INCREASING THE AIR DEFENSE CAPACITY BASED ON THE IMPLEMENTATION OF THE MODERN AIR DEFENSE MISSILES

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***Abstract**: The main objective of all air defense systems is to ensure the protection of the national territory, by carrying out its research having in the foreground the following goals:*

- air threats detection;
- identification and tracking of air targets;
- destruction of air targets.

The present case study focuses on the possibility of improving the air defense capabilities by implementing modern anti-aircraft missile systems and by adapting contemporary combat tactics. The obtained results are sustained by their Matlab simulations.

***Keywords**: air defense systems, air threats detection, air defense capabilities, Matlab simulations.*

Introduction

Due to the necessity to respect the conditions characteristic of the interarm operations corresponding to the alliances under whose directives we act, the authors decided to present in this case study the improvement of the air defense capability by implementing the Patriot PAC-3 system and by adapting to it the specific combat tactics.

In order to highlight the difference in defense capability depending on the system used to fight the targets and the combat tactics adopted, we organized operating groups of two anti-aircraft missile systems, each group acting according to a predetermined scenario.

The CA-94 antiaircraft missile complex is included in the composition of each task force to ensure the immediate defense of the target in the event of a surprise attack or at very low heights. The second component of each operating group is one of the "OSA-AKM", "KUB" or "Patriot" systems.

To project the appropriate scenario for each task force, we used the MatLab program, through which we performed the mathematical simulation of the missile trajectories and the target route. We think that comparing the results of the operating groups shows both the strengths of the complexes and their operational deficiencies, which are particularly important in the process of highlighting the improvement of the air defense capability.

In order to be able to perform the simulation itself, we have developed an algorithm, through which the continuous calculation of the target and missile coordinates is performed in order to choose the appropriate launch time and to follow the evolution of the target flight, the approach of the target missile and the meeting.

All of these will be detailed in the paper sections, being sustained by their corresponding Matlab simulations.The advantages of using the modern anti-aircraft missile systems will be clearly highlighted in this way.

The air defense system including CA-94 and OSA-AKM systems

To achieve the first scenario we assumed the following situation: There is information that the objective "Nest" (the reference point of the system) of coordinates $\boldsymbol{x = 0}\,;\boldsymbol{y = 0}$ is to be attacked. The enemy aircraft that is to execute the air attack is the "Sea Harrie" fighter aircraft with a maximum evolution speed of 550 m/s.

The first task force chosen for the action to combat the air threat is formed by the CA-94 and OSA-AKM systems. The result of the scenario scrutiny reflects the level of effectiveness of the task force. The data used in this simulation represent the maximum capacities or which are close to the maximum.

The input information is as follows:

- Maximum target discovery distance: 20000 m;
- The maximum distance at which the target can be fought: 10500 m;
- Maximum missile flight speed: 400 m/s;
- Initial target flight speed: 200m/s;
- Maximum missile flight time: 28 s.

Considering that through the process of illuminating the target, the position and intention of the operating group were revealed and that the altitude and speed of the target are variable, we have performed the following simulation:

