

Serhii Taranets

*Philosophy Doctor in History and
Archaeology
General Staff of the Armed Forces of Ukraine
Kiev, Ukraine
email: korsak111@gmail.com
ORCID: 0000-0002-0979-7496*

Artem Fylypenko

*Scientific & Research Center of the Armed
Forces of Ukraine "The State Oceanarium"
Odessa, Ukraine
email: fylypenko.niss@gmail.com
ORCID: 0000-0002-8283-5313*

THE ARTILLERY APPLICATION BY THE DEFENSE FORCES OF UKRAINE DURING THE RUSSIAN-UKRAINIAN WAR: ASSESSMENTS, TRENDS, USE OF INTERNATIONAL MILITARY ASSISTANCE

Abstract. *Artillery continues to play a key role in the Russian-Ukrainian war, remaining the main tool for enemy's personnel and equipment destruction. The use of new technologies, in particular, unmanned aerial vehicles, significantly affected the tactics of artillery application by the opposing sides.*

At the beginning of the full-scale Russian aggression, the Ukrainian Defense Forces used mainly Soviet weapons, however, the loss of artillery systems, their failure due to intensive operation, and the shortage of Soviet-style ammunition made the issue of obtaining both new artillery systems and ammunition from partner states extremely relevant, in particular, shells of the most common NATO 155 mm caliber and long-range missiles. New artillery systems have proven themselves to be the best, however, in the process of their operation, some organizational and technical problems have emerged that need to be solved.

European Union countries agreed to a 2 billion euro plan to send 1 million artillery rounds to Ukraine over the next year, but this plan met some obstacles. It is concluded that the success of efforts of the Defense Forces of Ukraine in repelling Russian aggression and liberating the temporarily occupied territories depends on solving obvious problematic issues and ensuring a stable supply of artillery systems and ammunition from partner states.

Keywords: *Russian-Ukrainian war, large-scale invasion of the Russian Federation to Ukraine, missile and artillery troops, artillery, artillery ammunition, Ukraine Defense Contact Group "Ramstein"*

Introduction

The large-scale invasion of the Russian Federation (hereinafter referred to as the RF) into Ukraine has significantly influenced assessments of the nature of modern wars. Contrary to the forecasts of analysts who saw these wars as fast-paced, maneuverable, and high-tech, the Russian-Ukrainian war has made us recall the classic wars of the 20th century with a clearly defined front line, the construction of deep-echelon defense, the dense use of engineering and mine-explosive barriers, and the widespread use of counter-battery warfare. Accordingly, the requirements for weapons and military equipment and their practical application have also undergone changes.

Due to the massive use of unmanned aerial vehicles, the Russian-Ukrainian war is called the "drone war". However, it can be called the "artillery war" with the same confidence. According to military experts, it was the Rocket (Missile) and Tube Artillery Forces of the Ukrainian Defense Forces that accounted for 70–80% of the fire damage to enemy manpower and equipment in the

first two years of the war [1]. And only since 2024 has this ratio changed in favor of various types of UAVs. Thus, according to research by Russian military doctors, 75% of personnel injuries were caused by UAVs, and only 20% by artillery fire [2].

Under conditions where the actions of the opposing sides' aviation were limited due to an effective and developed air defense system, artillery became a key element in ensuring successful offensive and defensive actions. The widespread use of various types of UAVs and, in particular, FPV strike drones by the Ukrainian Defense Forces also became a response, primarily, to the shortage of artillery ammunition.

Rocket (Missile) and Tube Artillery Forces in the Russian-Ukrainian war are recognized by military experts from militarily developed countries as a significant factor in the conduct of combat. In particular, the Chief of Staff of the US Army, General Randy George, in an interview with the publication "DefenceNews", stated the need to adapt the American strategy for the use of artillery, taking into account the experience of combat in Ukraine, and noted: "everything we see in Ukraine concerns the relevance of high-precision fire, but the main killer on the battlefield remains conventional artillery, high-explosive fragmentation artillery" [3]. National Defense Magazine, published by the National Defense Industries Association of the United States, noted: "Ukraine may offer a glimpse into the future of artillery. As Russia's previous blitzkrieg has degenerated into a trench warfare, the conflict has become an infantryman's nightmare but also a gunner's laboratory", noting that while artillery is less flexible than aviation, "it offers firepower 24/7 under all weather conditions and without relying on air bases vulnerable to bombing" [4].

