Technical and economic assessment of the weapons and military equipment exploitation

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Abstract

The development of military technologies encourages the military leadership of the states to purchase new models of weapons and military equipment (WME).

An analysis of the WME park in service with the Armed Forces of Ukraine shows that over the past eight years, the Armed Forces of Ukraine have adopted and commissioned a small number of new and modernized models of weapons. In addition, a significant number of different types of WME are under development or undergoing state testing.

It is clear that new or upgraded models of WME that come into service must be effective in performing tasks (troops). That is, to have greater firepower, protection from means of destruction, improved tactical and technical characteristics, reliability, unification, etc. However, an integral part of the purchase (adoption) of new (upgraded) WME models is not only the cost of their purchase, but also the cost of their operation. That is, how much money will need to be spent on maintenance, repair of relevant WME samples, costs of fuels and lubricants, and so on.

Therefore, the paper proposes a method of technical and economic evaluation of WME samples that are accepted into service or allowed to operate in the Armed Forces of Ukraine. It is proposed to divide the structure of total costs for the exploitation of WME into several components, ie: costs for storage of WME, costs for maintenance of WME, costs for fuel and lubricants, costs for repair of samples of weapons, ammunition costs. Accordingly, each of the components of total costs includes its own indicators, which together form the total cost of operation of the corresponding sample of WME.

Key words: weapons, equipment, material, cost, maintenance.

Introduction

During the development (modernization) and acceptance for service of new models of weapons and military equipment (WME) one of the indicators of evaluation is the cost of their exploitation. It should be noted that the constantly growing requirements to military and technical properties of WME lead to increased costs, including material, human and financial resources that are spent during the life cycle of the WME sample at all stages. The whole set of expenses is the full cost of the life cycle of WME samples. A special place in deciding on the feasibility of spending resources over the life cycle is the stage of cost of exploitation.

Exploitation of an WME item means the stage of the life cycle of a military product from the time it is accepted by a military formation from a manufacturer or repair facility to its decommissioning (DSTU B 3576-97).

The beginning of exploitation is considered to be the moment of acceptance of an WME sample by the Ministry of Defense from industrial enterprises, and eventually the moment of decommissioning of an WME sample through physical, moral wear and tear, or write-off due to expiry of its service life.

The period of exploitation of WME constitutes the main part of the life cycle, so the search for ways to optimize the exploitation process is an urgent problem, the goal of which is to achieve the minimum monetary and labor costs per unit of operating time during the operational cycle, while ensuring the requirements of combat training and a given level of combat readiness and reliability of WME (DSTU 2860-94; DSTU 2862-94).

$$\sum C_i \rightarrow min\ C \text{ when } K_Г(S) \geq K_Г(S)_{зад} \text{ or } P(S) \geq P(S)_{зад},$$

where $\sum C_i$ – specific total cost per cycle of exploitation;

i – type of costs;

S – development of the WME sample;

$K_Г$ – combat readiness factor;

$P(S)$ – probability of failure-free operation of WME sample.

Material and methods

A number of works are devoted to the study of the issues of technical and economic evaluation of the exploitation of WME models that have been adopted for service or are being developed and subsequently adopted for service, in particular, work (Pavlovsky, I. V., Chepkov, I. B., Borokhvostov, V. K., Borokhvostov, I. V., Ryabets O. M., 2017)) proposes approaches to the evaluation of the military-technical aspects of the life cycle of WME models. Work (Asadullin, M. R., 2016). gives examples of the application of contractual models of public-private partnership. Thus, work (Shishanov, M. O., Chechenkova, O. L., Pavlovsky, I. V., 2018) considers the issues of technical and economic evaluation of modernization of samples of WME, and work (Smal T., and Furch J., 2011) considers the technical conditions associated with the implementation of the system of repair of WME and the issues of unification and debugging of equipment in the process of design and production. The work (Zdenek Vintr, Rudolf Holub, A., 2000) is devoted to the issues of technical and economic evaluation of WME operation, where two criteria for evaluating the reliability of a vehicle are proposed One criterion has a technical character, and the other – economic, and in (Zianko, V.V., Polyakov, P.A.) an approach to determine the economic effect of improving the system of maintenance and repair of WME is proposed. Work (Dachkovskyi, V., Sampir, O., & Horbachova, Y., 2020) is devoted to assessing the economic efficiency of repair of samples of WME in two directions. One is the financial and economic costs of WME repair in stationary conditions, and the other is in moving repair and restoration military units (subdivisions), and work (Buravlev A.I., 2016) proposes a methodology that includes indicators of serviceability of WME samples and indicators for assessing the costs of their exploitation. Work (Mark Broude, Saadet Deger et Somnath Sen, 2013) focuses on economic growth and its links with the defense sector with a special emphasis on the military-industrial complex, while (Michael Beckley, 2010) determines that the concept of military force, which takes into account both the amount of a state's resources and the level of its economic development, is a reliable basis for defense planning and international relations. Work (Datsenko I. P., 2016) is devoted to the consideration of technical and economic indicators of welding production at the enterprises engaged in repair and modernization of WME.

