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Ukraine's Air Defence in the Russian-Ukrainian War (2022–2024): Progress in Regression

Summary: Russia's full-scale aggression against Ukraine, which began on February 24, 2022, posed serious challenges to the Ukrainian air defence system. Its traditional instruments – long- and medium-range anti-aircraft missile systems (S-300, Buk-M1) and fighter aircraft (MiG-29, Su-27) – did not always prove effective in the new conditions. It was necessary to repel mass attacks from cruise missiles which were characterised by having a small deflection area and the ability to fly at low-altitude targets. In September 2022, the Russians started to use numerous attack drones called Shaheds, which meant that the Ukrainian air defence had to adapt quickly to the new threat. In order to combat these missiles, mobile fire groups with machine guns and MANPADS on pickup trucks began to be used, which quickly advanced towards the enemy attack. The equipment used by these mobile fire groups was gradually improved. One example was from the Czech Republic, where Viktor sets were created. These consisted of twin-barrelled machine guns from the 1940s combined with thermal imaging cameras and mounted on pick-up trucks. German FlakPz Gepard self-propelled anti-aircraft guns transferred by partner countries also proved very effective. In NATO countries, this equipment was considered obsolete in the 1990s, but between 2022–2024 in Ukraine, it effectively destroyed UAVs and cruise missiles. Light training and sports aircraft, provisionally armed with machine guns and using tactics from World War I, have been successfully used to fight unmanned aerial vehicles. These examples show that even in regression, as highlighted by a return to air defence measures from previous decades, progress can be made to adapt to new threats from the air. This article aims to present the unconventional air defence measures used by the Armed Forces of Ukraine to eliminate the threat posed by Russian aerial attack assets.

Keywords: Russian-Ukrainian war, air defence, anti-aircraft missile system, anti-aircraft artillery system, fighter aircraft

https://doi.org/10.18778/3071-7779.2024.2.09 — **received:** 18.03.2024 — **verified:** 11.10.2024 — **accepted:** 14.11.2024

141–154

funding information: not applicable — **conflicts of interests:** none — **declaration regarding the use of GAI tools:** not used
ethical considerations: the authors assure of no violations of publication ethics and take full responsibility for the content of the publication
the percentage share of the author in the preparation of the work is: [AK 100%]

The aggression of the Russian Federation against Ukraine, which escalated to full-scale war on February 24, 2022, became the first full-scale war in Europe since World War II, involving the use of all types of weaponry (except nuclear). Ukraine's defence forces had to confront a significantly larger and stronger adversary, often resorting to unconventional and unexpected measures. This is particularly evident in air defence. This article aims to present the unconventional air defence measures used by the Armed Forces of Ukraine to eliminate the threat posed by Russian aerial attack assets. Photos and audiovisual materials confirm the use of various combat equipment that before this war, was previously considered obsolete. However, under the conditions of large-scale aerial warfare, accompanied by Russia's deployment of a wide range of offensive measures, these weapons demonstrate unexpected effectiveness. A phenomenon is being witnessed that can be described as 'progress through regression' – where outdated air defence systems, operating within a modern informational battlefield, prove effective against advanced air attack methods. This article analyses the use of unconventional technical and tactical means in Ukraine's air defence, developed in response to the challenges posed by Russia's full-scale aggression.

The issue of employing the aforementioned air defence methods has not yet become the subject of academic research or publications. Military archives containing relevant documentation from 2022–2024 are not yet accessible to researchers. Therefore, the primary sources used in this study are media articles and social media material, which illustrate the deployment of outdated air defence systems and their integration into the modern theatre of war.

