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PROSPECTS FOR THE DEVELOPMENT AND IMPROVEMENT OF DOMESTIC MISSILE COMPLEXES AND ARTILLERY SYSTEMS

The article analyses the current state and development prospects of domestic missile and artillery systems within the Missile Forces and Artillery of the Ukrainian Land Forces. It examines methodological principles for identifying avenues to improve armaments through a comparative analysis of principal tactical and technical requirements for effective combat employment, using the best domestic and foreign systems currently in service as benchmarks. The paper formulates key challenges to enhancing combat effectiveness, including measures to improve survivability, firing accuracy, and strike depth. Particular attention is paid to trends in the development of precision-guided munitions, including hypersonic missiles, and to the feasibility of their development in Ukraine. A comparative assessment of the combat capabilities of domestic and foreign missile systems, rocket artillery, self-propelled guns, and towed artillery is provided. The study finds that Ukrainian MLRS models "Vilkha-M" and "Bureviy", as well as the 2S22 "Bogdana" self-propelled gun, are comparable to or outperform the best foreign counterparts. Recommendations are presented for further development of missile and artillery weaponry, notably pursuing ranges up to 800 km and the indigenous development of hypersonic systems.

Keywords: *missile system, rocket artillery, artillery system, hypersonic missile, combat effectiveness, tactical and technical requirements, mortar, artillery shell, target destruction.*

Problem statement

In modern combat operations, missile complexes and artillery systems constitute the principal means of firepower for the Land Forces and are intended to destroy enemy targets in order to inflict decisive losses and prevent the enemy from accomplishing their objectives.

The methodological basis for determining the prospects for the development and improvement of domestic missile complexes and artillery systems is a comparative analysis of the main tactical and technical requirements that ensure the effective combat use of the best domestic and foreign models that have been adopted for service.

The problem of increasing the combat effectiveness of missile and artillery weapons in general terms includes the need to comply the following basic tactical and technical requirements [1-2]:

- ensuring the necessary survivability of missile and artillery weapons;
- ensuring maximum accuracy of firing (launching);
- increasing the maximum combat range.

Foreign and domestic experience in the development of rocket and artillery weapons shows that the set of tactical and technical requirements formulated above can be optimally solved by a differentiated approach to the creation of missile systems, reactive artillery systems, self-propelled artillery installations, towed artillery models, and mortars. [1-2].

In the 21st century, the development of hypersonic missiles (HSM) has become a widespread phenomenon. At least, that is what their developers call them. One thing can be said with certainty: there is currently no hypersonic missile system (MS) that has been confirmed to meet all the criteria and is in service. Three countries are currently engaged in active large-scale development and testing: the US, China, and russia. [3–5].

An analysis of the reference catalog of the main types of weapons and military equipment used by the opposing sides during the repulsion of the large-scale invasion of Ukraine by the russian federation and other sources [6–8] showed that the Missile Forces and Artillery of the Land Forces did not have missile systems equipped with hypersonic missiles. Currently, Ukraine is not developing hypersonic missiles.

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Formulation of the article's objective

The purpose of this article is to justify the list of rocket and artillery weapons with the necessary basic tactical and technical characteristics required by the Missile Forces and Artillery of the Land Forces, based on an analysis of the effectiveness of the best examples of Ukrainian-made rocket and artillery weapons, those supplied to Ukraine as part of international assistance, and those in service with the russian armed forces.

Presentation of the main material

An analysis of recent researches and publications [1-11] indicates that the main scientific and technical ways to improve domestic rocket and artillery weapons should be considered as follows:

- ensuring round-the-clock and all-weather combat readiness through the use of radar methods for searching, detecting, and identifying ground targets and guiding missiles and artillery shells toward them;

- use of high-precision methods for positioning missile (artillery) systems based on satellite (pseudo-satellite) navigation systems;

- restoring the production capacity of the domestic optoelectronic industry in terms of serial production of key components for search and targeting devices for missile (artillery) systems;

- restoration and improvement of the domestic range base for testing and testing high-precision missile and artillery weapons without limiting their combat range.

