The Maritime Safety System, its Main Components and Elements

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The basic concepts *safety at sea* and the *maritime safety system* have remained almost unchanged for a comparatively long time. However, the components and elements of these concepts are now subject to many changes created by the 'information age'. This paper presents thoughts on today's concept of the *maritime safety system*, its main components and their elements. Although the thoughts and ideas presented are those of the authors, they take account of the legal instruments in force and recent developments in technology, especially developments in radio-communications. The paper provides an overall review of the institutions, regulations and procedures concerned with *safety at sea*.

KEY WORDS

1. Safety. 2. Marine. 3. Communications.

1. INTRODUCTION. Safety at sea is inseparably connected with human activity at sea, especially through the development of maritime navigation, which has taken place over more than 5000 years. However, the maritime safety system is not as old as maritime navigation. Although some of its elements existed even in the distant past, the maritime safety system must be considered relatively young. It came into being only when international co-operation could be realised in real time, i.e. when radio had been invented and deployed at sea.

Since the end of World War II, the pace of development of maritime safety has accelerated considerably. The last ten years has seen particularly rapid development of terrestrial and space radio-communication technology that has dramatically increased safety at sea mainly as the result of the introduction of the Global Maritime Distress and Safety System (GMDSS). As well as radio-communication technology, there are many other factors that have resulted in improved safety. Among them, the most important factor is the modern international legal system that creates the compact set of regulations and requirements whose observance by all seafarers would ensure a proper level of safety at sea.

This paper discusses the following issues: the basic definitions regarding safety at sea; the maritime safety system and its main components; the law-making institutions, legal instruments, and operational institutions; the maritime navigation safety system and its regulations, requirements and operational institutions; the Global Maritime Distress and Safety System (GMDSS) and its elements; the Search and Rescue (SAR) system; and finally, preventing ships from polluting the maritime environment.

2. THE BASIC DEFINITIONS REGARDING SAFETY AT SEA. The term *safety at sea* has several closely relating meanings (Jurdziński and Urbański,

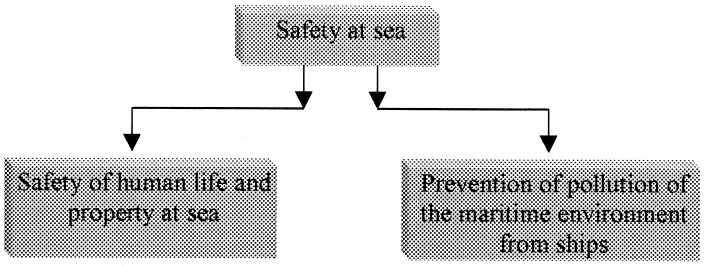

Figure 1. *Safety at sea* expressed by two constituent parts.

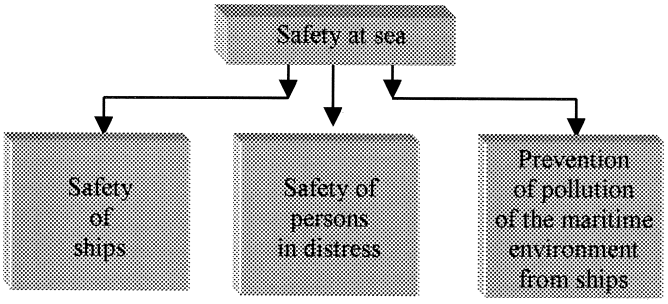

Figure 2. *Safety at sea* expressed by means of three constituent parts.

1994). It can be considered as 'such desirable conditions of human activity at sea that do not endanger human life and property, and are not harmful to the maritime environment'. The 'desirable conditions of human activity at sea' are specified in many legal documents. Among them, the most important is the convention on 'Safety Of Life At Sea' – the SOLAS convention. This convention was adopted at a London Conference in 1914, and it can be considered as the response of the international community to the best known sea catastrophe, the sinking of the *Titanic* on her maiden voyage in April 1912, when more than 1500 passengers and crew members died. The adoption of SOLAS was also a sign that human life at sea had priority over property, as often had not been the case before. This date can be considered as the birth of the *maritime safety system*. The second convention that directly specifies *safety at sea*, but which concerns protection of maritime environment from pollution is the convention for 'Prevention of Pollution from Ships' – the MARPOL 73/78 convention. There are also several other maritime conventions appertaining to safety at sea, some of which were issued earlier than the SOLAS convention, such as the COLREG convention. However, these are considered as supplementary to SOLAS and MARPOL. Thus, it is commonly agreed that *safety at sea* is composed of two main components: safety of human life and property at sea, and prevention of pollution of the maritime environment from ships (see Figure 1).

