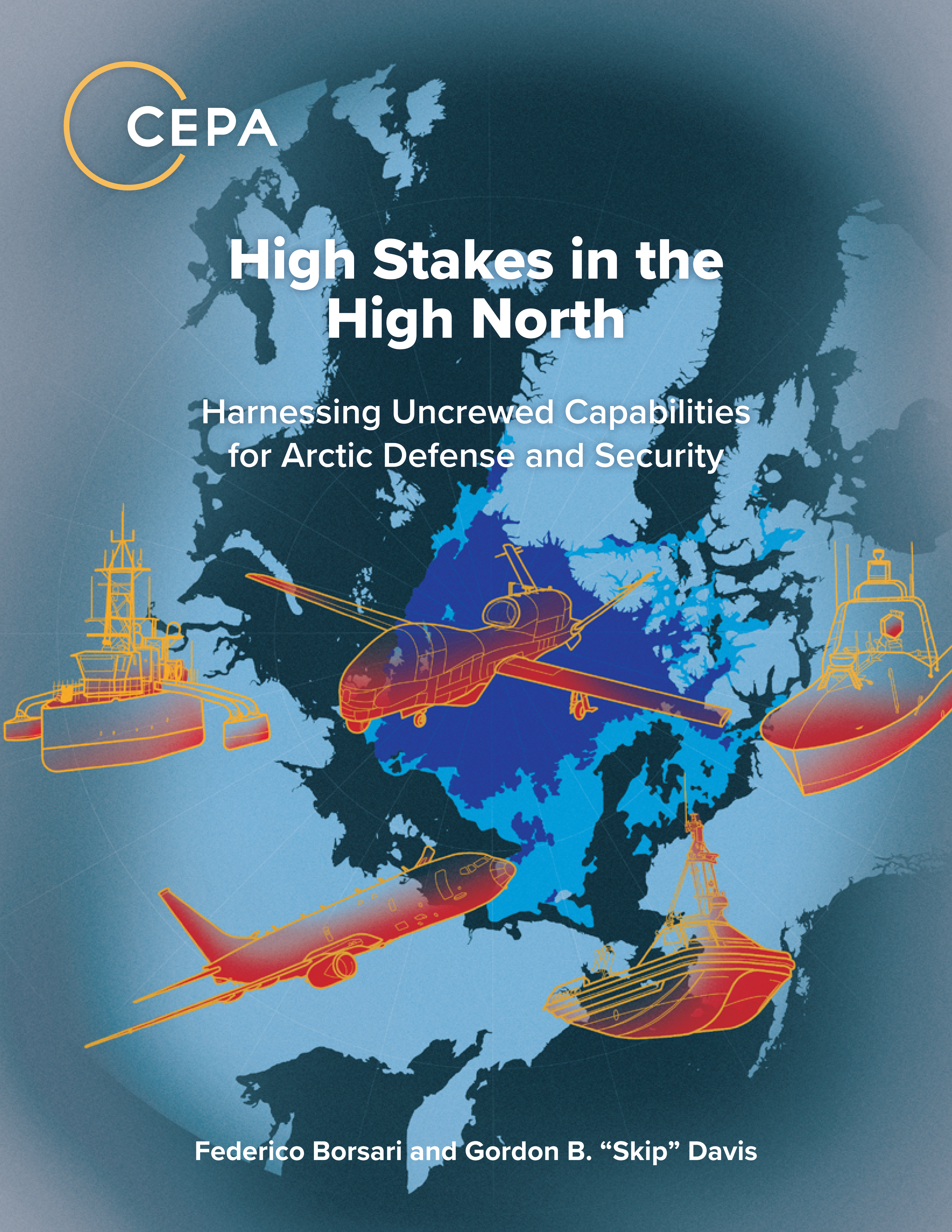

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High Stakes in the High North

Harnessing Uncrewed Capabilities for Arctic Defense and Security

Federico Borsari and Gordon B. "Skip" Davis

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Contents

Executive Summary

As climate change, militarization, and new technologies reshape the Arctic, the region is becoming a central arena of great power competition. Russia's expanding military presence and China's dual-use investments heighten strategic pressure on NATO's northern flank. Uncrewed and autonomous vehicles (UxVs or UxS; referred to throughout this paper as "drones") offer cost-effective ways to enhance domain awareness, deterrence, and resilience, across intelligence, targeting, logistics, and crisis-response missions. Yet harsh operational conditions, infrastructure gaps, adequate investment, and procurement obstacles hinder their integration and exploitation. Procurement of Arctic-capable drones across NATO remains fragmented, slow, and risk-averse, as most allies prioritize systems designed for temperate climates and only later adapt them for Arctic use, thus resulting in few NATO-certified Arctic-ready platforms.

To preserve a competitive edge and reinforce deterrence, NATO and its Arctic allies must integrate winterized uncrewed capabilities across the three physical domains. For such an effort to succeed, however, they must also reform procurement processes, accelerate joint acquisition, update doctrine and training models, improve intelligence and information sharing, expand support infrastructure, and ensure interoperability, among other priorities. Overall, uncrewed vehicles should complement rather than replace traditional assets, expanding situational awareness, enabling "deterrence by detection," and providing more targeting options across the High North. Ultimately, NATO's ability to embed these systems into planning, training, and innovation frameworks will determine whether the alliance can turn technological potential into credible deterrence and defense in one of the world's most demanding environments.

Introduction

"A secure Europe, a secure Atlantic, and a secure Arctic are priorities for NATO and essential for America's long-term security."[1]

Mark Rutte, *NATO Secretary General*

The Arctic is emerging as a decisive arena in the evolving global security landscape. Long perceived as a remote and stable region, this vast territory is now marked by accelerating geopolitical competition, climate-driven transformations, and technological disruption.[2] Melting ice and shifting sea routes are opening new corridors for trade, energy exploration, and military access. For NATO and its allies, this transformation raises pressing strategic and operational questions: How can the alliance secure its northern flank, protect critical infrastructure, and ensure freedom of navigation in an environment where adversaries are increasingly active and the climate imposes unique constraints?

Against this backdrop, uncrewed systems or drones stand out as both a challenge and an opportunity. They have proven their value in recent conflicts, offering cost-effective ways to extend reach, enhance situational awareness, and conduct multiple mission sets. Yet their deployment in the Arctic and High North raises unique challenges: extreme cold temperatures and weather conditions that test endurance and maneuverability, vast distances that strain communications and sustainment, and growing geopolitical competition that complicates deployment.

Both Russia and China are investing in their own uncrewed capabilities and defensive countermeasures and are strengthening and expanding their presence in the Arctic, exploiting surveillance and security gaps. As such, those allies face mounting pressure to adapt — making it urgent to translate the rapidly advancing integration of uncrewed systems from experimentation into operational practice. Drones offer both a vital tool for deterrence and defense, and a test case for how innovation can be translated into practical capability at scale.

This report seeks to contribute to the policy and expert debate on Arctic security and operations by analyzing the role that uncrewed systems can play in enhancing allied defense and deterrence in the region. Its purpose is threefold:

1. Strategic framing — to contextualize NATO's High North as a strategic region in great-power competition.
2. Operational analysis — to explore how uncrewed systems can support intelligence, logistics, combat, and crisis-response missions in a uniquely austere environment.
3. Policy and operational recommendations — to identify priorities for NATO, the US, and allies in bridging capability gaps and strengthening deterrence.

Photo: Soldiers in the 3rd Battalion, Royal 22e Régiment Canadian Army participate in military exercise Joint Pacific Multinational Readiness Center 22-02 held at the Fort Greenly, Alaska training area on March 11, 2022. Credit: Master Sailor Dan Bard/ via DVIDS.

By combining strategic assessment with operational analysis and concrete recommendations, the report aims to bridge the literature gap on the future of military operations in the High North and provide actionable insights for allied planners and policymakers tasked with shaping defense and deterrence posture in the region. For the purposes of this analysis, the terms "High North" and "Northern Flank" are used interchangeably to denote the portion of the strategic Arctic area encompassing the North Atlantic and regions within and close to but south of the Arctic Circle, including the territories of Canada, the United States, Iceland, Denmark (via Greenland), Norway, Sweden, and Finland, consistent with NATO's use of the term High North. The "Arctic" and "Arctic region" are used to reflect all land and ocean in the polar region, including territories of Russia.

Research Question and Thesis

The central research question guiding this report is: How can NATO and its Arctic allies leverage uncrewed systems to strengthen deterrence and defense in the High North, while addressing the region's unique environmental, operational, and strategic challenges? The report's hypothesis is that while drones are neither a panacea nor a full-fledged replacement for traditional capabilities, they represent indispensable assets and force multipliers for both NATO collectively and allies individually in the High North, provided that integration and sustainment challenges, capability gaps, and innovation bottlenecks are addressed with urgency.

Methodology

The report draws on a qualitative methodological approach combining open-source research, open-source satellite imagery, expert and practitioner consultations, applied exercises, and data analysis. Sources include academic literature, policy papers, military doctrine, and defense industry insights. Crucially, the analysis also benefits from three complementary streams of fieldwork and stakeholder engagements:

- Semi-structured interviews with industry, military, policy makers, and practitioners.
- Strategic scenario exercise: a scenario-based simulation conducted with subject-matter experts to test how uncrewed systems might be employed in an Arctic crisis scenario, followed by an expert survey.
- Delegation trip (Denmark and Norway): a fact-finding mission engaging with military, government, and industry stakeholders.

Finally, by applying Braun and Clarke's six-phase analytical framework, we conducted thematic analysis to distill recurring patterns, overarching themes, and key insights from the survey dataset.[3] This method included data screening, initial coding, pattern identification, theme review and refinement, and the final synthesis of the thematic findings.

Key Findings

The Expanding Battlefield Role of Drones

- Uncrewed systems provide scalable, cost-effective ways to extend reach, boost lethality, and enhance domain awareness, giving planners better visibility on adversarial activities for faster decisions and creating more tactical dilemmas for adversaries, thus strengthening allied deterrence in the Arctic.
- Drones can contribute to every phase of the find, fix, track, target, engage, assess (F2T2EA) targeting cycle and create a multiplier effect for traditional capabilities in multidomain operations.
- Uncrewed systems can generate budget and operational cost savings across the board. However, the extent of their operational effectiveness is commensurate with the degree of integration across the Doctrine, Organization, Training, Materiel, Leadership and Education, Personnel, Facilities, and Interoperability (DOTMLPFI) spectrum to absorb and sustain growing robotization. For Arctic allies, the goal is to use drones to increase their military capacity and capabilities while minimizing the logistic burden and balancing the size, weight, power, and cost (SWaP-C) of new vehicles.
- Procurement of Arctic-capable drones across NATO remains fragmented, slow, and risk-averse. Most allies treat Arctic-specific requirements as secondary modifications rather than purpose-built characteristics, resulting in limited NATO-certified Arctic-ready drones.

General Risks and Challenges Associated with UxS

- The hype surrounding drones risks generating hasty investments and operational blind spots due to overreliance on attritable vehicles that are rapidly outmatched by countermeasures and adversarial adaptation. Hence, allies must preserve traditional lethality and regard uncrewed systems as complementary assets to augment and enhance traditional capabilities in a high-low capability mix, rather than as full replacements.
- While decentralized grassroots innovation brings agility and competition (as seen in Ukraine), it also creates duplication and more volatile business models. As a result, the more heterogeneous the mix of uncrewed systems in use, the harder it is to achieve interoperability, economies of scale, and sustained long-term technological iteration.
- The move-countermove cycle surrounding segments of uncrewed/autonomous systems technology appears more compressed compared with other weapon systems due to a combination of factors, including:

1. A software-centric and highly iterative nature.
2. The widespread use of fast-evolving and easily accessible commercial technologies.
3. The lower barriers to entry and experimentation. The asymmetric advantage associated with this technology is likely short (i.e., measurable in months), although this doesn't apply evenly to all uncrewed and autonomous systems.

Uncrewed Systems and Escalation Management in the Arctic

- Findings from the interviews and the strategic scenario exercise suggest a broad perception that uncrewed vehicles have a limited escalatory impact on current Arctic security dynamics.
- During interviews and the strategic scenario exercise, drones emerged as platforms of choice to increase domain awareness and early warning to provide rapid situation assessment in case of crisis.
- While limited, empirical evidence from major interstate drone shootdown incidents in the past two decades indicates that the use/loss of uncrewed systems did not lead to direct escalation.[4]
- However, the constant evolution of drone technology and its operational roles significantly complicate the development of frameworks to measure or even define escalation in the context of autonomous systems use where human decision making is compressed or absent.
- As such, there currently is no shared understanding among governments and military planners of the effects of uncrewed systems employment on crisis and conflict escalation, which may also be influenced by differences in culture or regime type.

The New Security Reality of the Arctic Region

The Arctic is undergoing a profound transformation. Regarded as a remote but stable frontier governed by respected international agreements after the Cold War, the region risks transforming into a central arena of global strategic competition driven by three major converging trends: climate change, the return of great-power rivalry, and rapid technological innovation. As a result, the Arctic is no longer an area of “low tension,” or a region “somewhat removed from international affairs.”[5] On the contrary, it is increasingly characterized by militarization, contested governance, and delicate security dynamics.

The second Russian invasion of Ukraine has accelerated this trend, deepening the confrontation between Russia and NATO to Cold War levels, as well as adding tensions between NATO and China. Beijing has expanded its presence under the banner of “near-Arctic” status, tying the region to its broader global ambitions. Russia’s full-scale assault has also demonstrated the importance of technological innovation and rapid adaptation, along with the need to leverage them effectively while avoiding duplication and barriers to mass production. Together, these shifts underscore the Arctic’s emergence as a strategic arena, where NATO’s ability to deter adversaries, safeguard infrastructure, project power, and adapt technologically is increasingly tested.

