Document Revisions

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**IALA Maritime Radio Communications Plan**

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**XX 201X**

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Executive Summary

The International Association of Marine Aids to Navigation and Lighthouse Authorities (IALA) exists to:

* harmonize standards for aids to navigation systems worldwide;
* facilitate the safe and efficient movement of shipping, and;
* enhance the protection of the maritime environment.

This Maritime Radio Communications Plan (MRCP) is being developed by IALA to assist in the selection of radio communication systems required to support e-Navigation. The current status of radio communication in the maritime mobile bands is discussed and forms the basis of projections for future developments needed to support e-Navigation. This MRCP could be the basis for a possible future submission to ITU as a contribution to the continuing efficiency improvements with respect to radio spectrum. The plan provides guidance to IALA members regarding potential future developments, which will enable members to identify areas requiring resource allocation and research activity.

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

FAA (US) Federal Aviation Authority

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

IGSO Inclined Geosynchronous Orbit

IHO International Hydrographic Organization

IMO International Maritime Organization

INS Integrated Navigation System

IP Internet Protocol

IPBC Internet Protocol for Boat Communications

IRNSS Indian Regional Navigational Satellite System

ITU International Telecommunication Union

LEO Low Earth Orbit

LF Low Frequency (30 – 300 kHz)

LORAN Long Range Navigation system

LRIT Long Range Identification and Tracking

MBOC Multiplex Binary Offset Carrier

MEO Medium Earth Orbit

MF Medium Frequency (300 – 3 000 kHz)

MMS Maritime Mobile Service

MRCP Maritime Radio Communications Plan

MSAS Multi-Satellite Augmentation System (Japan)

NBDP Narrow Band Direct Printing

NAVDAT Navigational Data (the system name)

NAVTEX Navigational Data (the system name)

OFDM Orthogonal Frequency Division Multiplexing

PLB Personal Locator Beacon

PLT Power Line Transmission

PMR Private Mobile Radio

PNT Position, Navigation and Timing

QAM Quadrature Amplitude Modulation

QPSK Quadrature Phase Shift Keying

QZSS Quasi-Zenith Satellite System

RACON RAdar BeaCON

RCC Rescue Coordination Center

RAIM Receiver Autonomous Integrity Monitoring

RNAV Radionavigation

SBAS Satellite Based Augmentation System

SDCM System for Differential Corrections and Monitoring (Russian Federation)

SHF Super High Frequency (3 – 30 GHz)

SMS Short Message Service

SOLAS Safety of Life at Sea (IMO Convention)

TDMA Time Division Multiple Access

UHF Ultra High Frequency (300 – 3 000 MHz)

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

WWRNS World Wide Radio Navigation System

**IALA MARITIME RADIO COMMUNICATIONS PLAN**

# Introduction

## General

The International Association of Marine Aids to Navigation and Lighthouse Authorities (IALA) was formed in 1957 as a non-government, non-profit making, technical association that provides a framework for aids to navigation authorities, manufacturers and consultants from all parts of the world to work with a common effort to:

* harmonize standards for aids to navigation systems worldwide;
* facilitate the safe and efficient movement of shipping; and
* enhance the protection of the marine environment.

The functions of IALA include, among other things:

* developing international cooperation by promoting close working relationships and assistance between members;
* collecting and circulating information on recent developments and matters of common interest;
* liaison with relevant inter-governmental, international and other organizations. For example, the International Maritime Organization (IMO), the International Hydrographic Organization (IHO), the International Electrotechnical Commission (IEC), and the International Telecommunication Union (ITU);
* liaison with organizations representing the aids to navigation users;
* addressing emerging navigational technologies, hydrographic matters and vessel traffic management.

### e-Navigation

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

The working 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.

### Vision

The aim of IALA is:

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

while the Vision of IALA is:

*Safe marine navigation in a world of:*

* Larger and faster ships;
* Changing economy & technology;
* Stringent standards;
* Holistic approach (e-Navigation);
* Changing waterway use.

With this in mind, IALA has taken an initiative as part of the strategy for the future of e-Navigation by developing a World Wide Radio Navigation Plan supported by this IALA Maritime Radio Communications Plan.

## Scope and Objectives

The 3 key elements for e-Navigation are identified above. However, this document focuses mainly on the need for an agreed infrastructure of communications between ships and ashore. It presents IALA’s view on current, developing and future Radio Communication Systems for the maritime sector.

e-Navigation will require appropriately designed radio communication systems for a robust and reliable service to the mariner. This document is aimed at assisting in the formulation of policy for National and International spectrum allocation and usage.

It is also provided for IALA members and other administrations to assist them in offering their proposed use of radio spectrum as part of the on-going studies at ITU.

The core objective of this document is to state the IALA vision for the efficient use of Radio Spectrum in the Maritime Mobile Service.

# Background to Service Provision

## General

The challenge facing radio communication in the maritime sector is pressure on the availability of spectrum from other users and the requirement to relay more and more information over fewer and fewer channels.

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 moves 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 recent technological advance that can be applied to e-Navigation.

Recent advances with TDMA techniques, AIS is the prime example, have shown the way to have several hundred users effectively and efficiently using only two channels to share vast amounts of data.

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

### Institutional

Significant changes have occurred in the world wide marine institutional environment during the last five years:

In the near future, there will be a need for ever-closer co-operation between IMO, ITU, IHO, IEC, CIRM, RTCM and IALA in pursuit of the emerging e-Navigation concept.

Close co-ordination with ITU will be required to achieve the new approach in communications technology that e-Navigation will need. IALA national administrations are encouraged to ask their national representatives at ITU to support the MRCP.

## Regulatory

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

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

The MRCP is ITU and IMO-compliant in meeting the needs of the maritime industry.

There are moves towards charging market rates for the use of radio spectrum in some countries and proposals may be put forward for adoption of this approach internationally. GMDSS and other safety related communications should be free of charge.

## Commercial

Growth of the world fleet places greater stress on the ability of the existing radio communications 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 will be reached where no more calls can be made. Systems using but not limited to TDMA, such as AIS, can cope with multiple simultaneous users and are much more immune to overloading due to growth in the number of participants.

The option of more spectrum in the maritime mobile service is not readily available so alternatives have to be found to support future growth. Existing spectrum allocated to maritime use will need to be fully utilized

## 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 and growing reliance upon GNSS and its role underpinning navigation, situational awareness and communications for e-Navigation;
* Growing deployment of local and specific Traffic Management Schemes to meet ever more stringent requirements at higher capacity levels; and
* the balance between traditional navigation skills and the role of new technological advances such as ECDIS and IBS.

The introduction of GNSS has enabled mariners to navigate in areas and conditions in which they would not previously have done and the introduction of e Navigation will further change the way that ships operate. As part of its introduction, it is essential to understand what happens when key e-Navigation components (e.g. GNSS) fail or are denied. Getting the human factors part of this right is also critical: before adopting the technology - safety, liability, on-board training and duty of care must all be considered.

e-Navigation means that international bodies such as IMO, ITU, IHO, IALA, IEC, RTCM and CIRM) must work more closely together as the concept encompasses all their areas of responsibility.

