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Destruction of enemy air attack assets during the Russian-Ukrainian war

Resume. The article describes the balance of forces before the beginning of the Russian-Ukrainian war, the experience of destroying enemy air attack assets since the beginning of the large-scale invasion of the Russian Federation, how the enemy struck, with what means, from what directions and how the effectiveness of Ukraine's air defence system changed during the repulsion of missile and air strikes. The article covers the issues of peculiarities of missile and air strikes on the territory of Ukraine and tactics of their application. How the assistance from our partners in the form of anti-aircraft missile systems has affected the effectiveness of Ukrainian air defence. The article analyses the lessons learnt by the enemy since the beginning of the large-scale invasion and where we need to focus our efforts to improve Ukrainian air defence.

Keywords: air defense; effectiveness, missile troops; anti-aircraft missile systems; missile and air strikes; air offensive operation; air strike assets; airplanes; strike missiles; helicopters; unmanned aerial vehicles.

The **purpose of this article** is to answer the question of why the Russian Aerospace Forces, which at the beginning of the large-scale invasion had a sevenfold quantitative advantage and a significant qualitative advantage over the Ukrainian Air Forces, failed to achieve air dominance. At the same time, our Air Force managed not only to preserve their combat potential, but also, in cooperation with other components of the Ukrainian Defence Forces, to disrupt the enemy's air offensive, achieve parity and maintain control over the airspace of most of Ukraine's territory.

1. Before the large-scale Russian invasion of Ukraine.

First of all, it should be mentioned that the quantitative and qualitative component of the Russian Aerospace Forces (hereinafter referred to as the RF VKS) was overestimated before the invasion of Ukraine. The experts were surprised by the number of Russian warplanes in the air force group that was created to invade Ukraine. Thus, the numerical indicators of the initial quantitative and qualitative ratio of the parties' forces ranged from 1:7 to 1:30 or more in favour of the RF VKS.

Experts from different countries are of the opinion that the Russian Federation was and still is one of the few countries in the world that has offensive capabilities in airspace. If we talk about the aviation grouping along our borders, which was created on the eve of the invasion, it consisted of almost five hundred combat aircraft and several hundred helicopters. If the list of aircraft and helicopters strength is used as a basis, it is quite possible that the data was true. It should be noted that as of 24 February 2022, the Russian VKS unit created for the invasion of Ukraine alone outnumbered the Ukrainian Air Force by almost four to one.

The basis of the Russian grouping was modern models of aircraft, such as Su-35, Su-34, Su-30, Ka-52, Mi-28 and others. It was only later that they began to involve an older fleet of aircraft in the Ukrainian skies. At the same time, the Air Force of the Armed Forces of Ukraine was armed with physically and morally outdated aircraft and Soviet-made anti-aircraft missile systems that had not undergone any significant modernization and had long since reached the end of their intended service.

The enemy set itself the task of destroying Ukrainian air defenses within the first three days of the strategic air offensive, and the remnants of combat aircraft within another week. The Russian command was not particularly concerned about the air part of the plan for a 'special military operation' against Ukraine. It seemed to them that all objective indicators - from numerical superiority to localization and disproportionate capabilities of the enemy's air attack and Ukrainian air defence - pointed to the success of the operation. We should not forget that russian pilots were inspired by impunity in the skies over Syria.

With these intentions, the RF VKS invaded Ukraine's airspace on the night of 24 February 2022.

2. The beginning of a large-scale Russian invasion of Ukraine.

As early as the evening of 23 February, there was information that the Russian VKS had begun preparing for strikes, and from 3 a.m. onwards enemy aircraft took off and formed air

strike echelons to launch a massive air strike. After the massive missile launches, the number of air targets on the air traffic control screens of the aviation and air defence command posts was measured in hundreds.

From the very first day of the war the RF VKS attempted to gain superiority (dominance) in the airspace of Ukraine.

The aggressor prioritized more than 50 targets, which it attacked, as shown in Fig. 1. These were military infrastructure facilities, command posts, military airfields, permanent deployment points of military units and combat duty positions of anti-aircraft missile troops (AMT) and radio-technical troops (RTW) of the Ukrainian Air Force.

