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Architectural Concept of Shipborne Radio Communications GMDSS Network

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ABSTRACT

This paper introduces a new architectural concept of maritime radio communication in the function of enhances GMDSS network and equipment within the Very High Frequency (VHF), Medium Frequency (MF) and High Frequency (HF) Ship Radio Station (SRS) terminals. Since its establishment in 1959, International Maritime Organization (IMO) and its member states, in close co-operation with the International Telecommunication Union (ITU) and other international organizations, notably the World Meteorological Organization (WMO), the International Hydrographic Organization (IHO), the International Mobile Satellite Organization (IMSO) and the Cospas-Sarsat partners, have striven to improve maritime distress and safety radiocommunications, as well as general radiocommunications for operational and personal purposes. This paper also reviews concept of GMDSS network, overview of antenna, types of shipborne VHF radios, radio portable survival craft VHF radios, ans shipborne MF/HF radios. In addition, the type of the radio Search and Rescue Transponder (SART), and airborne Radio - Automatic Identification System (R-AIS) transponder for maritime SAR operations are also described in this paper.

1. Introduction.

This paper introduces radio subsegmens in the function of the GMDSS network and equipment within the VHF, M) and HF radio ship stations. Ships are currently being equipped with radio and satellite communications technologies that transport Voice, Data and Video (VDV) via mobile communication networks and in some cases broadband networks to receive or transmit strategic information regarding more safety, security, emergency, commercial and maintenance trends. Traditional radio ships communications are based on analog voice on either VHF or MF and HF radio waves. In the mid 1980s the use of databased communications became a reality.

Today, a maritime management team is transcending into the computer age and as new technology requirements evolve and the choice of an adequate GMDSS communications technologies and technique expand, regulating the world?s ships traffic flow that can safely become more automated and effective, especially during emergency and distress alerting situation. Therefore, the new regulations should suggest which radio devices can be used for maritime radio communication within the modern GMDSS concept as mandatory equipment onboard every oceangoing ships.

2. Precursors for Development GMDSS Network.

The end of last and start of the new millennium marks two special centenaries: more than 100 years since Russian professor Aleksander S. Popov invented first Radio in May 1895 and almost more than 110 years Guglielmo Marconi registered the first company Wireless Telegraph and Signal Company in the Great Britain for design and production of ships radio equipment. Shortly afterwards, he renamed it into Marconi's Wireless Telegraph Company, Ltd., which program was to design and produce radio telegraphs transmitters and receivers with antenna, for two-way maritime commercial and distress transmissions at the turn of the twentieth century.

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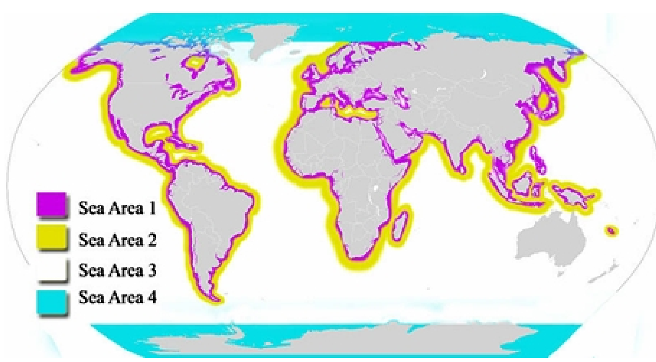
A very impressive development of maritime radio applications, was launched by mobile radio to help in distress and safety alerting. Likewise, the first technological revolution occurred in mobile radio and in the field of marine radio for both commercial and distress solutions. Changes and developments in the aeronautical industry have been slower than the maritime radio revolution. The first modern ship's radio station was pioneered at the beginning of the 20th century, and one of the first such stations was set up in 1912 on the ship White Star Liner s/s Titanic, so that its loss was subject to regulatory reviews covering a range of maritime practices, especially the first International Convention for the Safety of Life at Sea (SOLAS) in 1914.

Figure 1: Four GMDSS Sea Areas.



Source: Wikimedia Commons.

The use of radio communications has been an important part of ship safety for many years. Some of the history even dates back to the early part of the 20th century. At that time, maritime communications were mainly, if not exclusively, in the Low Frequency (LF) band. Around the 1930s, a paper discussed the use of frequency modulation as a technical solution to interference issues that were experienced in the HF frequency band.

Maritime radio was first used to save lives at sea in 1899, and since then it has helped to rescue tens of thousands lives and become the key element of SAR systems, and subsequently, numerous technological advances have been made. However, until the introduction of the GMDSS in 1992, the way in which an alert message from a ship in distress was sent had changed drastically from those early days, when a radio operator sending a message by Morse code or radiotelephone and hoping that another ship or shore station within range would hear the call and respond.

The previous distress and safety system under the SOLAS Convention it used exclusive Morse radiotelegraph and radiotelephone ystems controlled by the ship's and shore-based operators or mobile means of SAR and assistance. However, the new GMDSS infrastructure has introduced modern radio and satellite technology which completely transformed ships radio communications into a more efficient network. This new system enables a distress alert to be transmitted and received automatically over long range, with significantly higher reliability, [1, 2].

