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JUSTIFICATION FOR APPLYING EXPEDIENT/BATTLE DAMAGE REPAIRS OF WEAPON SYSTEMS IN COMBAT OPERATIONS

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Every armed conflict is connected with numerous losses in the equipment. Modern armies are still looking for new solutions allowing them to improve the possibilities of the battlefield maintenance system, which will be tailored to the conditions of the contemporary battlefield. One of the solutions is the ER/BDR – expedient repairs and battle damage repairs of weapon systems. The ER/BDR allows one to maintain the suitability of combat vehicles, especially mobility or an ability to provide fire during combat operations. What is more, ER/BDR operations can be conducted directly in the place of damage without the necessity of evacuation to maintenance collection points. In the article the authors present advantages and a justification for applying this solution, which is based on the analysis of theoretical calculations, a few historical data and a simulation they conducted.

Keywords: *logistics, combat service support, battlefield maintenance, battle damage repair*

INTRODUCTION

The Polish Armed Forces, as a NATO member, is obliged to implement allied procedures and regulations. One of them refers to expedient repairs, including battle damage repairs, of weapon systems, (ER/BDR) [1]. The primary purpose of battle damage repair is to restore sufficient strength and serviceability to weapon systems to allow them to conduct additional operational missions or to ensure partial mission capability [2, 3].

A properly developed Battlefield Maintenance system can create an advantage over an enemy by rapidly recovering and restoring all damaged objects with the exception of heavy combat damage. This is why, new and diverse solutions should be searched for in order to support fighting units in capable weapon systems without any necessity of evacuation to stationary workshops [4]. The battle damage repair system is a solution which can improve operation of a maintenance system. The diversification of various solutions and an appropriate design of equipment (reparability) will support logistic units in the recovery of weapon systems and can help create an advantage over an enemy [5, 6].

1. THEORETICAL ANALYSIS

The difference between the expedient (temporary) repairs of military equipment performed in peacetime and battle damage repairs in field conditions is that we should follow not only economic factors, which are the most important in peacetime, but also the provision of combat vehicle main functions, e.g. a fire system, vehicle mobility and communication. The survival time of a vehicle (a crew) and firepower of a fighting unit on a battlefield is crucial for deciding whether to perform a temporary repair. Simulations definitely indicate that during high intensity conflicts the availability of weapon systems becomes low within the first few days of the battle [7]. This is caused not only by numerous battle failures and system unreliability, but mainly by logistic delays, such as spare parts, a maintenance crew or equipment. Some of the abovementioned problems could be at least partially solved by applying ER/BDR procedures and methods.

Some simulation models for the availability of weapon systems under battlefield conditions could be developed. The functions used most often are exponential, Weibull or log-normal distribution to perform simulation [7, 8, 9, 10]. The recovery process of weapon system power might be viewed as a geometric sequence [11]:

$$nt = n0 \cdot q^{t-1} \tag{1}$$

where:

n_0 – the number of combat vehicles before the operation began,

n_t – the number of combat vehicles at the beginning of the day t,

q – a sequence quotient,

t – the number of days.

The magnitude of the sequence quotient q can be described as the ability to repair damaged combat vehicles with the extension of loss z, combat vehicle reparability ψ, and when considering the capacity and technical possibility of performing the repair with repair units ε.

Therefore

$$q = 1 - z + \psi \varepsilon z \tag{2}$$

Then, sustainability time is given by a decrease in the number of combat vehicles at an acceptable level n_x

$$n_x = n_0 \cdot q^{t_x - 1} \tag{3}$$

and therefore

$$t_x = \frac{\log n_x - \log n_0}{\log q} + 1 \tag{4}$$

when reaching the time t_x a unit has to be replaced or supplied with another combat vehicle.

Performing temporary repairs helps to increase the capacity of repair units by manpower saving, overcoming downtime due to the lack of spare parts, or involving crews in the repair process. This will be manifested in the rise in coefficient value ε [11]. Additionally, purchased weapon systems can be designed to perform higher reparability and vulnerability and, at the same time, the currently maintained equipment can be constantly improved by retrofit [4]. These activities will be manifested in the rise in coefficient value ψ.

2. ESTIMATION OF APPLYING ER/BDR IN COMABAT OPERATIONS

In practice, the values of this single coefficient are difficult to determine; therefore, a method based on taking into consideration the percentage disintegration rates is used for estimating the combat readiness[1] of fighting units. The percentage disintegration rates of the military equipment are often applicable historical data and prepared on the basis of historical armed conflicts and experiences. What is more, they take into consideration the repair possibility by own maintenance elements[2].

