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MARITIME RADIO INFORMATION SYSTEMS

Karol Korcz

Gdynia Maritime University
Department of Marine Telecommunication
Morska Street 81-87, 81-225 Gdynia, Poland
tel.: +48 58 5586406, fax: +48 58 5586556
e-mail: k.korcz@we.am.gdynia.pl

Abstract

The article presents and evaluates the technical and operational possibilities of the maritime radio communications systems to be used especially for the exchange of information between the land users and ships. The basic functional requirements and regulations for Global Maritime Distress and Safety System (GMDSS) referring to the maritime radio information systems, 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 information systems in the shipping and GMDSS as well. A current status of the maritime radio communication systems responsible for the exchange of information between the land users and ships has been presented. Operational and technical characteristics of the maritime radio systems used for the exchange of safety information and ships' operating information have been described. The analysis of the systems responsible for broadcasting to the vessels the Maritime Safety Information (MSI) has been made. In this context, the operation, methods and ranges of broadcast of the Maritime Safety Information by the NAVTEX system and Inmarsat SafetyNet system have been discussed. The analysis of the systems responsible for the ships' operating communications has been made too. The article also outlines the future of maritime radio information systems. In this context, two projects currently being implemented in the framework of the International Maritime Organization (IMO) by the Sub-Committee on Navigation, Communications, Search, and Rescue (NCSR) have been presented. The first of these projects under the name of e-Navigation refers to the use of the latest information and communication technologies in shipping. The second one concerns the modernization of the GMDSS. It is expected that as the outcome of these project works, among others, new maritime radio information systems presented here will be adopted.

Keywords: *communication systems, maritime safety communication, ships' operating communication*

1. Introduction

The Global Maritime Distress and safety System (GMDSS) used by most of the world's shipping is defined by chapter IV of the International Convention for the Safety of Life at Sea (SOLAS Convention) published by International Maritime Organization (IMO) and the International Telecommunication Union (ITU) Radio Regulations.

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) and public (including the ships' operating information – SOI) communications. It should be stressed that effective transmission of the maritime safety information and ships' operating information requires very effective radio information systems.

The SOLAS Convention lays down nine principal communications functions, which all GMDSS ships, while at sea, need to be able to perform [1]:

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 (MSI),
8. transmitting and receiving general (public) 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 efficiency of shipping, among above-mentioned functions, the most important functions are transmitting and receiving maritime safety information (MSI) and transmitting and receiving general radio communication to and from shore-based radio systems or networks, including ships' operating communication (SOC).

In accordance with the Radio Regulations in the maritime radio communication (GMDSS) there are four levels of communications priority [2]:

– Distress,
– Urgency,
– Safety, and
– Other.

The transmission of distress call and message indicates that:

– a mobile unit or person is threatened by grave and imminent danger, and
– requires immediate assistance.

Distress communications shall have priority over all other communications.

The transmission of an urgency call and message indicates that:

– the following information's refer to an urgent need for assistance or
– a medical transport or
– a medico message.

Urgency communications shall have priority over all other communications, except distress communication.

The transmission of a safety call and message indicates that:

– the following information's refer to the safety of navigation,
– weather conditions or
– nautical warnings or
– to the ship movement communication.

The safety communications is the communications responsible for broadcasting on ships so called Maritime Safety Information (MSI). This communications shall have priority over all other communications, except distress and urgency communication.

The other communications means the communications other than distress, urgency and safety communications. This communications is also called public, general, routine communications. Very important part of the other communications is the ships' operating communications (SOC).

Technological advances in the field of radio communications and information systems also affect the changes in the marine radio communication systems. Taking into account these changes IMO began work on two projects under the name of „E-navigation" and „Modernization of the GMDSS". Without a doubt, the communication systems for broadcasting on ships maritime safety information and ships' operating information will play an important role in these projects.

2. Current status of the maritime radio information systems

Up to date equipment and systems used in the GMDSS, with pointing the radio information 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.