Before the Full-Scale Aggression

On the eve of Russia's full-scale aggression, Ukraine possessed a fairly robust air defence system. In addition to five tactical aviation brigades equipped with fighter aircraft (though their actual strength was significantly below authorised levels), the system included approximately 250 long-range S-300 surface-to-air missile (SAM) launchers and 72 Buk-M1 medium-range SAM launchers.[1] There was also a corresponding network of radar stations and an automated air defence command system. By design, the structure and armament of Ukraine's air defence system were suited to the requirements of the Cold War era – focused on intercepting traditional targets such as combat jets. From 1991 onwards, the system underwent no qualitative changes; instead, outdated systems (S-75, S-125, S-200) were decommissioned. Significant efforts to strengthen air defence capabilities began only after 2014, following Russia's annexation of Crimea and the onset of the war in the Donbas. Unfortunately, these efforts were conducted under conditions of chronic financial shortages.

1 MB 2022, 213.

A comprehensive modernisation program for the Air Force was proposed only in 2020, and even then, it was presented not as a binding document but as the 'Air Force Vision 2035'. This document realistically assessed the primary threat posed by the Russian Federation, identifying its Aerospace Forces as the main carrier of combat potential. Based on this assessment, the procurement of 36 to 40 medium-range SAM systems (such as NASAMS or similar systems) was designated a priority, intended to be implemented between 2020 and 2025. The purchase of new combat aircraft – foreign-made 4++ generation fighters (Saab JAS-39E/F Gripen, F-16 Block 70/72, or others) – in quantities of 72 to 108 units was scheduled for 2025 to 2030. However, a smaller batch of such fighters (6 to 12 units) was proposed for purchase between 2023 and 2025 to initiate personnel training on the new aircraft.[2] None of these proposed measures were implemented before Russia's full-scale invasion. Only a small number of MiG-29 and Su-27 fighter jets were modernised, and even then, the scope of these upgrades was minimal. Since 2014, efforts have been made to gradually restore S-300V1 SAM systems to service, and work was undertaken to modernise the S-125 systems. However, the Kub SAM systems – also considered a means to bolster air defence, albeit quantitatively rather than qualitatively – could not be restored to operational readiness.[3]

New Challenges

The Ukrainian command had a fairly realistic assessment of the potential Russian aggression. For instance, on the first day of the 'United Efforts 2021' exercise ('Об'єднані зусилля 2021' – September 22–30), air defence units armed with S-300, S-125, Buk-M1, and Osa-AKM systems trained to repel a massive enemy missile and airstrike – precisely the scenario that the aggressor sought to implement on February 24, 2022. Simulations of hostile cruise missiles were conducted using Tu-141 and Tu-143 unmanned aerial vehicles (UAVs). MiG-29 and Su-27 fighter jets, as well as Su-25 attack aircraft, also operated in the air, simulating enemy air force activities.[4]

On February 24, 2022, Ukraine's air defence system faced its most serious challenge yet: repelling a massive missile and airstrike by the Russian Federation while simultaneously withdrawing its forces to avoid destruction. During the first 48 hours of combat, the enemy damaged nearly 75% of Ukraine's stationary air defence facilities, but only 10% of its mobile positions. On the first day, Ukraine's air defence system managed to intercept only 12–18% of incoming air attacks. That day, Russian tactical aviation conducted approximately 140 combat flights, striking targets up to 300 km deep.

2 *Viziya* 2020, 27–29.

3 *S-300V1* 2027.

4 *V Ukrayini* 2021.

Most attacks were carried individually, with only 25% conducted in pairs or larger aircraft groups (a trend that persisted in the following months and years of the war; Russian aviation lacks the capability to conduct mass strikes even at the squadron level).[5] At the same time, Ukraine's ground-based air defence system and fighter aircraft, despite suffering significant losses, retained their combat capabilities. Meanwhile, Russia's military-political leadership failed to achieve its goal of a swift victory over Ukraine. The war then transitioned into a protracted phase, and due to significant losses, the Russian command was forced, starting in mid-March 2022, to substantially limit tactical aircraft flights to targets at tactical or operational depths.