Therefore, taking into account the intensive development of WME samples and their adoption or commissioning, it is necessary to develop a methodological approach to technical and economic evaluation of these WME samples during their exploitation, which will be the purpose of this article. This methodological approach will allow predicting the cost of maintaining WME during their exploitation.

Results and discussion

Determining the cost of individual processes that make up the overall system of operation as a complex production and technical process is an urgent issue. Each of such individual processes (storage and maintenance; consumption of fuel and lubricants (FL) in the performance of basic functions, maintenance, etc.) requires for its implementation certain costs. (materials and spare parts, use of fixed assets; labor costs).

The costs of providing material means are determined by separate partial methodologies depending on the type of work (Dachkovskyi, V., Sampir, O., 2019). The approach to estimating labor costs is unified for all types of work. It consists in estimating the cost of maintaining such a number of servicemen, which ensures the exploitation of WME (Matsko, O. Y., 2018; Havryliuk, I., Matsko, O., Dachkovskyi, V., 2019).

The structure of total costs for the operation of WME can be considered as follows

$$C_{эк} = \sum^{s} C_i = C_{зб} + C_{TO} + C_{ПММ} + \sum^{n} C_{pj} + C_{бп} ,$$

where n – number of types of repairs at the cost of each type of repair $

$C_{зб}$ – costs for storage of WME;

C_{TO} – costs for maintenance of WME;

$C_{ПММ}$ – costs of fuel and lubricants;

$C_{p\gamma}$ – expenditures on repair of WME samples ($C_{план}$ – scheduled, $C_{п.план}$ – unscheduled);

$C_{бп}$ – costs of ammunition.

It should be noted that for each nomenclature of WME, costs will differ both in total and in proportion to each type of cost.

When estimating the cost of storing WME, it is necessary to take into account the type of storage (short-term, long-term), the method of preservation (sealing of buildings, without sealing) and the method of sealing.

The cost of storage of samples of WME consists of the cost of production and the cost of direct storage. Those and other costs take into account the cost of materials $C_м$, consumed; the cost of labor C_{oc} or maintenance of personnel who provide storage of WME; depreciation costs $\sum C_{ai}$ of storage facilities, hermetic coatings of various types, equipment used, etc.

The depreciation value is allocated to the lifetime of the particular equipment (service life) and the number of samples for which the equipment is used for storage. In general, the storage value can be determined by the following expression

$$C_{зб} = C_м + C_c + \sum C_{ai} , \quad (1)$$

Storage costs can be determined in more detail

$$C_{зб} = \sum^{n} \sum^{m} N_j C_i q_i + C + \sum C_{ai} , \quad (2)$$

where n – number of types and methods of storage of WME of a certain type;

N_j – relative number of storage units of the j-th type (method) of storage (in fractions of I);

C_i– cost of a unit of material;

q_i – the quantity in physical units of the materials of the i-th item consumed for the entire storage period for each of the C_j-th type (method) of storage;

m – the number of items of materials, etc., used in storage.

