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Sources of interferences in GMDSS

SUMMARY

In this paper the external and internal interferences which may disturb proper operation of the Global Maritime Distress and Safety System are discussed. All potential sources of the interferences are specified and classified. To find appropriate remedies an analysis of mechanisms of the generation of interferences is still needed.

INTRODUCTION

The Global Maritime Distress and Safety System (GMDSS) has just commenced its fourth year of existence. From the communication structures existing in this system (Fig. 1.) it results that communication means working with the use of medium waves and MF, HF, VHF also utilize satellite systems using frequencies from the 1,5/1,6 and 4/6 GHz bands. These frequencies are used to send distress signals with the help of DSC, EPIRB, in the COSPAS-SARSAT system as well as INMARSAT-E. From the conclusion of the III Conference in Plymouth, held in March 1994, devoted to the problems connected with the practical use of the GMDSS, it results that many unsolved problems or matters which need systemic as well as procedural changes still exist [3].

The basic problems in GMDSS are:

- the generation of false distress alerts in all the constituting GMDSS subsystems,
- the problem of electromagnetic compatibility and
- potential sources of interferences in the GMDSS as well as the methods of reducing or eliminating them [4].

The quality and reliability of the GMDSS depend to a high degree on its resistance to various types of interferences. The interferences are caused by natural phenomena as well as the results of intended or unwanted activities of man. The sources of interferences are ubiquitous. Their character as well as their intensity depend on many factors, so theoretical models of interference sources are usually approximate. Interferences occur in the environment which constitutes a set of natural, or caused by human activity factors where the system is being used.

TYPES OF INTERFERENCES

Interferences can be divided into determinate and indeterminate ones. The first type can be described by means of strict mathematical formulas. The second type have a random character and are described by means of statistical functions [8].

The interferences occuring in the GMDSS can be divided into external and internal ones. They can appear in transmitting and receiving devices as well as on paths of propagation of signals, on which ionospheric, cosmic, atmospheric etc features as well as the occurence of interferential disturbances in satellite and terrestrial radio communication systems influence the quality of the transmission. It is very important to know how the interferences occur in the electronic receiving devices which are particularly sensitive to various interferences.

Fig. 2 shows the influence mechanism of electromagnetic interferences on the electronic devices of the system [7].

External and internal interference signals should not have any influence on the devices. On the other hand these devices should not be sources of interferences for other devices and systems.

For instance, transmitters and receivers of various signals operate close together and are sources of mutual interferences. Such situation appears often where sources of interferences and systems sensitive to interferences are parts of the same devices.This is the problem of so-called internal interferences. If, however, the sources of interferences have their origin outside of a given device with subsets susceptible to interferences, then the interferences are called external ones (Fig. 3).

A sea-going vessel is a particular object of electromagnetic influence. On a relatively small area a large number of various machines and electric appliances are gathered such as: power station, electric auxiliary devices, transmitting and receiving radiocommunication devices, radionavigation and radio diffusing devices, and

