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PROBLEMATIC ISSUES AND WAYS TO INCREASE THE PROTECTION OF TROOPS IN THE CONTEXT OF THE RAPID DEVELOPMENT OF THE TREND OF USING SMALL UNMANNED AERIAL VEHICLES IN COMBAT OPERATIONS

Based on the analysis, a conclusion has been made that the use of small unmanned aerial vehicles on the battlefield affects the enemy capabilities. The authors have substantiated the need for the Ukrainian Defense Forces to gain an advantage in the context of using small unmanned aerial vehicles on the battlefield. It has been found that gaining such advantages involves not only intensifying efforts to use friendly small unmanned aerial vehicles, but also focusing on protecting troops from enemy small unmanned aerial vehicles.

The main areas of military activity crucial for protecting troops from small unmanned aerial vehicles have been outlined. In view of this, the authors have analyzed the problematic issues and identified ways to improve the protection of troops in the conditions of the enemy use of small unmanned aerial vehicles.

Keywords: *small unmanned aerial vehicles, troop protection, organizational and technical measures to protect troops.*

Statement of the problem. Over the past few years, the use of unmanned systems on the battlefield has developed rapidly. Unmanned aerial vehicles (UAVs) were introduced into military activities about thirty years ago, but they were mainly reconnaissance platforms or large strike UAVs used to perform certain special tasks over long distances.

One of the first military conflicts where UAVs were used as a weapon in the military was the Armenian-Azerbaijani conflict over Nagorno-Karabakh. Given the enemy rather weak air defense, the Azerbaijani side actively used Turkish-made UAVs manufactured by Bayraktar, which hit various targets directly on the contact line and in the enemy tactical zone.

The large-scale invasion of Ukraine by the aggressor country's troops in 2022 gave an even greater impetus to the intensification of the use of unmanned platforms, including UAVs, in all areas of military activity, including as strike weapons. At the beginning of the invasion, the Armed Forces of Ukraine actively used the aforementioned Bayraktar UAVs, which allowed them to achieve results in defeating enemy targets during their advance and deployment. Later, when the fighting became more positional and the enemy began to build an army air defense system, it became clear that it was futile to use large enough attack UAVs in the context of saturation of enemy combat formations with air defense systems.

As the fighting progresses, ideas are emerging to use small UAVs used for reconnaissance in the near tactical zone to directly engage identified targets by dropping munitions. These are multi-rotor platforms capable of hovering over a target, which allows for fairly accurate targeting. In late 2022 and early 2023, such UAVs are developed and rapidly deployed on the battlefield. This greatly complicates infantry operations in open terrain and poses a serious threat to stationary military infrastructure in the near tactical zone. Scaling up the use of this technology made it possible to compensate to some extent for the lack of artillery capabilities, which for objective reasons was particularly problematic for the Ukrainian army.

It should be noted that the massive use of UAVs for ammunition drops had a certain impact on the course of warfare. At the same time, due to the low effectiveness of drops against moving armored targets, it was practically not difficult for the enemy to conduct mechanized assaults using armored vehicles.

An evolution of the idea of using small UAVs for strike purposes in 2023 is the widespread use of FPV drones as strike drones, which are actually small and relatively cheap high-precision barrage munitions. Barrage munitions are not new and have been produced by military industrial complexes of a number of countries for some time. Examples include russian Lancets and American Switchblades. From the very beginning, these munitions were not considered as mass weapons, but were intended more for hitting individual important targets. The relatively low cost of FPV drones contributed to their mass production and rapid increase in use. Within a year of the first FPV strike drones being deployed, both the Ukrainian and russian sides announced that they would provide their armed forces with more than a million of them by 2024.

The capabilities of FPV drones to detect, recognize, identify and engage targets almost simultaneously, the ability to carry both anti-personnel and anti-tank munitions, to approach a target from the most convenient direction, and to make multiple attempts to approach a target surpass the capabilities of any other type of weapon used on the battlefield. The versatility, cheapness and mass production of this new type of weapon makes it possible to effectively use it to destroy both personnel and military equipment, as well as any enemy military infrastructure in the near tactical zone.

It can be argued that the decisive capabilities of FPV drones and the large-scale increase in their number have created an almost complete paralysis of traditional tactics of general combat. Probably none of the new types of weapons in recent decades has caused such rapid and critical changes in the nature of warfare. Therefore, gaining an advantage over the enemy in the use of small UAVs in the near future will become one of the determining factors of success on the battlefield.