One of the key problems in mastering foreign models of missile and artillery systems provided by partner countries, and which has not been resolved previously, is the absence of a complete and adequate set of technical and operational documentation needed to realize the equipment’s full combat potential, as well as shortcomings in training personnel in operational units and educational institutions. Addressing this issue will also help accelerate the adoption of NATO standards within Ukraine’s defense industry.

An analysis of trends in the development of high-precision weapons shows the potential effectiveness of HSMs in combat. No work is being done in Ukraine to create HSMs. The development of hypersonic weapons is a technologically complex and expensive process. The manufacture of such weapons requires heat-resistant materials and powerful power plants. The payload capacity of HSM is significantly lower than that of ballistic or cruise missiles. Therefore, HSM have a smaller warhead.

The characteristics of the main hypersonic weapons, based on an analysis of recent publications [3, 4], are presented in Table. Hypersonic weapons may be divided into two classes: operational systems and potentially operational systems. [4]:

- hypersonic glider;

- hypersonic cruise missile.

The United States, China, and russia are leaders in the field of hypersonic weapons [4]. Hypersonic systems will continue to become more sophisticated in the future.

Table

Characteristics of the main hypersonic weapons

Characteristics	Name				
	C-HGB	DF-ZF	Yu-71-71 (Yu-71-74) “Avangard”	3M22 (3K-22) “ Zircon”	Kh-47M2 “ Kinzhal”
Type of HSV (hypersonic vehicles)	HGV	HGV	HGV	HCM	HGBM
Country of manufacture	The US	PRC	rf	rf	rf
Possible carriers	LRHW launcher, destroyer class “Zumwalt”, Virginia-class submarine	Medium-range BM DF-17	Intercontinental BM PC-18A	Frigates of the Gorshkov and Grigorievich classes, submarine of the Yasen class	MiG-31K fighter (Tu-22M3 bomber)
Flight path altitude, km	40…100	60	40…100	20…30	20
Maximum range, km	2 775	1 800…2 500	6 000	500…1 000	2 000 (3 000)*
Flight speed, Max	17	5…10	20	5…8	10

A comparative analysis of missile systems [2, 6, 8, 10] of the Armed Forces (AF) of Ukraine, missile systems received as part of international military material and technical assistance, and missile systems of russian military formations in terms of maximum combat range is presented in Fig. 1.

The analysis of the presented materials allows us to conclude that:

- within a firing range of up to 500 km, the combat capabilities of the domestic “Sapsan” (“Hrim-2”) missile systems are on par with those of the russian “Iskander” system;

- within a firing range of up to 300 km, the domestic Neptune missile system is practically equivalent to the russian “Bal” system in terms of combat capabilities.;

- within a firing range of up to 120 km, the soviet-designed “Tochka-U” missile system, which is in service with the Ukrainian Armed Forces, is equivalent to the RGM Harpoon (USA), except for the number of missiles on the launcher;

- It is advisable to accelerate work on increasing the firing range of domestic missile systems to 800 km, which is equal to the firing range of the russian "Bastion-P" system with P-800 Onyx missiles.

After conducting a comparative analysis of the depth of fire damage caused by rocket artillery [2, 6, 7, 11] of the Armed Forces of Ukraine and military formations of the russian federation, presented in Fig. 2, the following conclusion can be drawn:

- the domestic 300 mm calibre "Vilkha-M" complex exceeds foreign counterparts, including the russian 9K512 "Uragan-M" and 9K515 "Tornado-S", in terms of maximum firing range (130 km);

- the domestic "Bureviy" complex exceeds the best Soviet-made 9K57 "Uragan" complex (35 km) in terms of maximum firing range (65 km);

- domestic complexes "Bastion-01", "Bastion-02", BM21U "Verba", BM21UM "Berest" with a calibre of 122 mm and a maximum firing range (40 km) are equivalent to the russian 9K51M "Tornado-G" complex.

