

Z. Kopacz, W. Morgaś, J. Urbański
Naval University of Gdynia

THE MARITIME NAVIGATION, ITS ENVIRONMENT AND ITS SAFETY SYSTEM

ABSTRACT In this paper, the considerations on the relations between the maritime navigation, its geographical and navigational environment and its safety system are presented. The most important issues of the ships' navigation, its environment and maritime navigation safety system are also discussed and the most important relations are shown.

INTRODUCTION

The maritime navigation is the kind of human activity and, therefore, a kind of human profession. It is also the field of education, especially higher education, and the branch of the applied science. The subject of our considerations is the maritime navigation as the field of human activity. The subject of this activity is the safe and efficient conducting the ships at sea between the given harbours or between the given positions.

The maritime navigation is being realized in the proper environment, i.e. in the geographical and navigational one. The conducting the ships at sea is being assisted by the maritime navigation safety system.

The following issues are presented below: ship's navigation function, ship's navigation process and ship's navigation system; the ships' navigation environment, and ships' navigational information; the maritime navigation safety system and its elements; and the operational institutions of the maritime navigation safety system.

THE SHIP'S NAVIGATION FUNCTION, SHIP'S NAVIGATION PROCESS AND SHIP'S NAVIGATION SYSTEM

The ship's navigation function is the one of four ship's functions by means of them the ships' assignments i. e. the ships' main tasks, are being realised. The other three ship's functions are [13]:

- ship's platform control function,
- ship's tasks realisation function,
- ship's command and control function.

The main objective of ship's navigation function is the safe and efficient conducting the ships at sea between the given harbours, or positions, and assistance of performing the ship's main tasks realization function.

The ship's navigation function is being performed by the means of the ship's navigation process i.e. by means of the series of prescribed navigational activities and procedures being done by the ship's bridge team, using the ship's navigation system.

The ship's navigation process may be reduced to several subprocesses. It is graphically shown in Fig. 1. It can be expressed by the following formula:

$$\text{nav} = [\text{cin} \wedge \text{vpl} \wedge \text{wea} \wedge \text{ste} \wedge \text{pos} \wedge \text{man} \wedge \text{rde} \wedge \text{mco} \wedge \text{rec}] \quad (1)$$

where:

- nav = the whole ship's navigation process,
- cin = communication and information, storing, up-dating and retrieving the standard navigational information,
- vpl = voyage planning,
- wea = minimizing the ship's weather losses,
- ste = steering the ship,
- pos = positioning the ship,
- man = maneuvering and handling the ship, when necessary,
- rde = Responding to the distress signals and navigational emergencies, when necessary,
- mco = monitoring and controlling the ship's navigation process (monitoring the ship's geographical and navigational environment and ship's track; avoiding collisions and groundings; modifying the course, speed and planned track when necessary; and regularly checking the navigational equipment and systems and ship's safety means),
- rec = recording the ship's voyage data and navigational events.

The ship's navigational subprocess "monitoring and controlling" (mco) is the main ship's navigational subprocess. It monitors and controls all the other ship's navigation subprocesses. This subprocess, in great extent, is assisted and performed by the officer in charge of a navigational watch.

While performing the ship's navigation, i.e. while conducting the ships at sea, the primary navigational information [Prin] is being transformed into the navigational parameters [Napa]. This process of information transformation can be expressed as follows:

$$\text{nav}: (\text{Prin}, \text{Stpr}) \rightarrow [\text{Napa}] \quad (2)$$

Where "nav" stands for transformation formula, [Stpr] stands for standards and procedures according whose the primary information [Prin] is being transformed into the navigational parameters [Napa].

