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MARITIME RADIO SYSTEMS FOR DISTRESS ALERTING

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Abstract

The most important function of a maritime radio communication system called the Global Maritime Distress and Safety System (GMDSS) is the distress alerting function. Distress alerting is the rapid and successful reporting of a distress incident to a unit, which can provide or co-ordinate assistance. This would be a rescue co-ordination centre (RCC) or another ship in the vicinity. The article presents and evaluates the technical and operational possibilities of the maritime radio systems for a distress alerting. Especially the basic functional requirements and regulations for GMDSS referring to the maritime radio systems for distress alerting, resulting from the provisions of the International Convention for the Safety of Life at Sea (SOLAS) and Radio Regulations have been described. The article presents the role of the maritime radio systems for a distress alerting in the shipping and GMDSS as well. A current status and analysis of the systems responsible for distress alerting has been made. In this context, the operation, methods and ranges of transmitting and receiving the distress alerts by the INMARSAT system, COSPAS-SARSAT system and Digital Selective Calling (DSC) system have been described. The article also outlines the future of the maritime radio systems for a distress alerting. In this context, the two projects under the name of „E-navigation" and „The modernization of the GMDSS", currently being implemented in the framework of the International Maritime Organization (IMO) by the Sub-Committee on Navigation, Communications and Search and Rescue (NCSR), have been presented as well.

Keywords: *communication systems, maritime distress communication, maritime distress alerting*

1. Introduction

Marine radio was first installed on ships around the turn of the 20th century. In those early days, radio was used primarily for transmission and reception of passenger telegrams. The disaster of *RMS Titanic* brought about a number of fundamental changes to maritime radio communication. First of all, the basic principles to ensure the ship's distress communication have been established. The *RMS Titanic* disaster also served as the catalyst for the introduction of the International Convention for the Safety of Life At Sea (the SOLAS Convention) of which the maritime radio communication was an important element.

Since that time, the maritime radio communication has developed both in terms of applied technology and communication procedures. In 1988, the Conference of Contracting Governments to the SOLAS Convention on the Global Maritime Distress and Safety System (GMDSS Conference) organized by the International Maritime Organization (IMO) adopted amendments to the SOLAS Convention concerning radio communications for the GMDSS [4]. These amendments entered into force on 1 February 1992, and the GMDSS was fully implemented on 1 February 1999. The basic goal of the introduction of the GMDSS system was to improve the safety of ships in the area of radio communications by the use of terrestrial digital and satellite systems. Obviously, since implementation of the GMDSS some changes both of the technical and regulatory nature have occurred. Recent years have brought a new threat to shipping which are pirate and terrorist attacks. In response to this threat, the IMO has taken action to protect ships, including the use of appropriate communication systems [7].

Technological advances in the field of radio communications and information also affects the changes in the marine equipment and radio communication systems. Taking into account these changes IMO began work on two projects under the name of „E-navigation" and, as a consequence of the first, „Modernization of the GMDSS". Without a doubt, the communication systems for distress alerting will play a significant role in these projects.

Principal functional requirements of the GMDSS

The original concept of the GMDSS is that search and rescue authorities ashore, as well as shipping in the immediate vicinity of the ship in distress, will be rapidly alerted to a distress incident so they can assist in a coordinated search and rescue (SAR) operation with the minimum delay. The system also provides for urgency, safety (including the promulgation of maritime safety information – MSI [8]) and public communications.

The GMDSS lays down nine principal communications functions, which all ships, while at sea, need to be able to perform [4]:

1. transmitting ship-to-shore distress alerts by at least two separate and independent means, each using a different radio communication service;
2. receiving shore-to-ship distress alerts;
3. transmitting and receiving ship-to-ship distress alerts;
4. transmitting and receiving search and rescue co-ordinating communications;
5. transmitting and receiving on-scene communications;
6. transmitting and receiving signals for locating;
7. transmitting and receiving maritime safety information;
8. transmitting and receiving general radio communication to and from shore-based radio systems or networks; and
9. transmitting and receiving bridge-to-bridge communications.