Analysis of recent research and publications. Among the works devoted to this topic, currently, studies of a practical-analytical nature prevail, the task of which is to determine, based on the analysis of combat operations, the changes that have occurred in the practice of using artillery and to prepare recommendations aimed at improving the tactics of using artillery weapons. Among them are works devoted to both the direct study of the combat of the Rocket (Missile) and Tube Artillery Forces, and studies that study the role of this branch of the army in a broader context. Among the first, the work of S. Baranov and S. Taranets "Thunder from Heaven" should be highlighted. The impact of the use of R(M)&TA units on the results of combat operations. The first stage, February 24 – April 2022. Stopping the advance of occupation troops and restoring territorial integrity in the North of Ukraine" [1], appendix "Features of application and comparative characteristics of rocket (missile) and tube artillery systems of the Armed Forces of Ukraine and the Russian Federation" in the publication "Military-Historical Description of the Russian-Ukrainian War (July 2022)" [5, p. 154-165]. Some aspects of the artillery weapons operation provided to Ukraine as part of international military-technical assistance are covered in the publications of O. Danylyuk [6], O. Ulusyan [7], S. Taranets, I. Kosyak [8] and A. Filipenko [9].

Also, the analysis of the artillery use in the Russian-Ukrainian war is contained in analytical materials prepared by the Royal United Services Institute for Defence and Security Studies (RUSI). In particular, it is worth highlighting the analytical report prepared by the team of authors "Preliminary lessons from conducting conventional military operations in the context of the Russian invasion to Ukraine: February-July 2022" [10], publications by Patrick Hinton [11] and Sam Cranny-Evans [12].

The purpose of the article is to investigate the role of artillery during the Russian-Ukrainian war and the main trends in its use, to identify problematic issues in the operation of artillery weapons provided within the framework of international military-technical assistance. The relevance of the article is due to the need to analyze the changes that have occurred in the use of rocket (missile) and tube artillery weapons during the Russian-Ukrainian war. Special emphasis is placed on the experience of operating samples of artillery weapons provided by partner states within the framework of international military-technical assistance. The chronological boundaries of the study cover the period from February 2022 to the end of 2023.

Presentation of the main material

It should be noted several important factors that largely determined the specifics of the use of artillery in the first stage of the large-scale invasion of the Russian Federation into Ukraine, which lasted from February 24 to April 2022 [1].

The enemy had a significant advantage over the Defense Forces of Ukraine in terms of missile and artillery weapons. At the beginning of the Russian aggression against Ukraine in 2014, the ratio of the number of Ukrainian and Russian artillery was approximately 1:10. Over more than nine years, it was possible to significantly restore the potential and combat capabilities of the Ukrainian Rocket (Missile) and Tube Artillery Forces (hereinafter referred to as the RM&TA), which had suffered significant losses in previous years as a result of ill-conceived, and sometimes frankly harmful reforms of the Armed Forces of Ukraine. As of February 2022, the RM&TA of the Defense Forces of Ukraine numbered 10 brigades and one regiment in the Ground Forces, as well as one brigade and one regiment in the Naval Forces. All mechanized brigades of the Ground Forces, as well as all brigades of the Marine Corps and the Airborne Assault Forces, received their own brigade artillery groups (in some cases, artillery battalions). The Armed Forces of Ukraine were armed with about 1,176 tube artillery systems (742 units of 152 mm caliber, 421 units of 122 mm caliber and 13 units of 203 mm caliber), about 1,680 multiple launch rocket systems of all calibers, as well as about 40 “Tochka-U” tactical missile systems [1].

As the authors of the report “Preliminary Lessons from Conducting Conventional Military Operations in the Context of Russia’s Invasion to Ukraine: February-July 2022” note, at the beginning of the large-scale invasion: “the difference in the number of Russian and Ukrainian artillery was not that significant”: 2,433 tube artillery systems versus 1,176, as well as 3,547 MLRS versus 1,680 [10]. Thus, the ratio was 2:1 for tube artillery systems and 2.1:1 for MLRS, respectively.

However, the real advantage of the occupiers in artillery weapons was much greater, thanks to the significant number of artillery systems in storage and, most importantly, significant amounts of ammunition, which quickly became scarce due to intensive hostilities.

At the beginning of the Russian large-scale invasion (until April 2022), the Ukrainian Defense Forces used Soviet-made artillery systems, a significant part of which was in unsatisfactory technical condition. The intensity of hostilities led to accelerated wear of artillery system parts and their frequent failure, as well as to a decrease in ammunition stocks, which were already significantly depleted both during the ATO (Joint Forces Operation) and as a result of sabotage (detonations) at warehouses and arsenals. Thus, since 2015 alone, six arsenals and ammunition depots with a total volume of 210 thousand tons have been destroyed in Ukraine [1].

Under such conditions, Ukrainian artillerymen performed missions mainly thanks to non-standard solutions, the organization of effective reconnaissance, the use of the automated combat control system “Kropyva” (Ukrainian software for intelligent mapping and calculation of firing positions). The use of “Kropyva” reduced the time for the deployment of artillery units and their readiness to open fire and perform fire missions by 80%, and the time indicators for the destruction of unplanned targets were reduced by two-thirds, the time for opening fire for conducting counter-battery combat by 90%. At the same time, the use of modern unmanned aerial vehicles (hereinafter – UAVs), including civilian quadcopters, allowed significantly improving the implementation of reconnaissance and fire adjustment.

