

# Getting serious about building Ukraine's air defence capabilities

Dr Julia Muravska



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*Cover image: An air defence unit of the Ukrainian Armed Forces, known as drone hunters, illuminates the sky with a powerful searchlight at night at a position in the Kyiv region of Ukraine, 24 March 2024*

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## About the Author

Dr Julia Muravska is a Visiting Senior Research Fellow at the Freeman Air and Space Institute and a Senior Associate Fellow at the NATO Defence College (NDC). Julia is also an independent defence analyst and consultant. Julia's research focuses on defence industry, defence acquisition, and innovation and new technologies in defence. She has a particular interest in Ukraine. Julia has previously worked in policy research and advisory, management consulting, academia, and the NGO sector, and has 14 years of experience leading research and analysis in the fields of defence industry, policy, and innovation. Julia holds a PhD and MSc in international relations from the London School of Economics and Political Science (LSE), as well as an Honours BA in international relations from the University of Toronto.

## Abstract

Despite initial calls for a NATO-enforced no-fly zone being rejected, Ukraine's allies have gradually supplied air and missile defence systems. However, since early 2024, Ukraine's air and missile defence capabilities have struggled to keep up with evolving Russian threats, including mass drone attacks and aerial bombardments, as well as targeted destruction of energy infrastructure. The current composition of Ukraine's air defence systems includes a variety of Western systems, but also relies on Soviet-origin equipment, with significant gaps due to shortages of interceptors and delays in international support. Ukraine's NATO supporters have sought to address these challenges in innovative ways, such as retrofitting Soviet-era systems to use Western interceptor missiles. Additionally, international coalitions have been established to improve Ukraine's defences, aiming to meet immediate and long-term needs. While helpful, these steps have not resolved the fundamental issue – namely, partners' insufficient and untimely supply of air defence capabilities given the scale and pace of Russian attacks.

This analysis calls for more decisive and calculated actions from NATO, suggesting that providing air defence coverage over parts of Ukraine from NATO territory could be crucial for signalling resolve to the Kremlin and helping protect Ukraine's cities and infrastructure, without escalating the conflict. It would also reinforce NATO's 'red lines' regarding Allied territory, following repeated incursions by Russian projectiles into NATO airspace along the Ukrainian border. This paper reviews the challenges of this approach, but concludes that it is both feasible and necessary if Ukraine's NATO supporters are serious in their commitment to the country's defence and the security of their own citizens.

## Introduction

In the early days and weeks of Russia's full-scale invasion of Ukraine in February 2022, the embattled Ukrainian government, its traumatised population, and shocked diaspora repeatedly called for a NATO-enforced no-fly zone over Ukraine. The aim was to protect Ukraine's civilians from sustained Russian air and missile attacks. While NATO powers rejected these calls due to concerns over 'escalation,' Ukraine's partners gradually provided various air and missile defence capabilities as the war progressed. In November 2023, a G7 foreign ministers meeting reportedly sought to 'work on building an air defence shield' for Ukraine. Since the beginning of 2024, however, despite enabling relatively robust protection for Kyiv, Ukraine's overstretched and depleting air and missile defence capabilities have struggled to shield military assets and population centres from evolving Russian threats, such as mass Shahed-type UAV attacks and aerial bombardments.

This paper will review the current publicly available composition of Ukraine's air defence capabilities, the evolving nature of the threats and attacks they face, and the critical gaps caused by delayed support, partner reluctance, interceptor shortages, and other issues. It will explore innovative ways to overcome these challenges and emphasise the need for decisive and strategic action to provide Ukraine with essential air and missile defence support. This includes assessing the feasibility of integrating NATO-based air defence systems with Ukraine's and using launches from NATO territory to engage targets over Ukraine.



Following the collapse of the Soviet Union, Ukraine inherited a formidable arsenal of surface-based air and missile defence systems

## Ukraine's Current Air Defence Capabilities

### Brief History: Fall of the USSR until Russia's Full-Scale Invasion

As Table 1 shows, despite significant depletion due to historic underinvestment and the ongoing Russo-Ukrainian war, Ukraine continues to rely on Soviet-origin air defence systems. Following the collapse of the Soviet Union, Ukraine inherited a formidable arsenal of surface-based air and missile defence systems. In the early 1990s, newly independent Ukraine possessed over 200 anti-aircraft missile battalions, including 43 equipped with S-300PT/PS systems and 23 operating Buk systems.<sup>1</sup>

Over the next two decades, Ukraine's air defence capabilities deteriorated due to underinvestment, mismanagement, pro-Russian policies of previous administrations, and the annexation of Crimea. At the same time, the latter event, combined with Russia directing and propping up separatist movements in the Donbas region, spurred sporadic efforts to overhaul and repair legacy S-300 and Buk systems, including their interceptor missiles. Ukrainian armed forces even brought out of storage and repaired obsolescent equipment like the 1960s-era S-125 Pechora short-range surface-to-air (SAM) missile launcher.<sup>2</sup>