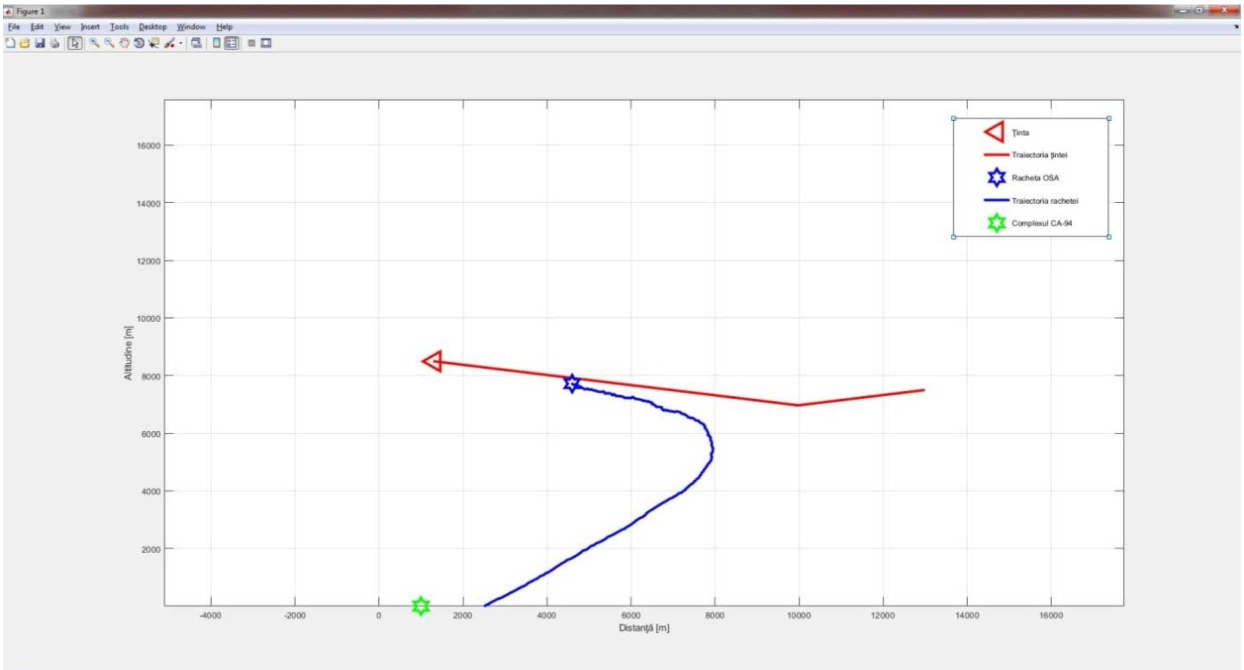

Fig. 1: OSA-AKM_CA-94 Task Force Result

The missile trajectory launched by the OSA-AKM system is represented in blue, the position of the CA-94 complex is represented in green, and the red trace is the trajectory of the target aircraft.

The above graph simulates a tactical situation with the role of testing the effectiveness of the CA-94 and OSA-AKM systems. As we specified, the illumination process led to a rapid discovery of the operating group, at which point the target executed an element of maneuver and suddenly changed its direction and speed. The fact that the capture of the enemy was inefficient, led to the loss of the target and thus to the diminution of the air defense capability.

The air defense system including CA-94 and KUB systems

The second operating group that we chose to submit to the script using the MatLab software, consists of the CA-94 and KUB systems. For the second simulation, the maximum and initial data are different from those used for the previous simulation.

The input information is as follows:

- Maximum target discovery distance: 40,000 m;
- The maximum distance at which the target can be fought: 20,000 m;
- Maximum speed of the KUB missile: 750 m/s;
- Maximum flight speed of the A-94 missile: 250 m/s;
- Initial target flight speed: 200 m/s;
- The maximum flight time of the KUB missile: 24 s.
- The maximum flight time of the missile A-94: 14 s.

On the same principle as in the previous case, we consider that through the process of illuminating the target, the position and intention of the operating group were revealed.

