10.53477/2284-9378-21-42

CONSIDERATIONS ON THE DESIGN OF THE AIR DEFENCE RESPONSE IN THE CURRENT AIRSPACE

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The unprecedented technological development in the field of weapons and ammunition used in the airspace, at low and very low altitudes, is one of the major challenges that the traditional air defense systems have to face. To this end, the military specialists of the modern armies pay special attention to the new types of air threats and seek solutions to maintain a balanced situation in the field of airspace security. In this regard, a number of transformations of the VSHORAD, SHORAD air defense missile systems are identified. The technical and tactical solutions mainly refer to increasing the capabilities of the weapons and ammunition systems, which can be used in achieving the specific algorithm of countering an air threat by applying certain specific methods, TEWA (Threat Evaluation and Weapons Allocation). This scientific approach highlights the possibilities of taking short and very short range air action as a starting point in the current development of the air defense systems, which by applying the operational art can temporarily compensate for the technological gap between the air threats and the air defense response.

Keywords: air threat; VSHORAD; SHORAD; TEWA; operational art.

The New Context of Airspace Combat

The need to expand the land battlefield has led directly to identifying the technological solutions in the close airspace, respectively to developing means of air action at low and very low altitudes. This is a reality of the modern battlefield, where more and more modern armies use phrases such as "tank-helicopter binomial". In this context, we can speak of an increase in user density in the airspace, especially at low and very low altitudes. In the spirit of the economy of a hypothetical opponent's forces and means used in a military conflict, there are several tendencies of airspace action, covering the entire spectrum of ranges. This is possible from the onset of the aggression by surprise, without resorting to previous measures of mobilization and formation of the joint task force.

In order to achieve air superiority during an offensive operation, it is expected that the first air strike employs the assets required to neutralize the air defence and to create gaps to penetrate the tactical depth of the battlefield, supported by bombings from medium and high altitudes. In order to maintain the initiative in the offense, one of the objectives is to achieve a maximum intensity of air strikes in the first 3 to 4 hours after the launch of the attack, using air assets with small radar cross sections, high velocities and increased maneuver capabilities under the protection of strong radio jamming. In this context, the most likely avenues of approach will be in the directions from which the attack is conducted and on the access routes to the objectives from the tactical, operational and strategic depth. Thus, it is expected that various types of weapons and ammunition will be used, mainly radio beam riding missiles, and last but not least, drones (as asymmetric air threats), observation sensors and long-range heavy artillery fire direction and surface-to-surface missiles.

Air Treat and Response in the Layered Air Space

Following the study of recent military conflicts, in this case the war in Nagorno-Karabakh (autumn 2020), new dimensions of the confrontation have emerged, in the sense of the existence of those technological changes in using the classical air means (multi-purpose aircraft and helicopters). The analysis of the conflict shows that a new generation of unmanned aerial vehicles (UAV) was introduced into combat. According to the military planners, the results of the analysis of air combat actions in the Nagorno-Karabakh war led to identifying three prospective areas, as follows:

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the need for an integrated air defence system as a critical prerequisite in conducting operations; the increasing role of the electronic warfare as an aspect of the confrontation which must be emphasized in all phases of the operations, as well as the preparation of the human factor or the decision-maker in conducting operations[1]. The need for an integrated air defence system (IADS) is a reality of the modern combat space, vital for countering air threats, which requires a new configuration of the air defence layered on altitudes and focused mainly on network integrated collaborative work[2]. Working within an integrated network, as a method of combat, can be the variant through which the simultaneous use of the air and air defence resources takes place, which would allow a much more efficient management of the multitude of challenges, from multi-purpose aircraft to the multiple technological configurations of UAVs.

The classic variant of air threat emerging at low and very low altitudes involves breaking through the air defence system and engaging targets in the tactical depth of the battle space. This is expected from the first hours of a military conflict, which can be achieved through a maneuverable approach of dynamically altering the combat formation and the firing procedures. Most likely, the strategic reconnaissance aviation will perform aerial survey day and night, with isolated aircraft flying at speeds ranging between 700 km/h and 900 km/h at high and stratosphere altitudes (10,000 m and 18,000 m) with frequent changes of direction, speed, altitude and heavy use of radio jamming.