At the same time, harsh environmental and logistical realities continue to test allied forces and capabilities. Extreme cold, remoteness, and minimal infrastructure hinder readiness and power projection. While technology can offset some challenges, effective adaptation requires faster procurement, tailored infrastructure, doctrinal reform, and specialized training and personnel. Arctic troops can burn up to 3,000 calories daily and suffer cold injuries despite advanced gear — underscoring how the High North remains a test of human endurance as much as one of strategy and innovation.[6]

This section examines the new Arctic security reality through four dimensions:

1. the region’s strategic value and environmental transformations;
2. Russia’s expanding militarization;
3. China’s growing ambitions; and
4. NATO’s evolving defense posture and challenges.

Photo: A North American Aerospace Defense Command F-35 Lightning II fighter aircraft from the Wisconsin Air National Guard's 115th Fighter Wing lands at Pituffik Space Force Base, Greenland, Oct. 7, 2025. Credit: Capt. Ryan Walsh

The Strategic Importance of a Changing Environment

The Arctic's geography carries enduring strategic weight, offering the shortest air and maritime corridors between North America, Europe, and Asia. Melting ice is rapidly altering Arctic geography: The region is warming nearly four times faster than the global average, and summer sea ice has declined by about 40% since 1980, with ice-free summers possible within decades.[7] Thawing permafrost destabilizes runways and infrastructure, while erratic freeze-thaw cycles disrupt logistics, making the region simultaneously more accessible and less safe for sustained operations. Thinning ice opens areas previously inaccessible to uncrewed underwater vehicles (UUVs) and submarines, while melt-driven shifts in salinity and temperature alter sound propagation, increasing acoustic clutter and complicating passive sonar, requiring updated sonar modeling and tailored anti-submarine warfare approaches.[8] These challenges are compounded by the effects of the Arctic environment, including higher risks of equipment failure and degraded communications, among others.

Overall, while year-round viability through the Northern Sea Route (NSR) may not emerge until late in the century, Russia and China are already positioning themselves for long-term access and control.[9] For NATO and Arctic allies, this increases exposure of Arctic Ocean sea lanes, critical underwater infrastructure (CUI), and strategic chokepoints to surveillance, interference, and hybrid threats, thus giving Moscow and Beijing new threat vectors vis-à-vis the alliance.

Russia's Expanding Presence and Militarization

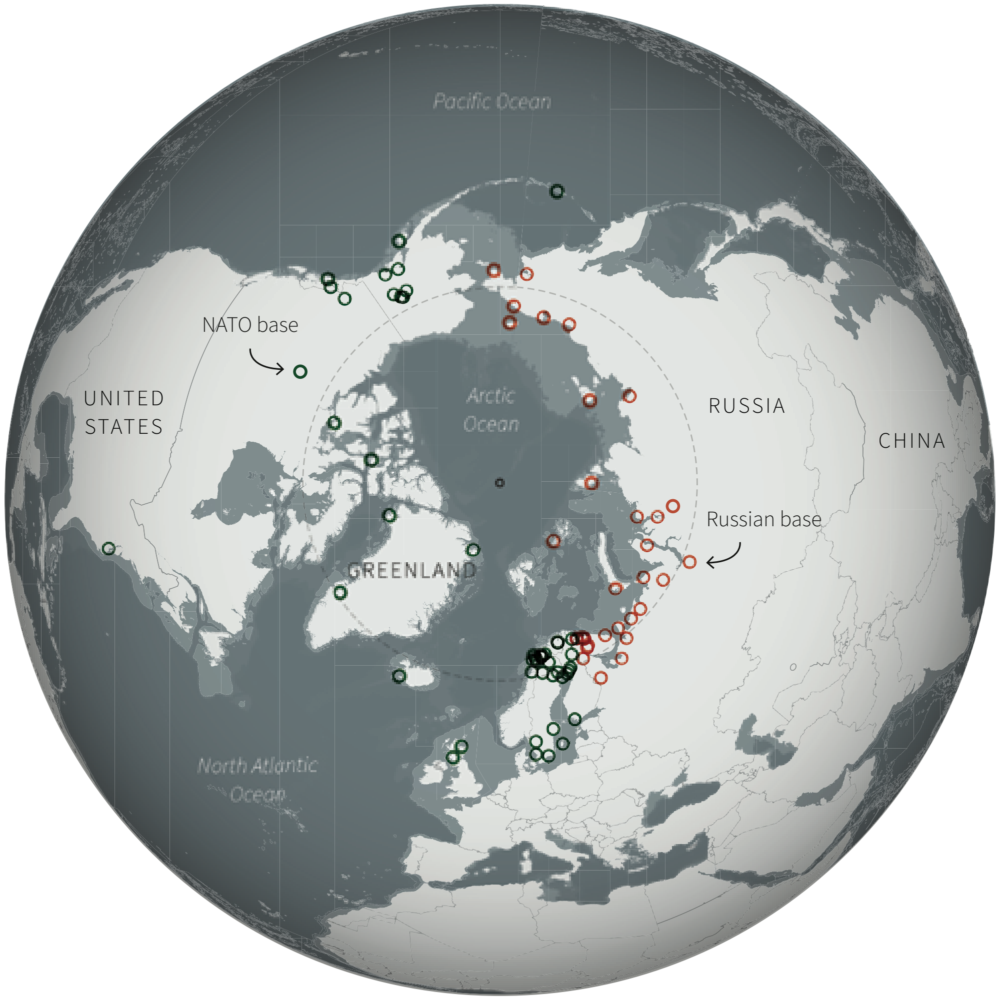
Russia, which holds more than 50% of the Arctic coastline, is the only Arctic Council country with nuclear weapons regularly operating in the polar region. The Northern Fleet stationed on the Kola Peninsula hosts much of Russia's nuclear second-strike capability.

Moscow's forthcoming revised Arctic Strategy and its 2022 Maritime Doctrine both highlight the Northern Sea Route, hydrocarbon exploitation, and expanded naval defense as core priorities.[10] The Maritime Doctrine states that Russia needs to "raise the combat potential and develop the bases of the Northern Fleet" and "enforce control over activities of foreign navies in the waters of the NSR."[11] Furthermore, the ambitious 25-year modernization program envisaged by the Kremlin's new long-term maritime strategy and the doubling of active land forces over the next decade are intended to counter NATO's enhanced posture following Finland and Sweden's accession.[12] Both plans stem from the entrenched Russian belief that the alliance is turning the Arctic into a 'conflict zone.'[13] Moscow is also pursuing de facto control over the NSR by treating it as internal waters rather than an international strait.[14] Domestic laws now require foreign ships to seek authorization for passage, reinforcing a more coercive legal posture backed by a growing fleet of nuclear icebreakers and Arctic-adapted patrol vessels.[15]

Russia is fielding advanced long-range surface-to-surface and air-to-surface missiles (e.g., Kh-101, 3M-14 Kalibr, Kh-47M2 Kinzhal) capable of striking European and Arctic targets from its own territory, airspace, and territorial waters. These capabilities are meant to complement the Bastion Defense concept by increasing deep strike options and introducing more threat vectors against NATO.[16] As a result, it is time for Western analysts and planners to reassess the geographic and operational functions of the Bastion concept.[17]

Since its full-scale invasion of Ukraine, Russia has intensified modernization of the Northern Fleet — the cornerstone of its Arctic defense and strategic deterrent — by adding assets such as the *Borei*-A K-555 Knyaz Pozharsky submarine, reactivating Soviet-era bases, expanding radar and air defense sites along the NSR, and conducting large-scale exercises, including under-ice operations.[18] Melting ice could strengthen Russia's maritime dominance and nuclear second-strike survivability by

NATO and Russian Military Bases in the Arctic



Sources: Natural Earth; International Institute for Strategic Studies; Telegeography; Reuters Reporting; Center for European Policy Analysis
Vijdan Mohammad Kawoosa; Michael Newton | Reuters; Center for European Policy Analysis Oct. 26, 2024

Map: Center for European Policy Analysis.

providing Russian SSBNs (e.g., *Borei*-class) more maneuver space and concealment options in the Barents and Kara Sea bastions.[19] Increasing under-ice operations will be supported by intensified anti-submarine warfare investment in submarine and surface vessels (frigates, corvettes) and the large-scale deployment of uncrewed systems, including various uncrewed underwater vehicles (UUVs).[20] Indeed, Moscow is heavily investing in uncrewed and robotic systems across all domains to offset capability gaps and reinforce conventional forces. Annual drone production now exceeds 1.5 million units, supported by China, Iran, and others, and Norwegian intelligence sources expect the number of Russian uncrewed systems to grow by an order of magnitude in the coming years.[21]

Drawing on extensive combat experience from Ukraine, Russia is now institutionalizing these technologies — allocating significant resources for drone technology and research and development (R&D), training thousands of drone operators for both near-term and future mobilization, and creating a dedicated branch for uncrewed systems and specialized units across its services, including new UAV naval regiments.[22] To this effect, the Russian Navy recently established a new drone control center in Kamchatka to oversee the deployment of *Forpost* and *Orion* UAVs, which will also conduct anti-submarine and maritime patrols along the NSR.[23]

Collectively, these trends suggest that Russia will likely possess more expertise, skilled personnel, and mature doctrine in robotic warfare than most NATO forces in a future confrontation. Moscow is also refining electronic warfare (EW) techniques, including wide-band GNSS disruption in the Baltic and Nordic regions as part of its hybrid strategy.[24] As a result, Russia's Arctic territory will remain both a strategic deterrence stronghold and a launchpad for asymmetric competition even as Moscow seeks to close its conventional gap with NATO.

China's Growing Arctic Ambitions

China is slowly but steadily increasing its presence in the Arctic region, guided by a multifaceted Arctic strategy that combines scientific investment, infrastructural reach, and strategic diplomacy. Beijing has established research stations in the Svalbard archipelago and satellite ground stations in Sweden and Iceland, and it operates the *Xuelong* "scientific research" icebreaker and its successor.[25] These civilian assets carry significant dual-use potential and add operational redundancy as well as a deniable, hybrid option to the country's agenda in the region.

Under the 14th Five-Year Plan, China has prioritized remote sensing, polar shipping technology, uncrewed systems, and communication networks to strengthen its situational awareness and support its penetration in the Arctic.[26] Economic ties further link Beijing to Arctic infrastructure. For example, Chinese state firms hold major stakes in Yamal LNG and Arctic LNG-2 projects in Russia and provide significant financing through Silk Road and energy funds, while Polar Silk Road initiatives link Chinese ports to Saint Petersburg via ice-capable vessels, combining commercial access with strategic presence.[27]

This dual-use footprint has established China as a self-styled "near-Arctic state," leveraging investment and scientific cooperation to legitimize its role.[28] Growing military cooperation with Russia, including joint bomber patrols, air defense drills, and anti-submarine warfare (ASW) exercises, extends this influence. Nonetheless, tensions persist over resource access and military supremacy in the Western Arctic — areas that Moscow very jealously safeguards.[29]

Photo: A US Air Force KC-135 Stratotanker engages in aerial refueling of a Navy P-8 Poseidon over Romania on October 23, 2025. Credit: Airman 1st Class Aidan Martínez/US Air Force via DVIDS.

NATO's Presence and Posture in the Region

The accession of Finland and Sweden into NATO has dramatically reshaped the Arctic security landscape. Their inclusion integrates the region fully into NATO's defense architecture, broadening the alliance's northern frontier. While these Nordic states bring unique operational knowledge, capabilities, and infrastructure for cold-weather operations they also increase NATO's proximity to Russian territory and introduce new vectors of exposure. This has inevitable implications for alliance defense planning and posture in the wider High North, especially as regional defense plans, new command and force structure, and new capability targets move toward implementation.

NATO has responded by scaling Arctic-focused exercises such as Cold Response and Steadfast Defender 2024, establishing a new Multi-Corps Land Component Command and a Forward Land Force contingent in Finland; a Nordic Air Force Division and a NATO Combined Air Operations Center in Bodø, Norway; and a Joint

Logistics Support Group HQ in Enköping, Sweden.[30] All of these add to pre-existent multinational defense cooperation initiatives such as the UK-led Joint Expeditionary Force and Nordic Defence Cooperation (NORDEFCO).[31] The deployment of an RQ-4D *Phoenix* high altitude long endurance (HALE) UAV to Finland's Pirkkala airbase for the first time in June 2025 underscores NATO's ability to project strategic ISR capability flexibly across alliance territory.[32]

But structural and conceptual gaps remain. To begin with, NATO doesn't have a formal Arctic strategy. While this is a sensitive policy matter, the lack of a dedicated strategic framework for the region risks diluting resourcing and cooperation between regional allies on various levels (doctrine, capabilities, training, etc.), leaving it to national or "minilateral" initiatives to compensate.[33] Second, despite the recent upgrades and expansion of Allied Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance (C4ISR) systems in the region, overall infrastructure across the High North remains thin. Likewise, North American Aerospace Defense Command's (NORAD) radar networks are aging, and their modernization program will take two decades to complete, leaving the Arctic approach to North America vulnerable to new threats at a time of unprecedented competition.[34]

Third, these shortfalls occur amid natural differences in threat perception, especially between North American and Nordic allies. Nordic officials often view China's Arctic role with less concern than Washington or Ottawa. For example, while Danish and Norwegian government officials did not categorize China's growing Arctic presence as a concerning threat in discussions with these authors, observers in Washington and Ottawa remain suspicious of Beijing, even amidst the recent diplomatic engagements.[35] At the same time, Nordic allies' approaches vis-à-vis Russia vary between Norway's cautious pragmatism that acknowledges the historical people-to-people connections across the border and Finland and Denmark's harder stance.[36] These divergences reflect NATO's broader struggle to harmonize national policies into an integrated Arctic policy.