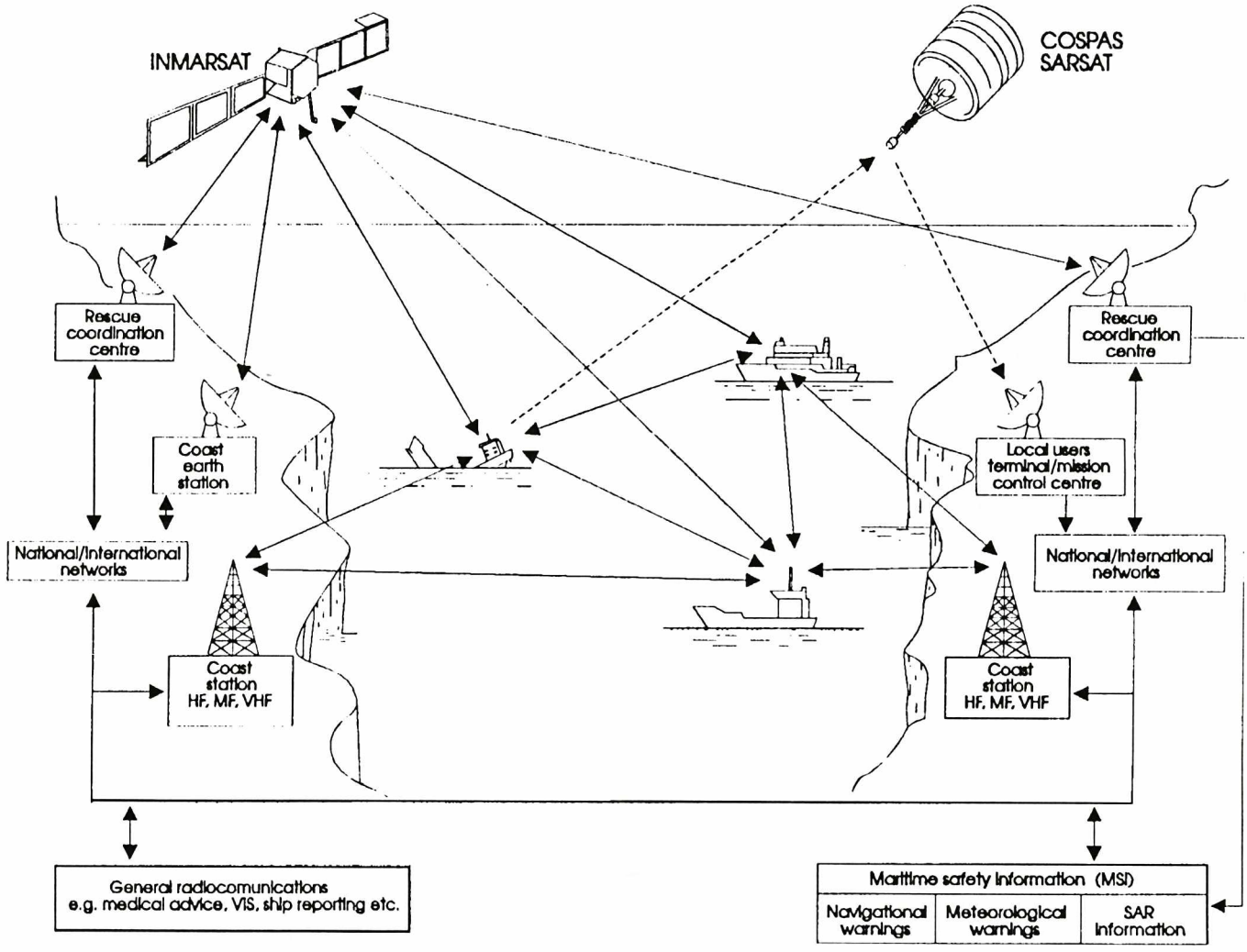

Fig 1. General concept of the GMDSS.