In general, with the beginning of the large-scale invasion, it was UAVs that became the main means of reconnaissance and fire adjustment, in contrast to the period of the ATO (JFO) where optical, sound and radar reconnaissance equipment prevailed. Among the reasons are the rapidity of combat operations, the high dynamics of changes in the location of forces and equipment, the ability to observe the battlefield (detect the enemy and adjust fire) in real time and at long distances, regardless of the landscape and ground obstacles. as well as the obvious advantages of aerial reconnaissance.

However, a serious problem for conducting effective artillery reconnaissance for Ukrainian artillerymen was the more active use of electronic warfare (EW) by the enemy. At the beginning of the large-scale invasion, the impact of Russian EW on Ukrainian artillery reconnaissance equipment and UAVs was insignificant, but later their importance increased, which led to an increase in the number of Ukrainian UAV losses.

In general, the use of UAVs (reconnaissance and strike), modern counter-battery radars, and satellite surveillance data have significantly affected the practice of using artillery. In particular, the practice of placing artillery in open terrain, concentrating forces and equipment in certain areas, and conducting prolonged fire from one firing position has become problematic.

To avoid premature detection by the enemy, artillery units were forced to take additional measures to camouflage firing positions, to avoid operations by large units. The practice of operations by firing groups, which could consist of one or two guns, the control of which was entrusted to the firing platoon commander, the senior officer of the battery or the battery commander - the commander of the firing group, became widespread.

At the first stage of repelling a large-scale invasion, the problems of Ukrainian artillery, namely: replenishing the losses of artillery systems and increasing their number, establishing their repair, providing ammunition, were partially solved by supplying partner states with Soviet-style artillery systems and ammunition that were in service or in storage. In particular, Ukraine was supplied with 122-mm towed howitzers D-30, 122-mm self-propelled guns 2S1 "Gvozdika", MLRS BM-21 "Grad". However, given the enemy's quantitative superiority in artillery systems and the ability to replenish them, such a solution was incomplete. This also concerned the need for Soviet-style caliber shells. In addition to the limited quantity, foreign-made ammunition (152 and 122 mm) could differ in some characteristics, for example, powder propelling charge, from standard Soviet-made ammunition, which led to certain problems when firing them.

In addition, the conditions of combat put forward new requirements for artillery systems, the main of which were: 1) mobility: the ability to change position quickly (here the advantage of self-propelled artillery systems (hereinafter referred to as SPAS) over towed models was revealed); 2) high accuracy: the ability to guarantee target destruction with a limited amount of ammunition; 3) an increased level of autonomy. The vast majority of Soviet-made artillery models did not meet the specified criteria. The production capacities of the partner states were focused on the production of shells of the most common NATO caliber – 155 mm, but they had a significant amount of 152 and 122 mm ammunition in storage. Under such conditions, the supply of Soviet-made artillery systems by the partner states seemed to be the optimal solution, which allowed to neutralize the enemy's quantitative advantage and ensured a stable supply of ammunition.

Starting from the second stage of repelling the large-scale invasion of the Russian Federation into Ukraine (May – August 2022), samples of foreign-made artillery weapons began to arrive in Ukraine from partner states, including both modern artillery systems (MLRS M142 HIMARS and M270 MLRS, 155-mm self-propelled artillery systems AHS "Krab", "Panzerhaubitze" 2000, CAESAR, "Zuzana-2", M777 towed guns, and others), as well as earlier systems from the second half of the 20th century (SPAS M109, "DANA", AS-90, towed and self-propelled howitzers L119, FH70, TRF1, etc.) [6; 24].

To coordinate directions and efforts to provide international military-technical assistance, on April 26, 2022, a permanent Contact Group on Defense Issues of Ukraine was established under the chairmanship of the defense ministers of the partner states in the "Ramstein" format [13].

In total, since April 2022, the Defense Forces of Ukraine have received more than 600 155 mm artillery systems of all types, 38 M142 HIMARS MLRS and more than 25 M270 MLRS of various modifications [14].

The use of foreign-made artillery weapons significantly changed the course of combat in favor of the Ukrainian Defense Forces. Thanks to their appearance, it was possible to achieve conditional parity with the enemy, contrasting the quantity of artillery systems with quality.

The advantages of the samples of missile and artillery weapons provided as part of international military-technical assistance were:

– superior firing range, which allowed firing beyond the firing range of russian artillery. Thus, the M777 towed howitzer with a barrel length of 39 calibers (5.08 m) was able to inflict damage with high accuracy at a range of:

M107 shells – up to 24 km; shell with improved aerodynamic shape and, accordingly, increased range ERFB (Extended Range Full Bore) – up to 30 km;

with high-precision “Excalibur” shells – up to 40 km.