**Table 1:** Ukraine's Current Surface-Based Air and Missile Defence Capabilities

Equipment	Classification	Quantity (Launchers)	Description
<b>2K22 Tunguska</b>	Point Defence Anti-Air Gun/ Missile System	75	Self-propelled, Soviet-design; anti-aircraft gun with a missile system
<b>9K38 Igla</b>	Man-Portable Air Defence System (MANPADS)	Unknown	Point-defence; Soviet-design, Russian production
<b>LMM</b>	MANPADS	Unknown	Point-defence; new UK system, supplied to Ukraine in early 2022
<b>Mistral</b>	MANPADS	Unknown	Point-defence; ageing French system, supplied to Ukraine in spring 2022 by Norway, subsequently by France
<b>Piorun</b>	MANPADS	Unknown	Point-defence; Polish system, originally acquired by the US, then supplied to Ukraine before the full-scale invasion
<b>Starstreak (LML)</b>	MANPADS	Unknown	Point-defence; UK system, supplied to Ukraine in spring 2022
<b>9K33 Osa</b>	Point Defence Self-Propelled Surface-to-Air Missile (SAM) System	65	Soviet origin; operational since the early 1970s; Poland donated at least one
<b>9K330 Tor-M</b>	Point Defence Self-Propelled SAM	6	Soviet design, in service since 1991
<b>9K35 Strela-10 and 10M</b>	Point Defence Self-Propelled SAM	Unknown	Soviet design; highly mobile system
<b>FV4333 Stormer with Starstreak</b>	Point Defence Self-Propelled SAM	6	UK systems: high-velocity Starstreak missile system mounted onto the Stormer armoured vehicle; delivered to Ukraine in summer 2022
<b>M1097 Avenger</b>	Point Defence Self-Propelled SAM	6	Highly mobile US system, first delivered to Ukraine in late 2022
<b>Crotale NG</b>	Short-Range Surface-to-Air Missile (SAM) System	4	Mobile French system, first delivered to Ukraine in late 2022
<b>IRIS-T SLS</b>	Short-Range SAM System	9	German short-range variant of the IRIS-T SLM system; latest delivery in August 2024
<b>NASAMS</b>	Short-Range SAM System	12	Towed; joint US-Norway development; first delivered to Ukraine in September 2022; supplied by the US, Norway, and Lithuania
<b>S-125 Pechora</b>	Short-Range SAM System	Unknown	Towed; obsolescent 1960s Soviet system
<b>9K37M Buk-M1</b>	Medium-Range Self-Propelled Surface-to-Air Missile (SAM) System	50 (estimated, incl. some converted to AIM-7 Sparrow)	Soviet-origin system
<b>IRIS-T SLM</b>	Medium-Range Self-Propelled SAM System	12	German-developed system, incrementally supplied to Ukraine since autumn 2022
<b>MIM-23B I-HAWK Phase III</b>	Medium-Range Self-Propelled SAM System	4	US system first developed in 1959, delivered to Ukraine by Spain and the US starting in late 2022
<b>M902 Patriot PAC-3</b>	Long-Range Self-Propelled Surface-to-Air Missile System	28	US system first delivered to Ukraine in April 2023, 22 provided by Germany; rest by US and Netherlands; proven highly effective
<b>SAMP/T</b>	Long-Range Self-Propelled SAM System	4	Joint French-Italian development; one battery/fire unit arrived in Ukraine in summer 2023
<b>S-300P, S-300PS, S-300PT</b>	Long-Range Self-Propelled SAM System	250	Soviet-designed family of systems
<b>S-300PMU</b>	Long-Range Self-Propelled SAM System	8	More mobile variant of the Soviet-era S-300 system, including one donated by Slovakia in April 2022
<b>S-300V</b>	Long-Range Self-Propelled SAM System	Unknown	Soviet-era system mounted on a tracked armoured vehicle; aimed at defeating mass attacks

**Source:** The International Institute for Strategic Studies (Military Balance+ Database); press reports; author's analysis, as of the end of September 2024.

**Note:** The table uses the International Institute for Strategic Studies (IISS) classifications. Air defence artillery is not depicted unless it can be classified as an air defence system.



Just a month after Russia's full-scale invasion, Ukraine's stocks of surface-to-air missiles were running low

Possession of some operational Soviet-era systems, combined with the skill, mobility and reactivity of Ukraine's air defence units, has been credited as a key factor in repelling the initial assault on Kyiv in February 2022. At that time, Ukrainian forces successfully intercepted and downed the majority of Russian cruise and ballistic missiles, as well as numerous fixed- and rotary-wing aircraft over the Kyiv region. The initial massive Russian attacks, which included airstrikes as well as sea- and surface-launched cruise and ballistic missile attacks, aimed to defeat Ukrainian air defence and radar units, as well as destroy military airfields. In the first hours of the full-scale invasion, Ukraine's armed forces also reportedly relocated most of their air defence units, effectively denying Russian strikes their intended targets.<sup>3</sup> Russian forces thus failed to incapacitate the critical majority of Ukrainian air defence capabilities, a crucial objective that, had it been achieved, would have significantly altered the trajectory of the conflict from an air defence perspective, as discussed below.

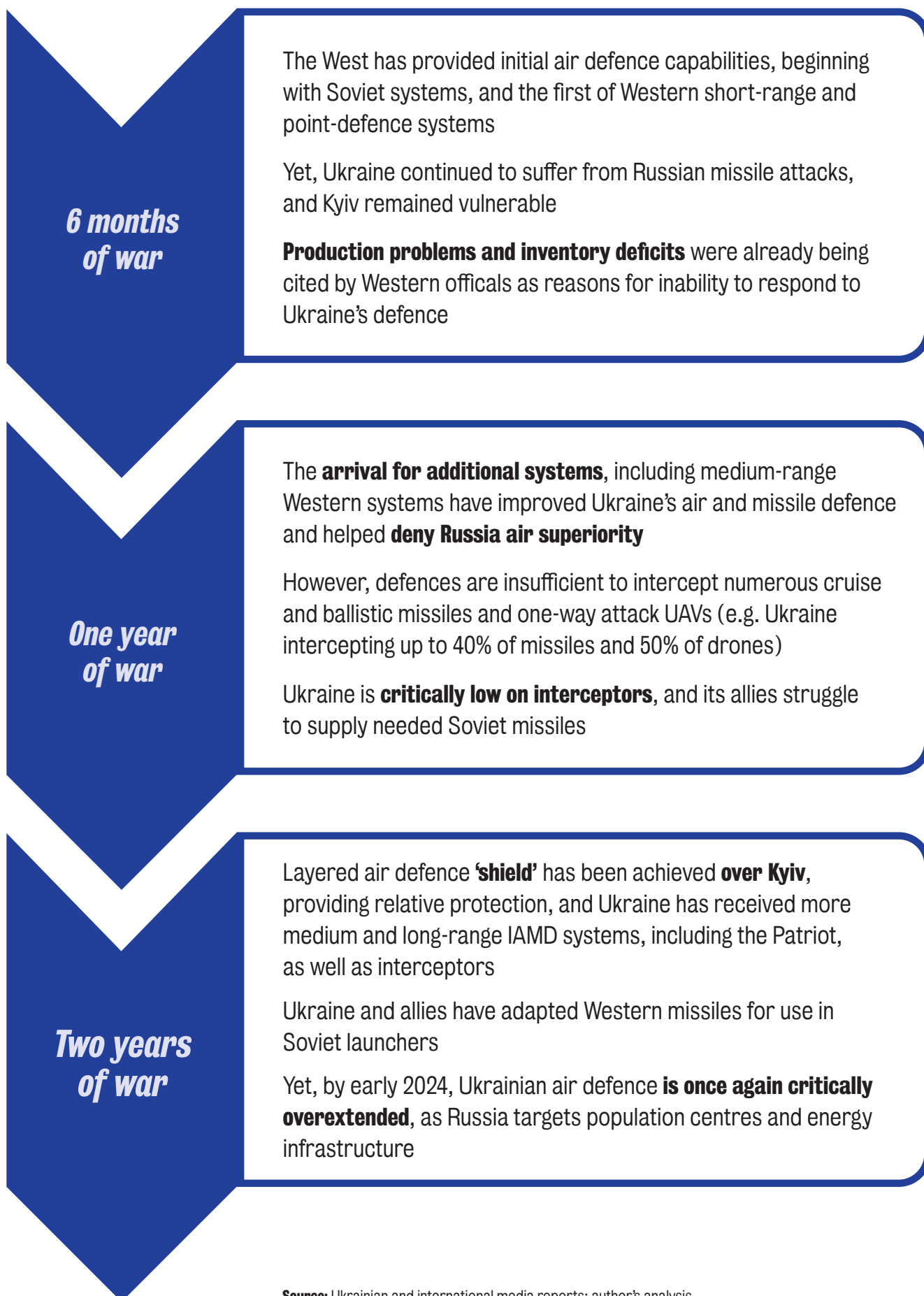
### **Building a Layered Defence Amidst Consistent Delays in Partners' Support**