2.1. Concept of GMDSS Network and Function Requirements.

The GMDSS concept is a globally SAR system accepted and adopted set of rules protocols and prescriptions, which assure safety navigation and shipping. The GMDSS equipment is applied to increase safety and make it easier and faster to rescue distressed ships, boats and aircrafts. The GMDSS enables a ship in distress to send an alert using various radio and satellite systems. Thanks to this system the distress alerts has a very high contingency to be received by shore rescue authorities and/or other vessels and SAR units in the area.

Due to the different radio systems incorporated into the GMDSS network having individual limitations with respect to range and communication service provided, the radio equipment required to be carried by a ship is determined by the ship's area of operation, rather than by its size. The GMDSS has divided the world?s oceans into four distinct sea areas. In Figure 1 are shown sea areas in which all oceangoing ships are required to carry radio and satellite equipment appropriate to the sea area or areas in which they operate, such as follows:

1. Sea Area A1 – This area is within the radiotelephone coverage of at least one VHF Coast Radio Station (CRS) terminal in which continuous VHF DSC alerting is available in approximately of 20 - 30 nautical miles (nm) for all Ship Radio Stations (SRS).

2. Sea Area A2 – This area is within the radiotelephone coverage of at least one MF CRS terminal in which continuous MF DSC alerting is available in approximately of 20 - 30 nm (excluding Sea Area A1).

3. Sea Area A3 – This area is within the coverage area of Inmarsat Geostationary Earth Orbit (GEO) satellites in which continuous alerting is available in approximately between 76^{o} North and South (excluding Sea Areas A1 and A2). This area can be also covered by HF radio and new proposed Iridium as global Low Earth Orbit (LEO) satellites

4. Sea Area A4 – These are the remaining sea areas outside areas A1, A2 and A3 covered by Iridium and HF radio (basically, the placePolar Regions).

Thus, in the GMDSS radio communication network and service, the SRS is a mobile radio station established on board a ship for communications with stations ashore and other ship stations, while the CRS is a ground radio station established on land for the purpose of communicating with ships at sea for commercial and distress purposes. The International Maritime Organization (IMO), a specialized agency of the United Nations, regularly publishes a list of planned and operational GMDSS shore based communications facilities available worldwide. This document is referred to as the GMDSS Master Plan.

The GMDSS integrated radio and satellite communication network developed by IMO and other participating partners and full implementation of the GMDSS network by on 1 February 1999 was an important date in maritime history, coming almost exactly 100 years after the first use of wireless technology to aid a ship in distress. Today, the GMDSS network should ensure that no ship in distress can disappear without trace, and that more lives can be saved at sea.

In this way, the GMDSS integrated communications system under SOLAS complements the International SOLAS of 1979, which was adopted to develop a Global SAR plan, so that no matter where an incident occurs, the rescue of crew, passengers and ships in distress will be coordinated by a SAR organization and, where necessary, by co-ordination between neighboring SAR member countries. Therefore, with the completion of the international SAR operational plans and the full implementation of the GMDSS infrastructure, seafarers and ships' passengers should feel safer and more secure at sea.

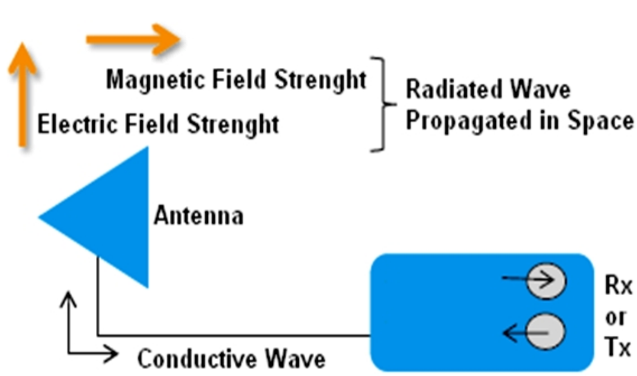
The SOLAS International Convention contains a set of international regulations and standards governing all aspects of merchant ship operations. The Convention has been ratified by all major maritime nations, which operate through the IMO plans. Amendments to the 1974 SOLAS Convention concerning radio communications for the GMDSS were published in 1989 and entered into force on 1 February 1992. At this point, all ships over 300 Gross Tonnages (GT) on international voyages, and hence subject to the 1974 SOLAS Convention, have been required to comply with the carriage requirements of the GMDSS since 1 February 1999.

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

a. Transmitting ship-to-shore distress alert by at least two separate and independent means, each using a different radiocommunication service.
b. Receiving shore-to-ship distress alert using a different radiocommunication service, and Maritime Safety Information (MSI);
c. Transmitting and receiving ship-to-ship distress or emergency alerts, on-scene communications, SAR coordinating communications, and locating signals; and
d. Transmitting and receiving general radio-communications relating to the management and operation of the ship, and ships bridge-to-bridge communications.

In addition, the functional requirements for GMDSS network compatible oceangoing or inland ships to which the SOLAS Convention does not apply are contained in Annex 3 of the Maritime Order 27 of 2016, which proposes a specific list of ship radio equipment to ensure safety in navigation, [1, 3, 4, 5, 6, 7].

Figure 2: Basic Antenna Functionality in Propagation.



Source: Rohde&Schwarz.

