to function correctly.

2.6.2 The antenna

The antenna has two functions:

- during transmission, to radiate into space the radio frequency energy generated by the transmitter
- during reception, to gather radio frequency energy from space and pass it to the receiver.

The antenna, therefore, is connected to either the transmitter or the receiver, depending whether transmission or reception is taking place.

The changeover is controlled by the 'press to talk' switch or button on the microphone or handset. When pressed, the transmitter is turned on and the antenna is connected to it. When released, the transmitter is turned off and the antenna is re-connected to the receiver.

On MF/HF transceivers, to achieve effective communications, it is essential to provide an earth to the water surrounding the ship. Usually, this is achieved by running a heavy flat copper strip from the earth terminal of the transceiver to part of the metallic superstructure.

2.6.3 The transmitter and the receiver

The function of the transmitter is to turn voice (audio) or data signals into a form where they can travel over very long distances. This is achieved by converting voice signals spoken into the microphone or data signals presented to the transmitter into high powered radio frequency energy which is passed to the antenna and radiated as ground and/or sky waves.

The function of the receiver is to select only those radio frequency signals which are required by the operator and amplify them. These signals are then converted back into voice or data signals and reproduced by a loudspeaker or fed to a data device.

It is usual with marine radio equipment for the transmitter and receiver to be combined in a single unit called a transceiver.

2.6.4 The power supply

The function of the power supply is to supply electrical energy to the transmitter and the receiver to enable them to carry out their tasks.

Fuses or breakers are located between the power supply and the transceiver protect the equipment against damage should a malfunction occur.

2.7 MODES OF COMMUNICATIONS

2.7.1 Overview

Marine radio equipment uses various modes of emission for different functions. These modes can be summarised as follows:

Radiotelephone — the most common mode of operation. In this mode, voice signals are transmitted over a radio link using various forms of modulation (see below).

NBDP — telex signals are transmitted over radio. This is not used in Australia.

DSC — A paging system that uses data signals to automate the transmission of distress, urgency or safety calls via MF, HF or VHF radio.

As outlined in section 2.4.6, the ITU has allocated a specific frequency in the MF, each of the HF and the VHF marine bands for distress and safety traffic via each of these three modes of operation. These frequencies are listed in Appendix 1 of this handbook.

The following sections explain the three modes.

2.7.2 Radiotelephone

In this system, at the transmitter, audio (voice) signals are modulated (or combined) with a radio frequency signal referred to as a carrier. In the receiver, these signals are de-modulated, the audio is separated from the radio carrier, amplified and passed to the loudspeaker.

There are two main types of modulation used in maritime mobile radiotelephone transmissions, AM and FM which are described below.

2.7.2.1 Amplitude modulation (AM)

This is the method of modulation used on all MF and HF maritime mobile bands. In this system, the amplitude of the radio frequency carrier is modulated or varied by the audio signal. This type of modulation produces a radio frequency carrier and two sidebands which contain the audio information. It is sometimes referred to as double sideband.

This system is used by broadcasting stations, such as commercial and ABC radio stations.

Single side band (SSB), suppressed carrier. The two sidebands in the double sideband system, described previously, each contain identical audio information. Single side band, suppressed carrier equipment contains special filters that completely remove the radio carrier and one of the sidebands from a double sideband signal. This allows a greater increase in efficiency, as all the radio frequency power is concentrated in one sideband only — either the lower side band (LSB) or the upper side band (USB). SSB receivers automatically re-insert the carrier, and de-modulate the audio signals in the same way as a double sideband AM (A3E) receiver.

Single side band, suppressed carrier (J3E) operation is mandatory on all maritime MF and HF radiotelephone channels, apart from 2 182 kHz. The upper side band (USB) mode of operation is used. Some equipment does provide facilities to enable selection of the lower side band (LSB) mode of operation — this must not be used.

Single side band full carrier. Under the ITU Radio Regulations this mode is only permitted on the MF international distress frequency of 2 182 kHz. This mode is known as compatible AM or H3E.

Due to its full carrier, double side band receivers are able to receive these signals. Although the H3E emission mode has been phased out, some ships and coast stations continue to use SSB full carrier (H3E) on 2 182 kHz. However, radiotelephone communications including distress traffic, on 2 182 kHz should be conducted on SSB suppressed carrier emission (J3E). (Further information is available in ITU *Radio Regulations (2016)* Appendix 15.).

The various forms of amplitude modulation are shown in Figure 6.

2.7.2.2 Frequency modulation (FM)

In this system the frequency of the radio frequency carrier is modulated or varied by the audio signal. As FM produces high quality sound, given sufficient bandwidth, it is used in television and radio broadcasting (eg FM stereo).

