DE GRUYTER OPEN
International Conference KNOWLEDGE-BASED ORGANIZATION
Vol. XXI No 3 2015

ANALYSIS REGARDING THE MAINTENANCE EFFICIENCY OF MILITARY TECHNICAL SYSTEMS

Ioan VIRCA, Gabriel MANESCU, Gheorghe PRUNESCU

"Nicolae Bălcescu" Land Forces Academy of Sibiu

Abstract: *The purpose of this paper is to highlight the necessity of rethinking and restructuring the current system of maintenance for the military technical systems, based on the criteria of technical and economic efficiency of maintenance, as well as its management. The current maintenance system, rigorously planned and organized, but with irregular allocation of financial and material resources, could be made more efficient to the extent in which appropriate financial funds are provided and conceptual changes are brought to the objectives and to the content of the two components of maintenance, that of preventive maintenance (PREMENT) and of corrective maintenance (CORMENT) respectively. These changes at the operational level will be able to determine the reorientation of the financial resources towards maximizing the preventive maintenance activities. This is a major trend of the management of technical military systems maintenance within the NATO member states which results in important achievements in the field of manufacturing and employing military equipment.*

Keywords: technical system, preventive maintenance, corrective maintenance, effectiveness, maintenance strategies.

1. Introduction

After studying some papers [1,2,3] on the topic of technical systems maintenance, the following conclusions can be drawn with regard to the objectives, typology and maintenance costs of the existing system in use:

- one of the main goals of the maintenance system is to optimize the maintenance interventions and maintenance costs in order to make this basic system of logistics of the armed forces efficient;
- the maintenance system that is currently applied to the military technical systems has a preventive character, planned as needed, so it is a rigid planning system combined with a system that requires intervention when needed, whenever the operational capacity is affected;
- given the great diversity of the technical systems available, the variety of the missions and tasks of the armed forces and of the logistical structures, both in peace and war time, the obvious conclusion is that the maintenance system to be applied to the technical systems can be only a complex one (Figure no 1).

DOI: 10.1515/kbo-2015-0153

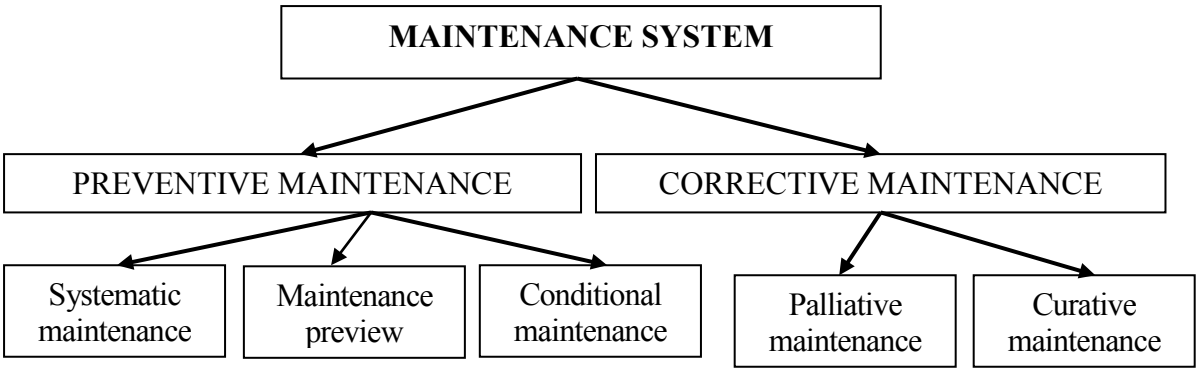

Figure 1. The maintenance system applied to military technical systems

2. Study regarding the possibilities of implementing the maintenance of military technical systems

The complex nature of the maintenance system is implemented in practice by establishing and carrying out maintenance works in the following ways:

a) *systematically*, which implies the existence of a plan which provides the types of technical maintenance, inspections and repairs, depending on the mileage, hours of operation, drawn strokes etc.;

b) *in a preventive way*, which involves the collection of data by the technical committees of the units, from the operators of the technical systems about the functioning of the equipment and by collating them with the data in the history of the operation of the respective technical system, possible failures and their effects can be predicted and the appropriate *decision* on the necessary maintenance measures can be made accordingly. In some cases, some simple diagnostic equipment can be used for finding failures, which is available for low maintenance formations;

c) *in a conditional way*, which involves using complex diagnostic equipment, available for high level formations, represented by the equipment in the existing technical inspection stations (gas analyzers, opacimeters, roller stands for checking the brake system, a device for checking the articulations in the steering system, etc.), vibration analyzers, oil analyzers, etc. After measuring the wear-out parameters, an accurate decision on the maintenance intervention opportunity can be made.

