"With Surface-Based Air and Missile Defence,
you cannot win a war, but you will lose without it."

General James H. Dickinson, U.S. Space Command

Challenges of Integrated Air and Missile Defence in the Future – Implications for the Baltic States

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Abstract

The present article is founded upon a Researche paper, which was composed during the Joint Command General Staff Course at the Baltic Defence College in 2025.

Thesis: The future of Integrated Air and Missile Defence (IAMD) in the Baltic States is set to be significantly impacted by the emergence of advanced threats, including missiles, cruise missiles, UAVs, and hypersonic systems. This necessitates operational innovation, enhanced mobility, and deeper regional and NATO integration to ensure adequate defence.

Original Contribution: The article synthesises recent combat lessons from 2022–2025, quantifies strike / interception trends, and applies these operational insights specifically to Baltic States vulnerabilities — radar gaps, stationary C2, limited DCA/OCA assets — and proposes practical operational / tactical level measures (passive AD, layered C-UAS, UTM, OWUAS employment) that go beyond prior strategic overviews.

The methodology and sources employed are as follows: The present study employs a combination of qualitative doctrinal analysis and empirical evidence derived from a range of open-source operational reports, air-war monitors, defence think-tanks and NATO documents (for example, the Kyiv Dialogue, RUSI, RAND, and NATO publications). The paper employs a cross-referencing approach, utilising statistical data on strikes and interceptions, imagery, diagrams, and doctrinal literature to derive recommendations.

Utility for readers: Defence planners, NATO policymakers, and researchers will find a focused, evidence-based assessment of Baltic States IAMD shortfalls and actionable operational options (mobility, sensor mix, UAS integration, networked C2) that bridge strategy and implementable procurement/integration choices.

Keywords: *IAMD, Baltic States, C-UAS, layered air defence, networked C2.*

Introduction

The necessity for IAMD systems is underscored by the need to safeguard civilian populations, military forces, and critical infrastructure from mostly conventional threats, which have evolved rapidly in recent years [1, p. 37]. Furthermore, as NATO emphasises collective defence strategies, the Baltic States must align their defence initiatives with broader NATO objectives to ensure mutual support and operational effectiveness. Ultimately, understanding the implications of IAMD in this region is vital, as it affects national security policies and contributes to regional stability and the overall deterrence posture of NATO in the emerging security challenges.

The new NATO force model focuses on deterrence and defence with a three-tiered readiness system but has some gaps and other challenges. For instance, European Allies have shortfalls in IAMD and other key enablers. This outcome was arguably foreseeable, given the deployment of military assistance to Ukraine and the high demand for AD systems in the region. The acquisition of the requisite systems will not be a rapid process and, in certain instances, may span a considerable period [2, p. 6].

Russia fired over 600 cruise missiles (CMs) and 700 own-way UAVs between October 10 and the end of 2022 [1, p. 18]. During the missile and air strike campaign in Ukraine, Russia usually launched up to 222 missiles per day from February 2022 to January 2023. Since October 10, 2022, and at times, Ukraine AD intercepted only 75–80 % of incoming missiles [1, p. 20]. This statistic illustrates the considerable challenges currently facing Ukrainian AD, even with the support and assistance of AD systems provided by NATO countries. Moreover, Israel is renowned for its sophisticated IAMD, of which the Iron Dome is a constituent element. The Israeli case demonstrates that even a well-developed air defence system is susceptible to considerable limitations in countering missile swarms. Iran launched a wave of more than 300 UAVs and missiles (170 UAVs, 30 CMs, and 120 BMs) on Israel in one day [3]. The term "challenges" in IAMD describes the various obstacles and complexities associated with effectively detecting, tracking, identifying, intercepting, and neutralising aerial threats such as aircraft, ballistic missiles, cruise missiles, UAS, and hypersonic weapons. This research paper examines the vulnerabilities of the current Baltic States IAMD in the face of modern, near-peer threats and proposes recommendations for an operational concept to address these challenges.

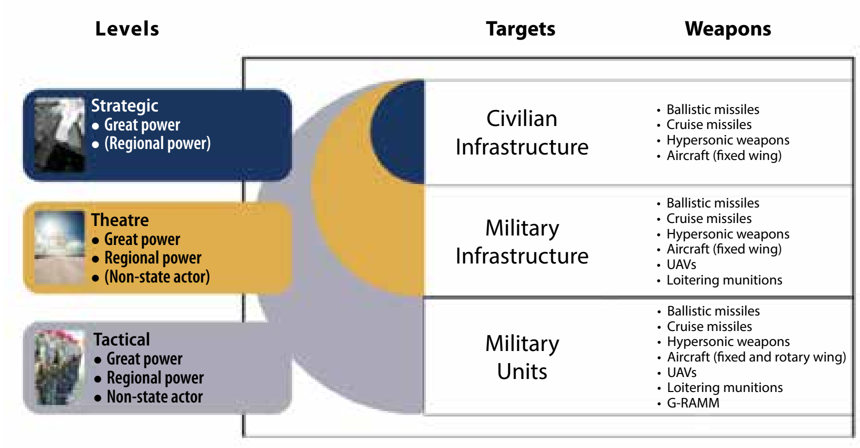
Thesis: This article argues that the future of integrated air and missile defence in the Baltic States faces significant challenges due to evolving air threats, technological advancements, and resource limitations, which will necessitate innovative solutions at an operational level and increased regional cooperation to ensure adequate air defence capabilities.

The scope of this article is to examine the doctrinal framework and analyse IAMD challenges related to the core roles and types of air operations. The focus is on defensive counter-air and offensive counter-air activities [4, pp. 1–8].

This article consists of four chapters, which will elaborate on the threats and technological advancements, the possible effectiveness of IAMD with limited resources, cooperation and integration with partners and recommendations for implementing IAMD in the Baltic States.

Evolving Threats Based on Technological Advancement

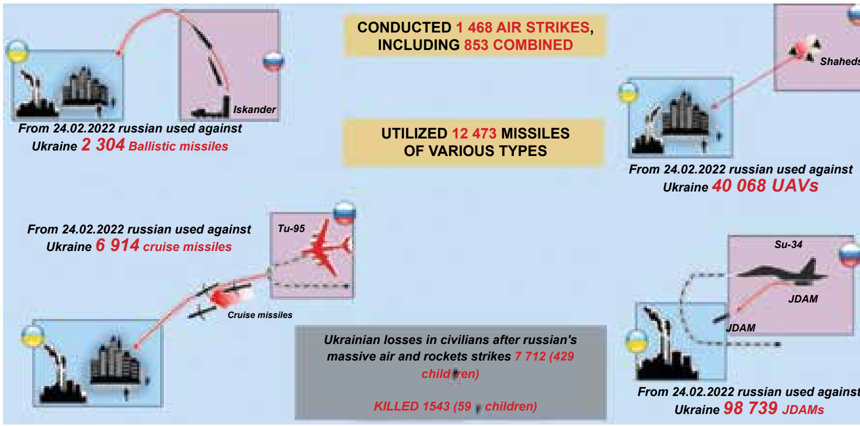
The chapter explores the evolving air threat environment affecting European and Baltic States' security. By understanding the various air threat capabilities, this chapter distinguishes threats at the strategic, theatre, and tactical levels and technical-tactical advantages of air threats.



1 picture. Summary of levels, targets, and weapons

Source: [5]

First, strategic threats target civilian infrastructure to coerce or deter adversaries. The goal is to undermine political will or deplete resources. At the same time, theatre are threats focus on military infrastructure to support offensive operations or defend against aggressors. Disrupting military capabilities can deter allies from intervening in conflicts. Furthermore, tactical air threats involve direct attacks on military forces. These threats use various weapons, including UAVs, and can be executed by state and non-state actors [5, pp. 14–15]. In summary, strategic threats aim at political influence, theatre threats target military capability, and tactical threats directly engage forces.



2 picture. Statistics from 24.02.2022 – 09.10.2025

Source: Ukrainian Air Force information

BMs are the first and most dangerous air threats[1]. BM can strike distant targets quickly, following a parabolic trajectory with three phases[2]. During their flight, vehicles travel at speeds ranging from 0.9 km/sec (Mach 2.6) to 6–8 km/sec (Mach 23+) at the time of re-entry and on a depressed trajectory at Mach 20 covering 6,700 km in seventeen minutes [5, p. 16]. The advancement of BM includes manoeuvrable re-entry vehicles, increased accuracy, multiple independent re-entry vehicles and hypersonic/supersonic glide vehicles [6, p. 3].

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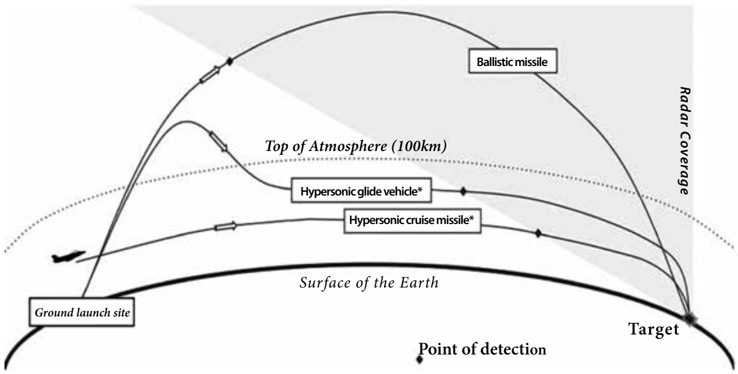
[1] The ranges that BMs: close-range BM (50–300 km); short-range BM (300–1,000 km); medium-range BM (1,000–3,000 km); intermediate-range BM (3,000–5,500 km); to inter-continental BM (>5,500 km) [5].

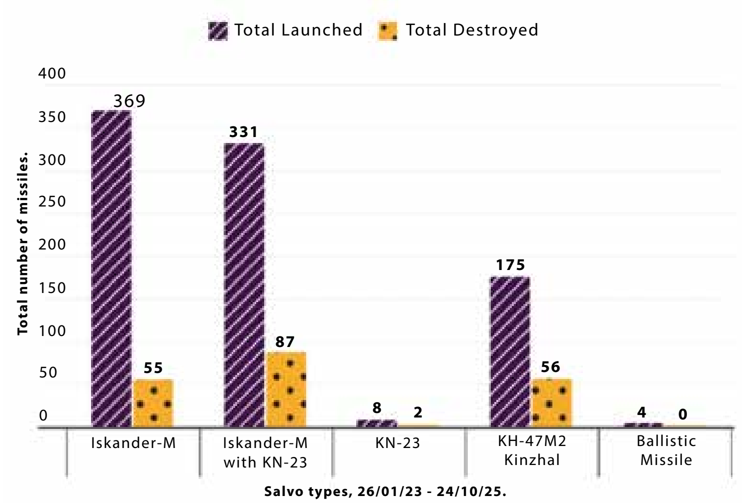
[2] The boost phase is powered by a rocket within the atmosphere, the midcourse phase glides in space, and the terminal phase during re-entry.