## Technical

Significant changes to underpinning services and systems are expected over the next two decades:

* development of data communication systems by ITU;
* development of AIS satellite detection;
* regulatory constraints from ITU;
* spectrum sharing and efficiency;
* compatibility with existing systems and services;
* application of Wi-Fi and WiMax in short range (e.g. when in port);
* adding data services to current voice channels;
* Change from analogue voice to digital voice.
* development of higher speed broadband over satellite through greater bandwidth availability
* introduction of new MeoSar services

# The IALA Maritime Radio Communication Plan

## Overview

The maritime domain uses a wide range of communications technologies across the radio spectrum in order to support safe navigation, efficient operations and to provide commercial opportunities. However, many of these technologies have been developed with a single application in mind. As a result a vessel needs to carry many different forms of radio in order to be able to receive relevant data to allow it to undertake its voyage.

In the e-Navigation environment there is the opportunity to plan the maritime communications system architecture afresh. This requires an assessment of the likely applications of communications as well as an understanding of the current radio spectrum available to the community. The following sections consider the current radio spectrum and the use made of it and then move on to consider what applications are likely to run on top of the future communications infrastructure. This section gives a brief summary of the existing and future Radio communication systems.

## Maritime Communication Requirements

The maritime domain uses communication links for a wide range of purposes, from essential safety of life applications through routine operational activities to commercial applications.

When establishing the communication requirements under e-Navigation it is essential to consider safety of life, operational, and commercial applications. In order to achieve the benefits of e-Navigation as soon as possible the design of the communications architecture will need to focus on a small set of known applications with the flexibility to grow to encompass others in the future as necessary.

**Safety**



**Safety**

**Operational**



**Operational**

**Commercial**



**Commercial**



AIS position reports



AIS AtoN



Digital Selective Calling



Long Range Identification and

Tracking



Differential GNSS



NAVTEX



VTS coordination



Emergency SAR





AIS position reports



AIS AtoN



Digital Selective Calling



Long Range Identification and

Tracking



Differential GNSS



NAVTEX/SafetyNET



VTS coordination



SAR



Weather data



Ship reporting



Notifications to coastal States



Port arrival notification



IALA Maritime Information

Objects



Port & VTS surveillance feeds



Electronic chart updates



Access to vessel & equipment

manuals



Remote maintenance & service



Telemedicine





Weather data



Ship reporting



Notifications to coastal States



Port arrival notification



IALA Maritime Information

Objects



Port & VTS surveillance feeds



Electronic chart updates



Access to vessel & equipment

manuals



Remote maintenance & service



Telemedicine



Voyage orders



Commercial port services



Operational reports



Crew personal communications



Crew e

-

training



Cargo telemetry



Passenger Internet access



Point of Sale





Voyage orders



Commercial port services



Operational reports



Crew personal communications



Crew e

-

training



Cargo telemetry



Passenger Internet access



Point of Sale

Distress and Urgency alerting/calling

Distress and Urgency alerting/calling



1. Overview of maritime communication applications by type

Figure 1 shows some example applications within e-Navigation broken down between the categories of essential communication application to ensure safety, important communication application for efficient operations and possible commercial communication applications.

## General overview of existing communication system technologies

This section details the current technologies used for maritime communications by frequency band. Please refer to the table in Annex 1 for system details, Annex 2 for maritime spectrum allocations and Annex 4 for specific ITU technical characteristics associated with the systems described in section 3.3 and 3.4.

### Low Frequency Band (LF)

There is some use of the LF radio spectrum by the maritime community. The Loran-C system broadcasts at 100 kHz and is used for radio navigation, although the system has been terminated in the United States, and other chains are being examined as to their on-going status.

### 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 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).

#### 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 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 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 16mhz. 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.

#### 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 widths are typically 3 kHz. Digital voice communication within the MF/HF bands is relatively new technology with limited use however growing with future technologies.

#### 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) by Globe Wireless[[1]](#footnote-1), and uses 4/8-PSK modulation to 32 sub-carriers. System 2 is an Electronic mail system using the Pactor-III protocol, including the system used by the Global Link Network (GLN) 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.

#### Narrowband Direct Printing (NBDP)

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.(NAVTEX)

#### 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 printing[[2]](#footnote-2) 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 coordinated by areas (NAVAREA) to share the same frequency.

#### 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.

### 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.

#### 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.

#### 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.

#### 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).

#### Automatic Identification System (AIS)

##### Primary purpose of Automatic Identification System

AIS is a TDMA-based data exchange system used by ships and shore authorities. The main purpose for ships is collision avoidance and to assist safety of navigation. Littoral states use AIS for the identification and locating of vessels, to obtain information about a ship and its cargo and as a VTS tool. 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 standing** 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. Data link loading should be considered when using application specific messaging.

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

AIS is also used on Aids to Navigation for the broadcast of navigation information, meteorological and hydrographic data and other application specific messages.

##### 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.

#### Two-way VHF Radiotelephone Apparatus

Two-way VHF radiotelephone apparatus is 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 onboard 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 provided services used for SMS, weather and tracking. Examples of such satellite systems include Orbcomm.

### 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 alert distress 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 via an in-built GNSS receiver, periodically (approximately 50 seconds interval) to the satellites in the 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 transmitter (EPIRB AIS) .

#### On board Communication

UHF hand-held radios are commonly used on board vessels for on board communications and for 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 band 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 Globalstar and Thuraya. Non-geostationary satellite systems include Iridium, 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 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. 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. GNSS may also be used for short message communication. 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 GHz to 9.5 GHz and S-band from 2.9 to 3.1 GHz. The radars are used for target 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 (alternative to AIS-SART) 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.

#### 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 data transfer up to Mbytes/second. 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 harbor environment.

## Future development of maritime radio communications

This section details future technologies or technologies not widely used for maritime radio communications by frequency band. Please refer to the table in Annex 3 for technical details.

### Low Frequency Band (LF)

#### Enhanced Long Range Navigation (eLORAN)

In the future the proposed enhanced Loran (eLoran) system might provide a 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)

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

#### The likely increase in ship traffic in polar regions, as a result of receding ice fields, may also create new potential for HF communications, since geostationary satellites do not cover these areas. Globe Wireless is studying increased data rates using 3 kHz channels which may produce data rates of 19.2 kbps.

#### Furthermore, a new data communication system using 10-20 kHz bandwidth for data rates up to 51 kbps, proposed by France, 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. Whilst not currently under consideration for maritime services, broadcasters have developed a digital HF (and MF/LF) technology known as Digital Radio Mondiale (DRM) which can offer data rates in excess of 20 kbps in a 10 kHz channel. Such techniques may offer additional future capability. WRC12 has also approved use of band 495-505khz for use of high-speed Navtex service.

#### NAVDAT (Navigational Data)

The NAVDAT is an MF radio system, use 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 utilize an OFDM modulation in this 10 kHz which provides a flow rate of about 15/25 kbit/s (more than 300 times the NAVTEX transmission)

Possibility to transmit any type of files:

* + Text, Graphs, Pictures, data etc.
  + Automatic reception
  + Very open to the future needs without modifications

The global architecture of the NAVDAT is similar as the NAVTEX and the coverage is about 250/350 NM by coast station.