Old and New Risks

Against this backdrop, hybrid threats in the Arctic are poised to increase. Undersea cables, energy pipelines, and satellite infrastructure are vulnerable to sabotage, cyber intrusion, and electronic warfare, as shown by recent cable damage in the Baltic Sea and GPS jamming across Scandinavia. Another vulnerability comes from the bilateral agreement between the Faroe Islands and Russia, which allows Russian fishing boats, with an obvious dual-use nature, access to the Islands' territorial waters and the ability to conduct discreet intelligence collection or even sabotage.[37] False flag operations used as a prelude to quick land grabs are another possibility NATO Arctic allies are preparing for.

This grey-zone contingency, which is widely perceived as one of the likeliest and most complex for the alliance to cope with, was tested during this project's scenario exercise and revealed that NATO's primary vulnerabilities lie in information fusion, decision speed, and alliance cohesion. In the expert survey, respondents stressed that Russia can exploit legal ambiguity and slow consensus-building to gain temporal and narrative advantage to produce a *fait accompli*. Persistent ISR and uncrewed systems were seen as essential for domain awareness, signaling, and transparency, yet they are insufficient without rapid intelligence sharing, unified political playbooks, and resilient Arctic logistics to uphold deterrence and allied sovereignty while avoiding escalation.

At the same time, climate-driven and other human security hazards call for a crisis-response role among Arctic allies, which also requires NATO's civil–military coordination and resources.

From a traditional defense and deterrence perspective, a more capable military footprint enables NATO to improve cross-domain situational awareness and strengthen allied deterrence in the High North. Nevertheless, any expansion in deployed capabilities and infrastructure in the region must be carefully weighed against the backdrop of mutual deterrence and escalation management mechanisms with Russia. Uncrewed and autonomous systems are no exception and exemplify this duality.

They enhance surveillance and targeting but — according to some scholars — may also lower the threshold for force use by reducing risks to friendly personnel, creating information overload, introducing autonomous unpredictability, or generating "use-them-or-lose-them" pressures on decision makers.[38] This has led analysts to warn of an emerging "Arctic drone race," echoing trends from Ukraine and raising concerns about a new security dilemma. [39] A contrasting view suggests uncrewed systems may reduce escalation by easing political pressure to retaliate after platform losses and by strengthening deterrence through improved visibility of adversarial activities.[40] While this study offers insights relevant to this debate, a deeper examination falls outside its current scope.

Leveraging Uncrewed Systems for Arctic Operations

In the High North's extreme environment, uncrewed systems allow NATO and Arctic allies to enhance domain awareness at lower operational costs, reduce risks to personnel, expand their operational reach, and free manpower and crewed platforms for other tasks. Drones' affordability and scalability compared with crewed systems make them particularly attractive to smaller allies who cannot afford fleets of patrol aircraft or major capital ships. Yet drones are not without challenges. Reliability in extreme cold and weather conditions diminishes, communications are constrained, and logistics and sustainment entail unique vulnerabilities and needs.

Drones and "Deterrence by Detection"

Deterrence in the Arctic greatly depends on situational awareness and signaling. Drones can contribute to this key objective through what scholars have defined as "deterrence by detection," the notion that persistent monitoring of adversary activity complicates their freedom of maneuver and raises the costs of covert or coercive actions. In practice, for NATO and allies, this means being able to track Russian submarine patrols leaving the Kola Peninsula, monitor aircraft flights across the Barents and Bering Seas, identify changes in Russia's Arctic force posture and infrastructure, and detect potential surface and subsurface threats to critical infrastructure. Overall, multi-domain situational awareness is by far the top priority for Arctic allies given the ISR gap and increased Russian and Chinese activity in the region.[41]

Uncrewed vehicles are uniquely suited for this as well as other missions. They can maintain near-persistent presence at lower cost and higher risk tolerance than crewed patrol aircraft or surface ships, complementing existing ISR assets. Furthermore, their cost-effective long-endurance ISR capabilities expose concealment and deception, supporting deterrence-by-denial while opening more avenues for burden-sharing: smaller NATO allies can contribute affordable capabilities — including through multinational acquisition schemes — that feed into the alliance's joint ISR architecture.

Mission Spectrum for Arctic Drone Employment

Joint Intelligence, Surveillance, and Reconnaissance and Targeting (ISR-T)

For this mission, aerial and maritime drones are the most mature categories of uncrewed systems. However, as we illustrate in this chapter, Arctic allies should leverage a broad array of drones, including uncrewed ground vehicles (UGVs).

Class III UAVs

High- and medium-altitude long-endurance (HALE/MALE) uncrewed aerial vehicles (UAVs) such as the MQ-4C Triton, and MQ-9B Sky/Sea Guardian can deliver near-persistent ISR over the Arctic, covering vast areas in a single sortie. Non-US systems like the *Akinci*, *Aarok*, and forthcoming *Eurodrone* offer similar roles, though with less operational maturity. The MQ-4C and MQ-9B are cold-weather capable, and exceed 24 hours of endurance, making them well-suited for monitoring choke points and sea lanes and for conducting deep-look intelligence. Their modular payloads, including maritime patrol radars, electro-optical/infrared (EO/IR), and signal intelligence (SIGINT), enable all-weather, day-night, multi-sensor operations.

These systems deliver higher cost-effectiveness compared with crewed aircraft for long-dwell ISR-targeting (ISR-T), airborne early warning (AEW), and communication relay missions. For instance, the MQ-9B *SeaGuardian* delivers roughly 80% of a crewed maritime patrol aircraft's (MPA) capability at only ~14% of the hourly cost ($5,000/hour versus ~$35,000/hour) while offering longer endurance (25 vs. 10 hours), 90% less fuel consumption, and reduced crew demands.[42] As a result, they also reduce the burden of crewed platforms for long-dwell ISR missions, helping preserve the latter's operational readiness and service life.

According to a 2020 study from the Center for Strategic and Budgetary Assessment, a mixed fleet of HALE and MALE UAVs could provide an extensive, nearly persistent ISR coverage and implement deterrence by detection in Europe at much lower financial and operational costs compared with traditional crewed aircraft for the same mission.[43]

Arctic allies such as Norway, Sweden, and Finland may be considering the adoption of HALE or MALE-class UAVs, which could significantly augment available standoff sensing capabilities and bridge major domain awareness gaps. Given the growing customer base across Europe, with Denmark being the latest purchaser, the MQ-9B stands out as one of the most palatable solutions, providing significant mission flexibility at more affordable acquisition and sustainment costs. The latter will partially be amortized by the contractual framework recently launched by the NATO

Table 1. Comparison between Unmanned Aerial platforms[44]

	P-8A Poseidon	MQ-9B	MQ-4C Triton	Euromale
Unit Cost ($M)	~201	~30	~238	~$50-60 (estimated)
Cost per Flight Hour (CPFH)	$42,300 (life cycle CPFH) $29,900 (average recurring CPFH)	~$5,000	~$31,904 (life cycle CPFH) $21,641 (average recurring CPFH)	NA
Aircraft Type	Maritime patrol aircraft	Medium altitude long endurance uncrewed aerial vehicle	High altitude long endurance uncrewed aerial vehicle	Medium altitude long endurance uncrewed aerial vehicle
Range	Up to 7,500km	Up to 9,200 km	Up to 13,700 km	Up to 10,000–12,000 km (estimated)
Endurance	Several hours (depending on mission type and air refueling support)	Up to 30 hours	24+ hours	Up to 40 hours
Role	• Ultra-wide area maritime surveillance • Anti-submarine warfare (ASW) • Anti-surface warfare (ASuW) • Airborne Command and Control • Search and rescue	• Wide-area maritime surveillance • Airborne communication relay • Electronic Warfare • Anti-surface warfare • Anti-submarine warfare • Kinetic strike • Humanitarian assistance/ disaster relief • Search and rescue • Law enforcement	• Ultra-wide area maritime surveillance • Standoff ISR • Long range AEW • Airborne communication relay • Search and rescue	• Wide-area maritime surveillance • Airborne communication relay • Electronic Warfare • Anti-surface warfare • Anti-submarine warfare • Kinetic strike • Humanitarian Assistance/ disaster relief • Search and rescue

Photo: US Marine Corps Lance Cpl. Andrew Hill fastens the propeller arms on a Tactical Resupply Vehicle 150 during a test flight in Setermoen, Norway on February 6, 2024. US Credit: Lance Cpl. Christian Salazar/US Marine Corps via DVIDS.

Support and Procurement Agency (NSPA), which aims to enhance interoperability, joint training, and economies of scale among MQ-9B users.[45]

However, the delivery of MQ-9B aircraft ordered by European countries is expected only in 2028, highlighting the timeline challenges associated with the procurement of this UAV class. Similar long delivery schedule issues affect other options like the MQ-4C *Triton* and the forthcoming *Eurodrone*. The latter will be certified for Arctic operations but will not be operational until 2030.[46] Importantly, both the MQ-9B and MQ-4C seamlessly integrate with NATO's fleet of five RQ-4Ds and could unlock national contributions in support of the NATO ISR Force (NISRF). The *Triton* is also being considered as a potential option to expand NISRF-owned assets in the future.[47]

Nevertheless, it is worth noting that all medium and large, non-stealth UAVs come with downsides. First, they have near-zero survivability in contested airspace,which is compounded by their low expendability due to a high unit cost.[48] This means that concepts of operation need to include risk mitigation tactics, techniques, and procedures (TTPs) to increase platform survivability, though any loss would obviously be more acceptable than that of a traditional aircraft and its crew. Second, HALE and MALE UAVs would still require a robust ground infrastructure and support element (paved runaways, de-icing and snow clearing operations, etc.), which limits their basing options and increases their exposure to threats.[49] This constraint is less acute for the MQ-9B thanks to the short takeoff and landing version currently under development, which will pave the way for both dispersed and carrier-based deployment in the near future.[50]

Class I UAVs

Small and medium-sized (NATO Class I) UAVs are paramount contributors to domain awareness at tactical and operational levels. In the land domain, these systems need to be deployed in large numbers and organically available across combat forces, providing constant ISR-T (and other support) to enable rapid targeting cycles via indirect fire assets.

Specifically, Class I UAVs in the “Mini” subgroup (<15kg) are responsible for supporting units in the close fight. They should be treated as expendable assets and have the following characteristics to effectively operate in the Arctic:[51]

- Polar-hardened rotary wing, or small fixed-wing designs under 5 kg.[52]
- Larger battery modules to enable extended use in cold temperatures (ideally 60 minutes endurance up to 30 km).
- Modular sensor payloads with EO/IR gyrostabilized optic for day and night conditions (Arctic winter) and target geolocation via laser rangefinder.
- GNSS-denied navigation capability.
- Interoperability with national/NATO tactical battle management systems (BMS) (e.g., TAK, FACNAV, SitaWare family).
- Onboard AI for automatic target identification and tracking.
- EW resilience through frequency agility provided by software-defined radio systems.
- Easy operation (hardware and software).
- A low unit price range: up to $10,000 (assuming bulk orders and mass production).

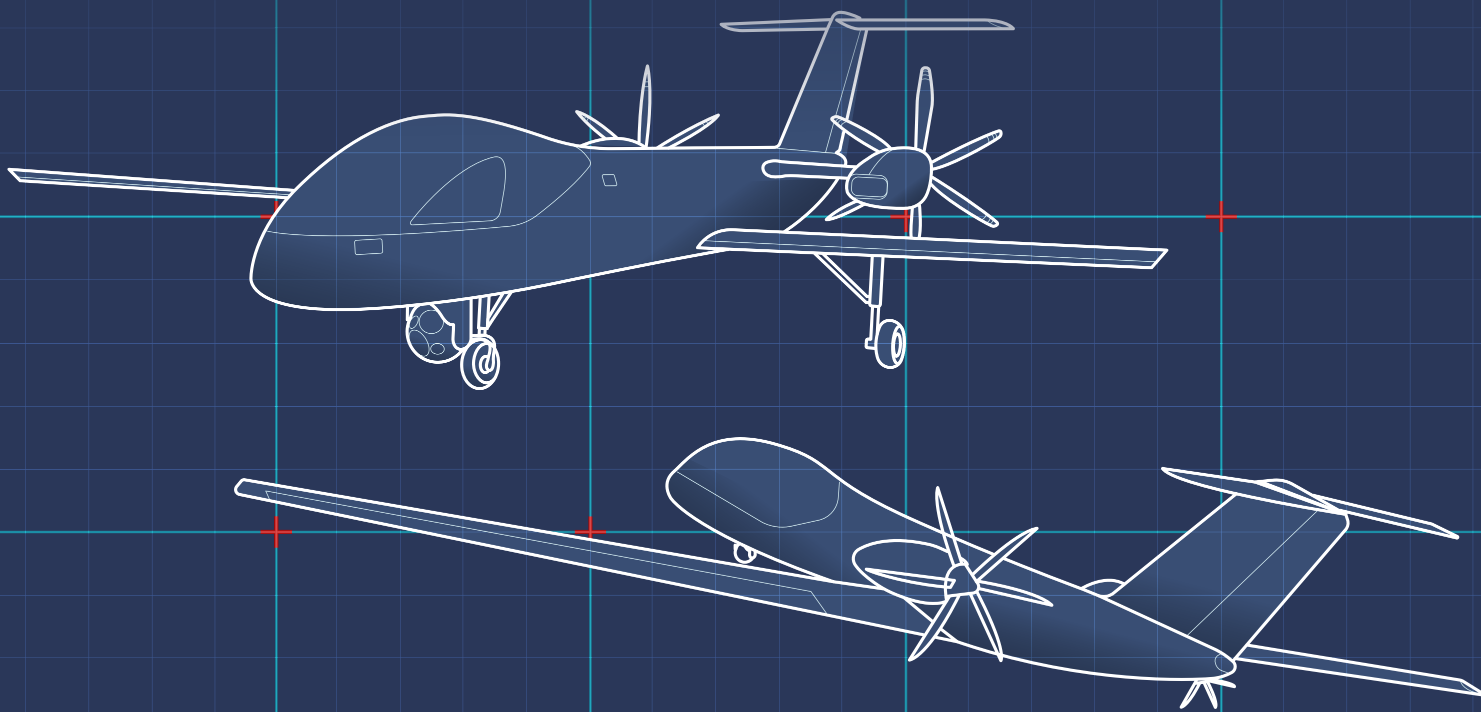
Norway recently inked a $9 million deal for Skydio X10D quadcopters to equip its small infantry units with tactical ISR drones.[53] This system is cold-weather certified and carries a powerful sensor package, meeting most of the above-mentioned requirements. However, at ~$28k per unit (likely lower if mass-procured) it remains too expensive for a class of UAVs expected to suffer high attrition in conflicts against peer adversaries.[54] That said, a higher cost per unit is not necessarily a

AIRBUS, DASSAULT AVIATION, LEONARDO S.P.A.