2.1.1. Overview of Antennas for Radio Communications.

Radio antennas act as converters between conducted waves and electromagnetic (EM), electric and magnetic, waves propagating freely in space, which diagram is illustrated in Figure 2. Thus, transmitter (Tx) is radiating EM via antenna and receiver (Rx) is detecting these EM affected by the propagation impairments. The name of antenna is borrowed from zoology, in which the Latin word antennae are used to describe the long, thin feelers possessed by many insects.

In Figure 3 it can be seen that the radio antenna is an important element in any radio or satellite system because it acts like a link of a chain. In such a way, the overall transmissions performances of radio waves in open space are significantly influenced by the performance of transmit and receive antennas.

At first glance, modern antennas may still look very similar to the ancient model developed by German physicist Heinrich Hertz and Russian professor Popov. However, they are nowadays optimized at great expense for their intended invention and radio application. Communications antenna technology primarily strives to transform one wave type into another with as little loss during propagation as possible.

This requirement is less important in the case of test antennas, which are intended to provide a precise measurement of the field strength at the installation site to a connected test receiver, instead their physical properties, need to be known with high accuracy. The explanation of the physical parameters by which the behavior of each communication antenna can be both described and evaluated is probably of wider general use.

The principal values used to determine the overall loss value for a radio (wireless) communication link include the free-space loss. In addition to any feed line propagation loss at the transmitting and receiving ends of the radio or satellite transmission link, which can be negligible when compared to the free-space segment losses. In most cases, it is impractical to install an antenna that tracks the movements of these spacecraft, and in this point omnidirectional communication antennas are normally used. Power levels for these types of installations must be carefully calculated so that a sufficient level of energy reaches the satellite regardless of its position in the sky at any given moment, (1, 2, 3, 8, 9].

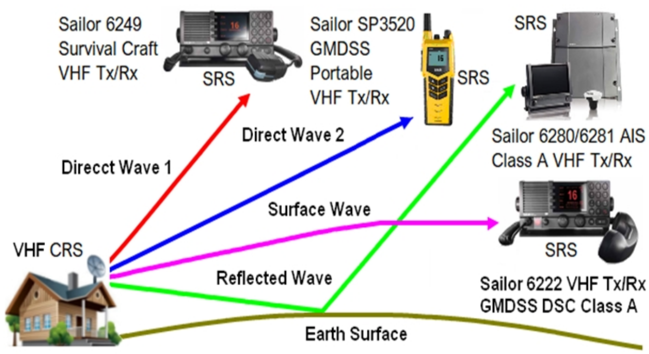
Figure 3: Block Diagram of Radio Link.

Source: Rohde&Schwarz.

3. Shipborne VHF Radio GMDSS Communication System.

The maritime VHF Radio Frequency (RF) spectrum is the designation of the International Telecommunication Union (ITU) recommendations and regulations in the range from 30 to 300 MHz, which enables radio communication within maritime mobile and shore-based users. In fact, VHF wavelength bands are very short and are able to have antenna unit that can be mounted on VHF moving or handheld (portable) devices, which is vital in the maritime transport industry as communications can be attained whilst on the move.

Figure 4: Maritime VHF Radio GMDSS Architecture.



Source: Author.

The shipborne VHF-band is used for Line-of-Sight (LOS) or direct wave communication, such as ship-to-ship or ship-to-shore and vise versa transmissions. The VHF frequency bands are divided into channels and one channel is usually as good as the next. Because mobile VHF-bands operate mainly by LOS, it is important to mount the antenna as high as possible onboard ships and land mobile to be free from physical obstructions onboard ships. The next problem onboard ships is to solve the negative influence of other transceivers or significant interference from other ships antenna systems. The VHF maritime radio communication networks are providing voice, data and navigation information service for oceangoing ships, fishing, cruise, inland, offshore and other vessels on dedicated VHF-bands. In Figure 4 is shown ground VHF maritime radio network that provides communication between VHF Coast Radio Station (CRS) and Ship Radio Station (SRS) terminals via direct, surface or reflected waves. The VHF SRS terminals are certain shipborne stations used as mandatory GMDSS equipment via dedicated VHF-bands.

As depicted in Figure 4, the GMDSS VHF service can provide installations of the following ship radio equipment in SRS terminals for Sea Area 1, produces by UK Cobham Company: Sailor 6222 VHF Tx/Rx (transceiver) with GMDSS Digital Selective Call (DSC) class A, Sailor 6280/6281 Radio Automatic Identification System (R-AIS) Class A VHF Tx/Rx, Sailor SP3520 GMDSS Portable VHF Tx/Rx radio, and Sailor 6249 Survival Craft VHF Tx/Rx station. Otherwise, these GMDSS VHF SRS terminals onboard oceangoing ships can be also used in Sea Areas 2, 3 and 4, for ship-to-ship radio communications. In general, the following types of shipborne VHF radio telephone stations are allowed in the maritime service depending upon the application as follows: (1) Ships VHF radio telephones capable of DSC and compliant with the GMDSS service; (2) Ships VHF radio telephones capable of R-AIS and compatible with the GMDSS; (3) Ships portable VHF radiotelephones, with or without DSC; and (4) Ships VHF radio telephones for survival craft.