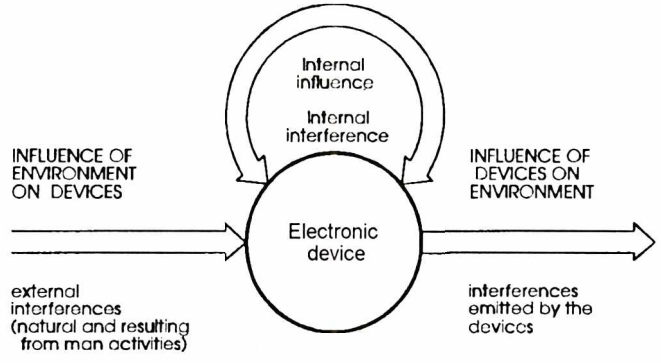

Fig. 2 Influence of interferences in electronic devices

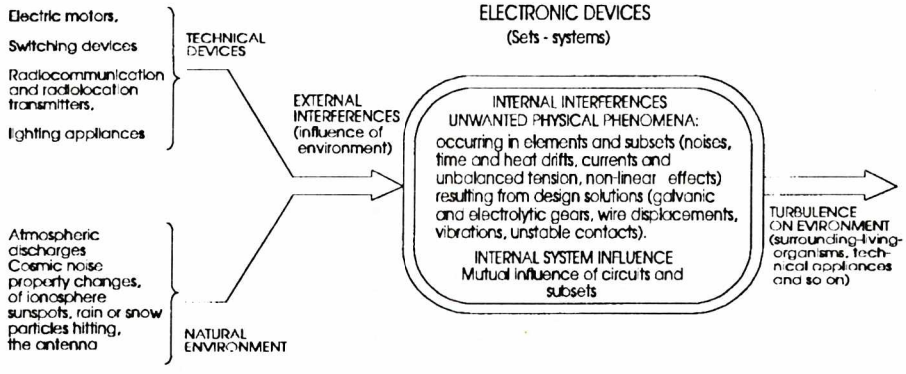

Fig. 3. Sources of interference signals in electronic devices

also equipment of general use. Sensitive receivers, computers and magnetic memories, sensitive to interferences, are very often placed in the proximity of electric machines, transmitting devices of high power and radar creating electromagnetic fields of high intensity.

Electromagnetic interferences on a ship can be divided into 3 basic groups, according to the sources which create them (Fig. 4) [5], [6]:

- natural interferences (caused by natural phenomena)
- interobject interferences (caused by devices installed on land, other ships, planes, satellites etc.)
- aboard-ship interferences (mutually disturbing influence of installations and systems on the ship).

Taking into consideration harmful influences on particular installations it is important to distinguish the interference sources according to the width of their interference spectrum: of wide or narrow band.

Taking into account their occurrence in time, continuous, transient and impulse interferences can be distinguished. The reliability of devices and telecommunication and teleinformatic networks in GMDSS depends on their resistance to electromagnetic exposures. So an increasing interest in electromagnetic compatibility of these devices and systems is being observed.

In the developed countries the requirements concerning electromagnetic compatibility of the telecommunication and teleinformatic equipment are limited today to the basic requirements such as resistance to mechanical and climatic exposures.The influence of the electromagnetic environment on devices, telecommunication and teleinformatic systems, and the influence of these devices and systems on the environment, is shown schematically in Fig.5 [2].

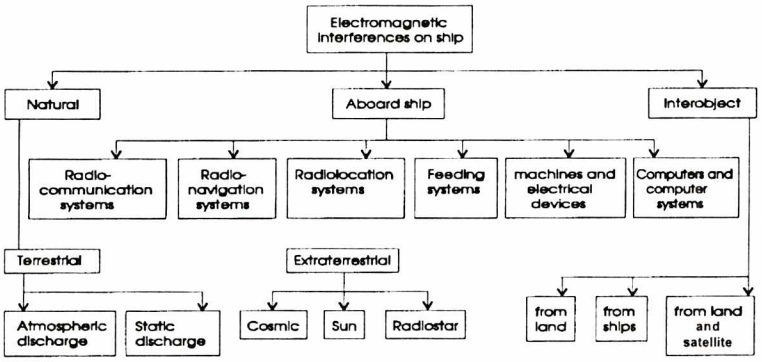

Fig.4 Division of electromagnetic interferences on sea-going ship

The problems of electromagnetic influences within the selected telecommunication system (viz. mutual influence of objects A, B, and C illustrated in Fig.5), connected directly with the assurance of its correct operation, are called „internal compatibility". The aim of internal compatibility is to assure a satisfactory margin of safety to all the objects of the system with their mutual influence taken into account.

The problem of internal compatibility is solved at the designing stage and when starting a new telecommunication system (device). The assurance of harmonious coexistence of devices and systems in the electromagnetic environment, i.e. the achievement of a state in which the considered object has an insignificant influence on the environment (ways 2 and 3 in Fig. 5) and is simultaneously little susceptible to influences from the environment (way 1 in Fig. 5), constitutes the subject of external compatibility. So, it is the protection of electromagnetic environment that is concerned (as far as possible) against purposefully and unparposefully created fields on one hand, and the assurance of a correct functioning of devices and systems (mainly telecommunication and teleinformatic ones) in the real environment on the other hand [6].

