# GMDSS as a Data Communication Network for E-Navigation

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ABSTRACT: In paper the functional requirements and the radiocommunication services of Global Maritime Distress and Safety System (GMDSS) in respect of the E- Navigation has been described. Some aspects of the improvement of GMDSS equipment and the utilization of the improved GMDSS as a data communication network for E-Navigation has been presented. The items relating to technical improvement of the GMDSS which should be considered as one of the discussion on the strategy plan of E-Navigation was given.

## 1 INTRODUCTION

For realizing the full potential of E-navigation, the following three fundamental elements should be in place:

.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.

## 2 REVIEW OF GMDSS

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.

The basic 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).

### 2.1 *Functional requirements*

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

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 co-ordinating communication;
5) transmitting and receiving on-scene communication;
6) transmitting and receiving signals for locating;
7) ransmitting 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 (Fig. 1):

- DSC - *Digital Selective Calling*;
- INMARSAT Satellite System;
- SATEPIRB - SATellite Emergency Position Indicating RadioBeacon;
- 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 mean as follows:

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

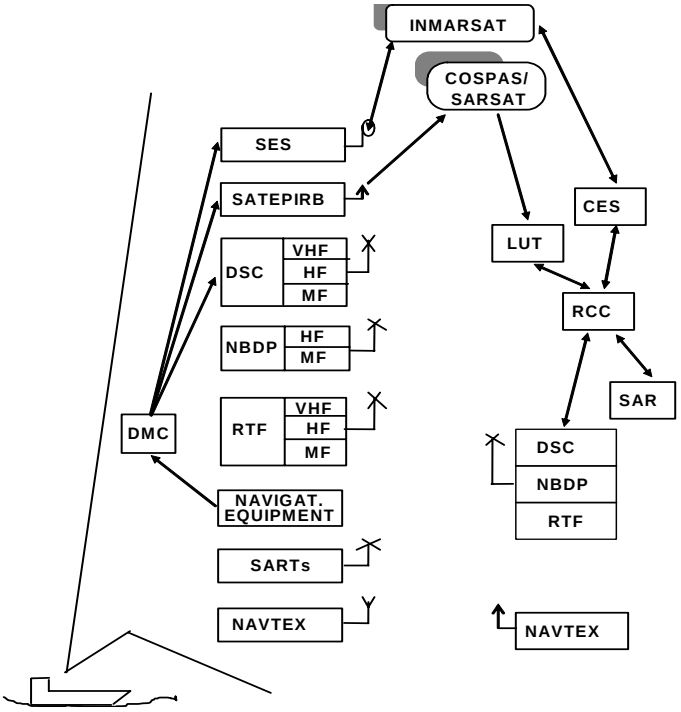


Fig. 1. Radio services of GMDSS

As a potential data communication elements for E-Navigation following GMDSS radio services should be recognized: DSC, INMARSAT, NBDP and NAVTEX.

## 2.3 *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 ship 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.

The classes of emission, frequency shifts and modulation rates are as follows:

- F1B or J2B 170 Hz and 100 Bd for use on MF and HF channels. When frequency-shift keying is effected by applying audio signals to the input of single-sideband transmitters (J2B), the centre of the audio-frequency spectrum offered to the transmitter is 1700 Hz.
- Frequency modulation with a pre-emphasis of 6 dB/octave (phase modulation) with frequency-shift of the modulating sub-carrier (G2B) for use on VHF channels; the modulation rate is 1200 Bd; frequency-shift is between 1300 Hz and 2100 Hz, the sub-carrier being at 1700 Hz.

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’.

## 2.4 *INMARSAT specification*

At present Inmarsat system provides not only a range of services and equipment types to cover GMDSS requirements.

***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 A services will cease to be supported on December 31, 2007.

***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 B is recommended for the any of the following applications:

- Data transfer
- Internet
- E-mail
- Fax
- SMS text
- Voice
- Crew calling
- Encryption

- Videoconferencing
- Remote monitoring
- Weather updates
- Telemedicine
- GMDSS

***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

***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'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 A888 (21). 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.

## 2.5 *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).

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 | – | – | + |

Teleprinters of the (international) telex networks use CCITT ITA-2 code (International Telegraph Alphabet Code) for communications. Each keyboard character is transformed to a five-element code of constant duration. This code is able to provide 32 combinations only but the use of the 'shift' key enables a further 26 combinations to be available. ITA-2 code has no error detection or correction possibilities. For that reason direct mode of telex communication with ITA-2 code is seldom used.