On the one hand, at the stage when Ukraine's defense forces are engaged in mostly defensive actions, the use of small UAVs gives them an advantage, creating significant difficulties for the aggressor country troops in moving across open terrain during the offensive. On the other hand, the use of small UAVs by the enemy significantly complicates the conduct of defense due to the possibility of preliminary detailed reconnaissance of the positions of defending units, high-precision destruction of firepower before and directly during the attack, as well as the ability to paralyze supply and evacuation in defending units. Thus, at first glance, with a certain parity in the number of small UAVs, neither side gains advantage, because the advantages in influencing the enemy are offset by the enemy corresponding influence. At the same time, in the current warfare, the situation for the Ukrainian Defense Forces is further complicated by the violation of this parity in favour of the enemy due to the advantages caused by the large number of personnel and insensitivity to their losses. As a result, we have recently witnessed a tactical crisis in the form of a permanent "creeping" advance of enemy forces at the cost of heavy losses.

In order to stabilize the frontline and move to the liberation of the occupied territories, Ukrainian Defense Forces need to gain decisive advantages over the enemy, including tactical advantages. For objective reasons, Ukraine cannot achieve parity with the enemy in terms of manpower and cannot afford to use the "successful" tactics of infiltration by small groups, which the enemy is actively using. In these circumstances, the only way to gain an advantage over the enemy is to use modern key technologies that have a decisive impact on the conduct of warfare. As noted above, such a technology for the tactical zone is the use of small UAVs.

At first glance, gaining an advantage over the enemy in the use of small UAVs requires efforts to maximize the number of small UAVs in use and improve their tactical and technical characteristics. Today, this is exactly what is happening: both the state and non-governmental organizations are focusing on scaling up the production and supply of drones to the military, improving their characteristics, and on management decisions that improve the organization of the use of small UAVs, comprehensive support for this activity, and the organization of appropriate training, etc. We see the results of such activities at the frontline, where it is often stated that the Ukrainian Defense Forces have advantages over the enemy in the use of small UAVs. For its part, the enemy, aware of the importance of small UAVs, is also stepping up its activities in these areas. Currently, there is already a certain "race" in the use of small UAVs, in which, given the resource capacities of the aggressor country, it will be difficult for Ukraine to maintain an advantage or even parity.

At the same time, there is another way to gain an advantage over the enemy in the field of small UAVs, namely, to focus on protecting troops from enemy small UAVs. It can be argued that the party that, in the short term, maintaining a high rate of intensification of the use of small UAVs, will be able to find and implement effective means and methods of protection against enemy small UAVs in the activities of its troops, will gain a key tactical advantage on the battlefield. Therefore, the urgent task is to identify the main problems and directions of increasing the protection of troops in the context of the enemy use of small UAVs.

Analysis of recent research and publications. An analysis of scientific publications in specialized military professional journals over the past two years, i.e. the period characterized by the intensive development of small strike UAVs and the introduction of their use on the battlefield, has shown that some attention is paid to the issue of UAVs defense [1–14]. This demonstrates that scientists understand the importance of protecting against the new threat of UAVs. However, it should be noted that the vast majority of such works cover the issues of direct counteraction to sufficiently large UAVs using anti-aircraft missile, rocket and gun systems, electronic warfare systems or large-caliber anti-aircraft machine guns as the main means of defense against enemy UAVs on the battlefield. To some extent, this indicates the desire of researchers to use existing air defense developments, which is not always an adequate approach in the context of defense against the new threat of small UAVs.

There is a lack of research in the professional scientific literature that would address the issues of systematizing activities to protect troops in the face of enemy use of small UAVs, improving the management activities of commanders and staffs in this area, changes in the tactics of warfare in view of the need for protection against small UAVs, as well as organizational and technical issues of protection of equipment and weapons, personal protection, improvement of fortifications, development of adequate means of combating small unmanned aerial vehicles in terms of mass and cost.

The purpose of the article is to identify the problematic issues and areas for improving the protection of troops in the context of the enemy use of small UAVs on the battlefield.