The value of $C_{зб}$ is the absolute sum of costs for all the time of storage over the cycle of operation, taking into account the withdrawal from storage and staging after the use of military equipment for its intended purpose.

In this case the value of storage costs taking into account the total storage time of WME T (years) and the total operating time per yearS_p (thousand km) can be determined as follows

$$C'_{зб} = \frac{C_{зб}}{T\bar{S}_p} . \quad (3)$$

It is clear that when calculating the values of $C_{зб}$ and $C'_{зб}$ it is necessary to take a certain structure of the park of WME samples studied by types (methods) of storage, values of annual operating time, number of staging and removal from storage, and by nomenclature of WME. The final result of evaluation of costs for storage and retention of WME depends to a large extent on the initial data of such nature. The average annual value of mileage per one item of WME can be determined by the following formula

$$\bar{S}_p = \frac{\sum^{n'} N_i S_{H_i}}{1000\ N} , \quad (4)$$

where n' – the number of groups of the WME park in storage;

N_i – number of WME in each group out of the total number of WMEN;

S_{H_i} – the mileage rate of each group of WME per year.

When calculating the value $\overline{S}_r$ it is necessary to take into account all types of equipment of the combat group (combat), training (transport), as well as those in long-term storage.

Expression (4) can be transformed into the following form

$$\overline{S} = \sum^{n^1} P_{Si} S_{Hi}, \quad (5)$$

where P_{Si} – is the relative number of WME samples in each operation group.

$$P_{Si} = \frac{N_i}{N}$$

The complexity of work during storage (installation of WME and work during storage) is determined on the basis of the normative labor intensity t_i for each i-th type of work in the q-th type of storage. This labor intensity $t_{зб}$ can be determined by the expression.

$$t_{зб} = \sum^{n} \sum^{m} N_j t_i \quad (6)$$

Using expression (6) and value T and $\overline{S}_p$ you can determine the amount of labor costs brought to 1000 km per year of operation

$$t'_{зб} = \frac{t_{зб}}{T\, S_p} \quad (7)$$

The size $t'_{зб}$ is a specific indicator of the labor intensity of storage work. Given the value $t'_{зб}$ it is possible to determine the cost of maintenance of personnel C_{oc}.

Depreciation costs of equipment $\sum C_{ar}$, used in storage (preparation and maintenance), reduced to a unit of WME equipment, are determined by the expression

$$\sum C_a = \frac{1}{N} \sum^{m} \frac{B_o}{T_{ai}} \quad (8)$$

where B_o– the cost of the i-th item of equipment;

T_{ai}– depreciation term of the i-th item of equipment;

m– the number of items of equipment.

Comparison of the values C_M, C_{oc} and $\sum C_a$, obtained on the basis of current standards and the actual consumption of various material resources on average allows to evaluate the level of organization of work on the installation and storage of WME (Dachkovskyi, V., Sampir, O., 2019).

The volume of expenses on fuels and lubricants can be determined on the basis of current consumption rates established by an order of the Ministry of Defense of Ukraine, or by statistical data on the effect of different climatic conditions, time of year, etc. Consumption can be determined both on the basis of consumption rates and on the basis of actual (average) consumption of all fuels and lubricants. Usually, the cost of this content is given to the cost of fuel and lubricants per 1000 km of mileage of tracked or wheeled vehicles of different purposes.

$$C_{ПММ} = 1000\left(\delta_p \chi_p + a_o \delta_p \chi_o\right), \quad (9)$$

where δ_p – specific fuel consumption per unit mileage, km;

a_o – oil consumption coefficient relative to fuel;

χ_p – cost per unit of fuel;

χ_o – cost per unit of oil.;

The value δ_p takes into account the specific fuel consumption during movement $\delta_{рух}$ and the fuel consumption during in-situ operation of the WME sample: $\delta_{міс}$

$$\delta_p = \delta_{рух} + \delta_{міс}\eta \quad (10)$$

where η – the ratio of on-site work time to work time in motion (average value).

Values $\delta_{рух}$ and $\delta_{міс}$, as already mentioned, are either normative or average data.