FM is not used on marine MF or HF frequencies. A close variant of FM, called phase modulation (PM), is used exclusively on the VHF marine band.

AM and FM are not compatible, even if operating on the same frequency.

Aircraft VHF radios use AM which is why, unless a vessel is fitted with an air-band VHF radio or an aircraft with a marine band VHF radio, they will be unable to communicate using VHF radio.

2.7.3 Narrow band direct printing (NBDP)

This system, also known as radio telex, is based on various combinations of two tones being sent over a radio link. Each specific tone combination represents different letters of the alphabet and figures 0 – 9. The modulation methods used for NBDP are very similar to those used in SSB or FM. The tones from a telex terminal are applied to the transmitter which modulates them on a carrier in the same fashion as a voice signal. The receiver demodulates the tones which are then fed to the telex receiving equipment in the same way as voice signals are fed to a loudspeaker.

NBDP is used in the MF and the HF bands for the promulgation of MSI and distress and safety communications. It is not used on the VHF marine band.

2.7.4 Digital selective calling (DSC)

DSC is a paging technique used to automate the initial call between two stations. The technical principles are almost identical to NBDP, in that two tone information is transmitted from one DSC system to another over a radio link.

DSC is used in the MF, HF and VHF marine bands for distress, urgency and safety alerting.

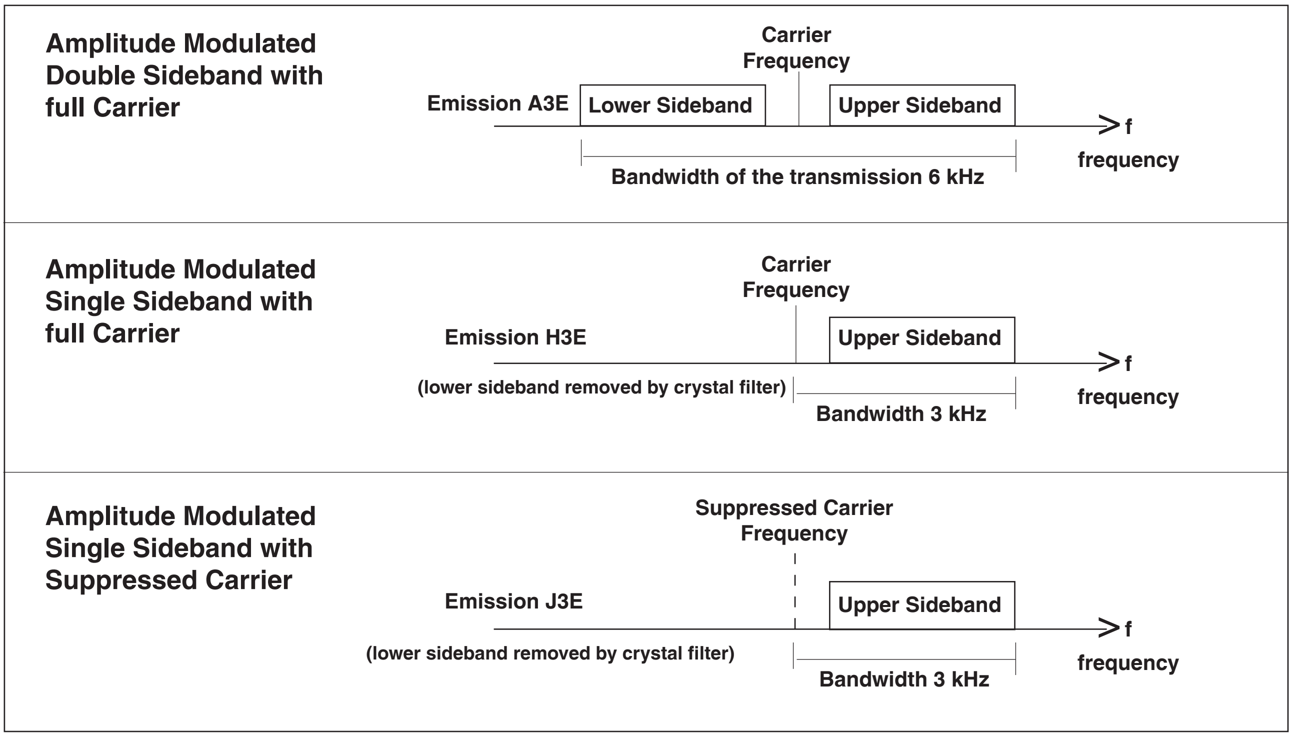

Figure 6 — Various forms of amplitude modulation

Although they work in a similar manner, there are technical differences between VHF and MF/HF DSC systems.