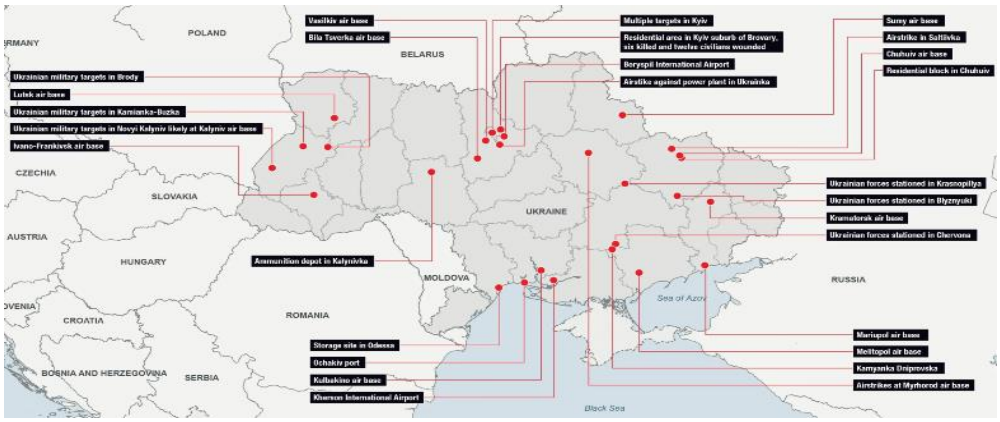


Figure 1. Objects of enemy attacks

On the fourth day of the war, after all the missile and air strikes had been carried out, the Russian command was confident that the task they had set themselves before the invasion had been accomplished, Ukrainian air defences had been destroyed, and the ground operation could continue with complete air dominance.

However, everything was not as the aggressor expected. The enemy used approximately 100 missiles of various types and 140 aircraft and helicopters from different directions. The types of missiles used by the enemy on the territory of Ukraine are shown in Fig. 2.

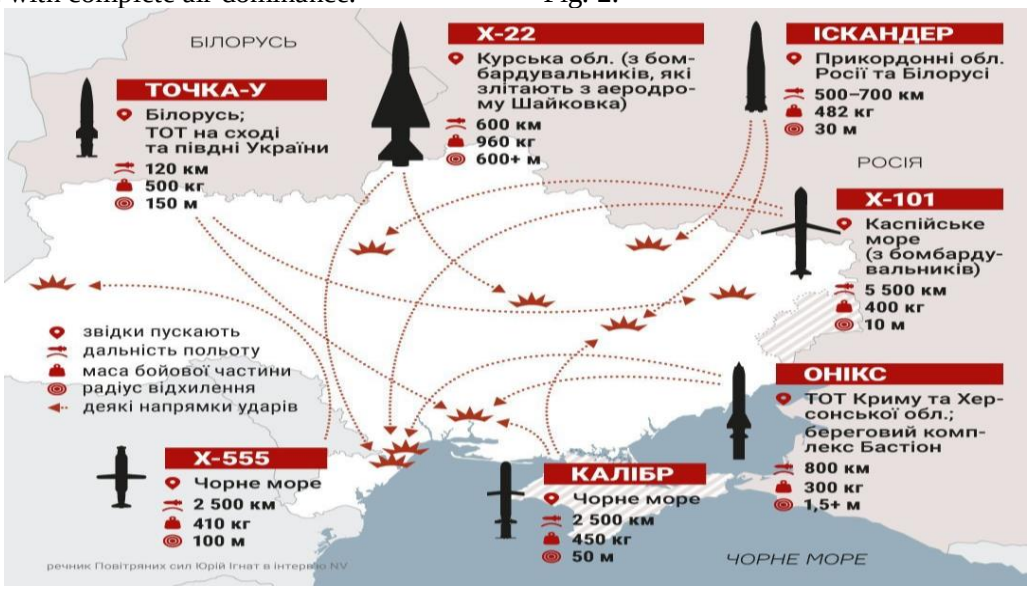


Figure 2. Types of enemy missiles in strikes on the territory of Ukraine

In reality that differs from the ‘whims’ of Russian generals and Putin, Ukrainian air defence has withstood and has been performing the task of covering Ukrainian skies and destroying enemy aircraft and missiles despite all odds.

The enemy audaciously discounted Ukrainian air defence, underestimated its survivability and resilience, as well as the courage and loyalty to the oath of our pilots and anti-aircraft gunners. The enemy thought it had gained air supremacy and moved on to its main task — air support for the ground forces that invaded our land. It was this catastrophic miscalculation that gave our air defence a much-needed respite and time to regroup and prepare a ‘warm welcome’ for the enemy.

At that time, the effectiveness of the Ukrainian air defence system was almost 10%. Some may have a question: ‘Why was it so low and was it enough?’. There is an answer to this

question.

To begin with, as early as 23 February 2022, the Ukrainian command received information from its partners and its intelligence that Russia was planning to strike first and take out air defence facilities.

In addition, on the one hand, the aggressor prioritised the destruction of the Ukrainian air defence system and aviation at airfields. And on the other hand, Ukrainian soldiers had a task to ensure the survivability of their equipment and units, as well as to defeat the enemy in the air [2].