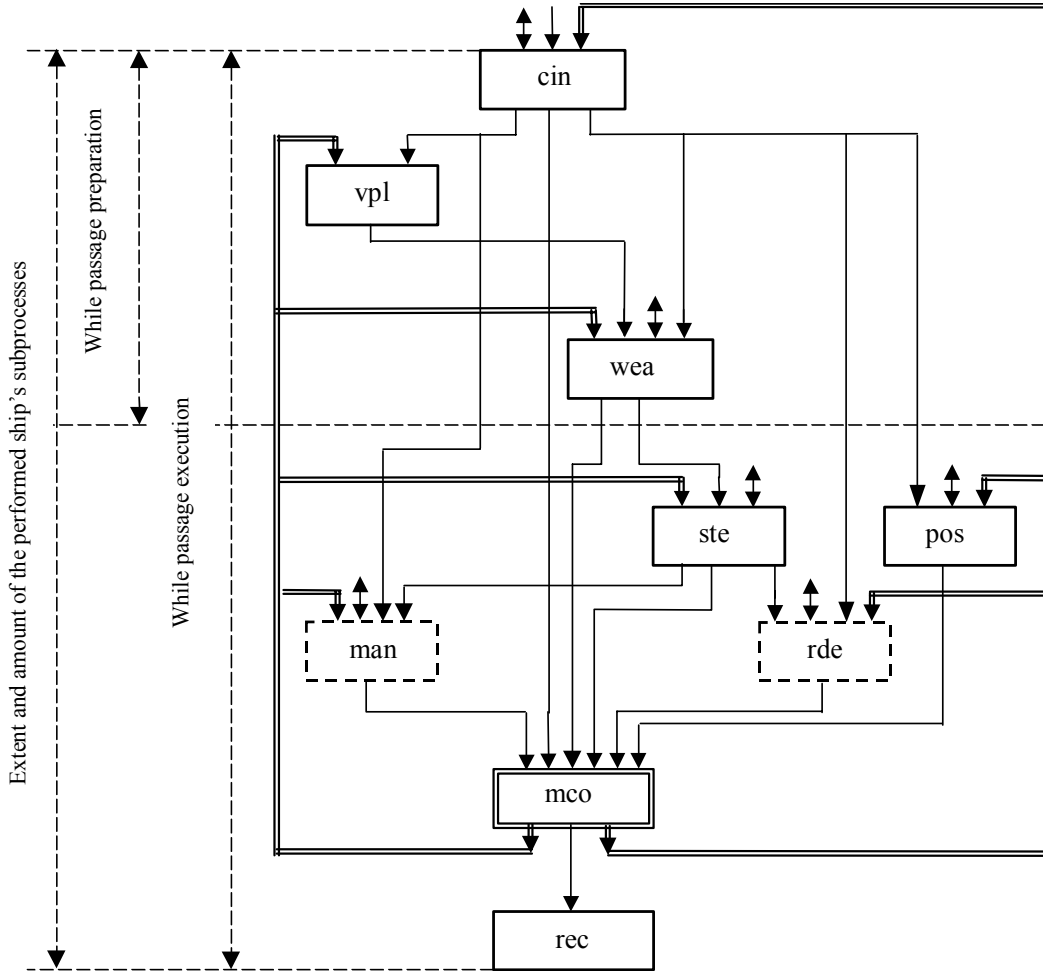


Fig. 1. The ship's navigation process and its subprocesses.

Notation in Fig. 1.

- cin = ship's navigation subprocess; the names of the subprocesses are given in text,
- man = periodically realized ship's navigation subprocess,
- = input of the navigational information,
- ↔ = ship's measurements and observations,
- ⇒ = feedback- and control information.

The ship's navigation process is being realised by the means of the ship's navigation system. Therefore, as first, we assume the definitions of the two following terms:

- ship's (shipborne) navigational system,
- ship's navigation system.

The term "ship's (shipborne) navigational system" is the habitual name of the radioelectronic and electronic ship's equipment, aid, etc. by means of which the particular navigational activity, procedure or subprocess is being realized.

The term "ships navigation system" means the arrangement of all the shipborne navigational equipment and systems at ship, properly connected and co-operated whose objective is to perform the whole ship's navigation process, i.e. to conduct the ship at sea safely and efficiently from one place to another.

The set of the obligatory shipborne navigational equipment and systems that constitute the ship's navigational systems of different ships, defined by their tonnage, are specified by the proper regulations of SOLAS-74 Convention [3].

The ship's navigational systems are very differentiated. They become more and more integrated with other ships' systems, especially with ship's platform control systems and ship's command and control system. The above results in the coming-into-being the Integrated Bridge System (IBS) and other much more integrated systems, including Ship's Operation Control Systems [13].

THE SHIP'S NAVIGATION ENVIRONMENT AND SHIP'S NAVIGATIONAL INFORMATION

By the term "maritime navigation environment", i.e. the environment in which the ship's navigation is being performed, we mean all the physical and informational conditions and circumstances influencing the surroundings of each ship's and effecting the safety of the ships at sea and efficiency of their conducting and realization of their main tasks.