In the following months, Russian forces shifted their focus to striking infrastructure deep within Ukraine and targeting Ukrainian cities, hoping to force Ukraine into capitulation. Air-launched cruise missiles (Kh-22, Kh-32, Kh-101, Kh-555) and sea-launched cruise missiles (Kalibr) became the primary means of attack. Ballistic missiles were used to a limited extent, including ground-launched (Iskander-M) and air-launched (Kinzhal) types.

From the autumn of 2022, the Russian aggressors increasingly relied on Iranian long-range strike UAVs (Shahed-131, Shahed-136).[6] This shift like air attack methods created the need to adapt Ukraine's air defence system to the new conditions.

Mobile Fire Groups

The distinctive features of Russian airstrikes on Ukrainian territory include:

- relatively low speeds for most strike assets (the cruise speed of the Kh-101 cruise missile is about 700 km/h, while the Shahed-136 UAV travels at just 150–170 km/h)
- low flight altitude of the strike assets (usually tens or hundreds of metres)
- mass deployment (dozens, and sometimes over one hundred cruise missiles and UAVs in a single attack)

The specific nature of the equipment used by the Russian military highlighted above, determines the tactics used for counteraction. The low flight speed (and in the case of the Shaheds, the distinct engine sound, which has earned them the nickname 'flying mopeds') combined with low altitude facilitates the detection of cruise missiles and UAVs without the use of radar or other technical means. However, their low altitude complicates interception by traditional methods – fighter aircraft radars often struggle to detect small targets against the ground surface, and ground-based radars have blind zones at low altitudes (typically addressed by elevating radar antennas on tall masts, but this requires additional technical resources). Furthermore, anti-aircraft missile systems find striking targets at low altitudes particularly challenging.

5 *Rik viyny* 2023, 253–254.

6 Charuk A. 2024, 212.

Low altitude and speed also make cruise missiles and UAVs vulnerable to small-calibre anti-aircraft guns, heavy machine guns and even standard small arms. This significantly reduces the cost of neutralising aerial targets since the cost of an anti-aircraft-guided missile is typically much higher than that of a Shahed. However, such anti-aircraft weapons have a short effective range, meaning they must be rapidly redeployed to intercept air attacks. This necessity gave rise to the concept of mobile fire groups – small units typically comprising three or four different anti-aircraft weapons mounted on pickups or trucks. Upon receiving an air alert, these groups are directed towards the likely approach of cruise missiles or UAVs targeting an object.

The composition of mobile fire groups includes a wide range of firepower. Typical examples are DShKM 12.7 mm heavy machine guns mounted on pickups or twin 23 mm ZU-23–2 cannons (including Polish ZU-23–2CP and Finnish 23 ItK 61 models) mounted on several types of trucks. More unconventional setups also exist – for instance, one mobile fire group was observed armed with a mount featuring three DP-27 7.62 mm machine guns installed on a tripod (the central machine gun in its usual position, with the two side guns vertically mounted). This system was placed on a single-axle trailer, towed by a UAZ-452 van. The second category of weapons includes portable surface-to-air missile systems: Soviet Igla, U.S.-supplied Stingers and French Mistrals provided by Norway.[7]

Mobile fire groups have been established within various structures. Initially, they appeared in the Air Force – not only within anti-aircraft missile units but also in radiotechnical brigades. Similar groups were formed in territorial defence brigades, the Ukrainian National Guard – including both frontline brigades and battalions protecting critical state infrastructure such as nuclear power plants. The Ukrainian State Border Guard Service operates its mobile fire groups, and the river flotilla of the Ukrainian Navy in the Kyiv region employs its boats for this purpose.[8] Geographically, mobile fire groups are deployed across all regions of Ukraine (except, of course, those occupied by Russia), including the relatively remote and peaceful Zakarpattia region.[9]

The use of simple weapons by mobile fire groups allowed for effective targeting in good visibility conditions, but their efficiency sharply declined in poor visibility. Consequently, groups began to be equipped with searchlights. At night, the direction of an approaching Shahed was determined by sound, after which the target was illuminated with a searchlight and fired upon.

