

Yesterday, Today and Tomorrow of the GMDSS

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ABSTRACT: Basing on a general concept, the main functions and the international requirements the Global Maritime Distress and Safety System (GMDSS) have been presented. The modifications of the system since its implementation and its current status have been described. The future of the GMDSS has been discussed as well.

1 INTRODUCTION

In 1988, the Conference of Contracting Governments to the 1974 SOLAS Convention on the Global Maritime Distress and Safety System (GMDSS) adopted amendments to the 1974 SOLAS Convention concerning radiocommunications for the GMDSS. These amendments entered into force on 1 February 1992. On 1 February 1999 the GMDSS has become implemented for all SOLAS ships.

Since full implementation of the GMDSS some changes both of regulatory and technical nature have occurred.

The Maritime Safety Committee (MSC) at its 81st session decided to include, in the work programmes of the NAV and Radiocommunications and Search and Rescue (COMSAR) Sub-Committees, a high priority item on "Development of an e-navigation strategy". One of the fundamental elements of e-navigation will be a data communication network based on the some GMDSS infrastructure elements. It follows that question on modernization of the GMDSS is legitimate.

2 THE ORIGINAL CONCEPT 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 operation

with the minimum delay. The system also provides for urgency and safety communications and the promulgation of maritime safety information (MSI) (Czajkowski, 2000).

2.1 *Functional requirements*

The GMDSS lays down nine principal communications functions which all ships, while at sea, need to be able to perform (IMO, 2004):

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

2.2 Radiocommunication services

The following radio services are provided for the GMDSS:

- a radiocommunication service utilizing geostationary satellites in the maritime mobile satellite service (INMARSAT);
- a radiocommunication service utilizing polar orbiting satellites in the mobile satellite service (COSPAS-SARSAT);
- a radiocommunication service for transmitting signals from survival craft stations in the 9200 – 9500 MHz band;
- the maritime mobile service in the bands between 156 MHz and 174 MHz (VHF);
- the maritime mobile service in the bands between 4,000 kHz and 27,500 kHz (HF);
- the maritime mobile service in the bands 415 kHz to 535 kHz and 1,605 kHz to 4,000 kHz (MF).

2.3 GMDSS Sea areas

Radiocommunication services incorporated in the GMDSS system have individual limitations with respect to the geographical coverage and services provided. The range of communication equipment carried on board the ship is determined not by the size of the ship but by the area in which it operates. Four sea areas for communications within the GMDSS have been specified by the IMO. These areas are designated as follows (IMO, 2004):

- Sea area A1 – an area within the radiotelephone coverage of at least one VHF coast station in which continuous DSC alerting is available.
- Sea area A2 – 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 – an area, excluding sea areas A1 and A2, within the coverage of an INMARSAT geostationary satellite in which continuous alerting is available.
- Sea area A4 – an area outside sea areas A1, A2 and A3 (the polar regions north and south of 75° latitude, outside the INMARSAT satellite coverage area).

2.4 Equipment carriage requirements

Based on the range limitations of each radiocommunication service the four sea areas have been defined according to the coverage of VHF, MF, HF Coast Radio Services and Inmarsat services. The type of radio equipment required to be carried by a ship is therefore determined by the sea areas through which a ship travels on its voyage.

2.5 GMDSS equipment and systems

The following equipment and systems are provided for the GMDSS (Fig. 1):

- DSC - Digital Selective Calling;
- INMARSAT Satellite System;
- EPIRB - Emergency Position Indicating Radio-Beacon (Inmarsat E, Cospas/Sarsat and VHF DSC);
- SARTs - Search And Rescue Transponders;
- NAVTEX System;
- NBDP - Narrow Band Direct Printing;
- RTF - Radiotelephony;
- DMC - Distress Message Control;
- navigational equipment (for support).

Other elements of GMDSS to be showed in Fig. 1 stand for as follows:

- CES - INMARSAT *Coast Earth Station*;
- SES - INMARSAT *Ship Earth Station*;
- LUT - COSPAS/SARSAT *Local User Terminal*;
- RCC - *Rescue Coordination Centre*.