The NAVDAT system is described in the Recommendation ITU-R **M.5B333 : 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 which will published very soon by ITU.**

### Very High Frequency Band (VHF)

#### 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. High speed digital data communications for e-Navigation is better handled using 25 kHz channels. However, AIS is a proven maritime data system, with ships equipped and shore infrastructure established. Therefore AIS is the quickest path for handling the increasing data exchange needs that will be required to support e-Navigation.

The future AIS channel plan should consider at least the following:

* AIS channels 1 and 2 for Safety of Navigation purposes:
* The AIS 1 and AIS 2 are internationally allocated with sharing basis. These frequencies should be retained and protected for safety of navigation purposes.
* 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. The use of these channels has been approved by 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 one way system (from earth to satellite); however in the GMDSS, the acknowledgement (from satellite to earth) is essential as 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. However, 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.
* Channel 70 for channel management purposes:
* In order to fully use available VHF spectrum, there must be a worldwide channel dedicated to manage and coordinate usage of the VHF Data Link. Additional protocols should not interfere with current usage specifically respecting DSC.
* TDMA or other protocols may share Channel 70 with minor changes to Appendix 18, footnote *j)* according to Recommendation ITU-R M.822-1.
* **WRC 2012 AIS Results**:
* AIS 1 and AIS 2 were made exclusive (effective 2025) in both Region 2 (Americas) and Region 3 (Asian Pacific), but not Region 1 (Europe/Africa)
* AIS on SAR (search and rescue) aircraft is primary in Region 2, secondary in Region 3, recognized by footnote in Europe
* AIS satellite long range messaging on channels 75 and 76 was approved worldwide effective 1 JAN 2013
* There was a primary allocation in Region 2 (Americas), secondary elsewhere
* Non-AIS operations will be limited to 1w on January 2013

Further details are explained in ANNEX 5.

#### 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 or else these nine channels can be combined into one 225 kHz wideband channel. The wideband radio has proved to have insufficient EMC characteristics, not sufficiently stable and the throughput slowed down when the signal strength is 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 proved in Norway to be very robust and stable and can perform a variety of service and gives a 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 of the modulation schemes and general characteristics for the transceivers; therefore the consideration of the standardized communication protocols is ongoing at ITU-R.

IALA is aware that further consideration of how best to achieve spectral efficiency in this band is worthwhile and 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 worldwide and 80, 21, 81, 22, 82, 23, 83, 24, 84, 25, 85, 26, 86 worldwide except region 2.
* Testing of future AIS applications on channels 27, 28, 87 and 88 was permitted.
* 160.9 MHz is reserved for experimental use for future applications or systems, e.g. MOB and AIS

#### Digital voice communication

Digital voice communication may, in the very 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 equipments should be encouraged.

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

#### 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.

#### Public mobile wireless communications

Public mobile wireless communications 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. Integration of these land based systems should be encouraged but recognizing their constraints in open water situations and should not be used for regulated maritime services.

## Overview of the current and future voice and data communication technologies

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 which 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.

1. Geographical classification of e-Navigation data and voice communication techniques





## 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 set certain voyage parameters at the start of each voyage, and can change the navigation 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 rules and the needs of the mariner which 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;
* Priority message handling – such as distress, urgency and safety related messages sending from own ships and receiving from another ships or shore in GMDSS;
* 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 rules and the operator’s commercial model. Others 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 was finalised 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 WRC18 need to be produced as agenda items at WRC15. Further consideration of possible future systems including spectrum requirements need to be carefully considered.

### 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 2 is used according to the GMDSS sea areas.

1. 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 | HF NAVTEX  SafetyNET  HF MSI | VHF R/T  HF R/T/NBDP  Inmarsat |
| A4 | VHF DSC  MF DSC  HF DSC  EPIRB | VHF R/T  MF R/T  HF R/T/NBDP | HF NAVTEX  HF MSI | VHF R/T  HF R/T/NBDP |

The problems in the current GMDSS include the following:

* high rate of false distress alerting by DSC and EPIRB;
* complicated operations of DSC;
* rapid decline of the NBDP use due to unfamiliar operation required; and
* short homing range of EPIRB by SAR aircraft.

To improve the above problems, many efforts have been made such as updating ITU-R Recommendations and IEC standards. Also, the new device AIS-SART has been introduced recently as an alternative to the radar SART. The AIS-SART is defined as a locating device and the 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 is also detectable by low earth orbit AIS satellites.

### Possible system components for the next generation of GMDSS

In the next generation of GMDSS, the AIS technologies may be used in addition to DSC. WRC-12 has allocated CH75 and CH76 for the improvement of satellite detection of AIS Class-A long-range broadcast messages by low earth orbit satellites. The AIS may, supplementary to DSC, transmit messages for distress/urgency/safety alerting. These messages can be received by AIS satellite and relayed to Rescue Coordination Center (RCC). RCC can respond via reverse links if a future WRC allocates these channels for transmission from satellites; therefore alerting messages by AIS could be used in all sea areas. While additional shore side infrastructure may be required these messages would also be received by nearby ships for quick assistance.

The distress/urgency/safety follow-on communications should follow the operational procedures after alerting which may be by voice or data through available mediums in use at that time..

The current SOLAS regulations defines locating and homing as a separate function; however if AIS-SART, EPIRB-AIS and AIS-MOB are used, there may be no need for separate definition since the messages from those devices include accurate position information and could be used as both locating and homing.

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 information in accordance with the draft new Recommendation ITU-R M.[500 kHz-16QAM], which could deliver relatively large volumes of information and may be a supplementary system to the current NAVTEX. If a future WRC allocates additional AIS channels (AIS 5 and AIS 6 in ANNEX 5 Table 9) to the mobile-satellite service, maritime safety information could also be delivered by AIS via AIS satellite in all sea areas.

The above ideas are summarized in Table 3 below.

1. Possible system components for next generation of GMDSS

| Sea  area | Distress/Urgency/ Safety Alerting | Distress/Urgency/ Safety Comms | Locating/Homing | On scene  Comms | MSI  Promulgation | General  Comms |
| --- | --- | --- | --- | --- | --- | --- |
| A1 | AIS V2\*1  EPIRB-AIS\*2  AIS-MOB\*3 | VHF R/T/Data | AIS-SART  EPIRB-AIS\*2  AIS-MOB\*3 | VHF R/T | AIS V2\*1  500 kHz Data  SafetyNET | VHF R/T/Data  MF/HF R/T/Data  Satellite\*2 |
| A2  A3 | AIS V2\*1  EPIRB-AIS\*2  AIS-MOB\*3  MF/HF Data  Satellite\*4 | VHF R/T/Data  MF/HF R/T/Data  Satellite\*2 |
| A4 | AIS V2\*1  EPIRB-AIS\*2  AIS-MOB\*3  MF/HF Data | VHF R/T/Data  MF/HF R/T/Data | AIS V2\*1  HF Data | VHF R/T/Data  MF/HF  R/T/Data |

\*1 AIS Version 2, see 3.4.3.1 and ANNEX 5

\*2 EPIRB with built in AIS-SART function

\*3 Man Overboard device using AIS-SART technology

\*4 Global or regional satellite services

# Securing the spectrum

## Situation with respect to existing spectrum usage

Section 3.3 described the existing maritime technologies 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.; however there are no indications, at present, that any additional or any different spectrum is required.

