Ukrainian Integrated Air and Missile Defence – Lessons Learned

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Resumé

De kontinuerliga lägesanpassade förändringar som genomförts av ett integrerat ukrainskt luft- och missilförsvar kan lära oss åtskilligt om elasticitet, anpassningsförmåga och betydelsen av en defensiv strategi med väl avvägda offensiva inslag i luftkriget. Striden, inom ramen för i artikeln definierade skeden, påvisar den helt kritiska betydelsen av att försvararen besitter numerär av olika luftförsvarssystem när angriparen använder sig av massinsatser för att slå mot och nöta ner kritisk samhällsstruktur liksom det luftförsvar som är förutsättningarna för att samhällets funktionskedjor ska kunna verka. Här är såväl de passiva som aktiva luftförsvarssystemen avhängiga av varandra, där en viktig erfarenhet från kriget i Ukraina är att det inte går att ersätta en luftförsvarskomponent genom satsning på en annan. En viktig lärdom är den ryska angriparens förmåga till kontinuerlig erfarenhetsrelaterad anpassning av såväl insatskoncept som utvecklingen av stridsmedel där massproduktionen av billiga UAV:er möjliggör kosteffektiva angrepp över tid.

IT WAS ALMOST impossible in February 2022 to find a military person in Ukraine that would be familiar with the Integrated Air and Missile Defence (IAMD) definition described in JP 3-01 and well known between Western armed forces officers educated at the war, command and staff or similar NATO oriented colleges and schools:

"Integration of capabilities and overlapping operations to defend the homeland and US national interests, protect the joint force, and enable freedom of action by negating an enemy's ability to create adverse effects from their air and missile capabilities" with its counterair framework components directly involved in air and missile defence (AMD) protection: attack operations, active and passive AMD.

It will be hard to find a Ukrainian air defence officer familiar with this definition today in 2025, even after 3 years of incredible fight for Ukrainian sky against one of the most powerful air powers in the world. This fight proved each point of the complex structure described many years ago in architecture, in close relationship between counterair and IAMD components, and that is only implemented in a complex effective enough to prevent air superiority of the numerous and technologically superior enemy.

Before analyzing IAMD in different stages of war and finding evidence of the effectiveness of each component of the defined architecture, it will be helpful to examine both sides' potential compared at the start of the full-scale invasion.

As of February 24, 2022, to protect critical national infrastructure (CNI), military objects and cities, the Ukrainian Air Force had only old Soviet AMD systems (only four types): SA-3 (S-125), SA-10 (S-300), SA-11 (BUK), SA-12 (S-300V1) but with sufficient stocks of interceptors. The effectiveness of the Ukrainian IAMD was assessed as low efficiency. Anti-tactical ballistic missiles (TBM) capabilities were almost non-existent.

And all that air and weak missile defence against more than 400 combat fixed-wing aircraft (old Su-24, Su-25, and new Su-30, Su-34, Su-35, MiG-31K) and about 250 attack helicopters (Ka-52 and Mi-24/28) concentrated in operational depth, which is only about 1/3 of all Russian tactical combat fleet, means there is a big potential to reconstitute the operational fleet in case of losses; 36 strategic bombers Tu-22M3, Tu-95, Tu-160; up to 20 naval cruise missile carriers with a simultaneous salvo capability of up to 140 cruise missiles; up to 5 000 high-precision missiles, which are about 3 000 air-launched cruise missiles (150 Kh-101, 300 Kh-555, 1 600 Kh-55, 1 000 Kh-59), 500 naval-launched cruise missiles 3M54-1 Kalibr (SS-N-27 Sizzler), 50 hypersonic air-launched ballistic missiles Kh-47M2 (AS-24 Killjoy), 900 ground based TBMs Iskander-M 9K720 (SS-26 Stone); more than 9 000 low-precision missile arsenal, which the enemy started using after wasting many high-precision missiles, with around 8 000 S-300 (SA-10), 470 P-800 Oniks (SS-N-26 Strobile), 370 Kh-22 (AS-4 Kitchen), and 500 Kh-35; and about 1 700 UAVs: 1 000 Orlan-10, 150 Forpost, 100 Orion, 450 ZALA/Lancet/Cube and others.

These numbers help to compare and understand the most essential lesson learned: You need sufficient means to protect your country against many threats. You need the mass of AMD means to stop the mass of threats, especially when your enemy has the potential for quick reconstitution and weapon production.