This made it possible to dominate practically all models of russian artillery weapons of the corresponding class during counter-battery combat.

At the same time, one of the most powerful examples of artillery weapons in service with the russian military formations – the 152-mm towed howitzer 2A65 “Msta-B” with a barrel length of 7.2 m – has a maximum firing range of active-reactive shells of up to 28.9 km.

The difference in the firing range of foreign self-propelled artillery systems compared to one of the most powerful and long-range models of self-propelled artillery installations in service with russian military formations – 2S19 “Msta-S” (see Table 1) was even greater, as well as other characteristics that influenced the course of combat:

– higher shooting accuracy compared to Soviet models;
 – use of a wide range of ammunition, including high-precision shells;
 – an effective loading system, in particular, the presence of automatic or semi-automatic loading systems, which allowed for a high rate of fire.

Table 1

Comparative characteristics of the 2S19 “Msta-S” self-propelled guns with the self-propelled guns received as part of international military-technical assistance

	2S19 “Msta-S” (modification 2S19M2)	PzH 2000	CEASAR	AHS Krab
Start of mass production	1988 (2012)	2000	2002	2008
Combat weight, t	42 (43.2)	55.3	18	48
Crew, people	5	5	4-5	5
Gun caliber, mm	152	155	155	155
Barrel length, calibers	47	52	52	52
Vertical guidance angle, degrees	-4...+68	-2.5...+65	-3...+66	-3.5...+70
Horizontal guidance angle, degrees	360	360	-48...+48	360
Ammunition carried, p.	50	60	18	40
Maximum firing range of a high-explosive fragmentation projectile, km	24.7	30	42 (ERFB)	330
Maximum firing range of an active-reactive projectile	29	40	55	-
Maximum firing range of a guided artillery projectile	20 (25)	-	49	40
Combat rate of fire	7-8 (10)	10	6-8	6
Maximum speed on the highway, km/h	60	60	80	60
Highway range, km	500	420	600	400

In addition, the samples of self-propelled artillery systems provided by partner states demonstrated other advantages in their use:

- high maneuverability;
- high level of autonomy due to the presence of electronic software (computer) and modern satellite navigation systems;
- high level of crew protection;
- opportunities for comfortable crew work due to better ergonomics of the fighting compartment;
- high speed of gun aiming and execution of fire missions, the ability to change settings for targets quickly. For example, the CEASAR self-propelled gun is equipped with a “SIGMA 30” fire control system (hereinafter referred to as SFC), which includes a “NAVSTAR” navigation system receiver. The SFC has a radar for measuring the initial velocity, a built-in ballistic control unit and an automatic projectile feeding system [15].

Thanks to the emergence of modern long-range artillery systems, it has become possible to inflict fire damage on the entire tactical depth of the enemy’s battle formations, to destroy command posts, logistics, and storage locations for ammunition and fuel.

Thus, at the end of June 2022, the headquarters of one of the Russian army units in the city of Izyum was destroyed by fire from the M142 HIMARS MLRS [16]. In July 2022, strikes from the same system managed to destroy an ammunition depot in Alchevsk near Luhansk [17]. Systematic strikes by the M142 HIMARS MLRS on the Antonivskyi Bridge across the Dnieper River became one of the factors (along with the disruption of the control system and the disorganization of the logistics support system of the occupation forces) that contributed to the liberation of the city of Kherson and the right-bank districts of the Kherson region in September–October 2022.

The use of 155-mm M777 towed howitzers was also effective, as evidenced by specific examples of their use. On June 12, 2022, in the area of the village of Dergachi, Kharkiv region, at least 15 servicemen of the occupation forces were destroyed with the first shot [6; 25–26], on June 27, 2022, in the area of the village of Tsyrkuny, Kharkiv region, during counter-battery combat, only according to confirmed data, 4 enemy artillery systems with crews and ammunition were destroyed [6; 26]. And these are only isolated examples of the effectiveness of the use of foreign samples of artillery weapons provided by partner states in a huge volume of effective execution of fire missions by Ukrainian artillerymen during combat.

At the same time, the combat use of artillery systems that were supplied to the Defense Forces of Ukraine as part of international military-technical assistance revealed a number of problematic issues that complicated their operation.

The problematic issues may be conditionally divided into two groups. The first includes problems that arose during the operation of most systems, and the second includes the specific features of each artillery weapon model that were taken into account during further operation.

All missile and artillery systems supplied within the framework of the international MTA were characterized by incomplete or absent spare parts (spare parts, tools and accessories), and generally low availability of spare parts. This limited the full maintenance and use of the systems, and led to long periods of artillery weapons being repaired.

Another common problem is the unadaptability and sensitivity to intense fire. For example, the standard mode of operation of the German self-propelled gun “PzH 2000” provides for up to 100 rounds per day. With a rate of fire of “PzH 2000” at a constant rate of 8 rounds per minute (maximum rate up to 12), this is only 12.5 minutes of continuous fire per day [18].

