TARGETING A ROCKET AT A MOVING OBJECT USING UNMANNED AERIAL VEHICALS (UAVs)

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This article discusses the evolving nature of modern warfare, emphasizing the shift towards, autonomous weapons and artificial intelligence-driven military operations. İt underscores the importance of high-tech combat vehicles, the need for constant improvements in military capabilities, and the role of well-trained units in achieving victory such as the Second Karabakh War and the Russian-Ukraine War. The article particularly focuses on the secure transportation of military personnel in warzones and the challenges associated with it. It highlights the use of unmanned aerial vehicles (UAVs) for constant observation, reconnaissance, and directing artillery missiles to enhance the safety of personnel during transport. The main research objective is to solve mathematically the problem of directing unguided rockets to destroy enemy vehicles in motion. The article presents a mathematical model for this purpose, taking into account various factors such as coordinates, speed, and trajectory of enemy vehicles. It also discusses the practical applications of this model in military scenarios. İn conclusion, the article emphasizes the significance of technologies advancements, especially in the use of UAVs and guided artillery projectiles, in modern warfare. İt offers a mathematical approach to targeting moving enemy vehicles, contributing to the development of military tactics and strategies.

***Key words*:** *Unmanned aerial vehicles, armored vehicles, movement trajectory, artillery shell, combat weapons*

1. INTRODUCTION

Modern wars are waged involving few personnel upgraded combat vehicles requiring state of art technology. However, in the future wars occur between autonomous weapons or distant command weapons functioning with artificial intelligence [1-3]. In those battles in which artificial intelligence or distant command unmanned aerial vehicles and weapon systems perform,

technological advantages will come forward, more rapid and accurate information delivery will be possible between command control centers and decision makers [4-7]. Accordingly, throughout the, modern battles the number of damaging vehicles are widely so constant improvements and fighting qualities of these vehicles lead to high accuracy, increasing the distance and damaging effect. Meanwhile all these factors truly provide combat opportunities of damaging vehicles, whole army and military units. Battles and military confrontations usually tend to reflect themselves in more dynamic and frequently changing conditions. Modern wars mostly stand out with their determination, high maneuverability and tension as well as new combat strategies. In the course of battles and military operations, the application of ordinary, but modern damaging vehicles manage to arise deep chaos among enemy troops within a short period of time. Research it is doubtlessly possible to carry out the combat mission in scheduled time and without having casualties by coordinating all artillery fires. Despite this, in order to perform this task the most essential condition to consider is the artillery units must have high combat readiness and benefit from up to date technologies.

Second Karabakh War and Russian-Ukrainian War proved the presence of well-trained units the key of victory. Moreover the secure transportation of this military personnel between warzones is the most crucial and trouble-making issue. While the progress of the wars we realize the battles a portion of military personnel become victim while being transported. According to this figure covers 10 to 20 percent of total personnel. In this regard, massive application of unmanned aerial vehicles in military operation zones guarantees the constant observation of these relocating vehicles, acquiring reconnaissance information, directing artillery missiles and fire impact on these regions [8, p.231].

It has to be emphasized that by hiring up to date unmanned aerial vehicles and other scout tools to find the solution of military based geoinformation systems, scanning the territory and exposing the covered objects, locating the coordinates of certain objects, besides guiding the rockets and artillery shells towards the target and so on [9-15].

As it has been displayed, until the recent combat tactics the field of activity for attacking combat units is supposed to be out of the area as they could be hit by enemy artillery troops. This operation field has to be 8 to 10 kilometers away from the defensive line of the enemy whereas small attacking units can be distance of 4-5 kilometers from the enemy troops. Considering this decreasing figure, firing positions are arranged behind natural cliffs and hills [16, p. 132].

However, application of innovative unmanned aerial vehicles and reconnaissance, approaching in

extensive units, detachments or platoons can be quite risky, even fatal.

Additionally, one of the further capabilities of unmanned aerial vehicles is directing the GPS-based missiles and mines towards certain targets [17, p.7; 18, p.373]. There is a military truck carrying roughly 20-30 enemy personnel coming close to the border, obviously this vehicle has to be shot down immediately. Annihilating the armored vehicles belonging to enemy troops is counted the best way to disrupt their plans.

In the article detecting what speed enemy vehicles are moving at, where they are exactly located depend on the plan of the enemies, terrain features, calculating predictable moving trajectory of enemy vehicles and considering the straight flight of unguided missiles, how to direct this missile to the target widely described.

