MODEL EFFICIENCY OF UTILIZATION OF AMMUNITION IN DEPENDENCE VALUE OF STORED SURPLUS AMMUNITION - THE COST OF THEIR STORAGE

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Abstract: Lifecycle management of defense products, in particular munitions is the basis for determining the real needs of the defense capabilities of defense products, anticipating and limiting the potential risks associated with the storage, dismantling and release of unneeded defensive products, overcoming excessive bureaucratization of logistics processes. And since dismantling and the removal of defense-evaded products is dependent on use, a process accompanied by a number of problem areas, which provokes our research in search for opportunities to increase its efficiency. From here the aim of our scientific research is to create a model for streamlining management solutions for efficient utilization of ammunition in dependence value of stored surplus ammunition-costs [2,3] for their storage. Modern security environment – dynamic, contradictory, generating new threats and risks, resource-provided, determines the need to create a conceptual model for lifecycle management of defence products on the principle of economy, effectiveness and efficiency in the spending of defence resources. Moreover, the close relationship "resources-capabilities-effects" as a basis for the development of an integrated system for effective defence management of the country, the maintenance and development of existing defence capabilities, and the construction and development of new ones that are technologically developed, balanced, and interoperable intensify discussions on effective lifecycle management of defence products, in particular ammunition. And since the decommissioning and the removal of useless defence products is in the basis of the lifecycle of defence products, our scientific quests are focused on the utilisation of ammunition. The accumulated problems in this direction have provoked our scientific research and resulted in the creation of a model for the effective utilisation of ammunition, based on the dependence between the value of the stored useless ammunition and the cost of its storage. In fact, this is the purpose of our research in this publication, the realisation of which is via the applicability of economic and mathematical instruments based on analytical data for a longer period. The baseline of our research is the analytical estimates of the lifecycle management of defence products and, in particular, the utilisation of ammunition as part of a more thorough work of the authors. For this reason, as well as the limited content of this publication, the authors' judgments are based on completed calculations using quantitative research tools in logistics and using Excel and MATLAB.
Keywords:: management; security and defence management; lifecycle management of defence products.

1. INTRODUCTION

Modern security environment – dynamic, contradictory, generating new threats and risks, resource-provided, determines the need to create a conceptual model for lifecycle management of defence products on the principle of economy, effectiveness and efficiency in the spending of defence resources. Moreover, the close relationship "resources-capabilities-effects" [2,3] as a basis for the development of an integrated system for effective defence management of the country, the maintenance and development of existing defence capabilities, and the construction and development of new ones that are technologically developed, balanced, and interoperable intensify discussions on effective lifecycle management of defence products, in particular ammunition. And since the decommissioning and the removal of useless defence products is in the basis of the lifecycle of defence products, our scientific quests are focused on the utilisation of ammunition. The accumulated problems in this direction have provoked our scientific research and resulted in the creation of a model for the effective utilisation of ammunition, based on the dependence between the value of the stored useless ammunition and the cost of its storage [6,7,9]. In fact, this is the purpose of our research in this publication, the realisation of which is via the applicability of economic and mathematical instruments based on analytical data for a longer period.

2. EXPLANATION OF THE MODEL

The baseline of our research is the analytical estimates of the lifecycle management of defence products and, in particular, the utilisation of ammunition as part of a more thorough work of the authors. For this reason, as well as the limited content of this publication, the authors' judgments are based on completed calculations using quantitative research tools [1,4,5] in logistics and using Excel and MATLAB. And since the processing of the 2018 reporting data is not yet complete, for the purposes of the present study the estimates for that report are prognostic.

Forecasting the cost of storing redundant ammunition against their value is a major problem in reducing the real function of the cost $Zr^{costs}_{prod\_fouk}(y)$. Besides, surplus ammunition contains two components – those intended for utilisation and those for commercial realisation. Consequently, the reduction of the real function of the cost $Zr^{costs}_{prod\_fouk}(y)$ allocated to maintaining the state of redundant ammunition is a major element in the policy of the management units of the Ministry of Defence of the Republic of Bulgaria. For the last years, the ratio of the amount of ammunition for utilisation $Ytil_{БП}$ and the market realisation $Mark_{БП}$ of the ammunition is presented in Fig. 1.

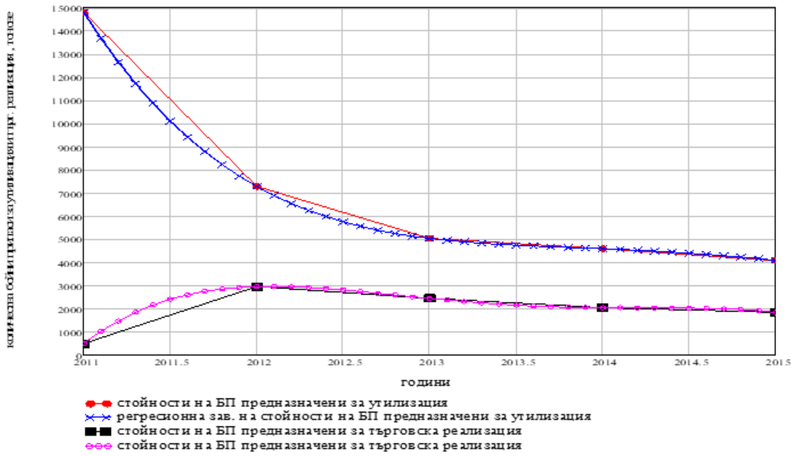

Figure 1: Dynamics in the changes of the amounts of ammunition for utilisation and market realisation in the period 2011 -2015

