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| **Radiocommunication Study Groups** |  |
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| International Association of Marine Aids to Navigation  and Lighthouse Authorities | |
| Working Document toward a draft new Report Maritime Radiocommunication Systems and Requirements | |
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1 **Background**

e-NAV14-10.3.6

The International Association of Marine aids to Navigation and Lighthouse Authorities (IALA) has undertaken a comprehensive review of maritime radiocommunication systems. This contribution is intended to initiate a report on systems in the Maritime mobile radiocommunication service and their mode of operation.

This document is proposed as a replacement for Annex 19 to ITU-R Document 5B/167.

2 **Discussion**

Maritime Mobile Radiocommunication service systems are involved in virtually all facets of modern maritime operations. On open ocean transits, while operating on inland waterways and in the logistical functions of ports these radiocommunication systems support safety and reliability. Systems critical to Global Maritime Distress and Safety System (GMDSS), to safety of life and safety of navigation are subject to specific maritime treaty requirements. New systems and applications continue to provide access to a wide range of other communication resources.

This is an extract of a larger IALA report on maritime communications.

The information presented is intended to support various ITU efforts to identify existing and evolving systems which support maritime radiocommunication services.

2.1 **World Radiocommunication Conference Preparation**

This Report is expected to beneficial to preparations for both WRC-15 and WRC-18.

Specifically, for WRC-15 agenda item 1.16:

“to consider regulatory provisions and spectrum allocations to enable possible new Automatic Identification System (AIS) technology applications and possible new applications to improve maritime radiocommunication in accordance with Resolution 360 (WRC-12);”

Resolution 360 (WRC-2012) invited the ITU-R:

1. to conduct, as a matter of urgency, studies that identify potential regulatory actions to accommodate emerging maritime mobile service and mobile-satellite service AIS requirements;
2. to conduct, as a matter of urgency, studies on additional or new applications for maritime radiocommunication within maritime mobile and mobile-satellite service allocations, and to identify potential regulatory actions to accommodate emerging maritime radiocommunication requirements;

Further, for WRC-18 preliminary agenda item 2.1 Resolution 808 (WRC-2012):

“to consider regulatory actions, including spectrum allocations, to support GMDSS modernization and implementation of e-navigation in accordance with Resolution 359 (WRC-12);”

Resolution 359 (WRC-2012) resolves to invite WRC-18:

1. to consider possible regulatory actions, including spectrum allocations based on the ITU-R studies, to support GMDSS modernization;

Annex 1 describes specific information about maritime radiocommunication systems.

Annex: 1

ANNEX

Maritime Radiocommunication Objectives and Requirements

An overview of systems in the Maritime mobile radiocommunication service

and their mode of operation

Scope

The purpose of this Report is to review existing maritime systems and build visions of future maritime communications technologies. Specifics will address emerging digital communications, navigational technologies, hydrographic matters and vessel traffic management.

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# Background[[1]](#footnote-1)

Maritime safety, including protection of crew, passengers, cargo, and the maritime ecological environment has become extremely dependent upon radiocommunication services. Routinely radiocommunication is the only form of communications available.

International organizations and regional/national agencies have a set of objectives and requirements that include interoperability, reliability, functionality, and security in operation. Considering that the radiocommunication needs of maritime operators at sea and the infrastructure developed to provide safety and support ashore are growing, future advanced solutions used by the maritime mobile community will require increased global coverage, higher data rates, and possibly video and/or multimedia capability.

This document focuses on the necessity for an agreed infrastructure of communications between ships and ashore. It presents an ITU view on current, developing and future Radio Communication Systems for the maritime sector. A further objective of this document is to express a vision for maritime systems through 2020 reflecting the efficient use of electromagnetic spectrum in support of the Maritime Mobile Service.

# Maritime Radiocommunication systems

# 1 Current Maritime Radiocommunication systems

This section details the current technologies used for maritime communications by frequency band. Please refer to the table in Annex A for system details, Annex B for maritime spectrum allocations and Annex 4 for specific ITU technical characteristics associated with the systems described.

## 1.1 Propagation

Both analogue and digital communications will suffer from propagation effects. It should be noted that propagation can limit or inhibit the transmission of digital communications. This means that measures may be required to mitigate adverse effects of propagation. Such measures could include automatic carrier selection (alternative routing for messages); or use of 'smart' protocol to send only the unsent information.

### 1.1.1 Low Frequency Band (LF)

There is some use of the LF radio spectrum by the maritime community. While Loran C is now obsolete, other systems such as eLoran and research projects are underway to evaluate the usage, if any, of this spectrum.

### 1.1.2 Medium Frequency / High Frequency Band (MF/HF)

Various uses are made of the MF/HF radio spectrum by the maritime community for communication of voice and data, in ship-ship, shore-ship and ship-shore modes of operation. MF/HF transmissions support both general, Maritime Safety Information (MSI) and distress related communications using DSC, NBDP, voice and data. These communications take place across the maritime mobile service bands within 1.6-26.5 MHz as defined in Appendix 17 to the ITU Radio Regulations, whilst distress related communications are consigned to a small set of specific channels as indicated in Appendix 15 to the ITU Radio Regulations. Channel bandwidths are typically 0.5 kHz (DSC and NBDP) and 3 kHz (voice and data).

#### 1.1.2.1 Digital Selective Calling (DSC)

DSC is a technique using digital codes which enables a radio station to establish contact with, and transfer information to, another station or group of stations, for distress or general communications over medium to long range distances. DSC is primarily used for distress alerting, urgency and safety calling within ship-to-ship, ship-to-shore and shore-to-ship prior to initiating distress, urgency and safety communications using radiotelephone or MF/HF radiotelex. DSC distress alerts, which consist of a preformatted distress message, are used to initiate emergency communications with ships and rescue co-ordination centres. DSC is intended to eliminate the need for manual watch keeping on a ship's bridge or on shore to monitor continuously radio receivers on the distress and safety frequencies. Six specific MF/HF frequencies are also set aside for Digital Selective Calling (DSC) distress and safety communications, one in each communication sub-band up to 16 MHz band. DSC is an element of the Global Maritime Distress and Safety System (GMDSS). DSC can also be used to call individual stations, groups of stations, or all stations in radio range. Each DSC-equipped ship, shore station and group is assigned a unique 9-digit Maritime Mobile Service Identity (MMSI) as defined in the Recommendation ITU-R M.585.

#### 1.1.2.2 Voice Communication

Various uses are made of the MF/HF radio spectrum by the maritime community for communication of voice in ship-ship, shore-ship and ship-shore modes of operation. General voice communication takes place across the band 1.6-26.5 MHz Channel bandwidths are typically 3 kHz. Digital communication within the MF/HF bands is a relatively new technology with high potential.

#### 1.1.2.3 Data Communication

Current and emerging HF digital modulation schemes provide new opportunities utilizing data transmission in this frequency band (1.6-26.5 MHz). The relevant technologies are described in the Recommendation ITU-R M.1798. The Recommendation ITU-R M. 1798-1, published on April 2010, includes three systems. System 1 is an HF data services modem protocol using orthogonal frequency division multiplexing (OFDM), and uses 4/8-PSK modulation to 32 sub-carriers. System 2 is an Electronic mail system using the Pactor-lll protocol, and uses QPSK modulation to 18 sub-carriers. System 1 and System 2 use 3 kHz channels for the data rate of 3 kbps or below. System 3 is a 10-20 kHz wideband HF data system for internet access and Electronic mail services using OFDM. This system uses QAM modulation to 228 sub-carriers at 10 kHz bandwidth or 460 sub-carriers at 20 kHz bandwidth for the data rate up to 51 kbps. All three systems are IP level-compatible making interoperability possible.

#### 1.1.2.4 Narrowband Direct Printing (NBDP)[[2]](#footnote-2)

NBDP is a technique which automates radio signals to telegraphy. NBDP (also known as radio telex) is FSK modulated onto HF channels of 0.5 kHz and supports low speed data transmissions (100 bps) in the maritime mobile service bands within 1.6-26.5 MHz. NBDP is an element of GMDSS and can be used as the text based distress follow-up communications and general communications between ship-to-ship, ship-to-shore and shore-to-ship especially to overcome the language difficulties. The use of NBDP for general communication is declining and is now used for position reporting from ships and promulgation of meteorological warnings and forecasts from coast stations.

#### 1.1.2.5 Navigational Telex (NAVTEX)

NAVTEX is an international, automated system for instantly distributing Maritime Safety Information (MSI) such as maritime navigational warnings, weather forecasts and warnings, search and rescue notices and similar information to ships. A small, low-cost and self-contained smart printing2 radio receiver (NAVTEX receiver) is an element of GMDSS and installed on the ship's bridge. Messages are broadcasted in English on 518 kHz, while 490 kHz and 4209.5 kHz are used to broadcast in English and/or local language. The messages are coded with a header code identified by using alphabets to represent broadcasting stations, type of messages, and followed by two figures indicating the serial number of the message. The time of broadcasting is internationally co-ordinated by areas (NAVAREA) to share the same frequency.

#### 1.1.2.6 Differential Global Navigational Satellite System (DGNSS)

The IALA Differential GNSS coastal radio beacon network broadcasts corrections and integrity information to maritime users in the LF/MF bands (between 283.5 and 325 kHz). Data rates can be 50, 100 or 200 bps. This is a data broadcast system from shore-to-ship.

### 1.1.3 Very High Frequency Band (VHF)

Voice communication using the maritime VHF band (156.025-162.025 MHz) is prevalent and the primary means of ship-shore, shore-ship and ship-ship communication in the domain. It is used for distress, safety information and general communications. Channel spacing is currently 25 kHz although the use of 12.5 kHz channels on an interleaved basis is allowed within Appendix 18 of the Radio Regulations as described in accordance with Recommendation ITU-R M.1084 to improve spectrum efficiency.

#### 1.1.3.1 Digital Selective Calling (DSC)

DSC is a technique using digital codes which enables a radio station to establish contact with, and transfer information to, another station or group of stations, for distress or general communications using channel 70 (156.525 MHz). DSC is primarily for distress alerting, urgency and safety calling within ship-to-ship, ship-to-shore and shore-to-ship prior to initiating distress, urgency and safety communications using radiotelephone. Additionally, DSC may be used for AIS channel management in specific geographic areas. DSC distress alerts, which consist of a preformatted distress message, are used to initiate emergency communications with ships and rescue coordination centers. DSC is intended to eliminate the need for manual watch keeping on a ship's bridge or on shore, to monitor continuously radio receivers on the distress and safety channels. DSC is an element of the GMDSS. DSC can also be used to call individual stations, groups of stations, or "all stations" in radio range. Each DSC-equipped ship, shore station and group is assigned a unique 9-digit Maritime Mobile Service Identity (MMSI) as defined in the Recommendation ITU-R M.585.

#### 1.1.3.2 Voice communication

Voice communication using the maritime VHF band (156.025 to 162.025 MHz) is prevalent and the primary means of ship to shore, shore to ship and ship-to-ship communication in the domain. It is used for distress, safety and general communications. Hand-held units are generally utilized for on-board communications. Primary channels used for distress and safety communications by voice are Ch 6, Ch 13 and Ch 16. The use of other channels is designated in Appendix 18 to the ITU Radio Regulations. Channel spacing is currently 25 kHz although there is provision in Appendix 18 to use 12.5 kHz interleaved channels as described in Recommendation ITU-R M.1084.

#### 1.1.3.3 121.5 MHz Locating Beacon

The frequency 121.5 MHz is an aeronautical emergency frequency. 121.5 MHz radiobeacons were developed in the mid-seventies for installation on aircraft, as Emergency Locator Transmitters (ELTs). However, they can also be used on board ship as part of Emergency Position-Indicating Radio Beacons (EPIRBs) or in Personal Locator Beacons (PLBs).

### 1.1.4 Automatic Identification System (AIS)

#### 1.1.4.1 Primary purpose of Automatic Identification System

AIS is a TDMA-based data exchange system used by ships and shore authorities. The main purpose of AIS should be to improve the safety of navigation by assisting in the efficient navigation of ships, protection of the environment, and operation of Vessel Traffic Services (VTS), by satisfying the following functional requirements:

* in a ship-to-ship mode for collision avoidance;
* as a means for littoral States to obtain information about a ship and its cargo; and
* as a VTS tool, i.e. ship-to-shore (traffic management).

AIS provides a means for ships to electronically exchange ship data including identification, position, course, and speed with other nearby ships and shore stations. This information can be displayed on a screen display. AIS is intended to assist the vessel's watch keeping officers and allow maritime authorities to track and monitor vessel movements. AIS uses VHF Channels AIS 1 (161.975 MHz) and AIS 2 (162.025 MHz) or regional channels in defined geographical areas. Additionally, AIS has the capability for data exchange by application specific messages for navigation and safety related purposes. The VHF Data link (VDL) loading should be considered when using application specific messages.

#### 1.1.4.2 Automatic Identification System Aids to Navigation (AIS AtoN)

AIS is also used on Aids to Navigation, which can include the incorporation in a physical aid to navigation, or the transmission from an AIS base station.

#### 1.1.4.3 Automatic Identification System Application Specific Messages

AIS can also be used for the broadcast of navigation information, meteorological and hydrographic data and other application specific messages.

#### 1.1.4.4 Automatic Identification System Search and Rescue Transmitter (AIS-SART)

AIS-SART is a locating device (alternative to radar SART). As an element of GMDSS, AIS-SART is used to locate survival craft and distressed vessels. The AIS-SART has no receiver and operates up to 96 hours on a primary battery. The position and time synchronization of the AIS-SART is derived from a built-in GNSS receiver.

#### 1.1.4.5 Man overboard device (MOB)

There are various systems available that operate on either DSC based or AIS based technology as well as others that utilize Bluetooth or other technologies. The MOB devices must be regarded as location aids in emergency situations and not as distress alert systems.

#### 1.1.4.6 Two-way VHF Radiotelephone Apparatus

Two-way VHF radiotelephone apparatus is defined in SOLAS Chapter III. In practice, this apparatus is used as an element of GMDSS. The apparatus is either a portable or fixed transceiver for use in survival craft. It is used for on scene communications between survival craft, to other vessels and rescue units. Communication is on Ch16 (156.8 MHz) and at least one other simplex channel. The transceiver can be used for on board communications using a secondary battery; however the primary battery must be used for GMDSS purposes.

#### Regional Data Communication Systems

In various regions VHF data communication systems exist for data exchange between shore to ship and ship to shore. Those systems are commercial and used primarily for vessel tracking, search areas in SAR operation, etc. An example of this technology is the Blue Box used in Italy for vessel monitoring. A further example is a Norwegian system that deploys a network of radio modems capable of switching between nine narrowband duplex VHF channels and is used for general data communication.

#### Satellite Data Communication

Satellite communications in the VHF band are commercially available, but not currently in the maritime VHF band. They can provide services for SMS, weather and tracking. Ultra High Frequency Band / Super High Frequency Band (UHF/SHF)

#### Emergency Position Indicating Radio Beacon (EPIRB)

Emergency radio beacons are alerting and tracking transmitters which aid in the detection and location of ships, aircraft, and people in distress. They are radio beacons that interface with COSPAS/SARSAT, the international satellite system for search and rescue (SAR). When activated, such beacons send out a distress alert signal that, when detected by non-geostationary satellites, can be located by the combination of Doppler shift measurement and triangulation.

