EDITORIAL

NATO INTEGRATED AIR AND MISSILE DEFENSE (IAMD) AND THE WAR IN UKRAINE: A MULTILATERAL IMPERATIVE

Curtis CORDON [1]***, Lieutenant Colonel, United States Air Force***

Executive Officer for the United States Military Delegation to the NATO Military Committee

ABSTRACT
The war in Ukraine has reshaped modern warfare, particularly in the air domain. The conflict has highlighted the importance of Integrated Air and Missile Defense (IAMD), which connects sensors, weapons, and decision-makers to counter air threats, including drones and missiles. Technological advancements have made drones crucial in gathering intelligence and performing attacks, challenging traditional air defenses. This paper examines IAMD's role in the Ukraine conflict, the rise of drone warfare, and the need for NATO's multilateral approach to bolster IAMD capabilities. A focus on cost-effective technologies, interoperability, and cross-border legislation is critical for NATO to protect its airspace and deter aggression.

KEYWORDS: *Integrated Air and Missile Defense (IAMD), Drone, Warfare, NATO*

J.E.L. CLASSIFICATION: H56, O33, F52

I. INTRODUCTION

The war in Ukraine has introduced dynamic and novel elements to warfighting. While the conflict on the ground has often resembled the trench warfare of the First World War, with static lines and large artillery barrages, the air domain has witnessed vast changes, and it has become increasingly critical to success in the conflict. Technological advancements in the air domain are rapidly reshaping the battlespace, potentially altering the nature of warfare itself. Drones and autonomous systems now provide commanders with unprecedented battlefield intelligence, real-time situational awareness, and targeting data. The miniaturization and proliferation of these new technologies have further amplified their influence on the war.

Failure to harness innovation and keep pace with the changing threat environment could have catastrophic consequences, as it did during the opening days of the Second World War. While Germany innovated and embraced fast-paced mechanized infantry, the Allies remained static and relied on heavily outdated defensive strategies like the Maginot Line. It is of critical importance at this time of great innovation in the air domain for NATO nations to take heed of US Air Force General Brown's motto to "accelerate change or lose" (Chris Gordon, 2023).

Integrated Air and Missile Defense (IAMD) is critical in modern warfare, particularly in the context of the war in Ukraine, where both sides have denied each other air superiority, leading to a relative stalemate on the ground. This paper will focus on the essential elements of IAMD, the rise of drone warfare and related technologies in Ukraine, and the necessity of multilateral solutions to counter authoritarian aggression and protect Allied territory from air attacks.

[1] Corresponding author. E-mail address: curtiscordon@gmail.com

II. WHAT IS IAMD AND WHY DOES IT MATTER?

IAMD is a comprehensive system of systems that connects sensors, shooters, and decision-makers to defend against a wide array of air threats, including ballistic missiles, cruise missiles, hostile aircraft, glide bombs, and unmanned aerial vehicles or drones. Sensors may come in various types of active radars tuned to specific frequencies, passive sensors looking for electromagnetic emissions, acoustic sensors, or infrared sensors. The shooters in an IAMD system may be various short, medium, and long-range missiles and interceptors, Anti-Aircraft Artillery (AAA), or other, directed energy weapons. To be effective, IAMD must be layered both vertically, covering threats from ground level to the outer edges of the atmosphere, and horizontally, coordinating across terrain, between the different systems, and even beyond borders with Allies. The integration of the shooters with command-and-control systems and decision authority is called shot doctrine, and shot doctrine determines how threats are neutralized, which shooters engage, and when these shooters engage. An effective IAMD requires a high level of interoperability and sensor fusion between the systems that make up a national IAMD, and even between allied nations that share borders.

The war in Ukraine has reinforced the critical importance of a robust IAMD in modern combat. One of the key challenges emerging from this conflict is the increasing complexity and sheer number of air threats. Miniaturization has made it possible for small and inexpensive drones to perform missions that once required large, costly manned aircraft or unmanned systems to perform. These cheaper drones have had a transformative impact on the battlefield, leveling the playing field for smaller nations that may not have vast financial resources, allowing them to deploy effective air assets. At the same time, this technological shift enables well-financed nations, like Ukraine with Western backing, or Russia, to deploy a staggering number of drones—Ukraine reportedly loses around 10,000 drones per month (Jack Watling and Nick Reynolds, 2024). Despite these losses, the sheer volume of drones provides unprecedented intelligence, surveillance, and reconnaissance (ISR) capabilities for ground commanders. The high number of drones in the air allows forces to find, fix, track, and target the enemy with remarkable speed and precision. This has fundamentally changed tactical combat, as the ability to hide troops and equipment far from the front lines is almost nonexistent (Mark T. Kimmitt, 2024). In this environment, a strong IAMD system is essential to counter these new and evolving air threats, providing a layered defense that can detect and neutralize a variety of aerial platforms, from small drones to larger missiles and aircraft before they strike their intended targets. Without an effective IAMD, the balance of power in the air domain could become severely compromised, and losing in the air is the first step to losing on the ground. This makes IAMD a top priority for NATO Allies and its partners (Utku Çakırözer, 2024).