Depending on the relief of the confrontation area corroborated with the aircraft's homing and engagement capabilities, the avenues of approaching the target are identified by flying at low and very low altitudes (20 - 150 m) on different flight paths of the aerial targets. The use of low and very low altitudes of the avenues of approach when engaging targets limits the continuous searching and tracking of aerial targets, with regard to the maximum capabilities of the radiolocation stations and thus an impediment to the destruction of hostile aircraft by the air defence response system.

In order to develop the topic of ”air threat” in the military action planning, we identified three distinct areas of approach, as follows: combat formation, their tactical deployment and the technical-tactical capabilities of the air enemy structures. Due to this, we covered four directions of analysis in the study of the air defence response: the air defended objective, the air enemy/opponent, the air and missile defence structures and the air space of responsibility. According to this approach, the study will focus on the airspace layered on altitudes and a dynamic evaluation of the possibilities to identify and visualize the trajectories of the aircraft, on combat sequences, together with the estimate of the most likely firing line of the aircraft. The war in Nagorno-Karabakh 2020 is also characterized in terms of its preliminary stages of technological preparation, which is why, starting 2010, there have been a significant number of high-tech weapons and ammunition acquisitions.

According to a report by the Stockholm International Peace Research Institute (SIPRI) published in 2018, ”Armenia has received a large amount of military equipment from Russia, including two S-300PS/SA-10C air defence missile systems, 10 Tigr armored vehicles, 400 Igla-S/SA-24 MANPADS, 25 Iskander ballistic missile units; 6 BM-30 9A52 Smerch 300 mm Multiple Launch Rocket Systems, 200 Verba SA-25 and an undisclosed number of 9M133 Kornet/ AT-14 anti-tank missiles”[3]. According to the Middle East Eye news office in London, apparently ”although the Armenian army aimed to strike the Azerbaijani capital of Baku, with Iskander ballistic missiles in the last days of hostilities in November 2020[4], the Azerbaijani army succeeded to neutralize the Iskander ballistic missile in flight, using the ”Barak-8” air defence system (an air defence system purchased from Israel)”[5]. This situation highlights the importance of the existence of an altitude layered air defence system. Depending on the final technical configuration of the air defence response system, the ”Barak-8” weapon system has the ability to simultaneously engage several aerial targets such as: anti-ship missiles, aircraft, UAV drones and supersonic missiles.

To understand the tasks of air defence response systems in the VSHORAD, SHORAD integrated concept, we chose the ”Barak-8” system used in the Nagorno-Karabakh war as a reference point for describing the new reality in the field of current airspace security. The situation analysis is based on the understanding of the extended configuration through the progressive launch areas of three types of Barak interceptors, namely ”Barak MRAD” (with single-stage rocket engine and a range of 35 km), the intermediate configuration ”Barak LRAD ”(with two-stage rocket engine and a range of 70 km) and the third configuration: ”Barak ER” (the interceptor with the longest range, which has a two-stage rocket engine and an additional booster for a 150 km autonomy)[6]. The concept of the ”Barak” air defence response has been developed in a new approach to airspace security. In order to meet the basic requirement of being able to deal with several types of air threats simultaneously, several types of radars and launchers have been integrated, which can build an optimized response against fighter jets, helicopters, UASs, cruise missiles, surface-to-air and surface-to-surface missiles. The possibility of a flexible configuration of the air defence response system on the three types of missiles (MRAD, LRAD and Barak ER) is based on the functional massing of the common elements of the subsystems: intelligence, command and control, fire and logistics. In the technical configuration performed on the four action subsystems, the significant advantage of continuous maintenance, training and solving training exercises by different users is generated. Such an innovative concept was developed based on ”working on functional modules” which offers high flexibility in terms of technological but also operational integration. In the further development of the new weapons systems according to the same concept, a new must air defend both a number of vital targets in the area of responsibility and also the troops conducting a military operation. The issue of assessing the performance of such air defence systems in a joint concept becomes a matter of paramount importance. The innovative aspect of the concept is the establishment of the BARAK Battle Management Center (BMC), where the airspace image is created through data/ pictures merged with sensors and interception coordinates, which analyzed electronically, help the decision-makers of the operational task forces to manage the engagement of the air enemy. Therefore, the open and innovative architecture of such an air defence system, based on the software of ”BARAK MX”, offers exceptional flexibility in operation and planning of the combat power in order to counter future air threats.

