Scientific Journals
Maritime University of Szczecin

Zeszyty Naukowe
Akademia Morska w Szczecinie

2014, 37(109) pp. 61–65
ISSN 1733-8670

2014, 37(109) s. 61–65

A simulation model of Radiocommunication Events Management

Piotr Majzner, Marcin Mąka

Maritime University of Szczecin
70-500 Szczecin, ul. Wały Chrobrego 1–2, e-mail: {p.majzner;m.maka}@am.szczecin.pl

Key words: radiocommunication, GMDSS, Radiocommunication Events Management System

Abstract
The presented simulation model of radiocommunication events management allows to investigate problems occurring in marine radiocommunications. Based on a variety of research methods, we focus on the method of computer-based simulation, and describe the stages of construction and structure of the simulation model. Finally, we discuss possible applications of the developed model.

Introduction

Initiated by the International Maritime Organization and the International Telecommunication Union, the SOLAS Convention (*Safety of Life at Sea*) Convention [1] is aimed at preventing accidents, and rescuing personnel and property at the sea. Amendments and revisions of the Convention resulted in the GMDSS – Global Maritime Distress and Safety System, in force since 1 February 1999 [2].

The system is composed of 10 subsystems. Functional requirements of the GMDSS are aimed at enabling ships in distress to send immediate signals to shore-based radio stations and marine search and rescue centers [3, 4]. Distress communication is executed by a digital selective calling (DSC) system, radio VHF and MF/HF radio channels and, radiobeacons and a system of Inmarsat terminals [5].

A GMDSS operator is forced to continuously monitor the stream of information and follow procedures set forth in the Radio Regulations. Radio operators, who receive many false alarms and a substantial amount of maritime safety information, face difficulties in making decisions and are unnecessarily engaged in handling them. To date, heuristic methods have been used to analyze problems related to decision-making, or to the right response to radiocommunication events in compliance with the regulations. We try using a comprehensive and systematic approach to handling all radiocommunication devices, components of the GMDSS system.

Phenomena occurring in marine radiocommunications, as well as traffic engineering are mostly random phenomena. Consequently, events taking place in these areas can be described by random variable. We can apply a number of research methods used in traffic engineering to analyze phenomena occurring in radiocommunication events management systems (REMS), then to find solutions to arising problems.

Therefore, it seems reasonable to develop a REMS model and corresponding research methodology, using research methods known in traffic engineering.

The research problem

The GMDSS system is common, requires a lot of verified information, contain complex procedures, and it happens to be mishandled by its operators. For these reasons the entire system is often inefficient, ineffective and unusable. The observations of, how the system has functioned allows us to formulate the following research problems:

- verification and archiving of the huge amount of data from shipboard and external sources;

- construction of models of radiocommunication subsystems management system and processes taking place in these subsystems;
- construction of a set of assessment measures for REMS functioning;
- identification of real marine radiocommunications processes for modeling;
- formulation of guidelines for the construction of simulators and training simulators for radio operators, allowing to assess the competences of these operators;
- construction of simulators for autonomous and non-autonomous research into marine radiocommunications.

The research methodology used in traffic engineering has been discussed in many publications [6]. The following methods play an essential role in REMS:

- measuring;
- expert;
- analytical-deterministic;
- analytical methods of the queuing theory;
- simulation, including computer-based simulation.

The publication [6] describes the usefulness of the above methods, particularly simulations.

In our case, simulation methods consist in a synthesis of an algorithm simulating random and other processes taking place in radiocommunication systems. A multiple computer-based execution of a process by using this algorithm, and subsequent statistical processing of the results, allow to find interesting interrelations and analyze values of measures systems and processes describing. Simulation methods provide an effective tool for analyzing complex systems with any structures of input streams and complex principles of management subsystem.

The following stages make up the process of constructing and operating simulation models of REMS:

1. Defining research objectives.
2. Construction of a model for identifying a system structure and measures.
3. Construction of a simulation model algorithm.
4. The model parametrization.
5. Developing model software.
6. Evaluation of model adequacy.
7. Planning of simulation experiments.
8. Performing of experiments.
9. Statistical processing of research results.
10. Interpretation of the results.
11. Documenting the research.

To solve the real problems, the research team should be composed of an industry specialist, problem-solving specialist and analyst, co-operating with each other.