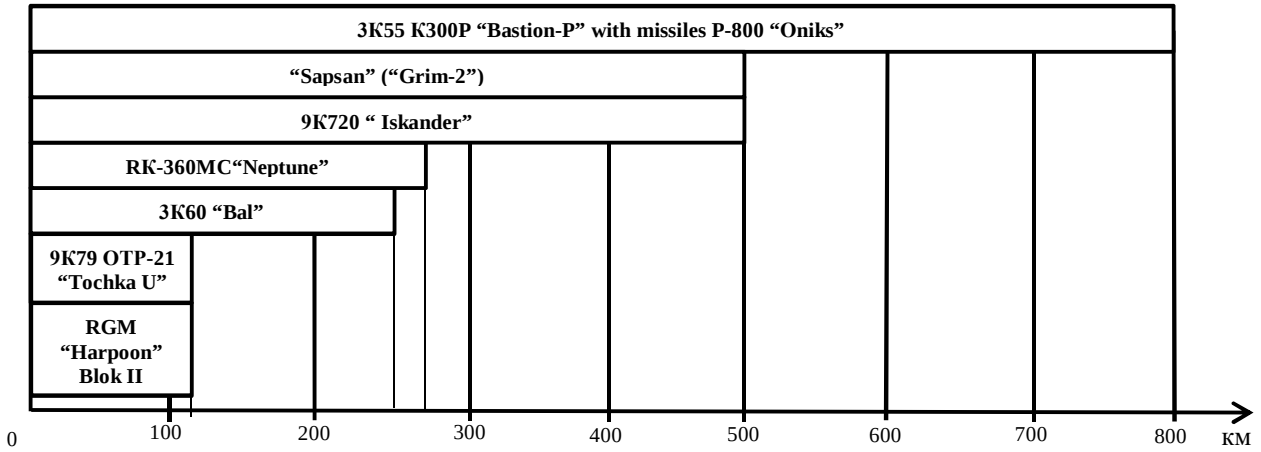

Fig. 1. **The depth of fire damage caused by missile systems of the Armed Forces of Ukraine and military formations of the russian federation**

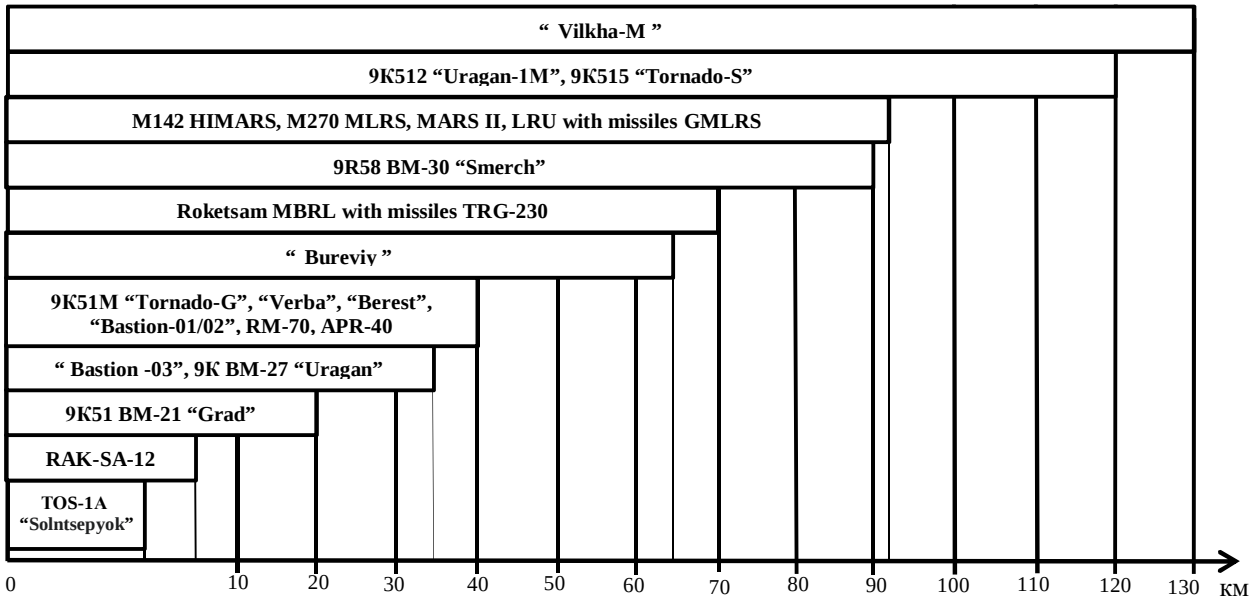

Fig. 2. **The depth of fire damage caused by the rocket artillery of the Armed Forces of Ukraine and russian military formations**