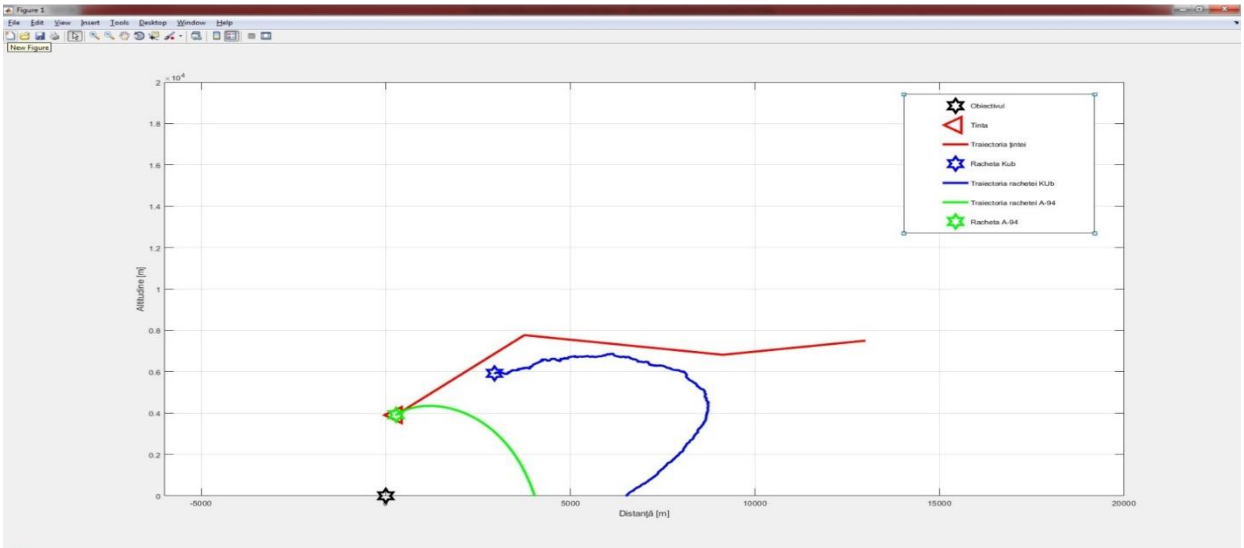

Fig. 2: The result of the operating group KUB_CA-94

The missile trajectory launched by the KUB system is represented by the blue trace, the missile trajectory launched by the CA-94 system is represented by the green curve, the position of the main objective is the black point and the trajectory of the aerial target is represented in red color.

As in the previous case, following the target illumination, the position of the operating group was discovered, following a series of maneuvers carried out by the target (figure 2) in order to avoid being intercepted and to fulfill its mission. The difference is that this time, in an attempt to reach the target, the target was destroyed by CA-94 complex. In the first phase, the target flies at a speed of 200 m/s until the operating group is discovered, when it suddenly changes direction and increases its speed. The missile launched by the KUB complex could not intercept the target due to the sudden change of parameters. In the second phase, in order to be able to execute the maneuvers necessary to hit the target, the aircraft reduces the flight speed and tries to get as close to the target as possible for a more precise destroying effect. Once entered into the area of CA-94 complex action, the plane is taken to accompany and fought.