The greatest influence upon the maritime navigation is being exerted by the following elements of the ship's navigation environment (Fig. 2):

- geographical environment,
- the ships traffic,
- the maritime navigation safety system.

The first two elements of the ship's navigation environment are changing permanently and, therefore, they are the sources of many and various ship's threats and dangers. However, the third element of the ship's navigation environment, being the man-created and man-maintained system, ensures the informational conditions for safe and efficient conducting the ships at sea.

The term, and notion "ship's navigational information" [Nain] is considerably wider than the notion "ship's geographical and navigational environmental information" [Envi].

ANNUAL OF NAVIGATION 4/2002

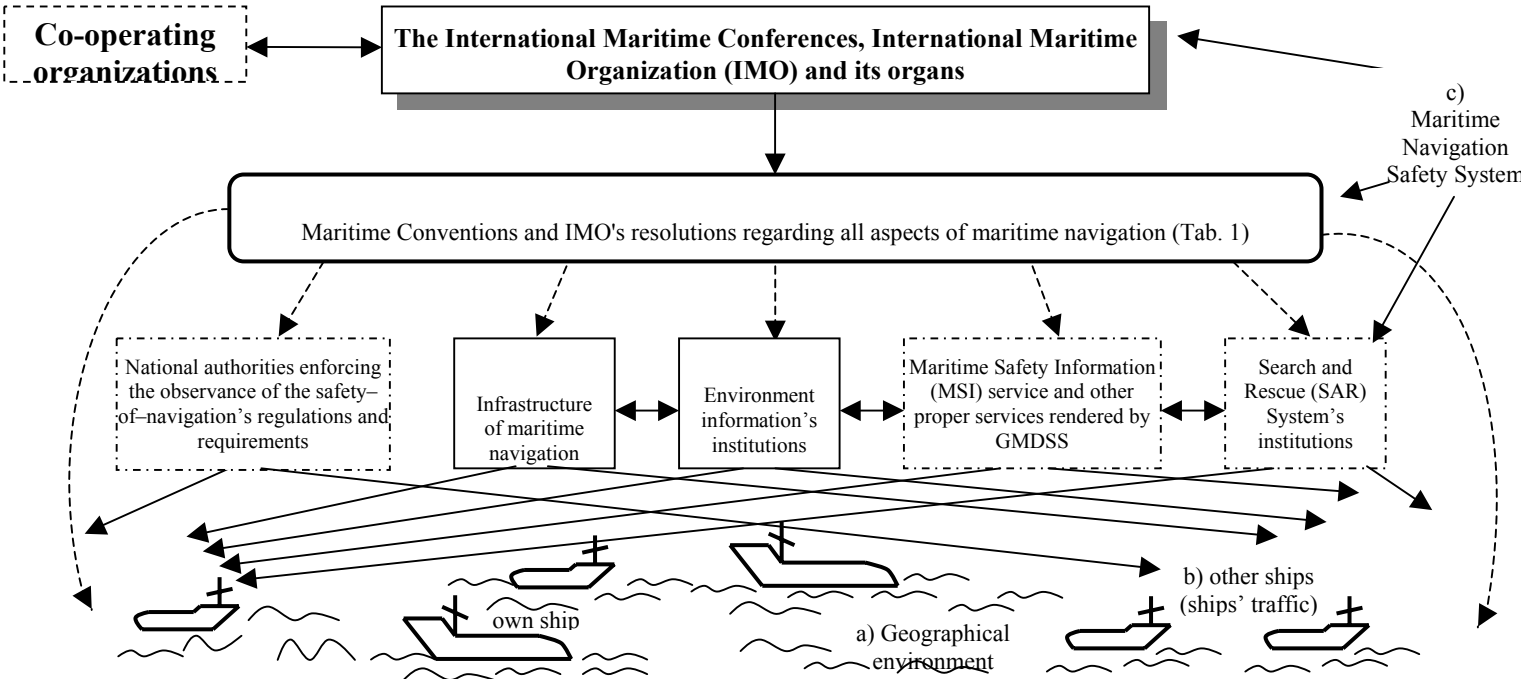


Fig. 2. The elements of the maritime navigation environment including the Maritime Navigation Safety System

- Notation in Fig.2**
- co-operating institutions,
 - - direct influence on navigation process
 - - indirect influence on the navigation process
 - ↔ - co-operation

ANNUAL OF NAVIGATION 4/2002

The term “ships navigational information” [Nain] means all the kinds of information necessary for conducting the process of ship’s navigation. This information besides the ship's geographical and navigational environmental information [Envi] contains also the information describing the navigational characteristics of the ships [Ship], as well as the operational [Oper] and legal information [Lega] necessary for safe and efficient conducting the ships at sea.