Please refer to the table in Annex 1 for system details, Annex 2 for maritime spectrum allocations and Annex 4 for specific ITU technical characteristics associated with the systems described in section 3.3 and 3.4.

## WRC-15 Agenda Items

A number of the agenda items for the 2015 World Radio Conference (WRC-12) have direct or indirect potential to affect maritime use of the spectrum, namely:

**4.2.1 Agenda Item 1.15 -**  **to consider spectrum demands for on-board communication stations in the maritime mobile service in accordance with Resolution** **COM6/3(WRC-12)**;

1 to consider, based on the results of ITU-R studies, the need to possibly identify additional UHF channels within the bands already allocated to the maritime mobile service for on-board communication stations,

**4.2.2 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** **COM6/21 (WRC-12)**;

1 to consider, based on the results of ITU-R studies, modifications to the Radio

Regulations, including possible spectrum allocations, to enable new AIS terrestrial and satellite

applications, while ensuring that these applications will not degrade the current AIS operations and

other existing services;

2 to consider, based on the results of ITU-R studies, additional or new applications for

maritime radiocommunication within existing maritime mobile and mobile-satellite service

allocations, and if necessary to take appropriate regulatory measures,

**4.2.3 Agenda Item 1.8 - to review the provisions relating to earth stations located on board vessels (ESVs), based on studies conducted in accordance with Resolution** **COM6/14 (WRC-12)**;

1 to review the provisions relating to ESVs which operate in the FSS in the uplink bands

5 925-6 425 MHz and 14-14.5 GHz and consider possible modifications to Resolution **902**

**(WRC-03)** in order to reflect current ESV technologies and technical characteristics that are being

used or planned to be used, while protecting the other services referred to in *recognizing a)* and *b)*

above;

**4.2.4** **Agenda Item 1**.**9** - **to consider, in accordance with** **Resolution** **COM6/15 (WRC-12)**:

1.9.1- possible new allocations to the fixed-satellite service in the frequency bands 7 150-

7 250 MHz (space-to-Earth) and 8 400-8 500 MHz (Earth-to-space), subject to appropriate sharing

conditions;

1.9.2 - the possibility of allocating the bands 7 375-7 750 MHz and 8 025-8 400 MHz to the

maritime-mobile satellite service and additional regulatory measures, depending on the results of

appropriate studies;

1 to conduct technical and regulatory studies on the possible new allocations to the FSS in the frequency bands 7 150-7 250 MHz (space-to-Earth) and 8 400-8 500 MHz (Earth-to-space) in order to ensure compatibility with existing services, with a view to extending the current worldwide allocation to the FSS in the bands 7 250-7 750 MHz (space-to-Earth) and 7 900-8 400 MHz (Earth-to-space);

2 to conduct the appropriate regulatory studies to ensure that any new FSS allocation

referred to in *resolves* 1 above is limited to FSS systems operated from a fixed known location in

order to enable compatibility with systems of other services, taking into account that the operational

requirements in the bands 7 150-7 250 MHz (space-to-Earth) and 8 400-8 500 MHz (Earth-to-space) do not encompass small VSAT-like FSS earth stations;

3 to conduct technical and regulatory studies on the possibility of allocating the bands

7 375-7 750 MHz (space-to-Earth) and 8 025-8 400 MHz (Earth-to-space), or parts thereof, to the

maritime-mobile satellite service, while ensuring compatibility with existing services;

**4.2.5 Agenda Item 1.12** - **to consider an extension of the current worldwide allocation to the Earth exploration satellite (active) service in the frequency band 9 300-9 900 MHz by up to 600 MHz within the frequency bands 8 700-9 300 MHz and/or 9 900-10 500 MHz, in accordance with Resolution** **COM6/18 (WRC-12)**;

1 that, taking into account the results of ITU-R studies, WRC-15 consider the possible extension of the current worldwide allocation to the EESS (active) in the frequency band 9 300-9 900 MHz by up to 600 MHz on a primary and/or secondary basis, as appropriate, within the frequency range 8 700-9 300 MHz and/or 9 900-10 500 MHz while ensuring protection of existing services and taking due account of the safety services allocated in the frequency band 9 000 to 9 300 MHz,

### agenda Item 1.

# Summary

The IALA Maritime Radio Communication Plan identifies current and future technologies used for maritime communication and addresses the IALA position regarding maritime related agenda items for WRC 2015.

e-Navigation is the future, digital concept for the maritime sector that responds to structural changes and 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 onboard 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 – at least during the transition to e-Navigation, if not beyond. 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 the e-Navigation concept due to the planning timescales required to protect or extend the use of the radio spectrum through the ITU WRC.

In general it is concluded that there are few concerns relating to e-Navigation from a spectrum management perspective. The general continued protection of the maritime mobile service allocations need to take place. Particular emphasis should be given to following items:

* keeping a watching brief on the (ITU) development of frequency plans for the 450 to 470 MHz band so as to protect on-board use; and
* engaging in discussions concerning the use of PLT/BPL 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:

Finally, the plan suggests e-Navigation should develop an automated selection process of available communication technologies that 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. The plan also suggests modernization of GMDSS should be based on the modern digital technologies such as VHF Data exchange (VDE), AIS and data communications in MF/HF and VHF bands.

Without a complete understanding of the e-Navigation concept and future user requirements, it is difficult to speculate what specific systems and spectrum will be required to achieve e-Navigation. As e-Navigation develops the IALA Maritime Radio Communication Plan needs to be reviewed and updated.