It can be considered that 'safety of human life and property at sea' is composed of two components: safety of ships, and safety of persons in distress. Figure 2 shows this relationship.

It can further be assumed that the *safety of ships at sea* is composed of technological and operational ships' safety, and safety of navigation, which leads to Figure 3.

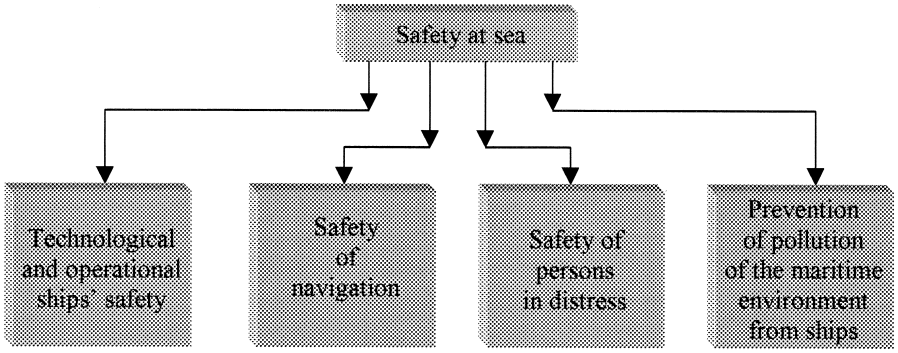

Figure 3. *Safety at sea* expressed by means of four constituent parts.

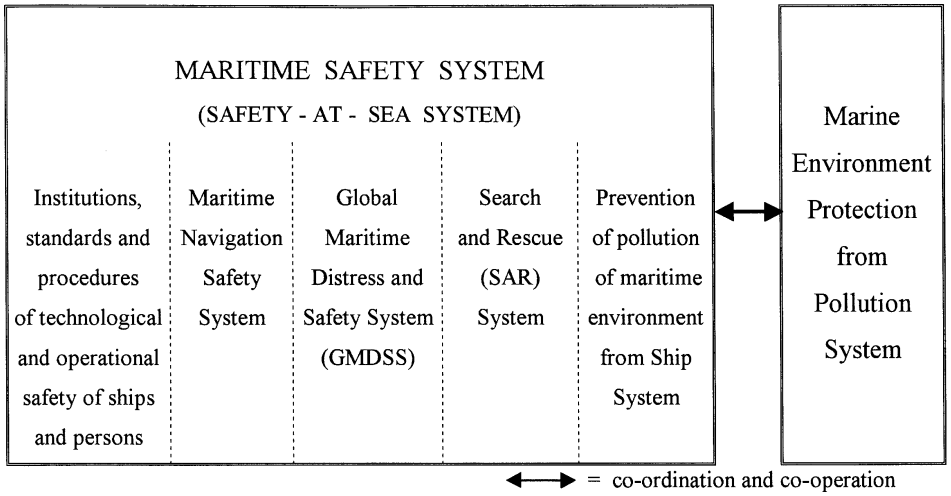

Figure 4. A general outline of the *maritime safety system*.

3. THE MARITIME SAFETY SYSTEM AND ITS MAIN COMPONENTS. We assume that the term *maritime safety system* means the system that ensures *safety at sea* as defined in Figures 1–3. We also assume that the term *maritime safety system* is interchangeable with the term *safety at sea system*. Figure 4 shows a general outline of the *maritime safety system*, being the set of particular institutions, standards and procedures, whose objective is to ensure *safety at sea*.

It is assumed that the *maritime safety system* is composed of the elements shown in Figure 5; that is:

a. Law-making institutions such as the international maritime conferences, the International Maritime Organisation (IMO) and its organs,
b. The legal instruments, such as the set of the international maritime conventions and other legal regulations and requirements that specify the conditions necessary for ensuring safety at sea, and the methods of their achievement,
c. The operational institutions creating the conditions necessary for ensuring safety at sea, and the methods of their achievement,