From the point of view of the safety of people and the sea-going ships, among above-mentioned functions, the most important function is the transmission and reception of the distress alerts (functions 1-3).

Distress alerting is the rapid and successful reporting of a distress incident to a unit, which can provide or co-ordinate assistance. This would be a rescue co-ordination centre (RCC) or another ship in the vicinity. When an alert is received by an RCC, normally via a coast station or a land earth station (LES), the RCC will relay the alert to SAR units and to ships in the vicinity of the distress incident.

In the GMDSS, distress alert functions are implemented by Digital Selective Calling (DSC), Cospas-Sarsat, and Inmarsat systems.

Up to date equipment and systems used in the GMDSS, with pointing the distress alerting systems, are showed in Fig. 1. Used in Fig. 1 devices and systems abbreviations mean:

- MES – Inmarsat Mobile Earth Station,
- LES – Inmarsat Land Earth Station,
- EPIRB – Emergency Position Indicating Radio-Beacon,
- LUT – COSPAS/SARSAT Local User Terminal,
- DSC – Digital Selective Calling,
- NBDP – Narrow Band Direct Printing,
- RTF – Radiotelephony,
- GNSS – Global Navigation Satellite System for support (mainly GPS – Global Positioning System),
- SARLD – Search and Rescue Locating Device,
- NAVTEX System,
- RCC – Rescue Coordination Centre,
- SAR – Search and Rescue Service,
- MF – Medium Frequency,

– HF – High Frequency,
– VHF – Very High Frequency.

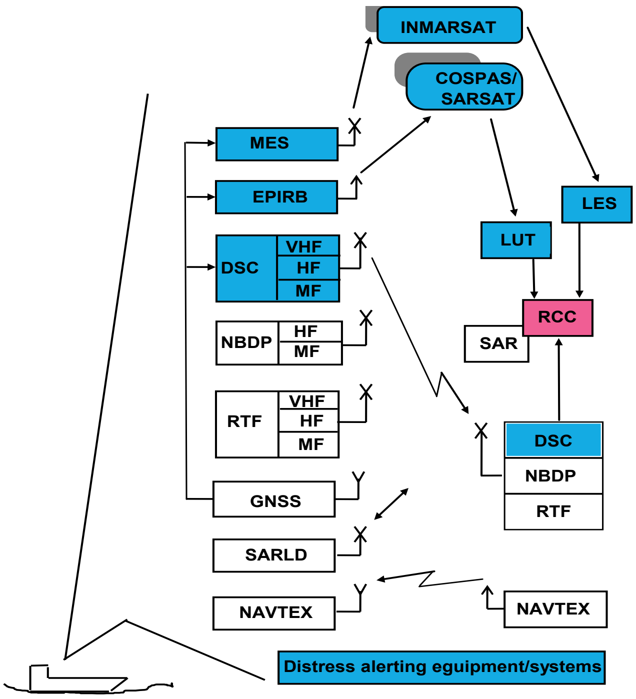

Fig. 1. Radio communication equipment and systems used for distress alerting

Sea Areas

The GMDSS is based on the concept of using four marine communication sea areas to determine the operational, maintenance and personnel requirements for maritime radio communications. Their definitions are as follows [4]:

– sea area A1 means an area within the radiotelephone coverage of at least one VHF coast station in which continuous DSC alerting is available:
– sea area A2 means an area, excluding sea area A1, within the radiotelephone coverage of at least one MF coast station in which continuous DSC alerting is available;.
– sea area A3 means an area, excluding sea areas A1 and A2, within the coverage of an Inmarsat geostationary satellite in which continuous alerting is available; and
– sea area A4 means an area outside sea areas A1, A2 and A3.

It should be emphasized that equipment carriage requirements for ships at sea (including systems for distress alerting) depend upon the sea area in which the ship is sailing.