THREATS IN THE ELECTROMAGNETIC ENVIRONMENT

The threats appearing in the electromagnetic environment are divided in two groups. The first group is constituted by electromagnetic fields of a continuous type which appear as a result of the action of transmitting devices, microwave ovens etc. The second group comprises a very wide class of pulse interferences. It concerns pulses of tension, current or electromagnetic fields influencing the devices, telecommunication and teleinformatic systems.The problem of electromagnetic threats has become particularly important since highly integrated circuits began to be used in the construction of telecommunication and teleinformatic devices as it is in GMDSS devices on a ship. The systems operate at a very low power, from 10^{-2} to 10^{-8} W for a single transistor. This has significantly diminished the sensitiveness threshold of these systems. Electric waves with energies of 10^{-3} to 10^{-6} J may cause a permanent deterioration of semiconductor junctions (Tab. 1). So it is necessary to conduct continuously research on the generation and propagation of interferences created by various sources as well as on the resistance (sensitiveness) of devices and systems to these interferences [1].

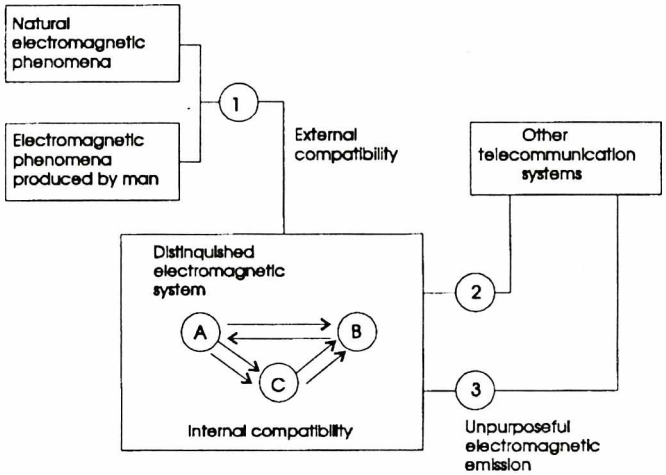

Fig. 5.Mutual influence of the electromagnetic environment and the telecommunication-system

Tab.1. Average energy values of a one microsecond impulse causing permanent damage of electronic components

Element	Energy value [mJ]
Electronic tube	1 ..... 10^{4}
Wire resistor	10^{3}
Carbon resistor	50
Relay	10 ..... 10^{3}
Thin layer resistor	10^{-1} ... 10
Rectifier diode	10^{-1} ... 100
Zener diode	10^{-1} ... 100
High power transistor	10^{-1} ... 10
Switching diode	10^{-2} ... 1
Low power transistor	10^{-2} ... 1
LSI Integrated circuit	10^{-2} ... 1
Microwave diode	10^{-4} ... 10^{-2}
VLSI Integrated circuit	10^{-6} ... 10^{-3}

Note: Temporary work disturbance of components creates 10 to 100 times lower energy.

The danger created by an electromagnetic impulse results mainly from not taking into account this influence at the designing stage of a device or system.This fact is less dangerous in the case of frequent electromagnetic impulses. They cause disturbances in the work of the device (system) at the time of setting it in motion. So, suitable remedial means should be applied though sometimes this can be expensive and troublesome.The case of rare and irregular impulses is much worse. Their influence on the telecommunication device or system is comprehended only after observing the abnormal work or damage of the device. It remains then only to evaluate the losses.

The sources of electromagnetic pulses (Fig. 6) are:

- nuclear explosions
- atmospheric discharges
- switching processes
- shorting in power distribution systems

These are high-energy impulses influencing devices and system localized on large areas. The sources of low-energy electromagnetic impulses which have a local influence are:

- electrostatic discharges
- sparkings
- momentary voltage drop and decay
- overvoltage etc.