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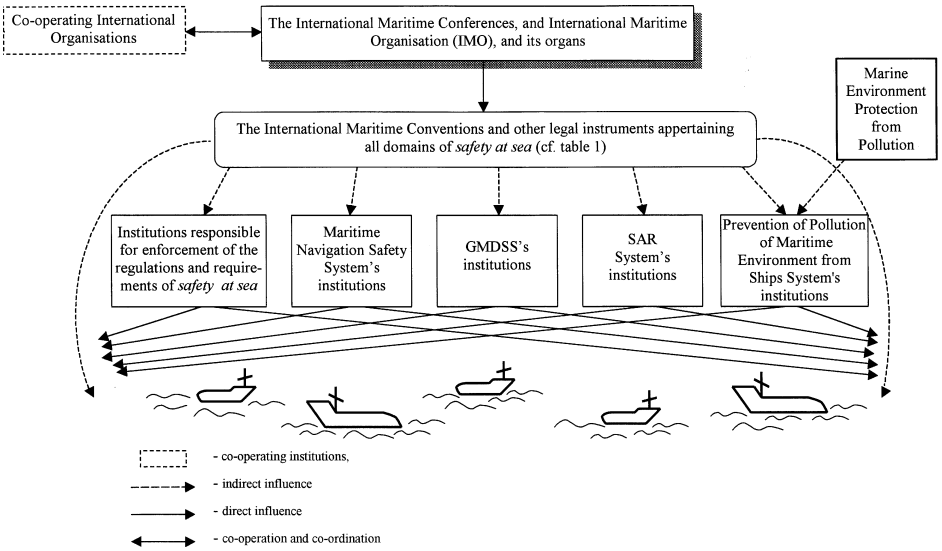

Figure 5. The main components of the *maritime safety system*.

d. The users of the sea who, by obeying all regulations and requirements, create the necessary conditions for ensuring safety at sea.

The requirement of all sea users to obey the regulations and requirements is self-evident. Therefore, further discussion is confined only to the first three elements of the *maritime safety system*; that is, the law-making institutions, legal instruments and operational institutions.

4. LAW-MAKING INSTITUTIONS, LEGAL INSTRUMENTS AND OPERATIONAL INSTITUTIONS. The main international body responsible for safety at sea is the International Maritime Organisation (IMO), which is an agency of the United Nation Organisation (UN). The International Maritime Conventions are adopted by the contracting states at conferences organised by IMO. The amendments to the SOLAS 74 convention can be also adopted by the Maritime Safety Committee special session, according to the procedure provided by Article VIII of this convention. IMO, which celebrated its 50th anniversary in 1998, embodies 156 contracting states. The main organs of IMO are: The General Assembly; The Council; The Committees (Maritime Safety Committee (MSC); Maritime Environment Protection Committee (MEPC); Legal Committee (LC); Facilitation Committee (FC)) and The Secretariat.

The IMO Council and IMO Committees, while preparing the drafts of the new maritime conventions and amendments, co-operate very closely with other international organisations responsible for safety at sea. The most important of these are:

a. World Meteorological Organisation (WMO),
b. International Maritime Satellite Organisation (INMARSAT),
c. International Telecommunication Union (ITU),
d. International Hydrographic Organisation (IHO),

e. International Association of Lighthouse Authorities (IALA),
f. International Labour Organisation (ILO), and
g. International Civil Aviation Organisation (ICAO).

The legal instruments of the *maritime safety system*, i.e. the regulations and requirements, are related to the basic domains of safety at sea shown in Table 1.

Table 1. The basic domains of *safety at sea*.

No.	Substance of the domain
1	Safety of navigation
2	Radio-communication
3	Life-saving appliances and SAR
4	Standards of seafarers training, certification and watchkeeping
5	Ships' design and equipment
6	Ships' fire protection
7	Ships' stability and load lines
8	Carriage of container goods and dangerous goods
9	Carriage of chemical bulk, liquids and gases
10	Fishing vessel safety
11	Prevention of pollution of maritime environment from ships

As discussed earlier, the legal instruments of the *maritime safety system* constitute mainly the international maritime conventions as follows:

a. The International Convention on 'Safety of Life at Sea' – SOLAS 74,
b. The International Convention for 'Prevention of Pollution from Ships' – MARPOL 73/78,
c. The Convention on 'International Regulations for Preventing Collision at Sea' – COLREG 72,
d. The International Convention on 'Standards of Training, Certification and Watchkeeping for Seafarers' – STCW 78/95,
e. The International Convention on 'Maritime Search and Rescue' – SAR 79.
f. The International Convention on 'Load Lines', 1966.

It should be stressed that the international maritime conventions are regularly amended. For example, the SOLAS 74 convention now in force in 2000 is not the same as SOLAS 74 in force in 1974; the content of the current version has less than 50 percent in common with the original. New chapters have been added, and the contents of the old chapters have been considerably changed; even the title of the chapter IV has been changed. The latest version also contains the 'International Safety Management (ISM) Code', which came into force on 1 July 1998, as well as the 'Safety measures for high-speed craft' and 'Special measures to enhance maritime safety'.