And it did work. The vast majority of units were withdrawn from the attack in time to reserve positions. Therefore, in most cases, the enemy attacked positions that were decoys or those from which the Ukrainian air force units had manoeuvred.

The main rule still applies today: fire and manoeuvre [3].

3. How the enemy struck, with what means, from which directions and how the Ukrainian air defence system operated.

The conditional flight path of the Kalibr cruise missile is shown in Fig. 3.

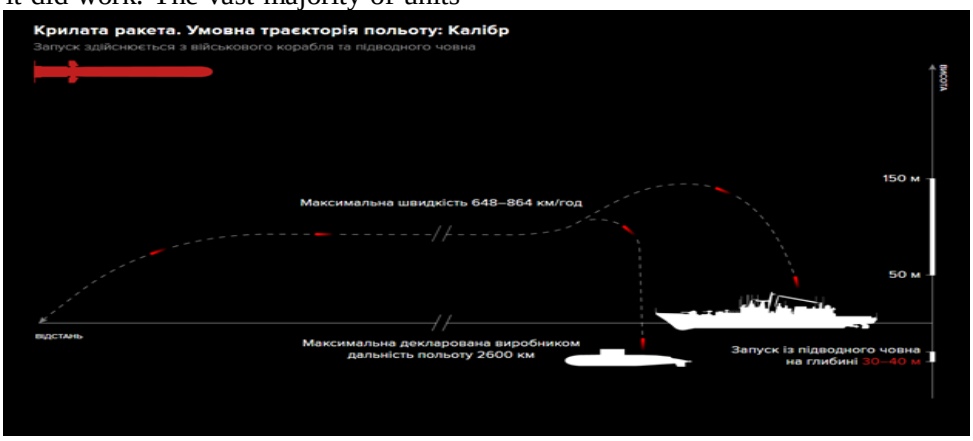


Figure 3. Main characteristics of the Kalibr cruise missile

According to many experts, it is a very serious weapon. The weight of the warhead is 350 kg. It is launched from ships, submarines, and land [4].

It is used to defeat key targets, such as command and control points, air defence bases and batteries, and critical infrastructure. The guidance system is combined: inertial in combination with satellite navigation, and Tercom (orientation by visually visible ground landmarks) for attacking ground targets.

One of the biggest features of the Kalibr cruise missiles is that they are launched from sea-based carriers that are part of the Russian Black Sea Fleet.

The next feature is that the missile has the ability to fly at low altitudes to complicate the air defence task. In-flight control of the missile is autonomous, and the flight itself is carried out along a predetermined route.

It should be mentioned that, given their speed of almost 800 km/h, the Ukrainian air defence system had roughly 30 minutes to respond to the threat, as the distance from the missile launch point to the point of crossing the Ukrainian land territory is approximately 300 km.

The conditional flight path of the Kh-101 cruise missile is shown in Fig. 4.

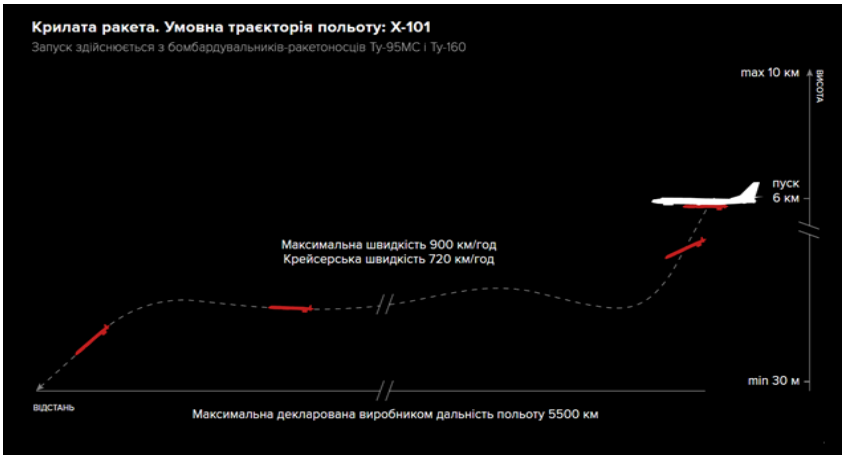


Figure 4. Main characteristics of Kh-101 cruise missiles

The Kh-101 missile is a new generation of Russian missiles. It is equipped with heat traps, has its own electronic warfare system, and a Pentium 5 on-board computer. It is made using stealth technology. The warhead is 450 kg. It is a subsonic cruise missile, but its manoeuvrability is higher than that of the Kalibr. It is used to destroy infrastructure facilities, defence enterprises, and ammunition depots. The range is up to 5 thousand kilometres [4].

