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THE OPTIMAL ORGANIZATION OF THE MAINTENANCE SERVICE IN ORDER TO MAINTAIN THE PERATIONAL STATE OF COMBAT VEHICLES PARTICIPATING IN THE CONDUCT OF MILITARY OPERATIONS

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Abstract: *Conducting military operations in optimal conditions must take into account the organization of the maintenance service as well. This study presents a computer application intended to design The Optimal Plan for the Organization of the Maintenance Service. This application has as theoretical support [5], but also intends to complete the module on the supply of spare parts shown in [4]. It is a useful application in the process of planning a military operation, the two modules, the one presented in [4] and the one presented in in this study, covering the logistic support in terms of the military equipment which includes the combat means, supply and storage of spare parts, supply and storage of fuel, maintenance facilities, as well as the human resource necessary to ensure this service.*

Keywords: evaluation model, military operation, optimum maintenance plan, technical specifications, computer application

1. Introduction

The computer application presented in this study is an improved version of that shown in [1] or [2] and has as theoretical support, as noted previously, the paper [5]. The input data are similar to those introduced to determine the optimum plans for the supply of spare parts, the required fuel and engine oil, a module that is described in detail in [4].

This time, however, the database covers maintenance operations and their duration, for all the types of combat means involved in carrying out the tasks of the military operation. Here, just as in papers [1], [2] or [4], the application has been developed for four different types of combat means.

The application provides, based on data relating to the tasks within the military operation and the technical characteristics of the means of combat, *The Optimal Plan for the Organization of the Maintenance Service*. More specifically, based on the specifications of each mission, on the technical specifications for all types of combat means, on the number of combat means of each type involved in carrying out each mission, on the timeframe of the military operation and daily determined working time for performing maintenance operations, the optimal number of maintenance structures needed to perform all the maintenance work needed to maintain the operational state of all means of combat destined for accomplishing the missions within the military operation is determined.

In the next paragraph some elements concerning the model that laid at the basis for developing this computer application will be specified.

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2. The Mathematical Model

The queuing theory appears in most operational research works, such as [3], [6] or [7], where various queuing models with one or more service stations are presented.

For this computer application the model used is presented in [1], [2] but especially in [5], where the new hypotheses that the corresponding model is built in are specified.

We will only make a few remarks on the model shown in [5] in order to have a better look at the application input data as well as the output data it supplies.

The table below contains a summary of the number of vehicles of each type required to perform each of the n missions, the distances that vehicles must go through in each mission, the duration of the military operation and the daily working time for a maintenance structure.

Table No. 1 The general data of the military operation

Mission / **Type of vehicle**	1	2	...	n	No. of vehicles available
Car	a_1	a_2	...	a_n	a
Truck	A_1	A_2	...	A_n	A
Armored transporter	Tr_1	Tr_2	...	Tr_n	Tr
Tank	Ta_1	Ta_2	...	Ta_n	Ta
More information about the military operation					
Mission	1	2	...	n	-
Distance	d_1	d_2	...	d_n	-
Duration	T				
Working time for a maintenance structure /day	t				

Based on the data regarding the number and types of vehicles involved in performing missions, of the distances that they have to cover within each mission and the technical specifications for each category of vehicles, the maintenance operations that must be performed are established together with the number of operations necessary and their duration for each unit of every type of vehicle, according to the model presented in [5], that is determining the values N_i and O_i, where $i \in \{a, A, Tr, Ta\}$.

In order to determine the optimum number of maintenance structures needed to ensure the necessary interventions to combat equipment in order to conduct the military operation under good conditions, we will calculate *the average rate of arrival* of a vehicle for maintenance services (regardless of its type) and *the average servicing rate* for a maintenance structure depending on the daily working hours. The relations used to calculate these parameters are presented in [5] and they are briefly presented hereinafter.

The total number of maintenance interventions for all vehicles is:

$$N_T = N_a \cdot a + N_A \cdot A + N_{Tr} \cdot Tr + N_{Ta} \cdot Ta \qquad (1)$$

Based on this *the average rate of arrival of vehicles for maintenance* is determined and is

$$\lambda = \frac{N_T}{T}. \qquad (2)$$

The total duration required for carrying out maintenance operations for all vehicles to fulfill all the missions within the military operation is

$$O_T = O_a^T \cdot a + O_A^T \cdot A + O_{Tr}^T \cdot Tr + O_{Ta}^T \cdot Ta. \qquad (3)$$

This means that, based on the duration of the military operation, the daily time to be allocated for carrying out maintenance works is

$$t_{ment} = \frac{O_T}{T}. \quad (4)$$

Having t_{ment} we can determine *the average servicing rate* which is

$$\mu = \frac{t}{t_{ment}}. \quad (5)$$

With this information we can determine the optimum number of maintenance structures, as follows:

$$N_{ment} = \left[\frac{\lambda}{\mu}\right] + 1, \quad (6)$$

Where by [ ] we noted the integer part of a real number.

