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METHODS AND MEANS USED BY FOREIGN ARMIES TO COUNTER UNMANNED AERIAL VEHICLES

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Abstract. In order to develop air defense, to protect troops, special facilities, territories and cities from air attack, one must first of all know the principles of operation of this system and the history of its development. It is necessary to approach this from a scientific point of view and study the air defense of foreign countries in order to create a unique air defense system of the Republic of Uzbekistan. The air defense of foreign countries is studied on the basis of various theories, concepts, approaches, positions, directions.

Key words: air attack, reconnaissance, concept, development, defense, direction, application.

The steady increase in the number of unmanned aerial vehicles (UAVs), the diverse scenarios for their use in military conflicts to accomplish various tasks, and the difficulty of neutralizing them with traditional air defense systems—largely due to their small size and varied flight altitudes—necessitate the development of specialized methods and means to counter them. It is essential to consider additional approaches and specific measures for countering UAVs. The challenges in destroying UAVs using air defense units stem from their small size, light weight, specific flight altitudes and endurance, and flight profiles that differ from those of manned aircraft or helicopters. Furthermore, there are other types of unmanned systems—such as loitering munitions, aerial bombs, and both guided and unguided cruise missiles—that present additional complexities due to their high flight speeds, extremely small radar cross-sections (RCS), and the presence of onboard radio, optoelectronic, photoelectronic, or infrared reconnaissance equipment. In the autumn of 2020, a military conflict broke out between Armenia and Azerbaijan in Nagorno-Karabakh. A distinctive feature of this conflict was Azerbaijan's extensive use of unmanned aerial vehicles (UAVs) to destroy Armenian weaponry and personnel.

Prior to the start of the conflict, the Azerbaijani armed forces had acquired Turkish "Bayraktar TB2" UAVs—equipped with laser-guided aerial bombs—as well as Israeli "Heron TP" and "Hermes-450" drones, and the "Sky Striker" loitering munition (kamikaze drone). Furthermore, through a joint venture with Israel, Azerbaijan had established the production of "Aerostar" UAVs, as well as the "Orbiter-1K" and "Orbiter-3" loitering munitions. In recent years, Armenia had not purchased any unmanned aerial vehicles. However, Armenia did produce the "Krunk" light-class reconnaissance UAV; these drones were designed solely for reconnaissance purposes and were not intended for striking or destroying targets. Before the conflicts began, the Armed Forces of Armenia were equipped with various anti-aircraft systems—manufactured in the Soviet Union and the Russian Federation—intended for air defense. The airspace over Nagorno-Karabakh was protected by "Osa-AK" and "Strela-10" surface-to-air missile systems. Additionally, a Russian-made "Tor" surface-to-air missile system—capable of effectively countering unmanned aerial vehicles (UAVs)—was acquired, though it was not deployed to this region. Both the "Osa-AK" and "Strela-10" systems were primarily designed to destroy aircraft and helicopters, rather than to counter UAVs. Nevertheless, following joint Armenian-Russian air defense military exercises held in June 2020, Russian military experts concluded that these air defense systems possessed high

combat capabilities. This assessment was based on an instance where an "Osa-AK" system successfully detected and tracked a "Hermes 900" unmanned aerial vehicle. With the outbreak of hostilities in Nagorno-Karabakh, the Azerbaijani armed forces—supported by Turkish military experts and drawing on lessons from Syria and Libya—employed combat unmanned aerial vehicles (UAVs) on a massive scale. Had the war in Nagorno-Karabakh been fought without UAVs, Armenia's air defense system would have effectively countered Azerbaijani aviation. Even after achieving air superiority, Azerbaijan exercised caution, limiting the use of its manned aircraft and helicopters because Armenia's air defense system remained a significant threat. Nevertheless, it became clear that Armenia was completely unprepared for the large-scale deployment of unmanned aerial vehicles.

On the very first day of the war, the mass deployment of unmanned aerial vehicles (UAVs)—including the Bayraktar TB2, the Sky Striker loitering munition, the Harop, and the Orbiter—resulted in the complete destruction of the Armenian "Osa-AK" and "Strela-10" surface-to-air missile (SAM) systems stationed in Nagorno-Karabakh, effectively neutralizing the region's air defense network. By launching pre-planned aerial strikes against the positions of these SAM systems on the first day, the defense infrastructure in Nagorno-Karabakh was dismantled; according to experts, 80% of the SAM systems—specifically six "Osa-AK" and three "Strela-10" units—were taken out of action, while four UAVs were lost in the process. Consequently, the mass use of UAVs resulted in a ratio of one drone lost for every 2.25 SAM systems destroyed. By leveraging these UAVs to consistently secure air superiority over Nagorno-Karabakh, Azerbaijan was able to strike Armenian ground forces from the air, inflicting significant casualties. This significantly facilitated the Azerbaijani army's offensive and enabled the achievement of important tactical successes. Furthermore, the S-300PS and S-300PT surface-to-air missile systems in Armenia were not designed to counter unmanned aerial vehicles (UAVs). Consequently, these systems could not be effectively employed to protect the airspace of Armenia and Nagorno-Karabakh from this new type of threat.