The above can be expressed as follows:

$$[\text{Nain}] = [\text{Envi}, \text{Ship}, \text{Oper}, \text{Lega}] \quad (3)$$

where [Nain] stands for the ship’s navigational information, [Envi] stands for all the kinds of ship's geographical and navigational environment information, [Ship] stands for all the kinds of information describing the ship’s navigational features and characteristics, [Oper] stands for all kinds of operational information necessary for conducting the ship's navigation, and [Lega] stands for all kinds of legal information needed for conducting the ships at sea.

The ship's geographical and navigational environment information [Envi] contains all the kinds of geographical environment’s information and all kinds of the information provided by the maritime navigation safety system necessary for safe and efficient conducting the ships at sea.

The ship’s environmental information [Envi] can be expressed as follows:

$$[\text{Envi}] = [\text{Char}, \text{Msin}, \text{Ltin}] \quad (4)$$

where [Char] stands for all the kinds of chart information, i.e. information that constitutes the content of the paper charts and nautical publication, or the content of ECDIS’s data base, [Msin] stands for maritime safety information that up-dates the chart information and is disseminated by the GMDSS system, and [Ltin] stands for long term weather information necessary for minimising the adverse-weather’s losses and damages.

The ships’ navigational information expressed by the formula (3) is the standard ships’ navigational information. The other kinds of ships’ navigational information, i.e. the complementary ships’ navigational information are the ships’ measures [Meas] and observations [Obse], i.e. the information from ships’ own information sources.

THE MARITIME NAVIGATION SAFETY SYSTEM AND ITS ELEMENTS

The Maritime Navigation Safety System has begun to be stepwise created yet in the distant past and whereafter was permanently improved. Now, it is farther developed and, improved. Its main task is to ensure and maintain the favourable navigational conditions for safe and efficient conducting the ships at sea. This System constitutes also the basic part of the Maritime Safety System [14](Fig.3).

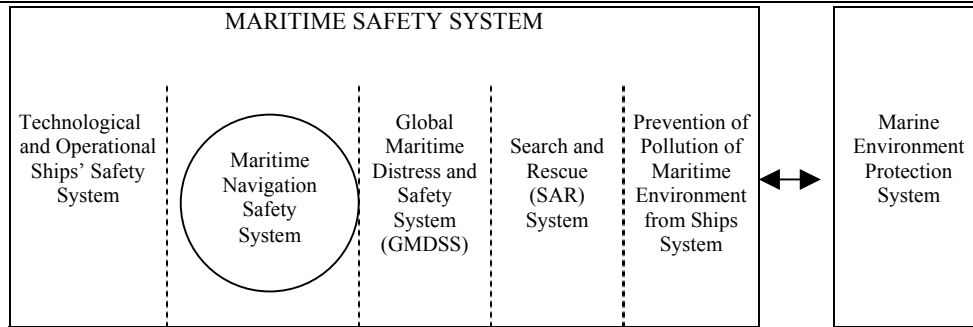


Fig. 3. The Maritime Navigation Safety System as the constituting part of the Maritime Safety System.

The main objective of the Maritime Navigation Safety System is to ensure the safety of navigation (ships' navigational safety), i.e. the safety against external ships' dangers such as wrecks and other underwater obstacles; collisions with other ships and objects; and damages and losses resulted from unfavourable weather conditions.

The ships' navigational safety (safety of navigation) is the main component of the maritime safety (Fig.4).

