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Mykola Zaitsev,
Roman Chunakov,
Ruslan Ransevych

DEVELOPMENT OF THE METHOD FOR EVALUATING THE EFFICIENCY OF FUNCTIONING OF THE TROPHY SAMPLES OF WEAPONS AND MILITARY EQUIPMENT

An analysis of the experience of the Russian-Ukrainian war shows that the issue of collecting trophy samples of weapons and military equipment has not been investigated. This determines the relevance of conducting research on the specified issue. The object of research is the system of collecting trophy samples of weapons and military equipment. The subject of the research is the effectiveness of the system of collecting trophy samples of weapons and military equipment. Inconsistencies in approaches to the collection of trophy samples of weapons and military equipment have been identified, which must be resolved. Decomposition of the existing system of collection of trophy samples of weapons and military equipment of groups of troops (forces) was carried out, functional connections between the elements of the system were studied, which made it possible to substantiate the indicators and develop a method for evaluating the effectiveness of the system of collecting trophy samples of weapons and military equipment of a group of troops (forces). In the course of the research, the authors used general scientific methods of analysis and synthesis. The analysis method was applied during the decomposition of the existing system of collection of trophy samples of weapons and military equipment of groups of troops (forces). The methods of synthesis and evaluation of complex hierarchical systems were used in the course of developing the method for evaluating the effectiveness of the system of collecting trophy samples of weapons and military equipment of a group of troops (forces). The proposed method is based on analytical dependencies that allow to evaluate the effectiveness of the system of collecting trophy samples of weapons and military equipment and is universal.

It is advisable to use the proposed method in the course of assessing the capabilities of the system for collecting trophy samples of weapons and military equipment of groups of troops (forces).

Keywords: *trophy collection system, trophy samples of weapons and military equipment, performance evaluation, indicators and criteria.*

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1. Introduction

The Armed Forces of Ukraine, in the course of repelling the full-scale armed aggression of the russian federation on the territory of Ukraine, captured a significant number of trophy samples of the enemy's weapons and military equipment (WME) [1, 2].

At the same time, the aforementioned revealed problematic issues regarding the collection of trophy samples of WME that were discovered (captured) by the Armed Forces of Ukraine and other components of the security and defense sector [3]:

– most of the time, commanders of units do not report to the commanders of military units information about the discovered (captured) trophy samples of anti-terrorist weapons, due to the reluctance to work out the documents regarding their registration and write-off, in case of their failure (destruction during hostilities). The commanding staff of military units discovers trophy samples of WME during the visit to the units' positions;

– unit commanders report on the discovery (seizure) of trophy samples of WME with appropriate documentation, as a rule, in the case when they are guaranteed to remain in the military unit;

– the low level of staffing of repair and recovery parts (subunits) with evacuation equipment (especially in the reformed parts), a significant period of its operation and frequent failure does not allow to perform the task of evacuating the trophy WME with high quality.

Solving the mentioned problematic issues and the need to create an effective system for collecting trophy samples of WME determine the relevance of the conducted research.

The practice of using trophy samples of WME was widely spread during the times of the Soviet Union during the Second World War [4].

At the same time, according to publicly available research, no known scientific publications have been found that allow to evaluate the effectiveness of the system for collecting trophy samples of WME.

However, the Armed Forces of Ukraine have regulatory documents that determine the procedure for collecting and registering trophy samples of WME [5–10].

The results of the analysis of publications in the mass media, scientific publications [1–4], requirements of regulatory documents [5–10] show that there is no scientific and methodological apparatus that allows a full and comprehensive assessment of the effectiveness of the trophy collection system samples of WME.

Therefore, *the aim of the research* is to reveal the main provisions of the method for evaluating the effectiveness of the system of collecting trophy samples of the military group (forces).

The object of the research is a system of collecting trophy samples of weapons and military equipment.

The subject of the research is an effectiveness of the collection system of trophy samples of weapons and military equipment.

2. Materials and Methods

In the course of the research, the authors used general scientific methods of analysis and synthesis:

– an analysis during the decomposition of the existing system of collection of trophy samples of weapons and military equipment of groups of troops (forces);
– synthesis and evaluation of complex hierarchical systems – in the course of developing a method for evaluating the effectiveness of the system of collecting trophy samples of weapons and military equipment of a group of troops (forces).

3. Results and Discussion

3.1. Development of a method for evaluating the effectiveness of the system for collecting trophy samples of weapons and military equipment. Efficiency assessment method of functioning of the system for the collection of trophy WME samples is intended to determine the quantitative and qualitative indicators of the effectiveness of its functioning with the aim of its further improvement.