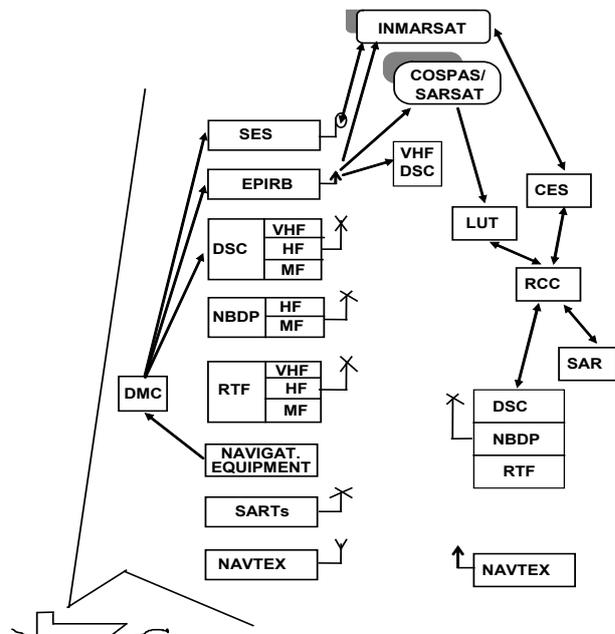


Figure 1. GMDSS equipment and systems (Korczyński, 2007)

2.5.1 DSC specification

Digital selective calling (DSC) is designed for automatic station calling and distress alerting. Each call consists of a packet of a digitized information. DSC calls can be routed to all stations, to an individual station or to a group of stations.

The system is used by ships and coast stations in the MF, HF and VHF maritime communication bands.

The system is a synchronous system using characters composed from a ten bit error-detecting code. The first seven bits are information bits. The last three bits are used for error-detection. Each character is sent twice but separated in time and a message check character added at the end of the call.

Technical characteristics and operational procedures for the use of DSC equipment are described in the following documents:

- Recommendation ITU-R M.493 ‘Digital selective calling system for use in the Maritime Mobile Service’.
- Recommendation ITU-R M.541 ‘Operational procedures for the use of digital selective-calling (DSC) equipment in the Maritime Mobile Service’.

2.5.2 *Inmarsat specification*

The original concept of the GMDSS includes three Inmarsat services: A, B and C.

Inmarsat A provides two-way direct-dial phone connection as well as fax, telex and data services at rates between 9.6kbps up to 64kbps.

Inmarsat B was first maritime digital service, launched in 1993, and remains a core service for the maritime industry. It supports global voice, telex, fax and data at speeds from 9.6kbps to 64kbps, as well as GMDSS - compliant distress and safety functions.

Inmarsat C is one of the most flexible mobile satellite message communication systems, it has the ability to handle commercial, operational and personal messages just as easily as distress and safety communications.

It offers two-way, store-and-forward packet data communication via a lightweight, low-cost terminal. Inmarsat C is recommended for the any of the following applications:

- E-mail and messaging
- Fax and telex
- SMS text
- Remote monitoring
- Tracking
- Chart and weather updates
- Maritime safety information
- GMDSS
- SafetyNET and FleetNET

2.5.3 *NBDP specification*

The Narrow Band Direct Printing – **NBDP** (radiotelex) systems employs error correction in the form of ARQ (*Automatic Retransmissions Request*) and FEC (*Forward Error Correction*). The technical details of the error correction are defined by the ITU-R in Recommendation M.476 and the Recommendation M.625. Radiotelex is also known as Telex Over Radio (TOR).

2.5.4 *NAVTEX specification*

International **NAVTEX** (NAVigational TeLEX) service means the co-ordinated broadcast and automatic reception on the frequency 518 kHz of mari-

time safety information (MSI) by means of Narrow Band Direct Printing (NBDP-FEC) telegraphy. The operational and technical characteristics of the NAVTEX system are contained in Recommendation ITU-R M.540. Performance standards for shipborne narrow-band direct-printing equipment are laid down in IMO Assembly resolution A.525(13).

The principal features of NAVTEX service are as follows:

- the service uses a single frequency (518 kHz) on which coast stations transmit information in English on a time-sharing basis to prevent mutual interference; all necessary information is contained in each transmission;
- the power of each coast station transmitter is regulated so as to avoid the possibility of interference between coast stations; Navtex transmissions provide a range of about 250 to 400 nautical miles;
- dedicated Navtex receivers are used on the board of the ships; they have the ability to select messages to be printed, according to a technical code (B1B2B3B4) which appears in the preamble of each message.