If we consider a specific situation in which a mechanized brigade equipped with IFVs (BMPs)[3] and tanks is conducting a defensive operation, it is possible to prepare more accurate calculations of repair needs, which results more from projected losses in the main groups of military equipment, where the basic criteria of classification are the type of the damaged item, the repair equipment of the serviceman, and the predicted manpower intensity of damage repair [12]. For that purpose the following assumptions were made:

a) the brigade is conducting a defensive operation in the key terrain[4] of the division and is grouped in one echelon with tactical reserves (a mechanized battalion);
b) the established period of time based on the [13] for the conducting of defensive operations by the brigade is three days of the fight;
c) the quantity of the items in the battalions which are available for operation: a mechanized battalion – 53 IFVs, an armoured battalion – 53 tanks;
d) the maintenance units of battalions and the brigade will carry out tasks connected with conducting the technical diagnosis, evacuation, and repair first for the equipment categorized as R1 and R2;
e) the forecast average day of the fight losses for BMPs were accepted at 34% and for tanks at 32%; the structure of losses is shown in Fig 1;
f) the approximate restoration of the equipment as the result of standard repairs will be:
   - R1, tanks – 5, IFVs – 5; repairs are conducted by the brigade maintenance company in UMCP, repaired vehicles will be returned to the fight at the end of each day of conducted operations;

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[1] Combat readiness - the degree to which a unit or sub-unit is considered capable of fighting effectively. *Dictionary of military terms – third edition*, pp. 51.

[2] According to this criterion the equipment can be qualified for the following field repairs: technical assistance to 16 man-hours, repair of the first level (R1) from 16 to 40 man-hours, repair of the second level (R2) from 40 to 60 man-hours, repair of the third level (R3) from 60 to 120 man-hours, repair of the fourth level (R4) from 120 to 300 man-hours, repair of the fifth level (R4) from 300 to 4000 man-hours.

[3] BMP – The Soviet series of infantry fighting vehicles (IFV). *Dictionary of military terms – third edition*, pp. 30.

[4] Key terrain – ground which you must occupy or control in order to achieve your mission. *Dictionary of military terms – third edition*, pp. 136.

– R2, tanks – 1, IFVs – 1; repairs are conducted by the division maintenance battalion in UMCP, repaired vehicles will be returned to the fight at the end of every day of the fight of the conduct of operations;
– R3, tanks – 2, IFVs – 2; repairs are conducted by the logistics brigade maintenance battalion in the elements of stationary logistic infrastructure, repaired vehicles will be returned to the fight at the end of the third day of the fight of the conduct of operations;

g) it was assumed that the maintenance elements of the brigade and battalions would be organizing recovery teams on flexible time to 30 minutes for one damaged item and the evacuation-repair squads on flexible time up to 2 hours for one damaged item.

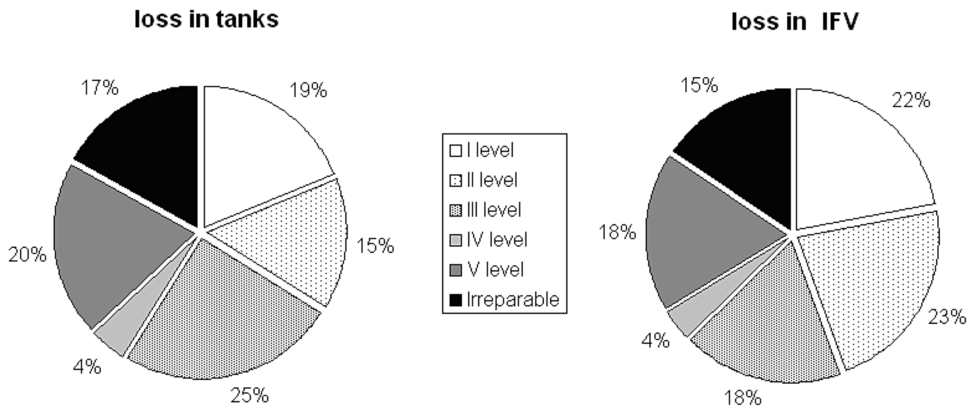

Fig. 1. The percentage extension of loss in tanks and BMP-1s in connection with the extent of repair

Source: Smyk S., Logistic support of battalion in tactic operations (In Polish). University of Defence, Warsaw 2004

3. THE EXPEDIENT/BATLE DAMAGE REPAIR SYSTEM PRELIMINARY CONCEPT

On the basis of the assumptions made, the brigade unit equipment[5] will be shaped without conducting repairs in the subsequent days of the fight as in Tab. 1. The data presented shows that the brigade will lose the ability to conduct an operation during the second day of the fight already. As a result, such solutions must be applied which enable the reconstruction of the technical applicability of damaged vehicles, because this gives a possibility of keeping and extending the combat readiness of troops. Recovery and standard repairs conducted by maintenance elements are a standard solution. Considering their repair possibilities, we get the following brigade unit equipment in the subsequent days of the fight (Table 2).

