OPTIMAL MANAGEMENT OF THE APPLICATION OF A GROUP OF UNMANNED AERIAL VEHICLES (UAVs) OF THE SAME TYPE TO DIFFERENT TARGETS

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In the article, a mathematical modeling method is applied to solving the combat activities of cumulative, thermobaric and fragmentation missiles used by a group of unmanned aerial vehicles against tanks (armored combat vehicles), air defense equipment, infantry group, and long-term firing point targets under favorable and unfavorable conditions. The results show the possible to determine the minimum and maximum number of destroyed targets. These results can be used in the optimal management of the combat activities of a group of unmanned aerial vehicles of the same type.

Key words: *group of unmanned aerial vehicles of the same type, different targets, mathematical modeling, optimal management.*

1. INTRODUCTION

The 21st century is called the age of technology, and it is developing rapidly. Its influence covers all fields and has had its effect on UAV technology as well. Currently, UAVs are widely used in various fields and it creates great opportunities. In addition to UAVs used in the civil field, various purpose strike, intelligence and multi-purpose UAVs are used in the military [1]. UAVs are made on the basis of high technologies. Elements of artificial intelligence and software ensure that UAVs belong to the category of high-precision weapons. The capabilities of UAVs exceed the results achieved by human labor several times. By staying in the air for a long time, UAVs facilitate the acquisition of any information and decision-making for the command that plans and directs combat operations. The destruction of the enemy provides a great advantage over the opponent by detecting the targets that are considered necessary and striking at the right time.

During the last ten years, the dynamics of the use of UAVs during combat activities has been increasing

according to a positive trend. UAVs, which are individually involved in the execution of ordinary tasks, are currently widely used on a massive scale. By performing various combat tasks, they reduce the loss of personnel, thereby ensuring that an advantage over the opponent is obtained in a short time. At present, armies equipped with modern UAVs directly consider the advantage gained by their application according to the tactical situations and possible scenarios that have arisen in various types of combat. UAVs, being applied in the most complex conditions, can influence the development scenario of combat activity and direct it in the direction that suits us. Well-known military experts study the results of the Second Karabakh War, in which UAVs were widely used by various types of troops, and anti-terrorist operations conducted by the Turkish Armed Forces in northern Syria and Iraq. The combat use of UAVs in the Russian-Ukrainian war maintains its relevance. In the Russian-Ukrainian war, UAVs hit military facilities as well as more important infrastructure facilities (power plants, transformers, water pumps, etc.). Wars conducted with the use of new generation high-precision weapons require its detailed study. The main goal is to plan various scenarios of the effective application of UAVs and their mathematical modeling methods is to solve using By applying the mathematical model, we facilitate the solution of such issues in the future, as well as the work of commanders and staffs planning combat operations.

2. APPLICATION OF A GROUP OF UNMANNED AERIAL VEHICLES OF THE SAME TYPE TO DIFFERENT TARGETS

In the armies of the developed countries of the world the production of UAVs and their use in combat conditions is highly preferred. These countries include the United States, Great Britain, Germany, France, the People's Republic of China and Israel. The UAVs produced by them are used in local wars and internal armed conflicts. However, the UAVs produced by the Turkish Defense Industry and the "Baykar" company have achieved great success in this direction in the last ten years. The same type of reconnaissance and strike drones were widely used in the anti-terrorist operations in Libya, Syria and northern Iraq, and in the Second Karabakh War. In some cases, military experts call this war a war won by the use of UAVs. Because the recent widespread use of UAVs has forced many countries to revise their military doctrine and military concept. Currently, UAVs are widely used in the Russian-Ukrainian war. The results obtained by the application of the group of unmanned aerial vehicles are in the focus of attention of military experts. In new-generation wars, the use of UAVs is preferred when one of

the sides does not have obvious success in ground operations. In modern wars, UAVs are considered as one of the main combat power elements. Analyzing and studying the results of wars, the armies of the developed countries of the world study the possibilities of fighting against UAVs and determine the tactics that meet the requirements.

A group of UAVs of the same type perform different tasks and are used against different targets. At this time, the targets destroyed in the offensive battle and the targets destroyed in the defensive battle differ according to their variety and importance.

It is known that the same type of drones under consideration carry four missiles per flight. It has cumulative, thermobaric and fragmentation missiles. Depending on the combat task being carried out and the nature of the targets planned to be destroyed, the command decides how many UAVs from the group of UAVs of the same type will be engaged and what type of missile they will be equipped with before their flight. Cumulative missiles are aimed at armored targets, fragmentation missiles at infantry and lightly armored targets, and thermobaric missiles at long-range firing points, elements of fortified areas, etc. Being applied. If we look at the Russian-Ukrainian war, we see that the list of targets destroyed by the use of UAVs is much wider. Energy blocks, electric power sources, water pumping stations, food supply blocks, etc., which ensure the life activity of residential areas. includes. The possibilities of using UAVs in a wide range require the commander and headquarters to study their capabilities and application in detail, taking into account the tactical situation and the development scenario of activities during the planning and conduct of combat activities. In the event that the enemy's armored fighting techniques prevail, it is considered appropriate to strike with thermobaric missiles in the event that the enemy is preparing for a long-term defense. At this time, the UAVs are equipped with missiles according to the nature of the target, which is destroyed before the execution of the task. These activities are mostly carried out at the tactical and operational level. Different approaches to the application of IEDs are possible within the framework of activities in residential areas and in the depth of defense. First of all, the factors that hinder their application should be taken into account and favorable conditions for their application should be provided. At this time, one of the main conditions is gaining superiority in the air. Achieving air superiority requires, first of all, the destruction of air defense and air attack means in interaction with other means of destruction. Once this is achieved, UAVs can easily support formations involved in ground operations. According to the tactical episodes of the scenario of combat operations, the UAVs take into account the importance of the targets and destroy