The Operational Art for the Design of Air Combat Action

The new current airspace security context calls for the development of new integrated and layered air defence structures appropriate to the range of air threats. Operational flexibility in this case may be one of the necessary solutions for modular design on combat functions, in a sequential air defence response algorithm, as follows: airspace reconnaissance, detection and classification of air targets, identification friend or foe of an aircraft,

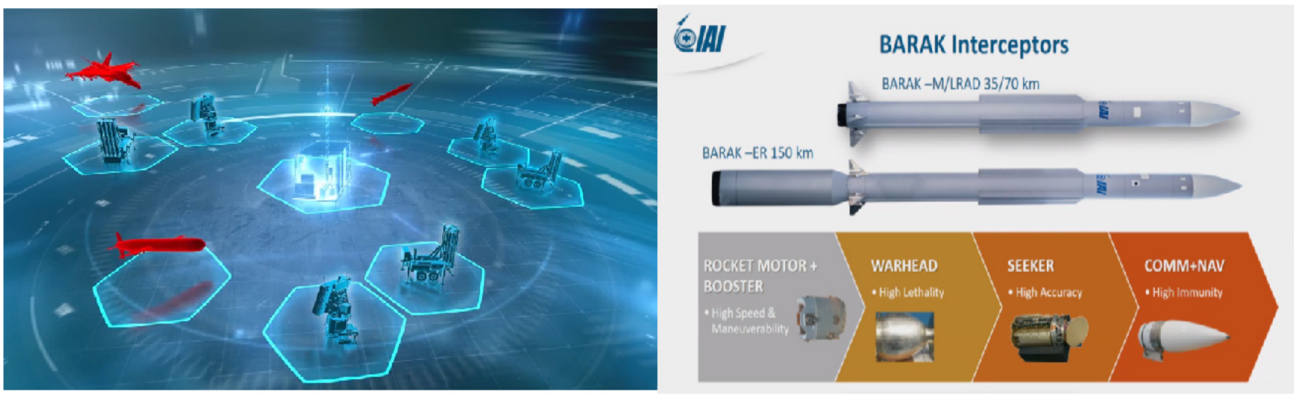

Figure 1 *Representation of the ”Barak-8” integrated modular concept for countering air threats with progressive range 30 – 70 – 150 km*[7]

much more efficient possibility of engaging the air defence systems results.

Due to the complexity of the work for an effective air defence response against the broad spectrum of air threats, the decision-makers engagement and destruction of hostile air targets, assessment of the effects of the air defence fire, cessation or resumption of the air defence algorithm.

A first observation is that technologically there are two tendencies to achieve the air defence response algorithm. The first variant refers to designing air combat on distinct sequences accomplished by specialized modules for each air defence operation, such as the older generation S-75 M3 ”VOLHOV” air defence missile system, or the newer generation MIM-104 ”PATRIOT”. The second variant refers to the integration of all the functions into a single technological module/ war machine which will conduct the air defence response, such as the SA-8 ”Osa-AKM” air defence missile system or the air defence artillery ”GEPARD”, respectively 2K22 ”TUNGUSKA” system.

The method of the air defence response in both technological variants is based on the results of the application of the operational art in designing the air combat actions. In other words, the success of the defence against the air opponent consists in the achievement of the combat device or in other words, it is conditioned by the way of combining four system variables, namely: the air defended objective, the air enemy/opponent, the air and missile defence structures and the air space of responsibility. The operational art is applied in the field of airspace security in order to establish the methods and means necessary to achieve the air defence of the objectives effectively and within the limits of accepted risks. A2AD (Anti-access Area Denial) is not an absolutely new concept, and as a direct result of applying the operational art in the Black Sea area, concrete actions of the Russian Federation have resulted for the resuscitation of the early warning radar systems and the installation of modern electronic warfare equipment” as new capabilities in Crimea[8]. Combining the air space combat assets involves a series of projections and integrated analyses to identify the most effective ways to counteract the actions of a hypothetical opponent in the area of responsibility. Thus, it is expected that in the Black Sea area, ”by deploying these capabilities, with the missile systems, Russia will be able to create a multilayered, interconnected defence network that can threaten or deny the presence of any other force inside the A2AD bubble”[9].