An Emergency Position-Indicating Radio Beacon (EPIRB) is an element of GMDSS and used to send a distress alert signal to the COSPAS/SARSAT satellite system for the purposes of notifying Search and Rescue (SAR) organizations. EPIRBs transmit a 144-bit message including 49 bits of identification plus optionally, GNSS position information originated from a built-in GNSS receiver. Information is retransmitted, at approximately 50 seconds intervals, to the satellites in the frequency band 406.0 to 406.1 MHz. The EPIRB is also equipped with a 121.5 MHz beacon transmitter for homing by SAR aircraft, modulated with a swept audio tone and may also have an incorporated AIS-SART based transmitter (EPIRB AIS).

#### On-board Communication

UHF hand-held and fixed radios are commonly used on vessels for on-board communications including communications with workers on the dock or berth when alongside. These radios are typically constrained to radiating less than 2 W in the band 450-470 MHz and are for voice communication only.

#### Satellite Voice and Data Communication

Satellite communications in the UHF band is commonly deployed on vessels to fulfill a number of distress, safety and general communications purposes.

Satellite communication links are capable of supporting analogue and digital voice, broadband connectivity, e-mail, SMS, crew calling, telex, facsimile, remote monitoring, tracking (position reporting), chart and weather updates and Inmarsat FleetNET services.

Satellite systems are commercially provided services, which may have global or regional coverage. These systems may be geostationary or non-geostationary.

Inmarsat[[3]](#footnote-3), a geostationary satellite system, is an element of GMDSS for distress alerting, urgency and safety calling. Other Geostationary systems include Thuraya. Non-geostationary satellite systems include Iridium, Globalstar, and Orbcomm.

#### Enhanced Group Call (EGC)

The Inmarsat-C maritime mobile-satellite system is an element of GMDSS and has an inherent capability, known as SafetyNET, via Enhanced Group Calling (EGC), which allows broadcast messages to be made to selected groups of ship stations located anywhere within satellite coverage. Four geostationary satellites provide near worldwide coverage for SafetyNET except for the polar regions. SafetyNET and NAVTEX are recognized by the GMDSS as the primary means for disseminating maritime safety information. Ships subject to the Safety of Life at Sea Convention (SOLAS) operating outside areas covered by NAVTEX must carry an Inmarsat-C SafetyNET receiver.

### Long Range Identification and Tracking (LRIT)

LRIT is an International Maritime Organization (IMO) mandated scheme through which all passenger ships, cargo ships and mobile offshore drilling units engaged on international voyages must report their position on a regular basis (at least 4 times a day) to their flag administration. In general satellite communications is used as the method for transmission of these reports, which are received and authenticated by an authorized service provider before being passed to the data center. The data from the vessel can be augmented with additional information by the shore-based authorities. Other States may be entitled to request this information from the flag administration.

### Global Navigation Satellite System (GNSS)

Global Navigation Satellite Systems (GNSS) are used for positioning, navigation and timing (PNT) and as an essential input into other ship systems. Current signals are in the frequency-band around 1 GHz to 2.5 GHz.

### X-band and S-band radar, radar beacon (racon) and radar SART

Radar systems are commonly deployed and typically operate in two bands: X-band from 9.2 to 9.5 GHz and S-band from 2.9 to 3.1 GHz. The radars are used for target detection and to support identification and for coastal and port navigation. These bands are also used by radar transponders, namely the racon and radar Search and Rescue Radar Transponder (SART) both create identifiable patterns when interrogated by vessel radars. Racons are used to highlight the location of a visual Aid to Navigation (AtoN) or hazards on a ship's radar screen and a radar SART is used to aid in locating a survival craft in a SAR operation. Racons operate in S- and X-band and SARTs are X-band only.

The radar SART is a locating device in the GMDSS and used to locate a survival craft or distressed vessel by creating a series of dots on a rescuing ship's radar display. A radar-SART will only respond to a 9 GHz X-band (3 cm wavelength) radar.

The adoption of new technology radar within the maritime community introduces improvements in radar performance. In addition, the reduced peak transmission power associated with these radars can reduce the triggering range of racons and SARTs.

### Other communication technologies using the UHF/SHF band

Various other communication technologies in the UHF to SHF bands are being used (or considered) for general maritime communications, namely GSM/GPRS, 3G, 4G, Wi-Fi®, WiMax™, and short range devices like ZigBee™ and Bluetooth™ links. These offer the possibility of high speed data transfer. However, it should be noted that the coverage of most of these systems is limited in range and they would therefore be confined to supporting data transfer within a port or harbour environment.

### Technologies not widely used for maritime radio communications

Please refer to the table in Annex 3 for technical details.

### Low Frequency Band (LF)

#### 1.1.10.1 Enhanced Long Range Navigation (eLORAN)

The enhanced Loran (eLoran) system is an experimental system to provide data channel modulated onto the approximately 100 kHz signals. Two formats for this data channel are currently available, known as Eurofix and 9th pulse respectively. Both techniques offer data rates below 100 bps although higher rate concepts have been proposed.

### Medium Frequency/ High Frequency Band (MF/HF)

#### 1.1.11.1 Digital data communication using MF/HF band

The likely increase in ship traffic in Polar regions, as a result of receding ice fields, may increase the requirements for HF communications, since geostationary satellites do not cover these areas. Various system operators are studying increased data rates using 3 kHz channels, which may produce data rates of 19.2 kbps, and other solutions to likewise increase data speeds.

Furthermore, a new data communication system using 10-20 kHz bandwidth for data rates up to 51 kbps, has been incorporated in the Recommendation ITU-R M. 1798-1. Appendix 17 to the Radio Regulations was revised at the World Radiocommunication Conference 2012 (WRC-12). The revision of AP17 will implement new digital bands for 3 kHz systems as well as wideband systems. WRC-12 has also approved use of band 495-505 kHz for use of high-speed Navigational Data service (NAVDAT).

#### 1.1.11.2 NAVDAT (Navigational Data)

The NAVDAT is an MF radio system, used in the maritime mobile service, operating in the 500 kHz band for digital broadcasting of maritime safety and security related information from shore-to-ship.

WRC-12 approved the worldwide exclusive usage of the frequency band 495 - 505 kHz for the maritime mobile service. The NAVDAT system utilizes an OFDM modulation in this 10 kHz bandwidth which provides a flow rate of about 15/25 Kbit/s (more than 300 times the NAVTEX transmission), featuring:

* Possibility to transmit any type of text, graphs, pictures, data etc. with encryption if required;
* Automatic reception;
* Possibility to use Single Frequency Network (SFN) technology, with no need for time slot allocation on the same frequency.
* The global architecture of the NAVDAT is similar to the NAVTEX and the coverage is approximately 250/350 NM from coast station.
* The NAVDAT system is described in the Recommendation ITU-R M.2010: Characteristics of a digital system, named Navigational Data for broadcasting maritime safety and security related information from shore-to-ship in the 500 kHz band, published by ITU on Mar 2012.

### Very High Frequency Band (VHF)

#### 1.1.12.1 Automatic Identification System (AIS)

It is recognized that by design AIS is not an ideal candidate for high speed and/or high volume data communications. However, AIS is a proven maritime data system, with ships equipped and shore infrastructure established. The future AIS channel plan should consider at least the following:

* AIS channels 1 and 2 for Safety of Navigation purposes:
* AIS 1 and AIS 2 are exclusively allocated to AIS usage in both Region 2 (Americas, effective 2025) and Region 3 (Asian/Pacific, effective 2013), but not in Region 1 (Europe/Africa) where they are still shared with land mobile and fixed services (WRC-12);
* Pending the outcome of GMDSS modernization at WRC-18, and if IMO integrates AIS as a component of the GMDSS the world-wide allocation for AIS 1 and 2 frequencies in the maritime mobile service will be reviewed.
* AIS channels 3 and 4 for satellite detection of AIS.

Since the satellites have very wide footprint, the frequencies for satellite detection of AIS should be exclusive for maritime mobile service. The Report ITU-R M.2169 proposes to use CH75 and CH76. These channels are guard band channels of CH16 and are the only maritime dedicated channels except CH16 and CH70 within Appendix 18.

AIS satellite long range messaging on channels 75 and 76 was approved worldwide effective 1 January 2013 with a primary allocation in Region 2 (Americas), secondary elsewhere (WRC-12) Non-AIS operations on channels 75 and 76 will be limited to 1watt on 1 January 2013 (WRC-12). In the future, the AIS technologies may be part of the GMDSS system. The distress alerting, urgency and safety communications should be by both terrestrial and satellite communications; therefore dedicated maritime frequencies are needed. The satellite detection of AIS is a one-way system (from earth to satellite); however in the GMDSS, the acknowledgement (from satellite to earth) is essential (a two way system). The CH75 and CH76 could be used for this purpose; however WRC-12 approved these channels in the Earth-to-space direction. At WRC-12 channels 27, 87, 28 and 88 have been identified for possible testing of AIS, under Note **YYY** in Appendix 18. AIS channels 5 and 6 for Data communication purposes:

In considering the future AIS system for terrestrial (non-satellite) data communication purposes, an additional two frequencies will be needed. These frequencies would be used to support the transmission of area warnings and advice, meteorological and hydrographical data, traffic management information and general ship-to-shore data exchanges. At WRC-12 channels 27, 87, 28 and 88 have been identified for possible testing of AIS, under Note **YYY** in Appendix 18. These channels are envisaged to be part of the VHF Data Exchange (VDE) project (see Annex E). Channel 70 for channel management purposes:

In order to fully use available VHF spectrum, there must be a worldwide channel dedicated to manage and co-ordinate usage of the VHF Data Link. Further details are explained in Annex E.

#### 1.1.12.2 Digital data communication

The use of VHF for digital data transfer has yet to be broadly implemented by the maritime community. To this end, ITU-R has developed and published Recommendation ITU-R M.1842 -"Characteristics of VHF radio systems and equipment for the exchange of data and electronic mail in the maritime mobile service RR Appendix 18 channels". Also, WRC-12 has identified digital bands within the Appendix 18 band. Development of the Recommendation ITU-R M.1842 was originally proposed based on the shore based network system trialed in Norway. This system deploys a network of radio modems capable of switching between nine narrowband duplex VHF channels in the maritime mobile band. These nine channels can be combined into one 225 kHz wideband channel. The wideband radio was proven to have insufficient EMC characteristics, indicated instability and the throughput slowed down when the signal strength was low. This system is described in the Report ITU-R M.2127, but not incorporated in the Recommendation ITU-R M.1842. Narrowband radio 25 kHz duplex on the other hand has been proven in Norway to be very robust and stable and can perform a variety of services giving good throughput of data. This system is incorporated in Recommendation ITU-R M.1842 together with other techniques to be applied more widely - from 25 kHz bandwidth systems providing 43 kbps data rates through to 100 kHz systems offering 307 kbps. The Recommendation ITU-R M.1842 currently specifies four systems for the modulation schemes and general characteristics for the transceivers. The consideration of the standardized communication protocols is on-going at ITU-R. Further consideration of how best to achieve spectral efficiency in this band is worthwhile. This consideration needs to address coverage range, robustness, channel spacing, and modulation schemes. The data speed/coverage trade off in the coastal range must be considered to achieve a cost effective service.

**WRC 2012 VHF Data Results:**

VHF Appendix 18 was modified to permit digital systems on channels: 24, 84, 25, 85, 26 and 86 for Region 2 from 1st Jan 2013 and 80, 21, 81, 22, 82, 23, 83, 24, 84, 25, 85, 26, 86 worldwide except Region 2 and specific countries (footnote **D1**)) from 1 Jan 2017;

Testing of future AIS applications on channels 27, 28, 87 and 88 was permitted from 1 January 2013;

160.9 MHz (channel 2006) is reserved for experimental use for future applications or systems, e.g. MOB and AIS from 1 January 2013.

Further details are explained in ANNEX E.

#### 1.1.12.3 Digital voice communication

Digital voice communication may, in the long term, replace the present analogue VHF voice communication service, i.e. ship-to-ship/ship-to-shore/shore-to-ship. In the meantime introduction of mixed digital / analogue equipment should be encouraged. It is recognized that global digitization will make spectrum use more efficient, but this will take some time to complete.

### Ultra High Frequency Band / Super High Frequency Band (UHF/SHF)

#### 1.1.13.1 Satellite communication using the UHF/SHF band

In the future, navigational satellite payloads may include transponders connected with GMDSS and may function as additional SAR resources, (i.e. return link capability is possible functionality within Galileo).

#### 1.1.13.2 Public mobile wireless communications

Public mobile wireless communications (public correspondence) such as GPRS, CDMA and 3G are being used by mariners in coastal waters and could be further developed to support evolving maritime communication needs. Recognizing their constraints in open water situations, this type of communications should not be used for regulated maritime services.

#### 1.1.13.3 On-board communications

Limited availability of spectrum for on-board communications gives rise to congestion and interference. Consideration of this issue under Agenda item 1.15 (WRC-15) may develop new techniques for communication in this band.

**Maritime Radiocommunication systems for the future**.

#### 1.1.13.4 e-Navigation

e-Navigation is an International Maritime Organization led concept based on the harmonization of marine navigation systems and supporting shore services, driven by user needs.

The definition of e-Navigation, as adopted by IMO is:

e-Navigation is the harmonized collection, integration, exchange, presentation and analysis of maritime information onboard and ashore by electronic means to enhance berth to berth navigation and related services, for safety and security at sea and protection of the marine environment.

There are 3 key elements or strands that must first be in place before e-Navigation can be realized:

* Electronic Navigation Chart (ENC) coverage of navigational areas;
* a robust electronic positioning, navigation and timing system (with redundancy);
* and an agreed infrastructure of communications to link ship and shore.

This report establishes the basis of current radio communication in the maritime mobile bands and forms projections for future developments needed to support e-Navigation. It may also identify additional areas requiring resource allocation and research activity.

A stated aim of future maritime radiocommunication is:

* Fostering the safe, economic and efficient movement of vessels by improvements and harmonization of aids to navigation worldwide.

While one vision is:

* Safe marine navigation in a world of:
* Larger and faster ships;
* Changing economy &technology;
* Stringent standards;
* Holistic approach (e-Navigation);
* Changing waterway use.

This report identifies ITU engagement to contribute to the implementation and deployment strategy of e-Navigation.

Since e-Navigation will require appropriately designed radio communication systems for robust and reliable services. As part of on-going ITU studies, this report may assist in the assessment of spectrum allocation and usage.

**VHF Data Exchange System (VDES)**

VHF Data Exchange System (VDES) is a technological concept developed by the IALA e-NAV Committee and now widely discussed at ITU, IMO and other organizations. VDES was originally developed to address emerging indications of overload of VHF Data Link (VDL) of AIS and simultaneously enabling a wider seamless data exchange for e-Navigation, potentially supporting the modernization of GMDSS, both processes that are currently developed by IMO. VDES is capable of facilitating numerous applications for safety and security of navigation, protection of marine environment, efficiency of shipping and others. VDES will prospectively have a significant beneficial impact on the maritime information services including Aids to Navigation and VTS in the future. Functional aspects of VDES utilize two-way VHF data exchange communications in ship-ship, ship-shore and ship-satellite modes.

In collaboration with IALA, the ITU-R has further developed the basic VDE concept into a more comprehensive concept of VDES. The VDES now integrates the function of AIS, ASM and VDE and includes the channels for these functions with satellite transmission and reception. An arrangement of the globally available channels and usage is shown in Table 1.