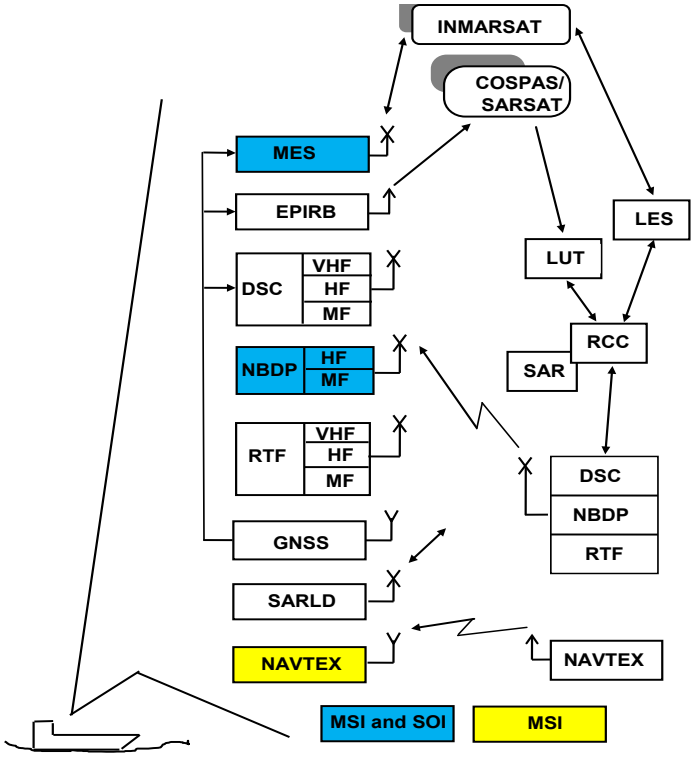

Fig. 1. Up to date GMDSS equipment and systems

Maritime safety information

Maritime safety information (MSI) means navigational and meteorological warnings, meteorological forecasts and other urgent safety-related messages broadcast to ships. Maritime safety information service means the internationally and nationally coordinated network of broadcasts containing information, which is necessary for safe navigation.

MSI are received on ships by equipment, which automatically monitors the appropriate transmissions, displays information that is relevant to the ship and provides a print capability. There are no charges for receipt of MSI messages by a ship.

Two principal methods are used for broadcasting MSI in accordance with the provisions of the SOLAS Convention, in the areas covered by these methods [5] (Fig. 1):

– NAVTEX: broadcasts to coastal waters, and
– SafetyNET: broadcasts, which cover all the waters of the globe, covered with Inmarsat satellite system.

International NAVTEX service means the coordinated broadcast and automatic reception on 518 kHz of maritime safety information by means of narrow-band direct-printing (NBDP) telegraphy. Besides frequency 518 kHz, for national services, the frequencies 490 kHz and

4209.5 kHz may be used for NAVTEX broadcasts. Experience indicates that the average communication range for international frequency 518 kHz is about 250 to 400 nautical miles from transmitting coast station [4].

International SafetyNET service means the coordinated broadcast and automatic reception of maritime safety information via the Inmarsat Enhanced Group Call (EGC) system [4].

The combination of 518 kHz NAVTEX and the international SafetyNET service through the Inmarsat satellite EGC service provides a highly reliable method of distributing navigational warnings, weather forecasts and other urgent information all over the world.

This MSI concept was described by the author in [5].

Ships' operating information

Ships' operating information (SOI) means any information related to the effective management of the ship. At present, besides radiotelephony, two techniques are used for exchange of information between the land users (ship-owner, agents and port authorities) and ships (Fig. 1):

– Inmarsat satellite system, and
– Narrow Band Direct Printing (NBDP) telegraphy.

Inmarsat is the only satellite operator that meets GMDSS requirements (SOLAS requirements). Among the various Inmarsat systems, these requirements meet only Inmarsat C and Inmarsat Fleet 77. The Inmarsat system has three major components: 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. 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 [3]. The comparison of the technical characteristics of Inmarsat C and Fleet 77 systems is presented in Tab. 1.