The main operational institutions of the *maritime safety system* comprise the following:

a. Institutions responsible for enforcement of the regulations and requirements,
b. Maritime navigation safety system institutions,
c. Global Maritime Distress and Safety System institutions,
d. Search and Rescue (SAR) system institutions,

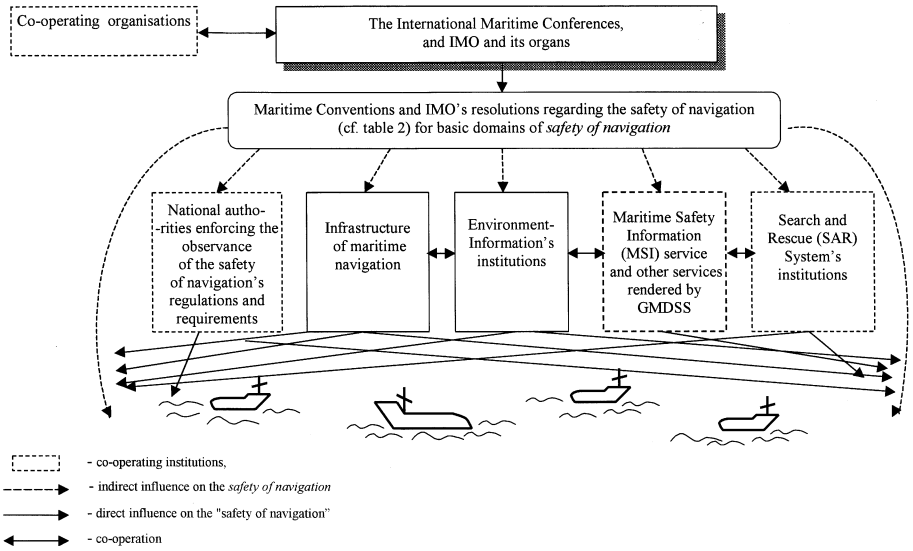

Figure 6. The main elements of the *maritime safety system*.

e. Institutions associated with the prevention of pollution of the maritime environment from ships' systems.

The institutions responsible for enforcement of the regulations and requirements comprise the following:

a. Coastguard and maritime administration authorities,
b. Maritime courts,
c. Ships' classification organisations,
d. Ships' underwriters organisations,
e. Harbour authorities, and others.

5. THE MARITIME NAVIGATION SAFETY SYSTEM. Safety of navigation is a major constituent of safety at sea. Safety of navigation can be considered as 'such conditions of conducting the ships at sea which ensure that ships are not endangered by collisions, stranding or storm damage'. Such safety is achieved by the proper navigation processes, as well as by ensuring the proper environmental and operational conditions for the realisation of these processes. However, these navigation process are not the subject of this paper; they are well presented in the articles by Kopacz and Urbański (1998) and Urbański and Holec (1998).

The content of the term *safety of navigation* is specified mainly in Chapter V of the SOLAS 74 convention. This chapter is in the process of thorough and profound changes. The other legal sources that specify *safety of navigation* are the COLREG 72 convention, STCW 78/95 convention, SAR 79 convention, as well as other IMO General Assembly and Maritime Safety Committees (MSC) resolutions that contain the numerous and various navigational performance standards and operational procedures.

The *maritime navigation safety system* is young by comparison with the trade of maritime navigation. It was formed only after the development of radio-communication services, and in the past was exclusively composed of the national

systems. However, since the development and deployment of the Global Positioning System (GPS) and the Global Maritime Distress and Safety System (GMDSS), it has become an international system. Another characteristic feature of the maritime navigation safety system is its growing importance 'to create and maintain favourable operational conditions for safe and efficient conduct of ships at sea'.

The main elements of the *maritime navigation safety system* are shown at Figure 6; they comprise the law-making institutions, the regulations and requirements of the legal, technological, operational and professional aspects of maritime navigation, the operational institutions and procedures and, of course, the ships themselves.

6. THE REGULATIONS AND REQUIREMENTS. The maritime convention and IMO's resolutions concerning safety of navigation comprise the following basic domains:

Table 2. The basic domains of *safety of navigation*.

No.	Substance of the domain
1	Ships' navigational properties, navigational equipment and systems,
2	Navigational infrastructure,
3	Navigation – environment's information,
4	Maritime Safety Information (MSI) and its services,
5	Navigational proficiencies of the crew,
6	Ships' navigation process and its subprocesses,
7	Ships' traffic,
8	'Ship-in-distress' procedures,
9	SAR procedures regarding the ships at sea.

Regulations and requirements regarding the technological and operational aspects of maritime navigation, and thus *safety of navigation*, are contained in numerous resolutions adopted by the IMO's General Assembly and MSC meetings. These resolutions contain mainly the performance standards and operational procedures concerning maritime navigation and its safety and efficiency requirements. Apart from the resolutions and their regulations and requirements, there are also many operational procedures. These procedures are contained in nautical publications such as the *Admiralty List of Radio Signals* and similar publications, as well as the 'operational manuals' of navigational equipment and systems.

