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RECOMMENDATIONS ON METHODS OF CONDUCTING COMBAT OPERATIONS IN A CONTROLLED ZONE OF AN INTERNAL ARMED CONFLICT BY THE AIRMOBILE DETACHMENT OF THE OPERATIONAL PURPOSE UNIT OF THE NATIONAL GUARD OF UKRAINE

One of the most critical functions of the National Guard of Ukraine units is the suppression of activities by illegal armed formations (groups) not authorized by law, to wit, the localization and cessation of armed conflicts occurring within the territory of Ukraine.

It has been determined that, under the conditions of an internal armed conflict, the peculiarities of the operational and combat tasks of the National Guard of Ukraine are defined by the necessity of deploying specific types of units, such as combat groups and detachments. Traditional methods of detection and neutralization are insufficient to fully resolve the problem of disabling illegal armed formations near the objects under protection. The complete elimination of illegal armed formations requires the involvement of reserves. Under such conditions, the creation of an airmobile detachment as a mobile reserve (amdr) within the operational brigade appears to be the most effective solution.

The optimal composition and rational choice of combat formation for the airmobile reserve of operational brigades of the National Guard of Ukraine have been substantiated. Mathematical models for interception have been developed and proposed for implementation, providing solutions for optimizing the system of protection and defense of objects. A mathematical formulation of the task to optimize the combat formation of the airmobile detachment has also been provided.

Keywords: *illegal armed formations, interception models, combat group, detachment, airmobile detachment, detection and neutralization system.*

Statement of the problem. The issue of neutralizing illegal armed formations (IAFs) near protected objects cannot be fully resolved using detection and neutralization systems alone. While reconnaissance-combat posts can locate the enemy and constrain their actions, complete neutralization requires the deployment of mobile reserves. Therefore, it is advisable to coordinate the actions of mobile reserves. The most effective approach is to utilize units equipped with high-mobility combat vehicles and helicopters. This ensures full control over the situation in the designated area and allows for timely defeat of the enemy before they reach the protected object.

Under such conditions, the creation of an airmobile detachment with reinforcement capabilities within the operational brigade appears to be the most practical solution. In order to save time, helicopters can be used to transport the detachment quickly, as well as to search for and pursue the enemy.

The development of relatively simple mathematical models for various types of interception of IAF would further support this effort by enabling the selection of the most effective methods for conducting combat operations in the controlled zone of an internal armed conflict.

Analysis of recent studies and publications. The experience of military and armed conflicts in recent decades indicates that in modern conditions, the success of military operations is determined not so much by the balance of forces and means of the parties but by the efficiency and ability to practically manage military formations [1, 5].

The specific tasks and forms of operational unit deployment, as well as the unique characteristics of armed conflicts, necessitate the search for new methods and tactical approaches for employing forces and means. The methods of action largely depend on the zone where they are conducted. In studies [2, 3], the combat zone (CZ) is divided into the following zones: zones controlled by the National Guard of Ukraine (CZNGU); zones

controlled by illegal armed formations (CZIAF); and zones uncontrolled by either NGU or IAF (UCZ). The National Guard of Ukraine conducts guarding (conditionally defensive) combat operations in CZNGU and destructive (conditionally offensive) operations in CZIAF. In CZIAF, the IAF also conduct guarding (conditionally defensive) combat operations, while in CZNGU, they engage in guerrilla (conditionally offensive) operations. In UCZ, the adversary carries out specialized combat actions that cannot be classified as purely offensive or defensive. In each battle, offensive or defensive elements are present to varying degrees.

Since the defense by IAF in an armed conflict is likely to be of a localized nature, brigades (units) should be assigned specific areas (zones) where they would operate independently or in coordination with Armed Forces of Ukraine (AFU) units. The primary targets will be the largest and most active enemy groups, followed by groups in remote settlements. Brigade units in such situations may operate on foot, deploying small detachments to outflank and attack the enemy's strongholds from the flanks and rear [6].

Ukrainian military scientists and researchers have devoted significant attention to developing theoretical principles and practical recommendations for military command bodies regarding the forms and tactics of combat use of operational units and methods of conducting operations in zones of internal armed conflict. However, no mathematical analysis or qualitative assessment of the content and influence of information on the outcome of combat operations has been conducted.