The development of the Ukrainian IAMD is taking place in conditions of high-intensity air attacks, constant changes in enemy tactics, and constantly changing air attack means. All the main changes in tactics and air threats allow to divide the offensive part of Russian aggression against Ukraine from the beginning of 2022 into different stages.

Stage 1—Classic "Blitzkrieg" (until March 2022)

The enemy's primary goal at the beginning of the armed aggression of the Russian Federation against Ukraine was aimed at destroying the entire AMD system of the state and creating conditions for air superiority, and later, dominance in the air.

Enemy tactic specifics: fixed-wing and rotary-wing aircraft fly deep into Ukraine;

20 enemy aircraft constantly in the air in combat air patrolling duty zones; 4–18 fixed-wing aircraft per sortie; 1–3 attack waves per day; 1 000 cruise missiles and TBMs attacked during this stage in total.

Massive attacks were made to destroy air defence, airpower, surveillance, and C2, using two general air force formations to attack from the North and another from the East and the South. Hundreds of missiles were fired from different directions.

Ukrainians' top priority at stage one was to save the defence potential.

Lessons learned from this stage: Passive air and missile defence, particularly detection and warning, dispersion, and, most importantly, mobility, are decisive actions when you are facing the first extremely massive attack of the superior enemy forces. Moving away from attacking friendly means, GBADs, radars, aircraft, logistics, supply, and sus-

tain nodes is very important. You need to be flexible in fast reconstitution and changing tactics. Saved and regrouped Ukrainian active AMD after reformations, shot down dozens of Russian aircraft.

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Stage 2—Frontline Stabilization (April–June 2022)

It took the enemy over a month to realize that there would be no fast victory, and it moved its power to Eastern Ukraine.

Enemy tactic specifics: fixed-wing and rotary-wing aircraft don't fly deep into Ukraine, but still act a lot inside the Ukrainian air defence systems kill zone; same massive attacks with 4–18 fixed-wing aircraft per sortie; 1–3 attack waves per day; air and missile attacks concentrated mostly on military objects and the supply chain to block foreign support.

Reacting to the enemy's changes in tactics, Ukraine moved its AMD means to the new most dangerous axes, improving its reconstitution capabilities (another crucial passive AMD component). It conducted the first successful attack operation (in air and missile defence domain), destroying the "Moscow" cruiser, which became not only an incredible motivating factor for the entire Ukrainian Defence Forces but also deprived the Russian Black Sea Fleet of a floating air defence "umbrella" and reduced aviation activities in the Black Sea.

At the same time, the besieged city of Mariupol became a terrible example of Russian air domination in the absence of AMD when the enemy can easily bombard military and civilian objects with all its carriers (Su-24, Su-34, Tu-22M3) with all kinds of bombs (from FAB-250 to FAB-3000).

Stage 3—Calm Period for IAMD (June–August 2022)

It has been a pretty calm period for Ukrainian IAMD. Russian aircraft are flying far away from the Ukrainian air defence systems' kill zone, and the enemy is using more reconnaissance UAS and increasing attacks with unconventional weapons using Kh-22 (AS-4), Oniks (SS-N-26 Strobile) and S-300 (SA-10) missiles to attack surface-based Ukrainian objects.

Stage 4—Massive Attacks on CNI[1] (September–December 2022)

The period of extremely intensive massive attacks (2–3 per month) concentrated mainly on the critical energy national infrastructure. Iranian "Shahed" drones appeared on the stage—a new unknown weapon for Ukrainian air defenders, successfully used in combination with up to one hundred per one attack cruise missiles (Kh-101/555 and Kalibr) with two main goals—destroy the energy generation capabilities and exhaust Ukrainian AMD.

Ukrainian CNI objects had no passive AMD at that time and survived that challenging period only because of enough active AMD (there are still many legacy systems and interceptors). First modern foreign air defence systems just started to arrive and showed high efficiency, but because of their limited numbers, they have not yet played a decisive role in Ukraine's AMD.

Stage 5—IAMD Transformation (January–July 2023)

It became obvious that new Russian tactics, such as massive air attacks, led to the risks of a shortage of munitions, especially Soviet Union-produced ones. Ukraine received many systems, including counter-TBM capable ones, and proved its power by intercepting the first Kh-47M2 (AS-24 Killjoy), which is not as invincible as Russia has claimed. Partner-nations donations reset the Ukrainian IAMD and put it on a higher level.