IAMD is essential for NATO's future, as any conventional attack on NATO territory will likely begin with air strikes, similar to the early stages of the Ukraine conflict. The NATO Washington Summit declaration emphasized the growing threat posed by the proliferation of ballistic missiles and highlighted the need for a robust IAMD ("NATO Washington Summit Declaration," 2024). The proliferation of technology is a concern not just from state actors, but also non-state entities and terrorist regimes. A comprehensive, 360-degree approach is a hallmark of NATO and of IAMD, and thus systems are needed to address both high- and low-tech air threats from a variety of states or terrorist organizations. Without such defenses, NATO risks air vulnerability, particularly along its eastern flank, where Russian drones and missiles have breached NATO airspace in Romania and Latvia.

In the war in Ukraine, IAMD has been vital to the country's defense. With relatively stable front lines, the conflict has shifted to large-scale air assaults using One-Way Attack (OWA) drones and ballistic missiles. The provision of missile defense systems has been crucial to Ukraine's ability to maintain control of its airspace and hold at bay Russian ground forces. If Ukraine had lost air superiority to Russia early in the conflict in 2022, the war would have been lost quickly. Likewise, if Ukraine were to lose the air

war today and should its IAMD fail, a loss on the ground would likely follow. This highlights the importance that needs to be placed on defending NATO skies today.

III. THE RISE OF DRONES: ASYMMETRIC COST AND TACTICAL INNOVATION

The rapid proliferation of drone technology, particularly low-cost drones, has posed a significant challenge to expensive military systems. In Ukraine, $500 hobby drones have repeatedly and effectively targeted and destroyed multimillion-dollar assets, such as main battle tanks, expensive radar systems, and command and control nodes. The success of hobby drones highlights the asymmetric cost advantage of these types of weapons. These drones, which are cost-effective and adaptable, often evade traditional air defense systems. Many modern IAMD sensors were originally designed to detect high-speed threats and they have struggled with low and slow-moving drones, requiring adaptation. Additionally, shooting down a $10,000–$20,000 drone with a $1–$4 million missile is economically unsustainable, making this imbalance a major concern in modern warfare. Both Ukraine and NATO must get on the right side of the cost curve going forward, especially if a conflict is to enter a phase of attrition as it has in Ukraine.

Ukraine has become a testing ground and research laboratory for drone use in combat, and NATO is in a unique position to benefit from the lessons learned by Ukraine. This is not the first conflict with drones, but the scale is unlike anything prior, and the innovation is staggering. Both Ukrainians and Russians are adapting to widespread drone use for attacks as the destruction of ammunition stocks and the limited supply of artillery has driven an increased reliance on linking artillery support with drone support teams for targeting. Other tactical innovations are appearing such as an increased reliance and more proficient use of “shoot-and-scoot” tactics to limit the success of counterbattery attacks by drones (Jack Watling and Nick Reynolds, 2024). Additionally, Electronic Warfare (EW) has been a developmental testbed in this war of drones, as each side seeks to counter the signals used to operate and control the drones. The Russians have proven particularly adept at EW and have placed a special focus on ensuring the emplacement of powerful jammers nearly every 10km of the frontline (Jack Watling and Nick Reynolds, 2024). The success of new tactics, techniques, and procedures in Ukraine should be watched closely and be harnessed and implemented into NATO IAMD modernization.