Analysing the depths of fire damage caused by self-propelled guns [2, 6, 8, 11], shown in Fig. 3, we can conclude that the 2S22 "Bogdana" self-propelled gun, in terms of its overall technical characteristics, is on a par with the world's best analogues, the "PzH 2000" (Germany), "Archer" (Sweden) and "CAESAR" (France) with a calibre of 155 mm, and significantly exceeds the Soviet-made 152 mm calibre 2S5 "Giatsint-S" and 2S19 "Msta-S" self-propelled guns. An analysis of the depth of fire damage caused by towed artillery [2, 6] of the Armed Forces of Ukraine is provided in comparison with the best foreign models in Fig. 4.

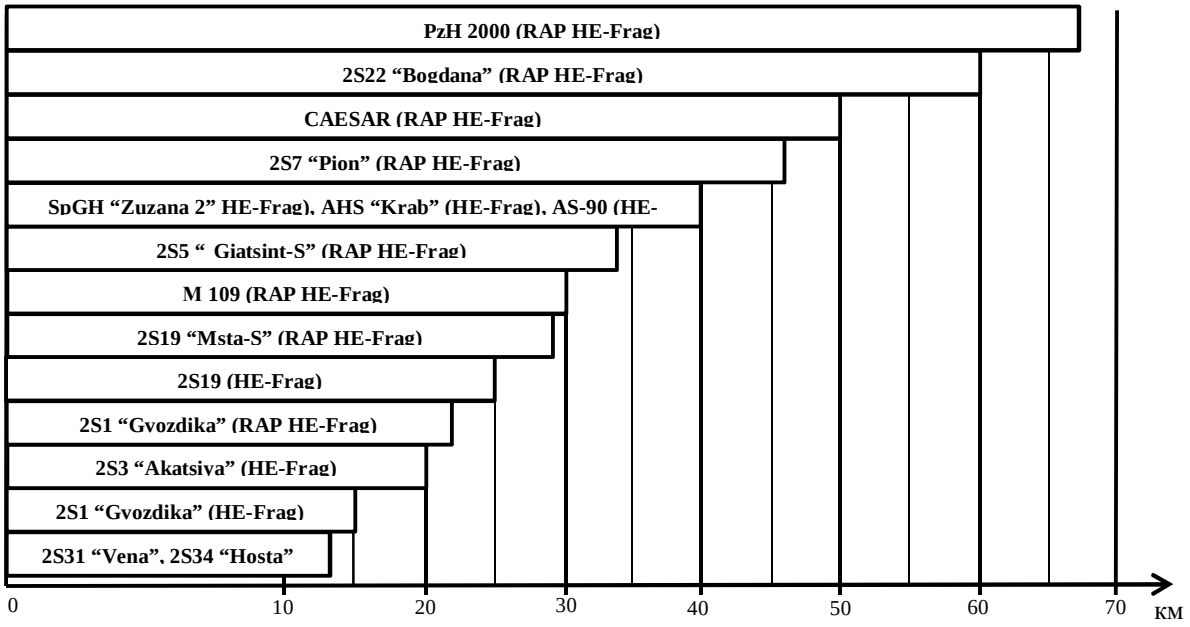

Fig. 3. **The depth of fire damage caused by SPA system of the AF of Ukraine and russian military formations**