1. System Description
2. System Description Table

| **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 |
| Portable VHF voice | | VHF | | 156.025 to  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 | Near future | Long | International | digital | Mobile to mobile | Location / Homing | Line of sight |
| EPIRB | | UHF | | 406 MHz |  | Current | Long | International | Digital | Mobile to satellite | Distress alerting | COSPAS-SARSAT Satellite;  Global converge |
| 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 converge |
| RADAR SART,  X-Band | | SHF | | 9.2 – 9.5 GHz |  | Current | medium | International | analogue | Mobile to mobile | Homing | Line of sight |
| **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 print. (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 to 1646.5 MHz.  Rx 1525.0 to 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 | | | 100 kHz |  | Current | Very Long | Regional | Carrier  (Analogue) | Fixed to mobile. | Positioning | Long distance |
| DGNSS | MF | | | 285 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 |
| 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:    Compass  Galileo |  | Current  Current  Future  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. |  | Future | Short | 3rd party | Data  (Digital) | Inmarsat | Security. Vessel tracking. Environmental protection. | Global coverage |
| Radar  S Band |  | | | 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 |
| TOR/SITOR | | MF & HF. | | 1.6 to 26.5 MHz. | 0.5 kHz | Near Dead | Short. | Regional. | Text | Mobile to mobile.  Fixed to mobile. Mobile to fixed. | General text communication. | Long distance,  > 250 nm |
| Narrow band direct print. (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 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 |
| 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  MMBe | | 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  MMBe | | 156.025 to  161.950 MHz. | 25 kHz | Current | Long | regional | data | Mobile to mobile.  Fixed to mobile. Mobile to fixed. | General data communication. | Line of sight |
| Satellite | | UHF | | Tx 1626.5 to 1646.5 MHz.  Rx 1525.0 to 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 |
| GSM | | UHF | |  |  | Current | Long | regional  3rd party | Digital. Voice and data. | Cellular.  Mobile-fixed-mobile. | General voice and data communication | Medium range in locality |
| GPRS | | UHF | |  |  | Current | Long | regional  3rd party | Digital. Voice and data. | Cellular.  Mobile-fixed-mobile. | General voice and data communication | Short range in locality |
| 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). |
| AIS 3rd & 4th Channels | | | VHF | Within RR App 18 | 25 kHz  Min 9600 bps  TDMA | Near Future | Long term | International | Data  (Digital) | Mobile to satellite. | Security. Environmental protection.  Vessel tracking.  GMDSS (AIS EPIRB) | Closely related to current AIS. Same transponder on ship |
| AIS 5th  & 6th Channels | | | VHF | Within RR App 18 | 25 kHz  Min 9600 bps  TDMA | 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.  Security and tracking. | 1. Closely related to current AIS. Same transponder on ship |
| 1. AIS MMB channel management | | | 1. VHF | 1. Channel 70 2. (AIS 1 and AIS 2) | 1. 25 kHz 2. 9600 bps 3. TDMA | 1. Near Future | 1. Long term | 1. International | 1. Data 2. (Digital) | 1. Mobile to mobile. 2. Fixed to mobile. Mobile to fixed. | 1. To manage data transfer over channels in the MMS. | 1. E.g. “go to channel XX to get chart update for Tokyo Bay. |
| 1. VHF Digital data.  * ECDIS chart data * Digital voice * Virtual channels * UMDM support * Internet access | | | VHF  Mobile | 156.025 to  161.950 MHz. | 25 to 100 kHz.  See note 3. | 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. | Rec.ITU-R M. 1842  SC 123  Managed or autonomous systems. |

1. 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 2008.

1. Maritime Frequency Allocations

| 1. **Frequency** | 1. **Region 1 Allocation** | 1. **Region 2 Allocation** | 1. **Region 3 Allocation** | 1. **Status of Maritime Use** |
| --- | --- | --- | --- | --- |
| 1. 90 – 110 kHz | 1. RADIONAVIGATION 5.62   Fixed  5.64 | | | No constraints |
| 285 – 315 kHz | AERONAUTICAL RADIONAVIGATION  MARITIME RADIONAVIGATION (radiobeacons) 5.73  5.72 5.74 | AERONAUTICAL RADIONAVIGATION  MARITIME RADIONAVIGATION (radiobeacons) 5.73 | | No constraints |
| 315 – 325 kHz | AERONAUTICAL RADIONAVIGATION  Maritime radionavigation (radiobeacons) 5.73  5.72 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  5.72 | MARITIME MOBILE 5.79 5.79A  Aeronautical radionavigation 5.80  5.77 5.78 5.82 | | No constraints |
| 435 – 495 kHz | MARITIME MOBILE 5.79 5.79A  Aeronautical radionavigation  5.72 5.82 | MARITIME MOBILE 5.79 5.79A  Aeronautical radionavigation 5.80  5.77 5.78 5.82 | | No constraints |
| 495 – 505 kHz | MOBILE 5.82A  5.82B | | | No constraints |
| 505 – 510 kHz | MARITIME MOBILE 5.79 5.79A 5.84  AERONAUTICAL RADIONAVIGATION  5.72 | MARITIME MOBILE 5.79 | MARITIME MOBILE 5.79 5.79A 5.84  AERONAUTICAL RADIONAVIGATION  Aeronautical mobile  Land mobile | No constraints |
| 510 – 525 kHz | MARITIME MOBILE 5.79 5.79A 5.84  AERONAUTICAL RADIONAVIGATION  5.72 | 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   * 1. 5.92 | * 1. BROADCASTING 5.89   2. 5.90 | * 1. FIXED   2. 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 RADIONAVIGATION | FIXED  MOBILE  RADIOLOCATION  RADIONAVIGATION  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 |
| 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  5.126 | | | No constraints |
| 4063 – 4438 kHz | MARITIME MOBILE 5.79A 5.109 5.110 5.130 5.131 5.132  5.128 | | | 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 |
| 156 – 156.4875 MHz | FIXED  MOBILE except aeronautical mobile (R)  5.226 | FIXED  MOBILE  5.225 5.226 | | Operation protected by footnote 5.226 |
| 156.4875 MHz – 156.5625 MHz | MARITIME MOBILE (distress and calling via DSC)  5.111 5.226 5.227 | | | No constraints |
| 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 MHz – 156.8375 MHz | MARITIME MOBILE (distress and calling)  5.111 5.226 | | | 1. No constraints |
| 1. 156.8375 - 162.050 MHz | 1. FIXED 2. MOBILE except aeronautical mobile (R) 3. 5.226 5.227A 5.229 | 1. FIXED 2. MOBILE 3. 5.226 5.227A 5.230 5.231 5.232 | | 1. Operation protected by footnote 5.226 |
| 1. 406 – 406.1 MHz | 1. MOBILE-SATELLITE (Earth-to-space) 2. 5.266 5.267 | | | 1. No constraints |
| 1. 456 – 459 MHz | 1. FIXED 2. MOBILE 5.286AA 3. 5.271 5.287 5.288 | | | 1. Footnote 5.287 specifies maritime mobile use |
| 1. 460 – 470 MHz | 1. FIXED 2. MOBILE 5.286AA 3. Meteorological-satellite (space-to-Earth) 4. 5.287 5.288 5.289 5.290 | | | 1. Footnote 5.287 specifies maritime mobile use |
| 1. 1525 – 1530 MHz | 1. SPACE OPERATION (space-to-Earth) 2. FIXED 3. MOBILE-SATELLITE (space-to-Earth) 5.208B 5.351A 4. Earth exploration-satellite 5. Mobile except aeronautical mobile 5.349 6. 5.341 5.342 5.350 5.351 5.352A 5.354 | 1. SPACE OPERATION (space-to-Earth) 2. MOBILE-SATELLITE (space-to-Earth) 5.208B 5.351A 3. Earth exploration-satellite 4. Fixed 5. Mobile 5.343 6. 5.341 5.351 5.354 | 1. SPACE OPERATION (space-to-Earth) 2. FIXED 3. MOBILE-SATELLITE (space-to-Earth) 5.208B 5.351A 4. Earth exploration-satellite 5. Mobile 5.349 6. 5.341 5.351 5.352A 5.354 | 1. Complex |
| 1. 1530 – 1535 MHz | 1. SPACE OPERATION (space-to-Earth) 2. MOBILE-SATELLITE (space-to-Earth) 5.208B 5.351A 5.353A 3. Earth exploration-satellite 4. Fixed 5. Mobile except aeronautical mobile 6. 5.341 5.342 5.351 5.354 | 1. SPACE OPERATION (space-to-Earth) 2. MOBILE-SATELLITE (space-to-Earth) 5.208B 5.351A 5.353A 3. Earth exploration-satellite 4. Fixed 5. Mobile 5.343 6. 5.341 5.351 5.354 | | 1. Complex |
| 1. 1535 – 1559 MHz | 1. MOBILE-SATELLITE (space-to-Earth) 5.208B 5.351A 2. 5.341 5.351 5.353A 5.354 5.355 5.356 5.357 5.357A 5.359 5.362A | | | 1. Complex |
| 1. 1616 – 1626.5 MHz | 1. MOBILE-SATELLITE (Earth-to-space) 5.351A 2. AERONAUTICAL RADIONAVIGATION 3. Mobile-satellite (space-to-Earth) 5.208B 4. 5.341 5.355 5.359 5.364 5.365 5.366 5.367 5.368 5.369 5.371 5.372 | 1. MOBILE-SATELLITE (Earth-to-space) 5.351A 2. AERONAUTICAL RADIONAVIGATION 3. RADIODETERMINATION- SATELLITE (Earth-to-space) 4. Mobile-satellite (space-to-Earth) 5.208B 5. 5.341 5.364 5.365 5.366 5.367 5.368 5.370 5.372 | 1. MOBILE-SATELLITE (Earth-to-space) 5.351A 2. AERONAUTICAL RADIONAVIGATION 3. Mobile-satellite (space-to-Earth) 5.208B 4. Radiodetermination-satellite (Earth-to-space) 5. 5.341 5.355 5.359 5.364 5.365 5.366 5.367 5.368 5.369 5.372 | 1. Complex |
| 1. 1626.5 – 1646 MHz | 1. MOBILE-SATELLITE (Earth-to-space) 5.351A 2. 5.341 5.351 5.353A 5.354 5.355 5.357A 5.359 5.362A 5.374 5.375 5.376 | | | 1. Complex |
| 1. 2900 – 3100 MHz | 1. RADIOLOCATION 5.424A 2. RADIONAVIGATION 5.426 3. 5.425 5.427 | | | 1. No constraints |
| 1. 9200 – 9300 MHz | 1. RADIOLOCATION 2. MARITIME RADIONAVIGATION 5.472 3. 5.473 5.474 | | | 1. No constraints |
| 1. 9300 – 9500 MHz | 1. RADIONAVIGATION 2. EARTH EXPLORATION-SATELLITE (active) 3. SPACE RESEARCH (active) 4. RADIOLOCATION 5. 5.427 5.474 5.475 5.475A 5.475B 5.476A | | | 1. No constraints |