## Table 1VHF Channels and Frequencies for VDES (AIS, ASM and VDE)

|  |  |  |
| --- | --- | --- |
| Channel number in Appendix 18 | Transmitting frequencies (MHz) for ship and coast stations | |
| Ship stations (ship-to-shore) Ship stations (long range AIS) Ship stations (ship-to-satellite) | Coast stations Ship stations (ship-to-ship) Satellite-to-ship[[4]](#footnote-4) |
| AIS 1 | 161.975 | 161.975 |
| AIS 2 | 162.025 | 162.025 |
| 75 (long range AIS) | 156.775 (ships are Tx only) | N/A |
| 76 (long range AIS) | 156.825 (ships are Tx only) | N/A |
| 2027 (ASM 1) | 161.950 (2027) | 161.950 (2027) |
| 2028 (ASM 2) | 162.000 (2028) | 162.000 (2028) |
| 24 (VDE 1) | 157.200 (1024) | 161.800 (2024) |
| 84 (VDE 2) | 157.225 (1084) | 161.825 (2084) |
| 24/84 (VDE 3) | 50 kHz channel  (1024/1084, merged) | 50 kHz channel  (2024/2084, merged) |
| 2024/2084 (SAT 1) | N/A | 50 kHz channel  (2024/2084, merged)  (For satellite broadcasting to ship) |
| 25/85/26/86 (VDE 4, SAT2)  25  85  26  86 | 100 kHz channel  (25/85/26/86, lower legs, merged) | 100 kHz channel  (25/85/26/86, upper legs, merged) |
| 157.250 (1025) | 161.850 (2025) |
| 157.275 (1085) | 161.875 (2085) |
| 157.300 (1026) | 161.900 (2026) |
| 157.325 (1086) | 161.925 (2086) |

**FUNCTIONALITIES**

Since VDES is designed for higher robust data exchange capability with world wide coverage, various functionalities can be considered. The radio links enabled by VDES and their use by ships, shore stations and satellites are illustrated pictorially in Figure 1.

**Figure 1: VDES radio links**

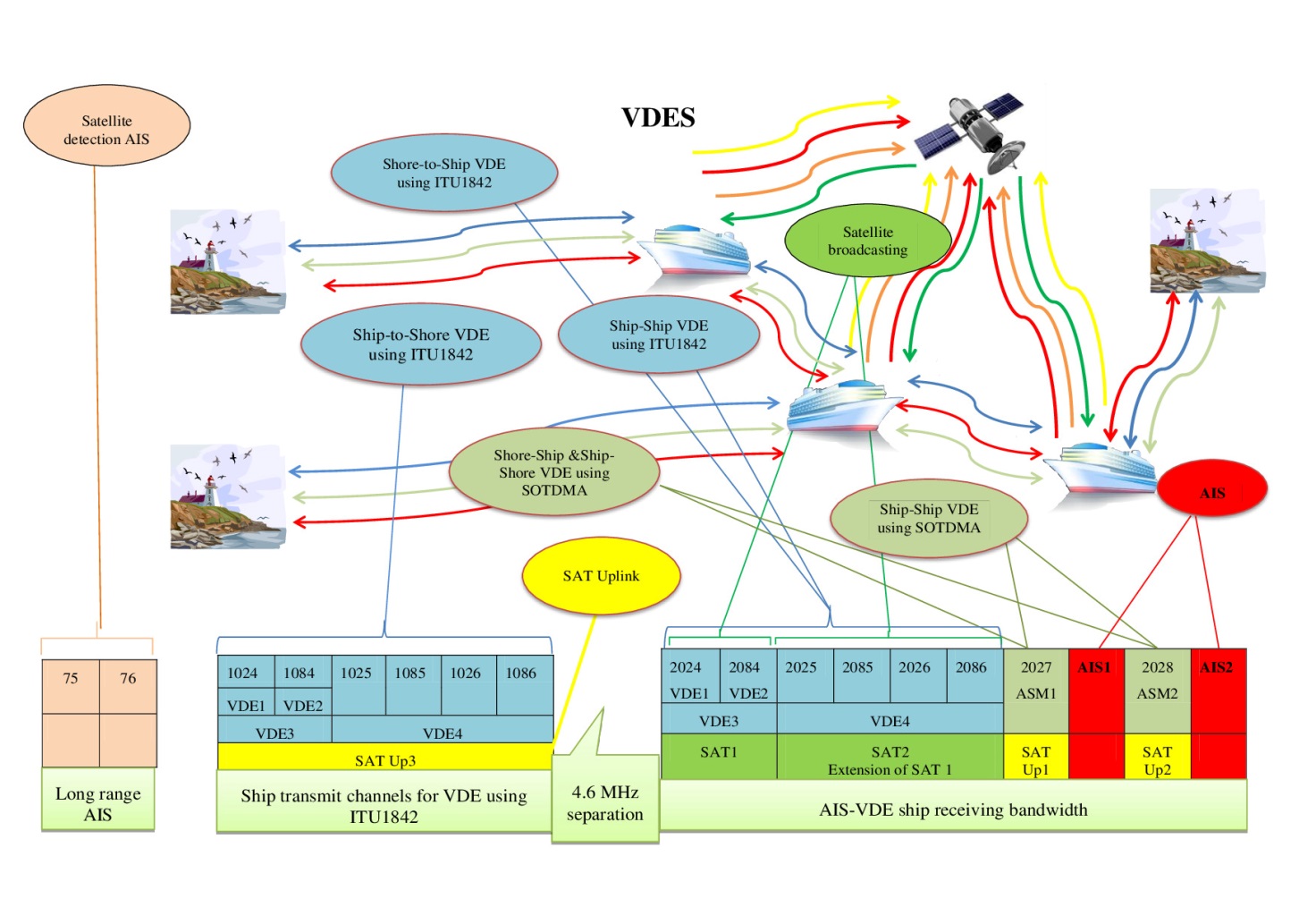


Table 2 provides a summary of the proposed technical assignment of various VHF channels for communication including protocol and types of messages to meet the functionality required by user needs.

## Table 2 VDES Communications including AIS, ASM and VDE

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | *VHF Data Communications (including ASM and VDE)* | | *AIS* | |
| **Sub-group** | ***Data communications for ASM*** | ***Data communications for VDE*** | ***AIS for safety of navigation*** | ***AIS long range*** |
| **Radio channels** | * *Channels 27 and 28* * *World-wide dedicated channels (WRC-15 target)* | * *Channels 24, 84, 25, 85, 26, 86 for VDE* * *Channels 2024/2084 for VDE satellite communications* | * *AIS-1 & AIS-2 (simplex)* | * *Channels 75 and 76 (simplex)* |
| **Functionality** | * *Marine safety information* * *Marine security information* * *Short safety related messages* * *General purpose information communication* | * *General purpose data exchange* * *Robust high speed data exchange* * *VDE satellite communications* | * *Safety of navigation* * *Maritime locating devices* | * *Satellite detection of AIS* * *Locating during SAR* |
| **Message types for AIS protocol** | * *IMO SN.1/ Circ.289 international application specific messages* * *Regional application specific messages* * *Base Station* |  | * *Vessel identification* * *Vessel dynamic data* * *Vessel static data* * *Voyage related data* * *Aids to Navigation* * *Base Station* | * *Satellite detection of AIS* * *Message 27* |
| **Sub functionality** | * *Area warnings and advice* * *Meteorological and hydrographic data* * *Traffic management* * *Ship-shore data exchange* * *Channel management* | * *High message payload* * *Satellite communications* | * *Ship to ship collision avoidance* * *VTS* * *Tracking of ships* * *Locating in SAR* * *VDL control (by Base Station)* | * *Detection of vessels by coastal states beyond range of coastal AIS base stations* |

As explained above, radio communication technologies are characterized by performance parameters. These include range, bandwidth, latency, and the need for shore facilities. The tables below list, in the column headings, the communications techniques that are presently available for maritime voice and data communications. It also includes some techniques which may become available in the short to medium term. Separate tables are provided for ship-to-shore and for ship-to-ship communications. Six geographical regions are listed at the left column, defined by the ranges of a selection from the available communications technologies. The GMDSS sea areas, which approximately correspond, are also noted in the second column. The suggested most likely candidates for voice and data communications, for e-Navigation, in each of the six geographical areas are indicated by yellow color, with ‘E’ for existing technologies, and ‘F’ for future technologies or technologies currently not widely used in the maritime domain.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Table 3 Geographical classification of e-Navigation data and voice communication techniques Ship-Shore | | | | | | | | | | | | | | | | |
| e-NAV Area Definitions | GMDSS Sea Area (approx) | Broadband phone line or cable. (When ship at berth) | Wi-Fi® | WiMax™ | Mobile phone technology | AIS | VDE | Digital VHF voice and data | Data by modulated RADAR | Geostationary Satellite | Commercial MEO/LEO satellite comms | MF & HF (including Navtex / MSI) | DGPS beacon data broadcast service | Current MF & HF NDBP | HF digital data service | MF/HF digital data services for MSI (incl NAVDAT) |
| 1 – Inside port | A1 | E | F | F | E | E | F | F |  | E | E | E | F |  |  | F |
| 2- Approaching port area | A1 |  |  | F | E | E | F | F | F | E | E | E | F |  |  | F |
| 3A – Coastal navigation out to cell phone coverage (approx. 5nm) | A1 |  |  | F | E | E | F | F | F | E | E | E | F |  | E | F |
| 3B - Coastal navigation VHF coverage range (approx . 25nm) | A1 |  |  | F |  | E | F | F | F | E | E | E | F |  | E | F |
| 4 - Coastal approach (approx. 100nm) | A2 |  |  |  |  |  |  |  |  | E | E | E | F | E | E | F |
| 5 - High seas | A3 |  |  |  |  |  |  |  |  | E | E | E |  | E | E | F |
| 6 - Polar regions | A4 |  |  |  |  |  |  |  |  |  | E | E |  | E | E | F |
| Legend: |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Existing technology | | | E |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Future: Not existing or not widely used | | | F |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Possible preferred technology (Existing, Future) | | | E | | F | |  |  |  |  |  |  |  |  |  |  |

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Table 4 Geographical classification of e-Navigation data and voice communication techniques Ship-Ship | | | | | | | | | | | | | | | | |
|  |  |  | Technologies for data transfer ship <-> ship, listed generally in order of geographical range | | | | | | | | | | | |  |  |
| e-NAV Area Definitions | GMDSS Sea Area (approx) | Broadband phone line or cable. (When ship at berth) | Wi-Fi® | WiMax™ | Mobile phone technology | AIS | VDE | Digital VHF voice and data | Data by modulated RADAR | Geostationary Satellite | Commercial MEO/LEO satellite comms | MF & HF (including Navtex / MSI) | DGPS beacon data broadcast service | Current MF & HF NDBP | HF digital data service | MF/HF digital data services for MSI (incl NAVDAT) |
| 1 – Inside port | A1 |  | F | F | E | E | F | F | F | E | E | E |  |  |  | F |
| 2- Approaching port area | A1 |  |  | F | E | E | F | F | F | E | E | E |  |  |  | F |
| 3A – Coastal navigation out to cell phone coverage (approx. 5nm) | A1 |  |  |  | E | E | F | F | F | E | E | E |  |  | E | F |
| 3B - Coastal navigation VHF coverage range (approx . 25nm) | A1 |  |  |  |  | E | F | F | F | E | E | E |  |  | E | F |
| 4 - Coastal approach (approx. 100nm) | A2 |  |  |  |  | E | F | F | F | E | E | E |  |  | E | F |
| 5 - High seas | A3 |  |  |  |  | E | F | F | F | E | E | E |  |  | E | F |
| 6 - Polar regions | A4 |  |  |  |  | E | F | F | F |  | E | E |  |  | E | F |
| Legend: |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Existing technology | | | E |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Future: Not existing or not widely used | | | F |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Possible preferred technology (Existing, Future) | | | E | | F | |  |  |  |  |  |  |  |  |  |  |

# BACKGROUND TO SERVICE PROVISION

### General

The challenge facing radio communication in the maritime sector is the need to relay more information, which puts pressure on the availability of spectrum.

Spectrum, as a finite resource, is under increasing demand from all users globally. Recent trends from national licensing / regulatory authorities have been to use pricing / cost to drive efficiency improvements.

The move from analogue to digital and from voice to data show the way forward for future radio communications. Time sharing of voice and data communications on a common channel is a technological advance that can be applied to e-Navigation.

Experience with AIS has shown that TDMA techniques can enable several hundred users effectively and efficiently share vast amounts of data using only two channels.

Selection of appropriate bandwidth given the constraints of required range, data rates and channel availability means that narrow band techniques should be considered.

### **Institutional**

Co-operation and coordination between maritime organizations including, but not limited to, IMO, ITU, IHO, IEC, CIRM, RTCM, WMO, IMSO and IALA is necessary to develop an e-Navigation environment for the future.

Close co-ordination within the ITU-R is required to achieve the proposed approach in terrestrial and satellite communications technology that e-Navigation needs. [Editor’s note: National administrations are encouraged to engage their maritime stakeholders and participate in this ITU-R effort to support the vision of this report.].

### Guidance and control

The carriage requirement for radiocommunication equipment comes from IMO. This includes AIS, GMDSS, LRIT, DSC, voice communications and radar systems.

Electromagnetic spectrum is regulated by the ITU, which includes not only the frequencies but the technologies and standards for the systems employed.

This report merges the requirements of ITU and IMO, in addressing both the needs of the maritime industry and potential benefits to the small vessel maritime communities.

As in the past, GMDSS and other safety of navigation related communications, such as AIS, shall be available free of charge.

### Commercial

Growth of the world’s fleets places greater stress on the ability of the existing radiocommunication systems to cope with the traffic. Voice systems that occupy a channel for the duration of the call can be viewed as an inefficient means of relaying information. As the number of vessels increases, a saturation point on VHF may be reached. There could be a point reached where it may be difficult to make a call, specifically if analogue systems are used. To avoid the inherent problems with VHF, AIS uses TDMA, which can cope with multiple simultaneous users and is more resistant to overloading due to growth in the number of participants.

The commercial aspect includes both commerce and public correspondence.

Appreciating that allocating more spectrum to the maritime mobile service is not an immediate solution, existing spectrum allocated to maritime use will need to be examined to ensure full utilization.

### Operational

There are many changes taking place in the operational environment that present new challenges including:

* the development and implementation of e-Navigation;
* the widespread reliance on GNSS and its role underpinning position, navigation and timing required for situational awareness and communications for e-Navigation;
* growing deployment of local and specific traffic monitoring schemes and Vessel Traffic Services to meet ever more stringent requirements at higher capacity levels; and
* the balance between traditional navigation skills and the role of technological advances such as ECDIS and IBS.

The introduction of GNSS has enabled mariners to navigate more safely. As part of the introduction of e-Navigation, it is essential to understand the consequences when key e-Navigation components fail or are denied (e.g. GNSS or communications capabilities).

Before adopting any future technology, human factors must be addressed (safety, liability, on-board training and duty of care).

e-Navigation requires the active participation of international bodies such as IMO, IHO, IALA, IEC, WMO, RTCM, IMSO and CIRM.

### Technical

To ensure networks and technologies seamlessly interconnect, significant changes to underpinning services and systems are projected over the next two decades:

* development of data communication systems;
* development of satellite systems and services (e.g. AIS, MeoSAR, broadband);
* development of terrestrial systems and services (e.g. AIS, wireless broadband
* spectrum sharing and efficiency;
* compatibility with existing systems and services;
* adding data services to current voice channels;
* change from analogue to digital communications.

## 

## UNDERSTANDING MARITIME RADIOCOMMUNICATION

### Overview

The maritime domain uses a wide range of communications technologies in order to support safe navigation, efficient operations and commercial aspects (commerce and public correspondence). However, many of these technologies were developed with a single application in mind. As a result, a vessel carries many different types of communications equipment, in order to receive relevant data.