them sequentially. At this time, possible scenarios obtained by the effective application of UAVs can be determined. Typical problems with the application of UAVs include:
technologically superior enemy forces that can be an obstacle to the use of UAVs (application of air defense means, especially in interaction with Radio Electronic Combat means);

- stable defense of the airspace and superiority on the side of the enemy;

- Protection of various types of targets destroyed by the application of UAVs using all natural and artificial means (creating a thick smoke and aerosol curtain by burning tires due to air defense equipment means and artificial means);

- of UAV (dense fog, strong wind, etc.).

- obtaining certain information about how combat activities will turn out in advance.

3. INVESTIGATION OF THE APPLICATION OF A GROUP OF UNMANNED AERIAL VEHICLES OF THE SAME TYPE TO DIFFERENT TARGETS

A strike group consisting of a number of UAVs armed with a group of unmanned aerial vehicles of the same type $M$was created. The combat kit $m_1$of each UAVs includes number A_1, $m_2$number A_2 and includes m_m a number A_m of types of missiles. $k_1$number of H_1, k_2 number of H_2 and etc. has k_n number of H_n different goals. It is considered an urgent issue to pre-investigate the possibility of applying the anti-aircraft strike group against various targets in favorable and unfavorable conditions (table 1).

Table 1. Efficiency coefficients of the application of the unmanned aerial vehicle to various targets

Serial no	Unmanned aerial vehicle the means of fire he used	Under favorable conditions				In unfavorable conditions			
		H_1	H_2	...	H_n	H_1	H_2	...	H_n
1	A_1	p_{11}	p_{12}	...	p_{1n}	p_{11}	p_{12}	...	p_{1n}
2	A_2	p_{21}	p_{22}	...	p_{2n}	p_{21}	p_{22}	...	p_{2n}
...	...	...	...	...	...	...	...	...	...
m	A_m	p_{m1}	p_{m2}	...	p_{mn}	p_{m1}	p_{m2}	...	p_{mn}

Let's assume that the UAV $m$uses a number of different means of fire as a

means of fire, during combat operations against a number of different targets.n

x_{ij}- is the number of destroyed targets of the j −th type with the i- th missile

p_{ij} - are the efficiency coefficients of the application of the i- th missile to j th the type h_j target.

Then $p_{ij}.x_{ij}$ − the average value of the result expected from the application of the i- is missile to the target $j-$ th of type h_j. Average value of targets destroyed if used during combat operations against all different m numbers of missiles with different numbers of targets n

$$MH(x) = \sum_{i=1}^{n}\sum_{j=1}^{m} p_{ij}\, x_{ij}$$

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The function $MH(x)$ the average number of destroyed targets during combat operations to against different targets n of missiles m means. This is the objective function of the problem.

Then it is required to find the optimal option so the at the maximum number of targets is hit. At the same time, it would be interesting to hit the minimum number of targets according to the most unfavorable situation. According to the given situation, the mathematical model of the problem is as follows:

The objective function

$$MH(x) = \sum_{i=1}^{m}\sum_{j=1}^{n} p_{ij}\, x_{ij} \rightarrow \max(min) \qquad (1)$$

Conditions of limitation

$$\sum_{j=1}^{n} x_{ij} = a_i, \qquad i = 1, 2, \dots, m \qquad (2)$$

$$\sum_{i=1}^{m} x_{ij} = b_j, \qquad j = 1, 2, \dots, n \qquad (3)$$

$$x_{ij} \geq 0 \qquad (4)$$

here

a_i- $i$type of means of destruction,

b_j and - $j$is the number of type -th target.

Suppose that p_{ij} values $i = 1, 2, \dots, m;\ j = 1, 2, \dots, n$ are of the efficiency coefficients, a_i - destruction and b_j – targets are given.

The above data, solving problems (1) - (4) in favorable and unfavorable conditions x_{ij}, $i = 1, 2, \dots, m;\ j = 1, 2, \dots, n$ is possible to find the smallest and largest values of the function $MH(x)$ of the number of destroyed targets[3, 4, 5].

4. THE RESULT

Based on the results obtained in this way, the minimum and maximum number of targets destroyed during combat operations with missiles of the same type of UAVs group against targets such as tanks (armored targets), air defense equipment, infantry group, long-range firing point in favorable and unfavorable conditions. Before starting their activities can be determined in advance.

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