3 picture. Air threats and differences

Source: [7]

Ukrainian statistics show that Ballistic missiles fell to 57 (previous: 106). For the first time, a possible Iskander-1000 — an Iskander-M variant with ~1,300 km range and 200–300 kg warhead — was reported, extending reach beyond the standard 500 km. Ballistic missile interception fell to ~25 % (previous: 30 %) [8].



4 picture. Missile launch and interception totals show a gap to bridge for Ukraine's air defence (2026-01 / 2025-10)

Source: [9]

It is evident that technical enhancements have a significant impact on the survival and accuracy of BMs. The munitions employed in this instance are equipped with cluster warheads, decoys, enhanced targeting devices, and the capacity to manoeuvre in the terminal phase. Firing the Iskander on a higher, steeper ballistic trajectory shortens defenders' reaction time and increases terminal speed and manoeuvrability. Additionally, coordinated salvos contribute to successful strikes: large, multi-axis attacks can overwhelm defences, but many BMs hits occurred without simultaneous missile hits and salvo effects are inconsistent, so salvoing is a limited explanation [9].

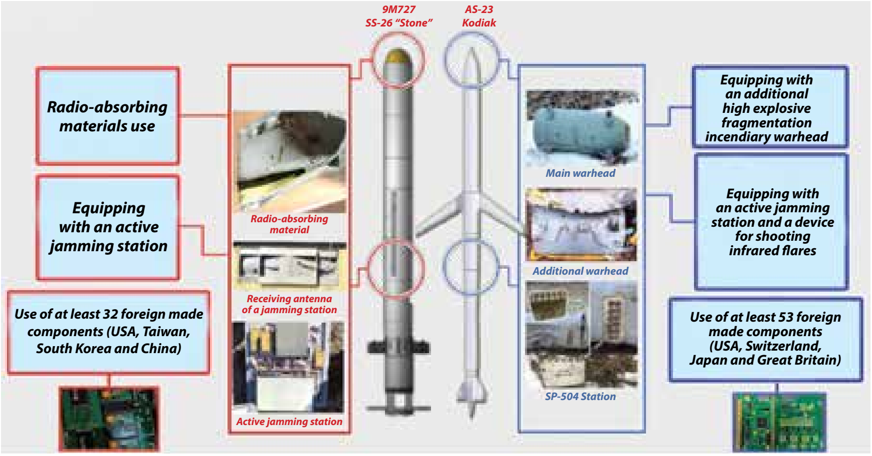
5 picture. BM modernisation

Source: Ukrainian Air Force information

CMs are the most difficult detectable and traceable air threat because CMs[3] can fly at low altitudes, using terrain features for concealment. Russia is developing ground-, sea-, and air-launched CMs utilising various conventional launch platforms. Furthermore,

[3] CMs receive guidance during launch, midcourse, and terminal phases from respectively: (1) an inertial navigation system; (2) a satellite navigation system; (3) a terrain contour matching system; (4) a radar or optical scene matching system; (5) from a more accurate scene matching system or optical or radar-based sensor within the target area; or (6) active radar homing (ARH) seekers that can find and track targets autonomously [5].

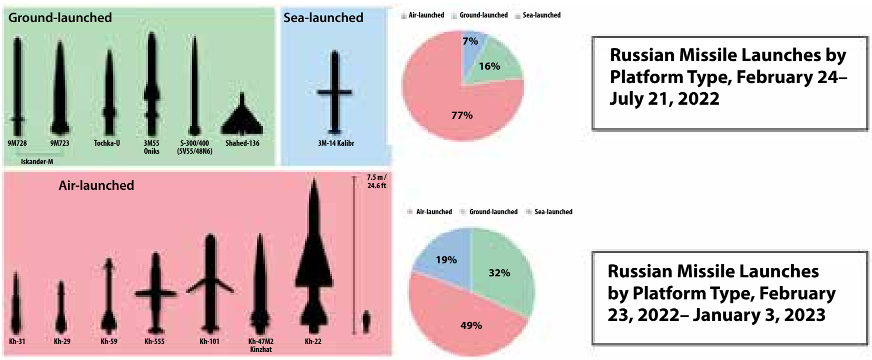
long-range, low-observable, advanced CMs enable Russia to present air and missile defence challenge with missiles capable of 360-degree avenues of approach to air defence systems and the critical assets they protect [6, p. 3]. Additionally, the CM are equipped with passive and active electronic protection measures, including radar reflection reduction, communication jamming devices and flares. These features make the CM more difficult to detect and shoot down.



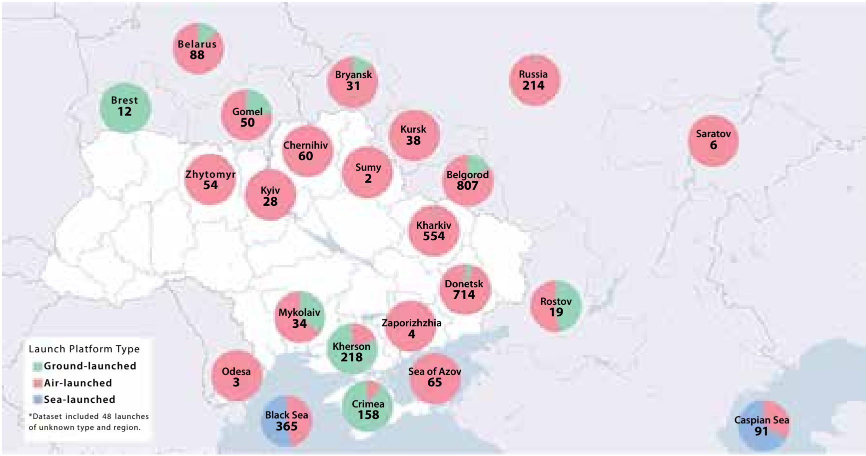
6 picture. CM modernisation

Source: Ukrainian Air Force information

It is estimated that Russia launched more than 2,700 air-launched missiles during the initial five-month period of the war in Ukraine, with half of these deployed from locations outside of Ukrainian airspace [1, p. 26]. In addition, between February and July 2022, Ukraine intercepted 174 cruise missiles, which indicates a successful interception of 10 %. However, by December 2022, Ukraine successfully intercepted 75–80 % of incoming cruise missiles on average [1, p. 27]. The increase roughly correlates to the arrival of Western-made air defence systems such as IRIS-T (succeeded in 90 %) and NASAMS (100 % succeeded) [1, p. 22]. To sum up, CMs remain an effective weapon to be launched in standoff mode to evade defence systems and carry out precision attacks because of their manoeuvrability and ability to fly at varying altitudes.

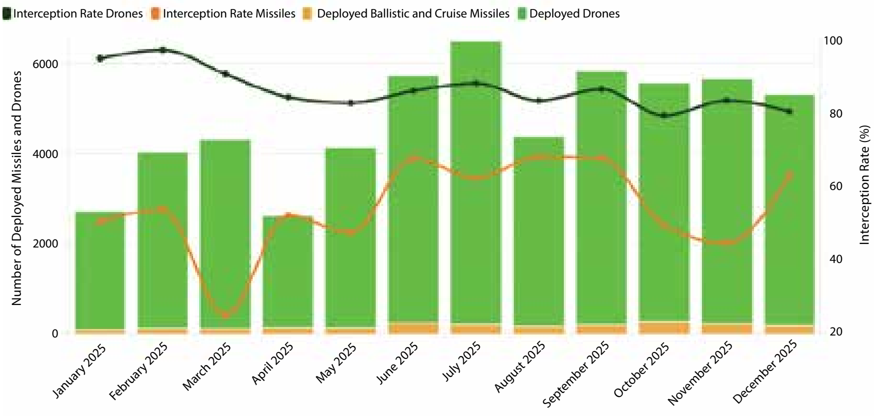


7 picture. Russian missile strike data



8 picture. Russian missile launches by type and launch location, February 24–July 21, 2022

Source: [1, p. 18 and 27]

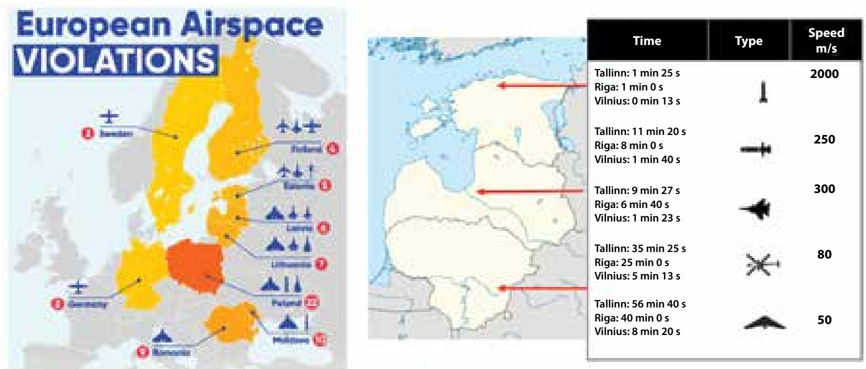


9 picture. Interception rates of Russian missiles and drones by month (2025)

Source: [8]

Hypersonic[4] weapons are touted as "unstoppable", combining the speed and range of BMs with the manoeuvrability of CMs. There are two main types: hypersonic glide vehicles (HGVs) (speed Mach 5–Mach 20) and hypersonic cruise missiles (HCMs) [6, p. 19]. It ensures the creation of a highly flexible offensive weapon capable of identifying and striking targets in minutes within a 1,000 km radius. Thus, this missile would reach the capitals of the Baltic States from the border with Russia in seconds or minutes. Ukrainian reports that Russia has launched numerous hypersonic missiles (Kh-47M2 Kinzhal) during the ongoing war with Ukraine. However, the exact number of Kinzhal missiles launched is not consistently reported, but it is known that they have been used sparingly due to limited production capacity and high cost [10]. Moreover, Russia's stockpile of Kinzhals is limited, including successful interceptions by Ukrainian air defence systems (Patriot PAC-3) [11]. In conclusion, hypersonic missiles represent the most significant threat and risk to air defence capabilities due to their high speed and manoeuvrability.

[4] **Subsonic**: Speeds below the speed of sound (343 m/s). **Transonic**: Speeds at or slightly above the speed of sound (800 to 1200 m/s). **Supersonic**: Speeds greater than the speed of sound (Mach 1 and above). **Hypersonic**: Extremely high speeds, generally considered Mach 5 or more [47].