It appears that this method of determining the maintenance needs includes: the existence of a complex diagnostic equipment, of some specialized fixed or mobile laboratories used to carry out the analyses of the physical-chemical properties of fuels and lubricants, of special liquids, etc.; the existence of highly qualified specialized personnel; the existence of an advanced system of checking the quality, which in some cases is only in the hands of the producer of the analyzed technical system or of third companies that sign contracts for ensuring the maintenance during the warranty and post warranty period;

d) *in a palliative way*, which involves the execution of provisional necessary repairs due to the lack of available technical human and material resources, the system being able to partially fulfill the mission, tasks, functional role, etc. This mode further requires the execution of curative maintenance activities to restore the functional parameters affected in the nominal values;

e) in a curative way, which involves the execution of repairs at all levels of maintenance intervention: basic, intermediate and general. The complexity of this method of execution is given by the many maintenance operations (testing, sorting out of the parts, their reconditioning or replacing, restoring of functionality through adjustments, checking on stands or route tests, etc.) and the high level of specialization of the

maintenance personnel, the maintenance costs being the highest in this case.
The constructive complexity of the current military technical systems, their high performance, as well as the mobility need of the means of combat, combat support and combat service support (logistical) in the theaters of operation, call for the elaboration of an effective maintenance system, applied through a maintenance strategy having a heavy financial support, according to the strategic, operational and tactical level of deployment of military actions.
The issue of applying one of the strategies of maintenance or of any combination is less discussed in theory, but the effects can be expressed by the operational capacity of the technical systems.
One of the works of reference [3] on the topic of the management of maintenance activity in our country presents seven types of pure maintenance strategies that can be adopted by any organization in general, but the current dynamics of the social financial, technical, military phenomena and processes determines a major risk in applying only a pure strategy:
- the strategy of total productive maintenance;
- the strategy of orienting the investments of the firm;
- the strategy of restricting maintenance activities (survival);
- the strategy of concentrating the maintenance activity;
- the strategy of diversifying the activities;
- the strategy of maintenance based on reliability;
- the strategy of the new equipment.
As such, the combined application of maintenance strategies will create profit/success for the organization that will adopt this system, so benefitting from the functional reserve called *redundancy.*
The author [4] in the work specified in the bibliographical list discusses the issues related to these types of maintenance strategies for the military field, concluding that "restricting the activity is present in most situations, with a great emphasis on orienting investments and on focusing the activity. There is a downward trend in diversifying the activity and the total productive maintenance strategies, as well as the strategy based on reliability are not adopted and made known at the level of the units ... "
However, at the level of the Ministry of National Defence, there are concerns regarding the application in the near future of the maintenance strategy based on reliability to the technical systems available, as this is the strategy currently used by NATO countries and which conducts to the efficiency of the maintenance system.
This strategy takes into account the principles of work and of allocation of financial, technical and human resources specific to the category of *operational reliability* as "the category of reliability determined through working out the data on a large number of products, belonging to different beneficiaries, under actual operation/use, being also called the actual reliability or reliability at beneficiary "[5].
The bibliographical source [5] presents the following categories of reliability according to the modality used for calculating the reliability of the technical systems:
- the estimated reliability;
- the extrapolated reliability;
- the preliminary reliability;
- the technical reliability;
- the operational reliability.
The category of operational reliability is of interest for the study and implementation of the maintenance based on reliability, such research being justified and correlated with the principles of the concept of integrated logistical system which envisage the operational costs for executing the maintenance activity throughout the life cycle of the product (LCC- life cycle cost).
The authors [6] specify in the formula for calculating the costs of a product throughout its life cycle a 60% of maintenance costs (Fig. 2), which demonstrates the importance that should be

given to the financial support of this activity.

In the actual version of ensuring proper financial support for the maintenance of technical systems, a part of the funds allocated for the execution of high complexity repairs (planned at great intervals of mileage) and for general overhaul (planned at a relatively low number of years in relation to the uncovered mileage) could be directed towards investments in the infrastructure and technology necessary for the maintenance based on reliability.