Summary of the main material. The emergence of the latest types of equipment and weapons has always required new organizational, engineering, technical and technological solutions, which were subsequently formalized into separate systems. Their goal was to maximize the effect of using innovations for their troops and minimize the enemy impact on their troops. Subsequently, such systems were organically integrated into existing military systems, which was accompanied by the emergence of new types and branches of troops, services, provisions of statutes and regulations, adoption of new models of equipment and weapons, introducing of training of relevant specialists, etc.

Today, the Ukrainian Defense Forces are actively developing a system aimed at maximizing using the capabilities of small UAVs to influence the enemy: a new branch of the military has emerged, new units and subunits are being formed, relevant specialists are being trained, drones are being supplied, etc. At the same time, the system for protecting troops from enemy small UAVs is significantly lagging behind, remaining the domain of mostly military and civilian enthusiasts, volunteers, and non-state oranizations that develop and purchase electronic warfare equipment, test weapons that can be used against small UAVs, equipment and positions with protective devices, create methodological literature, etc. This area requires appropriate systematization and targeted activities of state bodies, scientists and developers to minimize the enemy ability to influence the Ukrainian Defense Forces using small UAVs.

Let's outline the general features of the system of protecting troops from enemy small UAVs. The main areas of military activity that are important for the protection of troops from small UAVs are as follows:

- receiving and transmitting information about small enemy UAVs;
- actions to deprive enemy small UAVs of the ability to inflict damage or reduce such capabilities;
- measures to reduce the damage caused by enemy small UAVs or to prevent the consequences of damage.

Below, for each of these aspects, we will conduct a general analysis of the problems and opportunities for protecting troops in the context of the enemy use of small UAVs.

Receiving and transmitting information about enemy small UAVs. This aspect of the activity involves conducting reconnaissance (detection, recognition and identification) of small UAVs, targeting, warning, and information transmission.

The problems of reconnaissance of small UAVs are caused by their small size, the presence in their construction of a large number of materials with poor reflectivity, relatively small thermal and acoustic signatures, and the ability to move at low altitudes, hiding in the folds of the terrain, behind vegetation and local objects. These features make it ineffective to detect small UAVs with standard radar reconnaissance equipment of brigade-level air defense units.

A possible way to solve this problem is to assign the function of reconnaissance of enemy air assets in the form of small UAVs to low-level tactical units with the appointment of freelance observers. They should receive appropriate training: acquire the skills and abilities to conduct surveillance, in particular using

appropriate surveillance equipment, detect, recognize and identify small UAVs by acoustic signatures and visual demasking features, and provide targeting. At command and observation posts of units, it is advisable to set up observation posts equipped with modern radar and radio detectors capable of detecting small UAVs.

The transmission of small UAVs detection, targeting and warning information should be considered in the development of appropriate negotiation and command and control signal tables. Information on the air situation regarding small UAVs can be collected and processed at battalion headquarters. In addition to information from subordinate units, it is also important to receive information from adjacent units, brigade air defense units, and information on the presence and movement of friendly UAVs from the brigade strike unmanned aerial vehicle units. Based on this information, warning signals and targeting data should be generated. Given the importance and timeliness of information on small UAVs, a separate person on duty should be appointed to process it.

The next area of military activity important for protecting troops from small UAVs is *actions aimed at depriving enemy small UAVs of their capabilities to engage or reducing such capabilities.* This includes direct destruction of enemy small UAVs, suppression of control channels, destruction of repeaters and operators.

Modern weapons that can be used to defeat UAVs are divided into kinetic weapons, high-energy radiation weapons (laser and microwave) [15], and interceptors based on other UAVs. Kinetic weapons mainly include automatic guns of 20–40 mm caliber combined with electronic-optical systems for detecting and tracking targets. Such weapons, as well as laser and microwave systems, are capable of effectively engaging small UAVs at distances of up to 1–2 km. However, they have large weight and size characteristics and are expensive. Obviously, at the time of their development, it was assumed that the threat posed by UAVs would be mainly single UAVs that could be detected and destroyed at fairly long distances, and that their scope of use would be to cover large important objects. In today's reality, the majority of UAVs on the battlefield are small UAVs capable of approaching stealthily and at extremely low altitudes. In most cases, they can be detected and hit at distances ranging from tens to 100–150 m. The energy of the munitions of these systems is too excessive. In addition, the saturation of platoon and company level units with such systems is impossible for economic reasons. Such systems can be seen as an effective replacement for the outdated anti-aircraft artillery systems used in brigade air defense units.