The CCIR recommended code is a 7-unit synchronous code. This code is able to provide 128 combinations but it uses only those bit combinations having a ratio of 3 Mark bits to 4 Space bits to represent valid characters. There are 35 of the 3/4 ratio combinations, allowing all 32 ITA-2 characters to be represented. Each of the five-unit ITA-2 characters is converted to 7-unit code. The recommended code needs no start or stop bits because it is synchronous. No error-detecting parity is required because the Mark/Space ratio is constant. This allows efficient transmission of messages, since all character bits are used to determine the character.

The characteristics of *ARQ* communication can be summarized as follows:

- it practically guarantees error-free data, assuming reception is possible at all;
- automatic exchange of identities guarantees connection with the requested station, also after rephasing conditions;
- communication is possible between only two stations at a time;
- this gives some limited protection against unauthorised eavesdropping;

- the receiving station must have an operating transmitter.

The primary characteristics of FEC are folowing:

- a message may be transmitted to several receiving stations simultaneously.
- it does not require transmitters at the receiving stations;
- there is no acknowledgement of transmissions;
- there is no active error correction;
- there is no protection against eavesdropping.

### 2.6 *NAVTEX specification*

International NAVTEX (NAVigational TelEX) service means the co-ordinated broadcast and automatic reception on the frequency 518 kHz of maritime 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 GMDSS ELEMENTS AS A DATA COMMUNICATION SERVICES

### 3.1 *Present situation*

At present, taking into account above consideration, the only GMDSS element which can be recognized as a data communication system is Inmarsat, in particular Fleet 77 and future FleetBroadband services.

Because ***Fleet F77*** is IP compatible, it supports an extensive range of commercially available off-the-shelf software, as well as specialized maritime and business applications. Fleet F77 also ensures cost-effective communications by offering the choice of Mobile ISDN or MPDS channels at speeds of up to 128kbps.

Mobile ISDN is best suited for applications where data throughput and speed are important, including:

- videoconferencing;
- store-and-forward video;
- video streaming;
- large data file transfer, including FTP and digital images;
- high quality digital voice;
- secure voice and data communications;
- electronic chart downloads;
- anti-virus updates.

MPDS is more suitable for interactive, short-burst data and web-based applications, such as:

- e-mail;
- Internet and private network access;
- instant messaging;
- universal messaging, including SMS;
- office/management software applications
- 'thin client' applications;
- electronic chart downloads;
- real-time online weather/oceanographic information;
- vessel telemetry, SCADA and technical support applications;
- telemedicine.

***FleetBroadband*** is Inmarsat's next generation of maritime services delivered via the Inmarsat-4 satellites. It is currently planned to be commercially available in 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). The proposed FleetBroadband service will provide:

- simultaneous voice and data functionality;
- standard IP with speeds of up to 432kbps (contended service);
- ISDN at 64kbps;
- streaming data up to 256kbps.

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 |

Users will have the choice of two products (FB250 and FB500). Both will use stabilised, directional antennas, which will vary in size and weight. The above deck antennas will be smaller than existing Fleet products used today. The whole system is designed specifically for the marine environment and will be rigorously tested to Inmarsat's exacting standards.

FleetBroadband supports an extensive range of commercially available, off-the-shelf software, as well as specialised 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

### 3.2 *General comments*

The above considered GMDSS equipment (Fig. 1) like Inmarsat system can be also used as a way of data communication for the E-Navigation system, provided that the GMDSS MF, HF and VHF equipment is 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 means 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 communication aspects required for E-navigation, the following should be taking 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); and
- the use of a single language, perhaps with other languages permitted as options.

## CONCLUSIONS

The improved GMDSS equipment can be an effective way to increase the reliability of E-Navigation data communication network.

This goal can be achieved as the result of the work on two items:

- technical improvement of GMDSS equip-ment taking into account the above chapter 3.2; and
- utilization of technically improved GMDSS equipment as a data communication network for E-Navigation.

During this work it is necessary to first identify user requirements and secondly, that the development of E-navigation 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 development and operation of GMDSS and AIS should be taken into account in the development of E-Navigation as well.

In consideration on GMDSS as a Data Communication Network for E-Navigation the sea area A1, A2, A3 and A4 should be also recognized.

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