The next logical step was to develop an anti-aircraft system mounted on a pickup truck equipped with a thermal camera. One such system, the MR-2 Viktor, was created for Ukraine in the Czech Republic. It combines a twin-barrelled ZPU-2 14.5 mm heavy

7 *Norvehiya* 2022.

8 Charuk A. 2024, 61–62.

9 *Protypovitryanu* 2023.

machine gun (1949 model) with a Toyota Land Cruiser 70 pickup, along with a collimator and thermal imaging sights. Its ammunition load consists of 600 rounds (300 ready for immediate use and 300 in reserve), and its effective firing range reaches 2 km.[10]

A vintage machine gun upgraded with contemporary sights and placed on a mobile platform has demonstrated its effectiveness in targeting low-altitude threats. In November 2022, Czech entrepreneur Dalibor Dédek initiated a campaign to raise 3.85 million USD for the production of 15 MR-2 Viktor systems. In February 2023, the Dutch government declared its plan to finance the creation of another 100 systems. The initial MR-2 systems were produced in March 2023.

Overall, additional equipment with thermal imaging sights has become a major focus for improving air defence equipment. The scale of such initiatives, conducted mainly through volunteer efforts, is impressive. The 'Technari' engineering group from Odesa developed a method for mounting thermal cameras on Igla, Stinger and other MANPADS launchers. In October 2023, the Serhiy Prytula Charitable Foundation announced the purchase of 100 Guide TK 431 and 150 Guide TK PRO 35 thermal cameras for MANPADS for 318,000 EUR. In February of the following year, the foundation reported that since early 2024, it had delivered 900 thermal imaging devices to units – 400 Guide TK631 sights and 500 Guide TK431 monoculars.[11]

Another significant project by the 'Technari' group was the Wally thermal sight, designed for the Strela-10 air defence system. While mobile fire groups do not use this system (no evidence was found during the research for this article), it remains a crucial air defence component for Ground Forces on the front line. Outfitting the Strela-10 with the Wally sight significantly improved its effectiveness against Russian UAVs.[12] As of early 2024, during six weeks of testing, the Wally prototype achieved five confirmed kills of Zala, Lancet and Supercam UAVs. This solution was rapidly scaled – by mid-July 2024, 40 Strela-10 vehicles had been equipped with Wally sights, with 10 more awaiting installation. At that time, Strela-10 systems equipped with Wally sights had already downed 14 Zala reconnaissance UAVs, which Russia frequently uses for targeting Iskander-M missiles.

Anti-Aircraft Artillery System: Gepard

The Russo-Ukrainian War unexpectedly highlighted the effectiveness of outdated air defence systems. A schoolbook example is the German FlakPz Gepard anti-aircraft artillery system (AAA). Developed in the early 1970s, it was retired from service in the Bundeswehr in 2010 due to defence budget cuts. After Russia's large-scale invasion of

10 Mashchenko O. 2024.

11 *Fond Prytuly zakupyv* 2024.

12 *Fond Prytuly peredav* 2024.

Ukraine, the German government began supplying Gepards as part of military-technical assistance. The intention to deliver this type of weapon was first announced during the initial meeting of the contact group in the Ramstein format on April 26, 2022. The first batch of Gepards arrived in July, with subsequent deliveries occurring in small batches as these AAA systems were repaired from storage (Fig. 1). In total, Germany delivered 52 Gepards in 2022–2023.[13] In 2024, an additional 60 anti-aircraft systems arrived in a different configuration – former Dutch Gepards, which feature a different radar type. These systems were purchased by Jordan in 2013 and later acquired by the U.S. government in May 2023 for Ukraine. The 118 million USD contract included repairs in Jordan and delivery to Ukraine by the end of May 2024.