A Model of Radiocommunication Events Management System (REMS)

The primary task of a REMS system is to manage information and control radiocommunication events. From the viewpoint of the theory of systems [6], we can write down the REMS structure in this form:

$$\begin{aligned} \mathrm{REMS} &= \langle \Omega; \mathrm{R} \rangle \\ \Omega &= \langle \mathrm{A}, \mathrm{M} \rangle \\ \mathrm{R} &= \langle \mathrm{A}_{RX}, \mathrm{A}_{TX}, \Gamma', \Gamma'', S', S'', Z \rangle \end{aligned} \tag{1}$$

where:

- Ω – set of elements (objects),
- R – set of relations between elements (objects),
- A – subsystem of radiocommunication systems,
- M – subsystem of radiocommunication events management,
- A_{RX} – stream of incoming (received) radiocommunication events,
- A_{TX} – stream of outgoing (sent) radiocommunication events,
- Γ' – stream of decisions controlling radiocommunication devices,
- Γ'' – stream of radiocommunication events directed to a control subsystem,
- S' – stream of events implicating radiocommunication events,
- S'' – stream of events developed on the basis of radiocommunication events and a stream of assessment measures of REMS functioning,
- Z – stream of disturbances.

The subsystem of radiocommunication systems A is a set of models of radiocommunication systems, limited to represent only their functionalities. In the simplest case, it will include 10 models of a GMDSS subsystem. The control subsystem M manages the operation of the whole REMS system, with a radio operator as its indispensable part, holding one of the required certificates, mostly GOC or ROC. A stream of incoming radiocommunication events A_{RX}, and a stream of outgoing radiocommunication events A_{TX} are respectively received and transmitted radio messages. A stream Γ'' is the stream of received messages A_{RX} processed by the models of the radio subsystems and directed to the management subsystem. This stream also comprises events, generated by radio devices alone. The stream Γ' is a set of all possible commands controlling radiocommunication devices. The stream S' is composed of all possible events implicating a decision to be made by the control subsystem, whilst S" the stream of all events managed by the subsystem M, not relating directly to radiocommunications devices. S" also contains a set of assessment measures of the system REMS functioning. Z is a stream of radio, meteorological and other disturbances defined at the modelling stage.

On a micro-scale, the above model can be referred to a single ship, while a macro-scale approach applies to a set of interrelated radio stations. In the latter case, a set of assessment measures will dominate in the stream S".

A simulation model of radiocommunication events management system

By the digital simulation [6] we mean an algorithmic computer-based method of conducting experiments on existing or hypothetical models of systems remaining in time-varying state. In case of REMS, these models will be radiocommunication system models. The system consists of a set of elements (objects) characterized by relevant measures written in a three-dimensional matrix of state $\mathbf{K}_{ijk}$:

$$\mathbf{K} = \{k_{0,0,0}, k_{0,0,1}, \ldots, k_{n-1,\, m-1\, l-1}\} \tag{2}$$

where:
i – object number;
j – subsystem number;
k – number of subsystem variable;
n – number of objects;
m – number of subsystems assumed at the model designing stage;
l – number of variables characterizing i-th subsystem.

Measures of subsystem states may be quantitative or qualitative, discrete or continuous. In REMS, objects are vessels, shore-based radio stations, maritime rescue co-ordination centers, and measures are variables describing the state of radio devices and systems. Each sensible combination of the values of measures characterizes the state of the system. A change in the system state means a radiocommunication or non-radiocommunication event in the system under consideration. A transition from one state to another is executed through an action, defined as an elementary, indivisible at an assumed level of detail operation, that an object performs or is subject to in time. A time-ordered set of events referring to a state of a specific object is referred to as a process.

The figure 1 presents a macroscopic approach to the general algorithm of the REMS simulation model.

First, initial data, defined by the research objective, are introduced into the model. Then system objects are generated. The objects are shore-based radio stations and rescue coordination centers of an assumed number, and vessels, whose positions are two-dimensional random variables resulting from a preset mean traffic density ρ, defined by the formula:

$$\rho = \frac{N}{S} \quad [1/(\mathrm{Nm})^2] \tag{3}$$

where:
N – number of objects (vessels),
S – surface area of the water area.

At an instant $t = 0$ initial values of subsystem measures are sent to the subsystems:

$$k_{i,j,l}(0) = a_{i,j,l} \tag{4}$$

where:
$a_{i,j,l}$ are initial values of subsystem measures.