The purpose of the article is to develop mathematical models for various types of interception of illegal armed formations and determine the most effective methods for conducting combat operations in controlled zones of internal armed conflict.

Summary of the main material. The primary function of mobile reserves, including the airmobile detachment, is to conduct interceptions [4]. Let us consider mathematical models of interception.

Interception along the direction of movement of IAF. An IAF unit advances in a specific direction, while the *amgr* conducts a covert maneuver to an interception point to neutralize the enemy (Figure 1).

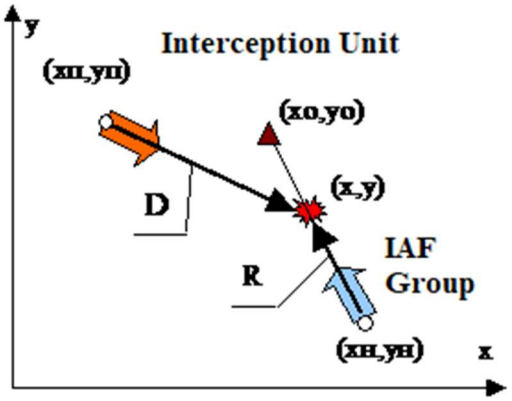

Figure 1 – Interception along the direction of movement

Interception along the direction has two key characteristics: $D(\alpha)$ – the distance between the deployment point of *amgr* and the interception point, which depends on the angle α formed between the direction of movement of the IAF and the line leading to the *amgr*'s deployment point; $D_h(\beta)$ – the displacement of the interception point from the object, which depends on the angle β formed between the direction from which the IAF advances toward the object and the line connecting the *amgr*'s deployment point with the object.

These characteristics are derived by comparing the movement times of the adversaries to the collision point and solving the so-called interception equations $t_p(D, L, R, V_h, \alpha) = t_b(R, V_b)$; $t_{\text{p}}(D_h, R_0, V_h, \beta) = t_b(R_d, D_h, V_b)$ for the unknown parameters D, D_h. These equations are solved as follows:

$$D(\alpha) = \frac{LV_bV_h\cos\alpha - LV_h\sqrt{V_h^2 - V_b^2\sin^2\alpha}}{V_d^2 - V_b^2}, \quad (1)$$

$$D_h(\beta) = \frac{V_h^2R_d - V_b^2R_0\cos\beta - V_h\sqrt{V_b^2L^2 - V_b^2R_0^2\sin^2\beta}}{V_h^2 - V_b^2}. \quad (2)$$

Head-on interception of IAF. An IAF unit moves toward the object to capture or sabotage it, while the *amgr* conducts a covert counter-maneuver to destroy the IAF (Figure 2).

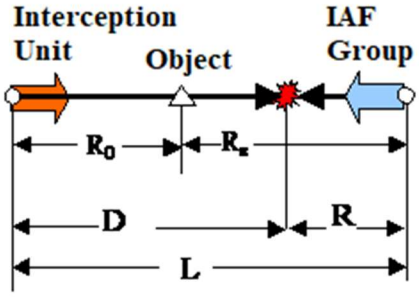

Figure 2 – Head-on interception

The head-on interception of IAF is assessed using the following parameters:

$$D(0) = \frac{LV_h}{V_h+V_b}, D_h(\pi) = \frac{V_h R_d + V_b R_0}{V_h+V_b}. \quad (3)$$

Pursuit interception. An IAF unit moves in a certain direction to exit the controlled zone, while the *amgr* covertly maneuvers to overtake and neutralize it (Figure 3).

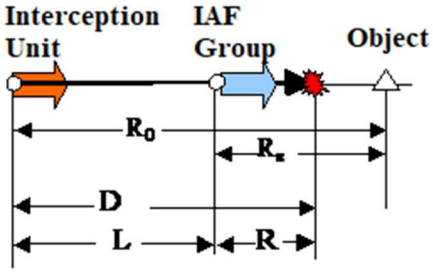

Figure 3 – Pursuit interception

Pursuit interception is assessed using the following parameters:

$$D(\pi) = \frac{LV_h}{V_h-V_b}, D_h(0) = \frac{V_h R_d - V_b R_0}{V_h-V_b}. \quad (4)$$

Interception along the route. An IAF unit moves along a known and clearly defined route, while the *amgr* maneuvers covertly to the interception point along the route to neutralize it (Figure 4).