When determining the cost of maintenance of WME it is necessary to take into account all the costs of the operating cycle, ie the cost of daily maintenance (DM), maintenance № 1 and № 2, as well as inspection and seasonal maintenance.

The general structure of maintenance costs can be expressed as a dependence

$$C_{mo} = C_м + C_c + \sum C_a, \quad (11)$$

where $C_м$ – expenses for material means (MM), necessary for maintenance of the sample of WME;

C_c – expenses for maintenance of the staff of repair specialists;

C_a – expenses for depreciation of equipment.

The cost of material resources required to maintain a sample of WME is determined as follows

$$C_м = \sum^{n} \sum^{m} \delta_i \, \chi_i \quad (12)$$

where n – number of service types;

m – the number of items of materials, spare parts and other disposable values used in the maintenance of all types of services.

δ_p – specific consumption of materials, spare parts;

χ_p – the cost of one item of material resources.

Depending on the purpose of the analysis of the amount of materials used, and hence their cost is determined based on existing standards or their actual needs during actual exploitation. Most often, the analysis is comparative in nature. In this case, the amount of costs can be estimated both by regulations and by actual costs (Dachkovskyi, V., Sampir, O., & Horbachova, Y., 2020).

When assessing the types of services, it is difficult to determine the number of DM and control inspection (CI) ($m_{ЩТО}$; $m_{КО}$). These values for the operating cycle can be determined as follows.

It is known that, on average, the duration of movement of one sample of WME is $\bar{t}$ h, and the average speed of movement, taking into account the entire set of road conditions, is $\bar{V}$ for each nomenclature of samples of WME. On this basis, the average mileage for one exit is

$$\bar{S} = \bar{t}\bar{V} \quad (13)$$

Using the value of $\bar{S}$ and the annual operating rate we can determine the value of $m_{ЩТО}$

$$m_{ЩТО} = \frac{S_н}{\bar{S}} \quad (14)$$

where $S_н$ – normative mileage per trip.

The values of $m_{ЩТО}$ and $m_{КО}$ are related by the statistical coefficient K^{cm}

$$m_{КО} = K^{cm} \, m_{ЩТО} \quad (15)$$

The value of K^{cm} depends on the operating conditions and the nature of use of military and transport WME samples.

The amount of personnel costs for maintenance C_τ is determined by the labor intensity of all work t_{TO} per cycle of operation of the type of WME

$$t_{TO} = \sum^{m} t_i \, n_i \quad (16)$$

where t_i – labor intensity of each of m types of service;

n – the number of each type of service.

Knowing the length of the working day, you can determine the number of people needed for the hour of work required for the maintenance of the relevant type of WME, and hence the cost of maintaining personnel in the performance of maintenance work.

Also, these costs can be determined not for the operating cycle, but for a certain interval of operation, (10^3km; 10^4 km), then

$$t'_{TO} = t_{TO} \, 10^{-3} \quad (17)$$

In this case, the cost of labor during maintenance is determined based on the value t'_{TO}.

The cost of ammunition used in peacetime for the training of personnel of military formations (units) can be determined as follows

$$C_{бп} = \frac{\sum^{m}\sum^{n} B_{бп} g_{ij}}{T\bar{S}_г}, \quad (18)$$

where m – the number of training types in which ammunition is expended;

n – the number of ammunition types;

$B_{бп}$ – the price of each ammunition type;

g – the number of ammunitions of the i-th type used in the j-th type of training;

T – the period of training for the crew;

S_p – average annual mileage per sample per year, thousand km.

Costs $C_{бп}$ characterize the annual cost of ammunition, which is spent on the appropriate type of WME during crew training, when firing in a military formation (unit).

It is clear that the value $C_{бп}$ characterizes the costs of this species only in peacetime exploitation. The cost of using ammunition in combat will be incomparably higher.

Estimation of costs for military repair of WME is carried out as in the direction of determining the cost of individual types of repair and in the direction of determining the total repair costs for the cycle of operation of the sample of WME (Dachkovskyi, V., Sampir, O., & Horbachova, Y., 2020).