During the first two months of the war, these missiles were launched from the Black Sea in two directions. And since April of the same year the enemy has changed its tactics and subsequently carried out launches from the territory of the Russian Federation, namely from the area of Engels, Volgodonsk and over the Caspian Sea [5,6].

In case of use of Kh-101 missiles, the flight of which is carried out on predetermined routes, the Ukrainian air defence system had approximately 30 minutes to one hour to respond to the threat.

Figure 5 shows statistics on the number of missiles launched and destroyed and the effectiveness of Ukrainian air defence system.

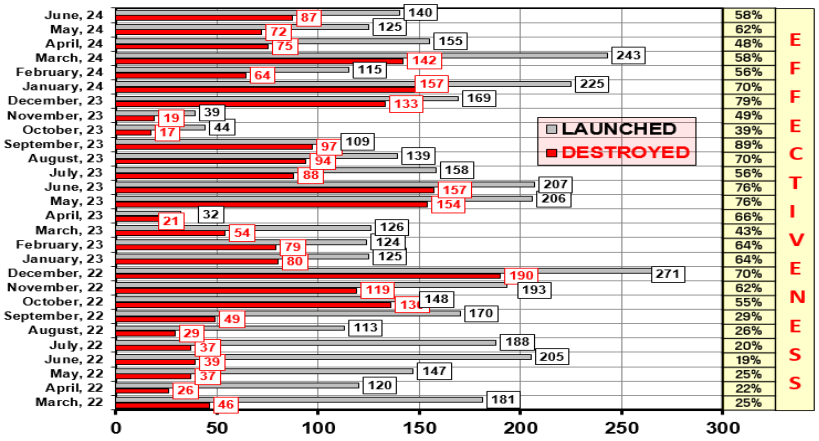


Figure 5. The number of missiles launched and destroyed and the effectiveness of Ukrainian air defence system

Starting in September 2022, Ukraine began to receive a significant number of medium-range anti-aircraft missile systems from its Western partners, and in October 2022 the whole world saw the results of their successful use.

The conditional flight path of the "Shahed-136" unmanned aerial vehicle is shown in Fig. 6.

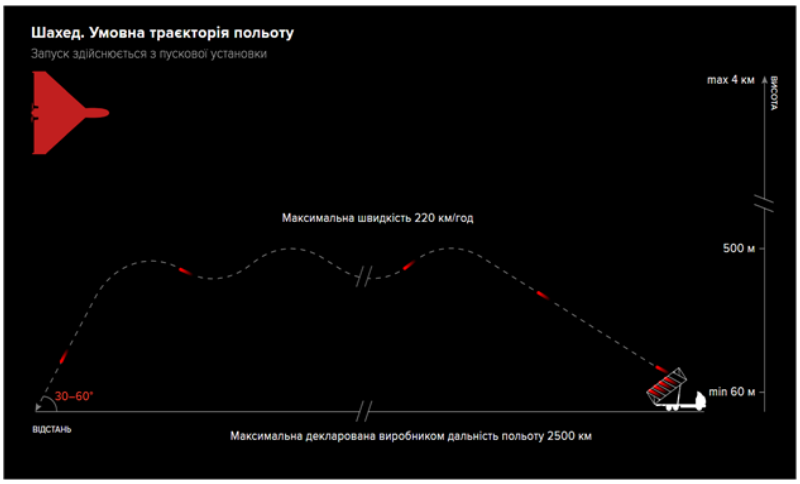


Figure 6. Main characteristics of the unmanned aerial vehicle Shahed-136

"Shahed-136" is an Iranian-designed loitering munition, carrying 40-50 kg of explosives. First introduced in 2020. As a rule, the aircraft is launched in five units in a salvo. It belongs to high-precision weapons [4].

Their distinctive sound, low flight speed of up to 200 km/h, mostly predictable routes and directions, low price and the possibility of being destroyed even by firearms were the main features of their use at the initial stage of the war.

After receiving information about the launch of the "Shahed-136" UAV, Ukraine's air defence system had one to two hours to prepare to repel the attack, which also gave time to predict possible UAV flight routes and for air defence units to manoeuvre to the most threatening areas and select the best positions for destruction.

Fig. 7 shows statistics on the number of

launched and destroyed “Shahed-136” UAVs and the effectiveness of Ukrainian air defence system.

