Methodology of determining the probability of firing the enemy target by the unit

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Abstract

Technological development of the warring parties, the introduction of new forms and methods of armed struggle, the trend of transition to a network-centric war necessitate the search for new approaches to evaluating the effectiveness of units in carrying out combat tasks. The combat effectiveness will largely depend on a detailed assessment of the capabilities of the available weapons of the warring parties. Therefore, the improved methodology for determining the probability of firing by the unit is based on the most acceptable algorithm based on probability theory. The proposed partial methodology, based on known methods for determining the probability of firing, the number of weapons samples and their tactical and technical characteristics, allow to determine the number of successful shots fired by the warring parties during the battle. Taking into account the conditions specified in the improved methodology, the probability of firing the enemy target by the unit is determined, taking into account its counteraction. The practical value of the improved methodology is to enable the unit commander to adjust his decision taking into account the assessment of the effectiveness of the firing means at his disposal. At the same time, the improved methodology can be a part of the mathematical model of the targeted unit against enemy targets, which is based on the method of two functions.

Key words: methodology, combat potential, probability of firing, effectiveness, means of fire, successful shots.

Introduction

The experience of modern combat operations shows that the quantitative superiority of one of the warring parties cannot fully ensure the achievement of success in combat operations. The capabilities of the warring parties are becoming increasingly difficult to measure simply by the presence of a certain number of calculated combat units, since these units may differ in qualitative characteristics, and at the same time the possibility of temporarily combining them to perform a combat task greatly increases their effectiveness.

Material and methods

Currently, during the combat operations planning for determining the ratio of the warring parties the value of the combat potentials of the available means of firing is usually used (Collection of Tactical Calculations; Aliev A., Bairamov A., 2018). The relative simplicity of calculations allows them to be performed without the use of additional equipment in a relatively short time. However, not taking into account the capabilities of small arms of the warring parties, does not fully ensure the reliability of the results. At the same time the technical development of weapons and military equipment of the warring parties, the introduction of new forms and methods of armed struggle, the trends of transition to a network of centralized warfare

(Bielieskov, M., 2021) necessitates the search for new approaches to assessing the effectiveness of combat missions.

The analysis of publications (Senatorov, M., Senatorov, V., Kuchynskyi, A., Derkach I., 2020; Gubin, S., 2012; Droban, O., Zhogalskyi, E., 2018) shows that considerable attention is paid to the issues of evaluating the effectiveness of fire weapons. However, it should be noted that the existing methods are aimed mainly at determining the probability of firing by individual fire weapons of the same type and in the vast majority do not take into account the counteraction of the enemy.

The presence of different types of fire weapons on the warring sides and their intensive use during combat action requires determining the probability of firing the enemy target by the unit, taking into account the enemy counteraction.

In this case, the known methodologies are quite difficult to apply to determine the probability of firing by the unit that includes a variety of fire means and on which during the battle the fire action is carried out by the enemy.

Therefore, **the aim of this article** is to improve the methodology for determining the probability of firing the enemy target by the unit, taking into account its counteractions.

Results and discussion

The structure of the methodology for determining the probability of firing the enemy target by the unit, given in Table 1, consists of four blocks: a block of initial data; a block of determining the probability of firing with the *j*-weapon; a block of determining the probability of firing the enemy target by the *k*-unit with regard to counteractions and conclusions.