Atmospheric discharges are one of the most important impulse sources of electromagnetic threats. They may disturb work and even cause damage to various electronic devices on a ship. During storms strong electromagnetic impulses are caused by [1]:

- preliminary discharges spreading by leaps from the charge centre in a cloud to the earth
- main discharges when stroke currents flow in the channel created by preliminary discharges
- discharges in clouds and between clouds

The main discharge starts from the clouds, when the preliminary discharges have reached the earth. When analysing the overvoltages caused by a main discharge, the following parameters are considered:

- peak value of the discharge current
- speed of current rise
- speed of current wave moving in the discharge channel

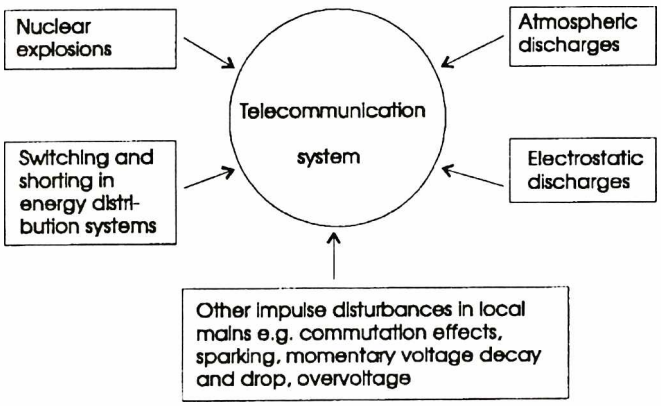

Fig. 6. Sources of electromagnetic impulse threats

Due to differentiation of types of discharges and geophysical conditions, the mentioned parameters can be defined in a statistical way only. The values taken to calculate the parameters also depend on the required level of reliability of the devices and telecommunication systems. Preliminary discharges, called also leading discharges, are the source of several tens to several thousands of electromagnetic impulses. The top value of these pulses are much smaller if compared with pulses appearing during the main discharge. Most often the action of these impulses amounts to disturbances in the work of the telecommunication devices, mainly digital ones, which are now more and more frequently used on ships. The top value of the leading discharge current is of several kiloamperes, the rising time - of several nanoseconds, the step length of the leading - of several tens to several hundred meters, the time between impulses - of tens of microseconds. Processes that occur during discharges in clouds or between clouds are hardly known. There is no clear idea on the differences occuring between discharges in clouds and discharges between clouds as they result from the various characteristics of insulating centres [1].

There is lack of information about parameters of discharging current. More information is available about electromagnetic fields created by these discharges. The impulses of the electromagnetic fields observed during discharges in clouds and between clouds can be divided in two groups:

- regular, one-polar impulses with the rising time of 0,2s or shorter and the duration time of about 0,75s , appearing about every 5s during100÷400s
- bipolar impulses having amplitudes and rising time of about 0,65s, appearing at intervals of about 700s.

A hypothesis has been formed that short impulses are caused by step discharges similar to preliminary (leading) discharges. These discharges establish a channel where currents of a high intensity start flowing relatively slowly and create a magnetic fields changing relatively more slowly. In the spots where electric current is delivered disturbances appear, which may have source not only in the above described phenomena but also in the effects of the work of other devices and systems located in the vicinity and supplied from the same power source. Among the most often met disturbances there are short changes of voltage which are added to or subtracted from the basic sinusoidal wave in the line supplied by alternate current (50Hz, 400Hz) or nominal voltage in the line supplied by direct current (on board mains). Typical sources of disturbances are thyristor devices, impulse sources of power supply, switches. They cause short disturbances lasting from 50 to 500μs and their amplitudes may reach 500V.

Besides, overvoltage and short decays are often observed in the power supply sources.

CONCLUSION

From the presentation of the problem it can be seen that interferences in GMDSS may be various and complex. The interferences, beside the human factor, procedures of dealing with the equipment, proper maintenance and programmed functions (software) of the devices, are the most important factor that can cause the generation of false distress signals in all subsystems constituing the GMDSS and affect directly the quality of information transmission.

The discussed interference sources in GMDSS refer to signals of very high frequencies used in the satellite INMARSAT system as well as of low frequencies, including medium waves in the NAVTEX system.

Therefore a deep analysis of the mechanisms of the generation of interferences is needed to define methods of their reduction at the system and at the instrument level as well as an analysis of location and installation of specific and various equipment on board ships.

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Appraised by Ludwik Spiralski, Prof.,D.Sc.,E.E.