Tab. 1. Comparison of the technical characteristics of Inmarsat C and Fleet 77 systems

Features	Inmarsat Fleet 77	Inmarsat C
Overall Weight	about 70 kg	about 10 kg
Size of antenna	0.5-1.0 m	approx. 0.3 m
Antenna type	Parabolic antenna, mechanically steered	Small omnidirectional antenna, does not need to be steered
Communication type	Real time (immediate)	Store & forward
SERVICES		
Telephone	YES	NO
Fax	YES	YES (only from the ship)
Telex	YES	YES
Data communication	YES (64 kbps)	YES (600 bps)
e-mail	YES	YES (via e-mail Provider)
Internet	YES	NO
High Speed Data (HSD)	64/128 kbps	NO
SafetyNET	YES (if installed)	YES
FleetNET	YES (if installed)	YES
DISTRESS & SAFETY		
GMDSS Compliant	YES	YES
MSI	YES (if installed)	YES
Distress Button	YES	YES

The purpose of NBDP (radio telex) in the maritime mobile service is the exchange of information in direction ship to shore, shore to ship, ship to ship and broadcast to all stations.

Two modes of operation are used dependent upon the message destination, i.e., whether the message is addressed to one specific station or to all stations:

– ARQ (*Automatic Repeat on reQuest*), and
– FEC (*Forward Error Correction*).

ARQ is the mode for communication between two stations to transmit and receive information during a certain connection.

FEC is the mode for communication broadcasting to all stations or to transmit to an individual station in one direction only during a certain connection. This mode would be used, for example for NAVTEX broadcasts.

The Mode of emission for NBDP is F1B. In the F1B method, telex signal codes are transmitted at MF (Medium Frequency) or HF (High Frequency) as a sequence of two audio tones.

3. Future of the radio information systems

The above presented analysis shows, that today maritime radio information systems, as a whole, are a complementary system well fulfilling the expected goals. Further increase of the safety and efficiency 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.

E-navigation is defined as [7]: *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 [7]:

– 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.

The solutions S2, S4 and S5 are directly designed to improve communication between ship and shore for safety and operational purposes. The implementation of E-navigation involves the development of on-board communication and navigation systems that integrate all relevant ships sensors and supporting information. It should be noted that the IMO considers the implementation of E-navigation in the world's fleet as a long-term objective rather than a short-term fix.

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". 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.

Parallel to the work on the above-mentioned projects, the work on new, specific solutions for these projects is underway. Examples of such a solution, in terms of the maritime radio information systems, can be following systems:

– NAVDAT, and
– VDES.

NAVDAT is a medium frequency (MF) radio system operating in the 500 kHz band for digital broadcasting of maritime safety and security related information from shore-to-ship. NAVDAT

coverage is similar to the global system NAVTEX coverage. The technology allows important data rate with regard to the frequency band: rates up to 18 kbit/s are possible with NAVDAT, to compare to the 100-bit/s of NAVTEX. There is a possibility of encryption of NAVDAT messages, if necessary [8].

The NAVDAT system is organized upon five vectors performing the following functions [8]:

1. System of information and management (SIM):
   – collects and controls all kinds of information,
   – creates message files to be transmitted,
   – creates transmitting programme according to message files priority and need of repetition.
2. Shore network:
   – assures the transportation of the message files from sources to the transmitters.
3. Shore transmitter:
   – receives the message files from SIM,
   – translates message files to orthogonal frequency division multiplexing (OFDM) signal,
   – transmits RF signal to the antenna for broadcast to ships.
4. Transmission channel:
   – transports the 500 kHz RF signal.
5. Ship receiver:
   – demodulates the RF OFDM signal,
   – reconstructs the message files,
   – sorts and makes the message files available for the dedicated equipment according to the message files applications.

Figure 2 shows the diagram of the broadcast chain.