The next of the above-mentioned weapons are UAV interceptors, which have already proven to be effective in destroying high-altitude reconnaissance UAVs. They can also be used to defeat large multi-rotor UAVs, UAV repeaters, and are even considered as an alternative means of fighting enemy combat helicopters. Specialists in the use of UAV interceptors can be part of companies of brigade strike unmanned aerial systems and perform tasks under targeting instructions from radar reconnaissance units or battalion headquarters.

The biggest problem is the defeat of small UAVs – FPV drones. Their small size, high speed, and ability to quickly change direction make it possible to defeat them only at distances of tens of meters. The only currently available means of destruction in such context may be light small arms. The light weight and size of the weapon allow the shooter to aim and track targets moving relative to him at high angular velocities. Practice shows that a shooter can inflict critical damage to an FPV drone at distances of 30–50 m [16, 17]. However, this distance is not enough to ensure the shooter's safety if the drone was moving towards him. In this case, shotguns have the best performance.

The effectiveness of countering small UAVs can be significantly improved by combining small arms with appropriate means of detection, tracking and automation of weapon guidance in a single complex [18, 19], based on the principle implemented in modern gun anti-aircraft systems. Today, there are all the technological prerequisites for the creation of such systems, so we should predict their appearance in the near future.

However, until these systems begin to appear and spread, small arms remain the only possible means of defeating FPV drones. Therefore, research and development aimed at improving the effectiveness of small arms against small UAVs so that shooters can engage them at longer distances is currently a pressing issue.

First and foremost, firing techniques and rules, as well as aiming methods and sighting devices, need to be improved, as most common small arms are usually designed for cases where the angle of the target is 30°, in some cases up to 60°. Firing at small UAVs often requires much wider angles, up to and including zenith firing. Under such conditions, the use of standard sights results in a significant shift of the point of impact from the point of aim [20]. The next area of research and development is the improvement of small arms ammunition.

Research is needed on the construction of the fire system and fire control, in particular: determining the relevant zones and sectors of fire, reconnaissance of relevant targets, assessing their importance, determining the order of destruction, selecting the type of weapon and ammunition, type and method of fire,

issuing commands to open fire, observing the results of fire and adjusting fire, maneuvering fire, controlling ammunition consumption, etc., as well as education and training of relevant categories of personnel.

Important measures to protect troops from small enemy UAVs include reconnaissance and destruction of enemy UAV operators. Such measures are implemented by artillery and other means of destruction based on targeting obtained through electronic and aerial reconnaissance.

The next measure to counter small enemy UAVs is to influence the control channels of enemy UAVs using electronic warfare (EW). Although widely used today as a means of defense, electronic warfare means will gradually lose their effectiveness as means and methods of circumventing them develop [21]. They are completely ineffective in the case of UAVs operating in autonomous mode [22] or controlling UAVs via a fiber-optic channel [23]. The use of electronic warfare equipment can create the illusion of security, as it is impossible to reliably predict its effectiveness in each case. In addition, the use of electronic warfare equipment is in fact a major disguising factor. A source of powerful electromagnetic radiation can be used to target advanced munitions or UAVs. Therefore, electronic warfare equipment should be considered as an additional means of protection in the context of enemy use of small UAVs. Their use in units should also be subject to regulation, in particular prevent interference with the use of their own electronic equipment, communications and control channels of friendly UAVs.

The next identified area of military activity that can play a significant role in protecting troops from small UAVs is *measures to reduce damage from enemy small UAVs or prevent the consequences of damage*. In order to reduce potential losses, such measures should include improving the engineering equipment of positions and defensive structures, equipping machinery with passive protection means, acting on warning signals, and adapting tactics (methods of performing tasks).

The engineering equipment of positions and defenses has long been designed to protect against fragments and bullets that have a straight or close to straight flight path. FPV drones can appear suddenly, follow complex trajectories, pass through small openings, etc. It is necessary to study the vulnerability of typical fortifications with a view to their further improvement in order to increase the protection of personnel, equipment, weapons and materiel, as well as the ability to continuously monitor and conducting fire with emergency fire weapons in context of enemy use of small UAVs.

Today, there are a lot of options for equipping machinery with protective grilles, nets, canopies, etc. Such designs are mostly handmade, so it is impossible to assess their effectiveness. It is desirable that protective equipment for machinery be manufactured on the basis of standardized and certified samples that have undergone appropriate research, design and testing stages in the process of their creation.