During this period, the Ukrainian Defence Forces conducted very important attack operations that helped to reduce Russian air attacks: first air defence ambushes (SAM-bushes) closed a few axes of the enemy's glide bomb attacks; Ukrainian attacks with unmanned naval drones in the Black Sea forced Russian ships (including Kalibr cruise missiles carriers) to move from Sevastopol to Novorossiysk; attacks on the Crimea air bases wiped out Russian jets from the peninsula; attacks on the Engels strategic bombers' air base forced Tu-95 aircraft—Kh101/555 cruise missiles carriers, to redeploy far away to the north.

Stage 6—Preparation for the CNI Protection (August–December 2023)

Ukraine, having experience with the previous year's attacks on CNI, is now paying special attention in preparing to repel massive attacks by one-way attack drones and cruise missiles, creating thousands of fire mobile teams and building up passive AMD (mostly hardening the assets with concrete, sand and ground).

Russia didn't conduct such massive attacks as they had the year before, at the same time, they tested a lot of weapons such as the black Shahed drones (attacking at night, when it is hard to detect them visually), cruise missiles with jammers and flares to jam Ukrainian radars and confuse interceptors' seekers, new Kh-59MK2 cruise missile (launching once per day from the same area at different assets in Ukraine), the first 3M22 Zircon (SS-N-33) hypersonic cruise missiles launched from Crimea, and the first North Korean KN-23 TBMs launched from Russian territory.

Stage 7—Current (January 2024–Present Time)

This is the stage when the enemy implemented all well-tested weapons and tactics with the most effective aerial attack means.

Russia started to conduct well-synchronized attacks with different weapons (one-way attack drones, cruise missiles, TBMs, and aerial-launched missiles). All launched drones and missiles arrived at the Ukrainian objects simultaneously. The enemy significantly increased the amount of glide bomb attacks: 15 times more than a year ago (from 1 500 per month in January to 3 000 per month by the end of the year). Attacks of Russian-produced one-way attack drones in combination with decoy drones (designed to overload Ukrainian IAMD) become a daily routine with up to 150 drones per night, showing their capabilities to produce a mass of relatively cheap air threats and requiring development of cost-effective solutions from the Ukrainian side.

From the Ukrainian side, this period showed that well-prepared objects of the CNI could not be protected enough by passive AMD means from the high-intensity attacks

without a significant amount of active AMD means (systems and interceptors).

As an example, on April 11, 2024, during the Russian attack on the energy infrastructure, one of the most important thermal power plants was destroyed. That powerplant was under the protection of the modern, highly effective western-produced air defence system, which previously destroyed 90 cruise missiles in that area during the year. That day the enemy launched 6 cruise missiles to destroy the power plant, 4 of which were successfully intercepted, but 2 reached the target just because of a lack of interceptors. Physical protection (passive AMD) could not replace active AMD. This is the one from many other events that shows that expensive AMD is cheaper than none at all.

The development of cost-effective solutions involved in the air fight light aviation and helicopters with machine guns, and improved electronic warfare equipment. Innovation and electronic warfare will be the integral parts of the new IAMD architecture.

> *The evolution of Ukraine's IAMD throughout the conflict serves as a powerful example of resilience, adaptability, and the critical importance of a balanced defensive strategy.*

Attack operations during this stage played a significant role. Successful SAM-bushes, conducted at the beginning of the year, stopped the enemy from dropping glide bombs in some axes for a few days to a few months and wiped out some 50 aircraft to date. A successful attack on Kursk oblast on Russian territory forced the enemy's air force to drop up to 30 percent of all glide bombs on their own country. Permission from the partner-nations to use the western long range attack capabilities to attack Russian territory allowed the Ukrainian Defence Forces to destroy S-300 sites that Russia used as a surface-to-surface missiles to terrorise pre-border Ukrainian territories. Regular deep drone attacks on Russian fuel production infrastructure, air bases, and munitions storage reduced attacks from air.

Conclusion

The evolution of Ukraine's IAMD throughout the conflict serves as a powerful example of resilience, adaptability, and the critical importance of a balanced defensive strategy. From the initial blitzkrieg attempts by Russian forces in 2022 to the sophisticated, synchronized attacks seen in 2024, every stage of this war has underscored the indispensable role of all components within the classic IAMD framework: attack operations, active, and passive AMD. All components, mentioned in the classic definition of the IAMD (JP 3-01), are effective only when implemented in coordination. It is impossible to replace one component by adding additional elements of another component. Yet the main role (most effective and resultative) is played by attack operations and active AMD (systems and effectors).

The author is a colonel in the Ukrainian Air Force.

Note

1. Critical National Infrastructure.