10 picture. Europe airspace violation (2024–2025) and Potential air threats and their respective timeframes for Baltic States

The aircraft is the leading air power distributor in gaining air superiority and enabling author air power distribution activities. Firstly, the Russian AF have conducted Suppression of Enemy Air Defences (SEAD) operations in Ukraine using advanced aircraft like the Su-35S and Su-34 with anti-radiation missiles (Kh-31PM) designed to target radar systems [12]. Second, despite these efforts, Ukraine's air defences, bolstered by SBAMD systems like "Patriot", NASAMS, IRIS-T and S-300 systems, have managed to deny Russia air superiority. Successful AD actions forced Russian aircraft to rely on standoff tactics, limiting their operational effectiveness [13]. Third, Russia upgraded the UMPK (Unified Gliding and Correction Module) and UMPB (Universal Interspecific Glide Munition).[5] With an extended range, enabling strikes up to 200 km from launch points. These munitions are launched minimising the risk to aircraft from Ukrainian SBAMD [14]. The upgrade enables Russian aircraft to undertake close air support operations without

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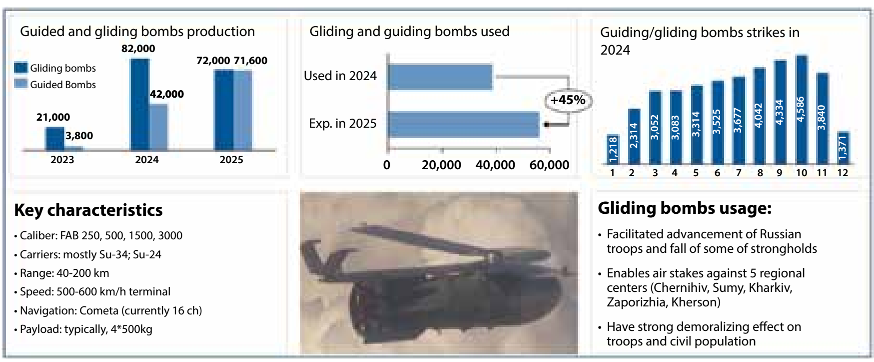
[5] The **UMPK** ($20,000) is designed to be strapped onto FAB-500 and FAB-1500, allowing Russia to convert its vast stockpiles of unguided munitions into glide bombs. Early UMPK versions had a crude construction and relied on civilian-grade electronics, exposing production to supply chain vulnerabilities. **UMPB** integrates the warhead (reportedly based on the FAB-250) and guidance systems into a more aerodynamically refined package. UMPB ranges up to 90 km (UMPK's 60–70 km), and may include enhanced resistance to EW.

entering within the range of Ukrainian AD systems. To sum up, the aircraft is the primary air power distributor that obtains air superiority and facilitates other air power distribution activities at strategic, theatre, and tactical levels. Along with adopting stand-off tactics, it underscores the importance of long-range strike capabilities in modern warfare.



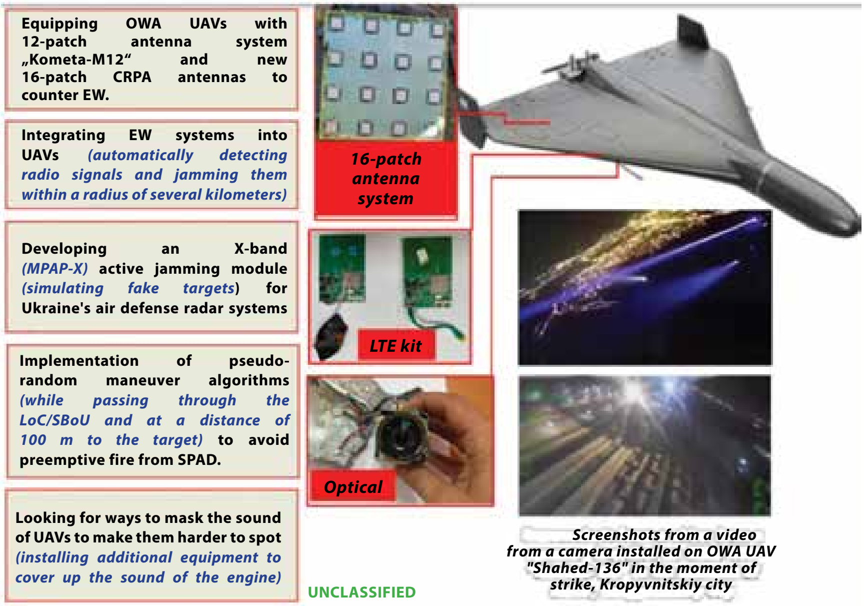
11 picture. UMPK and UMPB used in Ukraine

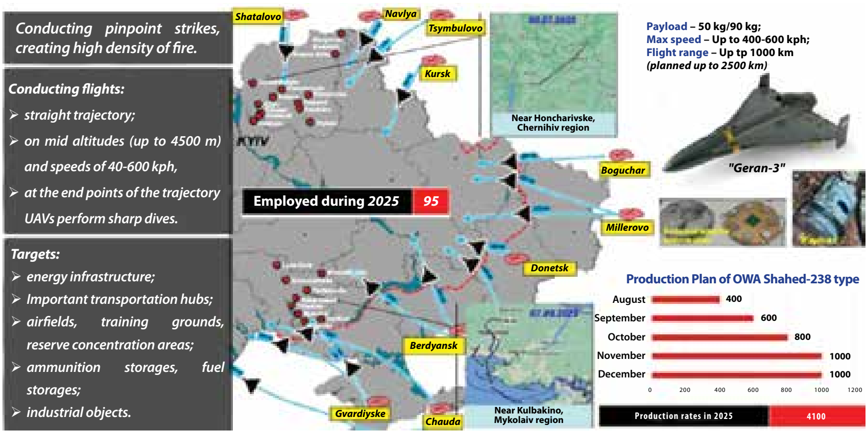
Source: [15]

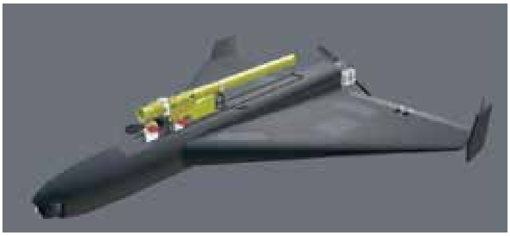
UAS[6] extensive range of platforms in terms of size, velocity, range, altitude, quantity, and capability makes this a particularly challenging mission area for IAMD systems and ensuring force protection for manoeuvre units. Firstly, Russia deploys tactical reconnaissance UAVs, such as the Orlan-10 or 30, for artillery targeting. However, many of these systems have sustained significant losses during the ongoing conflict in Ukraine [16]. Second, Russia relies significantly on Iranian-designed UAVs, including the Shahed-136 and Shahed-131 [17]. Furthermore, according to Ukraine's military intelligence, Russia has developed

[6] **Class I** (up to 150 kg): Typically unarmed, used mainly for reconnaissance; includes various subcategories such as Nano, Micro, Mini, and Small UAVs. **Class II** (tactical UAVs): Equipped with multiple payloads and can carry lightweight ordnance, though generally unarmed. **Class III** (medium-altitude long-endurance and high-altitude long-endurance): Capable of carrying weapons and primarily used for ISR or combat operations [48].

a new variant of the Geran-2 drone that can carry both a Verba MANPADS and a thermobaric warhead. This enables it to target both air and ground threats. Third, Russia uses commercial off-the-shelf drones (Class I), often imported from companies like DJI, FPV and others, for battlefield applications [17]. Typically, up to five UAVs fly over tactical positions to acquire targets through indirect fire or an OWUAV. This indicates that UAV swarms can be remotely operated, fly autonomously (Loitering munitions (LM)), or may accompany ground vehicles and aircraft that attempt to harm troops. These activities cannot be reached without at least artificial intelligence (AI) and had some influence on machine learning in air power distribution.



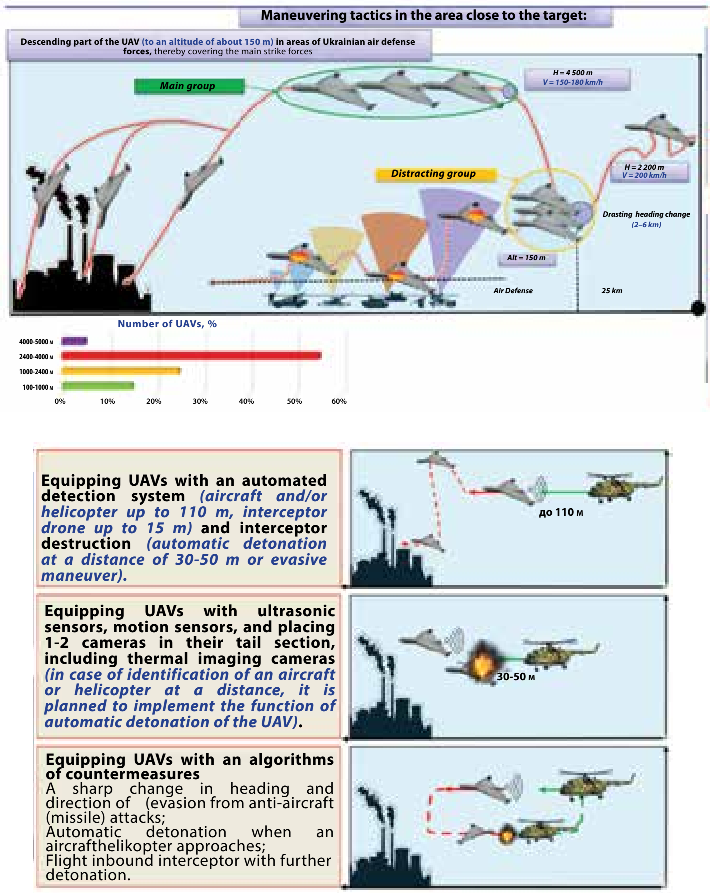




12 picture. Employment OWUAV Geran-2 and Geran-3 and technical improvements

Source: Ukrainian Air Force information

It is evident that the Russian Air Force employs a range of tactics with the objective of deceiving, disrupting, or suppressing air defence efforts.



13 picture. Russian Air Force maneuvering tactics in the area close to the target

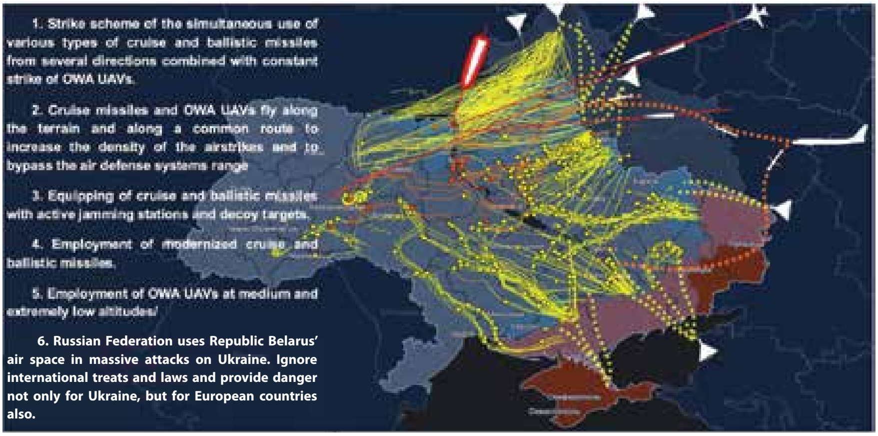
Source: Ukrainian Air Force information

Additionally, Iranian One-Way UAS (OWUAS) is utilised as an element of composed air operations (COMAO) alongside BM and CMs. In 2025, on October 5th, Ukrainians reported that Russian forces launched 53 missiles and 290 UAVs in Ukrainian airspace [18]. Statistical analysis indicates that for every 50 UAS, there is an average support of one or two BMs/CMs in terms of COMAO. By the conclusion of 2025, the ratio had increased to one or two BMs/CMs for every 5–10 UAS. The data presented herein indicates the intensity of air strikes.