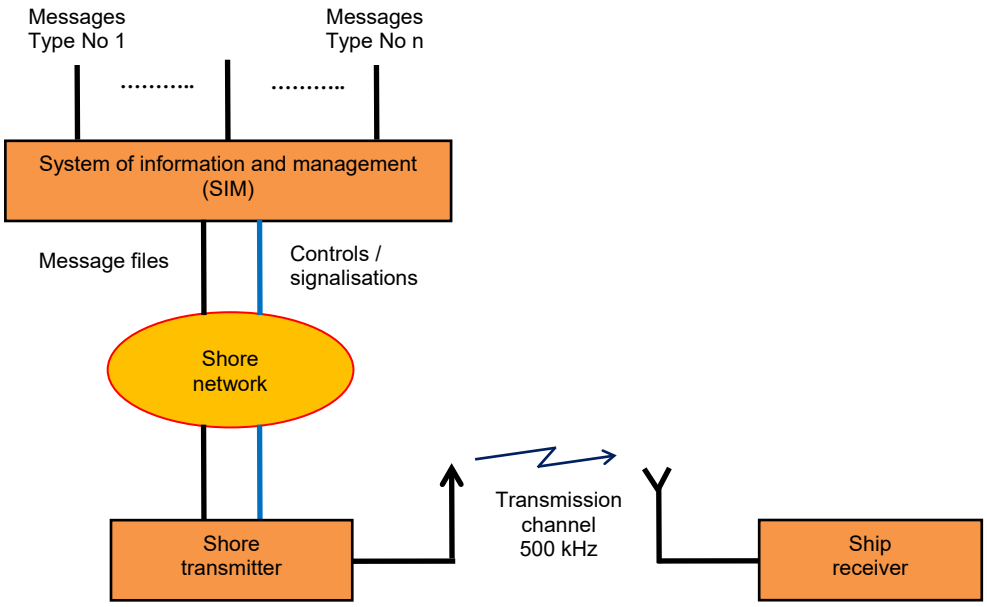

Fig. 2. NAVDAT 500 kHz broadcast chain block diagram

VHF data exchange system (VDES) integrates the functions of VHF data exchange (VDE), application specific messages (ASM) and the automatic identification system (AIS) in the VHF maritime mobile band. General assumptions regarding VDS are as follows:

– the system should give its highest priority to the automatic identification system (AIS) position reporting and safety related information,
– the system installation should be capable of receiving and processing the digital messages and interrogating calls,
– the system should be capable of transmitting additional safety information on request,

– the system installation should be able to operate continuously while under way, moored or at anchor,
– the system should use for the terrestrial links time-division multiple access (TDMA) techniques, access schemes and data transmission methods in a synchronized manner,
– the system should be capable of various modes of operation, including the autonomous, assigned and polled modes,
– the system should provide flexibility for the users in order to prioritize some applications and, consequently, adapt some parameters of the transmission (robustness or capacity) while minimizing system complexity.

VDES functions and frequency usage are illustrated pictorially in Fig. 3 [6]. VHF data exchange system is capable of a data exchange between terrestrial stations and between satellites and terrestrial stations as well.