The essential purpose of this research is to mathematically solve the matter of how to destroy enemy machines by directing unguided rocket. Practically an unguided missile to the target in motion is the scientific innovation of this report. Result of the research mathematical solution how to eliminate the enemy vehicles by using a rocket.

1.1. The mathematical model of how to guide an artillery shell to the target

The essence of the matter. It is believed that enemy vehicle is detected in certain amount of time, and the immediate coordinates and speed of it are determined accordingly [2]. Additionally, it is supposed that taking into account combat itinerary and terrain features the calculation of predictable movement of enemy vehicles is possible. This trajectory can be designed in the spline model [19-21].

It is strongly demanded that with the purpose of hitting the enemy vehicle the flying course and distance to the target have to be determined.

Being sure about the straight flight of the unguided rocket the movement of the target on the ground or terrain may not be as necessary compared to the flight height of the rocket. Alternatively directing an unguided rocket to any target can be, conducted with claim coordinates.

1.2. Mathematical formalization of the issue

If you intend to develop the mathematical model of the matter, you have to include Oxy rectangular coordinate system. You are supposed to arrange this coordinate system in a such way that the beginning of it coincide the region where the enemy vehicles assemble. The axis 0y should be aimed to the North (Fig.1).

Let's imagine any enemy vehicle has been detected in any t_0 moment and this vehicle is rushing towards the area where the coordinates begin. It is believed that the speed as well as the moving trajectory of it according to its combat task, terrain features and Oxy coordinate system has been computed. Depending on the time $t \geq t_0$, let's

mark the moving trajectory as $(x_1(t); y_1(t))$. Apparently, $x_1(t)$ və $y_1(t)$ functions will be counted as stable functions. Moreover, we are likely to think the function $y_1 = y_1(x_1)$ is monotone.

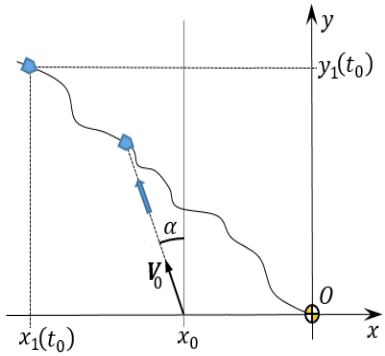

Fig.1 Scheme of movement of enemy vehicle

In order to simplify the matter the vehicle receiving reconnaissance data about enemy vehicle is positioning on certain points like $(x_0; 0), |x_0| \leq |x_1(t_0)|$ along the line of $\{y = 0\}$. If it is marked the speed of launched rocket with V_0 and possible azimuth angle of it with α. If it is defined – the angle that falls between north direction of the meridian and given direction is called azimuth and it is measured with clockwise direction. The figure of azimuth changes between 0 and 360 degree. The angle measured basing on an actual meridian is called the actual azimuth (A). The angle measured for magnit meridian is titled magnit azimuth (A_m), whereas the angle measured starting from the ask meridian is called steering angle (Fig.2) [22, p. 60].

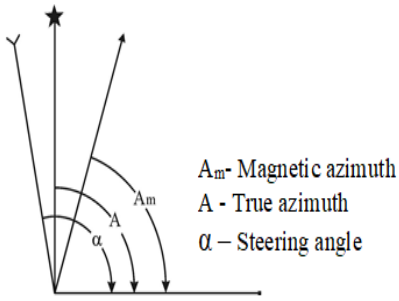

Fig.2 Direction angles

The matter directing and unguided rocket to enemy vehicles can be defined as below:

– Following spending some time to process, the received data during the period of t_1 and artillery shell is launched to annihilate the enemy vehicle. We are supposed to find such t_2 moment and α angle, the rocket launched at the moment of t_1 has to unite with the enemy vehicle at the moment of t_2.

Problem solving: Taking into account all mentioned above the formulas of the moving rocket may be written as below:

$$\begin{cases} x(t) = x_0 + V_0 \cdot \sin\alpha \cdot (t - t_1), \\ y(t) = V_0 \cdot \cos\alpha \cdot (t - t_1). \end{cases} \quad (1)$$

The condition of how a rocket reaches enemy vehicle should be described as below:

$$\begin{cases} x_1(t_2) - x_0 = V_0 \cdot \sin\alpha \cdot (t_2 - t_1). \\ y_1(t_2) = V_0 \cdot \cos\alpha \cdot (t_2 - t_1). \end{cases} \quad (2)$$

If we square up the equations and add them according to the t_2 we may infer this equation:

$$(x_1(t_2) - x_0)^2 + y_1^2(t_2) - V_0^2(t_2 - t_1)^2 = 0. \quad (3)$$

It is illustrate that for during of the short time indicator $x_1(t)$ or $y_1(t)$ functions are stable. We can localize the possible solutions of the equation and solve it with the help of dichotomy [23, p.190,197].