Fig. 1. Geprad in the marking of the Ukrainian Army. May 2023, Ukraine. (Source: Sofinov T. 2023)

The Gepards were first used on the frontline during the Ukrainian Kharkiv offensive in September 2022.[14] Some issues arose with ammunition supplies – by late October 2022, German Defence Minister Christine Lambrecht sent a letter to her Swiss counterpart, Viola Amherd, explaining that the anti-aircraft guns had been used so intensively that despite significant ammunition deliveries, a shortage had developed. The Gepard is equipped with Swiss-made 35 mm Oerlikon KDA cannons, for which ammunition production had ceased in Germany. Switzerland, due to its political stance, refused to supply ammunition (or any other military goods) to Ukraine.[15] Efforts to source ammunition even extended to countries as far away as Brazil, which also declined to sell rounds to Ukraine. The problem was finally resolved in early 2023 when

13 *Zbroya rosiys'ko-ukrayins'koyi viyny* 2023, 194–199.

14 *Zenitni ustanovky 'Gepard'* 2022.

15 *Nimechchyna* 2022.

the German government signed a contract with Rheinmetall to resume production of 35 mm rounds for the Gepards.

Despite these challenges, since autumn 2022, the Gepard anti-aircraft artillery systems have been actively used both on the frontlines and within mobile fire groups protecting critical infrastructure. These systems have proven highly effective against drones and cruise missiles. Owing to their radar stations, Gepards can engage targets at night, and their targeting systems allow rapid switching between multiple targets. This capability was particularly valued in October 2022, when Russian forces attempted to overwhelm Ukrainian air defences with mass Shahed drone attacks.

In December 2023, a representative of the Ukrainian Air Force Command stated that among all air defence systems, the Gepard was the most effective in neutralising enemy drones, considering the cost-effectiveness ratio. As a result, the possibility of increasing their numbers in Ukraine's armed forces cannot be excluded. While the available stock of Gepards (the last of which was manufactured in 1980) is gradually depleting, some units are still available on the market – for example, the Belgian company OIP Land Systems has approximately 40 units in stock, acquired from the Belgian Ministry of Defence.

FrankenSAM Anti-Aircraft Missile Systems

Soviet-origin anti-aircraft missile systems have been and remain a crucial component of Ukraine's air defence. The supply of Western air defence systems – both modern (Patriot, NASAMS, IRIS-T, SAMP/T) and older generation ones (I-HAWK, Crotale, Aspide 2000) – has not fully met Ukraine's needs. Meanwhile, the capabilities of Ukraine's anti-aircraft missile units have significantly diminished throughout the ongoing war. This is not only due to the loss of systems (or their components such as launchers, radars, or command cabins) but also the inevitable depletion of Soviet-made missile stockpiles. To address this situation, the concept of integrating Western and Soviet anti-aircraft missile system components was proposed. The initiative was named FrankenSAM, encompassing several distinct projects.

The most well-known FrankenSAM project involves integrating RIM-7 Sea Sparrow and AIM-7 Sparrow missiles with the Buk-M1 anti-aircraft system. The U.S. government first announced its intention to supply RIM-7 missiles to Ukraine as part of a military aid package on January 6, 2023, followed by AIM-7 missiles on May 31, 2023. These announcements caused controversy, as no ground-based launchers for the missiles were included, and integrating AIM-7 missiles with Soviet-made fighter jets was impossible. Experts quickly speculated about the potential use of these missiles with the Buk-M1 systems.[16] The idea appeared feasible, especially since similar experiments

16 Kozatskyi S. 2024.

had previously been conducted in the Czech Republic and Poland to integrate Sparrow missiles with the Kub system (the predecessor to the Buk-M1).

For a long time, progress on the FrankenSAM program was not disclosed. Ukraine's Air Force Command confirmed the integration of the Buk-M1 with the RIM-7 in November 2023, and on the night of January 17, 2024, the system shot down its first aerial target – a Shahed drone – at a significant range of 9 km.[17]

The second project within the FrankenSAM program, developed jointly by Ukrainian and American specialists, involves an anti-aircraft system using American short-range air-to-air AIM-9 Sidewinder missiles paired with a Ukrainian radar system. This project was first mentioned in October 2023, but no details regarding its deployment have been released so far.