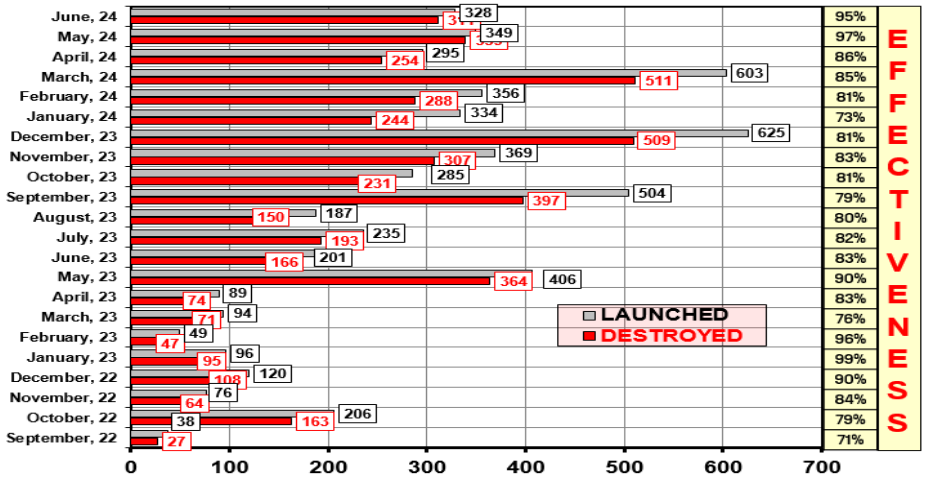


Figure 7. The number of launched and destroyed “Shahed-136” UAVs and the effectiveness of Ukrainian air defence system

Starting in September 2022, Russia began to strike at populated areas and critical infrastructure in Ukraine using “Shahed-136” UAVs [7].

The high effectiveness of Ukraine’s air defence system is due to the assistance of partners and the resilience of Ukrainian defenders.

Fig. 8 shows a comparison of the effectiveness of Ukraine’s air defence system in destroying missiles and “Shahed-136” UAVs.

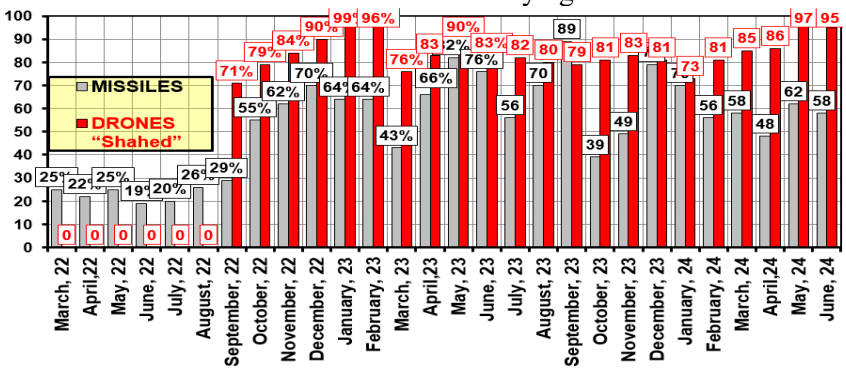


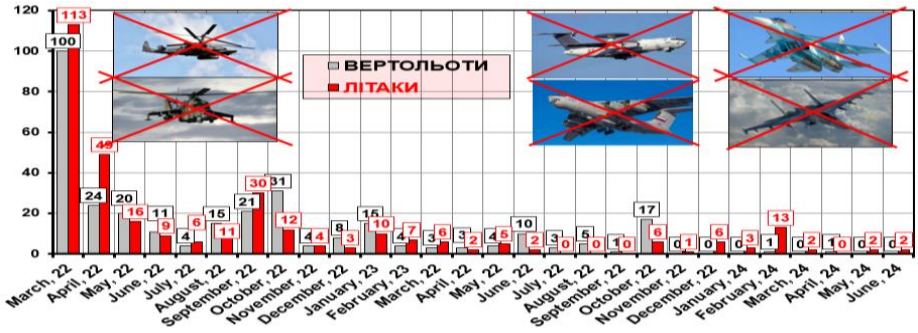
Figure 8. The comparison of the effectiveness of Ukraine’s air defence system in destroying missiles and “Shahed-136” UAVs

Since October 2022, with the help of our partners, Ukrainian defenders have destroyed with almost equal effectiveness both challenging targets — cruise missiles, and simple targets — “Shahed-136” UAVs.

The combined massive air strikes with ballistic missiles, cruise missiles and “Shahed-136” UAVs, along with the rapid advance of Russian ground forces, were intended to suppress any will of the Armed Forces and civilians to organise resistance. However, the skilful planning and use of a limited number of available units of the Air Force of Ukraine, combined with measures to disperse, camouflage and directly cover facilities and troops, did not allow the enemy to achieve its goals.