Ukraine's relative success in the initial 'battle of Kyiv' and preserving air defence capability came at a high cost. It required the concentration of available defence capabilities, leaving other major population centres, like Kharkiv, Mariupol, or Chernihiv, with limited defences against Russian attacks. The widespread civilian deaths and devastation to critical infrastructure that resulted from these attacks have been widely documented and captured by international media sources. Nevertheless, Ukraine's Soviet-era systems, both from its own inventory and those eventually donated by partners, proved robust and effective against short- and medium-range cruise missiles, as well as Russian aircraft. These systems were also successfully employed to counter massed attacks by one-way attack drones. The S-300 system reliably engaged long-range targets, while the 9K37-M1 Buk system handled medium-range threats.

However, just a month after Russia's full-scale invasion, Ukraine's stocks of surface-to-air missiles for these Soviet-era launchers were running low as its armed forces defended against massed and frequent long-range attacks (see the 'Snapshot' below). A 24 March 2022 article in the *Financial Times* emphasised that Soviet-era long-range missile systems were 'seen by Kyiv as crucial to its ability to halt Russia's advance.' The article also described the Biden administration's challenges in 'sourcing and moving the equipment.'<sup>4</sup>

The crux of the matter was that countries with significant inventories of S-300 systems – namely Slovakia, Greece, and Bulgaria – refused to make these available to Ukraine (see Table 2 below). Their refusal stemmed from concerns about depleting their own domestic defences, as well as fears of provoking Russia into unspecified aggressive actions, reportedly including direct military attacks on the donating NATO countries.<sup>5</sup>

**Figure 1:** Snapshot of Ukraine's Air Defence Capabilities vs Threats, February 2022 – March 2024





Slovakia ultimately supplied an S-300 system to Ukraine in the spring of 2022. Meanwhile, the Bulgarian parliament approved the transfer of defective, ageing S-300 missiles for spare parts. However, Greece continues to refuse to supply its S-300 systems despite having a significant inventory of Patriot PAC-2 systems (see table below).<sup>6</sup> Throughout the war, Western systems such as the short-range NASAMS and Crotale NG, the medium-range IRIS-T and legacy HAWK, and the long-range Patriot PAC-3, have become critical to Ukraine's defence of its troops, critical infrastructure, and population centres. This is due not only to the capabilities of these systems but also because interceptor missiles for them can be more readily supplied to Ukraine.

As a long-range system, the Patriot has proven effective against a wide range of Russian air and missile threats, including Shahed-type one-way attack UAVs and air-launched Kh-47M2 Kinzhal ballistic missiles. According to the then Ukrainian Air Force spokesperson, Yuriy Ihnat, Patriot systems had intercepted 25 Kinzhal missiles between the start of the full-scale invasion and early January 2024. Russia had initially claimed these weapons were 'uninterceptable' by existing air defence systems.<sup>7</sup>

In addition to SAM-based air and missile defence systems of varying ranges, Ukraine also relies on what its military refers to as 'mobile fire groups.' These highly mobile air defence units are equipped with anti-aircraft guns, man-portable air defence systems (MANPADS) of both Soviet and Western origin, and even adapted heavy machine guns. They are integral to Ukraine's layered defence against one-way attack UAVs and cruise missiles. According to Mykola Oleschuk, a commander in the Ukrainian Air Force, by the end of 2023, Ukrainian mobile air defence units were responsible for approximately 40% of downed or destroyed "Shaheds."<sup>8</sup>

The data presented above starkly illustrate that, apart from brief periods lasting perhaps several months, Ukraine's armed forces have been operating in a near-constant state of air and missile system and/or interceptor shortages. Support from partners often takes months to arrive and become operational, and when it does, it is quickly outpaced by the volume and intensity of Russian aerial attacks. For instance, the 28 Patriot launchers listed in Table 1 represent, at most, four batteries (also referred to as 'systems'), and more likely amount to only three. Each patriot system contains between six and eight launchers.

## Current Air Threat Environment

Russian ballistic and cruise missiles, along with Iranian-origin Shahed-131/136 one-way attack UAVs – now license-produced in Russia and designated as Geran' 1 and 2 – have been persistent elements of the Russo-Ukrainian war since Russia's full-scale invasion. Often, attacks have combined UAVs and missiles (both cruise and ballistic). According to the former acting Ukrainian ambassador to the UK, Eduard Fesko, between February 2022 and May 2024 Russia has launched over 8,000 cruise missiles, more than 5,000 ballistic missiles, and over 9,000 Shahed-type UAVs against targets in Ukraine.<sup>9</sup>

The third year of the war, however, has introduced two additional air threats to Ukraine: the deployment of aerial glide bombs and increasingly devastating missile and UAV attacks on energy infrastructure. Both developments are consequences of Ukraine's insufficient air and missile defence capabilities and have become critical enablers of Russia's tactical successes throughout 2024.



In 2024, two additional air threats emerged: aerial glide bombs and more destructive attacks on energy infrastructure

## Aerial Glide Bombs

Russia began using low-cost, air-launched glide weapons, commonly referred to as glide bombs, in early 2023 and has steadily increased their deployment. These weapons are Soviet-era general-purpose projectiles designed to be dropped directly over their targets from Su-34 and Su-35 combat aircraft. However, this approach risks the aircraft being intercepted by Ukrainian air defence systems.