The third project, also reported in October 2023, involves integrating Patriot missiles with the Soviet S-300 air defence system. Tests for this system were conducted in the United States at the White Sands Missile Range.[18]

Additionally, there are two systems that experts do not formally classify as part of the FrankenSAM program, though they are conceptually similar. The first is an improvised anti-aircraft missile system created by British specialists, using short-range AIM-132 ASRAAM air-to-air missiles. The system features a dual-missile launcher mounted on a three-axle SupaCat off-road vehicle, with additional missiles (possibly four) stored as spares. This system lacks a radar and instead uses an electro-optical targeting head mounted on a mast behind the vehicle's cabin. In this configuration, the system is effective against helicopters, drones and cruise missiles, but destroying aircraft would require external targeting data. The British government announced the delivery of such systems to Ukraine in early August 2023.[19]

Another example is the adaptation of the Osa-AKM anti-aircraft system to use R-73 air-to-air missiles. This was a workaround for the shortage of missiles for these air defence systems (an issue that had previously been addressed by attempting to purchase missiles from Middle Eastern countries). Instead of the six standard 9M33 missile containers on the Osa-AKM launcher, two R-73 missiles were mounted on open rails (APU-73 aircraft launchers). This configuration increased the range of target engagement from 9–10 km to 12 km but slightly reduced functionality. The 9M33 has a radar-guided warhead, while the R-73 has an infrared-guided warhead, meaning it can only target thermally contrasting objects (e.g., cruise missiles) but not Shahed drones with their low thermal signatures. The first images of the Osa-AKM with R-73 missiles appeared in November 2023, with a detailed description published in May 2024.[20]

17 *Hibrydnyi ZRK* 2024.

18 *FrankenSAM* 2023.

19 Kharuk A. 2024a.

20 *U ZSU nareshti* 2024.

The 'ePPO' System

Prior to the widespread use of radar, air attack warning systems depended on an extensive network of ground-based observation posts linked via telephone lines to air defence control centres. The observers' eyes and ears were the sole means of detecting aerial targets. It may seem that, with the advent and continuous improvement of radar technology, this method has been relegated to history. However, in Ukraine, during the defence against Russian aggression, this approach has been revived at a qualitatively new level and is being successfully utilised. This is facilitated by a smartphone application called ePPO (єППО), developed by the 'Technari' group. The app enables users to send notifications concerning missiles and drones (UAVs) that have been sighted or heard. Based on these reports, ePPO's artificial intelligence calculates the most likely flight path of the aerial target, displays the trajectory on a map, and alerts other users of the app if their current location is dangerously close to the flight path, signalling a direct threat of an explosion nearby. Submitting a report is not anonymous – authorisation is required through the Diia electronic administration system, which minimises the chance of intentional false reports.[21]

The first version of the ePPO was launched on October 4, 2022. By October 22, the first successful interception of a Kalibr cruise missile was confirmed thanks to data received from three system users. The missile was flying at a low altitude and was difficult to detect with traditional methods due to the terrain. However, thanks to the ePPO users, a mobile fire team had enough time to shoot down the Kalibr using an Igla MANPADS. At that time, ePPO had approximately 100,000 users, and within a year, this number grew to 460,000.[22]

Substitute for Fighter Aircraft

The rapid development of unmanned aerial vehicles (UAVs), their growing capabilities and improved combat tactics have exacerbated the challenge of countering them. Unfortunately, Ukrainians have learned firsthand that the appearance of a Russian reconnaissance UAV, even dozens of kilometres from the front line, is often a precursor to a missile attack. Traditional methods of combating UAVs do not always perform well in this role – for example, classic fighter jets such as the MiG-29 and Su-27 were not designed to counter small, slow aerial targets. A turbo-propeller light attack and training aircraft, such as the globally popular A-29 Super Tucano, could better fulfil this role. However, Ukraine did not possess such aircraft and their acquisition was not a priority. However, a private initiative rescued the situation. The 'Civil Air Patrol',