14 picture. COMAO with the BMs and CMs, and UAS statistics

Source: Ukrainian Air Force information

The following image illustrates the complexity of the air strikes in Ukraine. In the context of airstrikes, Russia has demonstrated a strategy of employing a wide range of air power components.



15 picture. The complexity of air strikes in Ukraine

Source: Ukrainian Air Force information

Russia's deployment of UAS and its integration of AI and ML in military operations reflect its strategic ambitions and the inherent challenges associated with these technologies, particularly in its involvement in the Ukraine conflict. First, defence priorities are high-precision weaponry; UAVs like the KUB-LA (OWUAV) and Lancet-3 (loitering munition) (I class) are highlighted as key initiatives employing AI technology [19]. Second, AI enrolment increases electronic protection measures against C-UAS systems [19]. Moreover, lessons learned from the Ukraine war may influence future AI strategies, pushing for improved responsiveness and technological integration in military operations [19]. Finally, UAVs (all classes) are changing the nature of warfare at the tactical level and the UAV acts as a cost-effective and rational carrier of air power.

The threat posed by rockets, artillery, and mortars (RAM) is a persistent one that IAMD forces are actively addressing in the present day. These threats will likely continue to expand in the near and midterms [6]. Furthermore, guided RAM encompasses a range of weapon systems, including small mortars and long-range rocket artillery systems. While unguided projectiles are predictable and more manageable to intercept, guided variants present challenges due to their trajectories, which make them difficult to target [5, p. 26].

In conclusion, it is important to understand that the Baltic States are NATO territory, and Russia will not be able to dominate their airspace. Therefore, all of the aforementioned air threats cover the entire Baltic Sea region, and it is likely that they will be launched from the aggressor's airspace. The most significant threat is a sophisticated, multifaceted assault that incorporates many threat capabilities in a meticulously coordinated and synchronised attack (COMAO). Such attacks may include stand-off approaches for ACs, CM, OWUAS and TBMs to neutralise IAMD and attack critical assets.

Challenges of Developing and Maintaining an Effective Defensive Counter Air with Limited Resources

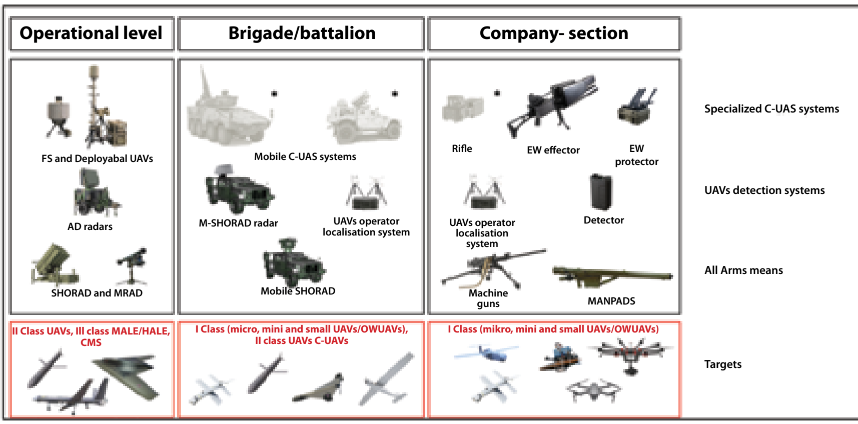
This chapter analyses the existing, planned capabilities and the possible effectiveness of counter-air operations with limited resources and integration with Allies. Russia's actions in Ukraine highlight air threats multi-use and make counter-air operations crucial for protecting civilian populations, military forces, and critical national infrastructure (CNI).

The Baltic States have the most developed active defence Surface-based air and missile (SBAMD) capabilities up to medium range[7], which enable them to counter air threats to guarantee the protection of their military forces and limited capabilities to protect CNI. Lithuania has bolstered its air defence by acquiring a second and third NASAMS battery by 2028-30, Mobile-SHORAD systems by 2030 and Tactical ballistic missile defence capabilities on a list will be by 2035. Meanwhile, Latvia and Estonia have procured the German-made IRIS MRAD (up to 2–3 batteries per state) systems to strengthen their air defence capabilities [20]. These acquisitions will significantly strengthen the active AD capabilities of the Baltic States, fulfilling the principles of MASS and Mix AD and countering CMs, fighters, helicopters and UAVs (Class I and II).

Baltic States face challenges countering UAVs, especially Class I UAS. According to the NATO doctrine, given UAS' low detectability, short detection to defeat timeline, and ability to operate at very low altitudes, C-UAS is part of the IAMD and Force protection [21, pp. 1-2]. Traditional air defence systems can intercept Class I UAS, but even SHORAD missile cost is exceptionally high compared to the price of a UAV. Furthermore, the speed of FPV UAVs makes them almost undefeatable. Nevertheless, Baltic States use soft-kill means rather than kinetic-kill means, but focus on combining both. Moreover, integrating C-UAS to IAMD FAAD C2 is necessary to conduct a precise engagement sequence. In addition, airspace

[7] SBAMD ranges: long range – beyond 50 km; medium range – maximum 50 km; short range – 15 km; very short range – 5 km [43].

management regarding UAVs is another challenge the Baltic States must solve soon. To sum up, it is difficult for Baltic States and other states to cope with UAVs, particularly small, slow, low-flying UAS.



16 picture. Threat allocation according to IAMD and force protection means

Source: LTU DS info

The Baltic States have no anti-aircraft artillery capabilities, which could work countering the UAS as Ukrainian air defence units do. The Baltic States have limited indigenous air forces. They are working to develop capabilities through regional cooperation. Since 2004, NATO has conducted enhanced air policing missions in the Baltic region. These missions entail the deployment of fighters from member states to deter potential aggression and assure air security [22].

An important element of passive AD[8] is the rapid process of the Air Raid Warning (ARW). All three countries highlight Air

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[8] Passive AD – all other measures taken to minimize the effectiveness of hostile air and missile attacks, through individual and collective protection of friendly forces and critical assets: camouflage, concealment, and deception; hardening; dispersion; reconstitution, and low observable or stealth technologies. These passive AD measures for the survivability of the joint force are part of the overall Force Protection (FP) doctrine [4].

Force cooperation with the Civilian Agencies[9] in the event of air raids to inform the civilian population [23]. In this case, the civil authorities' role is limited of the report, which is a time-consuming process. Furthermore, the Baltic air forces can receive Ballistic Missile Warning capability from NATO allies, utilising existing communication networks and the Shared Early Warning Plus application. Overall, ARW is closely related to and dependent on C5ISR. To sum up, the duration of the air raid warning process is contingent upon the operational depth of the Baltic States.

Command, Control, Communications, Computers, Cyber, Intelligence, Surveillance, and Reconnaissance (C5ISR) remain key elements for the integrability and integration of the Baltic State's air defence assets. First of all, in 2018, the International Centre for Defence and Security assessed and conclude that the region has a significant shortfall in air defence capabilities, making it vulnerable to Russian aggression. Second, there are considerable deficiencies in radar coverage, particularly at low altitudes in terms of detecting UAVs, as well as in interoperability with NATO systems [24, p. 27]. Even though there were two air defence clusters in Vilnius, Kaunas for SBAMD, CAP mission, AWACS worked 24/7, and AIR C2 was established during the NATO summit in Vilnius 2023 [25]. Third, the dependence on one Control and Reporting Centre (CRC) was solved, and each state integrated CRC, enabling redundancy of Air C2 for the Baltic States. It is also important that these CRCs are stationary, with various radars installed across the three countries to monitor and protect their airspace [26]. This renders them highly vulnerable and susceptible to destruction in the event of Russian aggression, and only mobile radars or sensors that work in passive mode (VERA) could survive and provide data to Recognised Air Picture (RAP). To conclude, the principal elements of integrating the Baltic States' AD capabilities are (C5ISR), which has been enhanced with the assistance of NATO allies.

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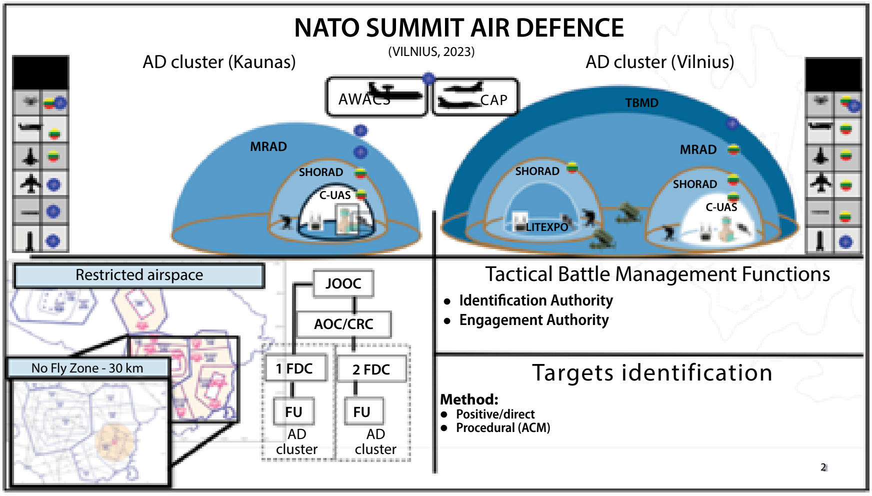
[9] Estonian Emergency Services Board, Latvian Fire and Rescue Service, the Lithuanian Department of Civil Protection and Disaster Management.



17 picture. Concept of the air defence during the NATO Summit in Vilnius, 2023

Source: LTU Defence staff information

The Baltic States air forces have none of the aircraft that can destroy possible enemy air force targets. To achieve control of the air, OCA and DCA operations must require the same resources and be conducted simultaneously in the same airspace. They cannot be considered in isolation from each other. [4]. Nevertheless, Baltic States have limited ability (Land, SOF components) to conduct OCA, for instance, direct actions (SOF), indirect fire (Land), and UAVs (Tactical level, Land, SOF). JFC may nominate the JFAAC as the overall supported commander for the initial phase of operations until the required level of air control is achieved [4].

Air traffic and Air space control in the Baltic States rely on civil agencies' authority and limited military flexible use of their purposes [27] [28]. In addition, Respective air navigation service providers[10] regulations for users of UAVs. Taking over the air traffic control and airspace control from civil agencies would possibly be the most challenging action for the Baltic state's air commanders

[10] The Estonian Civil Aviation Administration, The Latvian Civil Aviation Agency, air traffic management and air navigation services across Lithuania's airspace.

in the future. To sum up, the Air Force must be ready to take over airspace control over civil in terms of any airspace usage.

In conclusion, developing and maintaining an effective DCA capability within the Baltic States, constrained by limited resources, faces significant challenges. Despite notable advancements such as acquiring modern MRAD, the region's air defence infrastructure remains under strain from evolving air threats, particularly Class I UAVs. The integration of these systems into a cohesive C5ISR network, with NATO support, enhances their defence posture. However, critical vulnerabilities persist, including radar coverage gaps, reliance on stationary assets, and limited indigenous DCA capabilities. Moreover, the transition of airspace control from civilian to military authorities in crisis presents an operational and administrative challenge.