3 LAST DECADE GMDSS MODIFICATION

The last decade modification of the GMDSS has concerned both technical and regulatory issues.

3.1 *Technical modification of GMDSS*

The most important GMDSS modification has concerned the Inmarsat. In 1999, Inmarsat became the first intergovernmental organisation to transform into a private company and, in 2005, was floated on the London Stock Exchange. It caused that at present Inmarsat is recognised as a leader in mobile satellite communication field.

Inmarsat Fleet service provides both ocean-going and coastal vessels with comprehensive voice, fax and data communications. At present the Fleet range of services includes:

- Fleet 77
- Fleet 55
- Fleet 33

Inmarsat Fleet 77 has been introduced in 2002, and Inmarsat Fleet 55 and 33 in 2003.

Inmarsat Fleet's high-quality Mobile ISDN and cost-effective IP-based Mobile Packet Data Services offer unparallel connectivity for access to e-mail and the Internet, weather updates, video conferencing and vessel monitoring systems.

Fleet 33 offers global voice as well as fax and a choice of data communications at up to 9.6kbps.

Fleet 55 offers global voice and high-speed fax and data services at up to 64kbps.

Fleet 77 is Inmarsat's most advanced maritime service, providing global voice and high-speed fax and data services at up to 128kbps. It fully supports the GMDSS and includes advanced features such as emergency call prioritization, as stipulated by IMO Resolution A.1001 (25). *Fleet F77* also helps meet the requirements of the International Ship and Port Facility Security (ISPS) code, which enables the cost-effective transfer of electronic notices of arrival, crew lists, certificates and records.

Inmarsat Fleet series are recommended for the applications showed in Table 1.

Table 1. Applications of Inmarsat Fleet series

	Fleet 33	Fleet 55	Fleet 77
Data transfer	+	+	+
Internet	+	+	+
E-mail and messaging	+	+	+
Fax	+	+	+
SMS text	+	+	+
Voice	+	+	+
Crew calling	+	+	+
Encryption	-	-	+
Videoconferencing	-	-	+
Remote monitoring	+	+	+
Weather updates	+	+	+
Telemedicine	+	+	+
GMDSS functions	-	-	+

Because *Fleet 77* is IP compatible, it supports an extensive range of commercially available off-the-shelf software, as well as specialized maritime and business applications. *Fleet 77* also ensures cost-effective communications by offering the choice of Mobile ISDN or MPDS channels at speeds of up to 128kbps.

FleetBroadband is Inmarsat's next generation of maritime services delivered via the Inmarsat-4 satellites. It is commercially available since the second half of 2007. The service is designed to provide the way forward for cost-effective, high-speed data and voice communications (Table 2).

Users have the choice of two products (FB250 and FB500). Both use stabilized, directional antennas, which vary in size and weight. The above deck antennas are smaller than other Fleet products.

Table 2. FleetBroadband performance capabilities

	FB250	FB500
Data		
Standard IP	Up to 284kbps	Up to 432kbps
Streaming IP	32, 64, 128kbps	32, 64, 128, 256kbps
ISDN	-	64kbps
Voice	4kbps and digital 3.1kHz audio	
Fax	Group 3 fax via 3.1kHz audio	
SMS	Standard 3G (up to 160 characters)	

Antenna		
Diameter from	25cm	57cm
Height from	28cm	68cm
Weight from	2.5kg	18kg

FleetBroadband supports an extensive range of commercially available, off-the-shelf software, as well as specialized user applications. It is ideal for:

- Email and webmail
- Real-time electronic chart and weather updates
- Remote company intranet and internet access
- Secure communications
- Large file transfer
- Crew communications
- Vessel/engine telemetry
- SMS and instant messaging
- Videoconferencing
- Store and forward video.

It should be also noted that **Inmarsat E** service ceased to be supporting GMDSS in 2006 and **Inmarsat A** service – in 2007.

In the same time, instead of the Inmarsat E service, the new Cospas-Sarsat Geostationary Search and Rescue System (**GEOSAR**) has been introduced as completion of the Low-altitude Earth Orbit System (LEOSAR). These two Cospas-Sarsat systems (GEOSAR and LEOSAR) create the complementary system assists search and rescue operations (SAR).

As the result of the hard work of International Maritime Organization (IMO) other two new systems have been introduced:

- Ship Security Alert System – **SSAS** (in 2004),
- Long-Range Identification and Tracking of ships – **LRIT** (in 2009).