7. OPERATIONAL INSTITUTIONS. The operational institutions comprise the following:

a. national authorities enforcing the observance of regulations and requirements,
b. navigational infrastructure,
c. navigation-environment-information institutions,
d. Maritime Safety Information (MSI) service and GMDSS,
e. SAR systems co-operating with merchant ships in distress and with ships participating in SAR actions.

The national law-enforcement authorities comprise the administrations (coast-guard, harbour authorities, etc.) that supervise the possession and validity of ships'

certificates to be carried on board, possession and state of the navigational equipment, life-saving appliances, deck equipment, etc., as well as observance by the ships of the local traffic regulations. The law-enforcement authorities objective is to enforce all *safety at sea* regulations and requirements.

The navigational infrastructure of maritime navigation includes the following main groups:

7.1. *Aids to Navigation*. Aids to navigation comprise the following:

a. floating and fixed aids to navigation such as buoys, beacons, leading marks, light houses, landmarks, etc.
b. electronic position fixing stations and systems, such as radio-beacons, Loran etc.
c. satellite navigation systems, including DGPS reference stations, etc.

7.2. *Sea-ways Facilities*. The sea-ways facilities comprise:

a. artificial canals,
b. fairways,
c. anchorages,
d. passing places, and other facilities, together with the buoys marking their limits.

7.3. *Navigation Assistance Systems*. The navigation assistance systems include the following kinds of systems:

a. pilotage services,
b. Vessel Traffic Services (VTS),
c. Traffic Separation Schemes,
d. ships reporting systems, and other systems.

7.4. *Navigation Information Systems*. The navigation-environment information institutions are those that provide seafarers with the information regarding the geographical environment, such as charts and nautical publications (now also in electronic form). The main institutions concerned are:

a. national hydrographic services,
b. national oceanographic services, and
c. national hydro-meteorological services.

The Maritime Safety Information (MSI) service rendered by the GMDSS is presented in the following section describing the GMDSS system.

8. GLOBAL MARITIME DISTRESS AND SAFETY SYSTEM (GDMSS). The GMDSS is the youngest subsystem of the maritime safety system and was adopted in amendments to the SOLAS 74 Convention in 1988, which came into force in 1992. GMDSS has been fully operational since 1 February 1999. The basic concept of the GMDSS (shown in Figure 7) is that the SAR authorities ashore, and ships in the immediate vicinity of a ship or persons in distress, will be rapidly alerted to the distress incident to provide a co-ordinated search and rescue operation with the minimum delay. The system also provides safe and reliable general communication, and promulgation of the Maritime Safety Information (MSI) (navigational warning, weather forecast, storm warning and SAR information).

8.1. *GMDSS Radio-Communication Functions*. GMDSS enables each ship, irrespective of the area in which she operates, to perform the following radio-communication functions:

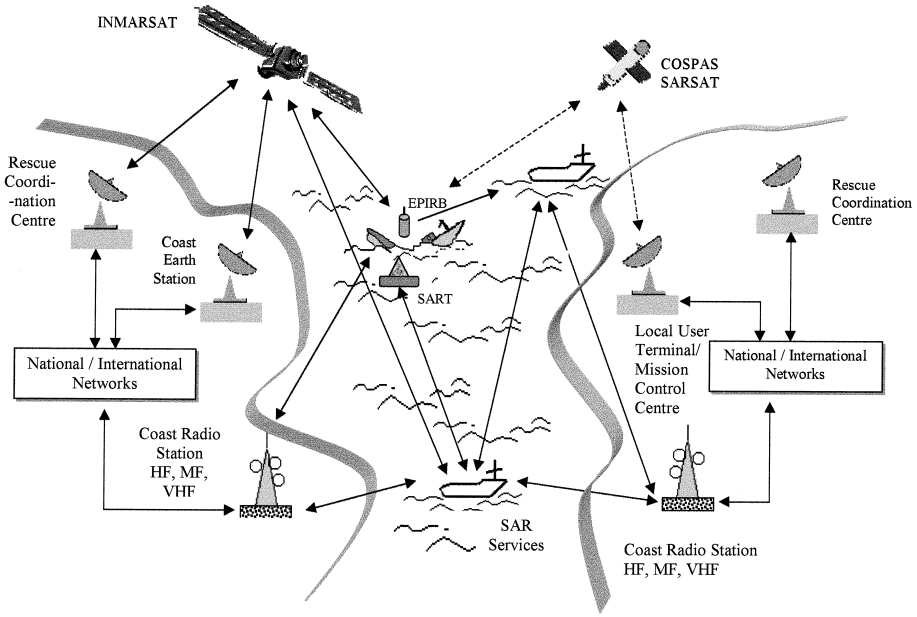

Figure 7. General concept of the Global Maritime Distress and Safety System (GMDSS).