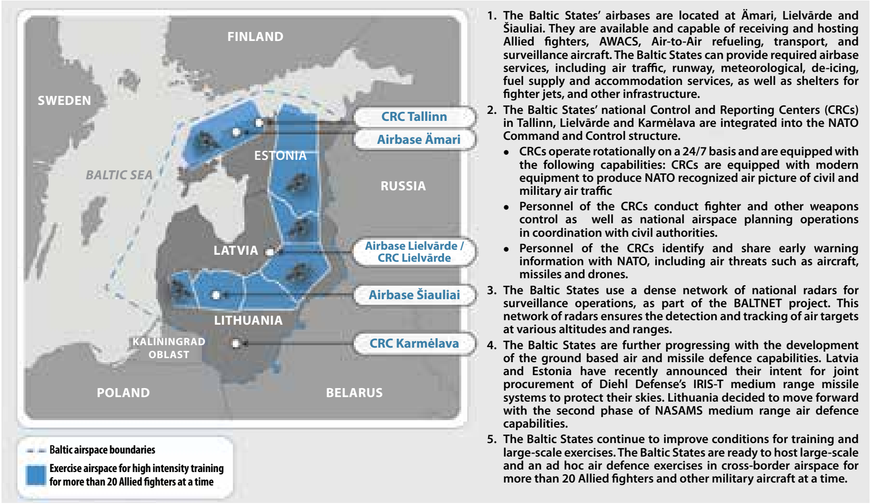
Regional Cooperation of Integrated Air and Missile Defence

This chapter analyses the initiatives of cooperation and the importance of collaborative defence initiatives among the Baltic States receiving and enabling NATO air defence activities among regions.

NATO has implemented a Rotational Air Defence Model (RM) in the Baltic States to enhance regional security and deter potential threats. Firstly, this model involves regularly deploying allied SBAMD and fighters to Estonia, Latvia, and Lithuania. These deployments are conducted ensuring continuous protection against airborne threats without the need for permanent basing of forces [29]. Secondly, The Baltic States have actively contributed to this initiative. This collaboration seeks to enhance the existing air policing mission into a more comprehensive air defence operation, integrating DCA elements strengthen regional defence capabilities [30]. Thirdly, the deployment of the Spanish NASAMS to Latvia is part of NATO's Rotational Air Defence Model. Overall, NATO's RM in the Baltic States exemplifies the Alliance's commitment to collective defence. Lastly, on 22 September 2025, NATO launched

Operation Eastern Sentry to strengthen its eastern flank against rising Russian aerial incursions. The multidomain deployment — land, sea and air — aims to close gaps from the North Sea to the Black Sea. Previously, allies handled air policing individually with occasional NATO support; the new strategy consolidates linked resources across the flank, including missiles and anti-drone systems [31].

The Military Air Bloc Concept for flexible airspace usage is a strategy designed to optimise the allocation and utilisation of airspace over the Baltic States to accommodate military aviation needs. This approach is particularly relevant in regions with limited airspace but significant military activities, such as NATO operations and dense commercial air traffic. These blocs are made available for military exercises or other operations and released back to civilian control when not in use [31].



18 picture. Baltic States' contribution supports the NATO Air Defence Rotational Model and Air exercises

Source: Ministry of National Defence of Lithuania

The BSC5I synchronisation board is a US-led, multi-national, multi-disciplinary forum that meets regularly to address interoperability initiatives. The BSC5ISB reinforces a strategic partnership to improve C5 interoperability among the US, Estonia, Latvia, Lithuania, and other interested Allies. The BSC5ISB allows Baltic States to synchronise communications system standards, requirements, interoperability, configuration, and management to ensure operational success in the Baltic region [32]. Second, Baltic States were among the initial signatories of European Sky Shield Initiative (ESSI) in October 2022, underscoring their commitment to regional security. Estonia and Latvia further solidified their involvement by signing agreements with Germany to procure the IRIS-T medium-range air defence missile system in 2023 [33]. Beyond ESSI, the Baltic States are engaging in additional collaborative defence initiatives. For instance, Lithuania agreed with neighbouring countries, including Poland, Norway, and Finland, to establish a "drone wall." This project aims to enhance border security through advanced surveillance and defence technologies.

To conclude, while regional cooperation and NATO collaboration offer substantial support, the Baltic States must continue to address shortcomings to ensure robust air defence and effective counter-air operations against a spectrum of contemporary threats.

There Are Opportunities for Baltic States to Implement IAMD Development at the Operational and Tactical Levels in the Future

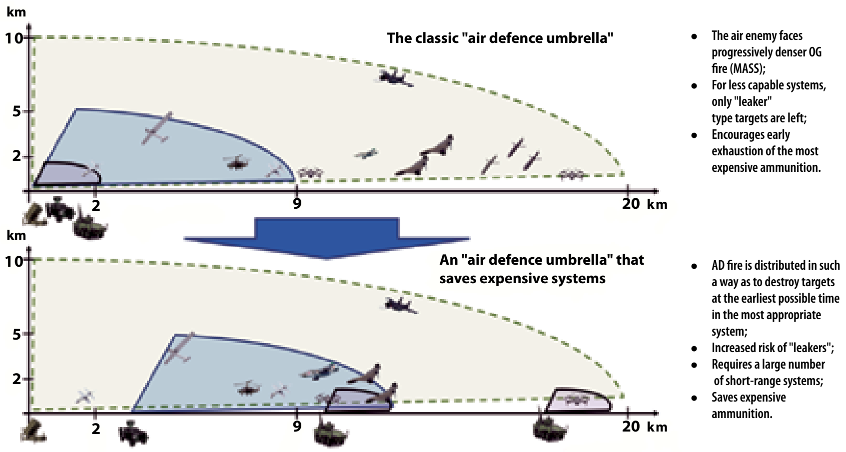
There are two contrasting perspectives on the future of integrated air defence. These are characterised by a divergence of opinion between those who advocate a DCA approach and those who favour an OCA strategy. This chapter offers guidance on a line of efforts suitable for operational planning and capacity development to enhance the IAMD capabilities of the Baltic States in anticipation of future challenges.

The first line of effort is to enhance DCA's integrated air and missile defence capabilities. Firstly, the Baltic States could disperse them more widely instead of concentrating air defence assets in a few significant locations. This would make them less vulnerable to a single, decisive strike. Smaller mobile units could be deployed to various locations using containerised launchers [34, p. 19]. Investing in mobile, efficiently relocatable systems and possibly containerised launch systems would significantly increase survivability and complicate targeting efforts [34, p. 36]. Secondly, equipping launchers with a mix of different interceptor types would enhance their adaptability. The Baltic States might consider using a mix of shorter-range and longer-range missiles, integrate offensive and defensive capabilities within the same launchers and develop missiles capable of multiple missions (anti-air, anti-missile, anti-ship). Furthermore, using containerised launchers improves mobility and concealment. Moreover, the lessons learned from Ukraine stress the importance of passive defences such as deception and camouflage. The Baltic States could invest in radar-absorbing materials, dummy launchers, and other measures to confuse and complicate enemy targeting efforts [34, p. 37]. Additionally, mobility works as a passive means not only for SBAMD but especially for having at least a deployable CRC, which increases the survivability of Air C2.

19 picture. Mixed-loud and containerised

Source: [34]

The Baltic States should focus on Non-Ballistic Threats in nearest future. The Baltic States should prioritise investing in sensors and systems to detect and counter these CMs and UAVs. This includes radar (passive and active) systems with better coverage and responsiveness, C-UAS systems. According to NATO C-UAS doctrine, countering the use is IAMD and Force protection mission [21]. The Ukraine experience dictates using a mix of hard-kill (anti-aircraft guns) and soft-kill means in the future. Furthermore, consider the establishment of a robust C-UAS architecture to expedite the kill chain and improve the coordination between C-UAS, other IAMD components, and civilian air traffic control authorities [35, p. 91].



20 picture. Change in the "layering" of the IAMD system

Source: Lithuanian AF Defense Staff info

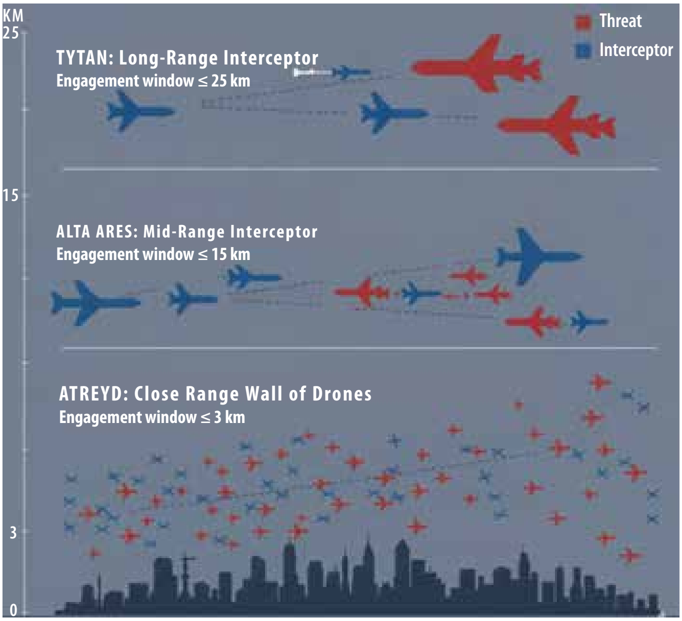
It is asserted that fighters remain the most versatile and fundamental platform for air forces, capable of fulfilling the essential core role of air power. Recently, there has been considerable discussion regarding the relative merits of the F16 and Gripen as the optimal choice. It is evident that the incorporation of fighters into the Baltic States' procurement plans is not a matter that is currently under consideration.

1 table. Gripen E (JAS 39E) vs F16V (Block 70/72)

Category	Gripen E (JAS 39E)	F16V (Block 70/72)
Role	Multirole lightweight 4.5gen, emphasis on low LCC & networked ops	Multirole 4.5gen workhorse, large global logistics & weapons ecosystem
Engine / thrust	GE F414, ~98–110 kN (with afterburner)	F100/F110 family, ~85–130 kN (model dependent)
Max speed	≈ Mach 2.0	≈ Mach 2.0
Combat radius (typical)	~600–1,000 km (mission/load dependent)	~500–900 km (mission/load dependent)
Ferry range	~3,600 km (with drop tanks)	~3,800–4,200 km (with drop tanks)
Service ceiling	≈ 50,000+ ft (~15,000 m)	≈ 50,000+ ft (~15,000 m)
Payload / hardpoints	~7,000–8,000 kg; 8 hardpoints	~7,000–9,000+ kg; 9 hardpoints
Sensors & avionics	AESA radar, advanced sensor fusion, builtin EW & datalink	AESA retrofit option (AN/APG83), advanced mission computer, broad 3rdparty EW/datalink options
Acquisition cost (unit, new, 2020s est.)	~$80–120 million	~$70–110+ million
Operating cost (per flight hour, est.)	~$4,000–8,000	~$8,000–20,000+
Pilot training to combatready	~$1.5–3.5 million per pilot	~$2–5+ million per pilot
Annual pilot currency / proficiency	~$150k–400k	~$200k–600k+
Strengths	Lower lifecycle cost, modern sensor fusion, short turnaround	Mature logistics & weapons ecosystem, wide supplier base
Primary tradeoffs	Fewer hardpoints/payload options vs lower costs and modern integration	Potentially higher operating/ training costs but larger payload/ options and global support

Sources: https://www.saab.com/air/aircraft/gripen, https://www.lockheedmartin.com/en-us/products/f-16.html

Another opportunity to improve active AD for Baltic States is developing UAS and the integration of UAS into DCA missions. The Baltic States will not be capable of developing UAS that can work in conjunction with fighters soon. However, using Class I UAS as drone-to-drone combat systems remains a viable option, and such capability would complement the SBAMD systems.