2. Distress alerting

Distress alert is a short message indicating that the ship is in distress situation, it contains only ship's identification, position (from GNSS) and, if time permits, nature of distress (chosen by the ship GMDSS operator). The list of nature of distress is approved by IMO and includes:

– undesignated distress,
– fire, explosion,
– flooding,
– collision,
– grounding,
– listing, danger of capsizing,
– sinking,
– disabled and adrift,

– abandoning ship,
– piracy/armed robbery attack,
– man overboard,
– EPIRB emission.

Distress alert is transmitted in a very simple way just by pressing so called „distress button" (sometimes also called „a red button") (Fig. 2). As already mentioned, a distress alert function is implemented by the DSC, Cospas-Sarsat, and Inmarsat systems.

Fig. 2. Front panel of SAILOR 6103 alarm panel

3. Digital selective calling system

Digital selective calling (DSC) system is designed for automatic station calling and distress alerting. Each call consists of a packet of digitized information [6]. DSC calls can be routed to all stations (e.g. when distress alert is transmitted), to an individual station or to a group of stations. Ships and coast stations in the MF (Medium Frequency), HF (High Frequency), and VHF (Very High Frequency) maritime communication bands use the system. Shas's DSC distress alert via the MF (communication range up to 200 nautical miles), HF (long-range communication), or VHF (communication range up to 50 nautical miles) coast stations is passed to the associated Rescue Coordination Centre – RCC (Fig. 1). Fig. 3 presents the front panel of the MF/HF DSC SAILOR 6301 radio station with a built-in distress button.

Fig. 3. Front panel of the MF / HF radio station with DSC SAILOR 6301

4. Cospas-Sarsat system

Cospas-Sarsat system is a satellite system designed to provide distress alert and location data to assist SAR operations, using spacecraft and ground facilities to detect and locate the signals of distress beacons operating on 406 Megahertz (MHz) [1]. The responsible Cospas-Sarsat Mission Control Centre (MCC) forwards the position of the distress and other related information to the appropriate RCC. The Cospas-Sarsat System is composed of (Fig. 4) [1]:

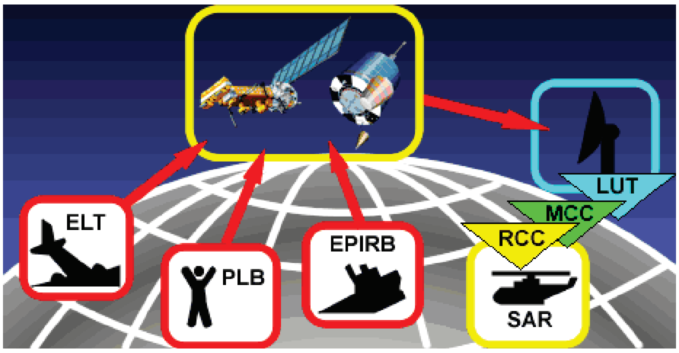

Fig. 4. Cospas-Sarsat system overview [1]

– radio beacons carried aboard ships – EPIRBs (Emergency Position Indicating Radio Beacons), aircraft – ELTs (Emergency Locator Transmitters), or used as personal locator beacons – PLBs,
– polar-orbiting satellites in low Earth orbit from the LEOSAR system and geostationary satellites from the GEOSAR system, and
– the associated Local User Terminals (LUTs) for the satellite systems (referred to as LEOLUTs or GEOLUTs) and Mission Control Centres (MCCs).

The Cospas-Sarsat LEOSAR system uses polar-orbiting satellites and, therefore, operates with basic constraints, which result from non-continuous coverage provided by LEOSAR satellites. The use of low-altitude orbiting satellites provides for a strong Doppler effect in the up-link signal thereby enabling the use of the Doppler positioning techniques. It also provides global coverage.