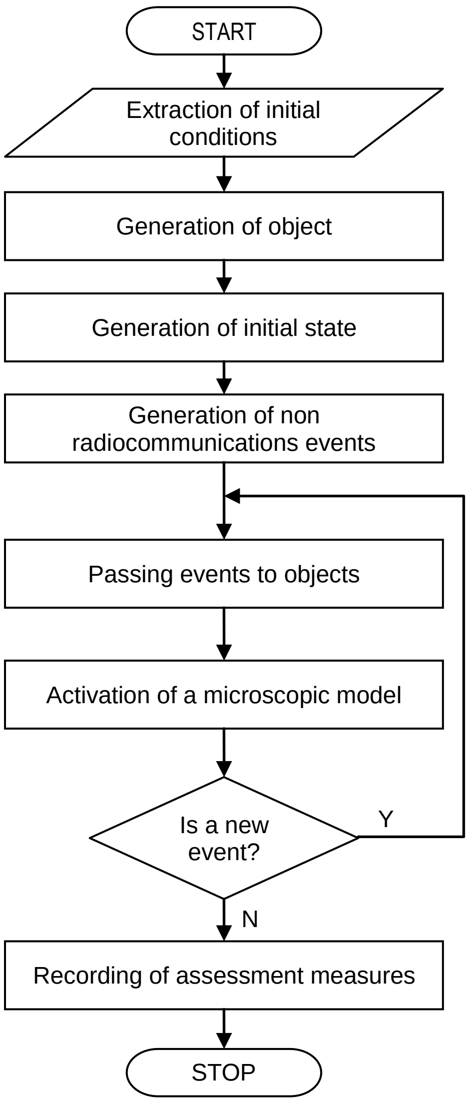

Fig. 1. A general algorithm of REMS simulation model [own study]

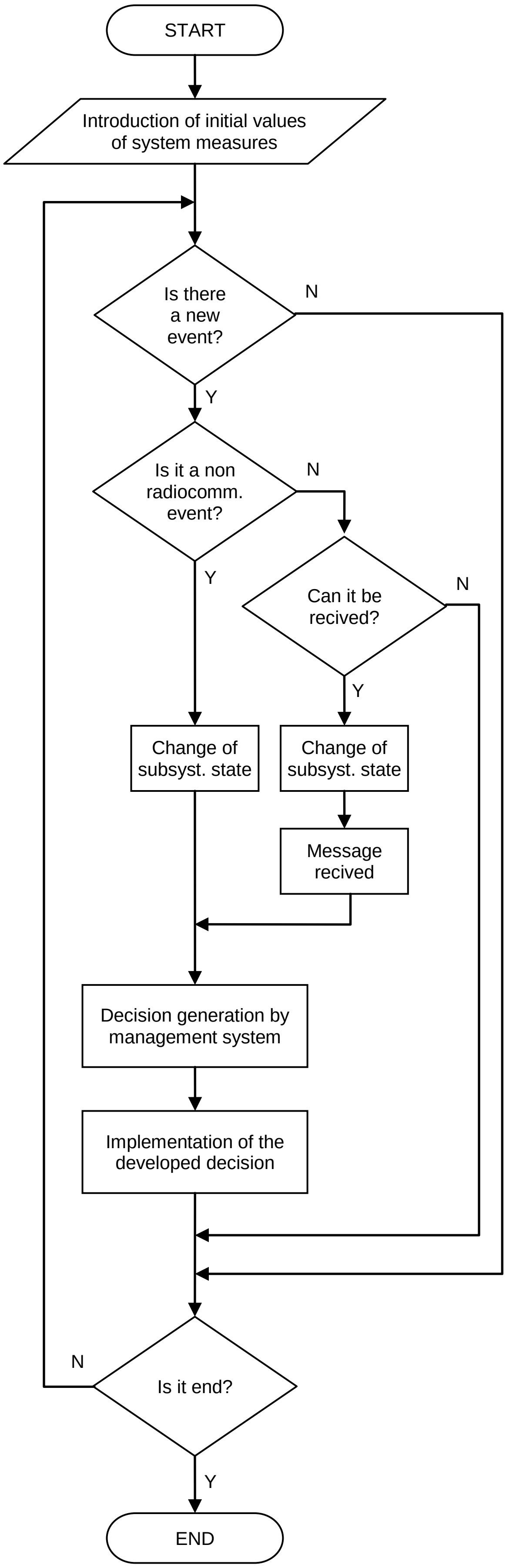

Fig. 2. An algorithm of an REMS microscopic simulation model [own study]