21 picture. NATO-Ukraine project – SKYFENCE Layered Solution for DCA mission (different type of UAS)

Source: [15]

For instance, the FAAD-C2 system has been enhanced with an Advanced Battle Manager that uses artificial intelligence to rapidly assess threats and coordinate appropriate responses rapidly [36]. Moreover, CAP missions extend the reach of air patrols to cover broader or more remote areas. The employment of drones in these scenarios is particularly advantageous due to their endurance and ability to operate in environments that may be too risky for manned aircraft to access. For example, on 21 February 2026 a Bayraktar AKINCI UAV launched an EREN highspeed loitering munition that intercepted and destroyed a Shahedtype target drone over the Black Sea off Sinop, marking the system's first confirmed airtoair engagement; the test validates an unmanned sensorshooter kill chain — AKINCI's longendurance AESA-equipped ISR and targeting suite detecting and cueing EREN's [38]. To sum up, incorporating UAS into DCA operations enhances the effectiveness of missions in countering enemy UAS, FABs and strengthening the airspace security of Baltic States in peace, crisis and wartime.

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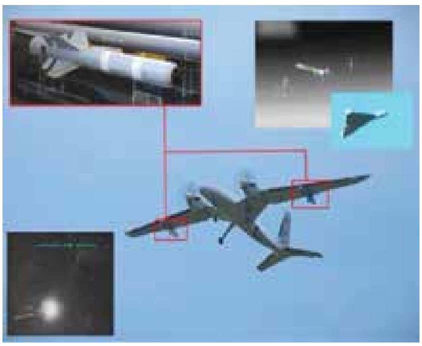
<td></td>
<td>
• Role: HALE UAV for ISR, strike and airborne counterUAS.
• Specs: ~6,000 kg MTOW, >1,500 kg payload, >24 hr endurance, ~30,000 ft operating altitude, twin turboprops, 8 hardpoints.
• Sensors/comms: MURAD AESA (SAR/GMTI/air modes), EO/IR turret, SATCOM, ESM/ECM, datalinks.
• Weapons: MAM-series, guided bombs/missiles, EREN loitering munitions.
• Tactics: Persistent sensor-shooter CAP, outer counter-UAS layer to reduce SAM/fighter usage; road/ship deployable.
• Vulnerabilities: Susceptible to advanced AD networks, GNSS/comm jamming, adverse weather for IIR seekers.
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<tr>
<td colspan="2">
• Roketsan EREN — key tactical/technical points
• Role: Turbojet loitering munition for air/surface targets (interceptor/strike).
• Specs: ~2 m, ~35 kg, turbojet, >100 km range, ~15+ min loiter, high terminal speed.
• Guidance/seeker: GNSS/INS midcourse, IIR seeker with ATR; operator can search, abort, reattack.
• Warhead: Fragmentation/shaped charge for small UAVs/light vehicles.
• Launch: Air, ground, vehicle, containerised or ship launch.
• Tactics: Standoff intercepts from UAV or launch cells, saturable lowcost counter-UAS layer.
• Limits: IIR degraded by weather/low signatures, GNSS jamming, finite stockpiles vs large swarms.
</td>
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22 picture. One of possible example of UAS for DCA missions (air-to-air)

Source: [38]

The engagement sequence or "kill chain"[11] is a logically related tactical activity that requires operational-level decisions. Firstly, Ukraine's low-cost solution has been Sky Fortress, an acoustic sensor that uses cellophane to detect the acoustic signatures of incoming threats. In Ukraine, a significant number of mobile phones are discarded by the populace at regular intervals. Through the triangulation of these sensors, it is possible to ascertain the

[11] The airframe or the payload needs to be targeted in the air, on the ground, or its logistic support needs to be negated. Each option has a so-called kill chain following the F2T2EA (Find, Fix, Track, Target, Engage, Assess) [48].

direction of movement as well as the velocity of the target [37]. While this information is sufficient for the ARW system. It helps to direct an aircraft or utilise SBAMD weaponry to neutralise the threat. Baltic States should focus on finding and tracking low-flying air threats.

Secondly, identifying friendly or foe ABT / UAVs remains a considerable challenge in terms of massive COMAO or swarms of UAVs. The concept of UAS Traffic Management (UTM)[12] is becoming increasingly vital to identify UAVs [38]. In the context of the Baltic States, adopting UTM systems could significantly enhance UAV operations, airspace safety [39]. First, a key direct component of UTM adoption involves building the necessary infrastructure for communication, surveillance and tracking technologies to monitor UAVs' positions in real-time. Second, it is atypical for the military to assume complete civilian control of air traffic. Consequently, the Baltic States' air forces must be prepared to assume airspace control. In summary, the Baltic States should progress in adopting U-space and UTM services to manage UAV operations, with civilian agencies primarily overseeing air traffic control and the military focusing on airspace defence.

Thirdly, allocating targets to effectors is imperative in multidomain operations, and this process cannot be accomplished without network-centric operations. Notably, efficient allocation conserves expensive missiles, prioritises destroying the most threatening air targets, and prevents the destruction of confusing targets. These actions are executed on the fire control centre and must be executed with extreme rapidity. Consequently, AI support will continue to be a pivotal instrument for target allocation in the future.

Fourthly, three options leverage networked sensors and C2 to

[12] In 2020, the EU (European Union Aviation Safety Agency (Regulation 2019/947) rolled out a pilot project, U-Space, as a UTM initiative to help manage drone operations in European airspace. This initiative involved the Baltic states to test UTM concepts, safety protocols, and airspace integration [39].

enhance the battlespace for modern IAMD systems[13]: launch on Remote (LOR), engage on remote (EOR), Interceptor Handover [40]. These concepts require effective information sharing among nations and firms, which administrative challenges and variability in data refresh rates hinder, particularly over networks like Link-16 and FAAD C2. [40]. Current refresh rates may prove inadequate for high-velocity threats, such as ballistic or hypersonic missiles and UAVs.

Lastly, effective Joint IAMD operations are based on the network-centric concept. The Baltic States should prioritise integrating their existing AD systems into networked architecture that enables Baltic States to work alone with Coalition partners and NATO. This would enhance communication and data sharing between IAMD elements. The goal is to create a common air operational picture, allowing for more efficient allocation of resources and improved coordination between different military branches [34, p. 24]. This likely means upgrading outdated communication systems and investing in new, interoperable technologies.

The second line of effort is to enhance OCA capabilities that could potentially target adversaries' air capabilities[14]. Ukraine's experience shows that there will never be enough interceptors to counter all potential missile threats. Furthermore, US Army Lt. Gen. Danial L. Karbler highlighted that focus should shift from merely defending against missiles to actively defeating the enemy's missile capabilities at multiple points in the development and deployment chain.

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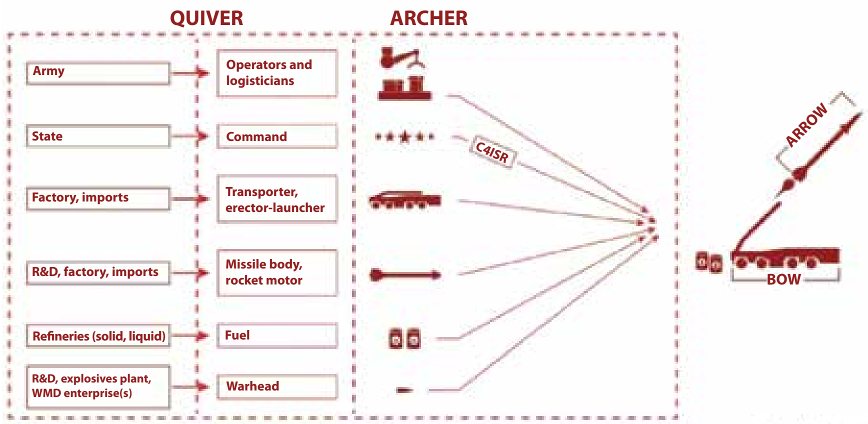
[13] **Launch on Remote (LOR)**: A unit fires a missile at a remote target it cannot directly see, relying on network cues. The launch must wait until the target enters the local sensor range for terminal guidance. This approach extends the operational range but remains limited by organic sensor capabilities. **Engage on Remote (EOR)**: Here, a unit can launch a missile without local sensor data, using the interceptor's active sensors and accurate, low-latency remote targeting. This allows engagement of targets beyond the unit's line of sight, removing the constraints of organic sensor limits. **Interceptor Handover**: In this model, the firing unit initially guides the interceptor before transferring control to a remote unit for final guidance. Though this enhances range capabilities, it faces challenges due to varying communication protocols and encryption, which may complicate handover processes.

[14] Airfields, Operating Bases infrastructure, Aircraft Carriers, tbms, cms, combat drone Launching Systems, Sites, Platforms, SBAMD sites, Electronic warfare systems, C2 systems and Air surveillance and control systems (ASACS).



23 picture. Adversary missile systems components, which supposed to be targeted according Lt. Gen. Danial L. Karbler

Source: [41, p. 15]

This involves using all domains, from cyber to space and encompasses offensive and defensive strategies [41, p. 12]. Karbler's main idea is that achieving missile defeat requires a multi-domain approach, utilising cyber, space, and special operations capabilities in addition to traditional AD systems. Moreover, the Baltic States OCA rely on indirect fire support and Special operation forces; besides these capabilities, there is a need for a more proactive, offensive approach, leveraging air component capabilities to negate the effectiveness of the Adversary's missile systems before being launched. Firstly, OWUAVs are employed in surface attack missions to target enemy SBAMD and other critical assets. These drones can be pre-programmed or remotely piloted to strike targets, that degrading the enemy's ability to contest air superiority [42]. The Baltic countries must develop this capacity for three fundamental reasons: cost-effectiveness, eliminating the risk to pilots, and precision and flexibility. In the context of the development of UAS capabilities, two approaches may be adopted: the creation of separate structures or the integration of structures into existing capabilities.