This is largely due to the design features of the guns provided to Ukraine within the framework of international MTA, as well as the practice of their previous use. Armed conflicts, which have mainly been waged in recent times with the involvement of NATO countries, have been focused on combating illegal armed formations and the resistance movement, rather than full-fledged conventional wars of high intensity with the involvement of regular armed forces

(formations). Accordingly, artillery was used in more favorable conditions than under the conditions of the Russian-Ukrainian war.

In addition, each of the artillery weapons samples had specific problematic issues that were identified during combat use during the repulsion of the large-scale aggression of the Russian Federation to Ukraine.

Thus, the Ukrainian Defense Forces received the self-propelled howitzers FH 70, jointly produced by Great Britain, Germany and Italy, and TRF 1, produced by France. Adopted in the late 1970s, they to some extent embodied the then views on the use of artillery weapons. Both guns differ in significant weight: 9.3 tons for the FH 70 and 10 tons for the TRF 1 (for comparison, the combat weight of the more modern M777, which has the same caliber, is 4.2 tons). The presence of an auxiliary power unit increases the mobility of the gun on the battlefield, but at the same time requires additional technical maintenance. In addition, if the power unit fails on the FH 70 howitzer, it is impossible to control the hydraulic system for raising/lowering the wheels, and in the absence of pressure in the hydraulic system, evacuation of the howitzer is practically impossible [9].

The M777 howitzer, which has proven itself in the best way due to its high accuracy and maneuverability (achieved thanks to the use of titanium and aluminum in the design, which affected the weight of the system), also turned out to be not without certain shortcomings. Among them, in particular, the vulnerability of the hydropneumatic system and other parts to external influences, including shrapnel damage, the sensitivity of the loading system, excessive contamination of the “mirror” of the bolt wedge, etc. [19, p. 36].

The considerable weight and low cross-country ability of the self-propelled guns are also one of the problems. In particular, for the self-propelled guns “PzH 2000”, a significant load on the platform, in addition to low cross-country ability on viscous soil, leads to premature wear and failure of the rollers and rubber tires [9, p. 101].

For such self-propelled guns as “PzH 2000”, CAESAR, AHS “Krab”, the saturation of electronics, along with significant advantages, also creates problems in operation. In particular, there were frequent cases of failure of complex electronic systems, software failures, etc., which made it impossible to perform combat missions and their further use for their intended purpose until the completion of repair work.

In general, statistics show that the main part of SPAS malfunctions falls on the artillery part – 23%, on the chassis – 16%, on fire control systems – 16%, and for towed artillery systems, the failure of the artillery part – 76% [7; 25-26].

The rearmament of artillery units of the Defense Forces of Ukraine to Western models of rocket and artillery weapons has made it possible to use a wide range of NATO-style ammunition, including high-precision and cluster munitions. The most famous of them are the 155-mm M982 “Excalibur” shells, which were actively used both during defensive and offensive operations (especially during the defense of the cities of Soledar and Bakhmut and the Ukrainian counteroffensive in the southern regions of Ukraine in 2023) [6; 27].

In addition to high-precision shells, partner states also supplied cluster munitions to the Ukrainian Defense Forces. On July 7, 2023, the US National Security Advisor Jake Sullivan announced the transfer of this type of munitions to Ukraine, but only for the defense of its territory [20].

The 155-mm M483A1 cluster munitions used to carry out fire missions from the M777 towed howitzer showed high efficiency. Only on August 30, 2023, during the liberation of the village of Staromayorske, a platoon of 120-mm mortars along with the crew was destroyed by just four such munitions [6; 28].

At the same time, the intensity of the use of ammunition, including 155-caliber shells, led to a fairly rapid depletion of existing stocks and forced Western countries to increase their production. NATO Secretary General Jens Stoltenberg emphasized in March 2023 that Ukraine

uses from 4 to 7 thousand shells per day, compared to 20 thousand used by the Russian Federation [21].

On February 14, 2023, the United States announced contracts worth \$522 million with Northrop Grumman Systems and Global Military Products to produce artillery ammunition for Ukraine. The contracts were funded by the U.S. government's Ukraine Security Initiative program, and deliveries of the ammunition to Ukraine began in March 2023 [22]. In total, since the start of the full-scale invasion, the US has provided Ukraine with over 2 million 155 mm shells [23].