[5] Unit equipment - the equipment prescribed by the table of organization and equipment, or national equivalents pertaining to that unit. *AAP-6 – NATO glossary of terms and definitions.*

Table. 1. Mission capable rates of brigade main vehicles in the division of repair levels (variant 1 – without repair system)

type of vehicle	day of combat	no. of vehicle before operation	no. of vehicle at the beginning of the day	no. of loss	level of repair						no. of repaired vehicle (standard repair)	no. of vehicle at disposal	percent of vehicle at disposal
					I	II	III	IV	V	irre-parable			
IFV	1	106	106	36	9	5	7	1	7	6	0	70	66%
	2	106	70	24	6	4	5	1	5	4	0	46	44%
	3	106	46	16	4	2	3	1	3	3	0	30	29%
tank	1	53	53	17	3	3	4	1	3	3	0	36	68%
	2	53	36	12	2	2	3	0	2	2	0	25	46%
	3	53	25	8	1	1	2	0	2	1	0	17	31%

Source: Own elaboration

Table. 2. Mission capable rates of brigade main vehicles in the division of repair levels (variant 2 – standard repair system)

type of vehicle	day of combat	no. of vehicle before operation	no. of vehicle at the be-ginning of the day	no. of loss	level of repair						no. of repaired vehicle (standard repair)	no. of vehicle at disposal	percent of vehicle at disposal
					I	II	III	IV	V	irre-parable			
IFV	1	106	106	36	9	5	7	1	7	6	6	76	72%
	2	106	76	26	6	4	5	1	5	4	6	56	53%
	3	106	56	19	5	3	4	1	4	3	8	45	42%
tank	1	53	53	17	3	3	4	1	3	3	4	40	76%
	2	53	40	13	2	2	3	1	3	2	4	31	59%
	3	53	31	10	2	1	2	0	2	2	5	26	49%

Source: Own elaboration

The data received show that, with the assumptions made, the brigade will lose combat readiness during the third day of the fight, especially when taking into consideration the number of IFVs. It is possible to state explicitly that the execution of tasks by maintenance elements extends the combat readiness of the units during defensive operations. The additional solution which will allow one to extend the combat readiness of the brigade during combat operations can be the ER/BDR system. And this will provide the expedient (temporary) repair of crucial weapon systems directly on the battlefield, and it will reduce the scale of the logistic delays associated with the lack of the spare parts in UMCP. An analysis of Norwegian experience from the ISAF operation has shown that recovery teams are able to carry out about 20% of expedient repairs on the site of damage with using ER/BDR kits [15]. Another example can be American experience from operations Allied Effort in Serbia and Desert Storm in Iraq, which proved that the elimination of intermediate-level repair capability at the deployed location can contribute to the significant decrease in mission readiness due to extended supply pipelines (lack of spare parts). To improve the sustainment of combat operations, there were centralized intermediate repair facilities deployed, which also had capabilities to execute improvised repairs. Owing to that, approximately 30-40% percent of all the removed parts were found serviceable and returned to the originating units [16, 17].

Assuming that the mobile elements of the brigade technical support are equipped with ER/BDR kits, which give them a possibility to conduct the expedient (temporary) repairs of the 20% of damage in R1 and in UMCP, and there is an ER/BDR squad acting, able to remove 30% of damage in R1 and R2 in the improvised way (in the case of a standard repair, it would not be possible because of lack of spare parts), in the subsequent days of fights the level of equipment will be as follows (Table. 3):

Table. 3. Mission capable rates of brigade main vehicles in the division of repair levels (variant 3 – standard and ER/BDR repair system)

type of vehicle	day of combat	no. of vehicle before operation	no. of vehicle at the beginning of the day	no. of loss	level of repair						no. of repaired vehicle (standard repair)	no. of repaired vehicle (BDR)	no. of vehicle at disposal	percent of vehicle at disposal
					I	II	III	IV	V	irreparable				
IFV	1	106	106	36	9	5	7	1	7	6	6	6	82	77%
	2	106	82	28	7	4	6	1	6	5	6	6	66	62%
	3	106	66	22	5	3	4	1	4	4	8	2	53	50%
tank	1	53	53	17	3	3	4	1	3	3	4	2	42	79%
	2	53	42	13	3	2	3	1	3	2	4	1	34	63%
	3	53	34	11	2	2	3	0	2	2	5	1	29	54%

Source: Own elaboration

The described calculations prove that the synergy of action resulting from connecting the standard maintenance system with the ER/BDR system should allow one to extend the brigade's combat readiness to three days of fight, which is shown in Figure 2.