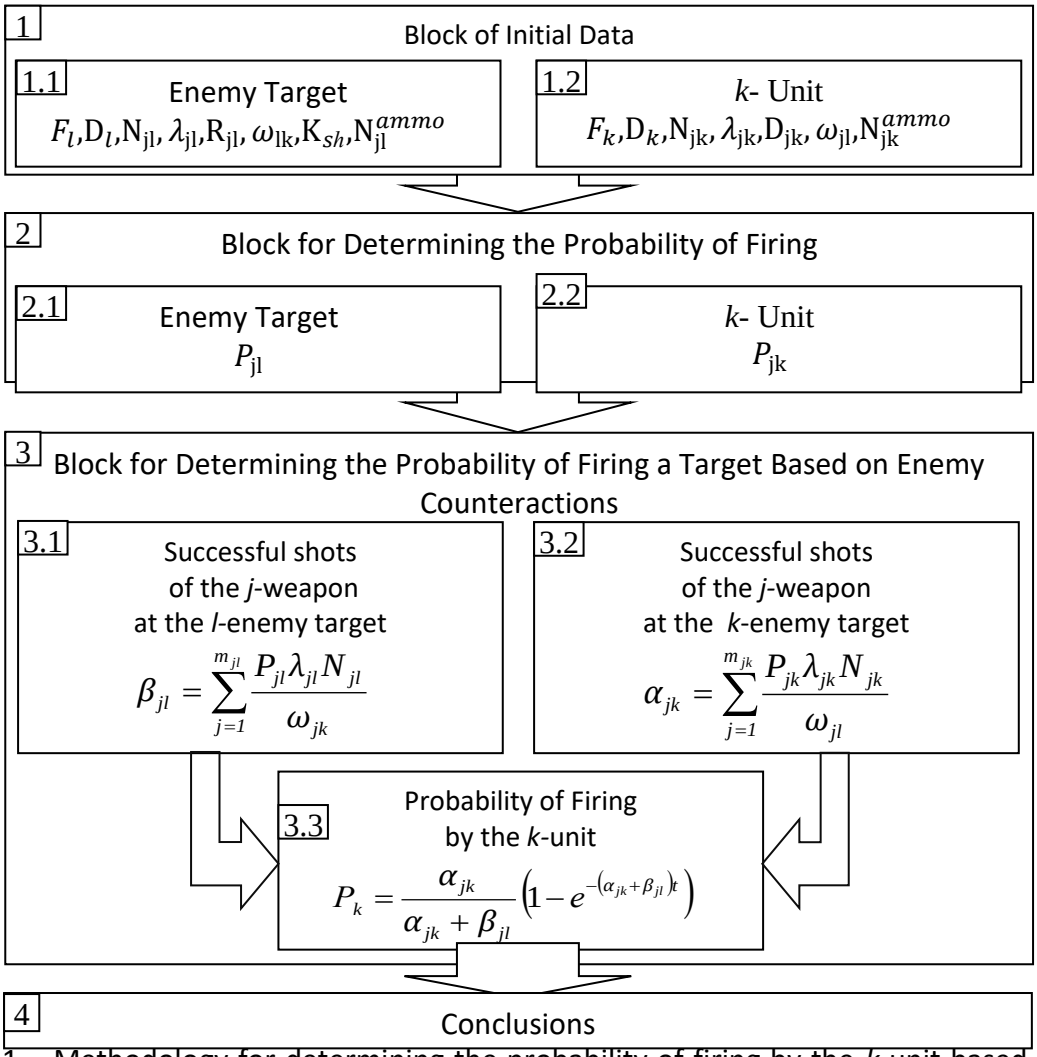

Table 1 – Methodology for determining the probability of firing by the *k*-unit based on enemy counteractions

The block of initial data is formed on the basis of the analysis of the possible number, state of forces and means in the composition of the enemy targets and the *k*-unit. Data on the enemy target may include the following information: size in front and depth (F_l, D_l); number of personnel, weapons, military equipment in its composition (N_{jl}) and their ammunition supply (N_{jl}^{ammo}); main characteristics of small arms and armored (lightly armored) equipment, namely: average rate of fire of the *j*-type weapon (λ_{jl}), its effective firing range (R_{jl}), the average required number of hits on the *k*-unit weapon (ω_{lk}) and the shape factor of the enemy's equipment (K_{sh}).

Data on the *k*-unit in turn may include: the number of personnel, weapons and military equipment, which are involved in carrying out combat missions (N_{jk}), the provision of their ammunition (N_{jk}^{ammo}); spatial indicators of the front and depth of attack units (F_k, D_k); the main characteristics of the weapons with which the *k*-unit is equipped $(\lambda_{jk}, D_{jk}, \omega_{jl})$.

In the second block, to determine the probability of firing of the different types of weapons available to the warring parties, it is advisable to use the methods given in (Wentzel, E., 1972; Wentzel, E., 1964; Abchuk, V., 1979; Makeiev, V., Pushkarev, Y., Lyapa, M., 2019; Fendrikov, N. Yakovlev, V., 1971).