Although the above mentioned systems are not a part of the GMDSS, in the direct way they use its communication means.

At the end it's worth to note that the International Cospas-Sarsat System has ceased satellite processing of **121.5/243 MHz beacons** on 1 February 2009 and that on 1.01.2010 AIS-Search and Rescue Transmitter (**AIS-SART**) have been introduced as well.

3.2 Regulatory modification of GMDSS

At a regulatory level a modification of the GMDSS is coordinated by two international organizations: International Maritime Organization (IMO) and International Telecommunication Union (ITU).

IMO modifications are mainly concerning to the amendments to Chapter IV of the International Convention for the Safety of Life At Sea (SOLAS) and to the IMO resolutions.

From the Radiocommunication point of view, the most important modification was adoption by IMO

of Resolution A.1001(25) dated 29.11.2007 on Criteria for the Provision of Mobile Satellite Communication Systems in the GMDSS and revision of Chapter IV of IMO SOLAS Convention extends the International Mobile Satellite Organization (IMSO) oversight to GMDSS Services provided by **any satellite operator** which fits criteria.

ITU modifications are mainly concerning to the amendments to Radio Regulations. These amendments were adopted by two World Radiocommunication Conferences (**WRC**).

The first World Radiocommunication Conference took place in 2003 (WRC-03) and in the field of maritime radiocommunication it took up following main issues:

- to consider Appendix **13** and Resolution **331 (Rev.WRC-97)** with a view to their deletion and, if appropriate, to consider related changes to Chapter VII and other provisions of the Radio Regulations, as necessary, taking into account the continued transition to an introduction of the Global Maritime Distress and Safety System (GMDSS) (Agenda Item 1.9);
- to consider the results of studies, and take necessary actions, relating to exhaustion of the maritime mobile service identity numbering resource (Resolution **344 (WRC-97)**) (Agenda Item 1.10.1);
- to consider the results of studies, and take necessary actions, relating to shore-to-ship distress communication priorities (Resolution **348 (WRC-97)**) (Agenda Item 1.10.2);
- to consider measures to address harmful interference in the bands allocated to the maritime mobile and aeronautical mobile (R) services, taking into account Resolutions **207 (Rev.WRC-2000)** and **350 (WRC-2000)**, and to review the frequency and channel arrangements in the maritime MF and HF bands concerning the use of new digital technology, also taking into account Resolution **347 (WRC-97)** (Agenda Item 1.14).

The second World Radiocommunication Conference took place in 2007 (WRC-07) and the main maritime radiocommunication items were as follows (ITU, 2008):

- taking into account Resolutions **729 (WRC-97)**, **351 (WRC-03)** and **544 (WRC-03)**, to review the allocations to all services in the HF bands between 4 MHz and 10 MHz, excluding those allocations to services in the frequency range 7000-7200 kHz and those bands whose allotment plans are in Appendices **25**, **26** and **27** and whose channelling arrangements are in Appendix **17**, taking account the impact of new modulation techniques, adaptive control techniques and the spectrum requirements for HF broadcasting (Agenda Item 1.13);

- to review the operational procedures and requirements of the Global Maritime Distress and Safety System (GMDSS) and other related provisions of the Radio Regulations, taking into account Resolutions **331 (Rev.WRC-03)** and **342 (Rev.WRC-2000)** and the continued transition to the GMDSS, the experience since its introduction, and the needs of all classes of ships (Agenda Item 1.14);
- to consider the regulatory and operational provisions for Maritime Mobile Service Identities (MMSIs) for equipment other than shipborne mobile equipment, taking into account Resolutions **344 (Rev.WRC-03)** and **353 (WRC-03)** (Agenda Item 1.16).

4 FUTURE OF GMDSS

In Author's opinion, the future of the GMDSS is closely connected with the development of the e-navigation project and with a role of the GMDSS in this process.

For realizing the full potential of e-navigation, the following three fundamental elements should be in place (Korcz, 2009):

- 1 Electronic Navigation Chart (ENC) coverage of all navigational areas;
- 2 a robust electronic position-fixing system (with redundancy); and
- 3 an agreed infrastructure of communications to link ship and shore.

It is envisaged that a data communication network will be one of the most important parts of the e-navigation strategy plan.