Having the number of maintenance structures determined we can also calculate the average queuing time in the system for a vehicle in order to execute maintenance works. We have:

$$W_s = \frac{1}{\mu - \lambda}, \text{ if } N_{ment} = 1 \text{ and} \quad (7)$$

$$W_s = \frac{1}{\mu} + \frac{1}{\lambda} \cdot \frac{\rho^{N_{ment}}}{(N_{ment} - 1)! \cdot (N_{ment} - \rho)^2} \cdot \left[\sum_{i=0}^{N_{ment}-1} \frac{\rho^i}{i!} + \frac{\rho^{N_{ment}}}{N_{ment}! \cdot \left(1 - \frac{\rho}{N_{ment}}\right)} \right]^{-1}, \text{ if } N_{ment} > 1, \quad (8)$$

where $\rho = \frac{\lambda}{\mu}$.

These are the relations based on which *The Optimal Plan for the Organization of the Maintenance Service* supplied by the computer application is established.

3. Maintaining the Operational Status of Vehicles within a Military Operation

As mentioned above, the model presented in paragraph 2 is the foundation upon which the application software was designed to provide, depending on the technical characteristics of the types of combat vehicles and the characteristics of the missions within the military operation, *The optimal plan for the organization of the maintenance service* in order to maintain the operational state of vehicles throughout the duration of the military operation.

Besides the model in paragraph 2, the application has a database regarding the types of maintenance that every vehicle type is required to make depending on mileage, as well as the duration of each type of maintenance operation.

The first window of the application is dedicated, as we mentioned in the previous chapter, to the features of the military operation and the number of missions that will take place within it, as shown in the figure below.

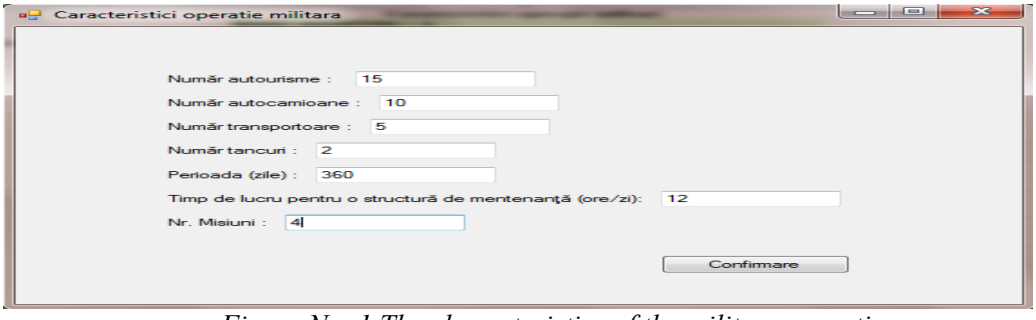

Figure No. 1 The characteristics of the military operation

It can be noticed that in this window the number of vehicles of each type to be used for the fulfillment of all missions within the military operation are given.

In what follows, after confirmation of the data related to the military operation, the characteristics of the 4 missions that will be conducted within this military operation are inserted, given that in the first window we specified that 4 missions will be conducted within the military operation.

The application generates a number of windows equal to the number entered in the *Nr. Misiuni (No. of Missions)* field. In the figure below the specific data of the 4 missions is inserted.

As can be seen this is information on the number of vehicles of each type to be involved in carrying out the 4 missions, the number of miles that they must cover and other information that is useful for another analysis which is not the subject of this study.

The information specific to each mission is entered in turns, being able to modify the entered data or to move on to the next mission specific data entry, after having confirmed the data regarding the current mission.

The application enables easy filling in of the input, the windows in Figures No. 1 and No. 2 containing all the information regarding the military operation.