Within the vision of a future e-Navigation environment is the opportunity to revisit the maritime communications system architecture. This requires an assessment of communications needs as well as an understanding of the electromagnetic spectrum available to the maritime community. This section gives a brief summary of the existing and future radiocommunication systems.

### Maritime Communication Requirements

The maritime domain uses communication links for essential safety of life applications and routine operational activities to commercial applications (commerce and general correspondence).

Establishing the communication requirements under e-Navigation compels consideration of safety of life, operational, and commercial applications. In order to achieve the benefits of e-Navigation the design of the communications architecture will need to focus on the set of well-known applications with enough flexibility to expand, to encompass others in the future.

Figure 2 shows some example applications within e-Navigation. The categories identify essential communication application to ensure safety, important communication application for efficient operations and possible commercial communication applications.

**Figure 2 Overview of maritime communication applications by type**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Safety |  | Operational |  | Commercial |
| * AIS position reports * AIS AtoN * Digital Selective Calling * Long Range Identification and Tracking * Differential GNSS NAVTEX/SafetyNET * VTS coordination * SAR * Distress and Urgency alerting/calling |  | * Weather data * Ship reporting * Notifications to coastal States * Port arrival notification * Maritime Information Overlays * Port & VTS surveillance feeds * Electronic chart updates * Access to vessel & equipment manuals * Remote maintenance & service * Telemedicine |  | * Voyage orders * Commercial port services * Operational reports * Cargo telemetry * Point of Sale * Crew personal communications * Passenger Internet access * Crew training * Infotainment |
|  | | | | |

### **Vision: Automated selection process of available communication technologies**

The tables above identify distinct communication technologies but do not consider the optimization that could be achieved through an automated selection process.

Some existing marine communication technologies, such as AIS, automatically carry out data communications without any need for the ship's crew to intervene in the communications process. (In the specific case of AIS, the crew sets certain voyage parameters at the start of each voyage, and can change the navigational status at any time, but the communications process is automatic.) Other existing marine communications technologies, such as VHF voice communications, require the ship's crew to adjust the communications apparatus, in the case of VHF voice this involves deciding on and selecting the appropriate communications channel.

An ideal e-Navigation communications system would operate automatically, selecting the best communications technology, channel, and characteristics in accordance with the ship's location, and the type of data to be exchanged. This automatic process would be managed in accordance with regulations and the needs of the mariner that might include the following:

* Need to avoid latency - such as when exchanging safety and navigation data with other vessels or receiving it from electronic systems ashore or on the water surface;
* Ability to delay the sending or receipt of data - such as the sending of non-urgent administrative data, or the receipt of chart corrections for the current voyage, a subsequent voyage or for a port to be visited later in the present voyage;
* Value / Cost of communications;
* Importance of the data for commercial services on board;
* Rate of data transfer (capacity of transmission).

Some of the rules managing this seamless data communications would be programmed into the system, for example those concerned with safety of navigation. Other rules might be set by the ship's operator in accordance with their procedures and the operator's commercial model. Further rules might be adjusted, from time to time, by the ship's crew. Such an automatic, seamless management of e-Navigation communications appears to be essential in the future.

### **Modernization of GMDSS**

The current GMDSS system was designed over 25 years ago. There has not been a full review since its full implementation in 1999 and technology has developed significantly in that time. Significant technology elements within the GMDSS have also evolved, although the functions have not been altered. The current system is seen to be relatively sound, but it is known that there are GMDSS elements where improvement could be made, e.g. managing the cessation of international telex, and to examine the continued use of narrow-band direct-printing in certain sea areas.

The elements that will be identified may need to be examined and reviewed as a matter of some urgency. The 14th session of IMO Sub-Committee on Radiocommunications and Search and Rescue (COMSAR 14, held on March 2010) initiated a Scoping Exercise and a Work Plan to define the requirements for the GMDSS Review and Modernization. The Scoping Exercise was finalized at COMSAR16 (March 2012) and the Review will be take place over a three-year period (2013-2015).

A further two-year period is envisaged (2015-2017) for the GMDSS modernization plan. This will be followed by development of legal instruments, revision/development of relevant performance standards and an implementation period.

While supporting the IMO's systematic approach, IALA should also be active in the review, push forward initiatives to ITU with a view to the fact that items for consideration at WRC-18 need to be produced as agenda items at WRC-15. Further consideration of possible future systems including spectrum requirements need to be carefully considered.

#### 1.1.23.1 Current GMDSS system components

The GMDSS functions are classified into distress/urgency/safety alerting, distress/urgency/safety communications, locating, homing, on scene communications, maritime safety information promulgation and general communications. To achieve these functions, the equipment listed in Table 5 is used according to the GMDSS sea areas.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Table 5 Current GMDSS system components | | | | | | | |
| Sea Area | Distress/Urgency/ Safety Alerting | Distress/Urgency/ Safety Comms | Locating | Homing | On scene Comms | MSI Promulgation | General Comms |
| A1 | VHF DSC  EPIRB | VHF R/T | Radar SART  AIS-SART | EPIRB  (121.5 MHz) | VHF R/T | NAVTEX  SafetyNET | VHF R/T |
| A2 | VHF DSC  MF DSC  EPIRB | VHF R/T  MF R/T | VHF R/T  MF R/T/NBDP |
| A3 | VHF DSC  MF DSC  HF DSC  Inmarsat  EPIRB | VHF R/T  MF R/T  HF R/T/NBDP  Inmarsat | NAVTEX  SafetyNET  HF MSI | VHF R/T  HF/MF R/T/NBDP  Inmarsat |
| A4 | VHF DSC  MF DSC  HF DSC  EPIRB | VHF R/T  MF R/T  HF R/T/NBDP | HF MSI | VHF R/T  HF/MF R/T/NBDP |

The problems in the current GMDSS include the following:

* Perceived high rate of false distress alerting by DSC and EPIRB;
* complicated operation of DSC; and
* decline in use of the NBDP

Efforts have been made to address these issues, such as updating ITU-R Recommendations and IEC standards. The AIS-SART was introduced in January 2010 as an alternative to the radar SART. The AIS-SART is defined as a locating device. Field trials have proved that the AIS-SART is detectable by SAR aircraft at a much greater range than 121.5 MHz beacons in 406 MHz EPIRBs and can also be detected by low earth orbit AIS satellites.

### Possible system components for the modernization of GMDSS

IMO COMSAR sub-committee finalized the draft work plan on 'Review and modernization of the Global Maritime Distress and Safety System' at its 16th session in March 2012, and this was approved by Maritime Safety Committee at its 90 session in May 2012. The work plan states that a detailed review is required on a minimum of 16 items including: the possible inclusion of AIS functions, LRIT functions and SSAS functions; the role of Narrow Band Direct Printing (NBDP) and MF/HF DSC expected evolution of satellite EPIRB systems; and the further evolution of Maritime Safety Information broadcast systems, etc. (see ANNEX 2 to COMSAR 16/17 for details). At present, the AIS-SART is recognized in GMDSS as a locating[[5]](#footnote-5) device and can be used as an alternative to a radar SART. While AIS (AIS-SART) is currently included in the GMDSS as a locating device, the review of possible inclusions of AIS functions in the GMDSS modernization work plan could see additional uses for AIS, which may include homing. New distress devices, using AIS or AIS like technology, are evolving and may be appropriate for inclusion in the review process of GMDSS. WRC-12 has allocated 495-505 kHz (plus 505-510 kHz in Region 2) to the maritime mobile service on an exclusive primary basis, this band could be used for promulgation of maritime safety and security related information in accordance with the Recommendation ITU-R M.2010. This could deliver relatively large volumes of information with a high data rate and may be a supplementary system to the current NAVTEX. The VHF Data Exchange (VDE) may also be a candidate for promulgation of Maritime Safety Information (shore-ship) and emerging ship-ship / ship-shore applications. The MF/HF data communications and VHF Data Exchange (VDE) may be candidates for general communications in addition to the existing radiotelephone and satellite communications.

The above ideas are summarized in Table 6.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Table 6 Potential system components for modernization of GMDSS | | | | | | |
| Sea Area | Distress/Urgency/ Safety Alerting | Distress/Urgency/ Safety Comms | Locating[[6]](#footnote-6) / Homing[[7]](#footnote-7) | On scene Comms | MSI Promulgation | General Comms |
| A1 | AIS\*1  EPIRB-AIS\*2 | VHF R/T/Data | AIS-SART  EPIRB-AIS\*2  AIS-MOB\*3 | VHF R/T | AIS\*\*5  VDE  NAVDAT SafetyNET | VHF R/T/Data  MF R/T/Data  Satellite\*4 |
| A2  A3 | AIS\*1  EPIRB-AIS\*2  MF/HF Data  Satellite\*4 | VHF R/T/Data  MF/HF R/T/Data  Satellite\*2 |
| A4 | AIS\*1  EPIRB-AIS\*2 | VHF R/T/Data  MF/HF R/T/Data | AIS\*\*5  HF Data | VHF R/T/Data  MF/HF R/T/Data |
| \*1 |  | using terrestrial and satellite messages | |  |  |  |
| \*2 |  | EPIRB with built in AIS-SART function | |  |  |  |
| \*3 |  | Man Overboard device using AIS-SART technology | | |  |  |
| \*4 |  | Global or regional satellite services | | |  |  |
| \*5 |  | using application specific messages | | |  |  |

## **Securing the Spectrum**

## Situation with respect to existing spectrum usage

The existing maritime technologies described, which use the radio spectrum and indicated the bands in which they operate. Whilst there is some ongoing consideration of variations to the technologies, which may be used, all such variations take, as their base assumption, the ongoing use of existing spectrum allocations. These variations may give rise to a need to change the channelization within certain bands.

Please refer to Annex A for system details, Annex B for maritime spectrum allocations and Annex D for specific ITU technical characteristics associated with the systems

**Concept Issues**

An overview of systems in the Maritime mobile radiocommunication serviceand their mode of operation helps identify both the current and future technologies used for maritime communication and addresses the IALA position regarding maritime related agenda items for WRC-15 and WRC-18.

e-Navigation is the future, digital concept for the maritime sector that will have a profound and long-term impact on the way the maritime sector operates. It is foreseen to be supported by many current and future technologies identified in this plan. The communications infrastructure should be designed to enable authorized seamless information transfer on board ship, between ships, between ship and shore and between shore authorities and other parties. This infrastructure will have to be capable of not only supporting future e-Navigation applications, but will also have to support legacy applications. It will therefore be bandwidth intensive and possibly rely upon a range of technologies.

Securing spectrum, or changing the use within existing allocations, is important for e-Navigation due to the planning timescales required to protect or extend the use of the radio spectrum through the ITU WRC.

In general, there are some concerns relating to spectrum allocation and management for e-Navigation. Protection of the maritime mobile service spectrum allocation needs to continue. Particular emphasis should be given to following items:

* development of frequency plans for the 450 to 470 MHz band so as to protect on-board use; and
* the use of PLT/PLB at a national level as and when the possibility or necessity arises;

In relation to the forthcoming WRC meeting, spectrum requirements to support e-Navigation should be addressed. In particular:

* on board communications needs;
* the requirements for VDE and VDES;
* protection of HF RT7WT allocations.

e-Navigation should develop automated processes for selecting the best communications technology, channel, and characteristics in accordance with the ship's location, and the type of data to be exchanged.

Modernization of GMDSS could include the modern digital technologies such as VHF Data exchange (VDE), VHF Data exchange system (VDES), AIS and data or voice communications in MF/HF and VHF bands.

The e-Navigation concept and future user requirements are rapidly being developed but it is difficult to speculate what specific systems and spectrum will be required to achieve e-Navigation.