Moreover, as a result of a meticulously planned operation, Azerbaijan destroyed two launchers and two radar stations belonging to an S-300PS surface-to-air missile system. According to media reports, one of the destroyed S-300PS units was positioned in an open area, lacking any form of engineering-based protective measures. This occurred because, during the initial phase of the military conflict, Azerbaijan utilized An-2 aircraft—configured as unmanned drones—to pinpoint the locations of Armenian air defense systems. Although these An-2 "drones" were shot down, the action allowed for the identification of the positions of the S-300PS systems, as well as the "Osa-AK" and "Strela-10" surface-to-air missile systems tasked with their protection. Following the destruction of a short-range air defense system, a 5P85S launcher belonging to an S-300PS surface-to-air missile system—along with its 36D6 radar—was destroyed by Israeli-made "Harop" loitering munition (kamikaze) drones. This tactic—using unmanned aerial vehicles (UAVs) to first neutralize air defense systems and subsequently destroy the military hardware and personnel of ground forces—was employed on a large scale during the war in Nagorno-Karabakh. Representing a first in global military experience, this approach has been dubbed a "drone war" in the media. The Azerbaijani side widely circulated footage showing high-precision strikes by these UAVs against Armenian positions. The primary targets for these strikes were, first and foremost, air defense systems, followed by armored vehicles, artillery, and personnel—whether in staging areas, on the move, or in established positions—with strikes also directed, to a lesser extent, at depots, warehouses, and barracks.

Following the destruction of the core elements of its air defense system in Nagorno-Karabakh, the Armenian side was unable to rapidly replenish its resources with new anti-aircraft missile systems. The adversary secured air superiority and leveraged it to gain a strategic advantage. The mass deployment of unmanned aerial vehicles (UAVs) inevitably led to an increase in both the losses sustained by the Armenian army's ground forces and the operational challenges they faced. The anti-aircraft missile systems that Armenia had planned to acquire failed to resolve the difficulties posed by unmanned aerial vehicles.

Estimated indicators of average turnover

Military conflict	Indicator
Syrian War (2017–2019)	1 ZRK for 5 UUA
Libyan War (2019)	1 ZRK for 2.8 UUA
Nagorno-Karabakh War (2020)	2.25 ZRK for 1 UUA

An analysis of the tactics involving the mass deployment of unmanned aerial vehicles (UAVs)—as seen in the context of the Nagorno-Karabakh conflict—reveals a clear trend: an increasing reliance on UAVs to secure air superiority and destroy key ground-based weaponry, particularly armored vehicles. This suggests potential, imminent shifts in the nature of warfare strategy. In future conflicts, the mass deployment of UAVs is expected to serve several operational purposes—ranging from reconnaissance and patrolling to the use of "kamikaze" (loitering munition) strikes—following a phased approach: the first phase focuses on reconnaissance; the second on neutralizing air defense systems; the third on destroying airfields, aircraft, and helicopters (both on the ground and in the air); and the fourth—once air superiority has been established—on targeting armored vehicles, ground forces, rear-echelon units, and critical state infrastructure. An analysis of the methods and outcomes regarding the use of unmanned aerial vehicles (UAVs) in military conflicts and terrorist attacks—observed in recent years in the Middle East, Ukraine, and Nagorno-Karabakh—indicates a clear need to develop an advanced, automated air defense system. Such a system must be capable of effectively responding to emerging threats by promptly identifying individual or grouped targets—along with their associated risk levels—and automatically managing the tactics and procedures required to neutralize them.

Without the development of an automated air defense system, the modernization and advancement of air defense forces remain extremely difficult to achieve.

An air defense system is a comprehensive set of measures designed to provide protection against an adversary's aerial attack assets. In essence, the entire sequence—detecting a target, determining its coordinates, identifying its origin, selecting the appropriate engagement assets, assigning tasks, and ultimately neutralizing the target—must be established as the primary mission for all air defense forces. It is essential to enhance operational efficiency through a unified communication and information-sharing network. Furthermore, cooperation should be established—where necessary—with airports, intelligence units, the border troops of the State Security Service (SSS), and hydrometeorological stations; only through such integration can the system achieve its full effectiveness.