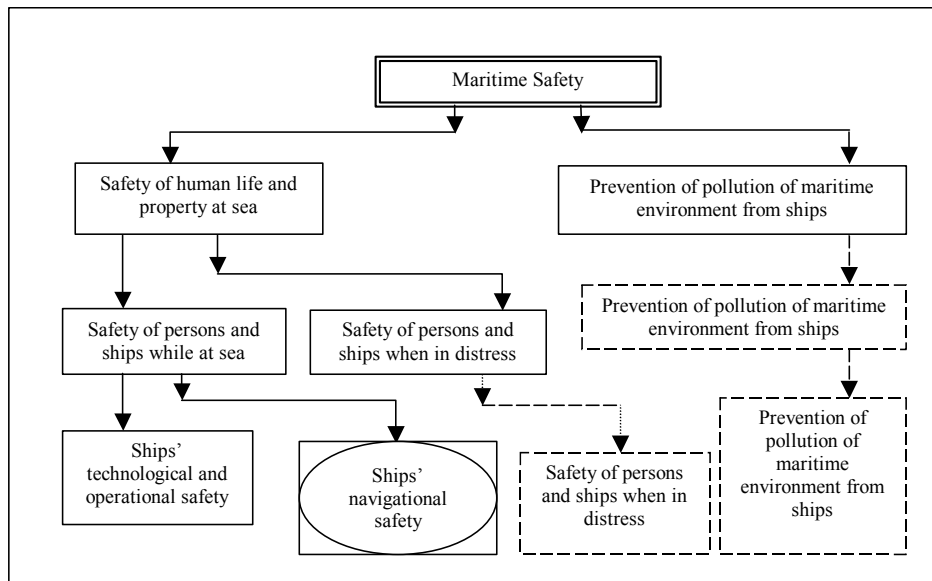


Fig. 4. The place of the ships' navigational safety (safety of navigation) among the other parts of the ship's maritime safety.

The main elements of the Maritime Navigation Safety System are the following (Fig.2):

- the international maritime conferences and the International Maritime Organisation (IMO) and its organs,
- maritime laws and regulations (requirements and procedures),
- operational institutions of the System.

The navigating ships at sea constitute the main users of the Maritime Navigation Safety System.

The main international body responsible for “safety at sea” and, therefore, for “safety of navigation”, is the International Maritime Organisation (IMO), being a specialised agency of the United Nation Organisation (UNO). The main Organs of IMO are:

- General Assembly,
- Council,
- Committees: Maritime Safety Committee (MSC), Marine Environment Protection Committee (MEPC), Legal Committee (LC), Technical Committee (TC) and Facilitation Committee (FC),
- Secretariat.

Maritime Safety Committee (MSC) is the main committee that, apart from the General Assembly and Council, is responsible for Safety and efficiency of maritime navigation.

The following international organisations very closely cooperate with the IMO’s organs while preparing and adopting the maritime conventions and IMO’s resolutions regarding the maritime navigation and its systems:

- a) World Meteorological Organisation (WMO),
- b) International Maritime Satellite Organisation (INMARSAT),
- c) International Telecommunication Union (ITU-R),
- d) International Hydrographic Organisation (IHO),
- e) International Association of Lighthouse Authorities (IALA),
- f) International Labour Organisation (ILO),
- g) International Civil Aviation Organisation (ICAO), and many other.

The second element of the Maritime Navigation Safety System constitute the maritime laws and regulations regarding the operation of maritime navigation and ensuring its safety and efficiency.

The maritime conventions and IMO’s resolutions, appertaining the maritime navigation, regard the following, basic domains of the maritime navigation (Table 1).

The regulations and requirements regarding the legal, technological, operational and professional aspects of maritime navigation constitute the one of the main instrument of the Maritime Navigation Safety System. This instrument is composed of the maritime conventions and the IMO’s resolutions issued by the General Assembly and the Maritime Safety Committee.

Table 1. The Basic Domains of the Safety and Efficiency of the Maritime Navigation.

No	Substance of the domains
1.	Ship's navigation process and its subprocesses
2.	Ships' navigational equipment and systems
3.	Ships' navigational features and characteristics
4.	Navigational infrastructure
5.	Navigation – environment's information
6.	Maritime Safety Information (MSI) and its services
7.	Navigational competencies of the seafarers
8.	Traffic management and navigational assistance
9.	Responses to the distress signals
10.	Responses to the navigational emergencies
11.	Ships' geographical environment

The “safety-of-navigation matters” are specified mainly in three maritime conventions:

- a. Convention for “Safety of Life at Sea” – SOLAS 74, but especially in its Chapter V: Safety of Navigation, being amended in 2000,
- b. Convention on the “International Regulations for Preventing Collision at Sea” – COLREG 72,
- c. Convention on “Standards of Training, Certification and Watch – keeping for Seafarers” – STCW 78/95.

The regulations and requirements regarding the technological and operational aspects of the maritime navigation are contained mainly in very numerous resolutions adopted by the IMO's General Assembly and the Maritime Safety Committee (MSC). These resolutions contain mainly the performance standards and operational procedures appertaining the ships' navigational equipment and systems, as well as aids to navigation systems.