In order to realize efficient and effective process of data communication for e-navigation system, the existing radio communication equipment on board (GMDSS), as well as new radio communication systems should be recognized.

The above mentioned GMDSS MF, HF and VHF equipment and systems (Fig. 1) can be also used as a way of data communication for the e-navigation system, provided that this equipment will be technically improved by means of:

- digitization of the analogue communication MF, HF and VHF channels;
- application of high-speed channel to GMDSS;
- utilization of SDR (Software Defined Radio) technology;
- adaptation of IP (Internet Protocol) technology to GMDSS;
- integration of user interface of GMDSS equipment; and
- any other proper technology for GMDSS improvement.

This technical improvement of GMDSS equipment may mean the potential replacement of the conventional equipment by *virtual* one.

In this approach to development of e-navigation it is very important that the integrity of GMDSS must not be jeopardized.

With respect to the radiocommunication aspects required for e-navigation (modernization process), the following should be taken into account as well :

- autonomous acquisition and mode switching;
- common messaging format;
- sufficiently robust;
- adequate security (e.g. encryption);
- sufficient bandwidth (data capacity);
- growth potential;
- automated report generation;
- global coverage (could be achieved with more than one technology).

The next ITU World Radiocommunication Conference will take place in 2012 (WRC-12) and the main maritime radiocommunication items which will be discussed are following (COMSAR 15, 2011):

- to revise frequencies and channelling arrangements of Appendix 17 to the Radio Regulations, in accordance with Resolution **351 (Rev.WRC-07)**, in order to implement new digital technologies for the maritime mobile service; and
- to examine the frequency allocation requirements with regard to operation of safety systems for ships and ports and associated regulatory provisions, in accordance with Resolution **357 (WRC-07)**.

From among other announcements concerning the future GMDSS modification the following should be given:

- the new Arctic NAVAREAs/METAREAs are expected to be transitioned to Full Operational Capability (FOC) on 1 June 2011;
- the new Arctic NAVAREAs/METAREAs are expected to be transitioned to Full Operational Capability (FOC) on 1 June 2011;
- Inmarsat Global Limited (Inmarsat) has informed of its intention to close the Inmarsat-B Service from 31 December 2014;
- the new Cospas-Sarsat MEOSAR system will be probably full operational on 2018.

5 CONCLUSIONS

Twelve years have passed since the time when the Global Maritime Distress and Safety System (GMDSS) became introduced. Planning for the

GMDSS started more than 25 years ago, so elements of it have been in place for many years.

There have been numerous advances in the use of maritime radiocommunication to maritime safety, security and environmental protection during this period. But now there are some obsolete GMDSS equipment and systems or the ones that have seldom or never been used in practice.

On the other hand there are a lot of new digital and information technologies.

Not only in the Author's opinion, the time is ripe to start the wide discussion on what the real condition and needs of the marine radiocommunication are, in particular with reference to the current discussion on the e-navigation strategy.

During this work it is necessary first to identify real user needs and secondly to realize that the modernization of the maritime radiocommunication should not be driven by technical requirements. In addition, it is necessary to ensure that man-machine-interface and the human element will be taken into account including the training of personnel.

The lessons learnt from the original development and operation of GMDSS should be taken into account in the modification of GMDSS as well.

Furthermore a systematic process is needed to review and modify the GMDSS to ensure it remains modern and fully responsive to changes in requirements and evolutions of technology and it will meet the expected e-navigation requirements.

For assuming this process a mechanism for continuous evolution of the GMDSS in a systematic way should be created.

At the beginning, for synchronization of this work a **work plan** for the process of the review and modernization of the GMDSS should be established, taking into account the above mentioned issues.

A framework document which defines timescales of this work should be recognized as well.

And finally it should be noted that a key to the success of the review and modernization process is not only that the work is completed on time, but also that it has the flexibility to implement changes ahead of schedule.

In the above context further it should be noted that the Sub-Committee on radiocommunications and search and rescue (COMSAR) since its last session in 2010 (COMSAR 14) has started work on issue *the Scoping Exercise to establish the need for a review of the elements and procedures of the GMDSS*. Finish of this process is planned on COMSAR 16 in 2012 and it is expected that as the result of this work a lot of answers will be given on the fu-

ture process of the review and modernization of the GMDSS (COMSAR 14, COMSAR 15).

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