To mitigate this, Russia's invasion-era innovation was to retrofit the bombs with unfolding glide wings and a satellite navigation system, extending their range to between 40 and 60–70 kilometres, depending on the version. This allowed the bombs to be launched from aircraft beyond the reach of Ukrainian air defences. Since early March, Ukrainian forces have also identified what they call 'universal interspecific glide munition' (UMPB) D-30SN guided glide bombs, which integrate the glide wings with the weapon's main body rather than attaching them as part of a conversion kit.<sup>10</sup>

While the technical terminology can obscure the nature of these weapons, it is important to understand that they are essentially aerial bombs much like those used in World War II aerial bombings. Their large volume, low cost, and formidable destructive power – carrying between 500 and 1,500 kilograms of explosives – make them tactically effective and devastating to civilian sites. Russian forces have relentlessly dropped them on residential buildings, industrial sites, power plants, and command posts, demoralising Ukraine's already exhausted frontline troops. The International Institute for Strategic Studies (IISS) assesses that Russia is increasingly using glide bombs to overwhelm Ukraine's strained air defence systems.<sup>11</sup>

Russian forces launched approximately 3,500 glide bombs between January and mid-March 2024, representing a 16-fold increase compared to all of 2023.<sup>12</sup> By the time President Zelenskyy addressed the Ramstein format meeting on 26 April, he stated that Russia had launched 9,000 guided aerial bombs at Ukraine in 2024 alone.<sup>13</sup> Given the lethality and impact of these weapons, which can leave craters as large as 15 meters, it is difficult to overstate the devastation they inflict on civilian population centres, especially in cities near the Russian border, such as Kharkiv and Sumy.



The use of glide bombs has allowed Russian forces to achieve localised air superiority

The use of glide bombs has also allowed Russian forces to achieve limited and localised air superiority over Avdiivka, with reports indicating that 500 glide bombs were launched at the town during the final days of the Russian assault, leading to its capture.<sup>14</sup> According to the Institute for the Study of War (ISW), this has enabled Russian combat air operators to provide support to infantry troops, which likely facilitated Russian capture of Avdiivka.<sup>15</sup> Ukraine's loss of Avdiivka helped Russian forces improve logistics in the areas in the Donbas which they currently control, and thus deepen their hold in the region as well as position for further expansion into Ukrainian-held territory. Combined with the critical shortage of ammunition and air defence interceptors, the fall of Avdiivka was highly demoralising for Ukrainian troops.

The ISW continues to identify glide bombs as essential to Russian advances along the frontline throughout 2024. Russian forces also appear to be taking a similar glide bomb-reliant approach in their offensive on another Ukrainian military stronghold, Chasiv Yar – a small, strategically positioned city in the Donbas that has been nearly levelled by Russian bombardments but remains in Ukrainian hands. The ISW unequivocally points to Ukraine's strained and insufficient air defence capabilities – caused by its allies' failure to replenish them – as the ultimate reason for recent Ukrainian losses, totalling 225 square miles between May 2024 and October 2023, when critical Western military support, particularly from the US, all but stopped.<sup>16</sup>

## Countermeasures

Russian glide bombs are devilishly difficult for Ukrainian armed forces to counter. These weapons can be theoretically intercepted with advanced air defence systems, despite their relatively small size and low signature. In practice, however, given how quickly and cheaply Russia can retrofit them with conversion kits, intercepting them after launch is not a viable strategy.

Russian Su-34 and Su-35 combat aircraft launch glide bombs just outside the range of Ukraine's air defence systems, meaning they remain airborne for a relatively brief period compared to cruise or ballistic missiles. While precise numbers are hard to come by, then Ukrainian Air Force spokesperson Colonel Yuriy Ihnat has noted that the cost of converting previously 'dumb' bombs is minimal – 'pennies compared to a missile'. Russia's stockpile of these bombs seems large enough to sustain frequent attacks, with, as an indicator, around 700 glide bombs dropped on Ukraine over the course of six days.<sup>17</sup>

As Ihnat emphasised, Ukrainian forces must be able to down the Russian aircraft which launch the glide bombs, which requires sufficient long-range air defence capabilities to strike Russian aircraft at such ranges.<sup>18</sup> The Ukrainian General Staff stated that Ukrainian forces managed to shoot down 13 Russian aircraft over a two-week period in February. However, this level of attrition has not deterred Moscow from continuing its glide bomb bombardments.

Additionally, these types of successes place Ukraine's scarce and therefore highly prized long-range air defence systems within the range of Russian missiles. There has been widespread speculation that Ukraine's apparent loss of two Patriot launchers near Pokrovsk – just 20 miles from the eastern frontline – to a Russian Iskander surface-to-surface missile may have resulted from Ukraine being forced to use these systems to target Russian glide bomb launch aircraft.<sup>19</sup>

## Energy Infrastructure

Beginning in early spring 2024, Russia not only renewed its attacks on Ukrainian energy infrastructure but also adapted its tactics to maximise destruction. Specifically, Russia has targeted power stations outside Kyiv, exploiting the relatively scarce air defence systems in regions beyond the capital. For example, between 22 March and 29 March, Russia launched assaults on seven thermal power stations and two hydroelectric power stations across various regions.<sup>20</sup> According to Ukrainian authorities, this barrage involved over 150 missiles and 240 strike UAVs, including 15 strikes on Kharkiv's energy infrastructure, which temporarily left Ukraine's second-largest city almost entirely without power.<sup>21</sup>

In contrast to the energy infrastructure bombardments of 2022–2023, Russia is now using ballistic missiles, long-range cruise missiles, and guided glide bombs to destroy or severely damage entire power stations in addition to targeting components and substations, which house transformers.

On 11 April, a large-scale attack targeted the Trypillia Thermal Power Plant in Kyiv Oblast, the largest electricity supplier to Kyiv, Cherkasy, and Zhytomyr Oblasts. The attack destroyed the coal-powered plant and wiped out 100% of the generation capacity of Centerenergo, the state-owned company operating it. The strike reportedly used the Kh-69 guided air-to-surface long-range cruise missile, a modified Kh-59 cruise missile (MK2 variant), showcased at the 2023 Dubai Airshow.<sup>22</sup> Ukrainian armed forces assessed that certain subsystems and components of the Kh-69, which they did not specify, were manufactured in 2023, indicating that Russia continues to produce complex weapons despite numerous rounds of sanctions.<sup>23</sup>



Russian attacks now destroy entire power stations in addition to targeting sub-stations

On 27 April, a mass attack targeted energy facilities in the Dnipropetrovsk, Ivano-Frankivsk, and Lviv Oblasts, using air-to-surface cruise missiles, including Kh-69, and various types of surface-to-air missiles. A total of 34 missiles were launched,<sup>24</sup> and initial assessments suggest that at least four power stations sustained significant damage.<sup>25</sup> Notably, Lviv and Ivano-Frankivsk, two of Ukraine's westernmost regions, are located hundreds of kilometres from the front lines and Russian-controlled territory. On 5 May 2024, Ukraine's Energy Minister, Herman Halushchenko, estimated that over one billion USD in damage had been inflicted on the country's energy infrastructure, with most resulting from attacks on thermal and hydropower generation facilities.<sup>26</sup>

In the largest attack of the full-scale invasion to date, Russia launched 127 missiles (including short-range ballistic missiles and air-launched cruise missiles) and 109 UAVs on 26 August 2024, targeting population centres and energy infrastructure in 15 of Ukraine's 24 oblasts, with at least 25 energy facilities damaged as a result.<sup>27</sup> Following these attacks, Halushchenko raised the alarm over Russia targeting electricity substations critical to the safety systems of Ukraine's nuclear power plants.