3.1. Radio GMDSS DSC class A VHF Transceiver.

The VHF-band radio transceivers are commonly integrated into one control and electronics unit. The shipborne radio transmitters and receivers fitted within VHF radio transceivers are designed to be ?pre-tuned? to specific VHF radio antennas, in which antenna tuning units are not used.

Figure 5: Radio VHF GMDSS Transceivers with Whip Antenna.

Source: Cobham.

In Figure 5 (Left) is illustrated Sailor 6222 VHF transceiver with GMDSS Digital Selective Call (DSC) class A produced by Cobham and in Figure 5 (Middle) is depicted an universal VHF fiberglass antenna.

The Sailor 6222 VHF transceiver provides flexibility through straightforward installation, either as part of a GMDSS console or on its own. It introduces several new hardware and software improvements, including the improved SAILOR Replay functionality. The highly advanced 3.2? QVA display ensures the information can be read regardless of the light conditions on the bridge during day or night. The text can be displayed as white on black background, and as black on white background, to provide the optimal reading condition in daylight. Red backlight protects the night vision of the user.

The technical features of this transceiver are as follows: (a) Power supply is 12 VDC with nominal (10.8? 15.6VDC), which is reverse polarity protected; (b) Frequency range of Tx is 156,000-157,425 MHz, and Rx is 156,000-163,425 MHz, (c) Channel spacing 12.5 kHz and 25kHz including all international maritime channels; (d) Transmit power Hi/Lo: 25 W and ¡1 W, (e) Loudspeaker 6 W; (e) External loudspeaker 6W/8 Ohm; (f) Control speaker microphones; (g) 3 Handset/Hand Microphones; (h) Printer interface; (i) Built in DSC Class A (ITU493-13); and (j) Integrated Voyage Data Recorder (VDR) unit.

Some models of shipborne VHF radio transceivers installed on the bridge offer remote control units for control of the equipment from other areas such as cargo control rooms, ship?s offices, etc. The special characteristics of this VHF transceivers are to provide frequency selection of the 57 allocated VHF marine channels, and control of on/off and volume, squelch, output power, dual watch, and international/USA control, which is kept in the international position at all times unless in the coastal waters of the USA.

3.2. Radio GMDSS Survival Craft VHF Transceiver.

The Sailor 6249 VHF Survival Craft, depicted in Figure 5 (Right), is Wheelmark (MED-B) approved and complies with the European Telecommunications Standards Institute (ETSI)

EN 301 466 standard, which allows it to be installed as fixed mounted VHF in a survival craft with antenna used in distress situation. It is rated waterproof to both IPx6 and IPx8 and in order to achieve this rating for an extreme series of testing, proving its resistance to fluctuating temperature, shock, water and oil among other environmental challenges. This VHF radio transceiver has not installed DSC capability; however all main technical features are similar to the above introduce VHF Sailor 6222 VHF transceiver with DSC capabilities.

3.3. Radio GMDSS Class A R-AIS VHF Transceiver.

Each shipborne R-AIS station consists of one VHF transmitter, two VHF receivers (R-AIS 1 and R-AIS 2), one VHF DSC radio receiver keeping watch at channel 70 (CH.70), a standard maritime electronic communications link and sensor system. Thus, timing and positional information comes from a Global Navigation Satellite System (GNSS) receiver.

Figure 6: Radio GMDSS R-AIS Class A VHF and VHF Portable Transceivers.

Source: Cobham.

There are two classes of shipborne R-AIS: R-AIS Cass A has been mandated by the IMO for ships of 300 gross tonnages and upwards engaged on international voyages, cargo ships of 500 gross tonnages and upwards not engaged on international voyages and all passenger ships (more than 12 passengers) irrespective of size, i.e. all SOLAS ships. Thus, R-AIS Class B provides limited functionality and is intended for non-SOLAS vessels. It is not mandated by the IMO and has been developed for vessels such as work and pleasure craft. The R-AIS equipment is included in the SOLAS Convention, and certain ships began fitting R-AIS in July 2002, which automatically and at set intervals, transmits dynamic information relating to the ship?s course, speed and heading. It also provides static information related to the ship?s name, length, breadth and voyage-related details such as destination, cargo information navigational status (underway or at anchor).

The R-AIS is a data exchange system that transfers packets of data over the VHF Data Link (VDL), which enables R-AIS equipped vessels and shore-based stations to send and receive identification and other information that can be displayed on a navigational display. This information can help in situational awareness and provide a means to assist in collision avoidance. The R-AIS units can be interfaced to radars, Electronic Chart Display and Information System (ECDIS) displays. When interfaced to radar, R-AIS provides a source of target data, additional to that enabled by Automatic Radar Plotting Aid (ARPA).

Thus, R-AIS can be fitted to the Aids to Navigation (AtoN), such as floating buoys and beacons, so shore R-AIS base stations can broadcast a non-physical synthetic R-AIS AtoN, to appear at the location of a real AtoN on R-AIS enabled display system (eg. R-AIS, ECDIS or radar). TSo, R-AIS base stations can also broadcast a non-physical virtual R-AIS AtoN at a particular location when no real (physical) AtoN exists. This R-AIS also has a simple text communications capability called Short Safety Related Messaging (SSRM) using the VHF maritime mobile band, but does not constitute a distress alerting system.