The GEOSAR system consists of repeaters carried on board various geostationary satellites and the associated GEOLUTs, which process the satellite signal. Since GEOSAR satellites remain fixed relative to the Earth, there is no Doppler effect on the received frequency and, therefore, the Doppler positioning technique cannot be used to locate distress beacons. To provide rescuers with position information, the beacon location has to be acquired by the beacon through an internal or an external navigation receiver and encoded in the beacon message. It provides near-global coverage (between 70 degrees south and north).

5. Inmarsat system

Inmarsat system is the only satellite system that meets GMDSS requirements. The Inmarsat system has three major components [2]: the space segment provided by Inmarsat, the Land Earth Stations (LESs) provided by Inmarsat signatories and Mobile Earth Stations (MESs) located e.g. on board ships. The nerve centre of the system is the operations control centre (OCC), located at Inmarsat's headquarters in London. The OCC is responsible for controlling the Inmarsat system operation as a whole. Four satellites in geostationary orbit 36,000 km above the equator cover four ocean regions, namely AOR-E (Atlantic Ocean Region-East), AOR-W (Atlantic Ocean Region-West), IOR (Indian Ocean Region), and POR (Pacific Ocean Region), and provide near-global coverage. In every ocean region, communication is coordinated by the Network Coordination Station (NCS). The coverage of the Inmarsat system is given in Fig. 5 [2].

GMDSS-compliant ships are able to send a distress alert – which is automatically given priority access to an RCC on shore - by pressing a dedicated distress button (Fig. 1). At present, among the various Inmarsat systems these requirements meet only Inmarsat C and Inmarsat Fleet 77.

The Inmarsat-C system was introduced in 1991. It does not provide voice communications but is a means of sending distress alert, text and e-mail messages to and from shore-based subscribers using a *store-and-forward* technique. Distress alert is transmitted via the land earth station operator (LES) directly to RCC. The global communications capability of the Inmarsat-C system, combined with its distress alerting and MSI broadcasts capabilities, has resulted in the Inmarsat-C system being accepted by the IMO as meeting the requirements of the GMDSS. The small size makes the Inmarsat-C especially suitable for smaller vessels, such as yachts, fishing vessels or supply craft but it is also widely used on large ships.

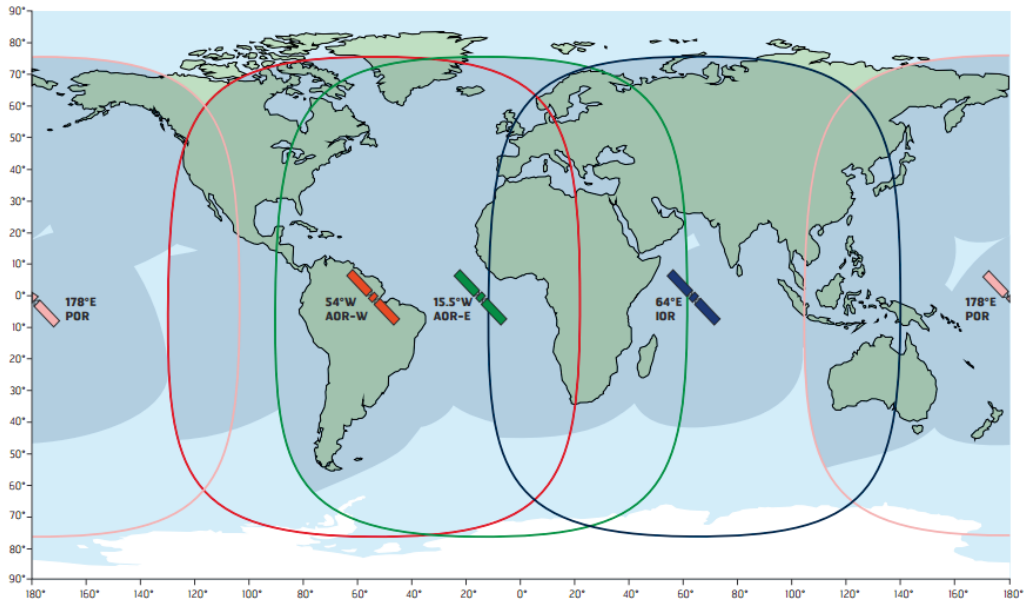

Fig. 5. The Inmarsat satellite coverage [2]