Therefore, the application of the operational art which promotes the joint action becomes essential for achieving the design of the airspace combat actions[10]. Observing the A2AD concept, we understand the spatial design and time synchronization of all specialized means that can engage a hypothetical adversary, on a large scale of the possible threats in an area of responsibility, such as the Black Sea. In this respect, we consider the fact that the application of the operative art results in the combination of the tactics, techniques and procedures with several services and capabilities, which jointly provide the development, establishment and execution of the so-called ”kill box” area, which allows the timely engagement of a target.

Therefore, we observe there are two integrative methods for achieving the air defence response: one according to the ”Barak-8/ BARAK MX” integrated modular concept and the second, according to the concept of achieving a ”kill box” area with several weapons systems. In the ”BARAK MX” variant with a flexible configuration of the air defence response system on the three types of missiles (MRAD, LRAD and Barak ER) there is the possibility of an extended ”kill box” layered area, for a certain type of threat, a situation that is performed for a certain type of dedicated air defence response, by a single combat unit (Figure 1), progressively, with the three types of missiles. In both previously mentioned variants,

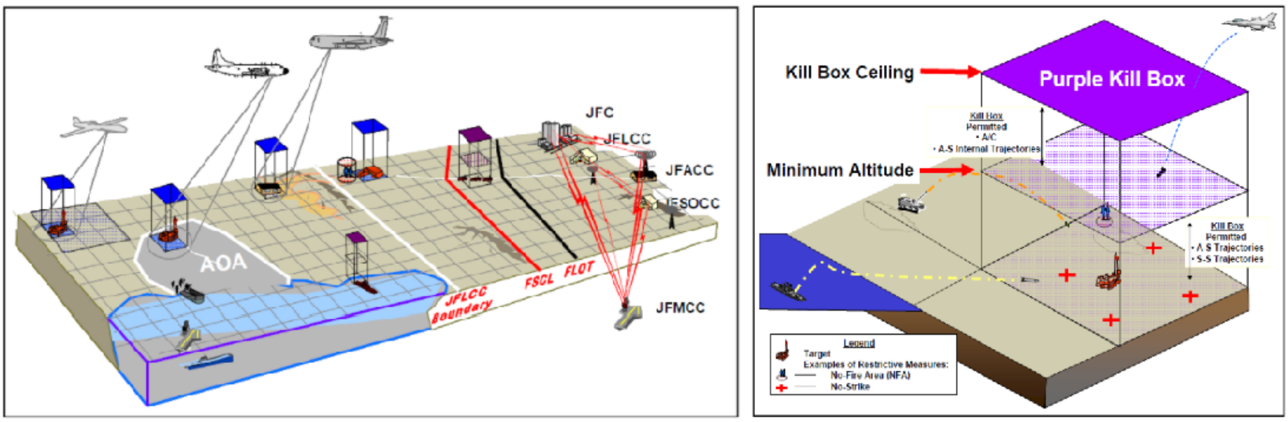

Figure 2 *Graphical representation of the concept of achieving a ”Kill box” area*[11]

we note that in the situations of air defence and air defence response, the decision-makers estimate the air combat in computer assisted coordinates, depending on the objectives in the territory or the troops involved in military operations[12]. Thus, an appropriate report of assigning the available air defence firing units for each combat sequence is developed in real time against air targets.