2.7.5 Bandwidth of emissions

The bandwidth of a signal is the amount of radio frequency spectrum occupied by that signal. Different modulation methods produce different bandwidths. Typical bandwidths for the various forms of modulation in maritime use are:

AM – 3 kHz

SSB – up to 3 kHz

NBDP – 304 Hz

MF/HF DSC – 300 Hz

VHF R/T & DSC – 16 kHz

	VHF	MF/HF
Emission Classes	F1B/G2B	J2B/F1B
Bandwidth	16 kHz	300 Hz
Tone separation	800 Hz	170 Hz
Modulation Rate	1200 baud	100 baud

* baud = bits per second

2.7.6 Classification and designation of emissions

Appendix 1 of the ITU Radio Regulations establishes a system of identifying radio emissions by designating the bandwidth and classifying the characteristics of the emission. As such an emission can be identified in terms of:

- the bandwidth allocated
- the characteristics of the modulation and the modulating signal
- any additional characteristics.

A total of nine letters and figures can be used to classify a radio emission, the first four indicating the bandwidth, and the next three the modulation characteristics. The last two characters are optional and may be used to identify the details of the signal and the nature of multiplexing where appropriate. The first two groups of characters are of greatest relevance to the GMDSS. An example of how these groups are employed is demonstrated below:

From the emission classified as: 2K80J3E

Bandwidth

The first four characters (2K80) designate a bandwidth of 2.8 kHz.

Classification

The next three characters give the:

1. type of modulation of the main carrier
2. nature of signal modulating the main carrier
3. The type of information to be transmitted.

For this example J3E this corresponds to:

J = single sideband, suppressed carrier

3 = single channel containing analogue information

E = telephony.

The following simplified designators are commonly used in the GMDSS:

J3E = Single sideband (SSB)

F3E = Frequency modulation (FM)

G3E = Phase modulation used on VHF

F1B = Narrow band direct printing (NBDP)

J2B = Digital selective calling (DSC)

F3C = Facsimile (Fax)

A3E = Double sideband (DSB)

A complete list of emission designators may be found in the Manual for use by the Maritime Mobile and Maritime Mobile-Satellite Services (Appendix 1, Section II). This publication is carried by all GMDSS ships.

2.7.7 Australian GMDSS terrestrial network

The Australian GMDSS HF DSC network has remote-controlled stations located at Charleville, Queensland and Wiluna, Western Australia. The stations are controlled from a single manned Network Control Centre (NCC) located in Canberra as shown in Figure 7.

The services provided by the commonwealth are those necessary to meet Australia's GMDSS obligations required under the ITU and SOLAS Conventions.

The network consists of a HF DSC alerting network with the ability to provide follow on HF voice or NBDP communications on at least two frequencies simultaneously. The network is centrally controlled and operated from Canberra alongside the JRCC with all HF sites being unmanned. The sites are linked to the network control centre (NCC) and the JRCC directly by a Ku-band satellite and indirectly by a C-band satellite via the DRF site as shown in Figure 8.

The Bureau of Meteorology has established transmit sites at Charleville (VMC – Weather East) and Wiluna (VMW – Weather West) for the provision of voice and weather fax broadcasts. This service is co-located with AMSAs GMDSS DSC network and uses common linking equipment to the operations centre in Canberra. The weather service uses dedicated 1 kW transmitters with high and low-angle take-off omni-directional antennas.

Details of the services and frequencies provided by the Bureau of Meteorology are provided on the Bureau's web site: www.bom.gov.au/marine.

For GMDSS compliant ships and GMDSS compatible vessels all the high seas weather information, and some of the coastal weather forecasts, provided by the Bureau of Meteorology MF/HF service is also provided via Inmarsat-C EGC. See Appendix 2 of this handbook for details.

The Australian GMDSS HF DSC network, MMSI 005030001 and station call sign (VIC) are used for communicating with either location. The Australian GMDSS HF DSC network does not provide voice watchkeeping on the distress radiotelephony frequencies. MSI is transmitted via Inmarsat-C EGC only.