The Inmarsat Fleet 77 system, besides distress alerting, offers a unique high performance service for high-speed shore-to-ship and ship-to-shore communications. It introduces a new Mobile ISDN and Mobile Packet Data Service (MPDS) delivering voice, fax, and data at speeds of up to 64 kbit/s. Fleet 77 provides improved voice distress and safety services. This means that routine and non-essential traffic can be pre-empted to allow distress, safety, or urgent calls to be received or sent instantaneously by a ship equipped with the system [3].

In general, Inmarsat Fleet 77 equipment consists of a parabolic antenna, a power supply unit, a transceiver, a PC, a keyboard, a printer, and a control unit. The control unit contains a distress button, a display, control buttons, and a handset (Fig. 6).

It should be noted that the Inmarsat has informed of its intention to close, with effect from 1 December 2020, the Inmarsat Fleet 77 service.

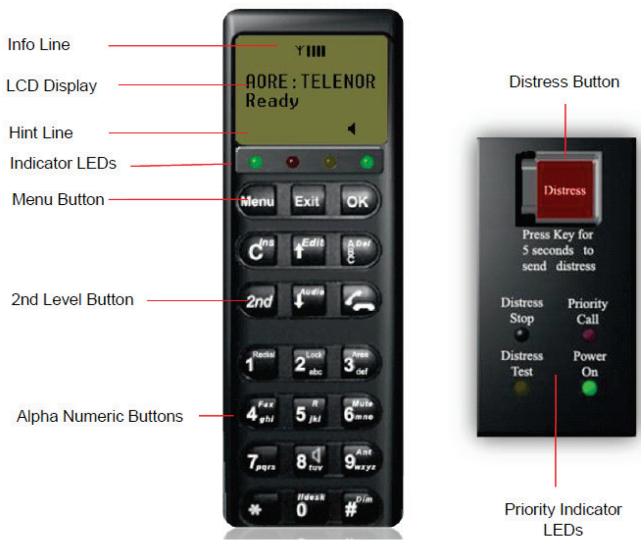

Fig. 6. Exemplary Inmarsat Fleet 77 SAILOR control unit

6. Future of the maritime radio systems for distress alerting

It can be stated that today‘s communication systems for maritime distress alerting, as a whole, are a complementary system well fulfilling the expected goals. Further increase of the safety of navigation can only be achieved by implementing new communication and information technology. Considering the above, in 2006, IMO began work on the „E-navigation“ project. Doubtless, one of the fundamental elements of e-navigation will be a data communication network based on the GMDSS infrastructure so, in 2012, IMO decided to start work on the new project: „Modernization of the GMDSS“. E-navigation is defined as *the harmonised collection, integration, exchange, presentation, and analysis of maritime information by electronic means to enhance berth-to-berth navigation for safety and security at sea and protection of the marine environment*. IMO has set a strategy on five solutions to provide a basis for supporting e-navigation [5]:

- S1: Improved, harmonization and user-friendly bridge design,
- S2: Means for standardized and automatic reporting,
- S3: Improved reliability, resilience and integrity of bridge equipment and navigational information,
- S4: Integration and presentation of available information in graphical displays received via communication equipment, and
- S5: Improved communication of VTS service portfolio.

In addition to other things, the solutions S2 and S4 are designed to improve communication between ship and shore for distress purposes. The implementation of e-navigation involves the development of distress communication by integration all relevant ships sensors and supporting information.