It is noteworthy that after 2013, there has been a significant decrease in the values of the rates of admissible amounts of the ammunition assigned for utilisation $Ytil_{БП}$. The same trend is also observed for the quantities of ammunition for commercial realisation $Mark_{БП}$ (fig. 1). When using the regressional dependencies forming functions for the changes of $Ytil_{БП}$ and $Mark_{БП}$, the relations between them ΔDev^{Mar}_{Yt} can be determined by

$$\Delta Dev^{Mar}_{Yt} = \int_{2011}^{2015} Ytil_{БП} - \int_{2011}^{2015} Mark_{БП} = 16291.839\, тона \qquad (1)$$

the dependence:

Therefore, in determining the effectiveness Eff^{cycle}_{life} of process management in the fifth life cycle of a type of defence product – unnecessary ammunition, it is always necessary to determine not only the value of the relationship between the means to maintain its condition and the possible revenue from its realisation on the market , ΔRe^{costs}_{prof} (3.xx), but also the value ΔDev^{Mar}_{Yt} of the redundant ammunition. Determining the magnitude of ΔRe^{costs}_{prof} in a prognostic period allows for economic instruments to be found on reducing total costs by allocating amounts for utilisation and by “making a profit” – having revenues from the components and exploiting the proceeds of the ammunition components – explosives, non-ferrous and ferrous metals, packaging, etc.

Hence, the cost of Z^{costs}_{main} maintaining it in account of the quantities of redundant ammunition assigned for utilisation $Ytil_{БП}$ or its commercial realisation $Mark_{БП}$ by certain purchasers requires an up-to-date interpretation. In addition, the real cost function expressed in leva in the fifth phase of $Zr^{costs}_{prod\_fouk}(y)$ of the life cycle management (LCM) can be modified by the dependence:

$Zr^{costs}_{prod\_fouk}(y) = -\left[+Ytil^{.lv}_{БП}\right] - \left[+Mark^{lv}_{БП}\right]$ (2), where: $\left[+Ytil^{.lv}_{БП}\right]$ = cost of the specified redundant ammunition for utilisation, (BGN); $\left[+Mark^{lv}_{БП}\right]$ = value of the determined redundant ammunition for commercial realisation, (BGN).

Taking into account the aforementioned dependence (2), it is necessary to determine the relative value of each of its elements – the value of the revenues from utilisation versus the value of the revenues obtained from their commercial realisation. To this end, it is necessary to monitor the handling of redundant ammunition for the period 2013-2015 and make a prognosis by 2018 [8,9,10]. The trends are presented in Figure 2.

Figure 2. Actual and predicted values of ammunition intended for utilisation in years of the fifth phase of LCM in tons.

The values of ammunition intended for utilisation for the period 2016-2018 determined by linear and non-linear prognosis show the following trends (Figure 2): the linear prognosis is unrealistic because it is not related to the financing of the process. Provided that in 2015 there were funds for utilisation in the amount of BGN 7,000,000, and actually BGN 0 were allotted [1,3, 4], for the prognosis of the other years, allotted funds were used amounting to BGN 1,000,000, where the non-linear forecast is more real. The designated amounts of ammunition are used to generate revenue, for example, in the average of $\left[+Ytil^{.lv}_{БП}\right] = 10....16\ \%$ of their initial cost in the second phase of their life cycle. For the other types of ammunition (marine, engineering, etc.), the value $\left[+Ytil^{.lv}_{БП}\right]$ is significantly lower.

An important part of the relative value to reduce the cost of maintenance of the condition of the ammunition is assigned to the values of their commercial realisation. For example, for the whole of 2012 alone, the amount of unnecessary ammunition is 7128.324 tons.

Provided there are commercial principles for the purchase of redundant ammunition, the price is 30 ... 60% of their initial value. This is a basic condition for searching for markets for the marketing of redundant ammunition, where the value of the real function of the cost, in leva in the fifth phase of the LCM of defence products, can be presented by the dependence:

$$Zr^{costs}_{prod\_fouk}(y) = -\left[(0.1..0.16)\left(+Ytil^{.lv}_{БП}\right)\right] - \left[(0.3...0.6)\left(+Mark^{lv}_{БП}\right)\right] \quad (3).$$

The actual function of the cost of maintaining the state of ammunition, expressed in leva in the fifth phase, defined in (3), strongly confirms the principle that redundant ammunition should be realised on the market with priority, and only a minority of them should be utilised. The cost of storing defence products, defined both in the predicted and statistical way, allows the efficiency of processes for their management to be improved, and instruments for their permanent reduction are made available through the use of economic mechanisms in the final phase of their lifecycle.