In the third block, to determine the probability of firing the enemy target by the *k*-unit, two conditions are taken into account. The first condition is that the fire influence of the warring parties is considered as a continuous process, and the second condition is that the weapon from the enemy target and the *k*-unit during the battle is in one of two states – defeated or retained combat effectiveness. Under these conditions, the probability of firing the enemy target by the *k*-unit can be calculated by the formula

$$P_k = \frac{\alpha_{jk}}{\alpha_{jk} + \beta_{jl}} \left(1 - e^{-(\alpha_{jk} + \beta_{jl})t}\right) \quad (1)$$

where α_{jk} – successful shots fired by the *k*-unit at the enemy target during combat action *t*;

β_{jl} - successful shots fired by the enemy target at the *k*-unit during combat action *t*.

Taking into account that both the *k*-unit and the enemy target use different types of fire weapons, the successful firing by the warring parties can be determined by the formulas:

$$\alpha_{jk} = \sum_{j=1}^{m_{jk}} \frac{P_{jk} \lambda_{jk} N_{jk}}{\omega_{jl}} \quad (2)$$

$$\beta_{jl} = \sum_{j=1}^{m_{jl}} \frac{P_{jl} \lambda_{jl} N_{jl}}{\omega_{jk}} \quad (3)$$

where m_{jk}, m_{jl} – the number of weapon types used by the *k*-unit and the enemy target;

λ_{jk} – average rate of fire of the *j*-type weapon of the *k*-unit (in accordance with the tactical and technical characteristics);

N_{jk} – the number of the *j*-type weapons in the *k*-unit, involved in firing the enemy target;

ω_{jl} – the average required number of hits to the *j*-type of a weapon (shooter) of the *l*-enemy target;

$\lambda_{jl}, N_{jl}, \omega_{jk}$ – similar values characterizing different types of enemy target weapons.

The fourth block considers the appropriateness of assigning the *k*-unit to a selected enemy target or the need to strengthen it.

As an example, consider a variant of calculating the probability of firing the enemy target by the *k*-unit, taking into account its counteractions.

Assume that the plan is to destroy an enemy target occupying a stronghold up to 300 m in front and 200 m in depth. The stronghold is expected to have up to 30 troops armed with up to 20 Kalashnikov assault rifle with a foldable butt-stocks-74; 1 Dragunov sniper rifle; up to 3 PK machine guns; 2 Kalashnikov LMGs; 3 automatic grenade launchers-17; 3 light anti-tank weapons-7 and 3 armoured personnel carriers-80. Up to two pieces of ammunition will be used for defensive combat.

The general military unit consists of: up to

100 servicemen, which are armed with 90 Kalashnikov assault rifle with a foldable butt-stocks-74; 3 Dragunov sniper rifles; 9 PK machine guns; 6 Kalashnikov LMGs-74; 9 light anti-tank weapons-7; 6 automatic grenade launchers-17 and 10 armoured personnel carriers-80. One ammunition is allocated for combat action.

Using the methodologies (Wentzel, E., 1972; Wentzel, E., 1964; Abchuk, V., 1979; Makeiev, V., Pushkarev, Y., Lyapa, M., 2019; Fendrikov, N. Yakovlev, V., 1971), we calculate the probabilities of firing the enemy target and the *k*-unit with different weapon types.

We get the following values:

for a general military unit P_{KAR}= 0,0165; P_{DSR}= 0,0009; P_{PKM}= 0,008; $P_{KLMG-74}$= 0,0026; P_{LAW-7}= 0,0077; P_{AGL-17}= 0,0056; P_{APC-80}= 0,017;

for an enemy target P_{KAR}= 0,0228; P_{DSR}= 0,0018; P_{PKM}= 0,0161; $P_{KLMG-74}$= 0,0054; P_{LAW-7}= 0,01; P_{AGL-17}= 0,013; P_{APC-80}= 0,047;

By formulas (2, 3) we count the successful shots made by the warring parties:α_{jk}= 257 and β_{jl}= 105.

By formula (1) we calculate the probability of firing the enemy target by a general military unit

$$P_k = \frac{257}{257+105}\left(1 - e^{-(257+105)t}\right) = 0{,}71$$

The calculations show that the *k*-unit with available forces and means is able to destroy the enemy target with a probability of 0.71.

Conclusions

Thus, the proposed methodology makes it possible to determine the probability of firing the enemy target by the *k*-unit. Calculations made with the help of this improved methodology can serve as the basis for decision-making for combat actions. Along with this, the improved methodology can be a part of the mathematical model of targeting *k*-units against enemy targets, based on nonlinear programming methods.

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