In addition to its innovative design and operation this R-AIS shipborne unit delivers high performance on basic parameters, such as sensitivity, immunity, and blocking, so user can be confident in its ability to deliver and receive all R-AIS information at all times. In Figure 6 (Left) is illustrated one of much known Sailor 6280/6281 R-AIS Class A VHF radio transceiver. All parts included in the box, even the Sailor 6285 active GPS antenna and other components:

a) Built-in self-diagnostic system; (b) Possibility for integrated-antenna installation with common VHF and GPS antenna; (c) River use compliant with Central Commission for Navigation on the Rhine (CCNR); (d) This unit supports both GNSS networks (GPS and GLONASS); (e) Supports message for long range satellite tracking on channel 75 and 76; (f) Provides interface for ”Pilot Plug”; (g) Exchanges information between a vessel and a shore station, such as a Vessel Traffic Service (VTS), to improve traffic management in the congested waterways; (h) Sending messages to a dedicated address as Maritime Mobile Service Identity (MMSI) number; and (i) This unit is designed to be used standalone or as part of an Integrated Navigation System (INS). Although R-AIS networks are not part of the GMDSS, it can be included in the future as an integrated part of the GMDSS due to the advent of R-AIS-SART (R-AIS Search and Rescue Transmitters). Since 1 January 2010, R-AIS started to be used in lieu of Radar SAR Transponders (SART).

The technical features of this transceiver are as follows: (a) Input voltage is 10.8 VDC to 31.2 VDC; (b) Power consumption is 12W (0.5A @ 24 VDC input voltage); (c) Receivers frequency is 156.025 - 162.025 MHz (TDMA) and 156.525 MHz (Channel 70 for DSC); (d) Channel bandwidth 25 kHz; (e) Transmitter RF output power high is 12.5 W and Low is 1W; and (f) Frequency is 156.025 - 162.025 MHz.

4. Radio Portable Survival Craft GMDSS VHF Transceiver.

Portable two ways VHF radiotelephone equipment is used for communications between survival craft and rescue vessels. It may also be used for onboard communications on channels 15 and 17. Newer models automatically reduce the power to 1 W when these channels are selected. The equipment typically comprises a small hand-held transceiver with integral whip antenna, which samples Sailor SP3520 GMDSS Portable survival craft VHF Tx/Rx radio transceivers are shown in Figure 6 (Right).

The Sailor SP3520 portable series provide seven models covering all maritime applications with three models specifically designed for fishing and workboat use. They come with a large, easy to read display with a red backlight to protect your night vision. This portable VHF was built for the professionals at sea with features such as: dual watch, tri watch and scanning, waterproof use, large display, large tactile buttons, hand microphone, frequency range is 149.3 - 174 MHz, and Channel Separation 25 kHz.

This portable VHF radio equipment should comprise at least a transmitter and receiver, an an antenna which may be fixed or mounted separately a microphone with a PTT and loudspeaker. The equipment should be capable of being operated by unskilled personnel, be capable of being operated by personnel wearing gloves or immersion suits, be operational within 5 seconds of switching on, be watertight to a depth of 1 meter for at least 5 minutes, be either of a highly visible yellow/orange color or marked with a surrounding yellow/orange marking strip, be capable of operation on the frequency 156.800 MHz (VHF Ch. 16) and on at least one additional channel, be fitted with channels for single?frequency voice communication only (i.e. duplex channels not allowed), unit is using lithium battery (primary battery), etc.

The equipment is operated in the same fashion as any handheld (or walkie-talkie) type unit. Controls are provided for volume, squelch, and channel operation. Transmission and reception is controlled by a push-to-talk switch located on the side of the unit.

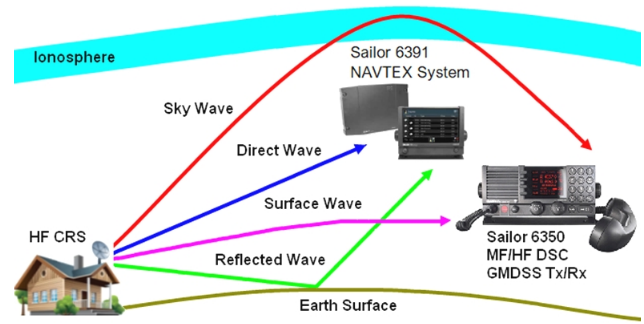
All GMDSS ships of 500 GT and upward are required carrying three portable survival craft VHF transceivers. Ships of over 300 GT but less than 500 GT are required to carry two. They are usually stored on or near the navigating bridge for easy transport to survival craft. As the equipment uses re-chargeable batteries the transceivers are stored in a ?drop in? type of battery charging cradle, [1, 3, 4, 6, 10, 11, 12].

5. Shipborne MF/HF Radio GMDSS Communication System.

The maritime MF and HF RF spectrum is the designation of the ITU recommendation and regulations in the RF range from 3 to 30 MHz, which enables radio communication within maritime mobile and shore-based users. In fact, combined MF/HF radios can transmit over thousands of nautical miles as the signal can be bounced off the ionosphere to overcome line of sight issues, which scenario is illustrated in Figure 7. Typically, marine MF/HF-SSB radio communication transceivers operate in the frequency range of 1.6 to 30 MHz, and maritime MF radio communication transceivers are using RF from 3 to 30 MHz.