Euromale RPAS

Medium Altitude Long Endurance Uncrewed Aerial Vehicle

UNIT COST ($M)	COST PER FLIGHT HOUR (CPFH)	RANGE
~$50-60 (estimated)	**Pending Flight Data**	**Up to 10,000–12,000 km** (estimated)



Credit: Center for European Policy Analysis

disadvantage if it means greater reliability and effectiveness, thus resulting in more sorties/missions completed per dollar. It follows that the cost per mission, rather than the cost per drone, provides a more accurate metric to assess the operational value of UAS. Currently, Western manufacturers struggle to lower small drone prices due to a combination of factors, including patchy and insufficient demand signals from governments, limited economies of scale, labor costs, supply chain bottlenecks, and low competitiveness vis-à-vis Chinese producers, particularly DJI.

Class I UAVs in the "Small" subcategory (>15 kg and <150 kg) have become major ISR providers for battalion/brigade-level formations thanks to their growing range, endurance, and cost-effectiveness, partially replacing larger Class II UAVs (>150 kg).[55] Given the growing dilatation of battlefield zones prompted by the proliferation of various precision weapons and the movement of key enablers (EW, self-propelled guns, etc.) farther from the contact line, these UAVs must be able to reconnoiter the enemy's depth up to 100 km and identify high-priority targets for long-range fire support and should be operated by dedicated, self-sufficient UAV formations — preferably at battalion or company level to achieve higher effectiveness.[56] In the High North, this requires a winterized, fixed-wing Class I UAV with a modular design and optional vertical take-off and landing (VTOL) capabilities that offers a balanced trade-off between cost, range, payload, speed, and endurance. Said system should cost in the range of $100k to $150k and be able to:

- Operate at up to 100km in depth from the forward line of own troops (FLOT) for ~2 hours.
- Conduct both day and night missions.
- Operate in GNSS-denied environments.
- Conduct SIGINT, communication relay, and/or EW missions (via modular payloads).
- Provide accurate target designation, geolocation, and custody via moving target indicator.
- Share target information in real time with other assets (including allied) via encrypted datalink.

Nordic allies can also extend the range and coverage of small UAVs by leveraging a distributed mesh of remote charging stations where UAVs can automatically land, recharge, and wait for a follow-on mission.[57]

Uncrewed Ground Vehicles (UGVs)

Uncrewed ground vehicles have received less attention but can also conduct tactical ISR using multispectral sensors on collapsible masts and offroad capabilities to overcome terrain obstacles. When networked into a battle management system (BMS), UGVs enhance situational awareness for the tactical commander and nearby units, cue UAVs and fire elements, and support coordinated targeting across the force.

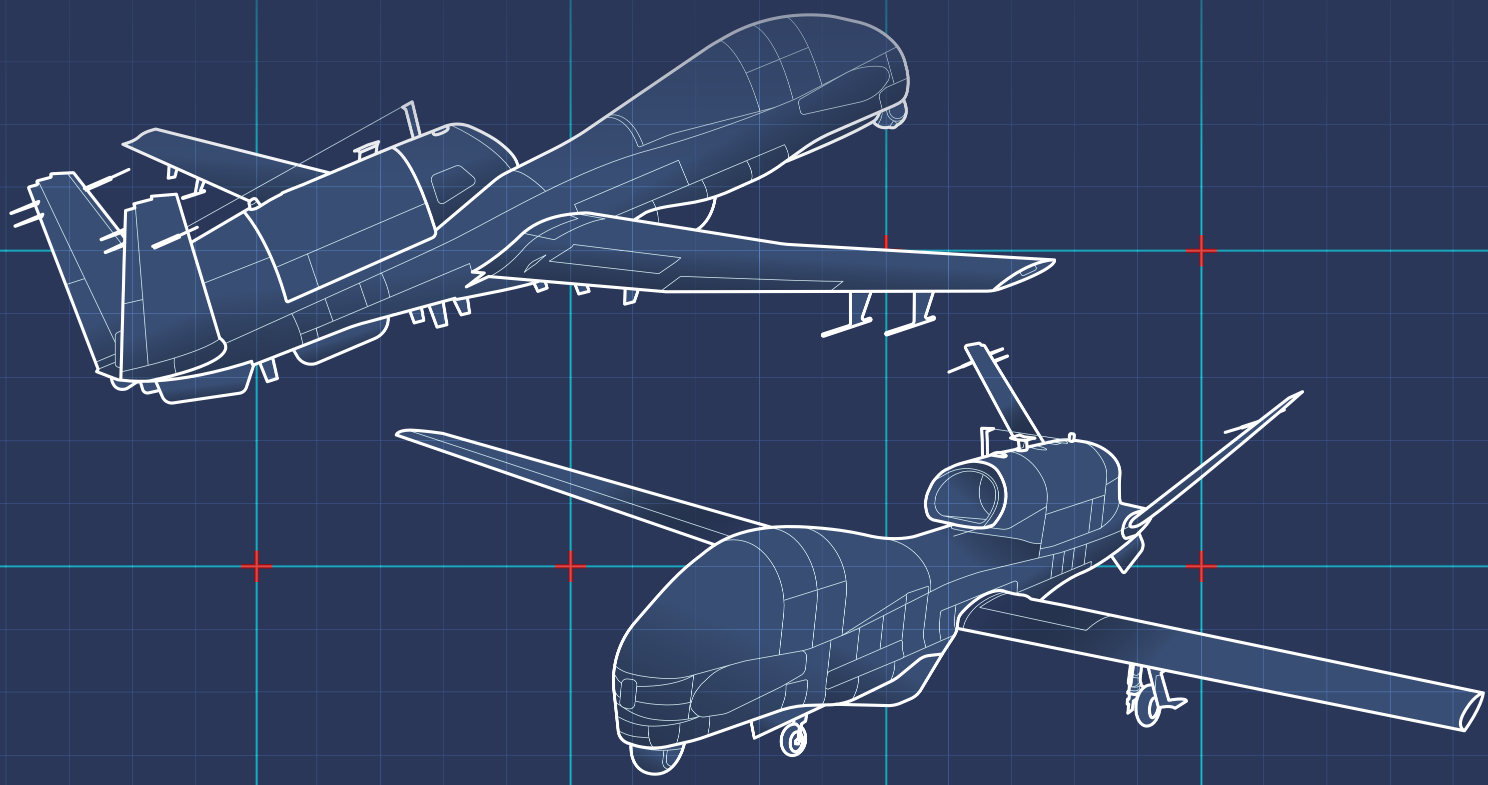
For example, in static or defensive operations, UGVs can be tasked to form a land-based sensing array or patrol pre-plotted routes to scan terrain that UAVs struggle to observe due to trees, vegetation, or man-made cover. When combined with UAVs, a UGV–UAV network provides a resilient sensing layer across the air-ground littoral, strengthening detection, tracking, and early warning for ground formations. Nevertheless, sensor latency or failure and limited mobility (especially in tracked configurations) still constrain their use in high-tempo situations and across complex terrain, although faster wheeled UGVs offer interesting options for Nordic allies to reinforce reconnaissance units with extended range and sensing capacity.[58]

NORTHROP GRUMMAN

MQ-4C Triton

High Altitude Long Endurance Uncrewed Aerial Vehicle

UNIT COST ($M)	COST PER FLIGHT HOUR (CPFH)		RANGE
~238	~$31,904 (life-cycle CPFH)	$21,641 (average recurring CPFH)	Up to 13,700km



Credit: Center for European Policy Analysis

At the same time, as with all robotic platforms and complex technologies, effective UGV employment requires strong human-machine teaming (HMT), sustainment capacity, and tailored doctrine to avoid adding cognitive or logistical burdens.[59]

Uncrewed Surface and Underwater Vessels

Uncrewed surface vehicles (USVs) and uncrewed underwater vehicles can create a resilient, scalable, and layered ISR posture uniquely suited to the Arctic. They can loiter for weeks or months as surface gateways for sensors (radars, EO/IR cameras, passive acoustic receivers, and sonobuoys), bathymetry, and communications relay.

Beneath the ice, different types of UUVs can map under-ice bathymetry, deploy towed and mounted passive and active sonar, and perform persistent acoustic classification at far lower costs than crewed ships. Fused with USV surface relays, UUV-collected contacts and sensing data can rapidly reach C4ISR nodes in near–real time, enabling cueing of aircraft, satellites, and surface assets.

Given the heavy-icebreaker capability gap across NATO, integrating drones aboard icebreaking or dual-use vessels is a cost-effective way to help mitigate this shortfall by turning a scarce surface asset into a force multiplier for sustained, contested operations across seasonally icebound sea lanes.[60] USVs and UAVs can extend sensor reach beyond the ship's horizon for persistent ISR, MCM, and Counter-UAV screening, while small UUVs can perform under-ice mapping and anti-submarine warfare tasks. This "mothership" approach also reduces risk to crewed assets, compresses logistic tails, and increases operational tempo in ice and marginal-ice zones.

A USV/UUV operational concept aligns with NATO's distributed "digital ocean" architecture, whereby mixed maritime drone fleets act as sensor webs and forward motherships.[61] Such a concept also mirrors the US 5th Fleet's Task Force 59 operational experimentation in the Middle East and is similar to NATO's Task Force X initiative in the Baltic Sea.[62] Maritime designs, robust autonomous navigation capability, adaptive power management, and resilient SATCOM/relay chains are essential to mitigate line-of-sight limitations.[63]

A maritime sensing mesh would widen Arctic allies' detection windows, shorten response times, and allow near-persistent monitoring of choke points, transit routes, and under-ice approaches — raising the cost and uncertainty of adversary operations in the High North.

Targeting and Fire Support

As widely acknowledged, uncrewed systems have revolutionized how militaries locate, identify, and engage targets through unprecedented levels of speed and integration in the sensor-to-shooter loop, commonly referred to as the kill chain. In contested Arctic settings, drones can close critical targeting gaps by 1) increasing sensor density and reach, 2) enhancing target detection and acquisition, 3) rapidly cueing long-range fires, and 4) engaging targets when directed from command nodes ashore or afloat.

Operationalizing targeting effects with drones requires three linked conditions: first, the integration of drones into a broader set of capabilities (cyber, space, EMS management, C2, etc.) to achieve a multidomain impact; second, digitized, secure, high-bandwidth, and low-latency processing, exploitation, and dissemination (PED) pipelines for rapid data ingestion, sharing, and exploitation by maneuver and fires

Photo: Canadian army prepare a defensive perimeter during Arctic Edge at the Donnelly Drop Zone in Fort Greely, Alaska on March 11, 2022. Credit: John Pennell/US Army/Alamy Live News.

units; and third, smooth fire integration so that naval, air, and ground fires can accept and execute sensor cueing with minimal friction.[64]

However, the Arctic's unique environmental challenges make local edge-processing and autonomous target classification essential to improving sensor-to-shooter networks. This is far from easy, as clouds, fog, and low visibility degrade the fidelity and performance of airborne sensors and cold-weather hardening imposes unique design tradeoffs, affecting endurance, range, and weapon options. Similarly, UUV and USV employment for undersea target acquisition and engagement demands under-ice navigation and secure communication — areas where mature solutions remain limited and constrained by low bandwidth, high latency, and range.[65]