On the basis of the model previously presented, the question is what effects can be expected from the disposal of unnecessary ammunition in a complex manner in regards to the discharged resource. In response, it should be taken

into account that reducing costs in terms of the value of $Zr^{costs}_{prod\_four}(y)$ makes it possible to acquire new defence products or to acquire technologies for their modernisation.
In addition, it is possible to use some of the means to improve the technology for utilisation. The released base structure for their storage can be used for commercial realisation, for use by other business environments, and to realise a secondary effect of economic benefits resulting from the disposal of the surplus amounts of ammunition.
At the same time, the dependence of the relative volume of revenues realised for the conducting of utilisation presented in the real cost function $Zr^{costs}_{prod\_four}(y)$, is within the fifth phase of the life cycle of the defence product and implies the determination of the degree of reliability for realisation of the management process in it. In this respect, in accordance with the solving of the main tasks of the theory of reliability, it is necessary to develop quantitative methods for assessing its values when assessing the management processes in solving the problems with the surplus ammunition through the selection of rational methods for ensuring efficiency in the final phase of the product life cycle. But ensuring reliability of T^{cycle}_{dur} in its duration is seen as a single process that in all its phases $T^{cycle}_{life} \in (T_{une}..T_{end})$ determines the need to develop and implement actions aimed at achieving the marginal security requirements.
And here we have to determine what we should understand by the reliability of the lifecycle of defence products, in particular, of ammunition? What is assumed by reliability of a defence product is the feature of the object to keep during its lifecycle of operation pre-established parameters that characterise its ability to perform the necessary functions in certain types and conditions of application, maintenance, storage, and transportation.
In addition, the reliability of a defence product is a complex property that contains the qualities of durability, maintenance and versatility in prolonged storage. This gives the defence product – ammunition, the quality for continuous storage of the working condition for some time $T^{cycle}_{life} \in (T_{une}..T_{end})$ until their removal from use or processing. The emergence of reliability problems with ammunition is mainly due to the following reasons: increasing the complexity of technical systems that are part of their constructive features, which is a condition for the occurrence of a halt; the complexity of external conditions in which defence products are used; the higher degree of mechanisation and automation and, last but not least, the role of the "human" factor.
Along with the above-mentioned reasons, two main strands are formed in the development of the theory of reliability of the ammunition lifecycle. The first is related to the development of methods to determine the reliability of the types of ammunition. The second is related to the development of methods for designing highly reliable systems, which is usually called design or synthesis of systems for reliability in operation. Mathematically speaking, the first strand determines the resolution of the problem of reliability in the functioning of the lifecycle management system of defence products R^{sys}_{t} through the probability of quality performance of $P^{f}_{qua}(t)$. Its value can be determined by the dependence:

$$P^{f}_{qua}(t) = \frac{P^{f}_{t}(t)}{R^{sys}_{t}} \leq Re^{sys}_{rel} \quad (4),$$

where: $P^{f}_{t}(t)$ = probability of functioning of the life cycle management system of defence products (LC) - (0-1); R^{sys}_{t} = system reliability in all phases or the most important of the duration of a LC - (0-1); Re^{sys}_{rel} = dedicated resources for ensuring system reliability - (0-1).
The reverse task of ensuring reliability of Re^{sys}_{rel} implies the determination of the value Re^{sys}_{rel} for a given period of system operation, which determines the value of $P^{f}_{qua}(t)$. The systematic approach to determining the values of the magnitudes $P^{f}_{t}(t)$ and Re^{sys}_{rel} to ensure a certain level of reliability in the life cycle management of defence products requires that account be taken of the environment in which the phases of the durability of $T^{cycle}_{life} \in (T_{une}..T_{end})$ are realised.
For this purpose, when determining the response options in the implementation of the management process, taking into account the reliability requirements, it is necessary to take into account such factors as: the accidental nature of

the events characterising the state of the defence sites, especially in the fourth and fifth phases; uncertainty of the information about the status of defence products at any point in time; conflicts of interest in opportunities for receiving revenues from the commercial realisation or investment of funds in the modernisation of defence products, etc. This implies a substantially comprehensive approach to the issue of reliability in the life cycle management of the tested defence products.

3. CONCLUSIONS

In conclusion, the developed model for the effectiveness of the utilisation of ammunition on the dependence "value of the stored redundant ammunition – cost of their storage" allows to predict the effects of the disposal of redundant ammunition in a more complex way in respect of the disposed resource. It is the basis for predicting the storage costs and net revenue from unnecessary ammunition, which is the basis of "what-if" performance management as a manifestation of the strategic approach for achieving the Capability Goals. Last but not least, the model proposed by us is the basis for our further research on the reliability and capabilities of modernisation of defence products and the effective management of their life cycle.

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