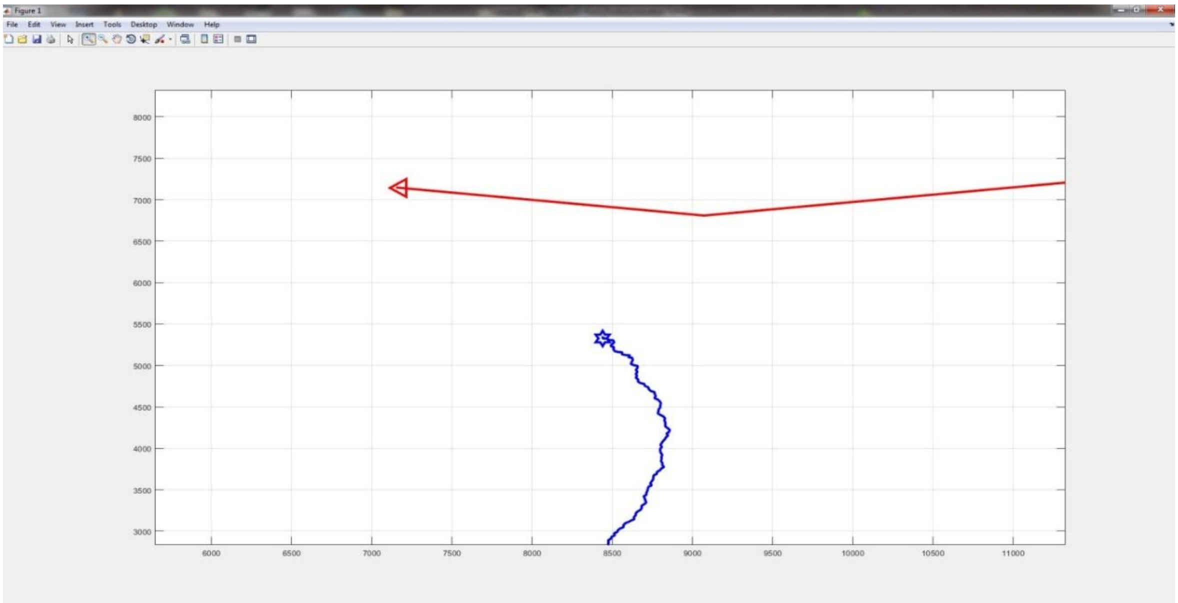

Fig. 3: Destabilization of the missile path

The graph above shows the effects after the target maneuvered in altitude and speed. One can easily see the destabilization of the missile on the trajectory.

The air defense system including CA-94 and Patriot systems

As opposed to the two previous cases, the third operating group has one of the most modern anti-aircraft defense systems, namely the Patriot system. In the next simulation we will be able to observe the degree of improvement of the air defense capability by implementing modern anti-aircraft missile systems.
The input information is as follows:

- Maximum target discovery distance: 60 km;
- The maximum distance at which the target can be fought: 40km;
- Maximum flight speed of the PAC-3 rocket: 1200m/s;
- Maximum flight speed of the A-94 rocket: 250 m/s;
- Initial target flight speed: 200m/s;
- The maximum flight time of the missile A-94: 14 s.

Fig. 4: The result of the Patriot_CA-94 Task Force

The path of the missile launched by the Patriot system is represented by the blue color, the trajectory of the missile launched by the CA-94 system is represented in green, the position of the objective is the black point, the trajectory of the aerial target is represented by the red curve and the purple represents the explosive charge with the infrared fingerprint.

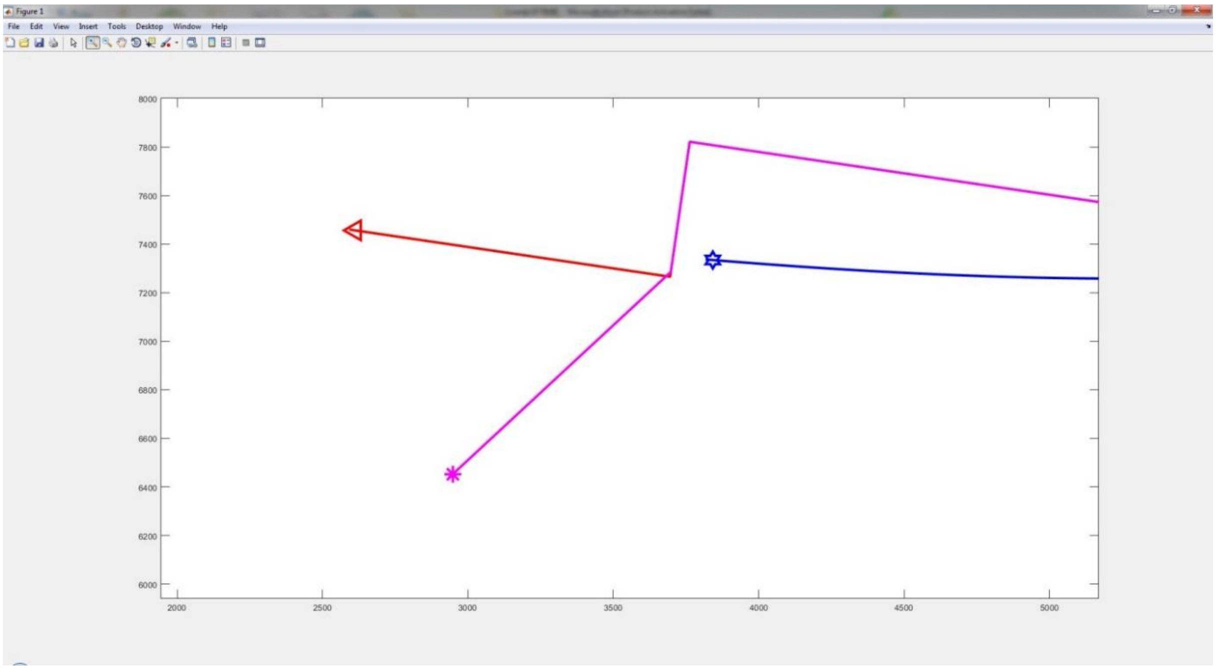

Fig. 5: Launch of the explosive charge

The above graph shows the clear difference in efficiency between the last operating group, the main component of which being the Patriot complex and the other two. In this case, the Patriot complex keeps pace with the sudden change of the target parameters (figure 4) and manages to fight it, but not before the target launches an explosive charge with an infrared fingerprint (figure 5). Even so, the defended target is not jeopardized because the A-94 missile launched by the CA-94 complex intercepts this load and destroys it.