a. ship-to-shore distress alerts by at least two separate and independent means,
b. receiving shore-to-ship distress alerts,
c. transmitting and receiving ship-to-ship distress alerts,
d. transmitting and receiving search and rescue co-ordinating communications,
e. transmitting and receiving on-scene communications,
f. transmitting and receiving signals for location,
g. transmitting and receiving Maritime Safety Information (MSI),
h. transmitting and receiving general radio-communications from shore-based radio systems or networks,
i. transmitting and receiving bridge-to-bridge communications.

8.2. *GMDSS Sea Areas.* The ships' radio-communication operating system provided by GMDSS depends upon sea areas in which ships are located:

a. *Area A1* – an area within coverage of at least one of shore-based VHF coast station,
b. *Area A2* – an area, excluding A1, within coverage of at least one MF coast station,
c. *Area A3* – an area, excluding A1 and A2, within the coverage of an INMARSAT geostationary satellite,
d. *Area A4* – an area outside A1, A2 and A3, i.e. the areas beyond INMARSAT range.

8.3. *GMDSS Elements.* The main elements of GMDSS are:

a. INMARSAT,
b. COSPAS – SARSAT,
c. Emergency Position Indicating Radio Beacons (EPIRBs) (1·6 GHz, 406 MHz, 121·5MHz),

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d. Digital Selective Call (DSC) system (VHF, MF and HF),
e. Enhanced Group Call (EGC) system,
f. VHF and MF communication systems, including portable VHF ships systems,
g. HF Radio Telex System,
h. NAVTEX System,
i. Search and Rescue Transponders (SARTs) (X-band).

8.4. *Maritime Safety Information* (*MSI*). MSI is composed of two complementary services: the NAVTEX service and the EGC SafetyNET service. There are seven basic categories of MSI:

a. navigational warnings
b. meteorological warnings,
c. ice reports,
d. search and rescue information,
e. meteorological forecasts,
f. pilot service messages (not in United States),
g. electronic navigational systems update messages.

8.5. *MSI Institutions*. The MSI service comprises the following institutions:

a. national hydrographic offices,
b. national meteorological offices,
c. Rescue Co-ordination Centres (RCCs),
d. International Ice Patrol for North Atlantic ice hazards.

9. SEARCH AND RESCUE (SAR) SYSTEM. The Search and Rescue (SAR) system has the objective of rescueing the crew and persons from a ship in distress, and/or to find and rescue shipwrecked persons in as short as possible time

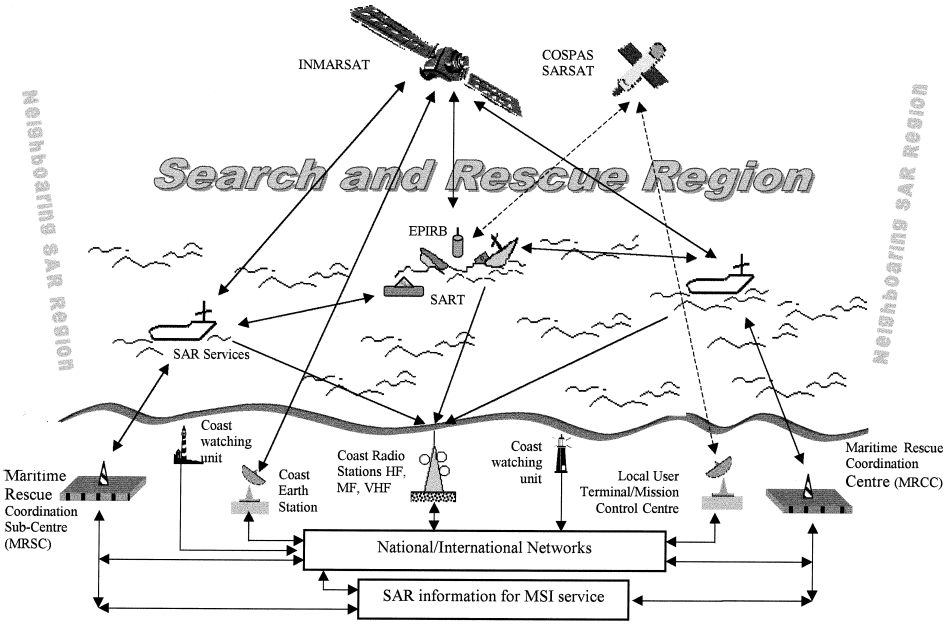

Figure 8. Search and Rescue (SAR) System and its main components.