In order to take timely measures to disperse, shelter personnel, equipment, material resources, prepare firepower for firing, use electronic warfare and other measures aimed at reducing the possible impact of the enemy use of small UAVs, it is necessary to provide appropriate warning signals, means and methods of their presentation, and to work out calculations of actions on such signals.

Techniques and methods of performing tasks by units in different conditions should be analyzed in terms of the vulnerability of personnel and equipment to the use of small UAVs by the enemy. Based on this analysis, the relevant techniques and methods of performing tasks should be improved, if possible, to reduce the vulnerability of personnel and equipment.

Conclusions

The rapid and widespread use of small unmanned aerial vehicles technologies on the battlefield has led to the rapid paralysis of traditional tactics of conventional warfare. The massive use of small reconnaissance and strike unmanned aerial vehicles by enemies causes significant difficulties for both the offensive and defensive sides. At the same time, even with a certain parity in the use of small unmanned aerial vehicles, the aggressor country has advantages due to the number of manpower and low sensitivity to losses.

In such circumstances, Ukrainian Defense Forces need to achieve key advantages in the context of using small unmanned aerial vehicles on the battlefield. To do this, it is important not only to intensify its own activities in the use of small unmanned aerial vehicles (in which the enemy can easily maintain parity due to significant resources), but also to direct efforts to ensure the protection of its own troops from enemy small unmanned aerial vehicles. This area requires appropriate systematization and targeted activities of state bodies, researchers and developers to build a modern system of troop protection in order to minimize the enemy ability to influence the Ukrainian Defense Forces with the use of small unmanned aerial vehicles.

Building an appropriate system for protecting troops, it is important to take into account the following areas of military activity that are relevant to protecting troops from small unmanned aerial vehicles:

- receiving and transmitting information about small enemy unmanned aerial vehicles;
- actions to deprive enemy small UAVs of their capabilities to defeat or reduce such capabilities;
- measures to reduce the damage caused by enemy small UAVs or to prevent the consequences of damage.

In these areas of activity, it is necessary to analyze problematic issues and identify ways to improve the protection of troops in the context of enemy use of small unmanned aerial vehicles. The results of research and development should include amendments to the relevant military regulations and guidelines, proposals for organizational and staffing changes, organizational and methodological documents for training relevant specialists, tactical and technical requirements for improving relevant models of machinery, weapons, equipment, etc.

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ПРОБЛЕМНІ ПИТАННЯ ТА ШЛЯХИ ПІДВИЩЕННЯ ЗАХИЩЕНОСТІ ВІЙСЬК В УМОВАХ СТРІМКОГО РОЗВИТКУ ТЕНДЕНЦІЇ ВИКОРИСТАННЯ МАЛИХ БЕЗПІЛОТНИХ ЛІТАЛЬНИХ АПАРАТІВ ПІД ЧАС ВЕДЕННЯ БОЙОВИХ ДІЙ

На основі проведеного аналізу зроблено висновок про вплив використання малих безпілотних літальних апаратів на полі бою на можливості супротивників. Обґрунтовано необхідність набуття силами оборони України переваги в контексті використання малих безпілотних літальних апаратів на полі бою.

З'ясовано, що отримання таких переваг передбачає не тільки інтенсифікацію зусиль у використанні власних малих безпілотних літальних апаратів, але і їх зосередження на захисті військ від малих безпілотних літальних апаратів противника. Зазначений напрям потребує відповідної систематизації та цілеспрямованої діяльності державних органів, науковців і розробників задля мінімізації можливостей противника щодо впливу на сили оборони України з використанням малих безпілотних літальних апаратів.

Окреслено головні напрями військової діяльності, які мають значення для захисту військ від малих безпілотних літальних апаратів: отримання та передавання інформації стосовно малих безпілотних літальних апаратів противника; дії щодо позбавлення можливостей малих безпілотних літальних апаратів противника завдавати ураження або зменшення таких можливостей; заходи зі зменшення шкоди від ураження малими безпілотними літальними апаратами противника або запобігання наслідкам ураження.

З огляду на це здійснено аналіз проблемних питань і визначено шляхи поліпшення захищеності військ в умовах застосування противником малих безпілотних літальних апаратів.

Ключові слова: *малі безпілотні літальні апарати, захищеність військ, організаційні й технічні заходи із захисту військ.*

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