This strategy having an effectively sized infrastructure (specialized maintenance formations with high mobility required for performing tasks in the units regionally subordinated to a coordinator of economic factors in the design and support of this new model financial resources), with available theoretical tools of analysis and research of the quality of maintenance, will particularly aim at identifying the essential objectives of *preventive maintenance* [4]:

3.The SWOT analysis of the maintenance strategy based on operational reliability

In the case of a military system, trying to implement a new organizational and execution approach for the maintenance of the technical systems in use, at the level of the whole national military system as well as at the level of

- the detection and correction of incipient defects;
- the reduction of the likelihood of failure of components;
- the detection of hidden defects that occurred;
- the increase of profitability of the maintenance program.

The increasingly complex construction of the existing military technical systems and their use on the battlefield require diagnostic equipment and state-of-the-art software that have a high degree of access to the data and interpretation of results, which demands a highly specialized qualification for the maintenance staff.

Therefore, *preventive maintenance* needs to be supported in practice by a strategy based on reliability.

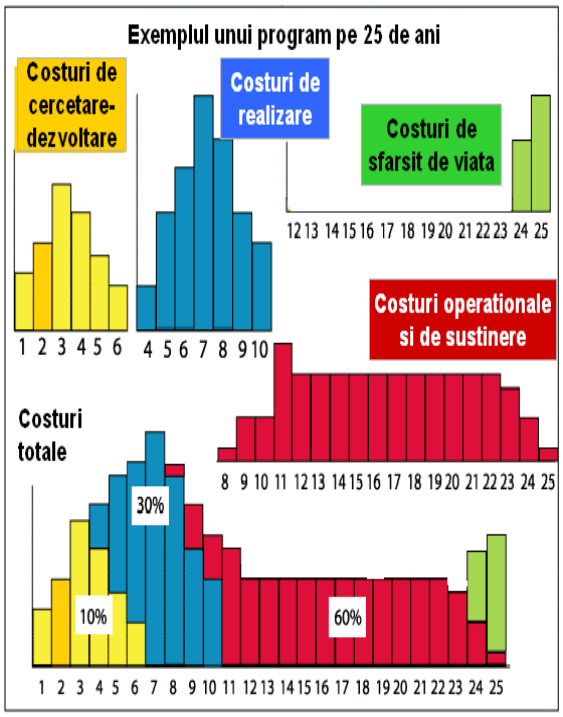

Figure 2. The cost structure of a technical system life cycle

The theaters of operation, is an action of a strategic nature which involves the engagement of military, political and

The starting point of such an approach must be the *need* to have a new maintenance strategy, in this case by analyzing the state of functionality of the technical systems supplied.

Here are below the steps that the authors of this article consider necessary:

- comparing the level of real functionality with the minimally allowed theoretical one (logical charts of modeling can be drawn);
- forming a working group of specialists in maintenance and the identification of a new strategy from a technical and managerial point of view;
- the financial analysis of the implementation of the new strategy and the possible alternatives of reallocation or redistribution;

- the access of the decision makers to the bodies established by law;
- the acquisition of resources and the establishment of the new system: command and execution structures, organization of staff, the system of norms, rules and regulations, etc.

Of course, all the effort to implement a new strategy is more extensive and elaborate, but the authors confine themselves only to the stages described in order to provide a logical thread to the carried out analysis.

In Fig. 3 we have a SWOT analysis of the maintenance strategy based on operational reliability, approached from three perspectives: strategic, qualitative and quantitative, used in the military logistics systems [6,7].

This model of analysis of the strengths, weaknesses, opportunities and threats or hazards to the new strategies that could be implemented in the military, highlights general milestones that must be considered when designing the system as a whole.

Strengths	Weaknesses
- allows the maintenance of technical systems in functional order; - gives accurate values for the measured parameters of the technical components; - reduces maintenance costs in time, if applied to a big park of technical systems.	- financial and material difficulties in implementing the strategy ; - lack of a normative framework of rules; - lack of training of the engineering and technical staff in the use of advanced computerized technologies of diagnosis.
Opportunities	**Threats**
- optimizing the maintenance programs; - creates the potential development for other maintenance strategies: diversification of activities and orientation of investments; - allows the exploitation of the potential of staff in third activities within the theatres of operation in special partnerships.	- insufficient allocation of financial funds for staff training and for the modernization of equipment; - reshaping military structures and, implicitly, satisfying the equipment requirements of the army by supplying them with new military technical systems; -the alternative offer of the personnel.