Air

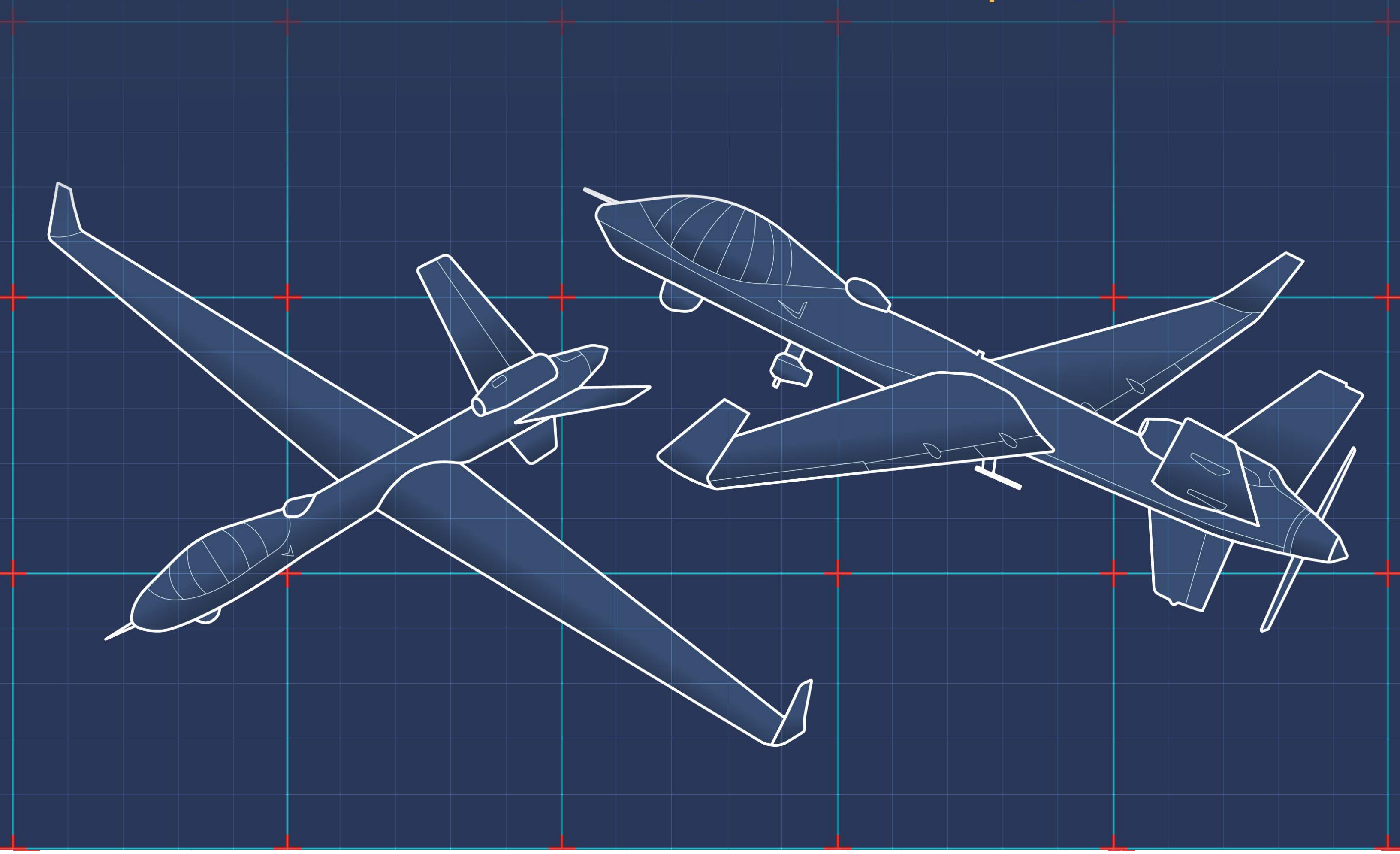
MALE UAVs like the MQ-9B represent large drones' evolution from ISR-only platforms into multi-mission assets that can shape the battlespace via airborne targeting and direct fire support. By leveraging long-endurance, advanced sensors, and modular payloads, they act as persistent ISR-T nodes detecting, classifying, tracking, and quickly cueing strike elements across air, land, and maritime domains.

GENERAL ATOMICS

MQ-9B SkyGuardian

Medium Altitude Long Endurance Uncrewed Aerial Vehicle

UNIT COST ($M)	COST PER FLIGHT HOUR (CPFH)	RANGE
~30	**~$5,000**	**Up to 9,200km**



Credit: Center for European Policy Analysis

Recent MQ-9B developments emphasize AEW and integrated sensing, offering scalable, affordable, persistent 360° detection of aircraft, missiles, and surface contacts that can complement or substitute more expensive crewed AEW platforms.[66] In the High North, this capability can fill airborne surveillance gaps over vast, sensor-poor approaches and remote littorals. MALEs can also support counter-air missions by:

1. Serving as long-dwell missile-warning nodes to cue fighters and surface-based air defense (SBAD) networks.
2. Carrying or guiding air-to-air effects for defensive counter-air tasks.[67]

The platform's endurance makes these concepts scalable for improved regional integrated air and missile defense (IAMD).

Two decades of weapon integration have also expanded the MQ-9's strike role. Hellfire missiles, guided bombs, loitering munitions, and potentially small cruise missiles enable standoff interdiction of a wide array of shore and maritime targets.[68] This flexibility would allow Arctic states to pursue sea control and denial without relying solely on fleet-scale manned sorties.

However, implementing bespoke applications in the Arctic faces major hurdles, including extreme weather, contested communications, adversary EW and countermeasures, and basing/logistics constraints, all of which degrade sortie generation and platform survivability. As such, planners must adopt mitigation strategies centered on flexible ISR-T procedures, distributed sustainment, hardened datalinks and communications, and agile doctrinal adaptation leveraging standoff capabilities.

Similarly, integrating highly autonomous Collaborative Combat Aircraft (CCA) into Arctic operations presents even greater challenges than in other environments, despite their significant potential. Because CCA requires a dedicated and more detailed analysis, it falls outside the scope of this study and are not examined further here.

Land

This section focuses on UAVs for close and deep strikes, with reference to UGVs as complementary enablers. Close combat and deep strike missions require distinct UAV requirements. The former necessitates portable, user-friendly, and modular solutions that can provide a scalable, cost-effective, and organic beyond line of sight (BLOS) precision strike capability to maneuver units down to the platoon level. The latter require larger, energy-efficient airframes for longer-range and heavier payloads with favorable costs compared to missiles.

Short-range Fires

At the tactical level, the purpose of small strike UAVs and loitering munitions is to slow, fix, and attrit hostile elements before they can engage friendly forces, inhibiting the adversary's ability to concentrate, maneuver, and react, while supporting and facilitating maneuver for Allied formations in cooperation with other effects. Priority targets for these systems include high-value maneuver-enabling assets such as protected mobility, engineering capabilities, UAV teams, short-range air defense (SHORAD), EW, and indirect fire systems, among others. They can also be used to establish near-persistent fire control over areas of interest, conduct counter-battery fire, and perform hunter-killer missions against hostile UAV teams and other high-value targets. As their employment in Ukraine and the current experimentation by European countries show, these systems should be available

Table 2. Recommended Tactical Strike UAV Design Characteristics and Roles[69]

Category	Ideal characteristics/specifications	Mission effect
Primary Mission Roles	Slow, fix, attrit enemy forces; C-ISR-T, counter-battery fire, counter-mobility, support friendly maneuver; strike time-sensitive targets.	Enables shaping of the battlefield at the tactical level, denies freedom of movement, and buys reaction time for friendly units.
Priority Targets	Protected mobility (armored vehicles), UAV teams, SHORAD, engineering assets, EW nodes, indirect-fire systems, tactical HQs, time-sensitive targets within range.	Hitting maneuver-enablers and C2 to degrade the enemy's ability to act and reconstitute.
Operational Environment	Arctic/all-weather operations (cold, wind, low visibility, GNSS denial).	Designs must survive extreme temps, strong winds, icing, and degraded sensors.
Range	Up to 100 km.	In-depth suppression and denial.
Logistics & Training	Minimal logistical footprint; low training requirement for operators/maintainers.	Enables mass employment, rapid resupply, and distributed operations with limited sustainment.
Hardening / Environmental Design	Cold-proof (weatherproofing, battery thermal management), strong wind tolerance.	Ensures reliability and endurance in Nordic/Arctic conditions.
C2 / Interoperability	User-friendly C2 user interface; full interoperability with national/allied tactical BMS (e.g., TAK, SitaWare, FACNAV).	Seamless tasking, shared situational awareness, and integration with maneuver formations.
Communications	Software-defined, frequency-agile datalink; optional support for mission uplink and remote abort/target update.	Rapid iteration to counter EMS threats and maintain control in contested EM environments.
Navigation	GNSS-denied navigation using INS and computer vision.	Robust navigation in GNSS denial and over uniform snow/poor-visibility conditions.
Sensors	Day/night EO/IR as baseline; thermal option recommended.	Enables target identification and engagement in all lighting conditions.
Warhead	3-5kg "Plug-and-play" modular warhead (HE-fragmentation, anti-tank, etc.).	Tailors lethality to target type while using a common airframe.
Terminal Guidance	Onboard terminal guidance for high accuracy (autonomous in predefined kill boxes).	Improves precision against point targets when required.
Swarms (Optional)	Coordinated autonomous swarm capability.	Force-multiplying effect and saturation to defeat defenses or overwhelm sensors.
Unit Cost Target	< $50,000 each; ideally < $30,000 at scale.	Keeps system mass-deployable and sustainable for continuous resupply and attrition warfare.
Airframe / Configuration	Cruciform wing or fixed/folded spring-loaded wing designs.	Proven configurations balancing payload, range, and launch flexibility.
Launch and Fielding Method	Vehicle-mounted modular palletized canisters/truck/track-launched; containerized pallet racks for dispersed rapid launch.	High mobility, rapid redeployment, survivable dispersed employment.
Concept of Operations (CONOPS)	Mass employment through dispersed rapid launch.	Enables sustained tactical effect.
Maintenance / Production	COTS components where possible; easy field maintenance; modular spare parts.	Reduces cost, simplifies sustainment, speeds production ramp-up.

to specialized formations (platoons, companies) for maximum effectiveness and fly fast to quickly prosecute mobile targets.[70] An often-underappreciated virtue lies in their suppressive role, which can open windows of opportunities for maneuver or increase the reaction time for friendly forces to organize adequate defense.

Cruciform wing (e.g., Russian Lancet-3, Auterion's MLM-20, Ukrainian RAM 2X) and fixed or folded spring-loaded wing (e.g., Switchblade-600, Warmate, RAM-II) setups provide the best tradeoff between speed, maneuverability, endurance, payload, and range.[71] Ideally, these should be fielded via vehicle-mounted (both wheeled and tracked) modular palletized canisters to ensure high mobility and flexibility in dispersed Arctic and sub-Arctic operations.

Based on the above discussion, we identify a set of key characteristics for tactical strike UAVs, as illustrated in the table below.[72]

The Challenges with Rotary-wing Systems in the Arctic

First-person View (FPV) Drones

Despite markedly lower price tags and extensive use in the war in Ukraine, small rotary-wing designs such as FPV systems currently offer shorter range and comparably smaller destructive power than fixed wing one way attack munitions. Given their limited warhead size (typically 1-3 kg), they often require multiple systems to ensure mission success against armored targets.[73] Ukrainian estimates place FPV drones' success rate (intended as the ability to reach, hit, and deliver effects on the target) at roughly 20–50% with significant variation between units.[74] Commercially derived FPVs and rotary wing UAVs lack robust EW resilience, have limited battery capacity, and are susceptible to cold, moisture, and icing due to their exposed engines, propellers, and sensors.[75] In a recent German winter exercise, for instance, the batteries of US military small quadcopters delivered only 25–50% of advertised flight time.[76] Short battery life also affects drone operators' controllers.[77] The use of silicone-based sprays on the propellers partially mitigates ice buildup problems but is not a foolproof solution.[78]

In addition, most FPV drone operations in Ukraine remain personnel-intensive, requiring various crews of pilots and paired operators — in a one-pilot-one-drone arrangement — to deploy multiple systems simultaneously, along with complex frequency allocation and deconfliction to avoid congestion.[79] Such a model is hardly scalable for Nordic allies. AI-enabled swarming can reduce manpower but adds extra cost, forcing quantity-versus-quality tradeoffs or budget adjustments.[80]

Therefore, rotary-wing designs appear suboptimal as the primary platform of a lethal short-range UAV suite for Arctic allies. However, emerging military-grade FPVs, including fiber-optic ones, can provide a complementary, on-demand precision strike option for platoon and company level formations.[81] Norway just moved in this direction by allocating almost $150 million for the purchase of small lethal FPV drones such as the domestically built "Wasp," which is now undergoing testing.[82]

Class I Rotary-wing Platforms

Larger Class I multi-rotor platforms, employed with notable success as "bombers" by Ukraine, face similar cold-weather limits unless combustion-powered. They can carry ~20 kg for 40–50 minutes and deliver heavier vertically-dropped munitions out to ~50 km, but have limitations:

1. They are relatively costly.
2. They increase logistical complexity (spares, payloads, maintenance).
3. They require specific training.
4. They typically use unguided munitions and struggle against moving targets.
5. They are easier to counter than faster fixed-wing strike UAVs.[83]

Consequently, for Arctic operations, they may be better suited to less demanding roles like logistics, signal relay, distance-mining, or mothership missions — inserting smaller lethal drones deep into enemy areas. Winterized designs and the integration of specific guided munitions will likely pave the way for kinetic roles of larger Class I rotary-wing platforms in Arctic warfare.[84]

The successful integration of the lethal UAVs illustrated above requires significant magazine depth, greater power generation, and organic intelligence, maintenance, and software support to exploit enemy vulnerabilities, ensure readiness, and stay ahead of adversary countermeasures.[85]

Deep Strike

For operational and strategic-level strikes (up to 1,000 km or more in depth), the primary capability requirements are cost-effectiveness, range, and scalability to complement or replace scarcer and more expensive cruise missiles (or short-range ballistic missiles). We will refer to this type of UAV/platform as an "affordable deep strike munition." In the High North, the target set of this munition would ideally include Russian fixed or stationary objectives such as airfields, troops staging areas, radar complexes, ammo/fuel depots, and — potentially — Bastion-P coastal batteries. Importantly, both Ukrainian and Russian experiences show that the added value of affordable deep strike munition capabilities lies not only in a more economic cost for deep strike campaigns relative to traditional effectors, but also in enhancing the latter's effectiveness through complementary and decoy roles in complex strike packages.[86] Hence, for Arctic allies (and NATO as a whole) there are valid reasons to take inspiration from Russian and Ukrainian one-way attack UAV capabilities for the development of allied variants.