2 table. Loitering Munitions and OWUAV — Comparison

Category	**Dornier DAR (DAR)**	**Shahed136**	**Harpy / Harop**	**LUCAS (FLM136)**
Origin / era	Germany, 1980s	Iran, modern	Israel (IAI), modern	United States, modern concept/ development
Primary role	SEAD (antiradar loitering munition)	Oneway strike / attrition	Autonomous antiradiation / loitering strike	Longrange oneway attack, saturation/ attritable strikes
Airframe / layout	Deltawing, rear prop	Deltawing, piston prop	Deltawing / canard variants, prop	Straight fixed wings, twinfin tail, rear pusher prop, composite airframe
Launch weight / size	Historic medium class	~240 kg launch weight; ~2.5 m wingspan	~100–300 kg class (varies)	Max launch weight ~81.6 kg; length 2.99 m; wingspan 2.50 m; height 0.46 m
Propulsion	Piston engine, rear prop	Piston engine	Piston engine / prop	Internal combustion engine driving rear pusher prop (fuelefficient for endurance)
Fuel / pay-load capacity	(historic)	Fuel/payload sized for long loiter	Varies by model	Fuel 33.1 kg; payload 18.1 kg (warhead)
Range / endurance	~600 km (historic DAR claim)	Long standoff / tactical ranges	Long loiter / targetseeking ranges	Range ≈ 822 km (444 nmi); endurance ≈ 6 hours
Wingspan / dimensions	Template delta dims	~2.5 m wingspan	Variable	Length 2.99 m; wingspan 2.50 m; height 0.46 m
Speed / performance	Designed for terminal dives	Tactical cruise/ dash speeds	Loiter and terminal dash	Cruise ~137 km/h; max dash ~194 km/h; service ceiling ~4,572 m
Seeker / guidance	Passive radar seeker	GPS/INS ± EO / simple guidance	Autonomous radar seeker (antiradiation)	GPS/INS, EO sensor forward; secure datalink; autonomous mission computer
Warhead / effect	Impactdetonating warhead	Oneway impact warhead	Impact/HE to destroy emitters	Up to 18.1 kg payload — HE/fragmentation, blast, or shapedcharge options

Launch methods	Various (historic)	Ground/air launcher options	Ground/ air launcher options	Ground rail/ catapult; shown deployable from littoral ships
Key strengths	Pioneering SEAD template; robust delta design	Cheap, massdeployable; combatproven	Mature antiradar autonomy; combatproven	Long range & endurance, precise EO targeting, low unit cost for attritable mass use
Why similar	Aerodynamic convergence: delta wing = structural strength, internal fuel, simple manufacture, good terminaldive handling	same	same	Mission/ aerodynamics converge; LUCAS uses straight wings/twinfin for stability & endurance but same attritable loiteringmunition logic

Source: https://www.armyrecognition.com/#google_vignette

Another option or opportunity for operational purposes is to enable air forces to use aeroclubs, which primarily focus on recreational flying, pilot training, promoting aviation culture and aeromodelling. Their aircraft are typically light, unarmed, and not designed for military operations, but prepared with some adaptation can work as low, slow OWUAS for OCA actions. Nonetheless, integrating such civilian organisations into AD missions poses significant challenges: aeroclub aircraft lack the speed, armament, and advanced avionics necessary for intercepting potential airspace violations; pilots in aeroclubs are not trained for combat scenarios, which require rigorous and specialised preparation. To sum up, OWUAS could potentially enhance the OCA capabilities of the Baltic States Air Force.

The third line of effort is to sustain and enhance operational cooperation in the Baltic region. The Baltic States must focus on closer collaboration with NATO allies. This would involve greater coordination of AD capabilities development and planning, flexible use of airspace, and the potential for shared resources. Firstly, existing initiatives should be used to develop AD in the Region. ESSI initiative can be used to increase the number of MRAD systems and procurement of missiles [33]. To become more integrated and interoperable with NATO, Baltic States use the BSC5I synchronisation initiative. Secondly, prioritising investments and carefully selecting which aspects of DCA to implement is crucial. The Baltic States have limited IAMD resources. The key step, AD priorities are established using the JPDAL[15] methodology according to NATO and national needs. However, the Baltic States must determine which IAMD capabilities, specifically MRAD units, will be transferred to NATO command (ToA), resulting in a shift in operational priorities. Thirdly, the airspace in the Baltic States should be flexible for military purposes. The Baltic States are halfway through the development of MABC to optimise the allocation and utilisation of airspace over the Baltic States to accommodate both civil and military aviation needs. The Baltic States could collaborate on developing and implementing UTM systems due to their geographic proximity and shared economic and defence interests. A regional UTM framework would facilitate cross-border UAS operations and allow seamless integration of UAVs into the national airspace. This could be achieved by harmonising regulations, procedures, and infrastructure across the three countries within the MABC framework. By concentrating on a combination of these factors, the Baltic States can considerably bolster their air defences, thereby reducing their vulnerability to attack and rendering any potential aggression more costly and challenging for an adversary.

In conclusion, The Baltic States can boost their defence by enhancing IAMD through improved strategies and advanced technology like mobile launchers, UAVs, and sensors. The Ukraine conflict underscores the need for mobility and countering threats like missiles and UAVs. Cooperation with NATO and regional allies is essential for better interoperability and resource sharing.

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[15] Joint Prioritized Defended Assets List – evaluated regarding criticality, vulnerability, recuperability and threat (CVRT). Criticality is how important an asset is for accomplishing a mission. Vulnerability is how easily an asset can be damaged by an air or missile attack or can be surveilled. Recuperability is how quickly an asset can recover from damage. Threat – the probability of an asset being targeted for attack by enemy aircraft or missiles.

Conclusions

The analysis of IAMD challenges facing the Baltic States reveals a complex interplay of evolving threats, technological advancements, and resource constraints. The region bolstering its defensive capabilities through investments in modern systems like NASAMS and IRIS-T. The sheer volume and variety of modern air threats, including hypersonic missiles, CMs, and swarms of UAVs, pose a formidable challenge to traditional defence architectures. The limitations in radar coverage, particularly at low altitudes, exacerbate this challenge, highlighting the need for a more comprehensive and integrated approach.

The current reliance on a relatively static architecture demonstrates the need for a flexible, layered IAMD system that incorporates OCA operations. The integration of C-UAS capabilities and the adoption of advanced, networked command and control structures are crucial. Furthermore, the effectiveness of IAMD in the Baltic States is critically dependent on close collaboration with NATO allies to leverage shared resources. The Rotational Air Defence Model exemplifies this cooperative approach, yet persistent challenges remain in interoperability, resource allocation, and the integration of civil and military airspace management. The following recommendations are proposed to enhance IAMD capabilities in the Baltic States:

- Enhance the Layered AD architecture. Invest in a more robust and flexible layered AD architecture that incorporates all range AD systems (including TBMD). Prioritize mobile and containerized launchers to improve survivability and deployment flexibility. Incorporate passive defence measures, such as deception and camouflage, to complicate enemy targeting efforts.
- Prioritize C-UAS capabilities. Given the increasing threat from UAV swarms, C-UAS capabilities are substantially enhanced. Investing in soft-kill and hard-kill countermeasures, integrating them into the layered AD architecture, and implementing advanced network-centric C2 systems.

- Enhance detection and air raid warning capabilities. Improve detection capabilities to enhance timely detection of air threats investing in advanced radar systems with low-altitude coverage and the integration of diverse sensor modalities.
- Integrate OCA and DCA capabilities. Shift towards a multi-domain approach to AD that incorporates OCA operations to proactively negate enemy capabilities before they can be employed. This approach integrates OWUAS alongside traditional IAMD systems and others core roles of air power.
- Invest in modernization and interoperability. Invest in interoperable technologies to ensure data sharing among different branches and with NATO allies. Prioritize the development and implementation of network-centric command and control systems to enhance coordinated responses to evolving threats.
- Foster regional cooperation. Strengthen cooperation, within the Baltic States and with NATO allies through harmonization of airspace management procedures, development of a seamless regional UTM system is crucial for managing the increased number of UAVs.

Editor's notes:

1. Some of the information of this article, with the author's consent, was used in Col. (Ret.) Romas Žibas's presentation at the international conference DAIMEX Baltics 2026, which took place on May 12.

2. The illustrations in the article are very informative. Given that the journal's pages are smaller than A4 format, readers may have difficulty fully assessing all the information while reading the article. If necessary, please visit the journal's website *https://www.journals.lka.lt/journal/mz*, where you can enlarge the images.

Bibliography

1. Williams, I. Putin's Missile War. Russia's Strike Campaign in Ukraine. Rowman and Littlefield, Washington D.C., 2023.

2. Deni, J. R. The New NATO Force Model: Ready for Launch? *War Series,* NATO Defense College, May 2024, No. 4, pp. 1–7.

3. Voice, G. Get the Facts About Iran's Unprecedented Attack on Israel. *AJC,* 19 April 2024. Online: https://www.ajc.org/news/get-the-facts-about-irans-unprecedented-attack-on-israel [Accessed 24 November 2024].

4. N. S. O. (NSO), AJP-3.3. Allied Joint Doctrine For Air And Space Operations. *Allied Joint Publication,* April 2016.

5. Van Hooft, P., Boswinkel, L. Surviving the Deadly Skies: Integrated Air and Missile Defence 2021–2035, December, 2021, pp. 1–86.

6. Air and Missile Defense Vision 2028, 2019.

7. Van Wuytswinkel, A., Anderson, K. Hypersonic Threat: Challenges and Imperatives for NATO. *JAPCC*, September 2025. Online: https://www.japcc.org/articles/an-operators-view-on-the-hypersonic-threat/[Accessed March 2026].

8. Welsch, M. Ukraine Air War Monitor, Vol. XII. *Kyiv Dialogue and Konrad Adenauer Foundation,* 20 January 2026. Online: https://www.kyiv-dialogue.org/en/news/newsreader/ukraine-air-war-monitor-vol-xii.html [Accessed 2 March 2026].

9. Cranny-Evans, S., Kaushal, D. S. Iskander: An Improved Russian Missile Tests Ukraine's Air Defence. *RUSI,* 18 November 2025. Online: https://www.rusi.org/explore-our-research/publications/commentary/iskander-improved-russian-missile-tests-ukraines-air-defence [Accessed February 2026].

10. Jensen, B., Atalan, Y. Assessing Russian Firepower Strikes in Ukraine. *CSIS,* 23 October 2024. Online: https://www.csis.org/analysis/assessing-russian-firepower-strikes-ukraine [Accessed 12 November 2024].

11. Goldstein, L., Waechter, N. China Evaluates Russia's Use of Hypersonic 'Daggers' in the Ukraine War. *RAND,* 12 January 2024.

Online: https://www.rand.org/pubs/commentary/2024/01/china-evaluates-russias-use-of-hypersonic-daggers-in.html [Accessed 28 November 2024].

12. Ripley, T. Ukraine Conflict: Russia Arms Su-35S for SEAD Operations over Ukraine. *JANES,* 8 March 2022. Online: https://www.janes.com/osint-insights/defence-news/defence/ukraine-conflict-russia-arms-su-35s-for-sead-operations-over-ukraine [Accessed 19 December 2024].

13. Kasapoğlu, C. Ukraine Military Situation Report | Special Edition: Ukraine's Air Defense Triumph. *Hudson Institute,* 6 March 2024.