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after alerting (Figure 8). Its main task is to supplement the effort of ships at sea by establishing and maintaining a life-saving service around the coasts of the maritime countries. Therefore, the SAR system can be considered as the supplementary system to the ships' efforts in maintaining safety of life at sea. Moreover, the SAR system can be also considered as a part of the special system; that is, the 'Protection of the human life at sea' System.

The organic elements of the SAR system are the radio-communication services of GMDSS, and the main legal instrument for establishing and maintaining the SAR System is the convention on 'Maritime Search and Rescue – SAR 79'. This SAR convention requires countries, being parties to the convention, to establish one or more Search and Rescue Regions (SRR) and maintain adequate search and rescue services around their coasts for rescue of persons in distress. The SAR convention comprises the following main issues:

a. organisation of the SAR system,
b. co-operation between states and with aeronautical services,
c. preparatory measures,
d. operating procedures for each phase of emergency, and on-scene co-ordination of rescue activities,
e. ships reporting system.

It is interesting to note that Article 98 of the United Nations Convention on Law of Sea (UNCLOS III), requires that each coastal state shall establish and maintain an adequate and effective search and rescue service regarding the safety on and over the sea, by way of mutual regional arrangements, and co-operate with neighbouring states for this purpose.

The maritime Search and Rescue (SAR) service in each Search and Rescue Region (SRR) is co-ordinated from a Maritime Rescue Co-ordination Centre (MRCC) or Sub-Centre by the means of GMDSS terrestrial and space radio-communication services. On-scene co-ordination of rescue activities is carried on by the On-Scene Commander (OSC) designated by the appropriate MRCC.

SAR forces are composed of rescue units, i.e. specially built and equipped ships and boats, as well as SAR helicopters, and other rescue units, and of ships at sea maintaining the proper conditions for protection of the Safety of Life at Sea convention. Chapter III of the SOLAS 74 convention (the life-saving appliances and arrangements) provides for such conditions. Chapter V of the convention (Safety of Navigation), especially Regulation 10, obligates ships' masters to participate in SAR actions. Ships should act accordingly to the procedures specified in the IMO International Aeronautical and Maritime Rescue Manual (IAMSAR). Proper knowledge and proficiency for the conduct and co-ordination of SAR actions by merchant ships is also required by the STCW 78/95 convention. Warships are also obliged (when possible) to participate in SAR actions.

10. THE PREVENTION OF POLLUTION OF THE MARITIME ENVIRONMENT. The *Prevention of Pollution of Maritime Environment from Ships* system can be considered as the constituent part of the Marine Environment Protection from Pollution System (Figure 9). The main legal act establishing the system is the International Convention for the Prevention of Pollution from Ships

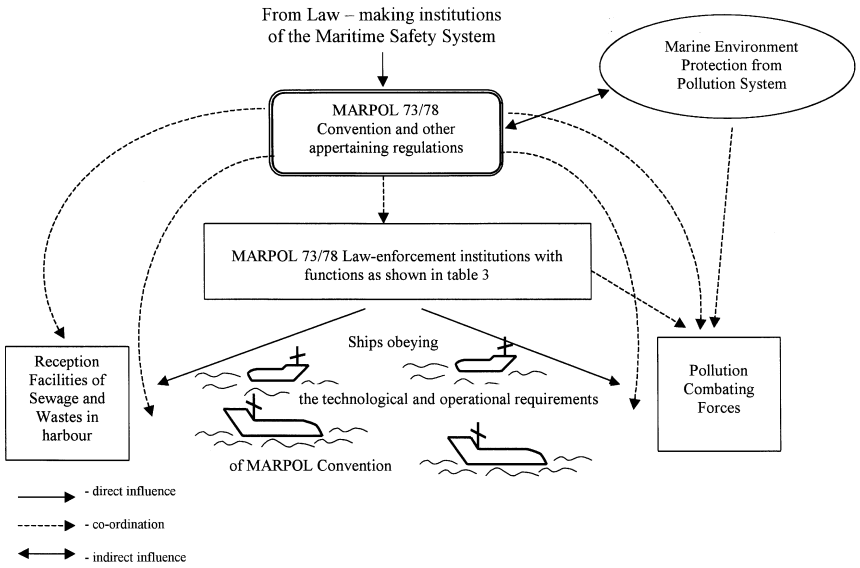

Figure 9. The system for the prevention of pollution of the maritime environment from ships.

Table 3. The main functions of the MARPOL 73/78 law-enforcement institutions.