## ANNEX A SYSTEM DESCRIPTION

| **System** | **Band** | **Frequency**  **Channel** | **Bandwidth**  **Data rate** | **Status** | **Life Span** | **Ownership** | **Mode** | **Service** | **Purposes** | **Notes** |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Distress and safety communication within GMDSS** | | | | | | | | | | |
| MF/HF Voice | MF/HF | 2182 kHz  4125 kHz  6215 kHz  8291 kHz  12290 kHz  16420 kHz | 3 kHz | Current | Long | Regional and International | Analogue voice. | Mobile to mobile.  Fixed to mobile. Mobile to fixed. | Distress communication | Long distance,  > 250 nm |
| MF/HF DSC | MF/HF | 2187.5 kHz  4207.5 kHz  6312.0 kHz  8414.5 kHz  12577 kHz  16804.5 kHz | 0.5 kHz  100 bps | Current | Long | International | Data  (Digital) | Mobile to mobile.  Fixed to mobile. Mobile to fixed. | Distress alerting | Long distance  > 250 nm |
| 121.5 DF | VHF | 121.5 MHz |  | Current | Short | International | Carrier  (Analogue) | Mobile to mobile. | Location. | Line of sight |
| VHF DSC | VHF | 156.525 MHz (Ch 70) | 25 kHz  1200 bps | Current | Long | International | Data  (Digital) | Mobile to mobile.  Fixed to mobile. Mobile to fixed. | Distress alerting | Line of sight |
| VHF voice | VHF | 156.300 MHz (Ch 06)  156.650 MHz (Ch 13)  156.800 MHz (Ch 16) | 25 kHz | Current | Long | International | Voice | Mobile to mobile.  Fixed to mobile. Mobile to fixed. | Distress communication | Line of sight |
| Two way VHF voice | VHF | 156.025 - 161.950 MHz | 25 kHz | Current | Long | International | Voice | Mobile to mobile. | On scene communication | Line of sight |
| AIS-SART | VHF | 161.975 MHz, 162.025 MHz | 25 kHz  9600 bps/ TDMA | Current | Long | International | digital | Mobile to mobile | Location | Line of sight |
| EPIRB | UHF | 406 MHz |  | Current | Long | International | Digital | Mobile to satellite | Distress alerting / Location / Homing | COSPAS-SARSAT Satellite;  Global coverage |
| Satellite  INMARSAT C, B, F | UHF | Tx 1626.5 to 1646.5 MHz  Rx 1525.0 to 1545.0 MHz |  | Current | Long | 3rd party | Digital. Voice and data. | Satellite to earth.  Earth to satellite. | Distress alerting, distress communication. | Global coverage |
| RADAR SART, X-Band | SHF | 9.2 – 9.5 GHz |  | Current | Medium | International | analogue | Mobile to mobile | Homing | Line of sight |
| EPIRB-AIS | UHF / VHF | 406 MHz  161.975 MHz (AIS 1)  162.025 MHz (AIS 2) |  | Current | Long | International | Digital | Mobile to satellite  Mobile to Mobile | Distress alerting / Location / Homing | COSPAS-SARSAT Satellite;  Global coverage |
| **Maritime safety information promulgation** | | | | | | | | | | |
| NAVTEX | MF/HF | 518 kHz  490 kHz and 4209.5 kHz (for local language) | 0.5 kHz | Current | Medium | International | Text | Fixed to mobile. | Reception of maritime safety information. | Long distance,  > 250 nm  Broadcast to mobile only. |
| Narrow band direct printing. (NBDP) | HF | . 4210 kHz  6314 kHz  8416.5 kHz  12509 kHz  16806.5 kHz  19680.5 kHz  22376.0 kHz  26100.5 kHz | 0.5 kHz | Current | Medium | International. | Text | Mobile to mobile.  Fixed to mobile. Mobile to fixed. | Reception of maritime safety information | Long distance,  > 250 nm |
| EGC | UHF | Tx 1626.5 - 1646.5 MHz  Rx 1525.0 - 1545.0 MHz |  | Current | Long | International | Digital data. | Satellite to mobile | Reception of maritime safety information (Safety Net) | Global coverage |
| **Safety of navigation** | | | | | | | | | | |
| Loran and e-Loran | LF | 90-110 KHz |  | Current | Very Long | Regional | Carrier  (Analogue) | Fixed to mobile. | Positioning | Long distance |
| DGNSS | MF | 283.5 to 325 kHz | 50/100 bps | Current | Medium. | Regional. | Digital | Fixed to mobile. | Augmentation of positioning | Medium distance |
| AIS | VHF | 161.975 MHz (AIS 1)  162.025 MHz (AIS 2) | 25 kHz  9600 bps/ TDMA | Current | Long | International | Data  (Digital) | Mobile to mobile.  Fixed to mobile. Mobile to fixed. | Collision avoidance, Environmental protection, Security, VTS,  Augmentation of positioning,  communication for navigational and safety related purposes. | Line of sight  LEO Satellite detection for tracking |
| AIS AtoN | VHF | 161.975MHz (AIS 1)  162.025MHz (AIS 2) | 25 kHz  9600 bps/ TDMA | Current | Long | International | Data  (Digital) | AtoN (fixed/floating) to mobile/shore | Navigational aid | Line of sight |
| VHF voice | VHF  Mobile | 156.025 to  161.950 MHz | 25 kHz | Current | Long | International | Voice | Mobile to mobile.  Fixed to mobile. Mobile to fixed. | communication for navigational and safety related purposes | Line of sight |
| GNSS | UHF | GPS: 1227.6 MHz 1575.42 MHz  GLONASS:  1559-1610 MHz  1240-1260 MHz  BeiDou  1.561098 GHz  1.589742 GHz  1.20714 GHz  1.26852 GHz  Galileo  1.164-1.215 GHz  1.260-1.300 GHz  1.559-1.592 GHz |  | Current  Current  Current  Future | Long  Long  Long  Long | International  International  Regional  International | Digital | Satellite to earth | Positioning | Global coverage |
| LRIT | Satellite | Tx 1626.5 to 1646.5 MHz  Rx 1525.0 to 1545.0 Mhz. |  | Current | Short | 3rd party | Data  (Digital) | Inmarsat | Security. Vessel tracking. Environmental protection. | Global coverage |
| |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | | Radar  S Band | Short | 3rd party | Data  (Digital) | Inmarsat | Security. Vessel tracking. Environmental protection. | Global coverage | |  | 2.9 to 3.1 GHz |  | Current | Long | International |  | Mobile and fixed | Collision avoidance, Navigational aid. | Line of sight |
| Radar  X Band |  | 9.2 to 9.5 GHz |  | Current | Long | International |  | Mobile and fixed. | Collision avoidance, Navigational aid | Line of sight |
| racon | 2.9 to 3.1 GHz and  9.2 to 9.5 GHz |  |  | Current | Long | International |  | Fixed. | Navigational aid | Line of sight |
| **General communication** | | | | | | | | | | |
| HF Voice | MF/HF | 1.6 to 26.5 MHz | 3 kHz | Current | Long | Regional and International | Analogue voice.  (ALE) | Mobile to mobile.  Fixed to mobile. Mobile to fixed. | General voice communication. | Long distance,  > 250 nm |
| Narrow band direct printing. (NBDP) | MF & HF. | 1.6 to 26.5 MHz | 0.5 kHz | Current | Long for GMDSS.  Short for general communication. | International. | Text | Mobile to mobile.  Fixed to mobile. Mobile to fixed. | General text communication. | Long distance,  > 250 nm |
| HF Data | MF/HF | 1.6 to 26.5 MHz | 0.5 – 3 kHz | Current | Long | Regional and International | Digital data. | Fixed to mobile. Mobile to fixed. | General data communication. | Long distance,  > 250 nm |
| VHF voice | VHF | 156.025 to  161.950 MHz | 25 kHz | Current | Long | international | Voice | Mobile to mobile.  Fixed to mobile. Mobile to fixed. | General voice communication | Line of sight |
| VHF data | VHF | 156.025 -  161.950 MHz | 25 kHz | Current | Long | regional | data | Mobile to mobile.  Fixed to mobile. Mobile to fixed. | General data communication. | Line of |
| Satellite | UHF | Tx 1626.5 - 1646.5 MHz  Rx 1525.0 - 1545.0 MHz | Current | Long | global  3rd party | Digital. Voice and data. | Satellite to earth.  Earth to satellite. | General voice and data communication. | Global coverage | Satellite |
| GSM | UHF | Current | Long | regional  3rd party | Digital. Voice and data. | Cellular.  Mobile-fixed-mobile. | General voice and data communication | Medium range in locality | GSM | UHF |
| GPRS | UHF | Current | Long | regional  3rd party | Digital. Voice and data. | Cellular.  Mobile-fixed-mobile. | General voice and data communication | Short range in locality | GPRS | UHF |
| UMTS/3G | UHF |  |  | Current | Long | regional  3rd party | Digital. Voice and data. | Cellular.  Mobile-fixed-mobile. | General voice and data communication | Short range in locality |
| IEEE 802.11 (Wi-Fi) | UHF/ SHF | 2.4 – 2.5 GHz  5.17 – 5.33 GHz  4.9 GHz | 11 Mbps  54 - 300 Mbps  54 Mbps | Current | Long | local  3rd party | Digital data | LAN  Peer-to peer | Internet access | Sort in locality  < 100m  <10 km |
| IEEE 802.16 (WiMax) | UHF/ SHF | 2.5 GHz  3.3 GHz | 75 Mbps | Current | Long | local  3rd party | Digital data | LAN  Peer-to peer | Internet access | Short range in locality  < 50 km |
| IEEE 802.15.4 (ZigBee) | UHF | 868-870 MHz  902 – 928 MHz  2.4 GHz | 20 kbps  40 kbps  250 kbps | Current | Long | local  3rd party | Digital data |  |  | Short range in locality  < 30 km |
| **Future development** | | | | | | | | | | |
| HF Digital data | HF | 4 to 26 MHz | 10 to 20 kHz. | Near Future | Long term | International | Data  (Digital) | Mobile to mobile.  Fixed to mobile. Mobile to fixed. | Binary data communication for navigational and safety related purposes. | KENTA (France)  Has range advantage over VHF  40 to 250 NM (>250 sky wave). |
| Satellite AIS | VHF | Channels 75 & 76 within RR App 18 | 25 kHz  Min 9600 bps  TDMA | On and after 1 January 2013 | Long term | International | Data  (Digital) | Mobile to satellite. | Security. Environmental protection.  Vessel tracking.  in future | Closely related to current AIS. Same transponder on ship |
| AIS 5th & 6th Channels | VHF | Within RR App 18 | 25 kHz  Min 9600 bps  TDMA | Future | Long term | International | Data  (Digital) | Mobile to mobile.  Fixed to mobile. Mobile to fixed. | Binary data communication for navigational and safety related purposes.  Security and tracking. | Closely related to current AIS. Same transponder on ship |
| AIS MMS channel management | VHF | Channel 70  (AIS 1 and AIS 2) | 25kHz  9600bps  TDMA | Near Future | Long term | International | Data  (Digital) | Mobile to mobile.  Fixed to mobile. Mobile to fixed. | To manage data transfer over channels in the MMS. | E.g. “go to channel XX to get chart update for Tokyo Bay. |
| VHF Digital data.   ECDIS chart data   Digital voice   Virtual channels   UMDM support   Internet access | VHF  Mobile | 156.025 to  161.950 MHz | 256 to 100 kHz. | On and after 1 January 2013 in Region2, 1 January 2017 in Regions 1 & 3 | Long term | International | Data  (Digital) | Mobile to mobile.  Fixed to mobile. Mobile to fixed. | Binary data communication for navigational and safety related purposes. | ITU 1842  SC 123  Managed or autonomous systems |

## ANNEX B MARITIME FREQUENCY ALLOCATIONS

The table below sets out the various current maritime frequency allocations as allocated by ITU Radio Regulation. Due to the size, footnotes to the allocation in the ITU Radio Regulation are not included. Please refer to Article 5 in the ITU Radio Regulation, Edition of 2012.

## Annex B Table 1 Maritime Frequency Allocations

| **Frequency** | **Region 1 Allocation** | **Region 2 Allocation** | **Region 3 Allocation** | **Status of Maritime Use** |
| --- | --- | --- | --- | --- |
| 90 – 110 kHz | RADIONAVIGATION 5.62  Fixed  5.64 |  |  | No constraints |
| 285 – 315 kHz | AERONAUTICAL RADIONAVIGATION  MARITIME RADIONAVIGATION (radiobeacons) 5.73  5.74 | AERONAUTICAL RADIONAVIGATION  MARITIME RADIONAVIGATION (radiobeacons) 5.73 |  | No constraints |
| 315 – 325 kHz | AERONAUTICAL RADIONAVIGATION  Maritime radionavigation (radiobeacons) 5.73  5.75 | MARITIME RADIONAVIGATION (radiobeacons) 5.73  Aeronautical radionavigation | AERONAUTICAL RADIONAVIGATION  MARITIME RADIONAVIGATION (radiobeacons) 5.73 | Secondary in Region 1 |
| 415 – 435 kHz | MARITIME MOBILE 5.79  AERONAUTICAL RADIONAVIGATION |  | MARITIME MOBILE 5.79  Aeronautical radionavigation 5.80 | No constraints |
| 435 - 472 | MARITIME MOBILE 5.79  Aeronautical radionavigation 5.77  5.82 | 5.77 5.78 5.82 |  | No constraints |
| 472 - 479 | MARITIME MOBILE 5.79  Amateur 5.A123  Aeronautical radionavigation 5.77 5.80  5.82 5.B123 |  |  |  |
| 479 – 495 kHz | MARITIME MOBILE 5.79 5.79A  Aeronautical radionavigation 5.77  5.82 | MARITIME MOBILE 5.79 5.79A  Aeronautical radionavigation 5.80  5.77 5.82 |  | No constraints |
| 495 – 505 kHz | MARITIME MOBILE |  |  | No constraints |
| 505 – 510 kHz | MARITIME MOBILE 5.79 5.79A 5.84  AERONAUTICAL RADIONAVIGATION | MARITIME MOBILE 5.79 | MARITIME MOBILE 5.79 5.79A 5.84  AERONAUTICAL RADIONAVIGATION  Aeronautical mobile  Land mobile | No constraints |
| 510 – 526.5 kHz | MARITIME MOBILE 5.79 5.79A 5.84  AERONAUTICAL RADIONAVIGATION | 510 – 525 KHz  MARITIME MOBILE 5.79A 5.84  AERONAUTICAL RADIONAVIGATION | MARITIME MOBILE 5.79 5.79A 5.84  AERONAUTICAL RADIONAVIGATION  Aeronautical mobile  Land mobile | No constraints |
| 1606.5 – 1625 kHz | FIXED  MARITIME MOBILE 5.90  LAND MOBILE  5.92 | 1605 – 1625 kHz  BROADCASTING 5.89  5.90 | FIXED  MOBILE  RADIOLOCATION  RADIONAVIGATION  5.91 | Region 1 only and subject to restrictions on permitted coverage area |
| 1635 – 1705 kHz | FIXED  MARITIME MOBILE 5.90  LAND MOBILE  5.92 5.96 | FIXED  MOBILE  BROADCASTING 5.89  Radiolocation  5.90 | FIXED  MOBILE  RADIOLOCATION  RADIONAVIGATION  5.91 | Region 1 only and subject to restrictions on permitted coverage area |
| 1705 – 1800 kHz | FIXED  MARITIME MOBILE 5.90  LAND MOBILE  5.92 5.96 | FIXED  MOBILE  RADIOLOCATION  AERONAUTICAL RADIONAVIGAT  ION | FIXED  MOBILE  RADIOLOCATION  RADIONAVIGATI  ON  5.91 | Region 1 only and subject to restrictions on  permitted coverage area |
| 2045 – 2065 kHz | FIXED  MARITIME MOBILE  LAND MOBILE  5.92 | FIXED  MOBILE |  | Region 1 only |
| 2065 – 2107 kHz | FIXED  MARITIME MOBILE  LAND MOBILE  5.92 | MARITIME MOBILE 5.105  5.106 |  | No constraints |
| 2107 – 2160 kHz | FIXED  MARITIME MOBILE  LAND MOBILE  5.92 | FIXED  MOBILE |  | Region 1 only |
| 2170 – 2173.5 kHz | MARITIME MOBILE |  |  | No constraints |
| 2173.5 – 2190.5 kHz | MOBILE (distress and calling)  5.108 5.109 5.110 5.111 |  |  | Distress and calling |
| 2190.5 – 2194 kHz | MARITIME MOBILE |  |  | No constraints |
| 2625 – 2650 kHz | MARITIME MOBILE  MARITIME RADIONAVIGATION  5.92 | FIXED  MOBILE |  | Region 1 only |
| 4000 – 4063 kHz | FIXED  MARITIME MOBILE 5.127 |  |  | No constraints |
| 4063 – 4438 kHz | MARITIME MOBILE 5.79A 5.109 5.110 5.130 5.131 5.132 |  |  | No constraints |
| 6200 – 6525  kHz | MARITIME MOBILE 5.109 5.110 5.130 5.132  5.137 |  |  | No constraints |
| 8100 – 8195 kHz | FIXED  MARITIME MOBILE |  |  | No constraints |
| 8195 – 8815 kHz | MARITIME MOBILE 5.109 5.110 5.132 5.145  5.111 |  |  | No constraints |
| 12230 – 13200 kHz | MARITIME MOBILE 5.109 5.110 5.132 5.145 |  |  | No constraints |
| 16360 – 17410 kHz | MARITIME MOBILE 5.109 5.110 5.132 5.145 |  |  | No constraints |
| 18780 – 18900 kHz | MARITIME MOBILE |  |  | No constraints |
| 19680 – 19800 kHz | MARITIME MOBILE 5.132 |  |  | No constraints |
| 22000 – 22855 kHz | MARITIME MOBILE 5.132  5.156 |  |  | No constraints |
| 25070 – 25210 kHz | MARITIME MOBILE |  |  | No constraints |
| 26100 – 26175 kHz | MARITIME MOBILE 5.132 |  |  | No constraints |
| 154 – 156.4875 MHz | FIXED  MOBILE except aeronautical mobile (R)  5.226 5.A114 | FIXED  MOBILE  5.226 | FIXED  MOBILE  5.226 5.A114 | Operation protected by footnote 5.226 |
| 156.4875 – 156.5625 MHz  (CH10, 70, 11) | MARITIME MOBILE (distress and calling via DSC)  5.111 5.226 5.227 |  |  | No constraints for CH70  CH10 and CH11 are protected by footnote 5.227 |
| 156.5625 – 156.7625 MHz | FIXED  MOBILE except aeronautical mobile (R)  5.226 | FIXED  MOBILE  5.225 5.226 |  | Operation protected by footnote 5.226 |
| 156.7625 – 156.7875 MHz  (CH75) | MARITIME MOBILE  Mobile-satellite  (Earth-to-space)  5.111 5.226 5.G110 (Ch 75) | MARITIME MOBILE  MOBILE-  SATELLITE (Earth-to-space)  5.111 5.226 5.G110 (Ch 75) | MARITIME MOBILE  Mobile-satellite  (Earth-to-space)  5.111 5.226 5.G110 (Ch 75) | Operation protected by footnote  5.226 |
| 156.7875 – 156.8125 MHz  (CH16) | MARITIME MOBILE (distress and calling)  5.111 5.226 |  |  | No constraints |
| 156.8125 – 156.8375 MHz  (CH76) | MARITIME MOBILE  Mobile-satellite (Earth-to-space)  5.111 5.226 5.G110 (Ch 76) | MARITIME MOBILE  MOBILE-SATELLITE (Earth-to-space)  5.111 5.226 5.G110 | MARITIME MOBILE  Mobile-satellite (Earth-to-space)  5.111 5.226 5.G110 | Operation protected by footnote 5.226 |
| 156.8375-161.9625 MHz | FIXED  MOBILE except aeronautical mobile  5.226 | FIXED  MOBILE  5.226 |  | Operation protected by footnote 5.226 |
| 161.9625-161.9875 MHz  (AIS 1) | FIXED  MOBILE except aeronautical mobile  Mobile-satellite (Earth-to-space) 5.F110  5.226 5.A110 5.B110 | AERONAUTICAL MOBILE (OR)  MARITIME MOBILE  MOBILE-SATELITE (Earth-to-space)  5.C110 5.D110 | MARITIME MOBILE  Aeronautical mobile (OR) 5.E110  Mobile-satellite (Earth-to-space) 5.F110  5.226 | No constraints in Region 2.  Operation protected by footnote 5.226 in Regions 1 and 3 |
| 161.9875-162.0125 MHz | FIXED  MOBILE except aeronautical mobile  5.226 5.229 | FIXED  MOBILE  5.226 |  | Operation protected by footnote 5.226 |
| 162.0125-162.0375 MHz  (AIS 2) | FIXED  MOBILE except aeronautical mobile  Mobile-satellite (Earth-to-space) 5.F110  5.226 5.229 5.A110 5.B110 | AERONAUTICAL MOBILE (OR)  MARITIME MOBILE  MOBILE-SATELITE (Earth-to-space)  5.C110 5.D110 | MARITIME MOBILE  Aeronautical mobile (OR) 5.E110  Mobile-satellite (Earth-to-space)  5.F110  5.226 | No constraints in Region 2.  Operation protected  by footnote 5.226 in Regions 1 and |
| 162.0375-174 MHz | FIXED  MOBILE except aeronautical mobile  5.226 5.229 | FIXED  MOBILE  5.226 5.230 5.231 5.232 |  | Operation protected by footnote 5.226 |
| 406 – 406.1 MHz | MOBILE-SATELLITE (Earth-to-space)  5.266 5.267 |  |  | No constraints |
| 456 – 459 MHz | FIXED  MOBILE 5.286AA  5.271 5.287 5.288 |  |  | Footnote 5.287 specifies maritime mobile use |
| 460 – 470 MHz | FIXED  MOBILE 5.286AA  Meteorological-satellite (space-to-Earth)  5.287 5.288 5.289 5.290 |  |  | Footnote 5.287 specifies maritime mobile use |
| 1525 – 1530 MHz | SPACE OPERATION (space-to-Earth)  FIXED  MOBILE-SATELLITE (space-to-Earth) 5.208B 5.351A  Earth exploration-satellite  Mobile except aeronautical mobile 5.349  5.341 5.342 5.350 5.351 5.352A 5.354 | SPACE OPERATION (space-to-Earth)  MOBILE-SATELLITE (space-to-Earth) 5.208B 5.351A  Earth exploration-satellite  Fixed  Mobile 5.343  5.341 5.351 5.354 | SPACE OPERATION (space-to-Earth)  FIXED  MOBILE-SATELLITE (space-to-Earth) 5.208B 5.351A  Earth exploration-satellite  Mobile 5.349  5.341 5.351 5.352A 5.354 | Complex |
| 1530 – 1535 MHz | SPACE OPERATION (space-to-Earth)  MOBILE-SATELLITE (space-to-Earth) 5.208B 5.351A 5.353A  Earth exploration-satellite  Fixed  Mobile except aeronautical mobile  5.341 5.342 5.351 5.354 | SPACE OPERATION (space-to-Earth)  MOBILE-SATELLITE (space-to-Earth) 5.208B 5.351A 5.353A  Earth exploration-satellite  Fixed  Mobile 5.343  5.341 5.351 5.354 |  | Complex |
| 1535 – 1559 MHz | MOBILE-SATELLITE (space-to-Earth) 5.208B 5.351A  5.341 5.351 5.353A 5.354 5.355 5.356 5.357 5.357A 5.359 5.362A |  |  | Complex |
| 1616 – 1610.6 MHz | MOBILE-SATELLITE (Earth-to-space) 5.351A  AERONAUTICAL RADIONAVIGATION  5.341 5.355 5.359 5.364 5.366 5.367 5.368 5.369 5.371 5.372 | MOBILE-SATELLITE (Earth-to-space) 5.351A  AERONAUTICAL RADIONAVIGATION  RADIODETERMINATION- SATELLITE (Earth-to-space)  5.341 5.364 5.366 5.367 5.368 5.370 5.372 | MOBILE-SATELLITE (Earth-to-space) 5.351A  AERONAUTICAL RADIONAVIGATION  Radiodetermination-satellite (Earth-to-space)  5.341 5.355 5.359 5.364 5.366 5.367 5.368 5.369 5.372 | Complex |
| 1610.6 – 1613.8 MHz | MOBILE-SATELLITE (Earth-to-space) 5.351A  RADIO ASTRONOMY  AERONAUTICAL RADIONAVIGATION  5.149 5.341 5.355 5.359 5.364 5.366 5.367 5.368 5.369 5.371 5.372 | MOBILE-SATELLITE (Earth-to-space) 5.351A  RADIO ASTRONOMY  AERONAUTICAL RADIONAVIGATION  RADIODETERMINATION-SATELLITE (Earth-to-space)  5.149 5.341 5.364 5.366 5.367 5.368 5.370 5.372 | MOBILE-SATELLITE (Earth-to-space) 5.351A  RADIO ASTRONOMY  AERONAUTICAL RADIONAVIGATION  Radiodetermination-satellite (Earth-to-space)  5.149 5.341 5.355 5.359 5.364 5.366 5.367 5.368 5.369 5.372 | Complex |
| 1626.5 – 1660 MHz | MOBILE-SATELLITE (Earth-to-space) 5.351A  5.341 5.351 5.353A 5.354 5.355 5.357A 5.359 5.362A 5.374 5.375 5.376 |  |  | Complex |
| 2900 – 3100 MHz | RADIOLOCATION 5.424A  RADIONAVIGATION 5.426  5.425 5.427 |  |  | No constraints |
| 9200 – 9300 MHz | RADIOLOCATION  MARITIME RADIONAVIGATION 5.472  5.473 5.474 |  |  | No constraints |
| 9300 – 9500 MHz | RADIONAVIGATION  EARTH EXPLORATION-SATELLITE (active)  SPACE RESEARCH (active)  RADIOLOCATION  5.427 5.474 5.475 5.475A 5.475B 5.476A |  |  | No constraints |
|  |  |  |  |  |