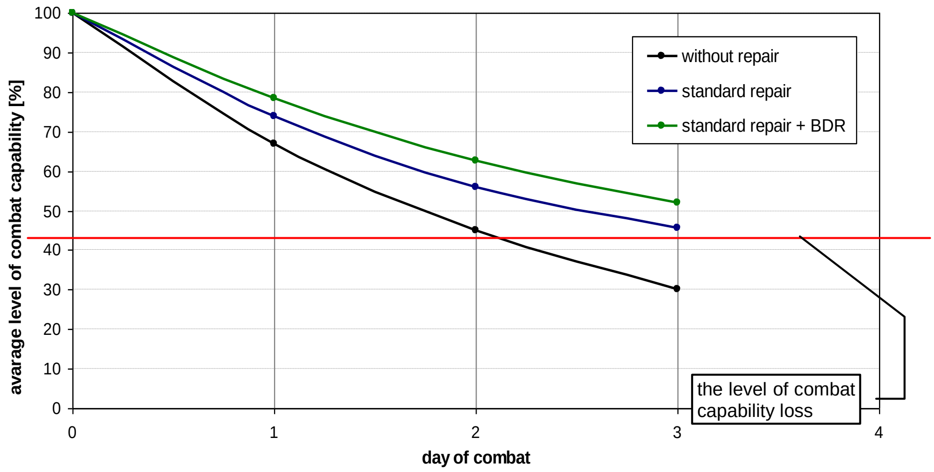

Fig. 2. Mission capable rates of main vehicles with reference to the assumed variants

Source: Own elaboration

CONCLUSIONS

The analyses and calculations conducted in this section enable one to formulate the following conclusions:

– The difference between the expedient repairs of military equipment performed in peacetime and battle damage repairs in field conditions is that we should follow not only economic factors, which are the most important in peacetime, but also the provision of combat vehicle main functions, e.g. a fire system, vehicle mobility and communication in order to restore sufficient strength and serviceability to weapon systems to to allow them to conduct additional operational missions or to ensure partial mission capability.

- The analysis of the literature as well as interviews with experts engaged in the problems with the execution of military equipment repairs directly on the battlefield allow one to conclude that the efficient functioning of expedient repair systems makes it possible to increase the recovery of damaged equipment by 20 to 40 % depending on the tactical level.
- The simulation of advantages resulting from supplementing the standard system of technical support of a mechanized brigade with the elements of the ER/BDR system, conducted on the basis of experience from previous military operations, makes it possible to state that a longer time of task execution by the unit under discussion is achieved along with the greater recovery of damaged military equipment.
- Equipping brigade mobile maintenance elements with necessary measures allows them to carry out ER/BDR activities directly on the site of damage without the necessity of evacuation to maintenance collection points. It means that damaged vehicles can return to the battle more quickly.

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UZASADNIENIE STOSOWANIA SYSTEMU DORAŹNYCH NAPRAW BOJOWYCH SPRZĘTU WOJSKOWEGO PODCZAS OPERACJI WOJSKOWYCH

Streszczenie

Każdy konflikt zbrojny wiąże się z licznymi stratami w uzbrojeniu i sprzęcie wojskowym (UiSW). Nowoczesne armie stale poszukują nowych rozwiązań, które pozwolą na rozwijanie możliwości prowadzenia napraw uszkodzonych systemów uzbrojenia w warunkach polowych oraz będą dostosowane do potrzeb współczesnego pola walki. Jednym z takich rozwiązań jest system doraźnych (improwizowanych) napraw polowych systemów uzbrojenia. Pozwala on utrzymać zdatność UiSW, a zwłaszcza jego mobilność oraz zdolność do prowadzenia ognia w czasie działań bojowych. Co więcej, naprawy ER/BDR mogą być prowadzone bezpośrednio w miejscu uszkodzenia, bez konieczności prowadzenia jego ewakuacji do punktów zbiórki uszkodzonego sprzętu. Oznacza to, że uszkodzone UiSW może znacznie szybciej powrócić do walki. W artykule autorzy prezentują zalety tego rozwiązania, które zostały oparte na analizie teoretycznych kalkulacji, wybranych przykładach i danych historycznych oraz przeprowadzonej symulacji zdarzeń taktyczno-logistycznych.

Słowa kluczowe: *logistyka, wsparcie działań bojowych, naprawy doraźne, utrzymanie systemów uzbrojenia*