At the beginning of the war, in March-April 2022, the Russian Federation, having spent most of its aviation and missile resources and suffered significant losses, was forced to abandon the large-scale use of its aviation in the airspace of Ukraine. The war in Ukraine has clearly proved to the world that the ‘ultra-modern’ Su-34 and Su-35, modernised MiG-31, Mi-28 and Ka-52 of various indices, Iskander, Kalibr and Kh-101, which Putin claims to have ‘no analogues’, are perfectly detected, shot down and fall burning to the ground. The experience gained by the Russian medal-winning ace pilots bombing defenceless cities and towns in Syria turned out to be irrelevant to the war in Ukraine, and the number of Russian pilots who ‘did not return from a combat mission’ was rapidly increasing because, unlike in Syria, they were countered by trained and motivated units of the Ukrainian Air Force (Fig. 9).

Thus, the Air Forces of the Armed Forces of Ukraine managed to disrupt the enemy’s air offensive, preserve their own combat potential, achieve parity and maintain control over the airspace over most of the territory of Ukraine.



4. Features of the application of enemy air attack assets.

Having failed to achieve its strategic goal, the enemy launched missile attacks on important critical infrastructure and settlements in Ukraine in order to create an extremely difficult economic situation in the country, in particular in the energy sector, with the expectation of a long-term destructive effect.

It should be noted that the peculiarity of missile and air strikes on the territory of Ukraine is that the enemy constantly changes its tactics:

1. Massive missile attacks with air- and sea-launched cruise missiles and ballistic missiles, which were spread out in time and direction (the number of missiles per strike was more than 100).

2. The use of outdated cruise missiles Kh-22 and Kh-59.

3. The use of "Shahed-136" UAVs since September 2022, which were launched on the eve of missile strikes, mostly at night.

4. The end of October 2022, the first use of Kh-55 strategic cruise missile, which carries a nuclear warhead.

5. In February 2023, before a missile attack, the enemy, for the first time in Ukraine, used balloons with angular reflectors, some of which had reconnaissance equipment on them. At the same time, Su-24MR, Su-34MR, and A-50U reconnaissance aircraft were in the air too.

6. Combined strikes using both missile weapons of various types and UAVs.

7. Having failed in the ground operation, the aggressor increased the use of guided aerial bombs not only on the contact line but also in strikes on Ukrainian settlements. Thus, since the beginning of 2024 alone, the Russian Federation has used more than 9,478 guided aerial bombs.

The aggressor upgraded existing guided bombs and equipped them with a wing release device. Some bombs have an ability to manoeuvre and adjust the route during a flight, which allows them to plan and increase their range from 10-20 to 80-100 kilometres, depending on the type of bomb and the type of upgrade.

All changes in the aggressor's tactics were taken into account.

Let's pay attention to the high performance of Ukraine's air defence system in May 2013.

The total number of drones and missiles destroyed in Ukraine and the effectiveness of the Ukrainian air defence system in May 2023 are shown in Fig. 10.

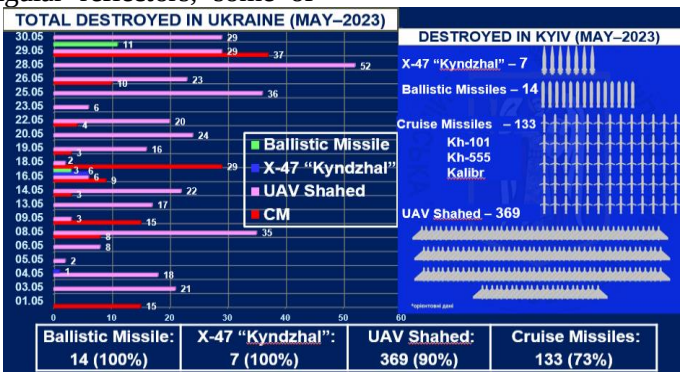


Figure 10. The total number of destroyed UAVs and missiles and the effectiveness of the Ukrainian air defence system in May 2013

What is special about May 2023?

First of all, Ukraine received Avenger, SAMP-T, and most importantly, Patriot anti-aircraft missile systems from its Western partners.

Second, the aggressor fired the largest number of "Kinzhal" missiles and "Shahed-136" UAVs at the territory of Ukraine.

The conditional flight path of the Kh-47 "Kinzhal" missile is shown in Fig. 11.