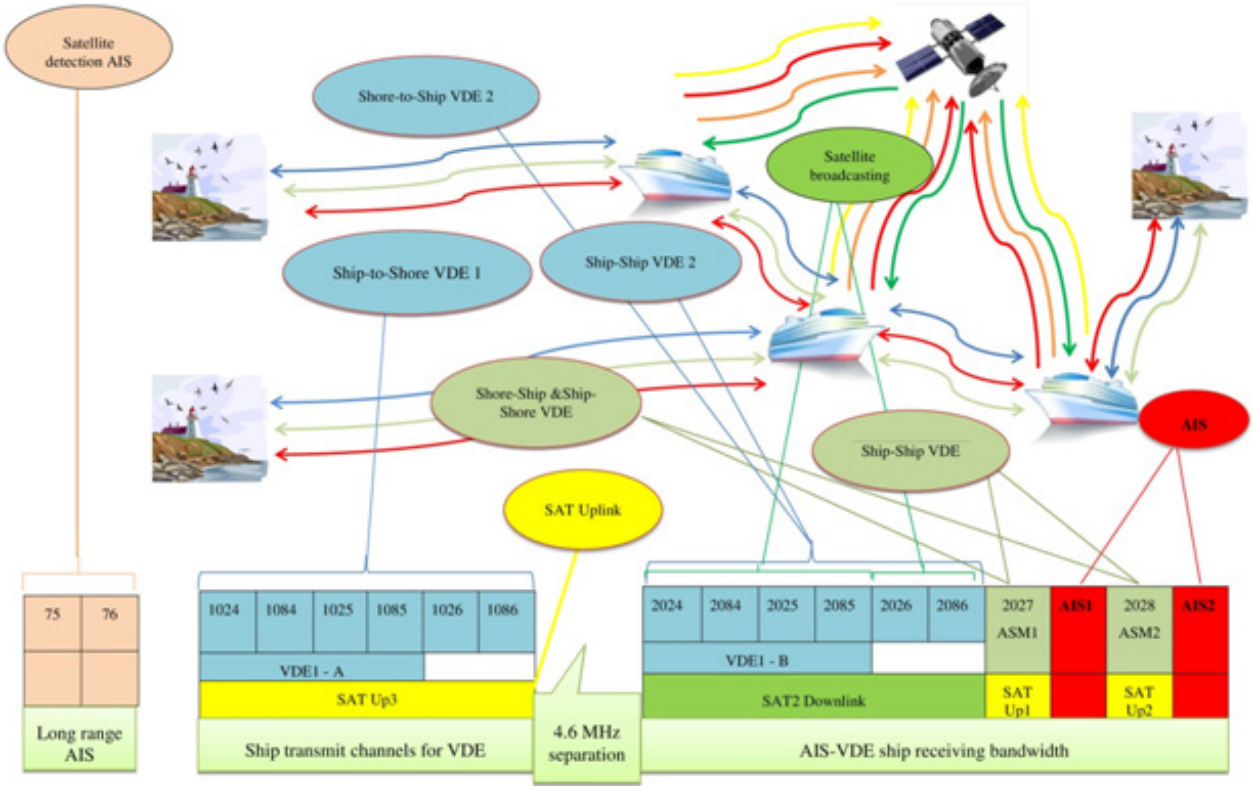

Fig. 3. VHF data exchange system functions and frequency usage [6]

According to the IMO E-navigation, strategic implementation plan (SIP) VDS system is intended for use in the following services:
– VTS (Vessel Traffic Service) Information Service (IS),
– Local Port Service (LPS),
– Maritime safety information (MSI) service,
– pilotage service,
– tugs service,
– vessel shore reporting,
– Telemedical Maritime Assistance Service (TMAS),
– Maritime Assistance Service (MAS),
– nautical chart service,
– nautical publications service,
– ice navigation service,
– Meteorological information service,

– real-time hydrographic and environmental information services, and
– Search and Rescue (SAR) Service.

4. Conclusions

The analysis presented in the article indicates that today's communication systems for safety and operating of ships, as a whole is a complementary system well fulfilling the expected goals.

Certainly, the combination of 518 kHz NAVTEX service and the international SafetyNET service provide a highly reliable method of distributing MSI.

It should be noted that at present and in the future the satellite systems play a key role in the subject. In the above context, it should be also noted that Inmarsat informed of its intention to close, with effect from 1 December 2020, the Inmarsat F77 service [9].

According to the author opinion, further increase of the safety and efficiency 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“. Good examples of the implementation of these projects can be presented NAVDAT and, especially, VDES systems. In the above context it should be noted that, following ITU World Radio communication Conference in 2015 (WRY-15), the full satellite capability of the VDES is still under development and will be reviewed at WRY-19.

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