1. Current and evolving wireless telecommunications technologies in the Maritime environment

There are an ever increasing number of wireless technologies which 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 metres or much less) and the frequencies employed are globally allocated for the purpose (e.g. the 2.4 GHz ISM[[4]](#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 6 below 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.

1. Summary of spectrum requirements of new commercial data links

| **Technology** | **Frequency Range** | **Notes** |
| --- | --- | --- |
| TETRA | 380 – 400 MHz  410 – 430 MHz  450 – 470 MHz  806 – 821 // 851 – 866 MHz | EN 300 392 |
| TETRA 2 (TEDS) | 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)[[5]](#footnote-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  790 – 862 MHz  824 – 894 MHz  880 – 960 MHz  1710 – 1880 MHz  1850 – 1990 MHz  1820 – 2170 MHz  2300 – 2400 MHz  2500 – 2690 MHz |  |
| W-CDMA (UMTS) |  |
| TD-CDMA | 1900 – 1920 MHz  2010 – 2025 MHz  (2570 – 2620 MHz) | ‘TDtv’ applications have been trialed in some EU countries |
| TD-SCDMA |  |
| 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 7 below shows, based on the latest version of the ITU Radio Regulations, the allocations in those bands (including any footnotes), highlighting the position of maritime services in those bands.

1. 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 E | | | No constraints |

| **Frequency (MHz)** | **Region 1 Allocation** | **Region 2 Allocation** | **Region 3 Allocation** | **Status of Maritime Use** |
| --- | --- | --- | --- | --- |
| 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 | | | No constraints |
| 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 | | No constraints |
| 2450 – 2483.5 | FIXED  MOBILE  Radiolocation  5.150 5.397 | FIXED  MOBILE  RADIOLOCATION  5.150 | | No constraints |
| 2500 – 2520 | FIXED 5.410  MOBILE except aeronautical mobile 5.384A  5.405 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 5.405 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  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.

**Conclusions**

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.

1. 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.

ITU Study Groups (SG) are responsible for developing draft recommendations to be provided to the periodic World Radio Conferences (WRC). Study groups are established and assigned study questions by a Radiocommunication Assembly to prepare draft Recommendations for approval by ITU Member States. In the case of e-Navigation two SG’s are likely to be involved in the development of material to be agreed at WRC, namely SG4 and SG5.

SG4 relates to satellite services, covering systems and networks for the following service:

* Fixed-satellite service;
* Mobile-satellite service;
* Broadcasting-satellite service; and
* Radiodetermination-satellite service.

SG5 relates to terrestrial services, covering systems and networks for the following services:

* Fixed;
* Mobile;
* Radiodetermination;
* Amateur; and
* Amateur-satellite.

Below the SG’s are subgroups, such as Working Parties (WP) and Task Groups (TG) that are established to study the questions assigned to the different Study Groups. For example, SG4 has the following WP’s:

* Working Party 4A - Efficient orbit/spectrum utilization for FSS and BSS;
* Working Party 4B - Systems, air interfaces, performance and availability objectives for FSS, BSS and MSS, including IP-based applications and satellite news gathering;
* Working Party 4C - Efficient orbit/spectrum utilization for MSS and RDSS.

SG5 has the following WP’s:

* Working Party 5A - Land mobile service excluding IMT; amateur and amateur-satellite service;
* Working Party 5B - Maritime mobile service including Global Maritime Distress and Safety System (GMDSS); aeronautical mobile service and radiodetermination service;
* Working Party 5C - Fixed wireless systems; HF systems in the Fixed and Land Mobile Services;
* Working Party 5D - IMT Systems;
* Joint Task Group 5-6 - Studies on the use of the band 790-862 MHz by mobile applications and by other services.

For maritime e-Navigation applications any necessary revision to, or creation of, technical characteristics will take place in one of two WP’s – SG4 WP4C and SG5 WP5B.