## ANNEX C CURRENT AND EVOLVING WIRELESS TELECOMMUNICATIONS TECHNOLOGIES IN THE MARITIME ENVIRONMENT

There is an ever increasing number of wireless technologies that aim to deliver voice and data connectivity to mobile users and which may be of use in the maritime environment. Aside from their technical capabilities, there may be regulatory issues and associated technical restrictions which prevent them being fully exploited. Such issues may include:

* the ITU radio regulations do not permit maritime mobile operation in the frequency bands concerned;
* frequencies are licensed on a national basis, such that there is no continuity of operation from country to country (this may even require equipment to be switched off when entering certain jurisdictions);
* the system parameters may have the potential to cause interference to ship-borne equipment;
* planning parameters may make use at sea (or even in ports) complex or difficult.

The following terrestrial technologies are currently in the process of either being rolled-out or standardized on an international basis and thus may be candidates for use in the maritime environment, particularly for commercial port services:

* digital PMR (to replace analogue PMR for on-board communications): TETRA, TETRAPOL, P25, dPMR, DMR, TDMA;
* 3G Mobile: UMTS (TDD & FDD), cdma2000, TD-SCDMA, IEEE802.20 (including iBurst), HSDPA;
* 3.5G Mobile: WiMax;
* 4G Mobile: LTE, UMB.

In addition to these commercial service technologies, there are various technologies which may offer potential solutions under the banner of ‘license exempt’ or ‘low-power’ technologies such as Wi-Fi, Bluetooth, ZigBee and UWB. The range of such services, however, is exceptionally limited (normally to 100 meters or much less) and the frequencies employed are globally allocated for the purpose (e.g. the 2.4 GHz ISM[[8]](#footnote-8) band) such that there is no need for a specific consideration of the impact on spectrum of their usage in a maritime environment.

Table 7 details, for each of the commercial technologies, the frequency band(s) in which they ‘prefer’ to operate, i.e. those for which there are known services, as well as the general range of frequencies over which they are specified to operate.

## Annex C Table 1 Summary of spectrum requirements of new commercial data links

| **Technology** | **Frequency Range** | **Notes** |
| --- | --- | --- |
| TETRA[[9]](#footnote-9) | 380 – 400 MHz | EN 300 392 |
| TETRA 2 (TEDS | 410 – 430 MHz  450 – 470 MHz  806 – 821 // 851 – 866 MHz | EN 302 561 |
|  |  |  |
| TETRAPOL | 70 – 933 MHz |  |
| P25 | 136 – 870 MHz |  |
| DMR | 30 – 900 MHz | TS 102 361 |
| dPMR | 30 – 900 MHz | EN 301 166 |
| GSM (incl EDGE)9 | 380 – 400 MHz  410 – 430 MHz  450 – 470 MHz  478 – 496 MHz  698 – 746 MHz  747 – 792 MHz  806 – 866 MHz  824 – 894 MHz  870 – 921 MHz  876 – 925 MHz  880 – 960 MHz  1710 – 1880 MHz  1850 – 1990 MHz |  |
| CDMA2000 | 450 – 470 MHz |  |
| W-CDMA (UMTS) | 790 – 862 MHz  824 – 894 MHz  880 – 960 MHz  1710 – 1880 MHz  1850 – 1990 MHz  1820 – 2170 MHz  2300 – 2400 MHz  2500 – 2690 MHz |  |
| TD-CDMA | 1900 – 1920 MHz  2010 – 2025 MHz | ‘TDtv’ applications have been trialed in some EU countries |
| TD-SCDMA | (2570 – 2620 MHz) |  |
| WiMax | 2 – 11 GHz  10 – 66 GHz | 3400 – 3600 MHz is being seen as a potential target following WRC-07 and EU WAPECS moves |
| 802.20 (MBWA) | Below 3.5 GHz |  |
| WiBro | 2.3 – 2.4 GHz | Currently Korea only |
| iBurst (HC-SDMA) | Below 3.5 GHz | Often uses 1785 – 1805 MHz or 1900 – 1920 MHz |
|  |  |  |

LTE and UMB are 4G extensions to UMTS and CDMA2000 respectively. At present, it is envisaged that existing spectrum assignments will be re-farmed such that no new spectrum will be necessary.

From the above, the bands of particular interest, and where there are most likely to be mobile communication systems providing value in maritime applications are:

* 380 to 400 MHz;
* 410 to 430 MHz;
* 450 to 470 MHz;
* 790 to 862 MHz (the ‘Digital Dividend’);
* 824 to 849 // 869 to 894 MHz (US ‘800 MHz’ cellular band);
* 880 to 915 // 925 to 960 MHz (EU ‘900 MHz’ cellular band);
* 1710 to 1785 // 1815 to 1880 MHz (EU ‘1800 MHz’ cellular band);
* 1850 to 1910 // 1930 to 1990 MHz (US ‘1900 MHz’ cellular band);
* 1880 to 1920 MHz (EU ‘3G TDD’ band);
* 1920 to 1980 // 2110 to 2170 MHz (EU ‘3G’ band);
* 2010 to 2015 MHz (EU ‘3G TDD’ band);
* 2400 to 2483.5 MHz (‘2.4 GHz’ license exempt, low-power band);
* 2500 to 2690 MHz (‘3G expansion’ band);
* 3400 to 3600 MHz

Table 2 below shows, based on the 2012 version of the ITU Radio Regulations, the allocations in those bands (including any footnotes), highlighting the position of maritime services in those bands.