The MF/HF maritime radio communication networks are providing voice, data and navigation information service for oceangoing ships, fishing, cruise, offshore and other vessels on dedicated MF-HF-bands between CRS and SRS via skywave (reflected from the ionosphere), direct, surface or reflected waves from the Earth. The MF/HF SRS terminals are certain shipborne stations used as mandatory GMDSS equipment via MF/HF-bands.

Figure 7: Maritime MF/HF Radio GMDSS Architecture.



Source: Author.

As shown in Figure 7, the GMDSS MF/HF radio communications service can provide, for example, Sailor 6391 NAVTEX ship equipment in SRS terminals for Sea Area 2, while for Sea Area 2, 3 and 4 are used Sailor 6350 MF/HF Tx/Rx with GMDSS DSC.

Otherwise, the GMDSS MF Rx and NAVTEX MF Rx SRS terminals can be used in Sea Areas 2 only, and GMDSS HF Tx/Rx SRS terminals are used for Sea Area 4, however they also can cover Sea Areas 2 and 3 as not mandatory HF terminals. In addition, as part of the GMDSS regulations, Single Side Band (SSB) MF/HF radios capable of Digital Selective Calling (DSC) are required on all SOLAS vessels operating outside of sea area A1 in order to maintain a continuous automatic watch on designated channels, listening for any distress signal alers. Rescue groups also monitor these channels.

5.1. Radio MF NAVTEX GMDSS Communication Receiver.

The NAVTEX radio system provides automatic dissemination of local MSI by Narrow Band Direct Printing (NBDP) operating in the Forward Error Correction (FEC) broadcast mode. Depending on the geographical features of its area of responsibility, in main, the length of coastline, the NAVTEX receiver (Rx) system may be chosen by administrations as an alternative to providing such information by the Inmarsat-C Enhanced Group Call (EGC) service.

The NAVTEX system provides maritime safety information, including weather warnings and forecasts relevant to ships within specified coastal areas in range of 300 to 400 nm. The NAVTEX system is presently used by countries in Asia, the Middle East, Europe and North America. Broadcasts of local MSI data by CRS terminals operating in the NAVTEX service are made on the MF frequency of 518 kHz. A second NAVTEX MF frequency of 490 kHz is available for national language broadcast. The HF frequency of 4,209.5 kHz is also allocated for national NAVTEX transmissions. Thus, there is also provision for radio transmissions on other nationally assigned frequencies for national transmissions, which may also be in language other than English. Some of these are on 424 kHz.

Each class of NAVTEX message carries a different subject indicator character allowing a shipboard operator to program a NAVTEX receiver to reject certain classes of messages that are not required. However, navigational and meteorological warnings, including SAR data cannot be rejected by an operator. In

Figure 4.8 (Left Above) is shown a modular design of the Sailor 6391 Navtex System, which consists of the Sailor 6390 Rx, for receives Navtex messages on the international Navtex frequencies 490 kHz, 518 kHz and 4209.5 kHz. Its control panels are a 7? touch screen that provides viewing clarity in all light conditions for reading of NAFTEX messages. It is also linked by dual LAN for National Marine Electronics Association (NMEA) any Integrated Navigation System (INS).

Figure 8: Radio NAVTEX Rx and MF/HF Transceiver with Whip Antenna.

Source: Cobham.

The technical specifications of NAVTEX Rx are as follows: (a) Receiver uses MF-band at 490 and 518 kHz, and HF-band at 4209.5 kHz simultaneous reception; (b) DC input range (isolated) 12 to 24 VDC and nominal supply voltage (10.8 - 31.2 VDC); (c) Typical power consumption of 6.5 W; (d) Short-wave up datable to future 500 kHz NAVDAT; (e) Support for both active and passive antenna (12 V @ 60 mA antenna supply); (f) NMEA0183 GPS input (or GPS input via LAN); and (g) Printer support via LAN.

5.2. Radio GMDSS DSC class A MF/HF Transceiver.

Modern maritime radio MF/HF transceivers are much more complex than those used by the previous system. The massive advances which have taken place in radio technology design have led to produce highly reliable for DSC, NBDP and MSI reception, telex and telephone facilities are fully integrated in the one unit. Radio GMDSS MF/HF transceivers are a modular system comprising three units. In Figure 8 (Left Below) is shown control unit of Sailor 6350 radio MF/HF transceiver with GMDSS DSC System and in Figure 8 (Right) is shown transceiver (black), and 500 W antenna tuning unit with whip antenna.

The following integrated transceivers must be located at a distance of 50 to 100 meters:

1. Operator Control Unit (OCU) – Provides control of all transceiver functions. Usually includes a telephone handset, keyboard for frequency selection, a digital frequency display and meters for monitoring equipment performance.

2. Transceiver Unit – Consists the radio transmitter and receiver electronics and control circuitry devices; and

3. Antenna Tuning Unit (ATU) – This special tuning unit enables the signals from the transceiver to be coupled (tuned) to the antenna, usually mounted externally, very close to the antenna.