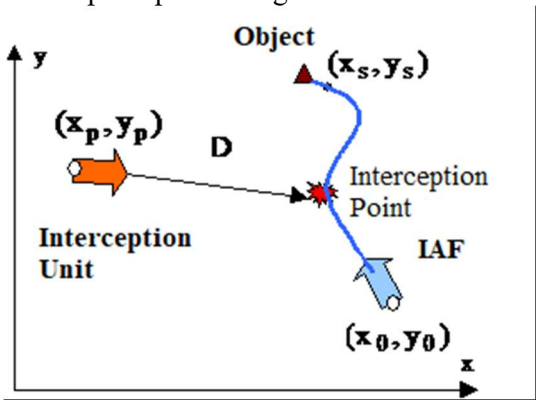

Figure 4 – Interception along the route

Calculating the interception range along the route involves discretizing the route and sequentially locating the interception point.

Open interception. An IAF unit is covertly positioned at a certain point within the CZ, while the *amgr* maneuvers to the adversary's location to to neutralize it. The detection of the IAF and the *amgr*'s movement toward this point to destroy it are immediately known to the enemy, prompting it to make a decisive maneuver to distance itself as much as possible from its previous position.

Interception succeeds if the time it takes the IAF to reach the boundary of the permissible zone is less than time it takes the *amgr* to arrive at the IAF's base location, i.e. $(r_{rpz}/V_b) > (D/V_h)$.

Mathematical models of interception allow solving a number of optimization tasks during the planning and executing the security and defense of objects within the controlled zone of an internal armed conflict.

Determining the required composition of airborne reserve forces. Using the open interception model (Figure 5) and assuming that *amgr*s are distributed evenly in the combat zone with an area of responsibility in the shape of a hexagon (Figure 6), we can demonstrate that M – the number of *amgr*s required for ensuring engagement with an IAF group at any point in the CZ is directly proportional to the ratio of the square of the group's speed during the evasion maneuver to the square of the *amgr*'s speed during its advance to the battlefield:

$$M = \frac{\pi R^2 V_{as}^2}{3 r_{rpz}^2 V^2}, \quad (5)$$

where $V > V_{as} \geq \frac{r_{rpz} V}{R}$; V_{as} – is the average speed of the IAF group; V – is the *amgr*'s speed during interception of the IAF; r_{rpz} – is the radius of the permissible zone in which the IAF group can be detected; r – is the radius of the circle that approximates the CZ.

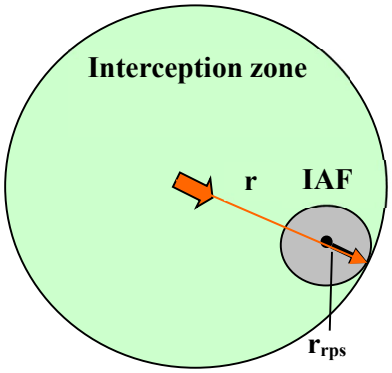

Figure 5 – Open interception model

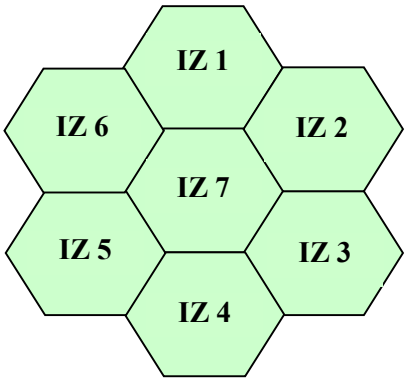

Figure 6 – Interception zones in the CZ

For example, for timely interception of IAF groups on foot within the CZ using IFVs, 278 units are required (the area of the CZ is 7850 km², the radius of the permissible evasion zone r_{rpz} = 1 km). However, three helicopter units with airborne troops can ensure timely interception of an IAF group at any point within this area.

Model for optimizing the combat formation of an airmobile detachment. The effectiveness of interception (Figure 7) depends on various factors, including the following key ones: the distance between the point of deployment of the *amgr* and the object D; the range R_d from the object to the detection line of the IAF; the range R_s from the object to the interception line; the interception speed V_b; the movement speed of the IAF V_h; the direction from which the IAF moves towards the object.