Apart from the above mentioned regulations and requirements, there is also the very great amount of operational procedures being applied while conducting the ships at sea, i.e. while realisation of ships' navigation processes. These procedures are applied for the cooperation, i.e. for the assistance of navigating ships by the Maritime Navigation Safety System. They constitute the one of many components of the standard ships navigational information expressed by formulae (3) and (4).

THE OPERATIONAL INSTITUTIONS OF THE MARITIME NAVIGATION SAFETY SYSTEM

The Maritime Navigation Safety System comprises the following kinds of operational institutions (cf. Fig.2):

- a. national authorities enforcing the observance of the “safety of navigation” regulations and requirements,
- b. navigational infrastructure,
- c. navigational information’s institutions,
- d. Maritime Safety Information (MSI) service and other navigational services rendered by the GMDSS,
- e. SAR – system’s institutions co-operating with the ships being-in-distress and with the ships being in the vicinity of ships and/or persons being-in-distress.

The national law-enforcement authorities (cf. Fig. 2) enforcing the observance of the safety-of-navigation's regulations and requirements, comprise this part of national maritime administration (maritime boards, coast guard, harbour authorities, etc.) that supervise the possession and validity of the ships’ certificates to be carried on board; possession and the state of the navigational equipment, life-saving appliances, etc., as well as observance by the ships the local and regional traffic regulations, and others. The law–enforcement authorities under discussion are the constituting part of the law-enforcement authorities whose objective is to enforce maritime-safety and marine-environment–protection regulation and requirements (cf.Fig.2).

The navigational infrastructure of the maritime navigation includes the following, main groups of infrastructure’s means:

- a. sea way facilities,
- b. aids to navigation systems
- c. traffic management and navigation assistance systems.

The sea-ways facilities comprise:

- fairways,
- recommended routes and traffic separation schemes,
- artificial canals,
- anchorages,
- manoeuvring areas and other facilities.

The aids to navigation systems comprise the following kinds of means:

- floating and fixed aids to navigation such as buoys, beacons,
- leading marks, lighthouses, landmarks, etc.,
- electronic position fixing systems, such as radiobeacons,
- Loran systems, etc.,
- satellite navigation systems including DGPS reference stations, etc.

The traffic management (and navigation assistance) systems and services comprise the following:

- pilotage services,
- ships reporting systems,
- Vessel Traffic Services, including (AIS), and others.

The navigation-environment-information's systems (cf. Fig. 2) provide the seafarers with the navigational information regarding the ships' geographical and navigational environment's information [Envi]. The main form in which this kind of information is being delivered to the seafarers are the navigational chart and nautical publications (now also in the digitised form). The main institutions that prepare and supply the seafarers with the environmental information [Envi] (cf. Expression 4) are the following:

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

The Maritime Information (MSI) service is rendered by the GMDSS. This kind of environmental information [Msin] (cf. expression 4) updates the environmental information [Envi]. This kind of information service is composed of two complementary services, i.e.:

- a. NAVTEX service,
- b. EGC SafetyNet.

There are seven basic categories of MSI:

- a. navigational warnings,
- b. meteorological warnings,
- c. ice reports,
- d. search and rescue information,
- e. meteorological forecast,
- f. pilot service messages (excluding the USA waters),
- g. electronic navigational systems update messages.

The MSI service is being provided by the following institutions:

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

The other navigational service rendered by the GMDSS is the "bridge-to-bridge radiocommunication".

The SAR-systems institutions co-operating with the ships being-in-distress and with the ships being in the vicinity of ships and/or persons being-in-distress comprise:

- a. most of the GMDSS radiocommunication services,
- b. SAR system institutions engaged in the SAR action or operation.

The ships engagement in SAR activities is being carried on accordingly to the IMO International Aeronautical and Maritime Search and Rescue Manual (IAMSAR).

CONCLUSIONS

Above, the main relations between the maritime navigation process, its environment and the maritime navigation safety system has been shown. However it should be stressed that the importance of that System for ships navigation is permanently growing and deepening. The ships at sea, in greater and greater degree, depend upon this System, i.e. upon the navigational infrastructure and upon the navigation-environment-information systems. This tendency confirms such events as the complement of the navigational infrastructure by the Automatic Identification System (AIS) and by many other events provided by the new regulations of the replaced text of chapter V (Safety of Navigation) of the SOLAS 74 Convention that entered into force in 2002.

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