As it is known, in order to be able to objectively judge the efficiency of the operation and perform comparisons of operations that are organized in different ways by efficiency, let's use certain numerical characteristics – efficiency indicators. They act as a quantitative measure of the quality of the decision and are obtained as a result of the application of operations research methods in the analysis of complex systems or processes. In practice, a system of several indicators is used to analyze complex systems [11, 12].

While conducting research on complex systems, the following types of indicators are used [12]:

– indicator of the type of probability of success;
– indicators of the average value of the achievable result;
– weighted average indicators, etc.

Any studied system can be quantitatively characterized by a certain set of performance indicators, each of which reproduces its specific feature. The specific form of the performance indicator depends on the specifics of the operation under consideration, its target orientation and on the purpose of the research, which can be formulated for the analyzed system in one form or another.

It is clear that the more complex the investigated operation is, the greater number of performance indicators can be assigned to it. Therefore, in order to quantitatively evaluate the efficiency of the system while performing a certain function, it is necessary to first evaluate all elements and subsystems in the same direction and determine the extent of their influence on the efficiency of the system as a whole [12].

General performance indicators characterize the studied process as a whole. Unlike the general ones, individual performance indicators are used to evaluate the performance of individual functions, both by the system as a whole and by its individual elements (subsystems) [12].

Since there can be a lot of performance indicators, a system of performance indicators is used for a comprehensive analysis of operations. As it is known, the following requirements are made to the set of indicators [12]:

– the completeness of the evaluation of the system (content) functioning;
– clear physical essence of each indicator;
– sensitivity to any influences of internal and external factors;
– ease of calculating indicators;
– compliance with the purpose of the operation;
– compliance with common sense (easy interpretability).

Depending on the task, performance indicators may have different weight (significance). From the system of indicators, as a rule, one or several of the most important, from the point of view of the researcher, are selected, the values of which characterize the degree of achievement of the research goal [12].

The evaluation of the effectiveness of complex systems is carried out in order to make specific decisions during the analysis and synthesis of such systems and in the process of their functioning. Such decisions are made as a result of the application of performance criteria.

The conclusion about the conformity of the system to its purpose is made using performance criteria – the rules by which the quality of the decision is determined. Generally, several criteria (a system of criteria) can be involved for this conclusion, which allow to evaluate the system comprehensively. Thus, all research and actions to improve the system are aimed at satisfying the selected criteria [12].

The evaluation of the efficiency of system functioning is very often carried out not only by one indicator, but also by their entire system. The main feature in such cases is that the indicators of the studied system can be contradictory. Such tasks are very common in practice. Achieving results can be done with defined limitations for indicators, the so-called trade-off for several indicators.

Based on the analysis of scientific research and relying on the experience of combat operations, the approaches of leading scientists who conducted research on complex systems for military purposes, let's develop a set of indicators and determine their limits for evaluating the effectiveness of the system of collecting trophy samples of WME [12].

The following indicators are proposed for evaluating the effectiveness of the system of collecting trophy samples of WME: the promptness of receiving information about trophy samples of WME, the reliability of information about trophy samples of WME, the ability of units and subdivisions in the area of responsibility to carry out technical

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reconnaissance and evacuation of trophy samples of WME and the degree of interaction with other components of the security sector system and defense.

Let's consider the procedure for calculating the values of each of the indicators for evaluating the effectiveness of the system of collecting trophy samples of the WME.

The efficiency of receiving information about trophy specimens of WME is defined as the ratio of the time of receipt of information about trophy specimens of WME (T_{insp}) to the normative time of receipt of information about trophy specimens (T_{norm}) and is described by the following expression:

$$T = \frac{T_{insp}}{T_{norm}}. \quad (1)$$

Criterion value T_{norm} is 24 hours, thus information on trophy specimens of WME should be updated once a day as of 24.00, as defined in the Table of urgent reports.

Therefore, the value of T can vary from 1/24 (for the minimum time of receiving information, let's take one hour) to 3 (3=72/24 – for the maximum time, let's take 72 hours, this is the time when the trophy sample of WME will be dismantled). For an example of calculation, let's take the time of information arrival as 4 hours.

The reliability of information about trophy specimens of WME is defined as the ratio of reliable information (D_{corect}) to unreliable (D_{false}) information and is described by the following expression:

$$D = \frac{D_{corect}}{D_{false}}, \quad (2)$$

where D_{corect} is the number of trophy specimens that were discovered (captured) in fact; D_{false} is the number of WME samples that are not displayed in reports, but are available.