The GMDSS was developed by IMO during 1980s and fully implemented on 1 February 1999. Therefore, it is quite an old system. Therefore, in 2012, a draft timetable for bringing the GMDSS up to date was agreed by the IMO. Modernization plan envisages a fully comprehensive review of the GMDSS requirements, contained in SOLAS chapter IV (Radio communications), to take place over a three-year period (2013–2016), followed by a further two-year period (2016-2018) for the GMDSS modernization plan, to be succeeded by the development of legal instruments, the revision or development of relevant performance standards and an implementation period (full implementation of the modernized GMDSS is expected to 2024).

The most important decisions taken so far by the IMO include a change to the definition of the sea area A3 and an introduction of a new function regarding communication related to the security of the ship. The new definition of the sea area A3 is following:

Sea area A3 means an area, excluding sea areas A1 and A2, within the coverage of a recognized mobile satellite communication service supported by the ship earth station carried on board in which continuous alerting is available.

This new definition of the sea area A3 will allow new satellite operators to be added to the GMDSS system, including those operating in local areas.

Parallel to the work on the above-mentioned projects, the work on new, specific solutions for these projects is underway, for example, the recognition of Iridium and Inmarsat FleetBroadband satellite operators as meeting the GMDSS requirements. It is also worth noting the work on the new Cospas-Sarsat system called MEOSAR (Medium-altitude Earth Orbit for SAR). Once fully operational, the MEOSAR system will provide global coverage and near-real-time beacon detection and independent location. It will complement the existing LEOSAR and GEOSAR systems. The MEOSAR system will facilitate other planned enhancements for Cospas-Sarsat beacons, such as a return-link-service (RLS) transmission to a distress beacons that will provide, for example, the user with a confirmation that the distress message has been received. It is expected, that the MEOSAR system will be declared at full operational capability (FOC) in 2018. The MEOSAR system concept is shown in Fig. 7 [1].

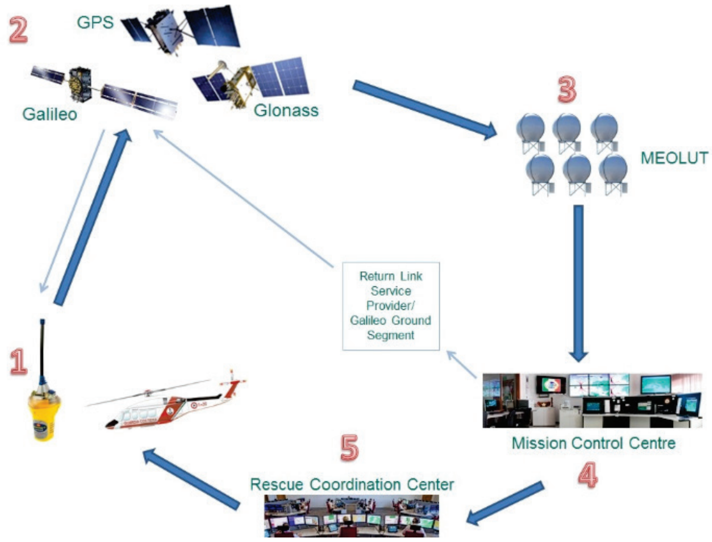

Fig. 7. The MEOSAR System Concept [1]

7. Conclusions

The above carried out analysis shows that at present communication systems for maritime distress alerting, as a whole, are a complementary system well fulfilling the expected goals. It should be noted that the satellite systems (Inmarsat and Cospas-Sarsat) play a key role in the subject. A major benefit of the satellite distress priority systems is to render it unnecessary to allocate dedicated frequencies for distress, safety and security communications and the global coverage. An additional benefit of the Inmarsat system is the ability to conduct further distress communication in a distress situation (by means of radiotelephony or text transmission).

According to the author opinion, further increase of the safety of navigation can only be achieved by implementing new communication and information technology. It will be possible within the framework of two projects carried out by the IMO on „E-navigation“ and „Modernization of the GMDSS“. The examples of the use of new satellite systems show that these systems have a significant interest in improving the safety of navigation. In this sense, it can be seen as a new means of distress alerting that will help to develop the GMDSS system. A good example of the implementation of this project can be presented MEOSAR system.

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