21 Korshak N. 2024.

22 Sul›din G. 2024.

an organisation of light aircraft owners, contributed its planes and crews to the effort. These sport and training aircraft are not equipped with built-in or external weapons, so drones are shot down by a second crew member using conventional firearms fired from the cockpit. This method is reminiscent of not the era of World War II but of the very beginnings of World War I when pilots of enemy aircraft exchanged fire using revolvers or rifles when they met in the air.

Implementing this concept required addressing several organisational challenges. One major issue was ensuring the safety of civilian aircraft operations in a warzone, preventing them from being targeted by friendly air defence systems. By the spring of 2024, the activities of the Civil Air Patrol in countering UAVs were not widely publicised. During the research for this article, only one reference was found which concerned the awarding of medals for 'The Liberation of the Kharkiv Oblast' to pilots of the Kharkiv Separatate Volunteer Aviation Unit of the Civil Air Patrol. The statement indicated that 'alongside soldiers of the 92nd Mechanised Brigade named after Otaman Koshevoi Ivan Sirko and the Special Operations Centre 'A' of the Security Service of Ukraine, eight aerial targets of the occupiers were destroyed'.[23] Based on this information, it is unclear whether these aerial targets were shot down by the aviation unit's crews or whether they merely alerted ground-based air defence systems.

Fig. 2. Yak-52 used to combat Russian drones. June 2024, Ukraine (Source: *Yakshcho odyn Yak-52.* 2024)

The first visual confirmation of a UAV being shot down by a Civil Air Patrol aircraft emerged on April 27, 2024, when a video was posted online showing the downing of an Orlan-10 UAV over Odesa by the crew of a Yak-52 (Fig. 2). The footage shows the drone descending by parachute while being circled by a Ukrainian aircraft. The shooter,

23 *Tsyvil'nyy* 2023.

reportedly armed with an RPK-74 light machine gun, is seen in the rear cockpit of the Yak-52.[24] New unusual images of the Yak-52 fighter taken by a Russian UAV camera over the Mykolaiv Oblast – surfaced in June 2024. The aircraft's unique camouflage pattern is clearly visible. At the same time, a photo was posted on Facebook showing a fragment of this aircraft's fuselage decorated with aerial victory marks: two Zala UAVs, six Orlan-10s and two additional silhouettes accompanied by supplementary markings. The first is the distinctive twin-tail silhouette of an Iranian Mohajer-6 UAV, paired with an image of a bird. The second is an Orlan-10 with a thundercloud.[25] These likely represent incidents where the Yak-52 crew witnessed enemy UAVs being destroyed, but not by their direct involvement – such as a collision with a bird or being caught in a storm.

The Yak-52 is not the only type of light aircraft used (or intended to be used) for countering UAVs. In July 2024, Ukraine's Ministry of Defence's Main Intelligence Directorate released a training video in which a shooter armed with a Maliuk rifle fires at a drone target from the cockpit of an ultralight Aeroprakt A-22 aircraft.[26]

The examples analysed demonstrate that combining technology from previous eras with modern solutions can create effective and inexpensive air defence measures relatively quickly and easily. Most of these methods cannot be used against modern jet fighters – they are effective only against UAVs and cruise missiles. However, these are the main categories of aerial threats appearing over Ukrainian territory. The use of simple yet numerous measures prevents the 'saturation' effect in air defence, where the number of targets exceeds the system's capabilities. In conclusion, Ukraine's experience constitutes a significant chapter in the history of aerial warfare and serves as a valuable example for other armies in organising defences against mass aerial attacks.

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