In the literature, the intelligence preparation of the battle space ensures the proper decision making for the achievement of the combat formation and the positioning of the weapon systems in the combat space. One of the methods used for this purpose is the networking of the threat evaluation and weapon allocation systems (TEWA). The problem of evaluating the performance of the collaborative work by network connecting the air defence response or enemy engagement systems is one of the challenges of the contemporary battle space. A hypothetical air adversary will engage targets in the target area by gradually changing the combat tactics at different altitudes and speeds, depending on the terrain configuration and the maneuvering possibilities in order to avoid air defence fire from the surface. The integrated modular concept of the ”BARAK MX” air defence response, as in Figure 1, contributes to understanding the need to redesign the entire air defence response system. One of the possible solutions in this regard can be using the model of the interconnected work of the air defence fire units and the development of a centralized system of data on the air situation, by the TEWA method, as shown in Figure 3.

Capitalizing on the unitary realization of an air defence collaborative network, by operationalizing the TEWA method, as it results from Figure 3, can be a transit solution from the classic air defence response systems to that unitary, automatic computer-assisted network system. This is based on the possibility of designing and executing several network information nodes, in which the common aerial picture is progressively composed, in the GUI (graphical user interface) module, which can be subsequently distributed to each of the six interconnected weapon systems, as in Figure 3. Depending on the flight altitude and other parameters of the air targets, according to the threat situation and the aggression in the layered airspace, we witness a progressive activation of the sensors and implicitly a triggering of the individual procedures for engagement, combat and destruction of air targets in the common airspace. According to the combat capabilities of each air defence system, they will contribute to the achievement of a progressive volume of air defence fire, the minimum necessary for an economy of effort per unit of combat and time. This results, in particular, for the situation of certain fixed objectives which need to be air defended in the area of operations. On the other hand, due to their mobility in the tactical field, in order to provide air defence to the troops conducting a military operation, the possibilities of air defence will decrease according to the terrain configuration and the dynamics of the military operations.

Therefore, there is a necessary situational compromise in achieving an effective air defence

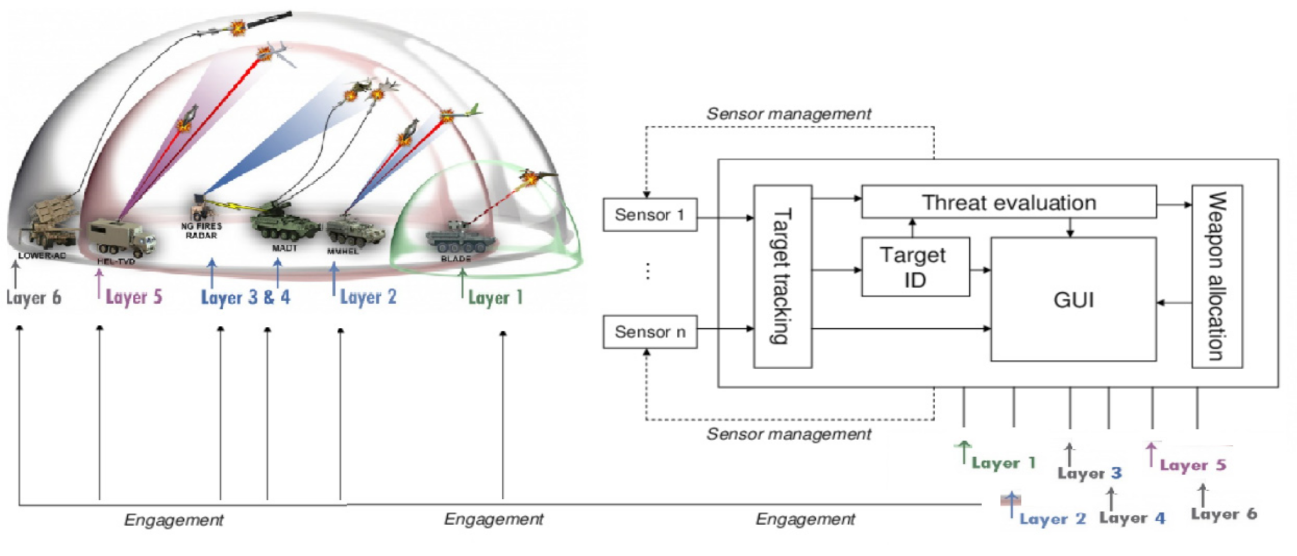

Figure 3 *Schematic variant for the interconnected work in the design of air defence response in TEWA concept*[13]