|  |
| --- |
| Annex C Table 2 Summary of maritime radio spectrum |

| **Frequency (MHz)** | **Region 1 Allocation** | **Region 2 Allocation** | **Region 3 Allocation** | **Status of Maritime Use** |
| --- | --- | --- | --- | --- |
| 380 – 387 | FIXED  MOBILE  5.254 |  |  | No constraints |
| 387 – 390 | FIXED  MOBILE  Mobile-satellite (space-to-Earth) 5.208A 5.208B 5.254 5.255 |  |  | No constraints |
| 390 – 399.9 | FIXED  MOBILE  5.254 |  |  | No constraints |
| 410 – 420 | FIXED  MOBILE except aeronautical mobile  SPACE RESEARCH (space-to-space) 5.268 |  |  | No constraints |
| 420 – 430 | FIXED  MOBILE except aeronautical mobile  Radiolocation  5.269 5.270 5.271 |  |  | No constraints |
| 450 – 455 | FIXED  MOBILE 5.286 AA  5.209 5.271 5.286 5.286A 5.286B 5.286C 5.286D 5.286 |  |  | No constraints |
| 455 – 456 | FIXED  MOBILE 5.286AA  5.209 5.271 5.286A 5.286B 5.286C 5.286 E | FIXED  MOBILE 5.286AA  MOBILE-SATELLITE (Earth-to-space) 5.286A 5.286B 5.286C  5.209 | FIXED  MOBILE 5.286AA  5.209 5.271 5.286A 5.286B 5.286C 5.286 E | No constraints |
| 456 – 459 | FIXED  MOBILE 5.286AA  5.271 5.287 5.288 |  |  | No constraints |
| 459 – 460 | FIXED  MOBILE 5.286AA  5.209 5.271 5.286A 5.286B 5.286C 5.286 E | FIXED  MOBILE 5.286AA  MOBILE-SATELLITE (Earth-to-space) 5.286A 5.286B 5.286C  5.209 | FIXED  MOBILE 5.286AA  5.209 5.271 5.286A 5.286B 5.286C 5.286 E | No constraints |
| 460 – 470 | FIXED  MOBILE 5.286AA  Meteorological-satellite (space-to-Earth)  5.287 5.288 5.289 5.290 |  |  | No constraints |
| 790 – 806 | FIXED  BROADCASTING  MOBILE except aeronautical mobile 5.316B 5.317A  5.312 5.314 5.315 5.316 5.316A 5.319 | BROADCASTING  Fixed  MOBILE 5.313B 5.317A  5.293 5.309 5.311A | FIXED  MOBILE 5.313A 5.317A  BROADCASTING  5.149 5.305 5.306 5.307 5.311A 5.320 | No constraints |
| 806 – 862 | FIXED  BROADCASTING  MOBILE except aeronautical mobile 5.316B 5.317A  5.312 5.314 5.315 5.316 5.316A 5.319 | FIXED  MOBILE 5.317A  BROADCASTING  5.317 5.318 | FIXED  MOBILE 5.313A 5.317A  BROADCASTING  5.149 5.305 5.306 5.307 5.311A 5.320 | No constraints |
| 862 – 890 | FIXED  MOBILE except aeronautical  mobile 5.317A  BROADCASTING 5.322  5.319 5.323 | FIXED  MOBILE 5.317A  BROADCASTING  5.317 5.318 | FIXED  MOBILE 5.313A 5.317A  BROADCASTING  5.149 5.305 5.306 5.307 5.311A 5.320 | No constraints |
| 890 – 902 | FIXED  MOBILE except aeronautical mobile 5.317A  BROADCASTING 5.322  Radiolocation  5.323 | FIXED  MOBILE except aeronautical mobile 5.317A  Radiolocation  5.318 5.325 | FIXED  MOBILE 5.317A  BROADCASTING  Radiolocation  5.327 | No constraints |
| 902 – 928 | FIXED  MOBILE except aeronautical mobile 5.317A  BROADCASTING 5.322  Radiolocation  5.323 | FIXED  Amateur  Mobile except aeronautical mobile 5.325A  Radiolocation  5.150 5.325 5.326 | FIXED  MOBILE 5.317A  BROADCASTING  Radiolocation  5.327 | No constraints |
| 928 – 942 | FIXED  MOBILE except aeronautical mobile 5.317A  BROADCASTING 5.322  Radiolocation  5.323 | FIXED  MOBILE except aeronautical mobile 5.317A  Radiolocation  5.325 | FIXED  MOBILE 5.317A  BROADCASTING  Radiolocation  5.327 | No constraints |
| 942 – 960 | FIXED  MOBILE except aeronautical mobile 5.317A  BROADCASTING 5.322  5.323 | FIXED  MOBILE 5.317A | FIXED  MOBILE 5.317A  BROADCASTING  5.320 | No constraints |
| 1710 – 1930 | FIXED  MOBILE 5.384A 5.388A 5.388B  5.149 5.341 5.385 5.386 5.387 5.388 |  |  | No constraints |
| 1930 – 1970 | FIXED  MOBILE 5.388A 5.388B  5.388 | FIXED  MOBILE 5.388A 5.388B  Mobile-satellite (Earth-to-space)  5.388 | FIXED  MOBILE 5.388A 5.388B  5.388 | No constraints |
| 1970 – 1980 | FIXED  MOBILE 5.388A 5.388B  5.388 |  |  | No constraints |
| 1980 – 2010 | FIXED  MOBILE  MOBILE-SATELLITE (Earth-to-space) 5.351A  5.388 5.389A 5.389B 5.389F |  |  | No constraints |
| 2010 – 2015 | FIXED  MOBILE 5.388A 5.388B  5.388 | FIXED  MOBILE  MOBILE-SATELLITE  (Earth-to-space)  5.388 5.389C 5.389E | FIXED  MOBILE 5.388A 5.388B  5.388 | No constraints |
| 2110 – 2120 | FIXED  MOBILE 5.388A 5.388B  SPACE RESEARCH (deep space) (Earth-to-space)  5.388 |  |  |  |
| 2120 – 2160 | FIXED  MOBILE 5.388A 5.388B  5.388 | FIXED  MOBILE 5.388A 5.388B  Mobile-satellite (space-to-Earth)  5.388 | FIXED  MOBILE 5.388A 5.388B  5.388 | No constraints |
| 2160 – 2170 | FIXED  MOBILE 5.388A 5.388B  5.388 | FIXED  MOBILE  MOBILE-SATELLITE (space-to-Earth)  5.388 5.389C 5.389E | FIXED  MOBILE 5.388A 5.388B  5.388 | No constraints |
| 2400 – 2450 | FIXED  MOBILE 5.384A  Amateur  Radiolocation  5.150 5.282 5.395 | FIXED  MOBILE 5.384A  RADIOLOCATION  Amateur  5.150 5.282 5.393 5.394 5.396 |  |  |
| 2450 – 2483.5 | FIXED  MOBILE  Radiolocation  5.150 | FIXED  MOBILE  RADIOLOCATION  5.150 | No constraints | 2450 – 2483.5 |
| 2500 – 2520 | FIXED 5.410  MOBILE except aeronautical mobile 5.384A  5.412 | FIXED 5.410  FIXED-SATELLITE (space-to-Earth) 5.415  MOBILE except aeronautical mobile 5.384A  5.404 | FIXED 5.410  FIXED-SATELLITE (space-to-Earth) 5.415  MOBILE except aeronautical mobile 5.384A  MOBILE-SATELLITE (space-to-Earth) 5.351A 5.407 5.414 5.414A  5.404 5.415A | No constraints |
| 2520 – 2535 | FIXED 5.410  MOBILE except aeronautical mobile 5.384A  BROADCASTING-SATELLITE 5.413 5.416  5.339 5.405 5.412 5.417C 5.417D 5.418B 5.418C | FIXED 5.410  FIXED-SATELLITE (space-to-Earth) 5.415  MOBILE except aeronautical mobile 5.384A  BROADCASTING-SATELLITE 5.413 5.416  5.339 5.417C 5.417D 5.418B 5.418C | FIXED 5.410  FIXED-SATELLITE (space-to-Earth) 5.415  MOBILE except aeronautical mobile 5.384A  BROADCASTING-SATELLITE 5.413 5.416  5.403 5.414A 5.415A | No constraints |
| 2535 – 2655 | FIXED 5.410  MOBILE except aeronautical mobile 5.384A  BROADCASTING-SATELLITE 5.413 5.416  5.339 5.412 5.417C 5.417D 5.418B 5.418C | FIXED 5.410  FIXED-SATELLITE (space-to-Earth) 5.415  MOBILE except aeronautical mobile 5.384A  BROADCASTING-SATELLITE 5.413 5.416  5.339 5.417C 5.417D 5.418B 5.418C | FIXED 5.410  MOBILE except aeronautical mobile 5.384A  BROADCASTING-SATELLITE 5.413 5.416  5.339 5.417A 5.417B 5.417C 5.417D 5.418 5.418A 5.418B 5.418C | No constraints |
| 2655 – 2670 | FIXED 5.410  MOBILE except aeronautical mobile 5.384A  BROADCASTING-SATELLITE 5.208B 5.413 5.416  Earth exploration-satellite (passive)  Radio astronomy  Space research (passive)  5.149 5.412 | FIXED 5.410  FIXED-SATELLITE (Earth-to-space) (space-to-Earth) 5.415  MOBILE except aeronautical mobile 5.384A  BROADCASTING-SATELLITE 5.413 5.416  Earth exploration-satellite (passive)  Radio astronomy  Space research (passive)  5.149 5.208B | FIXED 5.410  FIXED-SATELLITE (Earth-to-space) 5.415  MOBILE except aeronautical mobile 5.384A  BROADCASTING-SATELLITE 5.413 5.416  Earth exploration-satellite (passive)  Radio astronomy  Space research (passive)  5.149 5.208B 5.420 | No constraints |
| 2670 – 2690 | FIXED 5.410  MOBILE except aeronautical mobile 5.384A  Earth exploration-satellite (passive)  Radio astronomy  Space research (passive)  5.149 5.412 | FIXED 5.410  FIXED-SATELLITE (Earth-to-space) (space-to-Earth) 5.208B 5.415  MOBILE except aeronautical mobile 5.384A  Earth exploration-satellite (passive)  Radio astronomy  Space research (passive)  5.149 | FIXED 5.410  FIXED-SATELLITE (Earth-to-space) 5.415  MOBILE except aeronautical mobile 5.384A  MOBILE-SATELLITE (Earth-to-space) 5.351A 5.419  Earth exploration-satellite (passive)  Radio astronomy  Space research (passive)  5.149 | No constraints |
| 3400 – 3500 | FIXED  FIXED-SATELLITE (space-to-Earth)  Mobile 5.430A  Radiolocation  5.431 | FIXED  FIXED-SATELLITE (space-to-Earth)  Amateur  Mobile 5.431A  Radiolocation 5.433  5.282 | FIXED  FIXED-SATELLITE (space-to-Earth)  Amateur  Mobile 5.432B  Radiolocation 5.433  5.282 5.432 5.432A | Secondary |
| 3500 – 3600 | FIXED  FIXED-SATELLITE (space-to-Earth)  Mobile 5.430A  Radiolocation  5.431 | FIXED  FIXED-SATELLITE (space-to-Earth)  MOBILE except aeronautical mobile  Radiolocation 5.433 | FIXED  FIXED-SATELLITE (space-to-Earth)  MOBILE except aeronautical mobile 5.433A  Radiolocation 5.433 | Secondary in Region 1 |
|  |  |  |  |  |

None of the footnotes relating to the use of these bands specifically preclude any use for maritime services.

With the exception of the band 3400 – 3600 MHz, the mobile service (which includes, unless explicitly stated, the maritime mobile service) has a primary allocation meaning that the use of these bands for maritime applications will pose no regulatory issues at the ITU. In the band 3400 – 3600 MHz, many of the footnotes relate to the upgrading of the mobile service from secondary to primary status, however it is known that in some parts of the world (especially in high rainfall areas such as around the equator) this band is still heavily used for satellite downlinks and as such its development for mobile services is likely to remain constrained.

There does not appear to be any necessity to expend significant effort on the standardization or regulation of these mobile communication technologies to make them suitable for the maritime community.

## ANNEX D DEVELOPMENT OF NEW CHARACTERISTICS

The following tables summarizes the status of the various ITU technical characteristics relating to maritime communication applications both for those already existing as well as for those foreseen in e-Navigation. They outline where existing characteristics are likely to need updating or elsewhere new characteristics need to be developed. If changes are required they will take place through the appropriate ITU Study Groups.

As maritime e-Navigation applications are identified it may be necessary to consider revisions to, or creation of, technical characteristics in ITU-R Working Parties.

Table 1 catalogues various ITU-R Recommendations which may be impacted by the introduction of e-Navigation, future maritime radiocommunication systems and the modernization tasks for GMDSS.

|  |
| --- |
| Annex D Table 1 ITU-R recommendations for Maritime Radio Applications |