Photo: A US Air Force F-16 Fighting Falcon taxis before taking off at Eielson Air Force Base, Alaska on November 18, 2025. The aircraft took flight as apart of Arctic Gold 26-1, a readiness exercise designed to test the 18th Fighter Interceptor Squadron's preparedness to deploy. Credit: Airman 1st Class Mary Murray/ US Air Force via DVIDS.

Designing the Affordable Deep Strike Munition

A cost-effective, mass-deployable deep-strike alternative for (primarily) stationary targets should aim for a unit price roughly an order of magnitude lower that of cruise/ballistic missiles (~$100,000–$170,000 versus ~$1–1.5M).[87] To meet that price point, high-end jet engines, expensive terminal seekers, and complex C2 datalinks should be excluded in favor of slower designs with fuel-propeller (e.g., Auterion's LR) or affordable mini-jets or fan-drive engines.[88] Propeller airframes will need anti-ice coatings/lubricants while electric propulsion is generally unsuitable in extreme cold as battery performance degrades sharply.

Effectiveness in denied environments requires a hardened navigation suite with multi-element GNSS and INS for baseline resilience, supplemented by a multi-mode AI-enabled visual navigation (optical, radar, celestial) to tackle Arctic conditions (uniform snow/ice, polar night, fog).[89] Such a navigation suite increases complexity and power demand. An open-architecture design would enable incremental upgrades and mission-specific payloads without wholesale redesign.

Warhead sizing should balance lethality and platform constraints. A 50–70 kg weight is a practical baseline for damaging large, fixed targets at range and compensating for moderate propeller speeds (150–180 km/h). However, slower speeds raise vulnerability to air defenses. Hence, the most cost-effective solution could be a more complex but still affordable mini-jet or fan-drive configuration that improves speed and survivability, while retaining affordability. An emerging class of small cruise missiles such as Anduril's Barracuda-500 (ground-launched, ~$200k estimated) or Rotron's Defendor, represent an affordable deep strike option that could be palatable for Arctic allies (and others).[90]

Mobility and dispersal should be at the core of mass deep strike CONOPS and rely on launch from improvised strips, truck containers, or palletized canisters to enable rapid, dispersed salvos and reduce signature exposure to hostile sensors.[91] As Ukrainian and Russian employment shows, effectiveness will also depend on careful mission planning to 1) exploit gaps in enemy SBAD and EW, 2) account for high attrition rates, 3) and integrate affordable deep strike munitions as decoys or massed effectors within larger strike packages.

Uncrewed Ground Vehicles

Uncrewed ground vehicles can deliver persistent, precise fires and fire support in Arctic operations, reducing personnel exposure to harsh conditions and enemy fire. Scout UGVs can augment reconnaissance units, while rugged tracked or hybrid-electric UGVs can carry remote weapon stations or mortars as distributed firing nodes — raising tempo, lethality, and survivability of friendly fires while complicating enemy maneuver and response.[92] They can also perform terrain-denial tasks (e.g., distance mining, extensively used in Ukraine), provide suppressive or support fires for maneuver units in a combined-arms team, and undertake engineering, distributed air-defense, or even long-range fire missions against land and maritime targets.[93]

However, systematic UGV employment for high-tempo maneuver scenarios in the High North requires more robust technical development, human-machine teaming constructs, and cold-weather operational testing.[94] Furthermore, effective integration of UGVs entails doctrinal innovation and a profound rethinking of force design to ensure that robotic platforms do not create additional burdens (physical and cognitive) but rather act as a combat multiplier.[95]

Maritime

Maritime drones are especially promising for the High North, given the region's geography and Russia's growing focus on modernizing its northern fleet. Beyond ISR, three key maritime missions stand out as particularly salient for drone use in the Arctic: anti-submarine warfare, anti-surface warfare, and mine-countermine warfare (MCM).

Table 3. Affordable deep strike munition suggested specifications

Characteristic	Specifications (baseline)
Range	Up to 1,500 km
Unit Cost	Up to $170,000
Payload / Warhead	50–70 kg (high-explosive fragmentation/dual-stage penetration/ incendiary)
Propulsion	Option A: fuel-prop piston propeller engine; option B: commercial mini-jet or fan-drive engine (requires specific design)
Cruise Speed	150–200 km/h (with propeller engine); 500-700 km/h (with mini jet/fan-drive engine)
Navigation and Guidance	GNSS (multi-element Controlled Reception Pattern Antenna - CRPA) + INS + AI-based visual navigation (radar/optical/celestial); optional automatic target recognition (ATR) for terminal accuracy
C3 / Datalink	Basic pre-set geographic coordinates for one-way missions / optional SATCOM or LTE modem for
Signature	Moderate; success rate depends on a combination of sheer mass and careful route planning to avoid enemy countermeasures and overwhelm point defense
Deployment Method	Vehicle container/palletized canister and/or improvised/dirty runways
Target Set	Primarily fixed/stationary high payoff targets/critical infrastructure (ammunition/fuel depots, airfields, C2 nodes, etc.)
Environmental Hardening	Cold-hardened airframe and systems (battery thermal management, anti-ice propeller treatment, low-temperature lubricants, cold-rated fuel systems)
Survivability	Limited survivability (propeller design), moderate survivability (jet/fan drive design); moderate-to-high attrition expected
Employment Concept	Multiple rapid launches from dispersed sites; battalion level or higher asset
Manufacturing and Logistics	Commercial off-the-shelf components where possible; simple maintenance through modular spare parts; secure supply chain

Anti-submarine Warfare

Anti-submarine warfare remains essential for sea control, protecting sea lines, and secure chokepoints like the Greenland–Iceland–UK, Bering Strait, and Bear Island–Svalbard gaps. Yet it is among the most complex missions. Modern submarines are quieter, and changing salinity and ice conditions complicate acoustics sensing, thus, anti-submarine warfare operations typically require an operationally and logistically intensive multidomain package of assets to succeed.[96] UAVs, USVs, and UUVs can mitigate some of the challenges associated with this mission set in the High North by

1. Conducting the most time-consuming and repetitive missions and freeing crewed assets and human resources for other tasks.
2. Reducing risks to crewed platforms and personnel.
3. Increasing sensor reach and density and dramatically enhancing domain awareness at a cost saving.

In the air, large UAVs offer unmatched persistence for wide-area search and rapid cueing of other assets (e.g., MPA, destroyers, frigates).[97] Platforms like the MQ-9B can deploy sonobuoys and employ AI-augmented SIGINT to upscale and improve the detection of submarine communications (such as targeting information shared from Russian modernized Kilo and Yasen-M class boats), enhancing situational awareness over time.[98] Class II maritime UAVs extend sensor reach, deploy expendable sonobuoys and magnetic detectors, and provide scalable coverage of chokepoints or littorals through affordable, low-risk operations.[99]

On the surface, USVs can deploy dipping sonar, sonobuoys, mines, or torpedoes, forming a forward sensing and strike layer around and ahead of capital ships.[100] At the same time, UUVs enhance anti-submarine warfare, anti-surface warfare, and mine-countermine warfare through three functions: distributed sensing, persistent surveillance, and effects delivery, which are briefly illustrated below:[101]

- Distributed sensing: UUVs with active and passive acoustic payloads detect submarines and perform long-duration listening missions.[102]
- Persistent surveillance: Endurance allows patrolling chokepoints, deploying seabed nodes, and forming AI-enabled tracking networks (demonstrated in DARPA's ACTUV and NATO's human-machine teaming anti-submarine warfare concepts).[103]
- Effects delivery: Larger UUVs (e.g., US Orca XLUUV) can conduct MCM, submarine hunting, littoral targeting, and even special operators insertion and support, increasing tactical options and enhancing fleet protection.[104]

Anti-surface Warfare

Similarly, drones expand anti-surface warfare options by distributing sensing, targeting, and strike capabilities across the maritime battlespace while lowering risk to traditional ships and crews, increasing operational reach and lethality, and supporting a faster targeting loop. Overall, drones' contribution to the destruction or damage of hostile surface combatants (as well as assets in other domains) is but one metric of their operational impact. Another is disruption, which forces the adversary to reallocate assets and resources away from its main effort. UAVs enable wide-area reconnaissance and cueing for naval and coastal fires. During the Rim of the Pacific Exercise 2024, for example, the MQ-9B employed its maritime radar to cue long-range anti-ship missiles.[105] As the MQ-9B and other MALE UAVs receive a growing array of standoff PGMs, they can also deliver fire effects against ships and littoral targets.[106]

USVs can act as loitering platforms, expendable shooters, and network relays. As adjunct magazines and sensor nodes, large (60-90 meters in length) and medium (<60 meters in length) USVs extend a naval task group's missile capacity and persistence — enabling the concept of "Every Ship a Surface Action Group."[107] In such a concept, crewed ships are sheltered from first-order risk while forward USVs provide fires and reconnaissance, including in melting-ice or partially ice-covered waters. Specialized USVs can perform one-way attacks against vessels, ports, and infrastructure, forcing adversaries to disperse or increase resources for defense.[108]

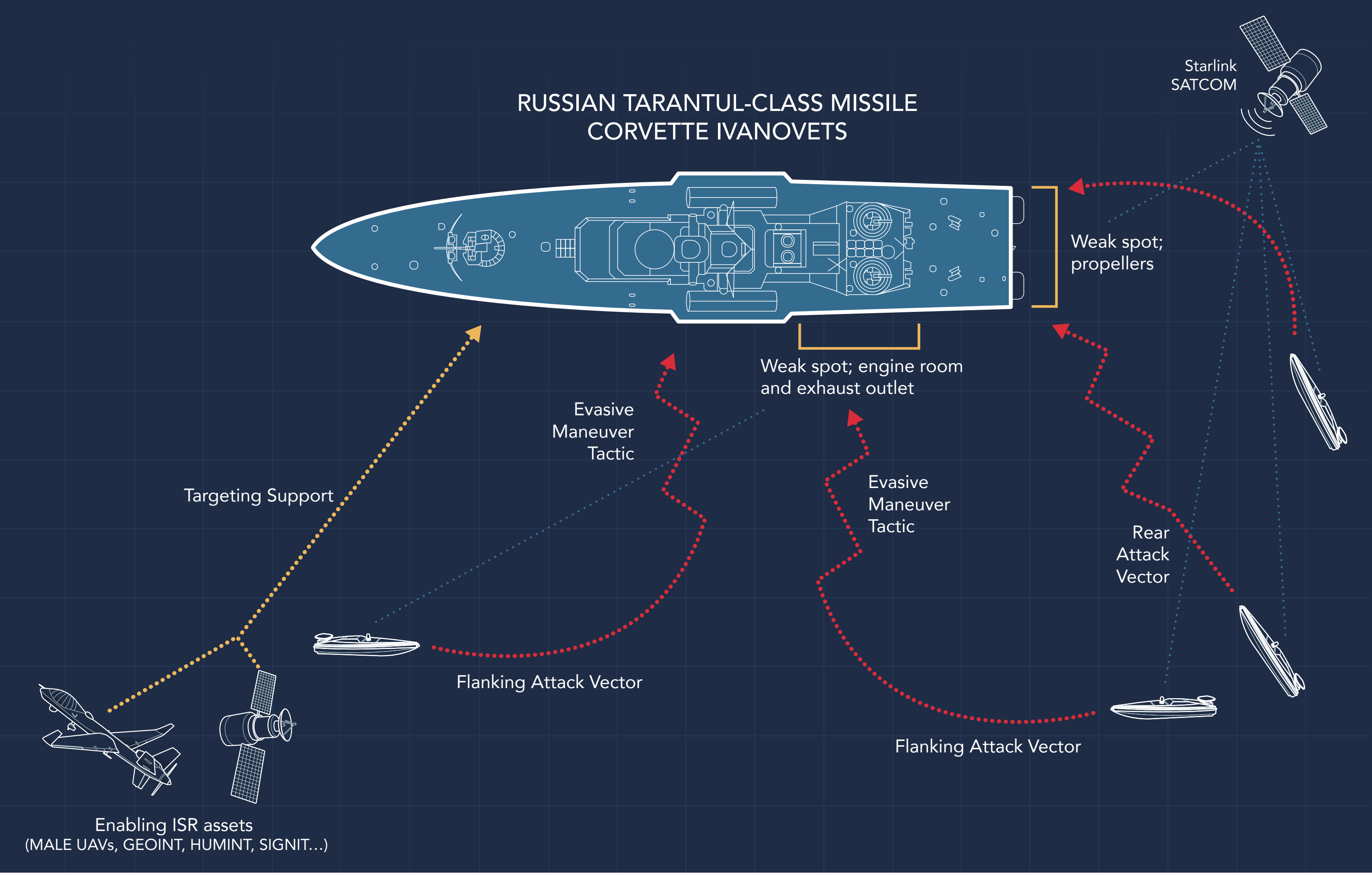
As successfully demonstrated by Ukraine, USVs' modularity and scalability would also allow planners to employ them as "motherships" and distribute area-denial capabilities such as surface-to-air missiles across a maritime component's area of responsibility, amplifying the reach of major surface combatants while reducing their exposure and presenting the adversary with multiple tactical dilemmas.[109]

UUV contributions include covert data collection, surveillance, targeting, tracking, and submerged strike options. Tactical UUVs excel at stealthy seabed mapping, approach-channel reconnaissance, and clandestine placement of sensors or mines, all of which shape where and when surface forces can maneuver. Extra-large UUVs also present soft- or hard-kill options from the sea.[110]

Mine-countermine Warfare

Uncrewed systems offer a decisive advantage for mine-countermine operations in the Arctic, where extreme conditions and limited infrastructure complicate traditional approaches. Both USVs and UUVs can carry mine-hunting payloads and tow side-scan sonars to detect and classify mine threats, including beneath the ice, while keeping crewed vessels outside high-risk areas.[111] In the Arctic, by

Case Study: How Sea Drones Attack a Russian Missile Corvette



Ukrainian "multipronged semicircular envelop" USV tactic against Russian Tarantul-class missile corvette Ivanovets, February 2024.[112] Credit: Center for European Policy Analysis

combining networked drones, Allied navies can build scalable mine-hunting networks that reduce single-point vulnerabilities and accelerate clearance timelines in chokepoints, straits, and harbor approaches to safeguard both commercial and military traffic.