14. Bronk, J., Reynolds, N., Watling, J. The Russian Air War and Ukrainian Requirements for Air Defence. Royal United Services Institute for Defence and Security Studies, London, 2022.

15. N. I. M. Staff. JATEC Final Report Project #1: Air Defence Innovation (with a Specific Focus on Technological Solutions Out of the Battlefield) „Russian Glide Bombs“. NATO, 18 December 2025.

16. Borsari, F., Gordon, B. An Urgent Matter of Drones. 27 September 2023. Online: https://cepa.org/comprehensive-reports/an-urgent-matter-of-drones/ [Accessed 24 November 2024].

17. Luzin, P. Russian Military Drones: Past, Present, and Future of the UAV Industry. 30 November 2023. Online: https://sites.tufts.edu/fletcherrussia/russian-military-drones-past-present-and-future-of-the-uav-industry/ [Accessed 30 November 2024].

18. Ukraine Conflict Updates. *ISW,* 17 November 2024. Online: https://www.understandingwar.org/backgrounder/ukraine-conflict-updates [Accessed 30 November 2024].

19. Zysk, K. Struggling, Not Crumbling: Russian Defence AI in a Time of War. *RUSI,* 20 November 2023. Online: https://www.rusi.org/explore-our-research/publications/commentary/struggling-not-crumbling-russian-defence-ai-time-war [Accessed 30 November 2024].

20. Gosselin-Malo, E. Baltic Nations Bet Big on NATO's Regional Defense Designs. *Defense News,* 23 June 2023. Online:

https://www.defensenews.com/global/europe/2023/07/26/baltic-nations-bet-big-on-natos-regional-defense-designs/ [Accessed 12 December 2024].

21. N. S. O. (NSO), STANAG 2663. C-UAS Doctrine – ATP-117, Edition A, Approval for Ratification. NATO, 2023.

22. ANON. NATO Air Policing Mission. 1 August 2024. Online: https://www.nato.int/cps/en/natohq/topics_132685.htm#:~:text=NATO%20Air%20Policing%20is%20a,quickly%20to%20possible%20airspace%20violations. [Accessed 15 December 2024].

23. ANON. 72.lt. Civilinės saugos ir gelbėjimo departamentas prie VRM. Online: https://lt72.lt/civilines-saugos-signalai-kaip-elgtis-juos-isgirdus/ [Accessed 20 December 2024].

24. Harper, C., Lawrence, T., Sakkov, S. Air Defence of the Baltic States. *ICDS,* Narva, 1 June 2018. Online: https://icds.ee/en/air-defence-of-the-baltic-states/

25. Vilniuje ruošiantis NATO viršūnių susitikimui sąjungininkai dislokuoja oro gynybos sistemą „Patriot". *15min.lt,* 2023-06-29. Prieiga internetu: https://www.15min.lt/naujiena/aktualu/lietuva/vilniuje-ruosiantis-nato-virsuniu-susitikimui-sajungininkai-dislokuoja-oro-gynybos-sistema-patriot-56-2076894 [Accessed 12 December 2024].

26. Höller, L. Latvia, Estonia tap German Industry for Air Defense Radars, Weapons. *Defense News,* 5 July 2024. Online: https://www.defensenews.com/land/2024/07/05/latvia-estonia-tap-german-industry-for-air-defense-radars-weapons/ [Accessed 12 December 2024].

27. Latvijas Gaisa Satiksme. 2024. Online: https://www.lgs.lv/en/?utm_source=chatgpt.com [Accessed 12 December 2024].

28. Air Navigation Service. 2024. Online: https://www.ans.lt/en/services/air-navigation-services?utm_source=chatgpt.com [Accessed 12 December 2024].

29. Budginaite-Froehly, J. NATO Air Defense Systems to Secure Baltic Skies. *Cepa.org,* 30 May 2024. Online: https://cepa.org/article/nato-air-defense-systems-to-secure-baltic-skies/ [Accessed

12 December 2024].

30. Spanish Air Defence System Comes Online in Latvia. 18 April 2023. Online: https://ac.nato.int/archive/2023/spanish-air-defence-system-comes-online-in-latvia [Accessed 12 December 2024].

31. McCluskey, M. NATO Launches 'Eastern Sentry' Operation in Response to Russian Drone Incursions. *CNN,* 12 September 2025. Online: https://edition.cnn.com/2025/09/12/world/nato-operation-eastern-sentry-russia-poland-latam-intl [Accessed March 2026].

32. Significant Step Towards a Stronger Baltic Air Defence – Declaration on Consolidated Airspace for NATO Needs Signed. *KAM.lt,* 11 July 2023. Online: https://kam.lt/en/significant-step-towards-a-stronger-baltic-air-defence-declaration-on-consolidated-airspace-for-nato-needs-signed/

33. B. S. C. S. Board. Baltic Sea C5I Sync Board Goals & Objectives. Vilnius, 2023.

34. Liechtenstein, S. Latvia and Estonia Sign Deal to Buy German-Made Missile Defense System. 11 September 2023. Online: https://apnews.com/article/germany-estonia-latvia-missile-defense-irist-sky-shield-24d27ba2bd4b184ff9640aac302318f5 [Accessed 18 December 2024].

35. Karako, T., Rumbaugh, W. Distributed Defense New Operational Concepts for Integrated Air and Missile Defense. *Rowman and Littlefield,* London, 2018.

36. Borsari, F., Davis, G. B. An Urgent Matter of Drones. *CEPA,* 27 September 2023. Online: https://cepa.org/comprehensive-reports/an-urgent-matter-of-drones/ [Accessed 27 December 2024].

37. Freedberg, S. J. Northrop Grumman Adds AI to Army's Command System for Counter-Drone Defense. *Breaking Defense,* 24 October 2024. Online: https://breakingdefense.com/2024/10/northrop-grumman-adds-ai-to-armys-command-system-for-counter-drone-defense/ [Accessed 31 December 2024].

38. Turkish AKINCI Drone Achieves First Air-to-Air Kill Using EREN Loitering Munition Against Shahed-Type UAV.

Army Recognition, 12 January 2026. Online: https://www.army-recognition.com/news/aerospace-news/2026/turkish-akinci-drone-achieves-first-air-to-air-kill-using-eren-loitering-munition-against-shahed-type-uav?fbclid=IwY2xjawQXnqxleHRuA2FlbQIxMABicmlkETBGbE01ZUFaTk04Y3cyRUJtc3J0YwZhcHBfaWQQMjIyMDM5MTc [Accessed 05 March 2026].

39. Carberry, S. AFA News: Ukraine Driving Air Force Search for Low-Cost Systems. *National Defense,* 17 September 2024. Online: https://www.nationaldefensemagazine.org/articles/2024/9/17/ukraine-driving-air-force-search-for-low-cost-systems#:~:text=Ukraine‘s%20low%2Dcost%20solution%20has, put%20all%20over%20their%20country [Accessed 20 December 2024].

40. Federal Aviation Administration. Unmanned Aircraft System Traffic Management. 17 November 2024. Online: https://www.faa.gov/uas/advanced_operations/traffic_management [Accessed 31 December 2024].

41. U-SPACE. *Interoperable Europe,* 2021. Online: https://interoperable-europe.ec.europa.eu/collection/rolling-plan-ict-standardisation/u-space [Accessed 31 December 2024].

42. Schmidt, A. Future Options for Surface-Based Air and Missile Defence? *The Journal of the JAPCC,* March 2018. Online: https://www.japcc.org/articles/future-options-for-surface-based-air-and-missile-defence/ [Accessed 27 December 2024].

43. Karbler, D. L. Introduction: From Missile Defense to Missile Defeat. *Military Review,* 2024. Online: https://www.armyupress.army.mil/Portals/7/military-review/Archives/English/March-2024/Introduction/Karbler-Missle-Defense-to-Missle-Defeat-UA.pdf

44. Panella, C. How Air, Land, and Sea Drones Are Causing All Kinds of Mayhem in Ukraine. *Business Insider,* 1 January 2025. Online: https://www.businessinsider.com/how-drones-are-causing-mayhem-in-the-ukraine-war-2024-12 [Accessed 5 January 2025].

45. Ho, B. Air Defence Challenges in the New Decade. *Asian Military Review,* 2020. Online: https://www.asianmilitaryreview.

com/2020/05/air-defence-challenges-in-the-new-decade/

46. Piranya-5: Russian Solution For a Mass-Produced FPV Trainer Drone. *Defense Express,* 1 December 2024. Online: https://en.defence-ua.com/weapon_and_tech/piranya_5_russian_solution_for_a_mass_produced_fpv_trainer_drone-12511.html?fbclid=IwZXh0bgNhZW0CMTEAAR0FwcOwCi2HAOkv_SnSyrAnBmBoVC0HnMUiEBNH8jKUpd5MN_2conH7B0Q_aem_2Dja14Xj-9Yw8HggK1Nffw [Accessed 30 November 2024].

47. Gordon, C. Air Force Chief: Small Drones Are Both 'Threat and Opportunity'. 29 October 2024. Online: https://www.airandspaceforces.com/air-force-chief-small-drones-threat-opportunity/ [Accessed 29 December 2024].

48. Karako, T., Dahlgren, M. Complex Air Defence. Countering The Hypersonic Missile Threat. Rowman and Littlefield, Lanham, Boulder, New York, London, 2022.

49. Palesteni, C. A Comprehensive Approach to Countering Unmanned Aircraft Systems. Ed.: Matthew Willis, Andre Haider, Daniel C. Teletin, Daniel Wagner. JAPCC, Kalkar, 2022.

50. NATO Bi-SC Capability Codes And Capability Sta-tements. *NATO,* 23 October 2023. Online: https://adl.baltdefcol.org/ilias.php?baseClass=ilLMPresentationGUI&ref_id=47592[&cmd=resume [Accessed 12 December 2024].

51. Speed, J., Stathopoulus, P. Challenges of Future SEAD Operations An Insight into SEAD in 20 Years. *The Journal of the JAPCC,* December 2018. Online: https://www.japcc.org/articles/challenges-of-future-sead-operations/

52. Evans, R. C. National Air Defense: Challenges, Solution Profiles, and Technology Needs. *Mitre.org,* 2024, pp. 3–8. Online: https://www.mitre.org/sites/default/files/pdf/04_1108.pdf [Accessed 24 November 2024].

53. Almodovar, G., Allmacher, P. D., Ames III, P. M., Davies, C. Joint Integrated Air and Missile Defense: Simplifying an Increasingly Complex Problem. *Joint Force Quarterly,* Vol. 88, 10 January 2018, pp. 78–84. Online: https://ndupress.ndu.edu/Media/News/News-Article-View/Article/1412812/joint-integrated-air-

and-missile-defense-simplifying-an-increasingly-complex-pr/

54. Rozman, J. Integrated Air and Missile Defense in Multi-Domain Operations. *Spotlight,* May 2020, pp. 1–12.

55. Stafford, J. C. Multidomain Ready: How Integrated Air and Missile Defense Is Leading the Way. *Joint Force Quarterly 100,* 17 February 2021.

56. Miller, A., Giare, V. Air and Missile Defense: Defining the Future. 2021, Vol. 35.