Increasing ammunition production for Ukraine has also become one of the key areas of support from the European Union (hereinafter referred to as the EU). At an informal meeting of defense ministers of the EU member states in Stockholm on March 8, 2023, Josep Borrell (High Representative of the European Union for Foreign Affairs and Security Policy) presented a proposal (supported by the meeting participants) to increase the production of ammunition worth 2 billion euros. The proposal consisted of three parts. The first of them provided for the allocation of 1 billion euros from the European Peace Facility (hereinafter referred to as the EPF) to replenish the national reserves of the EU countries that were ready to transfer ammunition to Ukraine. The second was the development of a joint coordinated approach to the procurement of artillery shells to replenish their own stocks and provide ammunition to Ukraine in the medium term through the European Defense Agency. According to the plan, such a collective approach was supposed to help reduce ammunition prices and shorten their delivery times. For this, it was proposed to allocate another 1 billion euros from the EPF. The third part of the plan was to increase the capabilities of the defense industry of EU countries to meet their needs [24].

On March 20, 2023, at a meeting of EU defense ministers in Brussels, they supported a document on the supply of one million artillery shells to Ukraine, which were to arrive within a year. 15 industrial enterprises in 11 EU countries were identified for the production of 155-mm artillery shells according to NATO standards and five manufacturers of 152-mm Soviet-style ammunition [25].

On June 1, 2023, the European Parliament adopted the Act in Support of Ammunition Production (ASAP). The legislative proposal came from the European Commission and contained measures to urgently strengthen the ability of the EU defense industry to supply Ukraine with artillery ammunition and missiles. To increase their production, 500 million euros were attracted from EU funds. The funds were allocated for the creation of new production facilities, optimization, expansion, modernization or re-profiling of existing facilities, retraining and upgrading of workers, and the establishment of cross-border industrial partnerships, including both public and private, in order to ensure access to strategic components and raw materials [26].

At the end of September 2023, it was reported that 7 EU countries had ordered 155 mm ammunition in accordance with the scheme approved in March at a meeting of EU defense ministers. According to the explanations of the European Defense Agency (hereinafter – EDA), the contracts reached concerned both complete rounds and individual components (shells, cases, fuses, charges and primers, etc.). The EDA refused to name the countries or indicate the volumes of the orders, citing the fact that much of the information is confidential.

In response to inquiries from Reuters (which published this information), Lithuania and Luxembourg reported that they were among the seven countries. The Luxembourg Ministry of Defense, in particular, announced the allocation of an additional 2 million euros for the purchase. The shells were to meet the needs of artillery systems, which were most widely used by the Ukrainian Defense Forces (mainly CAESAR, AHS "Krab", "PzH 2000", "Zuzana" and others) [27].

However, in October 2023, it became known that the European Union was falling behind on its plan to provide Ukraine with one million artillery shells by March 2024. According to sources and documents reviewed by Bloomberg, this initiative at that time provided about 30% of the planned volume [28].

A negative factor in providing artillery systems with shells is their diversity. While most countries have 2-3 types of artillery weapons in service, Ukraine has about 17, and accordingly, the problem of providing these systems with standard ammunition arises, as this affects the effectiveness of firing.

Artillery also played a decisive role during the counteroffensive of the Ukrainian Defense Forces, which began in the summer of 2023. In this context, the assessment given to the Ukrainian Defense Forces by experts from the Royal United Defense Research Institute (RUSI) from the United Kingdom is significant. In their report on the Ukrainian counteroffensive, it was noted that how far the Ukrainian Defense Forces managed to advance depended on fire advantage: “The advantage over the russians in range, combined with better means of enemy artillery detecting and conducting counter-battery combat, is an important advantage for Ukraine. This advantage is limited in its duration by the serviceability of Ukrainian artillery systems, the availability of interchangeable barrels and the continued supply of 155-mm ammunition” [29]. Therefore, investments by Ukraine’s international partners in ensuring a stable supply of artillery, which is more limited in number of types and at the same time in larger volumes, are extremely important. Otherwise, it could undermine Ukraine’s future progress. It is also necessary to accelerate the implementation of methods to protect artillery systems from Lancet strike UAVs, other loitering munitions, and FPV drones [29].

Conclusions

An analysis of the experience of artillery application during the russian-Ukrainian war allows us to draw the following conclusions.

1. Artillery remains the main means of defeating manpower and equipment, including the entire tactical depth of the enemy's battle formation. Despite the use of high-precision artillery ammunition, the latest missile weapons, FPV drones and other types of UAVs, the main burden falls on “classic” conventional barrel artillery and multiple launch rocket systems.

2. Aerial reconnaissance (especially with the help of UAVs), modern artillery counter-battery radars, increase the capabilities of detecting targets and significantly improve the possibilities of fire adjustment and counter-battery combat. At the same time, the presence of the specified reconnaissance means by the enemy and subsequently the active use of FPV drones significantly limited the capabilities of its artillery to concentrate systems in a limited area and conduct fire from one firing position for a long time, require the dispersion of artillery systems, increase the requirements for the mobility of artillery systems and their accuracy. Self-propelled artillery systems have confirmed their advantages over towed artillery systems, however, the organization of artillery will require a multi-level balanced approach, taking into account different systems and the use of different types of ammunition.