1. ITU 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. | No amendments are foreseen for the use of VHF DSC within the e-Navigation concept as currently envisaged. However, if the VHF voice channels are changed to make them more spectrally efficient (e.g. see VHF voice below) there may be a need to revise the VHF DSC characteristics. | 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 | Technical characteristics of VHF emergency position-indicating radio beacons using digital selective calling (DSC VHF EPIRB) |
| ITU-R M.689-2 | 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. | No amendments are foreseen for the use of HF/MF DSC within the e-Navigation concept as currently envisaged. N/A | N/A |
| ITU-R M.541-9 | Operational Procedures for the Use of Digital Selective-Calling Equipment in the Maritime Mobile Service |

| **Application** |  | **Current characteristics** |  | **Amendments** | **Mechanism** |
| --- | --- | --- | --- | --- | --- |
|  |  | ITU-R M.1173 | 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 signalling 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** |  |  | 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 subject is on the WRC-11 agenda under Item 1.10. However, there is unlikely to be any directly relevant outcomes. The work would therefore have to be addressed through  WP4C/SG4 Questions 84-4/4 (Iridium), 87-4/4 (satellite) coordinating with WP5B/SG5 for HF. |
| **Satellite** |  |  |
| **AIS** |  | ITU-R M.1371-4 | Technical characteristics for an automatic identification system using time division multiple access in the VHF maritime mobile band | There are a number of potential changes to AIS under e-Navigation that would require revision to the existing technical characteristics.  Firstly, the possible need for a dedicated channel to enable the detection of AIS transmissions from space.  Secondly the allocation of additional channels 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-11 agenda item 1.10 is considering the expanded use of VHF for port safety and security. Under this item, the allocation of a 3rd AIS channel for detection from space is being considered. 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 questions 232/5 and 96-2/5. |
| **VHF Comms** | **Voice** | ITU-R M.1084-4 | 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. | This task should be coordinated through WP5B/SG5 possibly under existing question 96-2/5. |
| 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. | This task should be coordinated through WP5B/SG5 possibly under existing question 96-2/5. |
| **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 | 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 signalling format |
| **Data** | ITU-R M.1081 | 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.). | The HF channeling requirements are being addressed within WRC-11 agenda item 1.9. The outcome could lead to a need to develop new characteristics in relation to the e-Navigation preferred HF datalink. See WP5B/SG5 and questions 145-2/5 and 158-1/5. |
| 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** | **MIO** | ITU-R M.625-3 | 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. However, if it is intended to include NAVTEX data along with other safety related information e.g. Maritime Information Objects, etc. then it may be more appropriate for a specific characteristic to encompass all maritime safety information. | This task should be coordinated through WP5B/SG5 possibly under existing question 98-5. |
| 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 |
| **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 | There is 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 | 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 | 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 | 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 | 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 question 212-3/5. |
| **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.628-4 | 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 | 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.690-1 | 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.633-3 | 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 |
| **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-Nav related comms change. | N/A |

1. AIS and VHF Data Communication

A5.1 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 dedicated 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.

A5.2 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.

A5.3 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.

A5.3.1 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.

A5.3.2 AIS base stations

* Coastal and inland AIS infrastructure continues to grow

i) driven by safety, security, and environmental protection considerations;

ii) EU Directive 59 requires all member countries to maintain coastal AIS coverage.

A5.3.3 Airborne AIS

* More SAR aircraft are being fitted with AIS stations.

A5.3.4 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.

A5.3.5 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.

A5.3.6 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)

A5.3.6.1 International

* IMO SN/Circ.289 providing 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;

1. a new meteorological-hydrographic message with a dynamic length of 2 to 5 slots;
2. an area message for navigational warnings.

A5.3.6.2 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.
* IALA is maintaining a registry of these regional application-specific messages.

A5.3.6.3 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.

A5.3.7 New AIS messages (23, 24, 25, 26 and 27)

* Messages 23, 24, 25, and 26 were added in recent editions of Recommendation ITU R M.1371.
* Message 27 was added in the IALA technical clarifications on Recommendation ITU-R M.1371-3, and has been incorporated in Recommendation ITU-R M.1371-4
* Additional frequencies were approved at WRC12 for use by Satellite AIS (Channels 75 and 76)

A5.3.8 GNSS differential corrections

* Use of Message 17 for GNSS correction data dissemination is increasing:

i) already being broadcast in Gulf of Finland and Tokyo Bay;

ii) Germany, Netherlands and England are planning introduction.

A5.3.9 FATDMA usage

* Competent authorities are increasingly using FATDMA slot allocations for various uses:

i) AIS AtoN;

ii) base station slot reservation broadcasts (Message 20);

iii) base station regular broadcasts (Message 17);

iv) reserved slots for ship replies;

v) safety text messages;

vi) meteorological and hydrographic messages (Message 8).

* There is an indication that the VHF Data Link will become more crowded and competent authorities resort to FATDMA reservations to ensure that their services are protected.

A5.4 Additional future use of AIS

A5.4.1 Increased use of AIS shore to ship data transmissions

* In a future e-Navigation scenario, the transmission of data from shore-to-ship is expected to increase significantly with the advent of mandatory ECDIS which provides a graphical display of information.:

Examples;

1. Ship off track warning
2. Territorial water advice
3. Environmental area warning
4. Navigational hazards
5. Weather warnings
6. Military test ranges and submarine exercises.

* Some of the present voice communications between shore and ship will move to data messaging:

i) ship reporting;

ii) routing information.

A5.4.2 Increased use of ship-to-shore data transfer

* Ship reporting by AIS
* Requesting data

i) weather data;

ii) docking data;

iii) routing information.

A5.4.3 Increased use of ship-to-ship data transmissions

* Reduced use of voice communications in favor of data messages.

A5.4.4 Limited base station

* There will be more fixed stations, some of these being private.
* Development of limited base stations will be driven by

i) private ports;

ii) bridges and locks;

iii) canals;

iv) offshore commercial facilities.

A5.4.5 Repeater station

* Repeaters will be used to extend coverage of shore AIS base station networks, and ship-ship AIS communications, and AIS AtoN range

i) requiring double the VDL slot count to transfer data;

ii) and are deployed to extend base station coverage when the usual base station-to- base station data links are unavailable.

A5.4.6 Future messaging

* Will be required as the suite of Recommendation ITU-R M.1371 messages increases

i) Originally 22 message types, now 27 have been defined.

* Improved set of messages are expected:

i) replacement for some old messages, when they have proved not to support proper data modeling (e.g. static ship data);

ii) reduction of tailored messages to essentially needed messages

iii) new flexibility for applications.

A5.4.7 Satellite detection of AIS

* Research continues on enhanced methods of detecting AIS signals, and hence monitoring shipping, by satellite.
* Satellite detection of AIS messages has been requested by administrations.
* Separate frequencies for satellite detection of AIS were selected from within Appendix 18 because the tuning range of the shipborne AIS Class A is limited to these frequencies. Report ITU-R M.2084 indicated that the interference environment resulting from the existing services in those bands must be taken into account in determining the feasibility of accommodating satellite AIS, due to the large satellite antenna footprint that overlaps both land and sea. Separate operating frequencies in addition to AIS 1 and AIS 2 are needed that are not subject to terrestrial use.
* Appendix 18 contains only 4 frequencies (channels 16, 70, 75 and 76) that are exclusively dedicated to maritime use (channels 75 and 76 have been approved to be shared with this service). This proposal meets the intent of footnote *n)* to Appendix 18 for interference mitigation.