No.	Substance of function
1	Contingency planning,
2	Certification of ships fulfilling the MARPOL requirements,
3	Surveying the ships' equipment required by the MARPOL regulations,
4	Surveillance of the maritime environment by aircraft and helicopters,
5	Punishment of violators of the MARPOL convention,
6	Starting pollution – response measures.

1973, as modified by the Protocol of 1978 relating thereto – MARPOL 73/78. This Convention contains five Annexes:

Annex I: Regulations for the Prevention of Pollution by Oil;
Annex II: Regulations for the Control of Pollution by Noxious Liquid Substances in Bulk,
Annex III: Regulations for Prevention of Pollution by Harmful Substances Carried by Sea in Packaged Forms, or in Freight Containers, Portable Tanks or Road and Rail Wagons,
Annex IV: Regulations for Prevention of Pollution by Sewage from Ships,
Annex V: Regulations for Prevention of Pollution by Garbage from Ships.

Two of the five annexes (IV and V) relate to all ships, i.e. even to these ships that are not engaged in carriage of crude oil and other chemical cargoes. The main elements of the 'Prevention of Pollution of Maritime Environment from Ships' System are (see Figure 9):

a. law-enforcement institutions of the MARPOL 73/78 Convention,
b. reception facilities of sewage and wastes in harbours,
c. pollution combating forces,
d. ships obeying the technological and operational MARPOL 73/78 Convention.

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The main functions of law-enforcement institutions of the MARPOL 73/78 Convention are shown in Table 3.

According to MARPOL's 73/78 convention regulations:

a. Sewage and wastes reception facilities must be established in harbours so that they do not generate an undue delay for ships arriving to harbour.
b. Pollution combating forces must be capable of combating all chemical spills and pollution both by the mechanical means and by chemical agents.
c. All ships, in compliance with performed tasks, number of crew, etc. must fulfil appropriate regulations of this convention.
d. And all ships at sea must fulfil all regulation provided by Annexes IV and V.

Apart from the MARPOL 73/78 convention, which is international, there are also supplementary, regional conventions on prevention of pollution of the marine environment. An example of a regional convention is the 'Convention on Prevention of Marine Environment of the Baltic Sea Area', 1980, revised in 1992.

9. CONCLUSIONS. This paper has reviewed all the components and elements of the maritime safety system including legal, institutional and organisational aspects. Recent advances in radio-communication, and particularly the introduction of GMDSS, have considerably enhanced *safety at sea*. The next introduction, the Automatic Indentification System (AIS), will provide another leap forward to enhance the maritime safety system and so the safety of life at sea.

REFERENCES

Admiralty List of Radio Signals. (1998/1999). *Volume 5: Global Maritime Distress and Safety System* (*GDMSS*). *Convention on Prevention of Marine Environment of the Baltic Sea Area*, 1980, *revised in* 1992.

Felski, A., Urbański, J. (1997). Satellite systems for positioning and ensuring the safety of navigation (in Polish). *Podręznik AMW*. Gdynia.

Dąbrowki, T., Urbański, J. (1993). The international system of safety of navigation (in Polish). Zeszyty Naukowe AMW Nr 2.

SOLAS 74. The International Convention on Safety of Life at Sea.

MARPOL 73/78. International Convention for Prevention of Pollution from Ships.

COLREG 72. International Convention on the International Regulations for Preventing Collisions at Sea.

STCW 78/95. International Convention on Standards of Training, Certification and Watchkeeping for Seafarers.

SAR 79. (1998). International Convention on Maritime Search and Rescue.

Kopacz, Z. and Urbański, J. (1998). Navigation at the beginning of the 21st century. *Geodezja i Kartografia t*. XLVII, z. 1–2, pp.59–68.

Kopacz, Z., Morgaś, W. and Urbański, J. (1998). The selected issues of the International Navigation Safety System (in Polish). *Podręcznik AMW*, Gdynia.

Jurdziński, M. and Urbański, J. (1989). Global Maritime Distress and Safety System (in Polish). *Budownictwo Okrętowe*, Nr 5.

Jurdziński, M. and Urbański, J. (1988). An attempt to define several issues regarding safety at sea (in Polish). *Prawo i Orzecznictwo Izb Morskich*, Nr 11–12.

Jurdziński, M. and Urbański, J. (1994). An attempt to specify the basic terms regarding safety at sea (in Polish). *Zeszyty Naukowe*, AMW Nr 3.

Jurdziński, M. and Urbański, J. (1995). The maritime safety system and its elements (in Polish). *Zeszyty Naukowe*, AMW Nr 1.

Urbański, J. and Holec, M. (1998). The ship's navigation process in the terms of the set theory. *Archives of Transport*, Volume 10, Issue 1–2.