The amount of these costs largely depends on the level of production organizations in the military repair bodies. Therefore, for the repair of WME samples necessary material resources, workforce. Even the level of quality is determined taking into account the objective assessment of the technical condition of the WME sample entering repair, and depends on the level of organization of production in the repair body, including the degree of training of repairmen (Dachkovskyi, V., Sampir, O., 2019). The technical condition of the repair fund is affected by both operating conditions and the nature of combat damage. The condition of the repair fund of WME samples in peacetime is determined by the level of reliability of WME samples (Dachkovskyi, V., Sampir, O., 2019; Matsko, O. Y.; Shishanov, M.O. Kondratyuk, I.V. Veretnov, A.O., 2021), by the general system of maintenance and training of crews. In combat conditions, the condition of the repair fund is determined mainly by the nature of combat damage.

The specifics of the production process of each repair body is explained by the peculiarities of the operating conditions of weapons in the military formation (unit); the degree of equipment, tools, as well as the quality and condition of production facilities (Dachkovskyi V., 2020). In addition, the subjectively formed methods of production management and control have a significant impact on the organization of the production process; the level of training of repair specialists and the level of competence of managers at all levels. All of the above significantly affects both the efficiency of repair bodies and the cost of military repairs in general.

In modern conditions, the assessment of military repairs should be based on quality, cost and productivity (Dachkovskyi V., 2020; Dachkovskyi, V., Rodchenco, L., 2019).

Assessment of repair quality is made by reliability indicators: no-failure and durability (Shishanov, M.O. Kondratyuk, I.V. Veretnov, A.O., 2021; Dachkovskyi, V., Rodchenco, L., 2019). Therefore, in this paper we will focus on the evaluation of the cost of repair and its productivity.

When analyzing repair costs, it is necessary to determine the unit cost for each type of repair, the cost per cycle of operation, unit costs. The main indicator is the cost of repair.

For military repair facilities, the cost of repairs (current and average) is determined by the following expression

$$C = \sum^{o=5} C_i = C_{зч} + C_м + C_с + C_{мр} + C_о \, , \quad (19)$$

where C_i – repair costs by elements (spare parts, materials; cost of personnel maintenance, overheads, amount of depreciation, etc.).

The cost of spare parts $B_{зч}$ is determined on the basis of an assessment of the technical condition of the sample of the WME, which is repaired, the current scheme, the technological process in the repair body, its level of equipment, the training of personnel, etc.

$$B_{зч} = \sum^{q} P_i B_i K \quad (20)$$

where P_i – the probability of replacing each of the q elements of the sample WME, which change during repair;

B_i – the cost of each of the q elements;

K – the number of interchangeable parts of the same name on the sample WME.

When forecasting the cost of this group instead of $B_{зч}$ you can use the values of different coefficients: – coefficient of variability $K_{зм}$; replacement factor $K_{за}$, etc. The value of $B_{зч}$ largely depends on the level of validity of technical requirements for defects in parts during military repairs.

Ideally, the need to replace worn or damaged parts that are defective in terms of technical requirements during military repairs should be met through the established values of $K_{зм}$ and $K_{за}$. But, in fact, due to insufficiently organized defect work or due to insufficiently justified technical requirements for defect (maximum allowable work of parts, gaps, tensions, etc.) the amount of defective parts may be too large (then the cost of repair increases) or too small (then deteriorating repair quality) (Dachkovskyi V., 2020).

The above shows that the cost of spare parts depends on subjective reasons and therefore should be strictly controlled.

The cost of materials $B_м$ is the expenses of the entire range of materials, fuel, electrodes, rags, etc., used in the repair of weapons, without which the repair of the sample of weapons is impossible. The value of $B_м$ largely depends on the technical condition of the repair fund and, as a rule, can be determined experimentally

$$B_м = \sum^{n} d_i B_j \, , \qquad (21)$$

where d_i – the quantity of materials of the corresponding nomenclature n, used;

B_j – cost per unit of materials of each nomenclature n, used.