A5.4.8 Future GMDSS platform

* COMSAR has been tasked to modify the performance standard for the 406 MHz EPIRB to include use of AIS. This suggests the use of AIS as a GMDSS locating / homing device.
* IMO has recognized AIS-SART as part of GMDSS. The potential for additional use of AIS as a supplement to the VHF DSC should be brought to the attention of IMO.

A5.4.9 PLB (personal locating beacon)

* There are initiatives to develop a PLB / MOB / Diver applications based on the AIS-SART technology.

A5.4.10 Use of AIS for PNT (position, navigation and timing) and ranging

* Improved time transfer capabilities shore to ship by using high precision time bases has been proposed.
* The e-Navigation Committee envisages a “Ranging” mode for AIS and trials are to be undertaken in Northern Europe as part of Accseas project

i) where the timing of AIS messages are used for position determination;

ii) by ship and shore.

A5.4.11 Coordinated channel management for future e-Navigation VHF digital data communications

* Designation of additional AIS frequencies may enhance the coordination of regional channel management.
* Using TDMA protocol on channel 70 to coordinate the usage of the VHF data link will enable channel management for other e-Navigation data services as well as AIS.
* Any additional protocols on Channel 70 are required to co-exist with current DSC requirements and operation.
* If it preferred that channel management is relocated to other channels such as 28B and 27B protecting distress and safety messaging on channel 70.

A5.5 Strategy for future AIS and VDE

A5.5.1 General thoughts

* AIS is a proven maritime data system, with ships equipped and shore infrastructure established, the full potential of AIS is yet to be achieved.
* AIS is the quickest path for handling the increasing low volume data exchange needs described above.
* Therefore, in order to meet the data communications needs set out above, IALA envisages that the present AIS system will need to be supplemented with VDE.

A5.5.2 AIS Channel plan

* Safety of Navigation purposes

i) The AIS 1 and AIS2 are internationally allocated on a sharing basis. These frequencies should be retained and protected for safety of navigation purposes.

* Satellite detection of AIS and future GMDSS

i) VHF Channels 75 and 76, dedicated maritime frequencies, have been approved for monitoring from space of message 27. Sharing with low power devices.

ii) in the future GMDSS could be supplemented by AIS technologies. The distress alerting, urgency and safety communications should be by both terrestrial and satellite communications; therefore exclusive maritime mobile service frequencies are needed. The satellite detection of AIS is a one way system (Earth-to-space) and could be considered as an additional alerting means. Methods of acknowledgement via alternative return links are also possible.

* Data communication purposes.

In considering the future AIS system for terrestrial (non-satellite) low volume data communication purposes, an additional two frequencies will be needed. These frequencies have already been selected within the Appendix 18. The Appendix 18 covers 156-162.025 MHz; however the current channeling arrangements only apply to limited parts of the band. As shown in the figure below, the blue bands (sharing basis) and red bands (maritime exclusive) are channelized. The yellow bands (sharing basis) are not channelized. The yellow bands are available for maritime mobile as well as terrestrial services and candidate frequencies may be selected on a sharing basis.



1. e-Navigation Communications – VHF elements only

| **Essential element of e-Navigation communications** | ***AIS*** | | * 1. ***e-Navigation VHF Data Exchange (VDE)***   ***(Toll free)*** | | * 1. ***GMDSS*** |
| --- | --- | --- | --- | --- | --- |
| **Sub-group** | ***AIS for safety of navigation*** | ***AIS long range (i.e. Sat-AIS)*** | ***using existing AIS protocol*** | ***using ITU standard protocol*** | * 1. ***Distress alerting, Selective calling*** |
| **Radio channels** | * *AIS-1 & AIS-2 (simplex)*   + *As now, no change* | * *Channels 75 and 76 (simplex)*    + *As per outcome from WRC 2012* | * *Channels 27B and 28B*    + *World-wide dedicated channels (WRC-15 target)* | * *Channels 24, 84, 25, 85, 26, 86* | * *Channel 70* |
| **Functionality** | * *Safety of navigation* * *Maritime and inland distress and safety communications* | * *Space detection of AIS* * *Future SAR* | * *Marine safety information* * *Marine security information* * *SSRMs* * *General purpose information communication* | * *General purpose data exchange* * *Robust high speed data exchange* | * *Maritime and inland distress and safety communications* |
| **Message types**  **for AIS protocol** | * *Vessel identification* * *Vessel dynamic data* * *Vessel static data* * *Voyage related data* * *Aids to Navigation* * *Base Station* | * *Space detection of AIS* * *Other messages for support of future SAR* | * *International application specific messages* * *Regional application specific messages* * *Base Station* |  |  |
| **Sub functionality** | * *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* * *Locating in SAR* * *Future distress alerting* | * *Area warnings and advice* * *Meteorological and hydrological data* * *Traffic management* * *Ship-shore data exchange* * *Channel management* | * *High message payload* | * *Future Distress alerting* * *Selective calling (DSC)* * *AIS Channel Management ([[6]](#footnote-12))* |

A5.5.3 Airborne AIS

* ITU Radio Regulations Article 51 Section III sets limits on aircraft VHF usage

i) this will be required to allow aircraft effective use for AIS message transmission in SAR cases.

* It may also require change in the future to permit and/or prohibit certain AIS message transmission.

A5.5.4 Legacy strategy

* Future advances in AIS will require updates to legacy systems.
* Legacy AIS functionality will be maintained.
* AIS channel management, using Channel 70, already available internationally, should be maintained until it is replaced by another internationally agreed method of channel management.

A5.6 Benefits of future AIS / VDE for the users

* Dedicated frequencies will provide for greater safety and integrity of data link, providing better protection for the transfer of safety related messages.
* Use of AIS for maritime information dissemination will mean that NAVTEX / NAVDAT could be supplemented and enhanced by AIS or VDE
* The possibility will be created to support the future function of AIS in GMDSS, with the benefit of making distressed vessels visible to all resources (land sea and air) in the vicinity.
* Future shipboard AIS / VDE installations could provide seamless communication means, supporting a modular concept for communication needs in the VHF band. Enabling scalability and inter-operability of communication solutions intended for SOLAS and well as Non-SOLAS vessels while remaining backward compatible with existing AIS equipment.. .
* Satellite detection of AIS will be facilitated.
* The rapidly increasing use of data transfer for the efficiency of navigation will be facilitated.

1. http://www.globewireless.com/network\_digitalhf.php [↑](#footnote-ref-1)
2. The self contained printer requirement was removed from IMO performance standards (MSC.148(77)) subject to provide 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 F77 are elements of GMDSS [↑](#footnote-ref-3)
4. Industrial, Scientific and Medical. These bands are used by devices such as industrial heaters and driers and domestic equipments such as microwave ovens. [↑](#footnote-ref-8)
5. According to 3GPP TS 45.005 [↑](#footnote-ref-9)
6. With the protection of the AIS1 and AIS2 frequencies, AIS channel management via both AIS message 22 and DSC is considered unnecessary and undesirable. [↑](#footnote-ref-12)