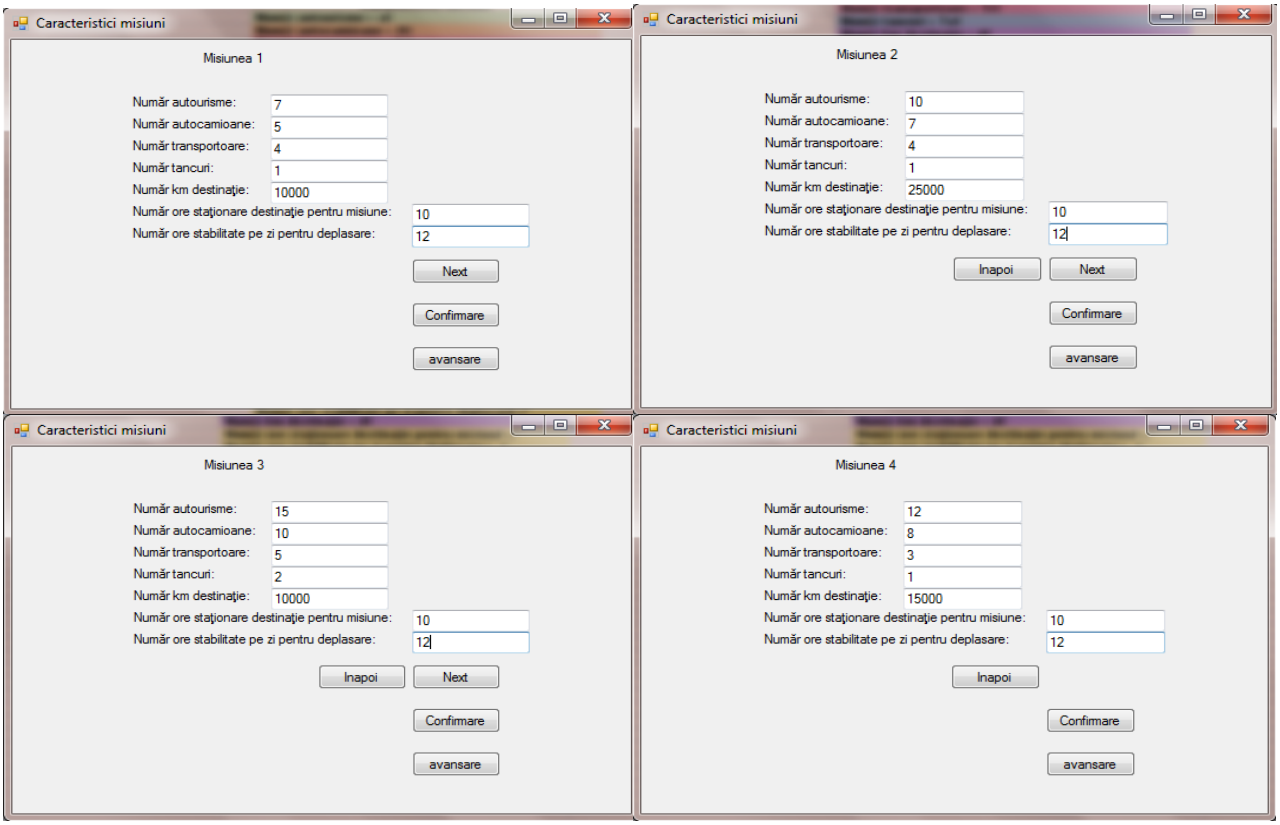

Figure No. 2 The characteristics of the missions within the military operation

Based on the relations presented in paper [5] and on the relations recurred to in this study, on the information regarding the characteristics of the military operation and of the missions that are to take place within it, as well as on the technical-tactical characteristics of combat vehicles, the application provides *The Optimal Plan for the Organization of the Maintenance Service* for the military equipment destined for the conduct of the military operation.

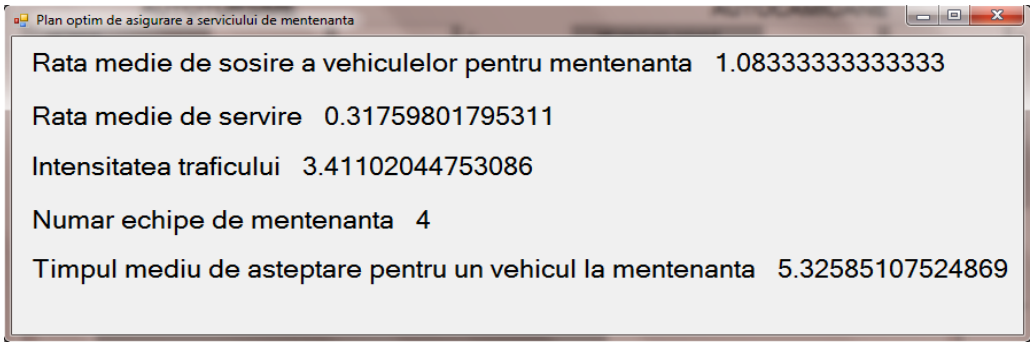

Figure No. 3 The Optimal Plan for the Organization of the Maintenance Service

As can be seen, in order to ensure a maintenance service able to uphold the military equipment operational under optimal conditions we will need a number of four maintenance teams and the average duration of the maintenance service for one vehicle (including queuing time) is of approximately 5 days and 8 hours.

Conclusions

Obviously in the planning phase such hypotheses or courses of action should be analyzed for the fulfillment of all the missions within the military operation, in order to harmonize them through a balanced use of resources made available in order to fulfill them, the software application being essential in simulating various scenarios of the military operation.

This application is based on the theoretical support presented in [5] and can be easily adapted to a wider variety of vehicles, as well as to more complex scenarios.

Along with the module presented in [4] this application will also constitute a module which will be integrated in an application able to provide the information regarding all relevant aspects pertaining to the conduct of a military operation.

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