response against an air opponent that can act at different altitudes at different speeds and progressively changing the combat tactics[14]. In other words, conducting an air defence response through the TEWA method includes two distinct planning hypotheses regarding the engagement and destruction of air targets. In formulating the planning hypotheses, we will refer to the possibility of allocating air defence weapons as a reactive measure to the air threat. This weapon allocation process must answer a question in order to activate the most appropriate weapon system, i.e. which unit or units will engage a certain air target. For this approach, the first planning hypothesis was developed, where the air defence objective is stationary, which implies the activation of all available firing units in a single stage. Such activation has direct implications on the conditions of economy of effort and direction of restricted air defence fire.

In the second case, in which the objective to be air defended is involved in the dynamics of the operation (troops conducting a military operation) we can talk about a dynamic allocation of weapons according to the progress of the battle, so that each firing unit will be allowed a certain number of discrete stages of combat. Another division that can be made regarding the air defence firing resource is the one in which the allocation of weapons is based on the evolution of the air situation, in which the targets are distributed among the air assets available in each sequence of the operation. In both cases, the application of the TEWA concept implies the existence of a unitary decision-making platform, which would make the entire air defence response system vulnerable if the information node for the distribution of the decisions to engage hostile air platforms were dismantled and taken out of action. In order to avoid the withdrawal of the “center of gravity”, respectively the decision-making hub for the air defence operations, we aim to redesign the network centered warfare. This is possible through a progressive connection of sensors, engagement systems and finally decision makers, as an effective unit, to the dynamics of the situation development in the airspace.

Conclusions

Following the above mentioned details regarding the possible evolution of the air defence collaborative work, we can foresee a new concept of the design of the air combat. Thus, a new development of the battle can take place based on the TEWA functionality, as a dynamic decision-making process aimed at the successful exploitation of the tactical resources (e.g. sensors and weapons) during the conduct of command and control activities. Extending the tactical field life of older generation air defence systems can be achieved in two ways. The first way refers to maintaining the initial configuration of the air defence systems and employing them in air combat by changing the parameters of the combat formation simultaneously with applying the tactics and maneuvers of direct protection and deception to avoid direct confrontation. The second way consists in identifying the technological upgrades by introducing a data reception and processing node in the information system, network connected, by means of which a separate air defence response can be carried out on combat stages in several ”kill boxes”, as shown in Figure 2.

In order to understand the new context of airspace combat, as in the Nagorno-Karabakh war in 2020, as well as other hypothetical conflicts based on modern weapons technology, a conceptual readjustment of the combat space is required. Due to the technological evolution of the air platforms and the way of managing the resources to engage targets in the enemy territory, one of the problems the commanders/decision makers have to face is the optimal use of the air defence response resources in complex situations, when lacking reaction time.

Another aspect is the introduction of a new generation of UAVs (unmanned aerial vehicle) into combat, which led to a series of important changes in waging war with the traditional means of air defence response without excluding the actions of the multi-purpose aircraft and helicopters. Bringing the TEWA method to the attention of the specialists in the field of airspace security in developing the operational art for the design of combat actions with a hypothetical air adversary, is the starting point for the re-conceptualization of the modern combat space. Also in this regard, it is worth paying special attention to the development of the A2AD (Anti-access, Denial Area) concept developed by the Russian Federation by ”reviving the early warning radar systems and installing modern electronic warfare equipment” as new capabilities under new coordinates of surface, respectively in the militarized area of Crimea.

The need to technologize the air defence response systems will determine the design of an open and innovative architecture based on the model of the air defence system, with the platform based on the ”BARAK MX” software, as a reference variant that offers exceptional flexibility in operation and in designing combat power for future air threats. Therefore, the application of the operational art based on the TEWA concept, combines the tactics, techniques and procedures with several services and capabilities in a joint manner, which can ensure the development, the establishment and the execution of the ”kill box” area as a three-step process: defining the threat, progressively assessing the threats and finally allocating the weapons and assigning them. Finally, we recommend adopting the concept of TEWA as a very effective tool for making decisions and achieving the economy of forces and means, but especially for saving reaction time in critical situations.

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