Although the target is changing direction, the Patriot missile does not undergo trajectory destabilization, so it continues to track the target till intercepting it, as shown in figure 6.
According to this chart, the Patriot missile maintains its stable trajectory (blue color) during the maneuvers of launching the explosive charge.

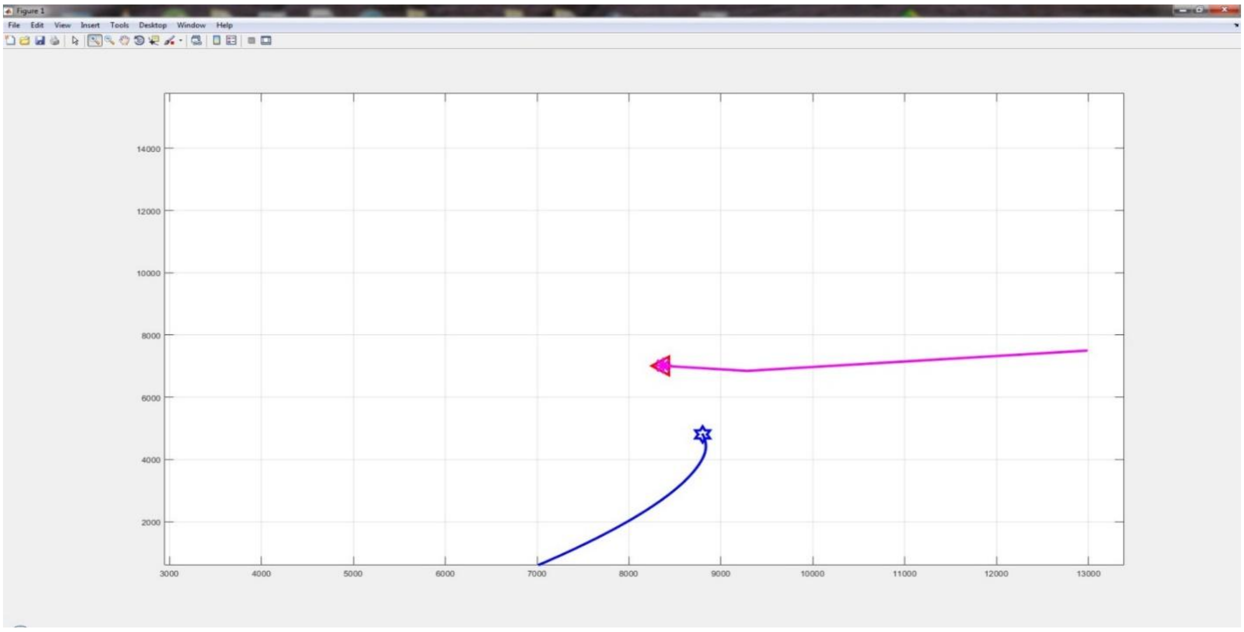

Fig. 6: Maintaining the stability of the Patriot missile trajectory

Conclusions

The following comparative analysis completes this study and highlights the anti-aircraft defense capability characteristic of modern systems.

First of all, the modernization of anti-aircraft defense systems oscillates around the electronic warfare field, so the Patriot system is able to withstand a variety of active and passive jams, while older systems like KUB or OSA-AKM systems are vulnerable to jam resistance.

Secondly, the range of air threats that a complex can combat can play a particularly important role in assessing air defense capabilities. In this case, the Patriot complex is again above the other systems, being able to combat both supersonic targets and ballistic missiles.

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