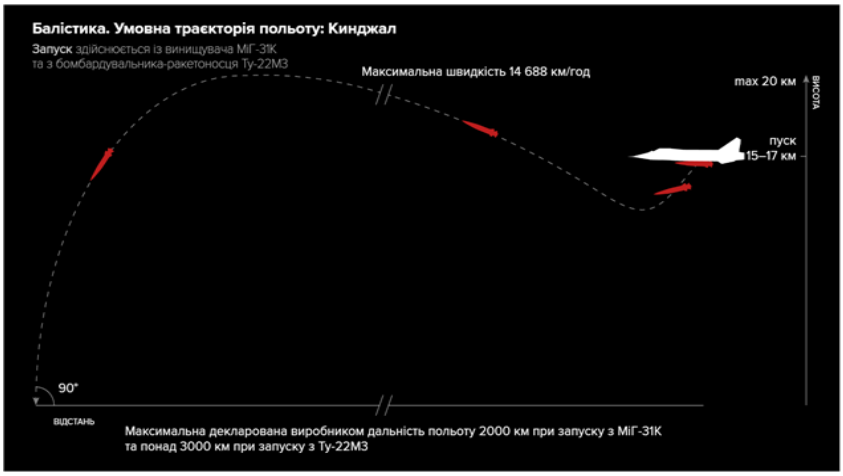


Figure 11. Main characteristics of Kh-47M "Kinzhal"

"Kinzhal" is a Russian hypersonic aircraft missile system. The Kh-47 hypersonic missiles of the "Kinzhal" complex are capable of hitting both stationary objects, such as ammunition depots, and infrastructure. "Kinzhal" is an aviation version of the "Kinzhal" system. Warhead weight — 500 kg of TNT [4].

Eventually, the enemy started launching combined missile and air strikes from different directions at the same time.

Now the aggressor has set itself the goal of detecting and destroying the Patriot system at any cost.

5. The impact of partners assistance on the effectiveness of Ukrainian air defence.

Before the Russian invasion, Ukraine was armed with obsolete Soviet-made air defence systems developed in the sixties and eighties of the twentieth century. This was the reason why, on the first day of the war, the effectiveness of Ukraine's air defence system was very low — about 10%.

Thanks to our partners, since the spring of 2022, Ukraine's air defence has turned a new page in its history, initially it was man-portable air defence systems of various types (such as Starstreak, Mistral, Piorun, Stinger) and then it was gradually reinforced by modern air defence systems, in the order of arrival, such as Gepard, Stormer, IRIS-T, Hawk, C-125, Nassams, Crotal, SAMP-T, Avenger, Patriot.

The receipt of new weapons made it possible to significantly increase the effectiveness of Ukraine's air defence system to an average of 70-80%.

As a result, the systems received from partners have been, are and will be able to destroy Russian missiles, UAVs and aircraft.

6. Conclusions.

Lessons the enemy has learnt. Russia's stockpiles of cruise and ballistic missiles are far from unlimited, and given the minimal capacity to produce them under sanctions pressure, they are forced to look for other, more affordable and cheaper means of destruction to continue terror campaign in Ukraine. One of the first steps was the wider use of "Shahed-136" attack UAVs. Subsequently, the aggressor decided to transfer most of the destruction tasks to air-launched cruise missiles.

The most likely scenario for the enemy is to expand the usage of missile weapons systems that use a aero ballistic trajectory or aero ballistic reentry vehicle at the final stage of the trajectory, taking into account their effectiveness, both on their and our side.

Ukraine's limited means of countering ballistic targets, the technical complexity of intercepting them, and their high accuracy and reach encourage the enemy to consider this option.

To compensate for its losses, Russia is constantly redeploying aircraft from its 'rear' districts and still has enough resources to continue fighting in the airspace with the current intensity for the coming years. Since the beginning of the invasion, the size of the aviation grouping around Ukraine has remained almost unchanged, this fact is significant, although its quality has deteriorated drastically, since the aggressor is forced to replace the loss of modern aircraft and helicopters with outdated modifications, sometimes even withdrawn from storage.

Just as any military stockpiles are not unlimited, so are Russia's stockpiles of air-launched cruise missiles, especially modern models. However, letting our guard down and assuming that air attacks will stop due to the enemy's lack of weapons is the worst solution in current situation. For months now, Russia's leadership has been searching for a way out of this situation. Unfortunately, certain changes are

already being implemented by the Russian leadership. One of them is based on the relative availability of air and missile weapons for external supply. Monetary expenditures or obligations to partners can eliminate the problems for Russia associated with the continuation of designing or increasing the production of air attack weapons.

With the increase in intelligence assets and their effective usage, the ability to detect, identify and defeat targets increases due to the decrease in their mobility.

It should be understood that despite the fact that the aggressor has concentrated a lot of forces and resources for air attacks, the intensity of hostilities not only on the contact line but throughout the country is not decreasing, and in some areas is even increasing. The disruption of civilian infrastructure such as energy facilities, especially in the cold season, is one of the biggest challenges for us, and it requires large material and financial resources to restore. And energy facilities are not the only critical infrastructure sector in our country.