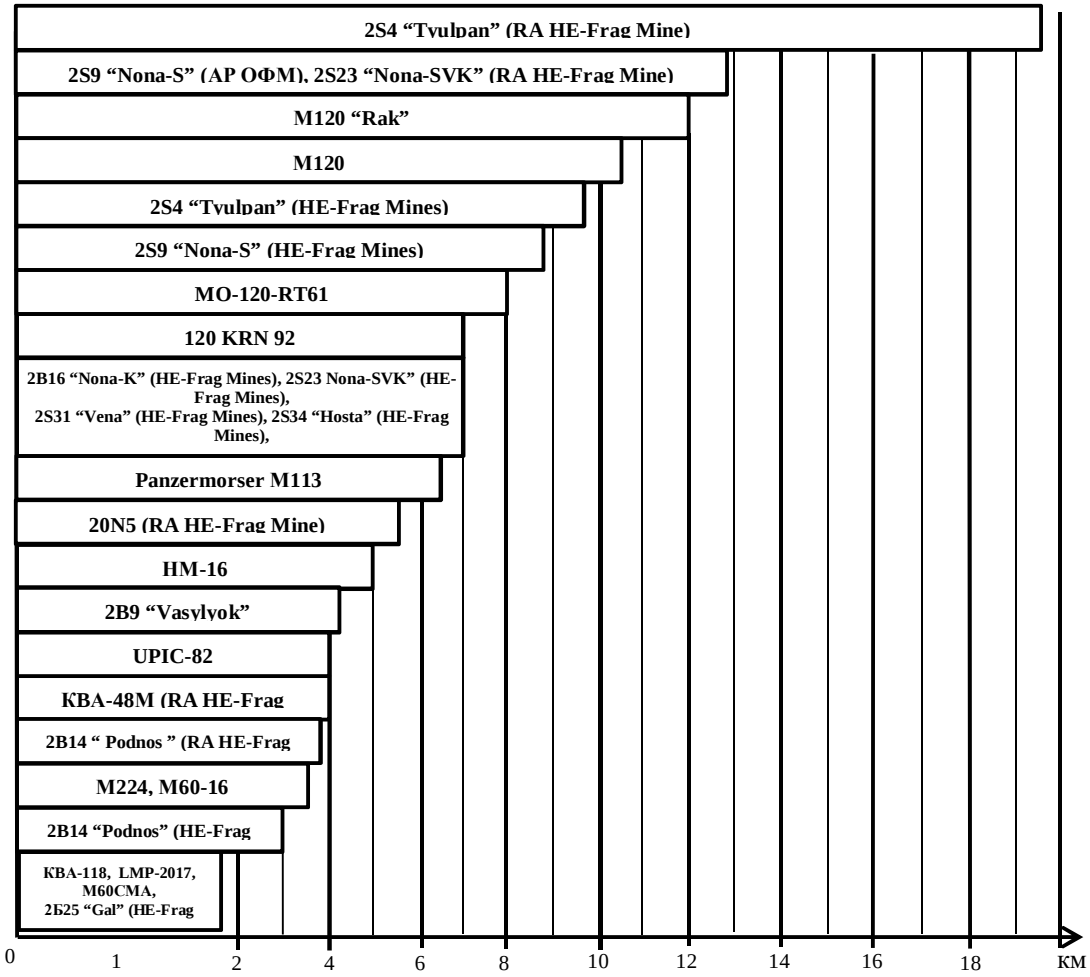

Fig. 4. **The depth of fire damage caused by mortars of the AF of Ukraine And russian military formations**