Figure 3. The SWOT analysis of the maintenance based on operational reliability

4. Arguments and conclusions

The maintenance strategy based on operational reliability (SMBFO) applied to preventive maintenance will gradually reduce the probability of disruption of the technical systems and as such will decrease the number of unforeseen repairs, the desirable results of this strategy being able to converge with the direct objectives of *the total productive maintenance strategy* [3]:

- accidental shutdowns of the technical system;
- accidents at work;

This strategy, SMBFO, will have positive effects on the efficiency of the technical system, highlighted by the following relations for calculating the technical and economic indicators of maintenance [8]:

a) *the average repair times* (rel. 1);

$$MTR=\frac{\sum_{i=1}^{r} t_i^{'}}{r}(1)$$

in which:

r – the number of maintenance activities undertaken;

t'i – the time for the maintenance activities.

With the increasing number of preventive maintenance activities required by the application of SMBFO, the average stationary time for repairing military technical systems will decrease, thus the technical system benefitting of high availability.

b) *the estimatedaverage costs of maintenance* (rel. 2);

$$E_{CM} = \frac{\sum_{1=0}^{D_S} C_i}{N} \quad (2)$$

in which:
N – the total number of failures;
Ci – the cumulative costs for executing preventive and corrective maintenance and during standardized DS service.
SMBFO will reduce the total number of flaws, but the costs will decrease as cumulative Ci strategy reduces the likelihood of accidental falls and consequently the average maintenance costs will decrease.
c) *the estimatedmaintenance labor* (rel.3);

$$E_M = \frac{\sum_{i=1}^{q}(n \times z \times t^{'})_i + \sum_{j=1}^{n}(f \times TP)_j}{H} \quad (3)$$

in which:
q – the number of groups of the technical system, including parts of the same type;
n – the number of pieces from a group;
z – the rate (intensity) of failure of parts;t' – the time required for the fault;
fj – the number of preventive maintenance;
TPj – the time in hours required to carry out preventive maintenance;
H – the duration of the operation or of the use of the vehicle.
Since the stationary time used in the repair of MTR is much higher than the time necessary for performing TPj preventive maintenance, an overall decrease of maintenance labor will result.
In *conclusion*, the present paper highlights the need to implement a new strategy for the maintenance of the military technical systems, regardless of their degree of physical or moral wear out.
The effects of the maintenance strategy based on operational reliability will have a beneficial impact on the technical and economic indicators of maintenance, as demonstrated by the above-explained calculation relations, but its implementation requires a serious financial, material and human support.

References

[1] Siteanu Eugen, Andronic Benone, *Managementul mentananţei*, Editura UNAP, Bucureşti, 2007, pp. 11-46.
[2] Lespezeanu Ion, *Mentenanţa autovehiculelor*, Editura Academia Tehnică Militară, Bucureşti, 2000, pp. 5-35.
[3] Verzea Ion, Marc Gabriel, Richet Daniel, *Managementul activităţii de mentenanţă*, Editura Polirom Iaşi, 1999, pp. 23-33, 37-47.
[4] Roşca Petru, *Strategii de mentenanţă aplicate în Armata României în Management şi tehnologii avansate în sistemele logistice – studii şi cercetări*, autori Bârsan Ghiţă, Petrişor Silviu Mihai, Badea Dorel, Editura AFT "Nicolae Bălcescu" Sibiu, 2011, pp. 117-124.
[5] http://cursuri/Ingineria calculatoarelor.
[6] BadeaDorel, Bârsan Ghiţă, Iancu Dumitru, *Bazele managementului sistemelor socio-tehnice militare,* Editura Academiei Forţelor Terestre "Nicolae Bălcescu" Sibiu, 2013, pp. 109-115.
[7] Petrişor Silviu Mihai, Badea Dorel, *Integrarea tehnologiilor avansate în managementul capabilităţilor logistic militare – Monografie ştiinţifică,* Editura Academiei Forţelor Terestre "Nicolae Bălcescu" Sibiu, 2013, pp. 98 -100.
[8] xxx – STP M 40542-99, *Standard professional militar.*