Disruption of the planned training of troops, restoration of combat capability, receipt of new weapons and military equipment - all this can become a purely military purpose for the enemy of continuing and increasing air strikes on targets in our rear. Therefore, not only the critical infrastructure of our country, but also military training grounds, supply bases and storage facilities, defence industrial facilities, military educational institutions and training centers will remain the targets of the aggressor's air strikes.

Prioritizing the strengthening Ukraine's air defence. If we want to close the skies over Ukraine, we need to start with solving the problem of detecting air targets. After all, detecting air targets usually requires more effort and it is more difficult than destroying them. Today, the Ukrainian Air Force solves this problem by skillful maneuvering of detection means in order to constantly confront the enemy with a new configuration of the radar field, which requires time and resources. However, this approach is more typical for covering groups of troops than objects in the rear, and is used in a certain way by necessity. The classic solution would be to build a continuous radar field covering the entire range of altitudes, including extremely low altitudes. Certainly, this is a long process that requires a lot of resources, effort and time, but this goal must be set. Complaints about the lack of funds should not prevent reliable protection of the lives of not only soldiers on the battlefield, but also civilians in the rear. Not to mention the fact that economic losses from air strikes not only on critical infrastructure but also on facilities that support the livelihoods of the Ukrainian people can significantly exceed these costs.

The re-equipment of the Ukrainian Air Force with anti-aircraft missile systems is a joint and long-term systematic work with our partners. It is important to remember that there are also other important factors.

First of all, we need to understand that our partners' stocks of anti-aircraft missile systems are exhaustive and extremely small. This means that any decision to transfer SAMs to Ukraine is and will be made by any country primarily to the detriment of its own security. Therefore, we understand that our partners have objective reasons, but today we are their shield against the invasion of the "hordes of orcs".

Second, the accumulation of heterogeneous foreign-made air defense systems in the Ukrainian Air Force is not a very positive tendency. However, we should remember that, unfortunately, the threat of Russian air strikes will not disappear, even after the war is over. The presence of various systems of such high-tech weapons as air defense systems in the troops will be a serious challenge for their usage and operation in a single system. That is why the future list of weapons for the Ukrainian Air Force in terms of air defense systems should be clearly defined, agreed upon and adopted for implementation by us and our partners.

Today, the Ukrainian Air Force needs to be equipped with three classes of air defense systems in terms of the range of air targets: short-range — up to 40 km, medium-range — up to 100 km, long-range — over 100 km.

Foreign-made medium-range and long-range air defense systems can fill the gaps in the Ukrainian air defense capabilities to combat ballistic targets. The unification of most foreign-made SAMs makes it possible to expand the capabilities of SAMs by changing the configuration and nomenclature of the anti-aircraft missile.

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Знищення засобів повітряного нападу противника під час російсько-української війни

Анотація

Кількісно-якісну складову Повітряно-космічних сил Російської Федерації (ПКС РФ) перед вторгненням на територію України було переоцінено. Експертів вражала кількість російських бойових літаків у складі створеного авіаційного угруповання, яке було створено для вторгнення в Україну. Чисельні показники початкового кількісно-якісного співвідношення сил сторін коливався від 1:7 до 1:30 і більше на користь ПКС РФ. Експерти різних країн притримуються думки, що РФ була та все ще залишається однією з небагатьох країн світу, що має наступальні спроможності в повітряному просторі. Якщо за основу брати відомість чисельного складу літаків і вертольотів, цілком можливо, що дані відповідали дійсності. Зауважимо, що станом на 24 лютого 2022 року лише те об’єднання ПКС РФ що було створено для вторгнення в Україну за кількістю бойових літаків чисельно переважало авіаційний склад ПС ЗС України майже в чотири рази.

Противник ставив перед собою завдання упродовж перших трьох діб стратегічної повітряної наступальної операції знищити українську ППО, протягом ще одного тижня - залишки бойової авіації.

У статті розкриваються особливості нанесення ракетно-авіаційних ударів по території України та тактик їх нанесення. Розглянуто, як вплинула допомога від наших партнерів у вигляді зенітних ракетних комплексів на ефективність української протиповітряної оборони. Проведено аналіз уроків, які отримав противник з початку широкомасштабного вторгнення та на чому саме нам необхідно зосередити зусилля для покращення української протиповітряної оборони.

Ключові слова: протиповітряна оборона; ефективність; зенітні ракетні війська; зенітні ракетні комплекси; ракетно-авіаційні удари; повітряна наступальна операція; засоби повітряного нападу; літаки; крилаті ракети; вертольоти; безпілотні літальні апарати.