IV. CURRENT IAMD CHALLENGES

The primary challenge NATO faces today in terms of IAMD, is the extreme cost imbalance between the offense and defense. As previously mentioned, the low-cost, low-flying, and very slow drones have proven a challenge for modern radars and sensors that are tuned and optimized for higher-flying and faster targets. And, when these low and slow targets are tracked and engaged, the modern inceptors used in state-of-the-art missile defense systems are, more often than not, orders of magnitude more expensive than these aerial threats they are engaging. Russia has capitalized on this by deploying large waves of One-Way Attack (OWA) drones in conjunction with cruise missiles and even hypersonic ballistic missiles. A coordinated attack using a range of altitudes, speeds, and numbers can quickly overwhelm an IAMD, and the Russians have used this tactic to great effect. This is of concern for NATO countries, as it is quite feasible that Russia, or even a non-peer adversary such as Iran, could potentially level the playing field against more technologically advanced NATO forces, and hold NATO territory or populations at risk.

While NATO seeks to close these vulnerabilities, particularly in low-altitude detection and tracking, key systems like the E-7A Wedgetail (a replacement for the NATO AWACS), which are quite capable of scanning the low-altitude environment, are still years away from full deployment. U.S. Air Force General James Hecker, Commander of NATO Air Command, recently highlighted that while the E-

7A will greatly enhance NATO's ability to detect and track low, slow-flying drones, interim solutions are urgently needed (Joseph Trevithick, 2024).

Another pressing issue related to the cost curve imbalance between the offense and defense is the financial strain on both the U.S. and European NATO Allies' militaries. The U.S. is currently fielding its smallest military in 80 years, and European nations have faced even deeper budgetary cuts. While Western-supplied surface-to-air missile (SAM) systems have been relatively successful in intercepting 60-80% of aerial threats in Ukraine, Russia's use of large drone salvos has depleted Ukraine's interceptors, making them increasingly dependent on Western supplies. This has become a significant burden on Western economies, which are already dealing with inflation and war-weary populations. Balancing the financial costs of defense while maintaining public support for continued military aid to Ukraine is becoming an ongoing challenge for NATO countries. One of the keys for NATO is to begin building and developing IAMD systems with more sustainable costs before they are urgently needed. Moreover, proactive development allows for a gradual integration of newer technologies into NATO's IAMD network, reducing the strain on already limited defense budgets.

V. MULTILATERAL AND NATIONAL APPROACHES TO STRENGTHEN IAMD

To strengthen both NATO and Ukrainian IAMD alike, nations must adopt a strategic, multilateral approach focused on three key corrections. First, NATO countries need to get on the right side of the cost curve by adapting existing technologies and developing new defenses that can effectively counter the masses of inexpensive aerial threats. Second, nations should prioritize testing and developing IAMD systems as a collective bloc rather than in isolated national programs. This will allow for better interoperability and will ensure that national IAMD systems are seamlessly integrated into NATO's broader defense framework if nations are using a joint procurement strategy. Finally, NATO members must not only work to ensure that national legislation allows combat commanders the broad authorities to engage hostile targets, but they must also establish cross-border legislation that allows the sharing of air tracking data across national boundaries, which allows a seamless handoff from one nation's defenses to another nation's defenses, thus enabling more coordinated and efficient defense operations.

The priority is reducing the cost of defending against low-cost threats by leveraging existing technologies and experimenting with innovative solutions. The proliferation of inexpensive drones and other aerial threats poses a significant challenge to traditional IAMD systems. By adapting older technologies and developing new ones specifically aimed at these cheaper threats, NATO can shift the cost balance. For example, systems like acoustic networks deployed along national perimeters, offer a low-cost method to detect and track drones and cruise missiles. Acoustic methods have been used since the First World War, but these fell out of widespread use with higher-flying aircraft. Now, with masses of low-flying drones penetrating their airspace, the Ukrainians have found that acoustic networks are quite successful at triangulating and tracking the buzz of drones. Such systems avoid the need for costly airborne sensors, demonstrating that even older technologies can be adapted and contribute meaningfully to IAMD. Ukraine's newly declassified acoustic system has been used to great effect and is the exact type of system that NATO should be looking to replicate or buy outright from Ukraine. The microphones used in Ukraine's "Sky Fortress" system pick up the sound of buzzing drones and cruise missiles and triangulate the position and direction of the target. Whereas a single radar costs about 6 million dollars and would need to be placed every 10 kilometers to pick up a low-flying target at 100 feet, these microphones merely cost between 300 and 500 dollars each and function quite well being placed every 4-5 kilometers (Ukraine Joins NATO Counter-Drone Exercise for First Time, 2024). The entire eastern flank of NATO could be covered by a Sky Fortress system for a very modest cost. This is a far more economical solution and the exact type of actions need to get on the right side of the cost curve. Affordable systems like this present a cost-effective