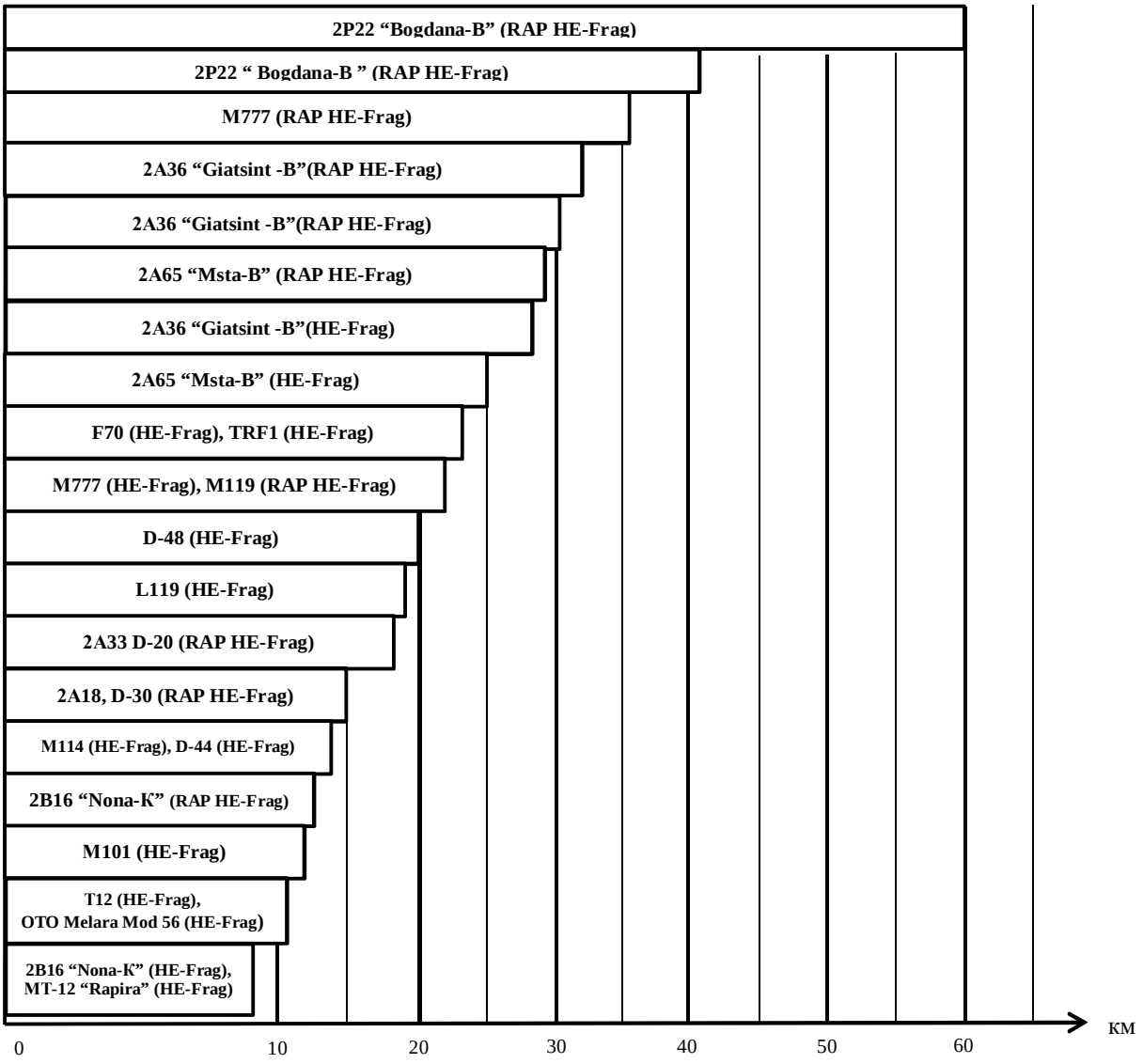

Fig. 5. **The depth of fire damage caused by the towed artillery of the AF of Ukraine and russian military formations**

The data presented allows us to conclude that:

- soviet-made towed artillery systems D-30, 2A65 “Msta-B”, 2A36 “Giatsint-B” and others, which are in service with the Armed Forces of Ukraine and were manufactured in the 1960s-1980s, are morally and physically outdated and have exhausted their potential for modernisation;

- the combat experience in Ukraine of the M777 howitzer (Great Britain), created in 2005, provides grounds for its use as a base for performing fire tasks at dual firing ranges of up to 36 km. [7, 11]

An analysis of the tactical and technical characteristics of self-propelled and transportable mortars [2, 6] of the Armed Forces of Ukraine gives reason to conclude that self-propelled, transportable and hand-held mortars of domestic and soviet production (Fig. 5) sufficiently satisfy modern requirements for combat use.

In Ukraine, the main enterprises involved in the creation of high-precision rocket and artillery systems are “Luch” Design Bureau, the “Pivdenne” Design Office, “Progress”, and the developers of component parts are Research and Production Complex "Photoprylad", Arsenal Factory, “Zirka”, “Kramatorsk Heavy Machine Building Plant” and others.

Conclusions

1. An analysis was conducted of the full spectrum of missile and artillery systems in service with the Armed Forces of Ukraine, using maximum engagement range as the primary criterion, while accounting for their classification by operational-tactical level and comparing them with foreign analogues supplied to Ukraine as part of international military assistance, as well as with systems fielded by the russian federation’s armed forces.