In a future contingency, drone-based mine-countermine capabilities would allow NATO to survey and clear minefields more rapidly — even in contested or frozen conditions — mitigating Russian sea denial while preserving scarce manned assets. Meanwhile, USVs and UUVs can also perform mine-laying, providing cost-effective, covert tools for sea denial or protection of reinforcement routes, adding flexibility and deterrent depth. As several allied navies already operate mine-laying vessels for sea denial and defense of territorial waters, clear incentives exist for the creation of regional or multinational task groups with drones to expand MCM and other capabilities and facilitate burden sharing.[113]

Counter-ISR-T and C-UxS

NATO and Arctic allies should expect Russia to use uncrewed systems at scale as a force multiplier and to create operational dilemmas for the alliance. This obviously elevates C-UxS among the urgent priorities for both collective and individual capability development. Thanks to their scalability and operational flexibility, drones are uniquely placed to support and conduct this mission set, including by actively countering hostile intelligence, surveillance, reconnaissance, and targeting assets across multiple domains. Friendly drones can be used to create layered, low-cost sensor-to-shooter networks and scan the battlespace in search of enemy drones and other collection means such as antennas, cameras, and so on.

As seen in Ukraine, dedicated interceptor drones such as the *Sting* from the Wild Hornets company offer cost-effective kinetic defense options against UAVs for both fixed infrastructure and maneuver units. They can neutralize various enemy attack drones, including jet-powered one-way attack UAVs like the *Geran-3*, and engage fixed-wing ISR drones, offering a low-cost, mobile alternative to more expensive countermeasures.[114] For operations in the High North, similar systems could be bundled into palletized, platform-agnostic launchers to complement laser-guided rockets (e.g. APKWS) or traditional anti-aircraft artillery at company level. Ukrainian first-person-view (FPV) drones and loitering munitions directed by long-dwell ISR drones have also proven effective in hunting Russian UAV operators and small unmanned ground vehicles (UGVs), targeting launch positions and mobile systems with precision at tactical depth. Russia is now using the same tactic with increasing success.

In maritime applications, shipborne UAVs and USVs can conduct choke point patrolling, with the latter carrying palletized interceptor cells, EW nodes, and remote weapon systems to counter enemy drones, including USVs. Russian forces, for example, have adapted FPV drone tactics to attack Ukrainian uncrewed surface vessels and disrupt their operations before they reach critical targets in the Black Sea.[115] These operational developments highlight how UAVs can serve not only as reconnaissance or strike assets but also as flexible countermeasures capable of disrupt the enemy's use of uncrewed systems.

A new generation of uncrewed mobile directed systems, such as the Epirus–General Dynamics Land Systems' Leonidas, also promises cost-effective swarm defeat capabilities for base defense or maneuver applications, although specific operational testing is required to validate these systems for the Arctic.[116] In addition, drones can play a complementary role in IAMD by serving as passive sensor nodes to enhance target detection, tracking, and engagement.

Photo: Aviation Electronics Technician First Class Steven O'Connor performs a post flight inspection on an MQ-4C Triton at Naval Air Station in Sigonella, Italy on July 2, 2024. The unmanned system was in a supporting role of Naval Forces Europe and Africa. Credit: LT Alex Delgado/US Navy via DVIDS.

To rapidly operationalize these capabilities in the Arctic, NATO and Arctic allies need to address three main challenges:

- Energy and sustainment: Long-endurance maritime and mobile drones impose increased energy demand. Cold-rated batteries, thermal management, containerized microgrids, and prepositioned spares are essential to sustain high sortie rates under extreme weather conditions.
- Sensor fusion and low-cognitive C2: Defeating rapid, multi-vector threats demands fusion of EO/IR, acoustic, radar, and radio frequency (RF) sensors into interoperable, intuitive human-machine interfaces that present fused tracks and engagement recommendations with minimal operator burden.[117]
- Training and human-machine integration: Arctic counter-uncrewed systems operations demand specialized training pipelines that fuse technical, tactical, and environmental competencies. Operators must master multi-sensor data fusion, autonomous system management, and rapid coordination of diverse effectors under EW and extreme weather conditions.

Overall, success also hinges on EW-resilient datalinks, and on doctrinal updates to formalize cueing, airspace, and electromagnetic spectrum deconfliction, and engagement authority.

Logistic and Search and Rescue

Drones provide significant tools for both logistics and search and rescue operations in the challenging environment of the Arctic. Their integration can reduce risks to military and rescue personnel, lower operational costs, and extend the operational reach of allied forces and civilian entities as well.

On land, hybrid crewed–uncrewed units could employ tracked UGVs to move supplies across snow and ice, limiting troop exposure and freeing personnel for other tasks. Robotic snowmobiles and medium VTOL drones can deliver blood, medical gear, and resupply to dispersed units or remote bases, avoiding costly helicopter sorties in dangerous conditions.[118] For example, a logistics platoon of UGVs and heavy-lift UAVs could sustain frontline, isolated, or dispersed elements while also supporting casualty evacuation (CASEVAC).[119] Ukraine offers a clear proof of concept, where ground and aerial drones routinely resupply remote positions or conduct CASEVAC missions due to persistent kamikaze drone threats.[120] UGVs can also conduct engineering and clearing tasks, emergency repairs, and demining, providing a scalable, low-risk option in a region where area denial and mobility challenges will increase.

At sea, USVs, UUVs, and UASVs are ideal for replenishing NATO naval forces, supplying forces in contested environments while freeing manned platforms. In combat situations, specialized USVs can help locate survivors and ferry casualties to ships or areas ashore.[121]

For search and rescue, uncrewed systems offer unparalleled advantages, including scalable, rapidly deployable, and persistent monitoring of disaster zones along with emergency resupply. Long-endurance UAVs can cue responders, deliver medical aid, or locate survivors, while maritime USVs and UAVs monitor chokepoints and deploy life rafts. UUVs are already in extensive use for underwater critical infrastructure monitoring and repair.

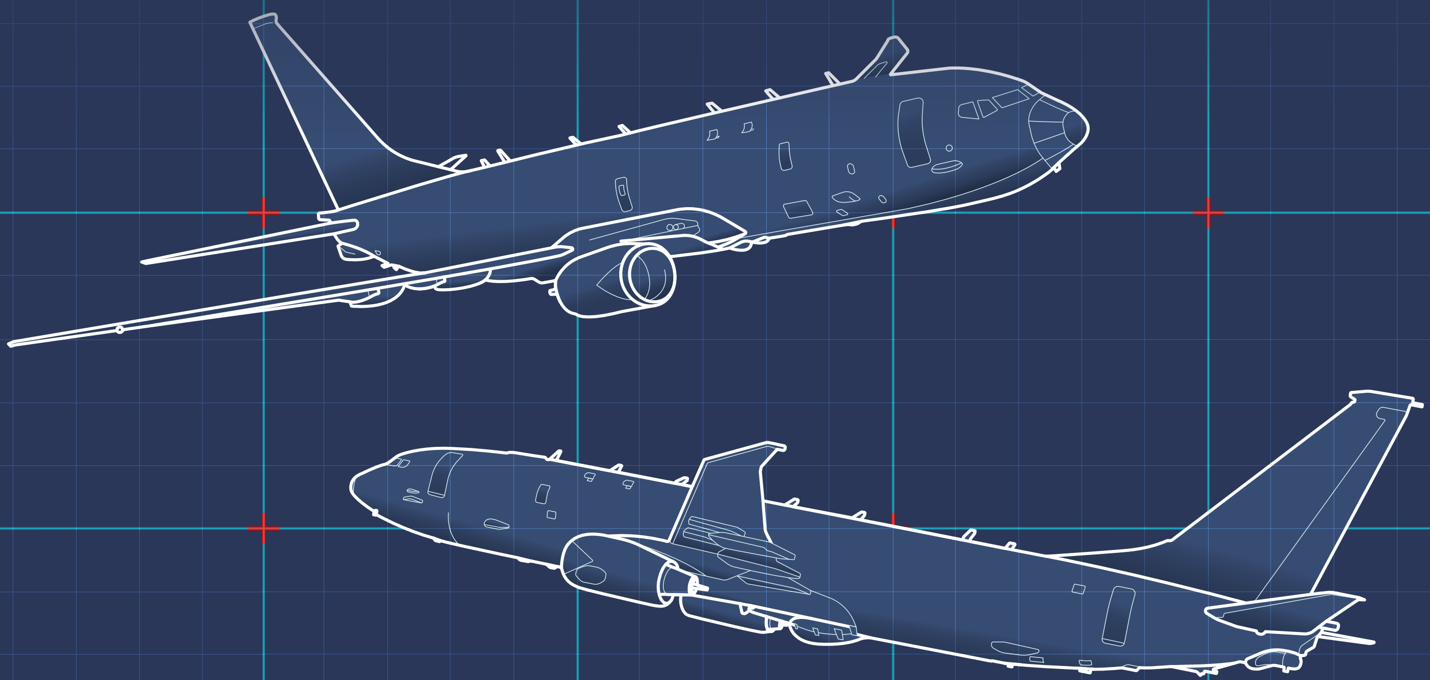
Taken together, these developments illustrate how uncrewed systems are reshaping the intelligence, maneuver, fires, mobility/counter-mobility, and logistics support dimensions of modern operations — transforming traditionally high-risk, manpower-intensive tasks into distributed, resilient, and adaptive processes. As these technologies mature, they will enhance NATO’s ability to enable, protect, and sustain forces across remote and contested environments like the Arctic and Northern Europe.

BOEING

P8-A Poseidon

Maritime Patrol Aircraft

UNIT COST ($M)	COST PER FLIGHT HOUR (CPFH)		RANGE
~201	**$42,300** (life-cycle CPFH)	**$29,900** (average recurring CPFH)	**Up to 7,500km**



Credit: Center for European Policy Analysis

NATO's Uncrewed Systems Integration: Challenges and Priorities

The Arctic's growing geopolitical relevance requires NATO to adapt its defense posture in the region. Uncrewed systems offer scalable and cost-effective means of enhancing domain awareness, resilience, deterrence, and defense. However, the region's extreme conditions, logistical constraints, and complex political dynamics complicate integration. This chapter outlines the principal challenges and priority actions for NATO with concern to drone capability, policy, and doctrine development, procurement, and innovation.

Technical and Operational Challenges

Environmental Challenges

Uncrewed systems offer NATO allies a unique opportunity to overcome human and operational constraints. By reducing the need for personnel, drones can expand the reach, duration, and persistence of operations in Arctic regions, including joint ISR, infrastructure monitoring, early warning, and communication relay missions in areas too dangerous or costly for crewed systems. They can also support resupply, evacuation, and layered defense missions — independently or in human-machine teaming constructs.

However, the environment still magnifies the technical vulnerabilities of uncrewed vehicles. Below –50°C, batteries lose endurance, ice buildup impairs propulsion and sensors, and UAVs face flight-envelope restrictions from icing, high winds, and scattered support infrastructure. UGVs must traverse deep snow and permafrost, while maritime drones contend with sea ice, GNSS and communication challenges, and saltwater corrosion. Most commercial USVs tolerate only sea states 4–5 (i.e., moderate to rough sea conditions, with waves about 1.25 to 4 meters high), which constrain their usage in the High North. UUVs rely on inertial and acoustic navigation under ice, which lose fidelity and reliability over distance.[122]

Priorities: Arctic conditions demand extensive cold-weather and maritime hardening (anti-icing and anti-corrosion systems, winterized electronics, advanced power systems, structural reinforcement) and multi-modal navigation for GNSS-degraded environments (e.g., inertial, visual, magnetic, and celestial solutions).

Estimated Flight Times to Key Locations from Tromsø

Map: Center for European Policy Analysis.

NATO Uncrewed Systems Capability Gaps

Multiple gaps exist between current NATO drone inventories and the specific demands of Arctic operations. Few vehicles are winterized or hardened for persistent use in the region's extreme conditions. The alliance lacks persistent under-ice UUVs for critical undersea infrastructure (CUI) protection, mine-countermine, or anti-submarine warfare, and possesses too few long-range HALE/MALE drones and an even more limited supply of low-cost attritable UAVs for Arctic tactical Joint ISR or sustained denial missions. The same shortfall applies to interoperable meshes of drones for monitoring high-latitude Sea Lines of Communications (SLOCs), the Greenland-Iceland-United Kingdom (GIUK) Gap and NSR chokepoints, and conducting the above-mentioned priority missions.

Exercises and operational experimentation such as REPMUS, Dynamic Messenger, and Task Force X in the Baltic amply demonstrate drones' potential for maritime operations, but Arctic-specific capability development remains underfunded.[123]

Priorities: Develop an Arctic drone capability strategy to synchronize requirements, cooperation, and joint procurement, following the example of NATO JISR and maritime capability development strategies.

Infrastructure and Logistics Constraints

Sparse infrastructure, port facilities, and airfields, and limited communications coverage restrict drone launch, recovery, maintenance, and sustainment. UUV retrieval under ice and UAV launch from austere bases or small decks, for example, are constrained by extreme cold or the need for specialized equipment.