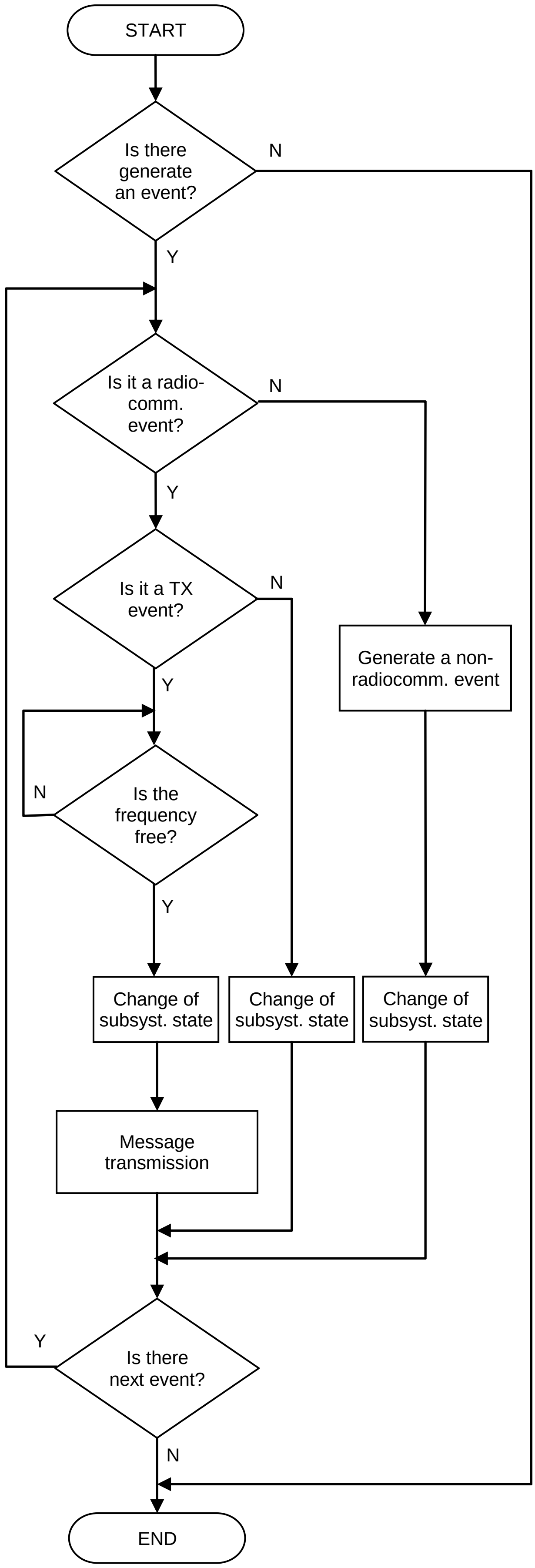

Fig. 3. An algorithm executing a decision generated by the management subsystem [own study]

At the end of the initial stage time intervals T_i between events are generated, based on a preset mean intensity $\lambda_{iśr}$ of i-th event and preset type of distribution. When a new event occurs, the fact is passed to microscopic models of the system. At the end of algorithm operation, REMS assessment measure values are determined, as defined within the research objective. The assessment measures include:

– measures of time length of a specific frequency occupancy;
– measures of time length of undisturbed specific frequency transmission;
– measures of message transmission delay times,
– probability of an event occurrence.

The figure 2 presents an algorithm of a microscopic model (single station, vessel). First, the algorithm identifies an event, and when a radiocommunication event occurs it checks if values of the subsystem state variables allow to receive and read out the event. Then, based on the events received, the management subsystem generates a new decision. This part of algorithm operation is most complex, as it takes into account legal instruments and operational procedures.

When a decision is generated or not, the management subsystem follows the steps of algorithm in the figure 3. The algorithm identifies an event generated on the basis of a decision, changes the values of subsystem states, and if a message is to be sent, it checks whether a frequency is occupied.

The algorithm concludes its operation when it reaches the simulation scope or the number of radiocommunication and other events reaches the value zero.

Coclusions

The presented model of simulations of Radiocommunication Events Management System allows to:

– autonomously or non-autonomously examine systems and processes occurring in marine radiocommunications,
– investigate various principles underlying decisions taken after event occurrence, which consequently may inspire users to propose amendments to provisions of the Radio Regulations or other legal instruments,
– design a training simulator for radio operators, a tool for imparting knowledge and skills of handling radiocommunications equipment, and assessing operators' competences,
– develop a real shipboard system decision support for the radio operator.

The developed simulation model may be an effective tool for examining phenomena occurring in marine radiocommunications, thus contribute to enhanced the level of safety at the sea.

References

1. IAMSAR Międzynarodowy Lotniczy i Morski Poradnik Poszukiwania i Ratowania. Tom III – Środki mobilne. Wydawnictwo Trademar, Gdynia 2001.
2. SOLAS, Consolidated edition. International Maritime Organization, 2009.
3. CZAJKOWSKI J.: System GMDSS regulaminy. Procedury i obsługa. Skryba, Gdańsk 2002.
4. SALMONOWICZ W.: Łączność w niebezpieczeństwie GMDSS. Szczecin 2001.
5. URIASZ J., MAJZNER P.: Systemy łączności morskiej. [In:] Nowoczesne systemy łączności i transmisji danych na rzecz bezpieczeństwa. Szanse i zagrożenia. (Edit.) A. Pach, Z. Rau, M. Wągrowski, LEX a Wolter Kluwert Bussines, Warszawa 2013.
6. MAJZNER P.: Ocena akwenów ograniczonych z wykorzystaniem symulacji ruchu strumieni jednostek. Rozprawa doktorska, AM w Szczecinie, Szczecin 2008.