Consequently, one or several numbers can be found for t_2. Our mission is to select top number among figures. Following this α angle from equation system can be calculated as below.

$$\alpha = \text{arctg}\frac{x_1(t_2) - x_0}{y_1(t_2)}. \quad (4)$$

The way of inhillation of the enemy vehicle which is detected immediate coordinates and moving speed of it have been determined as well as how to solve it, all this mentioned stuff has been presented in the essence of the matter. By benefiting from this equation it is possible to destroy the combat column of the enemy troops containing armored vehicles.

1.3. Some aspects of shooting casualties to columns

As a principal shooting casualties colomns are performed in order to block or decelerate the movement of them. With the purpose of correcting the fires and reconnaissance of the columns radiolocation station named SNAR, quantum range finder and helicopter are involved this task.

The whole division is mobilized to fire at infantry, an automobile column in the size of 700 meter leng. Meanwhile, a column itself is considered a target point. In case the column is long, several divisions are mobilized. Thereby, one of the divisions performs fire to the front enemy column. The fires of the rest division have to be splitted along the enemy columns in a such way the distance between two target points of the division should not be more than 700 meters. As long as firing at the enemy columns containing tanks, self-propelled howitzers and other vehicles. Two divisions equipped with 100 mm and other heavier howitzers are also involved into this operation.

To fire at columns some combat preparations are held beforehand. In order to achieve this goal division commander attempts to locate the possible routes of the enemy vehicles on the map. And all these routes are drawn on a tablet by the chief of radiolocation station.

On marked movement routes the commander of division teams up with the chief of radiolocation station, they start to mark passages and bridges,

narrow slopes, road intersections as meeting points. If the movement of the enemy column doesn't coincide with any route, the movement routes and the meeting points of it are determined according to the results of cuts.

The data for casualty shot is determined with full preparation method or by referring to the information gathered by an experiemental howitzer. During the fire preparation against the pre-recorded routes if the condition is suitable. The indicators for casualty shots are experimented one by one [24, p.153-155].

The loss of columns are held with frequent combat raids. If it is uncovered that the enemy column has suspended after the fire raid we can possibly proceed the raids by correcting some indicators. While the column is in motion new fires get prepared for further meeting points. And eventually fire attack is successfully carried out. In this case while shooting at the initial targets some lateral deviations are noted.

The division carries out the shooting at enemy column with a scale equalling to 100 meters. Whereas regardless the moving direction of the column there is fifteen meters distance two range fans [24, p.153-155].

Besides this, to destroy the armored targets and military bases with just a single shot 152 mm and 155 mm howitzers with reactive engines, the artillery ammunition with accuracy named Krasnopol are widely used [25].

The flight of an artillery projectile towards the target is carried out with aerodynamics surfaces depending on lasers. If you want to extend fire range of the shell you have to take an advantage of reactive engine and gas generator. Highly developed aerodynamic surfaces guarantee the planning of targets. It extends fire range of the shell and diminish the height. During the usage of this ammunition we may get great outcomes from the application of unmanned aerial vehicles. Having the top starting speed, big size warhead, low price make this ammunition absolutely different from rockets.

2. CONCLUSION

Unmanned Aerial Vehicles are used as a tool in order to conduct reconnaissance damage by fire and coordinate artillery strikes. It led to some changes related to combat tactics and established a unique innovation in terms of running large-scale battles. Consequently, the combat tactics involving UAVs considerably vary from any ordinary combat tasks. This difference reflects itself in the scale of war, the combat capability of enemy, as well as battles in hard terrain. Obviously, economical issues are as important as a human factor. The application of UAVs in military operations requires great deal of budget. Meanwhile by using unguided artillery projectiles and

estimating the data accurately we can possibly hit the targets.

The mathematical approach proposed above provides a possibility of how to direct an unguided projectile to moving targets or a column of enemy troops. It lets to build the mathematical model and algorithm of it.

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