3. The effectiveness of artillery in modern conditions of high-intensity warfare continues to depend directly on the available volumes of ammunition. Accordingly, both Ukraine and the partner states supplying it with artillery weapons have faced the problem of increasing the production of shells both to meet the needs of the Ukrainian Defense Forces and to form reserves for the armies of NATO member states.

4. The russian-Ukrainian war accelerated the transition of the Ukrainian Defense Forces to the use of artillery systems developed and adopted in NATO member states using ammunition of the most common caliber in NATO, 155 mm. The operation and combat use of artillery weapons samples provided to Ukraine within the framework of international military-technical assistance allowed us to identify both the strengths of these systems and problematic issues. In particular, the unsuitability of these systems for conducting intensive fire in the conditions of a modern high-intensity conventional war, the insufficient cross-country ability of some self-propelled artillery installations, the insecurity and vulnerability of the main components and structures in towed artillery systems were revealed.

5. Among the areas of development of the Rocket (Missile) and Tube Artillery Forces of the Defense Forces of Ukraine, the following should be highlighted:

- a certain unification of artillery systems entering service with the Defense Forces of Ukraine as part of international military-technical assistance (adopting a limited number of models) will avoid problems with the provision of spare parts, maintenance, repair work, and provision of regular ammunition;
- training repair teams to repair artillery systems received from partner countries, providing artillery units with the necessary technical documentation, operating instructions, etc.;
- taking into account the experience gained in the operation and combat use of artillery systems received from partner states in the preparation of artillery calculations;
- improving the supply of spare parts, creating joint ventures for the production of components for artillery systems or the production of some components at Ukrainian enterprises;
- strengthening the protection of artillery systems from loitering munitions and FPV drones by expanding the use of electronic warfare systems and improving camouflage measures.

References

1. Baranov S., Taranets S. "Thunder from Heaven". The impact of the use of RviA units on the results of combat operations. The first stage (February 24 - April 2022). Stopping the advance of occupation troops and restoring territorial integrity in Northern Ukraine. 15 p. URL: https://armyinform.com.ua/wp-content/uploads/2023/03/grim_z_nebes-1.pdf.
2. Russian doctors stated that 75% of the wounded occupiers received these injuries as a result of attacks by Ukrainian drones. URL: <https://politarena.ua/rosiyski-medyky-zaiavyly-shcho-75-poranenykh-okupantiv-distaly-tsi-travmy-vnaslidok-atak-ukrainskykh-droniv-95525/>.
3. Jen Judson Change of plans: US Army embraces lessons learned from war in Ukraine. Defense News, 09.10.2023. URL: <https://www.defensenews.com/land/2023/10/09/change-of-plans-us-army-embraces-lessons-learned-from-war-in-ukraine/>.
4. Michael Peck Ukraine war proves big guns are back. National Defense Magazine, 16.09.2023. URL: <https://www.nationaldefensemagazine.org/articles/2022/9/16/analysis-ukraine-war-proves-big-guns-are-back>.
5. Military-historical description of the Russian-Ukrainian war (July 2022). Kyiv: General Staff of the Armed Forces of Ukraine, 2022. 163 p.
6. Danylyuk O.P. The influence of the military equipment provided by the partner countries on the course and results of the hostilities. *Problematic issues of organizing international military material and technical assistance to the Defense Forces of Ukraine during the repulsion of the large-scale armed aggression of the Russian Federation*: collection of materials of the scientific and practical seminar, October 6, 2023. Kyiv: Central Military District of the Armed Forces of Ukraine, 2023. P. 23-29.
7. Ulusyan O.V. The state of weapons and military equipment, problematic issues and ways to solve them regarding the system of support for weapons and military equipment in the Armed Forces of Ukraine. *Problematic issues of organizing international military material and technical assistance to the Defense Forces of Ukraine during the repulsion of large-scale armed aggression of the Russian Federation*: collection of materials of the scientific and practical seminar, October 6, 2023. Kyiv: Central Military District of Ukraine, 2023. P. 85-95.
8. Taranets S.V., Kosyak I.A. Dynamics of the arrival of weapons and military equipment within the framework of international military-technical assistance, and their impact on the course of hostilities during the repulsion of the large-scale invasion of the Russian Federation into Ukraine. *Problematic issues of organizing international military-material and technical assistance to the Defense Forces of Ukraine during the repulsion of the large-scale armed aggression of the Russian Federation*: collection of materials of the scientific and practical seminar, October 6, 2023. Kyiv: Central Military District of Ukraine, 2023. P. 78-81.
9. Filipenko A.O. Problems and advantages of operating samples of artillery weapons received by the Armed Forces of Ukraine within the framework of international military material and technical assistance and their impact on the course of hostilities. *Problematic issues of organizing international military material and technical assistance to the Defense Forces of Ukraine during the repulsion of large-scale armed aggression of the Russian Federation*: collection of materials of the scientific and practical seminar, October 6, 2023. Kyiv: Central Military District of Ukraine, 2023. P. 99-103.
10. Zabrodskiy M., Watling J., Danylyuk OV, Reynolds N. Preliminary Lessons in Conventional Warfighting from Russia's Invasion of Ukraine: February – July 2022. URL: <https://static.rusi.org/359-SR-Ukraine-Preliminary-Lessons-Feb-July-2022-web-final.pdf>.
11. Hinton P. Lean on the barrage: the role of artillery in Ukraine's counteroffensive. URL: <https://rusi.org/explore-our-research/publications/commentary/lean-barrage-role-artillery-ukraines-counteroffensive>.