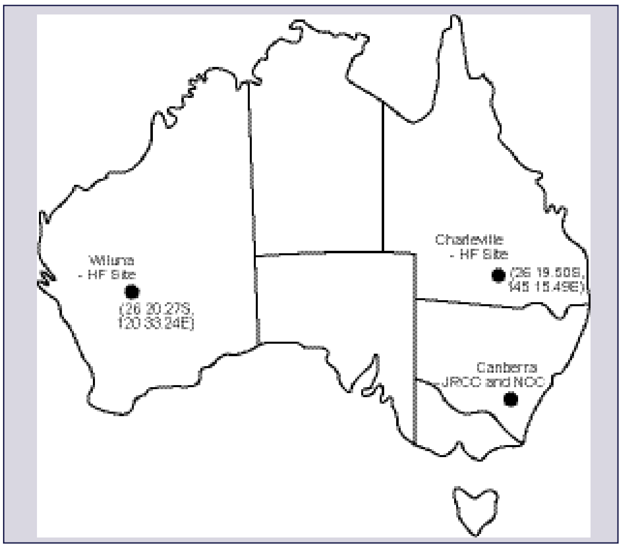

Figure 7 — Australian GMDSS Terrestrial Network

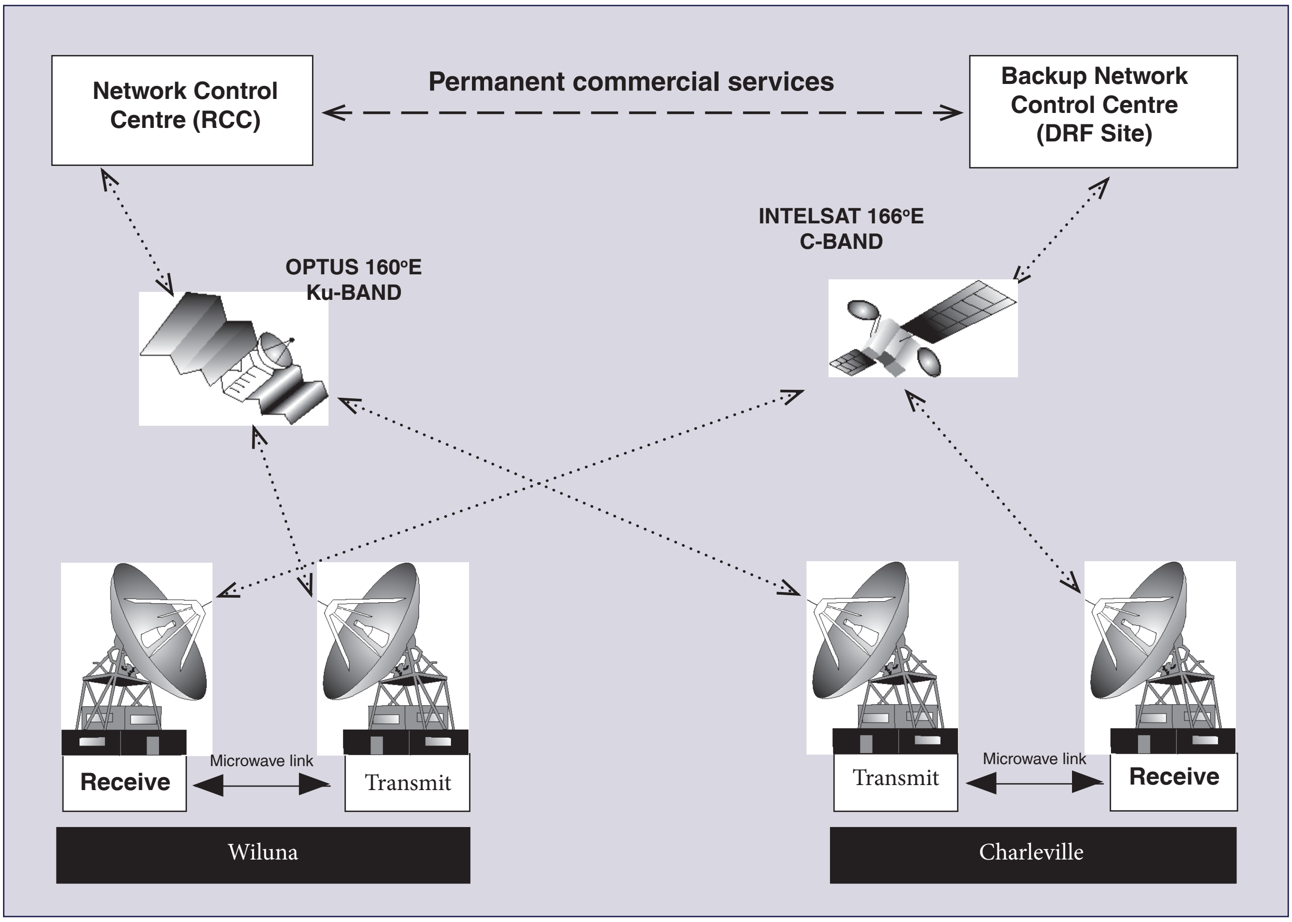

Figure 8 — AMSA HF DSC Network