2. The Ukrainian “Sapsan” and “Hrim” missile systems are comparable in combat capabilities to the Russian 9K720 “Iskander” system, while the Ukrainian RK-360MC “Neptune” is broadly comparable to the Russian BRK “Bal” in overall combat effectiveness. Efforts by Ukrainian missile designers should concentrate on achieving the performance characteristics of the Russian K-300P “Bastion-P” system.

3. In the category of 300 mm calibre multiple launch rocket systems, the Ukrainian “Vilkha-M” complex surpasses the Russian 9K512 “Uragan-1M” complex, while in the category of 220 mm calibre MLRS, the Ukrainian “Bureviy” complex significantly surpasses the Soviet-made 9K57 “Uragan” complex. In the category of 122 mm calibre MLRS, the Ukrainian BM21U “Verba”, BM21UM “Berest”, “Bastion-01” and “Bastion-02” systems are equivalent in combat capabilities to the Russian 9K51 “Tornado-G” system.

4. In the self-propelled artillery category, the domestic 2S22 “Bogdana” is not inferior in its technical characteristics to the best world analogues PzH 2000 (Germany), “Archer” (Sweden), “CAESAR” (France) with a calibre of 155 mm, and significantly exceeds the soviet-made 2S19 “Msta-S” and 2S5 “Giatsint –S” self-propelled guns with a calibre of 152 mm.

5. The category of towed artillery guns in service with the Armed Forces of Ukraine includes the 2A65 “Msta-B”, 2A36 “Giatsint-B”, and D-30, which were developed in the 1960s and 1980s and are now morally and physically obsolete and have exhausted their potential for modernisation. At the same time, the operational experience gained during combat operations with the M777 (Great Britain) gun, created in 2005, is a convincing argument for using them as the basis for a firing range of up to 36 km, and the domestic 155 mm 2P22 “Bogdana-B” for firing at ranges up to 60 km.

6. The category of self-propelled and transportable mortars of domestic and soviet production includes the necessary range of products for performing the entire spectrum of combat tasks.

7. An analysis of trends in the development of high-precision weapons shows the potential effectiveness of combat use of HSMs. The creation of HSMs involves solving a number of scientific and manufacturing problems that are only accessible to countries with advanced scientific and technical capabilities. The results of combat operations during Russia's large-scale aggression against Ukraine show that for the Armed Forces of Ukraine, the creation (development and production) of highly effective HSM is of current importance and is a priority area for the development of military equipment at the present stage.

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ПЕРСПЕКТИВИ РОЗВИТКУ ТА УДОСКОНАЛЕННЯ ВІТЧИЗНЯНИХ РАКЕТНИХ КОМПЛЕКСІВ І АРТИЛЕРІЙСЬКИХ СИСТЕМ

А.М. Зубков, Я.В. Красник, С.Ю. Каменцев, Р.В. Бубенщиков, В.О. Щигло

У статті проведено аналіз стану та перспектив розвитку вітчизняних ракетних комплексів і артилерійських систем РВіА Сухопутних військ України. Розглянуто методологічні засади визначення напрямів удосконалення озброєння на основі порівняльного аналізу основних тактико-технічних вимог до ефективного бойового застосування кращих вітчизняних та закордонних зразків, що стоять на озброєнні. Сформульовано проблеми підвищення бойової ефективності, серед яких – забезпечення живучості, точності стрільби та збільшення глибини вогневого ураження. Особливу увагу приділено тенденціям розвитку високоточного озброєння, у тому числі гіперзвукових ракет, можливостям їх створення в Україні. Наведено порівняльний аналіз бойових можливостей вітчизняних і закордонних ракетних комплексів, систем реактивної артилерії, самохідних артилерійських установок і причіпної артилерії. Визначено, що українські зразки РСЗВ "Вільха-М" та "Буревій", а також САУ 2С22 "Богдана" відповідають або перевищують кращі закордонні аналоги. Сформульовано рекомендації щодо подальшого розвитку ракетного та артилерійського озброєння, зокрема досягнення дальності ураження до 800 км і створення власних зразків гіперзвукової зброї.

Ключові слова: *ракетний комплекс, реактивна артилерія, артилерійська система, гіперзвукова ракета, бойова ефективність, тактико-технічні вимоги, міномет, артилерійський снаряд, ураження цілі.*