| **Application** |  | **Current characteristics** |  | **Amendments** | **Mechanism** |
| --- | --- | --- | --- | --- | --- |
| **DSC** | **VHF** | ITU-R M.493-13 | Digital selective-calling system for use in the maritime mobile service. | The revision work on Recommendation ITU-R M.493-13 is ongoing at WP 5B in cooperation with IMO, IALA, IEC and CIRM | N/A |
| ITU-R M.541-9 | Operational Procedures for the Use of Digital Selective-Calling Equipment in the Maritime Mobile Service |  |  |
| ITU-R M.693-1 | Technical characteristics of VHF emergency position-indicating radio beacons using digital selective calling (DSC VHF EPIRB) |  |  |
| ITU-R M.689-3 | International Maritime VHF Radiotelephone Systems with Automatic Facilities Based on DSC Signaling Format |  |  |
| ITU-R M.821-1 | Optional Expansion of the Digital Selective-Calling System for Use in the Maritime Mobile Service |  |  |
| **MF/HF** | ITU-R M.493-13 | Digital selective-calling system for use in the maritime mobile service. | The revision work on Recommendation ITU-R M.493-13 is ongoing at WP 5B in cooperation with IMO, IALA, IEC and CIRM | N/A |
| ITU-R M.541-9 | Operational Procedures for the Use of Digital Selective-Calling Equipment in the Maritime Mobile Service |  |  |
| **DSC** |  | ITU-R M.1173-1 | Technical characteristics of single-sideband transmitters used in the maritime mobile service for radiotelephony in the bands between 1 606.5 kHz (1 605 kHz Region 2) and 4 000 kHz and between 4 000 kHz and 27 500 kHz |  |  |
| ITU-R M.1082-1 | International maritime MF/HF radiotelephone system with automatic facilities based on DSC signaling format |  |  |
| ITU-R M.476-5 | Direct-Printing Telegraph Equipment in the Maritime Mobile Service |  |  |
| **Satellite** | ITU-R M.541-9 | Operational Procedures for the Use of Digital Selective-Calling Equipment in the Maritime Mobile Service | DSC over satellite is not currently defined explicitly through a technical characteristic. However, it could be appropriate to develop a complementary characteristic to those available for VHF and HF. | This task should be coordinated through WP4C/SG4 under existing question 227/4. |
| **LRIT** | **HF**  **Satellite** |  |  | The use of HF and Satellite data links to support the LRIT application should not need a new technical characteristic, as they are simply applications supported by existing data links. However, there may be merit in amending the existing recommendations in relation to HF and satellite communications to explicitly recognize the use of LRIT. | The work would have to be addressed through  WP4C/SG4 Questions 84-4/4 (Iridium), 87-4/4 (satellite) coordinating with WP5B/SG5 for HF. |
| **AIS** | ITU-R M.1371-4 | Technical characteristics for an automatic identification system using time division multiple access in the VHF maritime mobile band | WRC-12 allocated two channels for satellite detection of AIS, six channels for possible testing of future AIS applications and one channel for experimental use for future applications. Also, WP 5B is working on the revision of M.1371-4; however, there are a number of potential changes to AIS under e-Navigation that will require further revision to the existing technical characteristics.  Firstly, further studies of AIS applications and the usage of the dedicated channel.  Secondly the possible allocation of additional channels under WRC-15 Agenda Item 1.16 to provide extra capacity for e.g. environmental or security related messaging.  Thirdly, the possible need to define new AIS messages such as those relating to channel management.  Fourthly, the possible use of the AIS data link as a candidate technology for future maritime VHF data communications could also be a possibility. | WRC-15 Agenda Item 1.16 is considering the regulatory provisions and spectrum allocations to enable possible new AIS technology applications and possible new applications to improve maritime radiocommunication. As a result of this item, there could be a need to revise technical characteristics.  This task would likely fall to WP5B/SG5 under existing question 232/5. |  |
| **VHF Comms** | **Voice** | ITU-R M.1084-5 | Interim solutions for improved efficiency in the use of the band 156-174 MHz by stations in the maritime mobile service | Under e-Navigation, a general push to make more efficient use of the spectrum available for maritime voice communications may take place as existing channels are increasingly allocated to digital services.  The existing characteristics (e.g. M.1084) propose possible interim solutions such as the use of 12.5 kHz channel spacing. It may be desirable to develop a new technical characteristic to describe a permanent solutions for e.g. 12.5 kHz or 8.33 kHz voice channels in the future communication environment. |  |
|  |  | ITU-R M.489-2 | Technical characteristics of VHF radiotelephone equipment operating in the maritime mobile service in channels spaced by 25 kHz |  |
|  | **Data** | ITU-R M.1842-1 | Characteristics of VHF radio system and equipment for the exchange of data and electronic mail in the maritime mobile service RR Appendix 18 channels | A new technical characteristic will be required to support the use of VHF channels for digital data transmission – assuming that AIS is not selected as the maritime domain datalink of choice.  The current characteristic for VHF data exchange refers to the specific solution implemented by Telenor in Norway. If this solution is accepted by the maritime community, this characteristic could be amended. However, in the more likely scenario of a new datalink technology being proposed a new characteristic will be required.  WP 5B is working on the standardization of communication protocols for full implementation of standardized VHF data communications. |  |
|  | **SAR** | ITU-R M.489-2 | Technical characteristics of VHF radiotelephone equipment operating in the maritime mobile service in channels spaced by 25 kHz | No e-Nav related comms change is anticipated for the use of 121.5 MHz for short range SAR purposes. However, were the VHF channels to be revised the SAR associated  characteristic (M.489) would in any event be updated. | N/A |
| **HF Comms** | **Voice** | ITU-R M.1173-1 | Technical characteristics of single-sideband transmitters used in the maritime mobile service for radiotelephony in the bands between 1 606.5 kHz (1 605 kHz Region 2) and 4 000 kHz and between 4 000 kHz and 27 500 kHz | No e-Nav related comms change is envisaged for HF voice services. However, if there is a broad encroachment of digital techniques into the band there may be a need to revise existing voice characteristics to accommodate data. | N/A |
| ITU-R M.1082-1 | International maritime MF/HF radiotelephone system with automatic facilities based on DSC signaling format |
| **Data** | ITU-R M.1081-1 | Automatic HF facsimile and data system for maritime mobile users | There are a number of existing technical characteristics relating to data exchange in the HF band that include both outmoded legacy technologies as well as candidate future technologies.  There needs to be either an update to M.1798, or else a new characteristic to describe the selected HF digital data scheme to be used under e-Navigation. Currently M.1798 and F.1821 describes multi-channel HF data links such as the system currently deployed by Globe Wireless for commercial services (email, etc.). | WRC-12 decided channeling arrangements in AP17, effecting on 1 January 2017 for the implementation of HF data communications. |
| ITU-R M.1798-1 | Characteristics of HF radio equipment for the exchange of digital data and electronic mail in the maritime mobile service |  |
| ITU-R M.627-1 | Technical characteristics for HF maritime radio equipment using narrow-band phase-shift keying (NBPSK) telegraphy |
| ITU-R F.1821 | Characteristics of advanced digital high frequency (HF) radiocommunication systems |
| **NAVTEX / NBDP** | **MSI** | ITU-R M.625-4 | Direct-Printing Telegraph Equipment Employing Automatic Identification in the Maritime Mobile Service | If under e-Navigation the NAVTEX data is carried across different communication links there may be a need to provide a new characteristic to accommodate it. For this purpose, WP 5B developed Recommendation M.2010. Also, WRC-12 exclusively allocated 495-505 kHz to MMS for digital broadcasting of maritime safety and security related information using M.2010. |  |
| ITU-R M.540-2 | Operational and Technical Characteristics for an Automated Direct- Printing Telegraph System for Promulgation of Navigational and Meteorological Warnings and Urgent Information to Ships - Section 8B - Maritime Mobile Service; Telegraphy and Related Subjects. |
| ITU-R M.688 | Technical characteristics for a high frequency direct-printing telegraph system for promulgation of high seas and NAVTEX-type maritime safety information |
| ITU-R M.492-6 | Operational procedures for the use of direct-printing telegraph equipment in the maritime mobile service |
| ITU-R M.476-5 | Direct-Printing Telegraph Equipment in the Maritime Mobile Service |
| **NAVDATA** | **Data** | ITU-R M.2010 | Characteristics of a digital system, named Navigational Data for broadcasting maritime safety and security related information from shore-to-ship in the 500 kHz band | This technical characteristic may be used for e-Navigation for digital broadcasting maritime safety and security related information from shore to ship on 495-505 kHz with high data rate. | WRC-12 allocated 495-505 kHz to the MMS exclusively for the high-speed digital broadcasting, effective on 1 January 2013. |
| **On board Comms** | **UHF** | ITU-R M.1174-2 | Technical characteristics of equipment used for on-board vessel communications in the bands between 450 and 470 MHz | WRC-15 Agenda Item 1.15 will consider spectrum demands for on-board communication and there may be a need to update the existing characteristics to support the implementation of digital PMR. | This task should be coordinated through WP5B/SG5 most likely under a new question |
| **Wi-Fi** | ITU-R F.2086-1 | Technical and operational characteristics and applications of broadband wireless access in the fixed service | If Wi-Fi stations are to be adopted for on-board data communications there may be a need for a new characteristic associated with is use in the maritime mobile domain. | This task should be coordinated through WP5B/SG5 most likely under a new question. |
| **Satellite Comms** | **Broadband** | ITU-R S.1709-1 | Technical characteristics of air interfaces for global broadband satellite systems | Broadband over satellite is an existing application of current satellite systems and does not warrant a specific characteristic for the maritime domain | N/A |
| **MSI** | ITU-R S.1709-1 | Technical characteristics of air interfaces for global broadband satellite systems | The transmission of MSI over broadband may warrant a characteristic to define the data layers. | This task should be coordinated through WP4C/SG4 under existing question 87-4/4 |
| **DGNSS** |  | ITU-R M.823-3 | Technical characteristics of differential transmissions for global navigation satellite systems from maritime radio beacons in the frequency band 283.5-315 kHz in Region 1 and 285-325 kHz in Regions 2 and 3 | The current characteristic M.823-3 will ultimately need to be updated to accommodate new developments in GNSS such as Galileo and COMPASS. | This task should be coordinated through WP5B/SG5. |
| **Port Services** | **WiMax / 2G / 3G / 4G** |  |  | The maritime community will make use of technologies developed and standardized for other applications in port. No maritime specific characteristics are required. | N/A |
| **Inter-ship Broadband** | **WiMax** | ITU-R M.1801-1 | Radio interface standards for broadband wireless access systems, including mobile and nomadic applications, in the mobile service operating below 6 GHz | Under e-Navigation, ad-hoc mesh WiMax networks could be deployed to provide broadband coastal networks. This would require a specific form of implementation of WiMax that would necessitate a specific technical characteristic. | This task should be coordinated through WP5B/SG5 possibly under existing questions 212/8 and 238/8. |
| **Loran** | **eLoran data channel** | ITU-R M.589-3 | Technical characteristics of methods of data transmission and interference protection for radionavigation services in the frequency bands between 70 and 130 kHz | The existing technical characteristic will need to be revised to accommodate the definitive 9th pulse, Eurofix and/or new modulation schemes selected for the eLoran data channel. | This task should be coordinated through WP5B/SG5 under a new question. |
| **Radar** | **SART** | ITU-R M.628-5 | Technical Characteristics for Search and Rescue Radar Transponders | Relates to 9 GHz SART, so no change required. | N/A |
|  | **Racon** | ITU-R M.824-3 | Technical parameters of radar beacons (Racons) | No e-Nav related comms change. | N/A |
|  | **Radio determination** | ITU-R M.1460-1 | Technical and operational characteristics and protection criteria of radiodetermination radars in the 2 900-3 100 MHz band | No e-Nav related comms change. | N/A |
| **EPIRB** | **VHF** | ITU-R M.690-2 | Technical characteristics of emergency position-indicating radio beacons (EPIRBs) operating on the carrier frequencies of 121.5 MHz and 243 MHz | No e-Nav related comms change. | N/A |
| **Satellite (COSPAS / SARSAT)** | ITU-R M.633-4 | Transmission characteristics of a satellite emergency position-indicating radio beacon (satellite EPIRB) system operating through a satellite system in the 406 MHz band | No e-Nav related comms change. | N/A |
| **EPIRB** | **Satellite** | ITU-R M.632-3 | Transmission Characteristics of a Satellite Emergency Position Indicating Radio Beacon (Satellite EPIRB) System Operating Through Geostationary Satellites in the 1.6 GHz Band | No e-Navigation related communications change. | N/A |

## ANNEX E AIS AND VHF DATA COMMUNICATION

**AIS FOR E-NAVIGATION**

AIS is a proven technology suitable for playing a significant role in data communications for e-Navigation. However:

i) by design AIS is not an ideal candidate for high speed and/or high volume data communications;

ii) high speed digital data communications for e-Navigation is better handled by using multiple 25 kHz channels;

iii) the IMO/ITU Joint Experts Group has recognized that more than 200 kbps will be necessary for e-Navigation.

This document proposes a vision for technology to efficiently handle new applications as well as low volume data communications for e-Navigation.

**AIS TODAY**

AIS is technically defined by Recommendation ITU-R M.1371, mandatory for SOLAS vessels and for other vessels on a regional basis, and used voluntarily;

AIS has proved to be a powerful tool for various applications in the field of navigation, and distribution of safety related information, however these applications have not yet fully been exploited;

RR Appendix 15 (WRC-07) defines the frequencies used for GMDSS, and it includes the frequencies AIS1 and AIS 2 used by AIS-SART stations.

**INCREASING USE OF AIS**

The use of AIS is increasing rapidly, threatening to degrade the performance or to overload the current AIS frequencies AIS 1 and AIS 2.

**Number of ships**

Full implementation of SOLAS requirement for AIS is completed;

Increased use of mandatory AIS on non-SOLAS vessels is evident:

i) USA (USA commercial vessels);

ii) Europe (EU Directive for fishing vessels requiring Class-A AIS);

iii) Europe (EU Directive for inland vessels requiring Inland AIS (Class-A derivative));

iv) Korea;

v) India;

vi) Mexico;

vii) Australia.

Increased voluntary use of AIS:

i) both Class-A and Class-B units used on smaller vessels including rapidly increasing numbers of pleasure vessels.

Class-B increasing use:

i) Class-B (CSTDMA) visibility will eventually be reduced due to polite behavior;

ii) Class-B (SOTDMA) will be introduced near future.

**AIS base stations**

Coastal and inland AIS infrastructure continues to grow:

1. driven by safety, security, and environmental protection considerations;
2. EU Directive 59 requires all EU member countries to maintain coastal AIS coverage.

**Airborne AIS**

More SAR aircraft are being fitted with AIS stations.

**AIS AtoN, real or virtual, and AtoN monitoring**

AIS AtoN – real and virtual – are being used or approved by competent authorities.

A separate message for AtoN monitoring (often Message 6) is being used in most cases where an AIS AtoN station is deployed.

In addition, AIS AtoN stations are being deployed by commercial organizations to mark offshore platforms, wind farms, etc.

**AIS-SART**

IMO carriage option for the AIS-SART started in January 2010:

i) broadcasts eight times per minute on AIS 1 and AIS 2.

**SAR related equipment using AIS-SART technology**

Several kinds of AIS-MOB using AIS-SART technology have been deployed on the market and this device is identified to use unique IDs as defined in Recommendation ITU-R M.585-6.

EPIRB-AIS, AIS-MOB and Diver device using AIS-SART technology are being introduced on the market. IMO NAV58 considered the issue relating to these devices and decided that diver locating devices should not operate on the frequencies AIS 1 and AIS 2 for routine diver locating. It was further considered that the frequencies AIS 1 and AIS 2 should only be used when a diver was in a non-routine situation, that in these cases the device was similar to a MOB device and, therefore, the parameter and appropriate message for MOB should apply.

**Application-specific messages**

Application specific messages are being used more on AIS1 and 2; this leads to future developments under a combined application, VHF Data Exchange (VDE).

**International**

IMO SN/Circ.289 provides guidance on the use of international application specific messages. This circular retains most of the international application-specific messages that were developed for trial and the addition of new messages were created such as;

i) a new meteorological-hydrographic message with a dynamic length of 2 to 5 slots;

ii) an area message for navigational warnings.

**Regional**

Extensive use of safety-related application-specific messages for AtoN monitoring.

Application-specific messages being used in certain waterways e.g. St. Lawrence Seaway, River Thames.

**Mandatory application specific messaging in certain regions**

Additional application specific messages are being used for inland AIS in Europe

i) dedicated ship stations are type approved and in use.

## ANNEX F Glossary of Terms

|  |  |
| --- | --- |
|  |  |
| AIS | Automatic Identification System |
| ARPA | Automatic Radar Plotting Aid |
| AtoN(s) | Aid(s) to Navigation |
| BeiDou | China Navigation Satellite System |
| BPL | Broadband over Power Line |
| CDMA | Code Division Multiple Access |
| CS | Coastal Surveillance (Radar) |
| DGNSS | Differential Global Navigation Satellite System |
| DGPS | Differential Global Positioning System |
| DRM | Digital Radio Mondiale |
| eANSI | Electronic Aids to Navigation System Information |
| ECDIS | Electronic Chart Display Information System |
| EGC | Enhanced Group Call |
| EGNOS | European Geostationary Navigation Overlay System |
| eLoran | Enhanced Loran |
| ELT | Emergency Locator Transmitters |
| ENC | Electronic Navigation Chart |
| EPIRB | Emergency Position-Indicating Radio Beacon |
| EPIRB AIS | Emergency Position-Indicating Radio Beacon with AIS |
| FAA | (US) Federal Aviation Authority |
| FDD | Frequency Division Duplex |
| GAGAN | GPS-Aided Geo Augmented Navigation (System) (India) |
| GALILEO | European GNSS (not an acronym) |
| GBAS | Ground Based Augmentation System |
| GEO | Geostationary Orbit |
| GMDSS | Global Maritime Distress and Safety System |
| GLN | Global Link Network |
| GLONASS | Global Navigation Satellite System (Russian Federation) |
| GNSS | Global Navigation Satellite System |
| GPRS | General Packet Radio Service |
| GPS | Global Positioning System (US) |
| GSM | Global System for Mobile Communications |
| HF | High frequency (3 - 30 MHz) |
| HSDPA | High Speed Downlink Packet Access |
| IALA | International Association of Marine Aids to Navigation and Lighthouse Authorities |
| IBS | Integrated Bridge System |
| IEC | International Electrotechnical Commission |
| SOLAS | Safety of Life at Sea (IMO Convention) |

|  |  |
| --- | --- |
| TDD | Time Division Duplex |
| TDMA | Time Division Multiple Access |
| TETRA | Terrestrial Trunked Radio |
| UHF | Ultra High Frequency (300 - 3 000 MHz) |
| UMB | Ultra Mobile Broadband |
| UMDM | Universal Maritime Data Model |
| UMTS | Universal Mobile Telecommunications System |
| UWB | Ultra Wideband |
| VDE | VHF Data Exchange |
| VDES | VHF Data Exchange System |
| VDL | VHF Data Link |
| VDR | Voyage Data Recorder |
| VHF | Very High Frequency (30 - 300 MHz) |
| VTS | Vessel Traffic Service |
| WAAS | Wide Area Augmentation System (US) |
| Wi-Fi® | Wireless Fidelity |
| WiMax™ | Worldwide Interoperability for Microwave Access |
| WWRNP | World Wide Radio Navigation Plan |

1. This Report was developed through liaison with relevant inter-governmental, international and other organizations. For example, the International Maritime Organization (IMO), the International Hydrographic Organization (IHO), the International Association of Marine Aids to Navigation and Lighthouse Authorities (IALA), the International Electrotechnical Commission (IEC), IMSO and [Editor’s note: Add others]xxx have reviewed and commented. [↑](#footnote-ref-1)
2. The self contained printer requirement was removed from IMO performance standards (MSC.148 (77)) subject to provision of a dedicated display device and a printer port for the installations on or after 1 July 2005. [↑](#footnote-ref-2)
3. Inmarsat B, C and Fleet 77 are elements of GMDSS [↑](#footnote-ref-3)
4. To support satellite downlink for radiocommunication applications outside coastal coverage areas, it will be necessary to designate suitable channels. Candidate channels may be channels 2024/2084 (161.800 and 161.825 MHz) combined making a 50 kHz bandwidth. The block SAT2 in the figure 3 refers to the possibility of using the VDE4 spectrum range for satellite downlink, which would allow for the use of common technologies, such as spectrum spreading, in order to reduce any possible interference to land (mobile) systems. [↑](#footnote-ref-4)
5. Locating is defined to find a mobile unit in distress or the location of survivors. [↑](#footnote-ref-5)
6. Locating is defined to find a mobile unit in distress or the location of survivors. [↑](#footnote-ref-6)
7. Homing is defined to determine the bearing to the transmitting station. [↑](#footnote-ref-7)
8. Industrial, Scientific and Medical. These bands are used by devices such as industrial heaters and driers and domestic equipment such as microwave ovens. [↑](#footnote-ref-8)
9. This technology is widely used for government agencies and may not be available to commercial enterprise. [↑](#footnote-ref-9)