The value of D has the following range of changes from 0 (no trophy detected) to infinity (in case there are no trophy samples of WME, about which there is no information in the reports).

According to the experience of combat operations, the maximum number of trophy samples of WME per day of operation does not exceed 100. For our calculation example, let's take $D_{corect}=10$ and $D_{false}=100$.

The ability of units in the area of responsibility to carry out technical reconnaissance and evacuation of trophy samples of WME is defined as the ratio of the number of trophy samples of WME that are able to detect and evacuate units and units per unit of time $S_{fact}(t)$ to the normative $S_{norm}(t)$ and is described by the expression:

$$S = \frac{S_{fact}(t)}{S_{norm}(t)}. \quad (3)$$

For example, let's take $S_{fact}(t)=10$.

The normative number of trophy samples of WME, which can be detected and evacuated by parts and units per unit of time $S_{norm}(t)$ (in the research, the value of time is one day) is calculated from two components, namely:

1) the number of trophy samples of WME that can be detected by technical intelligence groups;

2) the number of devices that can be evacuated by parts and units in the zone of responsibility.

The value $S_{norm}(t)$ varies from 1 to N, where N is the upper limit of the number of trophy samples of WME that can be detected by technical intelligence groups and evacuated by the forces and devices of the repair and restoration regiment and is determined by the organizational and staffing structure of the regiment.

The number of trophy specimens of WME, that can be evacuated, is determined by the number of evacuation devices that are functional and available for the evacuation of each category of trophy specimens of WME and the length of the section of the evacuation route. The number of trophy samples of WME that can be detected by technical intelligence groups is defined as the number of trophy samples of WME located in the area on which technical intelligence is carried out for each of the technical intelligence groups (for example, let's take $N=40$).

The degree of interaction with other components of the system of the security and defense sector is defined as the ratio of the number of components of the security and defense sector that provide information on trophy samples of WME (N_{inf}) to the total number of components operating in the zone of responsibility of the group of troops (forces) (N_{fact}) and is described by the expression:

$$N = \frac{N_{inf}}{N_{fact}}, \quad (4)$$

where N_{inf} is considered 100 % if all components of the security and defense sector operating in the area of responsibility provide information on trophy samples of WME.

The minimum number of components is determined as 1, and the maximum number is determined in accordance with the Law of Ukraine «About the National Security of Ukraine» and the experience of combat operations in repelling armed aggression of the russian federation and is 12. For the example below, let's take $N_{inf}=1$.

The evaluation of the effectiveness of the system of collection of trophy WME should be carried out according to the generalized indicator of the evaluation of the effectiveness as a set of partial indicators (1)–(4).

Then, the generalized indicator of the effectiveness of the system of collecting trophy samples of WME E will have the following form:

$$E = f(X_1, X_2, X_3, X_4), \quad (5)$$

where X_i is an indicator of the effectiveness of the system of collecting trophy samples of WME; i is the serial number of the indicator.

To simplify the calculations of the effectiveness of the system of collecting trophy samples of WME, let's accept the hypothesis regarding its linear dependence on the selected indicators, then:

$$E = \sum_{i=1}^{4} K_i X_i, \quad (6)$$

where K_i is the weight coefficient of the i-th indicator in expressions (1)–(4).

To determine the weight of each of the indicators, let's use the generally accepted method of expert evaluation (ranking of indicators).

For the implementation of this method, 10 specialists (experts) competent in the specified field of research are involved.

Based on the results of processing expert evaluations using the simple ranking method, the following weighting factors were determined, which are listed in Table 1.

Table 1

The results of the ranking of the weighting coefficients

Promptness of receiving information about trophy specimens of WME	The reliability of information about trophy specimens of WME	The ability of units and units in the area of responsibility to carry out technical reconnaissance and evacuation of trophy samples of WME	The degree of interaction with other components of the system of the security and defense sector
K_1	K_2	K_3	K_4
0.13	0.16	0.47	0.24

Taking into account the information given in Table 1, the generalized indicator of the effectiveness of the system of collecting trophy samples of WME can be written:

$$E = 0.13X_1 + 0.16X_2 + 0.47X_3 + 0.24X_4. \quad (7)$$

Having normalized the obtained values of the indicators by normalizing them to the maximum value, expression (7) can be written as following:

$$E = \left(0.13\frac{4}{72} + 0.16\frac{10}{100} + 0.47\frac{10}{40} + 0.24\frac{1}{12}\right) =$$
$$= 0.07 + 0.016 + 0.118 + 0.2 = 0.404. \quad (8)$$

For a qualitative assessment of the effectiveness of the system of collecting trophy samples of the WME, let's substitute the numerical values of expression (8) in Harrington's verbal-numerical scale, which is given in Table 2.