12. Cranny-Evans S. Russia's artillery war in Ukraine: challenges and innovations. URL: <https://rusi.org/explore-our-research/publications/commentary/russias-artillery-war-ukraine-challenges-and-innovations>.
13. Brzozowski A. Ramstein meeting gives birth to global "contact group" to support Ukraine. URL: <https://www.euractiv.com/section/defence-and-security/news/ramstein-meeting-gives-birth-to-global-contact-group-to-support-ukraine/>.
14. Answering the call: heavy weaponry supplied to Ukraine. URL: <https://www.oryxspioenkop.com/2022/04/answering-call-heavy-weaponry-supplied.html>.
15. The Ukrainian military has evaluated the CEASAR self-propelled guns. URL: <https://mil.in.ua/uk/news/vijskovi-ukrayiny-daly-otsinku-sau-caesar/>.
16. Kalin S. New US guided rockets strengthen Ukraine's hand against Russia. URL: <https://www.wsj.com/articles/new-us-guided-rockets-strengthen-ukraines-hand-against-russia-11656698614>.
17. Media: In occupied Alchevsk, the Armed Forces of Ukraine destroyed an ammunition depot. URL: <https://www.pravda.com.ua/news/2022/07/17/7358541/>.
18. What's wrong with German self-propelled guns PzH 2000: constant breakdowns, short service life or first real use. Defence Express, 14.08.2022. URL: https://defence-ua.com/weapon_and_tech/scho_ne_tak_z_nimetskimi_sau_pzh_2000_postijni_polomki_malij_resurs_chi_pershe_realne_vikoristannja-8544.html.
19. Sampir O., Dachkovsky V. Analysis of the operation of the 155 mm M777 howitzer during combat use by units of the Armed Forces of Ukraine in the Russian-Ukrainian war in 2022. *Journal of Scientific Papers "Social Development and Security"*. 2023. Vol. 13. No. 2. S. 31-40.
20. The White House confirmed that the US will provide cluster munitions to Ukraine. URL: <https://www.radiosvoboda.org/a/news-ssha-kasetni-boeprypasy/32493903.html>.
21. Ukraine uses up to 7,000 shells every day – NATO Secretary General. URL: <https://www.pravda.com.ua/news/2023/03/23/7394663/>.
22. US awards \$522 million in contracts for artillery shells for Ukraine. URL: <https://www.rferl.org/a/ukraine-us-contracts-artillery-shells/32272154.html>.
23. Pentagon Press Secretary Air Force Brig. Gen. Pat Ryder holds a press briefing. US Department of Defense. URL: <https://www.defense.gov/News/Transcripts/Transcript/Article/3490413/pentagon-press-secretary-air-force-brig-gen-pat-ryder-holds-a-press-briefing/>.
24. Borrell presented three proposals for providing Ukraine with ammunition. URL: <https://suspilne.media/408078-borrell-predstaviv-tri-propozicii-zabezpecenna-ukraini-boepripasami/>.
25. EU hopes to clear hurdles for deal to procure ammunition for Ukraine. URL: <https://www.euractiv.com/section/defence-and-security/news/eu-hopes-to-clear-hurdles-for-deal-to-procure-ammunition-for-ukraine/>.
26. The European Parliament has adopted the Ammunition Production Act. URL: <https://www.dw.com/uk/evroparlament-uhvaliv-akt-pro-virobnictvo-boepripasiv/a-65793694>.
27. Seven countries order ammunition under the EU scheme to aid Ukraine. URL: <https://www.reuters.com/world/europe/seven-countries-order-ammunition-under-eu-scheme-aid-ukraine-2023-09-29/>.
28. Bloomberg: EU lags behind in ammunition supply plan for Ukraine. URL: <https://www.eurointegration.com.ua/news/2023/10/26/7172214/>.
29. Ukraine counteroffensive analysis: West needs to help Kyiv 'outrange' Russians, protect own artillery. URL: <https://breakingdefense.com/2023/09/ukraine-counteroffensive-analysis-west-needs-to-help-kyiv-outrange-russians-protect-own-artillery/>.