Currently, the primary methods for countering unmanned aerial vehicles (UAVs) include: electronic suppression of radio communication and radionavigation channels; electronic interference with control systems; disabling UAVs via laser or microwave radiation; and shooting them down using conventional air defense weaponry. These methods should be implemented through a variety of land-based, naval, and airborne technical assets. Ideally, these air defense systems should be configured as man-portable, mobile, vehicle-mounted, or containerized units.

Currently, countries such as the United States, Israel, China, and various NATO-member European states are directing their research and development efforts toward countering unmanned aerial vehicles (UAVs). This includes the creation and modernization of diverse systems—ranging from portable weapons to heavy, stationary installations—designed to neutralize UAVs and continuously enhance the combat capabilities of their armed forces. In the course of these efforts, several key principles are being established for modern counter-UAV systems: the integrated use of various detection and neutralization methods (optical, electronic, etc.), accounting for the full spectrum of potential UAV deployment tactics, flight profiles, and technical specifications; and ensuring the openness and scalability of the hardware-software architectures within these combat systems, thereby facilitating future modernization through the integration of new hardware and software components. Multifunctionality, enabling the use of countermeasures against various types of small-scale objects (such as missiles, projectiles, mines, munitions, and loitering munitions) across a wide range of rapidly evolving tactical scenarios; the execution of core functional tasks via a unified software framework, thereby reducing the time and costs associated with adapting combat systems to new operational environments; extensive integration of artificial intelligence—both in systems for detecting and identifying aerial objects and in the control systems for counter-UAV (unmanned aerial vehicle) assets, allowing for real-time adjustments to a constantly changing situation; the implementation of a unified information and communication system to facilitate data exchange among all deployed reconnaissance and engagement assets; and the application of a centralized command-and-control system for all distributed air defense forces and assets. In the context of countering UAVs, the air defense systems of developed nations utilize a comprehensive suite of capabilities, encompassing both traditional air defense assets and specialized countermeasures. It should be noted that, given the specific characteristics of unmanned aerial vehicles (UAVs), the use of radar systems—as opposed to optoelectronic or acoustic detection methods—enables the detection of UAVs at greater ranges. Currently, the U.S. Army employs the three-coordinate AN/MPQ-64A4 "Sentinel A4" radar to determine the coordinates of small-scale UAVs. The German Armed Forces have adopted the "Spekser 2000 3D" radar, which operates in the 9.2–10 GHz frequency range and is capable of detecting UAVs with a small effective radar cross-section (RCS). Since 2020, this has allowed for its integration into various mobile and stationary counter-UAV systems developed for the German Armed Forces. Another approach to enhancing the capabilities of existing air defense systems and assets is the modernization of their control systems. For instance, the Israeli-developed "Sky Capture" air defense control and monitoring system has significantly improved the ability to engage small, low-flying aerial targets using legacy anti-aircraft artillery and short-range surface-to-air missile (SAM) systems. The system includes the EL/M-2106 radar, electro-optical (EO) tracking equipment, and a control subsystem. Data acquired from the radar and electro-optical sensors is automatically processed to generate guidance and fire-control commands for various air defense systems. Another Israeli-made system, the "Red Sky 2" control unit—which incorporates infrared (IR) tracking sensors and various radars—can operate in integration with short-range (10 km) surface-to-air missile (SAM) and anti-aircraft gun-missile systems, including the American "Stinger" and the Russian "Strela" and "Igla" complexes. The complex is capable of detecting targets, controlling short-range SAM and anti-aircraft gun-missile systems, and assigning engagement tasks to intercept objects at ranges of 6 km or more. Additionally, the EL/I-4030 "Drone Guard"—a system also produced in Israel and designed for countering unmanned aerial vehicles (UAVs)—utilizes a 3D radar, electro-optical sensors, and infrared sensors to automatically detect and track up to 100 aerial objects simultaneously, including UAVs, aircraft, and helicopters.

Many modern counter-unmanned aerial vehicle (UAV) systems employ a modular design, incorporating a variety of tools—such as radar, optoelectronic, photo-electronic, and infrared reconnaissance—to detect, track, and neutralize aircraft and drones. In 2020, the British Royal Air Force received the first module of the "ORCUS" system, which includes radar, optoelectronic sensors, electronic warfare capabilities, and a command-and-control system. The development of modern, multifunctional air defense systems represents an effective approach to countering UAVs; it remains one of the primary methods for protecting troops from aerial threats—whether they are in staging areas, on the move, deploying, or actively engaged in combat. Consequently, the evolution of methods and technologies for both the deployment of UAVs and the countermeasures against them remains a critical focus, viewed as a decisive factor in the outcome of modern armed conflicts.

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