Table 2

Harrington's verbal-numerical scale for each indicator

No.	A meaningful description of gradations of assessment indicators	Numerical value
1	Very high	0.8–1.0
2	High	0.64–0.8
3	Average	0.37–0.64
4	Low	0.2–0.37
5	Very low	0.0–0.2

Then, the effectiveness of the existing system of collecting trophy samples of WME using the selected indicators and based on the division using the values of Table 2 can be considered average.

Evaluation algorithm of the effectiveness of the system of collecting trophy samples of the military group (forces) is shown in Fig. 1.

The given method will allow to evaluate the effectiveness of the system of collection of trophy samples of WME.

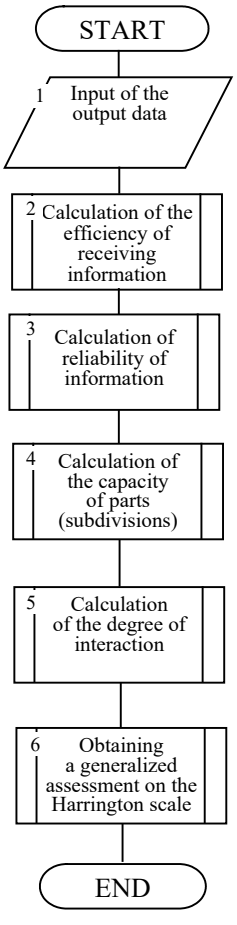

Fig. 1. Method implementation algorithm

3.2. Results of the analysis and discussion of the results. In the course of the research, the authors developed a method for evaluating the effectiveness of the system for collecting trophy samples of weapons and military equipment.

The proposed method allows:

– to evaluate the effectiveness of the system of collection of trophy samples of weapons and military equipment;

– to determine management measures to improve the efficiency of the system of collecting trophy samples of weapons and military equipment;

– to justify the organizational and staffing structure of units performing the task of collecting trophy samples of weapons and military equipment.

The advantages of the researches include:

– the simplicity of computer calculations;

– a complete assessment of the effectiveness of the system of collection of trophy samples of weapons and military equipment;

– adaptability of assessment indicators with melting system of collection of trophy samples of weapons and military equipment.

The shortcomings of the mentioned research include:

– the need for adequate software to implement possible research methods;

– the availability of time to carry out calculations of the state of the collection system of trophy samples of weapons and military equipment.

It is advisable to consider the practical implementation of the proposed method in the automated logistics management system «Logistics-IT».

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The direction of further research is the substantiation of recommendations for improving the system of collection and development of trophy specimens of WME.

4. Conclusions

1. The attack of the russian federation on the territory of Ukraine showed problematic issues regarding the collection of trophy samples of WME and revealed the lack of a scientific and methodical apparatus that allows to make comprehensive, complete and reliable assessment of the effectiveness of the collection of trophy samples of WME.

2. Decomposition of the existing system of collection of trophy samples of WME of military groups (forces) was carried out, functional connections between the elements of the system were studied. This made it possible to substantiate the indicators and develop a method for evaluating the effectiveness of the system of collecting trophy samples of the WME.

3. The proposed method:

– is based on analytical dependencies that allow to evaluate the effectiveness of the system of collecting trophy samples of WME;

– is universal and can be adapted to the organizational and staff structure of groups of troops (forces);

– allows to evaluate the system of collection of trophy samples of WME according to quantitative, qualitative and relative indicators, which allows to simplify the software implementation of the proposed mathematical apparatus.

Conflict of interest

The authors declare that they have no conflict of interest in relation to this research, whether financial, personal, authorship or otherwise, that could affect the research and its results presented in this paper.

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Data availability

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✉***Mykola Zaitsev,*** *PhD, Head of Legal Department, Research Center for Trophy and Perspective Weapons and Military Equipment, Kyiv, Ukraine, e-mail: zaitsev.n@gmail.com, ORCID: https://orcid.org/0000-0003-0322-5910*

Roman Chunakov, *Deputy Head of Legal Department, Research Center for Trophy and Perspective Weapons and Military Equipment, Kyiv, Ukraine, ORCID: https://orcid.org/0009-0003-8756-1512*

Ruslan Ransevych, *PhD, Deputy Head of Department of Robotic Systems Research, Research Center for Trophy and Perspective Weapons and Military Equipment, Kyiv, Ukraine, ORCID: https://orcid.org/0000-0002-6076-5633*

✉*Corresponding author*