As illustrated in Figure 7, *a*, the interception range can be determined using an interception along the direction of movement model. According to this model, the interception range is calculated by formula (2).

The criterion for interception effectiveness is the fulfillment of the inequality $D_h(\beta) > R_d$, where $D_h(\beta)$ – is the interception range in the a given direction (Figure 7, *b*). If we assume that the direction from which the IAF advances toward the object β, is a random variable, then the probability of interception can be used as an indicator of interception effectiveness $E_h = Lik\{D_h(\beta) \geq r_d\}$. Assuming that the value β is uniformly distributed in the interval [0,2π] we have:

$$E_h = \frac{\beta_2 - \beta_1}{2\pi}, \tag{6}$$

where $\beta_{1,2}$ – are the roots of the equation $D_h(\beta) = R_s$.

This equation with respect to β is solved as follows:

$$\beta_1 = arccos\left(-\frac{r_0^2+1-v_h^2(r_d-1)^2}{2r_0}\right), \beta_2 = arccos\left(\frac{r_0^2+1-v_h^2(r_d-1)^2}{2r_0}\right), \tag{7}$$

where $v_h = V_b/V_h$; $r_0 = R_0/R_s$; $r_d = R_d/R_s$.

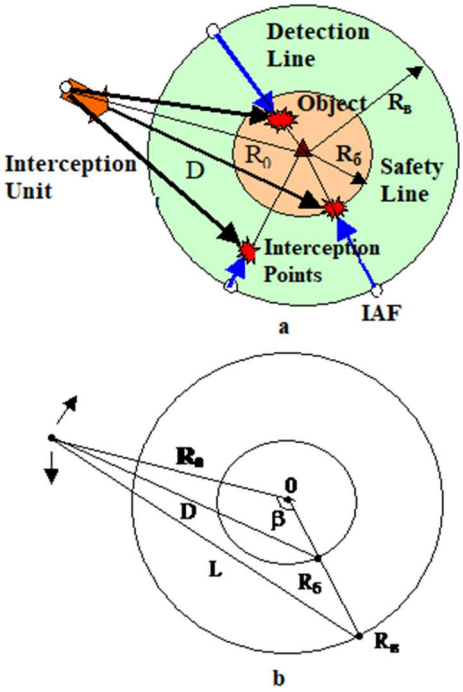

Figure 7 – Interception effectiveness at the line

Let us formulate the task of optimizing the combat formation of the airmobile detachment. Assuming that no more than one interception will be conducted simultaneously within the controlled zone, the expected number of objects preserved through the interception method can be determined by the following ratio:

$$Z(X) = \sum_{j=1}^{n} \max_{i=1}^{n} \{E_{ij} x_i\}, \tag{8}$$

where E_{ij} – is the effectiveness of intercepting the enemy at object *j* by the *amgr* deployed at the object *i*; *n* – is the number of objects requiring protection and defense; x_j = 1, if the *amgr* is deployed at the object *i*; x_j = 0, if object *i* is defended by regular security forces.

The task is to position the *amgr* based on the pre-calculated effectiveness indicators E_{ij} so that the sum of effectiveness values for all objects (i.e., the expected number of preserved objects) would be maximized.

The mathematical formulation of the task is as follows: find a set $X = \{x_i\}$, *i* = 1, 2…, *n*, that maximizes function (8) and satisfies the constraints:

$$\sum_{i=1}^{n} x_i = m, \quad x_i = \{0;1\}, \text{ i=1, 2…, } n. \tag{9}$$

This task is solved using the sequential redistribution method An *amgr* deployed at a certain object is selected and an attempt is made to relocate it to another object. If the value of the objective function (8) increases, then this movement is recorded as successful. Otherwise, another object, not previously analyzed, is selected

for evaluation. The calculation process ends when no further relocations lead to an increase in the objective function. The final *amgr* distribution is considered optimal.