The amount of materials used in routine repairs is relatively insignificant. With an average repair, the volume of these costs increases somewhat (Tkach I. M., 2018; Demenev O.M., Rychtyuk V.L., Muntian V.I., Tkach I.M., 2016).

The cost of maintaining personnel B_{oc} is determined by the expression

$$B_c = dB_r \eta K_л \qquad (22)$$

where d – the calendar period of stay of a WME specimen in repair,

B_r – cost of keeping one repair specialist for a day;

η – coefficient, taking into account non-productive losses of time;

K_r – number of specialists-repairmen.

Expenditures B_c include the maintenance of personnel of servicemen who are directly involved in the repair of WME. The number of specialists-repairmen K_r includes the total number of specialists working in the repair of samples of weapons and ammunition specialists of all specialties (mechanics of dismantling and installation and adjustment work, metalworkers, welders, tinsmiths, electricians, weapons repair specialists, etc.). This number of repairmen can vary considerably depending on the type of repair, its complexity and the nature of the damage.

The number of auxiliary personnel providing technological repair process is accounted for in the amount of overhead costs $B_{нв}$. This includes the maintenance of workers who provide the repair body.

The volume of overhead costs$B_{нв}$ takes into account the entire volume of work on support and auxiliary works during repairs, the consumption of energy of all kinds, the share of costs for the maintenance of auxiliary personnel per one repair, transport costs, etc. As a rule, these costs are determined indirectly by attributing the costs incurred by the repair body during a certain period of time (year) to one repair out of m_p, carried out during this period. These costs are determined by the experimental method on the basis of the analysis of past costs.

The amount of depreciation costs B_a includes the cost of assessing the depreciation of equipment, devices, tools in use, etc. The amount of depreciation of equipment is accounted for on the basis of the norms of supply of production and auxiliary equipment, as well as taking into account the costs of repair bodies.

Usually the volume B_a, as well as the volume $B_{нв}$, is determined by the research method as a percentage of the sum of B_a and $B_{нв}$. Thus, the cost of each type of military repair is determined by a number of components, the main share of which consists of expenditures on spare parts and maintenance of the personnel of specialists-repairmen.

Conclusions

Thus, in this paper, in accordance with the stage of the life cycle of WME samples, namely the stage of use, which includes the exploitation of WME samples proposed method of technical and economic evaluation of WME samples that are adopted or allowed to operate in the Armed Forces of Ukraine.

The paper proposes the structure of total costs for the operation of WME, which consists of determining the cost of storage, maintenance (daily maintenance, number maintenance), fuel and lubricants, repair of WME samples (scheduled, unscheduled).

In the future, to reduce costs, it is necessary to consider possible ways to optimize the operation of WME samples.

References

Asadullin, M. R. (2016). Method for technical and economic evaluation of the effectiveness of reliability improvement of military aircraft gas-turbine engines in their aftersales support based on outcome performance measures. *Vestnik Permskogo universiteta. Seria Ekonomika = Perm University Herald. Economy.* № 3(30). P. 92–104. DOI: 10.17072/1994–9960–2016–3–92–104

Buravlev A.I. (2016). Methodology for assessing the military-technical level of the AME fleet during the implementation of program measures for their purchase and repair. *Armament and economy*. No. 4 (37). P. 91-103.

Dachkovskyi V. (2020). Ways of determining quality indicators weapons and military equipment. *Modern Information Technologies in the Sphere of Security and Defence.* №2(38). p. 107-116. DOI: 10.33099/2311-7249/2020-39-3-107-116

Dachkovskyi, V., Rodchenco, L. (2019). Recovery methodology weapons and military equipment. *Modern Information Technologies in the Sphere of Security and Defence.* №3(36). P. 89-96. DOI: 10.33099/2311-7249/2019-36-3-89-96

Dachkovskyi, V., Sampir, O. (2019). Algorithm of logistic protection system operation. *Modern Information Technologies in the Sphere of Security and Defence* №2(35). p. 87-92. DOI: 10.33099/2311-7249/2019-35-2-87-92

Dachkovskyi, V., Sampir, O., & Horbachova, Y. (2020). Methodical approach to evaluation of economic efficiency of repairing the weapons and military equipment. *VUZF Revie w*, 5(1), 22-30. DOI: 10.38188/2534-9228.20.1.03

Datsenko I. P. (2016). Methodical bases feasibility assessment welding process in production of modernization of special vehicles. *Modern Information Technologies in the Sphere of Security and Defence.* №2 (26), p. 121-126.