### *Countermeasures*

Protective structures can shield smaller power stations from aerial attacks but constructing them over larger plants is not feasible. This presents a serious issue, as Ukraine's generation capacity is concentrated in a relatively small number of sites. To address this, Ukraine is planning and implementing structural changes to its energy system, including building numerous small power plants and wind and solar facilities to decentralise and diversify energy production.<sup>28</sup> However, these long-term solutions will require time, funding, and new technologies – resources currently scarce in Ukraine.

In the short term, the only viable solution to counter the immediate threat of Russian missiles and UAVs is to ensure the availability of much-needed air defence systems and interceptor missiles. President Zelenskyy directly linked the lack of interceptor missiles to the attack on the Trypillia Plant, stating that Ukraine's armed forces had 'run out of all the missiles that protected the Trypillia TPP,' which is why the attack had such devastating consequences.<sup>29</sup> Ukraine's air defence units had been forced to ration their dwindling stock of interceptor missiles.

## **Strengthening Ukraine's Air Defence Capabilities**



At the end of 2023, Russia significantly increased its missile, UAV, and aerial glide bomb attacks on Ukraine

At the end of 2023, Russia significantly increased its missile, UAV, and aerial glide bomb attacks on Ukraine. The second anniversary of the war, in February 2024, was marked by the fall of Avdiivka – Russia's largest territorial gain since the destruction and capture of Bakhmut in 2023. During this time, President Zelenskyy highlighted his country's urgent need for air defence systems following a months-long delay in passing the latest multi-billion-dollar military aid bill through the US Congress.<sup>30</sup>

In the spring of 2024, 'internal US assessments' reported in the press indicated that 'late March' of 2024 had been identified as a critical point when Ukrainian forces would face a 'potentially catastrophic shortage of ammunition and air defences.' This prediction appears to have been accurate.<sup>31</sup> Chasiv Yar looks increasingly vulnerable to Russian advances while Moscow's forces continue

to make steady tactical gains in eastern Ukraine. Meanwhile, Kyiv was forced to pull back its troops from several villages in northern Kharkiv, near the Russian border, due to renewed Russian offensives in the region. By autumn 2024, the Donbas city of Pokrovsk, a major military logistics and transportation hub in eastern Ukraine, was in danger of being taken by Russian forces.

Although the \$61.3 billion US military assistance bill for Ukraine finally cleared congressional deadlock on 18 April 2024, Ukraine's calls for additional air defence systems have been met with ongoing reluctance and delays from its international partners. As Table 2 below illustrates, several EU member states possess effective medium- and long-range air and missile defence systems, such as Patriot, SAMP/T, and NASAMS III. Among European NATO members alone, there are 94 Patriot PAC-3 launchers, not counting the 480 in the US inventory.

To demonstrate the scale of the air and missile defence needs in this war, President Zelenskyy stated in early April 2024 that Ukraine would require 25 systems (comprising 150–200 launchers) to cover its territory. He rightly noted that equivalent systems would also be effective and called for a layered and integrated defence that includes artillery, point-defence, and airborne assets, rather than relying solely on Patriots.<sup>32</sup> However, just a week later, this request was revised to only seven Patriot systems to defend critical targets.<sup>33</sup>



NATO members have not adequately responded to Ukraine's requests for air defence capabilities

Despite having the required capabilities (as shown in Table 2 below), NATO members have not adequately responded to Ukraine's increasingly urgent requests. Although this urgency has reportedly been acknowledged, actions remain insufficient. Germany, the US, and central bureaucracies within the EU and NATO – led by outgoing EU High Representative for Foreign Affairs and Security Policy Josep Borrell and former NATO Secretary-General Jens Stoltenberg – have played key roles in coordinating efforts to deliver air defence systems to Ukraine.<sup>34</sup>

Greece and Spain, in particular, have come under pressure to provide air defence capabilities. Greece, despite possessing ageing but effective systems of both Western and Soviet origin, has repeatedly refused to supply these to Ukraine, citing its longstanding security concerns regarding fellow NATO member Turkey.<sup>35</sup> Conversely, Spain appears to have been coerced into supplying Patriot PAC-3 interceptor missiles, though not complete systems.<sup>36</sup> Germany pledged to send an additional system (battery) and interceptor missiles to Ukraine in mid-April 2024, but it was only delivered in early July. Similarly, Italy announced its intention to supply a second SAMP/T battery to Ukraine in early June, with a commitment to deliver it by the end of September.<sup>37</sup> However, there was no confirmation of the SAMP/T's arrival as of mid-October, and even if it had been delivered as planned, it would still have taken nearly three months between the announcement and delivery.

During his May 2024 visit to Kyiv, US Secretary of State Antony Blinken announced that the US was 'rushing air defences' to Ukraine's frontlines but did not provide further specifics.<sup>38</sup> Meanwhile, Secretary of Defence Lloyd Austin had already spoken of 'rushing' air defence missiles to Ukraine at the end of April. However, he emphasised that Patriot launchers and complete systems would not be sent.<sup>39</sup>