solution for smaller NATO members that have skies to protect and want to contribute, but that lack the billions required to fully develop and deploy a modern IAMD with only high-tech equipment. By adopting such systems, even the smallest of NATO Allies and partners can contribute to the Alliance's defense and help counter large salvos of drones and missiles. This approach underscores the importance of aligning national defense strategies with NATO's broader goals, ensuring that all members, regardless of size or budget, can participate in safeguarding the Alliance's airspace. Cost savings need to be found not only in tracking but also in the destruction of hostile aerial targets. If drones can be tracked and predicted flight paths determined, mobile fire teams can be coordinated and moved into position to fire on the drones with low-cost Anti-Aircraft Artillery as opposed to expensive missile interceptors. Ukraine's relatively robust system of 8000 microphones time and again successfully guides these mobile fire teams to their targets, leaving very few places these OWA drones can hide ("US General Discussed the Work of the Ukrainian Acoustic Drone Detection System," 2024). This system of using old-fashioned machine guns on trucks has proven very effective and is now being tested by NATO nations in recent concepts of operations at Ramstein Airbase and in the Netherlands (Ukraine Joins NATO Counter-Drone Exercise for First Time," 2024).

Balloons have been used in war since the mid-19th century and they are another form of cheap defense that should be looked at by NATO. Hot air balloons have been used in Ukraine to confuse thermal targeting, and now, barrage balloons with protective nets are being used to defend critical targets (Kateryna Hodunova, 2024). These types of balloons can be raised quickly in the event of an attack and use lightweight nets to protect ingress routes. These types of tactics were used in WWII frequently and are being revived by the Russians. Cheap and effective barrage balloons are one more way to fight to get on the right side of the cost curve of IAMD.

The second priority for NATO is fostering multilateral collaboration to test and develop IAMD systems and sending clear demand signals to industry for research and development (R&D). When nations act as a bloc rather than pursuing individual programs, they can better integrate their common air defense capabilities into NATO's larger architecture. This will also encourage greater interoperability between national IAMD systems, strengthening the Alliance's collective defense posture. Recent demonstrations, such as the joint showing and testing of the Sky Fortress system to various NATO nations, highlight the benefits of multilateral development (NATO Shows Interest in Ukrainian Acoustic Detection Networks for Air Defense). By working together, NATO members can share resources, avoid duplication of efforts, and ensure that new technologies are developed with interoperability in mind, which is critical for tying national systems into the larger NATO structure. A focus on defense spending cannot be emphasized enough. Industry watches defense spending closely as it is a key signal for them to invest in R&D and the retooling of factories. National defense spending is a priority, but as NATO nations pool their money and buy common products the R&D costs can be shared and not duplicated, further encouraging businesses to make the investments needed to develop and test new systems. Interoperability will be the big winner in the long run.

Lastly, NATO must implement cross-border legislation to allow for more seamless coordination in air defense. The ability to track and engage aerial threats as they cross national borders is essential for the effectiveness of IAMD systems. Currently, many national air defense systems often only operate within their own boundaries, which can create grey areas near borders and limit the Alliance's ability to respond rapidly to threats near border areas. Determining who has engagement authority can be complicated. Legislation that allows for quick passing and transfer of engagement authority on air tracks across borders would enable more effective command and control, ensuring that threats are addressed in a timely and coordinated manner and that ground commanders have the authority needed to engage when they need it. Threats often move quickly and coordinating shot doctrine is critical. This cross-border collaboration is vital for addressing the complex, multi-layered nature of modern aerial warfare, where threats can emerge from various directions and altitudes.

In sum, the focus for NATO Allies and partners should be a multilateral approach that looks to adapting and creating cost-effective technologies, collaborating on testing and development, and enacting cross-border legislation to strengthen NATO's IAMD capabilities. As the nature of aerial threats evolves, particularly with the rise of low-cost drones and cruise missiles, NATO must stay ahead of the cost curve and ensure its skies are well-defended. These steps will not only help NATO nations individually but will also enhance the collective defense of the Alliance, allowing it to meet future challenges with greater resilience and preparedness.

VI. CONCLUSION

In conclusion, the centrality of Integrated Air and Missile Defense cannot be overstated. NATO must prioritize the development and deployment of robust IAMD systems not only to support Ukraine, but also to defend its own skies. The threat is not confined to the eastern regions—countries like Portugal and Spain are also at risk, as ballistic missiles and drones can easily overfly national borders. IAMD is an alliance-wide concern because, in modern aerial warfare, every nation is on the front line.
Events from recent conflicts demonstrate that any future attack on NATO will almost certainly begin in the air, underscoring the importance of maintaining air superiority. The devastating loss of Mariupol is a reminder of the consequences when air superiority is lost. To avoid a similar fate, NATO must ensure the skies are defended at all costs. By investing in sustainable IAMD solutions now, NATO can effectively protect its airspace and secure its future.