Demenev O.M., Rychtyuk V.L., Muntian V.I., Tkach I.M. (2016) Marketing and Logistics in the Armed Forces of Ukraine. 304 p.

DSTU 2860-94 Reliability of equipment. Terms and definitions. Kyiv: State Standard of Ukraine, 1994. 92 p.

DSTU 2862-94 Methods of calculating reliability indicators. General requirements. – Kyiv: State Standard of Ukraine, 1994. 32 p.

DSTU B 3576-97. Operation and repair of military equipment. Terms and definitions. - Kyiv: State Standard of Ukraine, 1998. 59 p.

DSTU V-P 15.004: 2000 System of development and supply of weapons and military equipment. Stages of the life cycle of armaments and military equipment. Kyiv: DP "UkrNDNC", 2000. 43 p.

Havryliuk, I., Matsko, O., Dachkovskyi, V. (2019). Conceptual basis of flow management in the system of logistic support of the armed forces of ukraine. *Modern Information Technologies in the Sphere of Security and Defence* № 1 (34). p. 37-44. DOI: 10.33099/2311-7249/2019-34-1-37-44

Mark Broude, Saadet Deger et Somnath Sen (2013). Defence, innovation and development: the case of Israel. *Dans Journal of Innovation Economics & Management.* 2 (n°12), p. 37-57.

Matsko, O. Y., Tereshchenko, A. M., Kopashynskyi, S. A, Ovcharenko, I. V, Dachkovskyi, V. O, Yalnytskyi, O. D, Openko, P. V., Yaroshenko, O.V., Momot, R. A., Grinchak, O. V. (2018). Fundamentals of Organization of Operation and Repair of Weapons and Military Equipment, Kyiv, NUOU, 400 p.

Michael Beckley (2010). Economic Development and Military Effectiveness. *The Journal of Strategic Studies* Vol. 33, No. 1. p. 43-79. DOI: 10.1080/01402391003603581

Pavlovsky, I.V., Chepkov, I.B., Borokhvostov, V.K., Borokhvostov, I.V., Ryabets O.M. (2017). Scientific and methodological approaches to the analysis of military-technical and technical-economic aspects of the life cycle of samples of armaments and military equipment. *Science and Defense*, №2. p. 43-51.

Shishanov, M. O., Chechenkova, O. L., Pavlovsky, I. V. (2018). Feasibility study of modernization of armored vehicles during its overhaul. *Weapons and military equipment.* № 1 (17), p. 62-65

Shishanov, M.O. Kondratyuk, I.V. Veretnov, A.O. (2021). Methodical bases of complex substantiation of requirements to reproducibility of difficult technical systems. *Modern Information Technologies in the Sphere of Security and Defence*. № 1(40), 2021, P. 85 – 94.

Smal T., and Furch J. (2011). Expedient repairs – analysis of possibilities and needs. *Advances in Military Technology*. Vol. 6, No.2, December, p. 69-82.

Tkach I. M. (2018). Conceptual principles of military and economic security of the state: monograph. Kyiv: 312 P. ISBN 978–617–7187–19–5

Zdenek Vintr, Rudolf Holub, A. (2000). Method of technical and economic evaluation of vehicle reliability. Seoul 2000 FISITA World Automotive Congress June 12-15, 2000, Seoul, Korea Available from: https://www.researchgate.net/publication/267845747_A_Method_of_Technical_and_Economic_Evaluation_of_Vehicle_Reliability.

Zianko, V.V., Polyakov, P.A. Feasibility study of recommendations for improving the efficiency of the system of maintenance and repair of tracked equipment. Available from: https://ir.lib.vntu.edu.ua/bitstream/handle/123456789/16822/3139.pdf?sequence=3