**Table 2:** NATO Holdings of Medium- and Long-Range Air Defence Systems

Equipment	Classification	Quantity (launchers)	Operating Military
<b>IRIS-T SLM</b>	Medium-Range Self-Propelled SAM System	4	Germany
<b>MIM-23B I-HAWK</b>	Medium-Range Towed SAM System	42	Greece
<b>MIM-23B I-HAWK Phase III</b>	Medium-Range Towed SAM System	36	Spain
<b>MIM-23 HAWK</b>	Medium-Range Towed SAM System	24 (estimated)	Turkey
<b>MIM-23 HAWK PIP III</b>	Medium-Range Towed SAM System	8	Romania
<b>MIM-23B Hawk</b>	Medium-Range Towed SAM System	Unknown	Sweden
<b>NASAMS III</b>	Medium-Range Towed SAM System	8	Hungary
<b>NASAMS III</b>	Medium-Range Towed SAM System	6	Lithuania
<b>NASAMS III</b>	Medium-Range SAM System, incl. towed variant	Unknown	Norway
<b>M902 Patriot PAC-3; M903 Patriot PAC-3 MSE</b>	Long-Range Towed SAM System	480	United States
<b>SAMP/T</b>	Long-Range SAM System	40	France
<b>M901 Patriot PAC-2</b>	Long-Range Towed SAM System	36	Greece
<b>S-400</b>	Long-Range Self-Propelled SAM System	32	Turkey
<b>M902 Patriot PAC-3</b>	Long-Range Towed SAM System	30	Germany
<b>M902 Patriot PAC-3</b>	Long-Range Towed SAM System	18	Netherlands
<b>M902 Patriot PAC-3</b>	Long-Range Towed SAM System	18	Spain
<b>SAMP/T</b>	Long-Range Towed SAM System	16	Italy
<b>M903 Patriot PAC-3 MSE</b>	Long-Range Towed SAM System	16	Poland
<b>S-200</b>	Long-Range Static SAM System	12	Bulgaria
<b>S-300 PMU-1</b>	Long-Range Towed SAM System	12	Greece
<b>M903 Patriot PAC-3 MSE</b>	Long-Range Towed SAM System	12	Sweden
<b>S-300PMU</b>	Long-Range Towed SAM System	8	Bulgaria

**Source:** The International Institute for Strategic Studies (Military Balance+ Database), as of September 2024.

**Note:** The table uses the International Institute for Strategic Studies (IISS) classifications. Air defence artillery is not depicted unless it can be classified as an air defence system.

The 2024 NATO Summit in Washington, DC was a major occasion for Ukraine's supporters to announce air defence contributions. On the summit's opening day, 9 July, the urgency of Ukraine's need was poignantly and tragically underscored by a major Russian attack, which targeted Ukraine's largest children's hospital in Kyiv with air-launched cruise missiles, among other sites. International media headlines trumpeted the 'five new strategic air defence systems' promised to Kyiv by US President Joe Biden on behalf of the Alliance.<sup>40</sup> According to the announcement, Germany, Romania, and the Netherlands would join the US in supplying Patriot batteries, while Italy and other allies would provide SAMP/T and shorter-range systems such as NASAMS and HAWKS.

In reality, however, most of these systems had already been promised months earlier. The US had already committed to supplying an additional (its second) Patriot system a month prior to the summit, to be drawn from its deployment in Poland. No timeline was given for its delivery, and it remains unclear if or when it arrived in Ukraine. Similarly, the Patriot system that President Biden appeared to promise from Germany had already been delivered prior to the announcement. The system promised by Romania only arrived in early October, nearly three months after the announcement. Finally, the Netherlands had announced in May its plan to cooperate with other countries to assemble a joint Patriot battery. However, its undisclosed partner withdrew in September, and as of early October, the Dutch initiative was still in search of a new partner to complete the system.



Ukraine's supporters and armed forces have sought creative ways to generate air defence capabilities

### Thinking Outside the Box

Considering the difficulty in sourcing and delivering air defence capabilities to Ukraine at a pace dictated by Russian attacks, and their deliberate targeting of civilian infrastructure, both Ukraine's supporters and Ukrainian armed forces have sought alternative solutions. These approaches reflect the magnitude and scale of the war and the limitations of peacetime processes.

#### 'Buy for Ukraine' Approach

Ukraine's backers have provided funds for air defence systems to be procured and transferred. The Netherlands, Belgium, and Canada have contributed approximately 450 million euros to the German-led 'Immediate Action on Air Defence' (IAAD) initiative (with the Netherlands and Belgium each contributing 200 million euros). This initiative aims to purchase air defence systems of varying ranges for Ukraine. Belgium has also provided interceptor missiles of unknown type and quantity, while Denmark has allocated over 320 million euros for Ukraine's 'air defence needs', though details remain undisclosed. Norway had committed a 'large part' of 340 million euros in additional Ukraine air defence funding to the IAAD.<sup>41</sup>

#### Creative Engineering Solutions

In October 2023, amid Ukraine's depleted stocks of air defence interceptor missiles, lack of new systems from partners, and continued delays to critical war funding in the United States Congress, Ukrainian out-of-the-box thinking, supported by the US, led to an innovative solution. This involved adapting Soviet-era SAM launchers, particularly from the Buk system, to fire Raytheon RIM-7 Sea Sparrow surface-to-air missiles, which are actually ship-based radar-guided variants. Publicly available information on what has been dubbed the 'FrankenSAM' system is limited. However, it appears that three versions exist: the Buk-based launcher, an undisclosed Soviet mobile point-defence launcher (possibly the Osa) firing US 1950s-era AIM-9 Sidewinder air-to-air missiles, and Soviet radars integrated with Patriot launchers and missiles.<sup>42</sup> The first two were reportedly delivered to Ukraine in autumn 2023

in unknown quantities – although no more than ‘a few’ launchers were supplied, according to Ukrainian government sources.<sup>43</sup> It is unclear whether the Patriot-based FrankenSAM systems, including missiles and various sub-systems contributed by different partners, have already been delivered to Ukraine or are still being tested in the US.

Another creative solution involved the UK modifying the Advanced Short-Range Air-to-Air Missile (ASRAAM), manufactured by MBDA, for a surface-to-air role, using a wheeled 6x6 armoured vehicle (Supacat HMT 600 variant) as the launch vehicle. There are also unconfirmed reports, including from unnamed Ukrainian intelligence sources, that Ukraine is using the 1960s-era S-200 (SA-5 Gammon) long-range SAM system, which had been scrapped over a decade ago.<sup>44</sup> One of its reported targets was the Russian Tu-22M3 long-range strategic strike bomber, which Russian forces use to launch Kh-22 anti-ship missiles, designed to destroy aircraft carriers, at civilian targets in Ukraine. Close observers of the war believe that Ukraine likely returned the S-200 missiles, with a range of up to 190 miles, to combat readiness. Former Warsaw Pact system operators like Poland or Bulgaria may have supplied these.<sup>45</sup>

In a tactical engagement, footage released by the Russian Ministry of Defence in May 2024 showed a Ukrainian uncrewed surface vehicle (USV) equipped with two Soviet-era short-range air-to-air missiles (possibly the R-73 or AA-11 ‘Archer’ in NATO terms). The USV attempted to engage a Russian Ka-29 helicopter over the Black Sea but was ultimately destroyed by the aircraft.<sup>46</sup> Finally, Ukrainian forces have adapted heavy, large-calibre machine guns for air defence roles with ‘thermal scopes and tablets, paired on a gun point.’ These operators have been integrated into the detection sensor network supporting air and missile defence around Ukrainian cities.<sup>47</sup>