REFRENCES

Altman, Howard, and Tyler Rogoway, *Ukraine's Acoustic Drone Detection Network Eyed by U.S. as Low-Cost Air Defense Option*, The War Zone. July 24, 2024. https://www.twz.com/air/ukraines-acoustic-drone-detection-network-eyed-by-u-s-as-low-cost-air-defense-option.

Biesecker, Cal. *U.S. Air Force Commander for Europe Pressing NATO to Pursue Low-Cost Sensors to Counter One-Way Drones* Defense Daily. September 17, 2024. https://www.defensedaily.com/u-s-air-force-commander-for-europe-pressing-nato-to-pursue-low-cost-sensors-to-counter-one-way-drones/air-force/.

Çakırözer, Utku. *NATO's Evolving Air and Missile Defence Posture: Preliminary Draft General Report*. NATO Parliamentary Assembly, April 15, 2024. https://www.nato-pa.int/document/2024-air-and-missile-defence-posture-report-cakirozer-048-dsc-24.

Gordon, Chris, *Brown's First Message to the Force as Chairman: 'Accelerate Change' Lives On,* Air & Space Forces Magazine. October 2, 2023. https://www.airandspaceforces.com/brown-first-message-chairman-accelerate-change/.

Gosselin-Malo, Elisabeth, *Ukrainian Forces Rig Machine Gun Networks to Down Russian Drones*, Defense News. April 5, 2024. https://www.defensenews.com/global/europe/2024/04/05/ukrainian-forces-rig-machine-gun-networks-too-down-russian-drones/.

Gressel, Gustav, Rafael Loss, and Ulrike Franke. *Drones in Ukraine and Beyond: Everything You Need to Know,* European Council on Foreign Relations (ECFR). Accessed September 20, 2024.

Hodunova, Kateryna, *Moscow to Use Barrage Balloons to Repel Ukrainian Drone Attacks,* The Kyiv Independent. July 7, 2024, 1:28 PM. https://kyivindependent.com/moscow-to-use-barrage-balloons-to-repel-ukrainian-drones-attacks-on-russia-the-telegraph-reports/.

How Ukraine's Integrated Air Defense System Really Works, *Wall Street Journal Opinion,* YouTube video, 11:14. April 5, 2023. https://www.youtube.com/watch?v=1O0sRM-uY7E.

Kimmitt, Mark T., *Developments from Ukraine: Precision Warfare on the Cheap,* Politico. February 13, 2024. https://www.politico.eu/article/developments-from-ukraine-precision-warfare-on-the-cheap/.

NATO Washington Summit Declaration, NATO. July 10, 2024. https://www.nato.int/cps/en/natohq/official_texts_227678.htm.

NATO Shows Interest in Ukrainian Acoustic Detection Networks for Air Defense, Ukrainian Military Portal. July 29, 2024. https://mil.in.ua/en/news/nato-shows-interest-in-ukrainian-acoustic-detection-networks-for-air-defense/.

Trevithick, Joseph, *Thousands of Networked Microphones Are Tracking Drones in Ukraine,* The War Zone. February 12, 2024. https://www.twz.com/land/thousands-of-networked-microphones-are-tracking-drones-in-ukraine.

Ukraine Joins NATO Counter-Drone Exercise for First Time, NATO. September 19, 2024. https://www.nato.int/cps/en/natohq/news_228911.htm.

Ukrainian World Congress, *UNITED24,* Accessed September 20, 2024. https://www.ukrainianworldcongress. org/united24/.

US General Discussed the Work of the Ukrainian Acoustic Drone Detection System, Ukrainian Military Portal. Accessed September 29, 2024. https://mil.in.ua/en/news/us-general-discussed-the-work-of-the-ukrainian-acoustic-drone-detection-system/.

Watling, Jack, and Nick Reynolds, *The Meatgrinder: Russian Tactics in the Second Year of Its Invasion of Ukraine,* Royal United Services Institute (RUSI). Accessed September 20, 2024. https://rusi.org/explore-our-research/publications/special-resources/meatgrinder-russian-tactics-second-year-its-invasion-ukraine.