Frequency selection is usually accomplished with a numeric keyboard. The three principal methods of frequency selection are: by stored ITU channel number for telephone and telex, such as 404 or 120; by memory channel location is provided a number of programmable channels, such as 12 for the 12 MHz distress frequency of 12 290 kHz, etc; and by direct keyboard entry, which transmit and receive frequencies must both be entered separately on the keyboard.

Before a DSC MF/HF radio transceiver can be used, the radio whip antenna must be tuned to the transmitter; then to select a broadcast class for SSB, J3E (telephony), to set NBDP and DSC by F1B, J2B or Telex; to adjust the volume control; to establish a precise adjustment of the amplifier or receiver; to adjust RF gain control and Automatic Gain Control (AGC); and power output control. The Sailor 6350 MF/HF radio provides several unique features such as message replay functionality, and the ability to connect two control units. An efficient power amplifier with control hardware ensures high performance and reliable radio communication in the marine RF bands from 1.6 to 30 MHz, and ensures constant and full output power on all ITU channels.

Figure 9: Maritime SART Units.

Source: Jotron, McMurdo/Musson.

The specifications of this transceiver are as follows: (a) Simplex and semi-duplex SSB radio telephony, DSC, TELEX and AM broadcast reception; (b) Supply voltage Nominal 24V DC; (c) Optional external AC power supply is 115/230V AC 50/60 Hz; (d) Automatic changeover to DC in the absence of AC supply; (e) Power consumption Rx idle, 40W (approx. at 24V DC) using Tx of 500 W is for SSB speech 600 W, for SSB two-tone 1100 W, and for DSC/TELEX 1000 W; (f) This transceiver provides user-programmable channels 199 frequency pairs with mode (1-199), and user-programmable stations 40 stations with name, MMSI and station channel; (g) Frequency range of Rx is 150 kHz to 30 MHz; and (h) Output Rx power is 500 W, but optionally can be 150 or 250 W, [3, 5, 6, 9, 10, 11, 12, 13, 14].

6. Radio Search and Rescue Transponder (SART).

The SART system is for identification of lifeboat, survival craft and Man over Board (MOB) equipped with SART units by the marine surveillance radar onboard ships and aircraft or helicopters during emergency and distress alert. This system can also serve in the special situation when aircraft landing at sea and in this case, aircraft will act as vessel to transmit the alert messages on the designated aeronautical air to ground route frequency and maritime distress frequencies as well. In this situation will also help already mentioned EPIRB for ships distress and ELT for aircraft alert and emergency situations.

In this context will be presented maritime emergency equipment known as SART that can be used for distress of ships and aircraft landed at sea. According to IMO SOLAS requirements SART unit has to be installed on every ship since 2011. In addition, some mini SART units can be discreetly installed onboard ships and powered by long life batteries or by ships supply, so if some pirates capture certain ship, it can be found easily on SART radar display.

1. Jotron R-AIS Search and Rescue Transponder (SART) – Jotron is a manufacturer of SART devices that offers a wide and flexible range of maritime safety products within GMDSS, R-AIS and emergency lights. The Jotron R-AIS SART devices designed and built for harsh maritime and offshore environments, which can be used worldwide on merchant ships, fishing vessels, tug boats, offshore supply vessels, as well as various navy ships and energy installations offshore and onshore. As stated, this units can be also used onboard all kind of aircraft fin distress operations.

The R-AIS SART device is waterproof, and a self contained, waterproof radar transponder intended for emergency use at sea, shown in Figure 9 (Left). The radar-SART is used to ships or helicopter radar display, shown in Figure 9 (Middle Below). A SART will only respond to a 9 GHz X-band (3 cm wavelength) radar within a range of approximately 8 nautical miles (15 kilometers), while the SART unit will not be seen on S-band (10 cm) or other radar. Unique R-AIS technology contribute to a more effective and less time-consuming SAR operation, due to superior position accuracy and that can detects on both R-AIS Class A and B, [www.jotron.com]. Locate a survival craft or distressed vessel by creating a series of dots onboard a rescuing.

Figure 10: Aircraft R-AIS Transponders.

Source: SAAB and Avionetics.

2. McMurdo Portable R-AIS SART – The new Smartfind S5 R-AIS SART is a new manual deployment survivor location device intended for use on life rafts or survival craft. It meets IMO SOLAS requirements and is an alternative to a Radar SART, illustrated in Figure 9 (Middle Above). Moreover, this SART is very suited to be used onboard ships, aircraft and helicopters. In fact, it will be very important to conclude that in an emergency situation when an airplane must land on the sea surface during an extremely dense fog, people with manual R-AIS SART devices on life rafts can easily be detected by radars on ships, helicopters or airplanes, which scenario is shown in Figure 9 (Middle Below),[www.mcmurdomarine.com].

3. Musson 505 R-AIS SART – This Ukrainian product is R-AIS SART device illustrated in Figure 9 (Right). This SART operates in A and B VHF channels of R-AIS inspire of standard SAR radar transponder operating in 9.2-9.5 GHz. This new SART model fully corresponds to IMO, SOLAS and GMDSS requirements. The Musson R-AIS SART 505 transponder uses the built-in GPS Rx module to send messages with coordinates of distress to near R-AIS installed onboard aircraft or ship, [3, 5, 10, 15, 16, 17].