### **Institutions and Coalitions**

In the autumn of 2022, President Zelenskyy called on G7 leaders (Canada, France, Germany, Italy, Japan, the UK, and the US) to help Ukraine establish an ‘air shield’ consisting of ‘a sufficient number of modern and effective air defence systems’ to defend against relentless Russian missile strikes.<sup>48</sup> The ‘air defence shield’ issue for Ukraine was again raised at the G7 meeting in early 2023.<sup>49</sup> By the time the foreign ministers of the Group met in April 2024, Ukraine’s then foreign minister Dmytro Kuleba explicitly stressed the urgency of his request for air defence systems, expressing concerns over the slow pace of decisions and deliveries, which left Ukraine exposed to devastating air and missile attacks.<sup>50</sup>

In early 2024, fifteen NATO member states formalised the Capability Coalition Integrated Air and Missile Defence (CC IAMD), with Belgium, Denmark, Lithuania, Greece, and the United Kingdom among the signatories. Germany and France co-led the initiative. The coalition had already begun its work at the end of 2023, committing to ‘collectively address and meet’ Ukraine’s immediate and long-term air and missile defence needs.<sup>51</sup> In addition to coordinating, sourcing, and delivering air defence systems to Ukraine, CC IAMD aims to facilitate Ukraine’s transition to a NATO-compatible air defence architecture. This is one of eight dedicated capability coalitions established under the Ukraine Defence Contact Group framework, which brings together fifty countries providing military assistance to Ukraine.

### **Early Warning and Targeting Information Sharing**

While there has been no official confirmation of this from either side, Mark Cancian, a senior adviser with the International Security Programme at the Center for Strategic and International Studies (CSIS), believes that ‘targeting information is already being

shared' by NATO forces with the Ukrainian air defence units, to help them more efficiently engage Russian air and missile targets more efficiently.<sup>52</sup>

What has been confirmed is that the NATO Airborne Early Warning and Control Force (NAEW&C Force), owned and operated by NATO rather than individual nations, has flown regular surveillance missions over NATO airspace near Ukraine's borders since the full-scale invasion began.<sup>53</sup> Flying over countries such as Romania and Poland allows the Airborne Warning and Control System (AWACS) aircraft operated by NAEW&C Force to provide a detailed and penetrating view of at least 400 kilometres beyond the aircraft, enabled by the AWACS's sophisticated, high-resolution sensors. Three aircraft are sufficient to 'cover' an area the size of central Europe. This reportedly allows AWACS crews to identify and 'watch' Russian combat aircraft, naval ships, and larger UAVs, as well as, in some cases, main battle tanks and other armoured vehicles as they move on the Ukrainian battlefield. Crucially, AWACS aircraft can 'determine the paths' of (Russian) missiles.<sup>54</sup> In this way, NATO has, quite literally, watched the destruction of Ukraine.

While AWACS's main function is to deter and protect NATO airspace, it has been widely reported that real-time intelligence gathered by AWACS aircraft is shared with Ukraine by individual NATO allies after being transmitted to a ground operations centre. This can provide the Ukrainian Armed Forces with a 'near real-time picture' of Russian forces and positions, potential threat warnings and air defence targets.<sup>55</sup>

### Decisive Action and a Degree of Calculated Risk Needed

It is not as though NATO governments simply refuse to abide by the commitments their leaders and the Alliance have repeatedly voiced to Ukraine's defence. As this paper has demonstrated, significant funds, equipment deliveries, and diplomatic efforts have been dedicated to bolstering and supporting Ukraine's air defence capabilities following Russia's full-scale invasion. The sense of urgency with which air defence systems are needed on the ground in Ukraine is not lost on national leaders, nor is the indivisibility of Euro-Atlantic and Ukrainian security. At the same time, rhetorical urgency cannot be translated into action at the speed and volume dictated by Russia's war. From an air and missile defence perspective, this conflict has demonstrated that rallying nations to donate systems and/or interceptors is inherently a limited strategy.

Many capitals repeatedly cite the criticality of air defence systems to national or regional defence plans. However, these arguments do not hold up to scrutiny when one considers the varying threat environments – NATO officials themselves often speak about how remote the threat from Russia can feel to southern European countries versus those in the Baltic region. Historic underinvestment in these capabilities, combined with the lack of a meaningful ramp-up even after Russia's full-scale invasion of Ukraine – despite rhetoric about the indispensability of SAMs for national defence – has resulted in depleted stocks that cannot be replenished quickly enough.<sup>56</sup> Ukraine's foreign minister, Dmytro Kuleba, captured this reality when he acknowledged that 'partners did provide [Ukraine] with different systems, we appreciated that, but it's just simply insufficient, given the scale of the war'.<sup>57</sup>

While helpful, the 'creative' solutions described in the previous section also cannot tackle the magnitude of Ukraine's air and missile defence needs. Providing funds rather than equipment, piecing together systems from radars, missiles, and launchers donated by different partners, and building a NATO-compatible air defence architecture in Ukraine are slow processes and long-term measures that cannot address urgent needs. As this paper has illustrated, partners' 'drip, drip' approach to providing military assistance facilitates a seemingly constant cycle of needs becoming



Rallying nations to donate air defence systems is inherently a limited strategy

urgent. FrankenSAM-type systems are effective and pragmatic but cannot be scaled in time. The US insistence that necessary engineering of US systems be conducted domestically will inevitably create delays, as it has done.



The issue of air defence highlights the unsuitability of peacetime processes and norms

More decisive, resolute, and strategic action is needed when assessing the track record of air and missile defence capability provision to Ukraine. This is imperative not only to live up to NATO members' repeated commitments to 'support Ukraine as long as it takes' but also to safeguard Euro-Atlantic security. The issue of air defence highlights the unsustainability of relying on peacetime, pre-Russian-invasion norms, processes, and assumptions, such as the belief that taking options off the table from the outset to avoid 'escalation' will achieve that result.