In combating IAF, the presence of an airmobile detachment enables timely responses to intelligence data, thereby reducing the operational range of IAF activities and neutralizing adversary actions swiftly. Given that a single helicopter can independently neutralize an enemy group of 7–15 personnel within an area of up to 5000 km² with a probability of 0.8–0.9, the airmobile detachment in the proposed composition, is capable not only of intercepting individual enemy groups but also of independently neutralizing up to two IAF detachments.

The results of solving the optimization task can be used to justify the appropriate composition of airmobile reserve forces under specific conditions.

Conclusions

The most effective approach for organizing the security and defense of critical objects in a controlled zone of an internal armed conflict is the formation of an airmobile detachment as a mobile reserve within the operational brigade. The airmobile detachment consists of airmobile combat groups. A mathematical formalization of the task to determine the optimal composition and rational combat formation of the airmobile detachment has been developed.

The primary function of the airmobile detachment is interception. Mathematical models of interception have been developed, enabling the resolution of various optimization tasks during the planning and execution of security and defense operations for objects in the controlled zone of conflict.

Additionally, a mathematical model for optimizing the combat formation of the airmobile detachment has been developed, which serves as a basis for determining the composition of airmobile reserve forces under specific conditions.

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РЕКОМЕНДАЦІЇ ЩОДО СПОСОБІВ ВЕДЕННЯ БОЙОВИХ ДІЙ У КОНТРОЛЬОВАНІЙ ЗОНІ ВНУТРІШНЬОГО ЗБРОЙНОГО КОНФЛІКТУ АЕРОМОБІЛЬНОГО ЗАГОНУ ВІЙСЬКОВОЇ ЧАСТИНИ ОПЕРАТИВНОГО ПРИЗНАЧЕННЯ НАЦІОНАЛЬНОЇ ГВАРДІЇ УКРАЇНИ

Обґрунтовано доцільний склад і раціональний вибір бойового порядку аеромобільного резерву бригад оперативного призначення Національної гвардії України. Розроблено й запропоновано до використання математичні моделі перехоплення, із застосуванням яких вирішуються завдання оптимізації у побудові системи охорони й оборони об'єктів. Надано математичне формулювання завдання оптимізації бойового порядку аеромобільного загону.

Однією з найважливіших функцій частин Національної гвардії України є припинення діяльності не передбачених законом незаконних збройних формувань (груп), тобто локалізація та припинення збройних конфліктів, розв'язаних на території України.

На частини і з'єднання Національної гвардії України, які беруть участь у припиненні конфлікту, покладаються завдання, що умовно можна поділити на три групи: охорона й оборона об'єктів у районі конфлікту; забезпечення охорони громадського порядку і суспільної безпеки; локалізація та припинення збройних конфліктів, розв'язаних на території країни.

Визначено, що в умовах внутрішнього збройного конфлікту особливість службово-бойових завдань Національної гвардії України зумовлена необхідністю поряд із класичними (відділення, взвод, рота, батальйон) застосовувати такі види підрозділів, як бойова група, загін.

У багатьох арміях світу бойова група є найменшим позаштатним військовим формуванням у складі механізованого відділення, котре не має штатного командира. Загін як постійне або тимчасове військове формування створюється для виконання бойового чи спеціального завдання. У нашому випадку це може бути тимчасове об'єднання кількох бойових груп у загін, який під єдиним командуванням і за єдиним планом виконує спеціальне бойове завдання.

Відомо, що під час організації охорони й оборони важливих об'єктів у контрольованій зоні внутрішнього збройного конфлікту створюється система виявлення та ураження, яка включає контроль за проникненням порушників на територію, що охороняється, і оповіщення про них варти (охорони): дальній рубіж виявлення, контроль за місцевістю з метою виявлення місцезнаходження незаконного збройного формування, напрямки руху і їх знешкодження.

За допомогою традиційних способів виявлення та ураження неможливо цілком вирішити проблему знешкодження незаконних збройних формувань поблизу об'єктів, що охороняються. Діями постів технічного спостереження і розвідувально-бойових постів можна знайти противника, скувати його дії, однак повна ліквідація потребуватиме залучення резервів. У таких умовах найприйнятнішим вбачається створення у складі бригади оперативного призначення аеромобільного загону як мобільного резерву (амзр).

Ключові слова: *незаконні збройні формування, моделі перехоплення, бойова група, загін, аеромобільний загін, система виявлення і ураження.*

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