7. Airborne R-AIS Transponder for Maritime SAR Operations.

Maritime SAR missions of the GMDSS network use various R-AIS transponders for enhanced SAR operations, but only two will be introduced in this section.

7.1. SAAB R4A Airborne R-AIS Transponder.

The SAAB class A R-AIS product is specifically designed to support the mariners in mission-critical decision-making during SAR operations of ships and aircraft in distress. Sometimes aircraft landed at sea has to act as ships in distress. This transponder satisfies all carriage requirements, but more importantly it will provide better situation awareness to the ship officer on watch. This transponder represents the latest generation of airborne R-AIS transponders, using state of the art technology to achieve excellent performance, reliability and flexibility. In the any kind of vessel, the unique simplicity and versatility of the man-machine interface will allow the operator to carry out all important tasks required to operate the R-AIS system, using the multipurpose display unit only. In Figure 10 (Left) are shwn SAAB R4 R-AIS transponder and its multipurpose display.

Thus, in the integrated bridge system, the R4 will feed reliable data to virtually any electronic chart system and/or radar, and thus vastly improve the quality of the information presented. However, predefined safety-related text messages will assist in quickly notifying other ships, aircraft and Vessel Traffic Service (VTS) ground stations in distress situations. Furthermore, the R4 vessel transponder offers unprecedented VHF radio coverage, thus allowing the mariner to see further ahead. This transponder is the second generation of SAR solution using the latest technology to achieve the highest performance and reliability. It is the first R-AIS transponder developed specifically for airborne use onboard rescue aircraft and helicopters, meeting the relevant requirements and standards for airworthiness.

7.2. Avionetics TX-20 Airborne R-AIS Transponder.

The Avionetics TX-20 airborne R-AIS radio transponder is certified for installation in fixed wing and rotorcraft aircraft compliant with maritime R-AIS standards, shown in Figure 10 (Right). The R-AIS message exchange with R-AIS vessels, aircraft and ground BS or CRS terminal. These R-AIS units transmits and receives SAR and aircraft R-AIS messages and autonomously monitors all R-AIS equipped vessels from aircraft. It is fully provisioned for interfacing with R-AIS cockpit or cabin display system. Three R-AIS Rx and one Tx are using RF range of 156 - 162.5 MHz and channel spacing at 25/12.5 KHz connected to VHF antenna. It provides data ports 3 I/O RS 422/NMEA 0183, 38400/4800 b/s and is integrated with 12 channels Differential GPS receiver (DGPS), which antenna is connected via TNC antenna connection, [3, 5, 6, 10, 18, 19].

Conclusions.

The future enhanced GMDSS network has to provide integration of radio and satellite CNS systems, which have to ensure rapid automated alerting and Search and Rescue (SAR) operations of ships in distress at sea and inland waters. The main maritime systems, networks and equipment that can be integrated into the GMDSS infrastructure are existing and new projected Radio Distress and Safety Systems (RDSS) and Satellite Distress and Safety Systems (SDSS).

References.

[1] Ilcev M., New Aspects for Modernization Global Maritime Distress and Safety System (GMDSS), TransNav, Vol. 14, No 4, Gdynia, Poland, pp. 991-998, 2020.

[2] IMO, Correspondence Group on GMDSS Modernization, London, UK, 2018.

[3] Ilcev D.S., Global placeMobile Satellite Communications for Maritime, Land and Aeronautical Applications, Volume 1, Theory, Springer, Boston, USA, 2016.

[4] IMO, Review and Modernization of the GMDSS, London, UK, 2012.

[5] CNS Systems, Global Maritime Distress and Safety System (GMDSS), Durban, South Africa, 2012.

[6] ITU, Introduction to GMDSS Network, Geneva, Switzerland, 2020.

[7] Kaplan D.E., Understanding GPS Principles and Applications, Artech House, London, UK, 2006.

[8] Rohde & Schwarz, Antenna Look Angles in the Northern Hemisphere, Munich,Germany, 2020.

[9] CNS Systems, Maritime Radio and Satellite Communication Systems,Durban, South Africa, 2019.

[10] Calcutt D. at al, Understanding GMDSS, Edward Arnold, London, UK, 1994.

[11] Cobham, Maritime Radio GMDSS VHF and R-AIS Transceivers, Fullerton, CA, USA, 2019.

[12] Ilcev M., Modernization of GMDSS System, CNS Systems, Durban, South Africa, 2019.

[13] Cobham, Maritime Radio GMDSS MF/HF DSC Communication Terminals, Fullerton, CA, USA, 2018.

[14] Cobham, Maritime Radio GMDSS NAVTEX and MF/HF Terminals, Fullerton, CA, USA, 2017.

[15] Jotron, Maritime R-AIS SART Terminals, Tjodalyng, Norway, 2012.

[16] McMurdo, Portable R-AIS SART Terminals, Portsmouth, UK, 2015.

[17] Musson Marine, Marine R-AIS SART Terminals, Nikolaev, Ukraine, 2019.

[18] SAAB, Aircraft R-AIS Transponders, pLinkoping, Sweden, 2020.

[19] Avionetics, Aircraft R-AIS Transponders for SAR Mission, Linkoping, Sweden, 2020.