Despite NATO leaders' preoccupation with keeping the war localised in Ukraine and preventing any 'spillover' into NATO or Russian territory, Russian strike drone debris has already been found inside Romania. The origin of two additional instances of drone debris in the country remains unconfirmed. In another incident on 27 September, Romania scrambled its F-16 combat aircraft following Russian drone attacks on Ukraine's civilian infrastructure close to the Romanian border. The Romanian ministry of defence also launched an investigation following indications that the Russian drones entered Romania's national airspace.<sup>58</sup>

In March 2024, Poland's Deputy Foreign Minister Andrzej Szejna stated in an interview with the Polish radio station RMF FM that 'NATO [was] analysing different concepts, including that... missiles should be shot down when they are very close to the NATO border.'<sup>59</sup> This statement followed an incident in which a Russian cruise missile, launched at western Ukraine as part of a massive Russian attack, entered Polish airspace for 39 seconds before changing course and heading back to Ukraine, where it struck critical infrastructure. The Polish armed forces tracked the missile throughout its flight on their radar systems, and the country's defence minister later stated that it would have been engaged if it had been determined the missile would strike a target in Poland rather than in Ukrainian territory.<sup>60</sup>

Shortly afterwards, in a comment for the *Frankfurter Allgemeine Sonntagszeitung*, one of Germany's leading news publications, prominent members from across the German parliament supported a proposal to 'station air defence systems at the borders of [NATO] states bordering Ukraine.'<sup>61</sup> The idea is to deploy air and missile defence systems to NATO member states neighbouring Ukraine, such as Poland and Romania, to engage Russian missiles in Ukrainian airspace. Some parliamentarians were careful to couch their statements as 'long-term' measures, subject to an adequate and steady supply of launchers and interceptor missiles, presumably for both Ukraine and its partners. Similarly, Poland's Szejna emphasised that in the hypothetical case of Polish air defence systems engaging a Russian missile, presumably over Ukraine, NATO forces would be acting 'outside the territory of the Alliance Treaty.'<sup>62</sup>

In a 14 May 2024 interview with the UK news outlet *i*, former NATO Secretary General Anders Fogh Rasmussen outlined how NATO could help defend Ukrainian cities and infrastructure against relentless Russian air strikes by firing interceptor missiles from air defence systems stationed in Poland and Romania.<sup>63</sup> At the time of publication, the latest call of this nature came from the Polish foreign minister Radosław Sikorski. In an interview with the *Financial Times*, Sikorski underlined the 'duty' of countries bordering Ukraine to 'ensure the safety' of their citizens by intercepting Russian missiles over Ukrainian territory before they reach the airspace of NATO members.<sup>64</sup> The minister argued that NATO membership, which has continued to reflexively reject these proposals, should not prevent national governments from safeguarding their airspace and populations.



A powerful catalyst for these discussions was the ‘coalition of the willing,’ composed of the US, UK, France, and Jordan, which quickly mobilised to repel Iran’s massive air attack against Israel on 15 April 2024. Although Israel is not a NATO member, thanks to the rapid actions of these countries and Israel’s formidable air and missile defence capabilities, ‘99%’ of approximately 300 projectiles – including both missiles and one-way attack UAVs – were intercepted, causing only ‘slight’ damage to a single target and no deaths.<sup>66</sup> Israel’s supporters did not become ‘parties to the conflict’ with Iran, nor did the conflict escalate due to their actions.

Indeed, more than a year ago, in his opening speech at the 2023 Black Sea Security Conference in Bucharest, Ukraine’s then foreign minister Dmytro Kuleba called for the ‘integration of the anti-aircraft and anti-missile systems of Ukraine and NATO allies in the region of the Black and Baltic Seas.’<sup>66</sup> Kuleba argued that, regarding air threats from Russia in the context of the Russo-Ukrainian war, ‘security in the Baltic-Black Sea region is indivisible.’<sup>67</sup>

Such an ‘integration,’ as well as the proposals described above for NATO air defence systems to engage Russian missiles over Ukrainian territory, would require automated or near-automated early warning data sharing and integrated fire controls between NATO assets and Ukrainian forces. If this sounds challenging, it is because it is – a task of this scale would demand that Ukrainian and NATO air defence systems be ‘plugged into’ a common network architecture. This is difficult even in peacetime, and Ukraine’s various systems further complicate the process. Voice and data networks must be established to ensure effective fire coordination and prevent ‘friendly fire.’<sup>68</sup> Moreover, cyber and network security, as well as data rights, will present serious obstacles.

Yet, all of this is technically possible. Considering a system like the Patriot, with its considerable range, it is feasible to support Ukrainian air defence from NATO territory – intercepting Russian missiles over Ukrainian territory, as has been repeatedly proposed. This would help defend Ukrainian infrastructure, save civilian lives, and alleviate pressure on Ukraine’s already stretched (and not exactly forthcoming from partners) air defence systems, particularly in frontline regions like Donetsk and Kharkiv. It would also serve as a powerful deterrent, reinforcing NATO’s red lines in this war and helping the Alliance regain some escalation dominance. It is exactly the kind of decisive and creative action that is required.

However, NATO capitals still view this step as escalatory. It is difficult to predict the actual dynamics of escalation in a scenario where an unpiloted missile, launched by a recognised aggressor state engaged in an illegal war of aggression, is intercepted by NATO air defence systems while en route to a civilian target. Throughout this war, NATO members have been determined to confine active hostilities to the territory of Ukraine. It is precisely this reactive approach to escalation management that led Polish officials to claim that the Russian cruise missile in Polish airspace would have been intercepted if it had been determined that it was headed for a target in Poland rather than in Ukraine. This line of thinking implies that a Russian offensive weapon transiting through NATO airspace on its way to strike a target in Ukraine is free to do so.

This approach, prevalent in most NATO capitals, raises the question of whether the response would differ if the weapon were, for instance, a column of main battle tanks “merely passing” through NATO territory en route to Ukraine without engaging their turrets. Would a line be drawn there? When it comes to air and missile defence, it is time to draw carefully calibrated but clear red lines – since without clarity, they may as well not exist.



It is feasible to support Ukrainian air defence from NATO territory by intercepting Russian missiles

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The Freeman Air and Space Institute (FASI) is an inter-disciplinary initiative of the School of Security Studies, King's College London. It is dedicated to generating original knowledge and understanding of air and space issues. The Institute seeks to inform scholarly, policy and doctrinal debates in a rapidly evolving strategic environment characterised by transformative technological change which is increasing the complexity of the air and space domains.

FASI places a priority on identifying, developing and cultivating air and space thinkers in academic and practical contexts, as well as informing, equipping and stimulating relevant air and space education provision at King's and beyond.

The Freeman Institute is named after Air Chief Marshal Sir Wilfrid Freeman (1888–1953), who was crucially influential in British air capability development in the late 1930s and during the Second World War, making an important contribution to the Allied victory. He played a central role in the development of successful aircraft including the Spitfire, Lancaster and Mosquito, and in planning the wartime aircraft economy – the largest state-sponsored industrial venture in British history.

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