Priorities: NATO allies should invest in containerized launch and recovery systems, mobile maintenance kits, and testing and support infrastructure in key Arctic or Arctic-bordering allies. For infrastructure, allies should explore forward basing agreements and/or NATO Security Investment Programme (NSIP) funding, along with leveraging dual-use Arctic facilities and cooperation with commercial actors (e.g., oil, gas, and shipping companies).[124]

Communications, Data, and Autonomy Gaps

The Arctic's remoteness and limited SATCOM availability — especially above 75°N — cause persistent communication gaps that hinder C2 and data sharing. Drones must therefore rely on edge computing and local autonomy to sustain operations and react to threats without constant operator input.

The JANUS underwater communications protocol (NATO STANAG 4748), developed in 2017 by NATO's Centre for Maritime Research and Experimentation (CMRE), provides NATO and civilian entities a common acoustic standard that enables interoperable military-civilian underwater communication for missions such as rescue, anti-submarine warfare, and mine-countermine operations.[125]

As for space, two NATO High Visibility Projects can reinforce drone connectivity. First, the Alliance Persistent Surveillance from Space (APSS) enhances persistent surveillance by integrating government and commercial space assets. Second, NORTHLINK seeks to expand High North communications via commercial SATCOM constellations.[126] Both can improve Joint ISR data flow and link drones for C2, targeting, and logistics.

NATO should

1. Develop Arctic-adapted communications using low-Earth orbit satellite relays, deployable ground nodes, resilient mesh networks, and hardened software-defined radios.
2. Expand edge-AI autonomy.
3. Institutionalize JANUS.
4. Fully leverage APSS and NORTHLINK for Arctic drone employment.

Electronic Warfare Threats

Ukraine demonstrates the scale and operational relevance of modern EW — jamming, spoofing, cyber-electronic attack — with its impact amplified in the Arctic's degraded environment. The alliance and individual allies must plan and exercise for extensive and aggressive Russian EW, which can disrupt Joint ISR, human-machine teaming, swarm coordination, and kill-chain connectivity essential for drone employment.

Priorities: Resilience, testing. NATO uncrewed systems must be designed with resilience in mind, i.e., visual navigation systems, edge autonomy, hardened communications and data links (including fiber optic cabling), EW detection and avoidance, and fallback operation modes when links are jammed or lost. NATO should also integrate EW survivability testing into Arctic drone trials and field modular countermeasures such as passive RF detectors, decoys, and onboard jammers. NATO's Joint EW Core Staff and Communications and Information Agency (NCIA) should lead Arctic EW threat simulation and embed resilience across drone development. The Testnor EW range in Andøya, Norway, offers a unique site to scale cold-weather EW experimentation for NATO and allied forces.[127]

Organizational, Doctrinal, and Interoperability Challenges

Interoperability Limitations and Constraints

Drones must operate within NATO's broader force structure, supporting human-machine teaming, Joint ISR, and shared targeting data. Yet many systems lack modularity and standardization, while divergent national procurement rules, software interfaces, and data protocols — combined with non-compliance with allied standards and NATO's slow standardization process — hinder interoperability.[128]

Priorities: NATO should continue digital transformation efforts, and should advance interoperability, JISR, and maritime capability development objectives. For example, the alliance should establish an Arctic drone integration initiative under Allied Command Transformation (ACT) in conjunction with the NATO Centre of Excellence for Cold Weather Operations (COE CWO) and interested allies, which could develop common payload interfaces, data formats, and tactical procedures for Arctic drones. NATO's Accelerating Interoperability and Standardization Fund (AISF) could support the development of Arctic-specific material or digital standards, while exercises like Cold Response, Steadfast Defender, and anti-submarine warfare/IAMD drills should integrate drones into scenario planning and force simulation.[129]

Aircraft Operators by Country

Countries	P8-A Poseidon	MQ-9B	MQ-4C Triton
Australia	X		X
Belgium		X	
Canada		X	
India		X	
Japan		X	
New Zealand	X		
Norway	X		
Republic of Korea	X		
UK	X	X	
US	X	X	X

Source: Boeing. "P-8A Poseidon Maritime Patrol Aircraft." Accessed December 3, 2025.; General Atomics. "MQ-9B SeaGuardian: Redefining Maritime Domain Operations." Accessed December 3, 2025.; Lauren Williams. "The Navy's dynamic sub-hunting duo." DefenseOne. June 17, 2025.; Northrop Grumman. "Royal Australian Air Force Welcomes First Northrop

Organizational Considerations

The effective integration of UxS and C-UxS capabilities into NATO's Arctic posture requires substantial adaptation across force structure, planning, training, and rules of engagement to meet the demands of high-latitude uncrewed operations.

- **Force Structure Adaptation:** NATO should establish modular, scalable, multidomain Arctic drone detachments or composite drone elements operating aerial, maritime, and land platforms with embedded EW and counter-drone capabilities. These formations should support NATO Rapid Deployable Corps and standing maritime groups for a flexible response. Arctic allies can draw valuable lessons from Ukraine and adapt those relevant to their environment and mission sets.
- **Training and Human Capital:** Operationalizing Arctic drone integration requires tailored training pipelines for operators, mission commanders, and support staff addressing cold-weather operations, autonomous systems

management, and electromagnetic spectrum operations. NATO Centres of Excellence and Allied commands should incorporate drone operations into their curricula, with Arctic allies leading in doctrine development and winter warfare instruction.

Personnel must be trained in the complexities of human-machine teaming, multi-domain Joint ISR fusion, and deconfliction with civil aviation and operations while being able to manage autonomous systems under degraded C2 and strict rules of engagement (ROE).

- **Command and Control and Rules of Engagement:** Arctic drone integration implies a shift in C2 models. NATO must establish C2 constructs that enable decentralized execution and high degrees of edge autonomy. Drone missions must be synchronized with force objectives, using operating frameworks that manage autonomy, data fusion, and operator-in-the-loop or on-the-loop authorities. For missions in areas with no civilian presence, the alliance should also envision ad hoc “operational boxes” permitting human-off-the-loop authority. ROE and legal protocols must clearly govern kinetic or electromagnetic effects near dual-use infrastructure and align with NATO peacetime and contingency planning.
- **Integration into NATO Plans and Planning Processes:** A critical organizational consideration is the integration of Arctic drone capabilities into NATO plans. Regional Defense Plans must account for uncrewed systems as both enabling and supported capabilities, whether in Joint ISR, logistics, IAMD, or maritime operations. Uncrewed systems should also be prioritized in NATO’s four-year Defence Planning Process (NDPP), including in the establishment of minimum capability requirements and capability targets.

Both NATO commands such as Joint Force Command Norfolk and Allied Command Transformation (ACT) and NATO Centres of Excellence (e.g., Cold Weather Operations, Combined Joint Operations from the Sea, Naval Mine Warfare, Security of CUI, and Integrated Air and Missile Defence) must embed Arctic drones into planning scenarios, capability development tracks, and operational experimentation campaigns to develop Arctic-relevant drone CONOPS.

Priorities: Organizational adaptation — not just technological development — is paramount. NATO must embrace institutional agility and align planning, C2, ROE, training, and structures to successfully operationalize drones and counter drone systems across the Alliance.

Photo: A MV-22 Osprey takes off from Keflavik, Iceland on October17, 2018. The aircraft dropped off US Marines as a part of the insertion phase of Exercise Trident Juncture 2018. The exercise brought together around 50,000 personnel from 31 NATO Allied and partner nations. Credit: NATO Flickr https://flic.kr/p/Q4KCEy.

Doctrinal Considerations

NATO's Arctic doctrine and drone concepts remain underdeveloped. The COE CWO recently issued its first cold-weather doctrinal publication (ATP-3.2.1.5) and is developing additional guidance on land tactics and a broader Alliance Concept for Cold Weather Operations, but these documents will not address Arctic drone employment or human-machine teaming in depth.[130] Exercises and experimentation can accelerate doctrinal progress, but recent events like Cold Response only partially incorporate drones and lack Arctic-optimized human-machine teaming concepts. Advancing doctrine will require clear direction from NATO authorities and sustained resourcing.

Priorities: NATO should develop doctrine for drone employment in Joint ISR and multi-domain awareness, area security, targeting, C2 support, search and rescue, and logistics and medical support, while also addressing human-machine teaming, collaborative or swarming operations in Arctic conditions. These doctrinal efforts should be validated in recurring Arctic exercises involving multiple drone types.

Procurement and Innovation Challenges

Agile Procurement

Procurement of Arctic-capable drones across NATO remains fragmented, slow, and risk-averse. Most allies buy vehicles optimized for global operations in temperate climates, treating Arctic-specific requirements as secondary modifications rather than purpose-built characteristics. This results in limited NATO-certified Arctic-ready drones. Furthermore, acquisition timelines for drone capabilities are misaligned with the pace of operational need and technological development. National procurement channels are often too slow to respond to emerging Arctic capability gaps, while multinational initiatives are slowed by divergent requirements and sovereignty concerns, thus limiting economies of scale.

Priorities: Alongside national procurement reforms,[131] the alliance should encourage multinational approaches leveraging NATO's Rapid Adoption Action Plan (RAAP), vendor consortia, framework or contractor-owned/operated contracts, and multinational projects to accelerate Arctic drone fielding and achieve economies of scale.

Enabling Innovation and Investment

NATO Tools

Despite growing interest in uncrewed vehicles, few European or North American defense firms prioritize Arctic-specific drone research and development due to small-scale procurement, fragmented funding, and high technical risk. Dual-use startups and small and medium enterprises are further deterred by low demand, complex certification requirements, and long procurement cycles related to defense contracts in general.[132] Innovation is also slowed by the lack of Arctic test ranges capable of validating systems in sub-zero, high-latitude conditions, thus creating barriers to entry for novel vehicles and reducing opportunities to adapt commercial technologies. A notable exception is NATO's CWO COE in Elverum, Norway, which launched HEIMDALL (Harnessing Emerging Technologies and Innovations for Multi-Domain Capability Development in the Arctic Littoral Landscape) — a REPMUS-inspired Arctic experimentation initiative. Starting in February 2026, NATO will test drone sensors and effectors in fjords and mountainous terrain to accelerate adaptation for High North operations.[133]

NATO has multiple innovation levers relevant to Arctic drones. For example, nine of Defence Innovation Accelerator for the North Atlantic's (DIANA) ten 2025 challenges are applicable to NATO Arctic-drone capabilities and employment.[134] Three stand out: Autonomy and Unmanned Systems, Operations in Extreme Environments, and Maritime Operations. Six additional cross-cutting areas are applicable (e.g., Energy and Power, Resilient Space Operations). NATO and interested allies should leverage these avenues to spearhead the development of Arctic-capable drones. Another tool is the NATO Innovation Fund (launched in 2023), which invests in deep-tech. Its current portfolio includes autonomous maritime vehicles, AI edge computing, and energy storage. Arctic allies in the fund (Denmark, Finland, Iceland, Norway, Sweden) could steer priorities toward Arctic drones.[135]

Finally, the Rapid Adoption Action Plan adopted at the 2025 NATO summit in The Hague aims to field new capabilities within 24 months by accelerating testing, procurement, and industry collaboration, and could be used to fast-track Arctic-ready drones.[136]

NATO Arctic 7 Countries Participation in Defense Funding

Countries	NATO DIANA	NATO Innovation Fund	NATO Rapid Adoption Action Plan (RAAP)	European Defence Fund (EDF)	European Defence Fund (EDF)	European Defence Industry Reinforcement through Common Procurement Act (EDIRPA)	European Defence Industry Programme (EDIP)
Denmark	x	x		x	x	x	x
Norway	x	x		x	x	x	x
Finland	x	x	x	x	x		x
Sweden	x	x	x	x	x		x
Canada	x			x	x		
Iceland	x	x		x			
United States	x				x		x

Table: Center for European Policy Analysis • Source:

European Union (EU) Tools

NATO allies who are EU member states may be able to leverage EU defense innovation instruments to support Arctic drone development. The EU Defence Innovation Scheme (EUDIS), launched in 2022, supports startups, SMEs, and dual-use technologies through accelerators and EDF funding of up to €2 billion by 2027, including co-financing.[137] The EDA's Hub for EU Defence Innovation (HEDI) — with ~€25 million (2023–2027) — promotes cooperation, experimentation, and information sharing among member states for developing innovative defense capabilities aligned with EU strategic priorities.[138]

Although Arctic drones are not an explicit EU priority, they align with capability needs in the EU Capability Development Plan (CDP) and collaborative opportunities highlighted in the Coordinated Annual Review on Defence (CARD) report.[139] As a result, most NATO allies (25 of 32, including Norway and the UK in certain programs) can tap EU funding instruments for Arctic-relevant projects, such as:[140]

Photo: A US Marine with Marine Rotational Force-Europe 20.1, Marine Forces Europe and Africa, fires a Shoulder-Launched Multipurpose Assault Weapon during a live-fire range in Setermoen, Norway, Nov. 6, 2019. Credit: US Marines/ZUMA Wire/ZUMAPRESS.com

- EDF (~€5 billion for 80–100% R&D funding).
- Security Action for Europe (SAFE) — (up to €150 billion in EU-backed loans, 2025–2030).
- European Defence Industry Reinforcement through common Procurement Act (EDIRPA) (€500 million, 15% co-financing for procurement, 2023–2025).
- European Defence Industry Programme (EDIP) (€1.5 billion in grants, pending approval, 2025–2027).

Finally, the forthcoming Defence Security and Resilience Bank (DSRB), with a projected $1 trillion in capital, may soon provide low-cost, long-term loans for defense capabilities, including Arctic drones.[141]

Priorities: NATO and allies should respond with a targeted Arctic drone innovation strategy or address innovation in an Arctic drone capability development strategy. This should leverage DIANA, the NATO Innovation Fund, NATO's Rapid Adoption Action Plan, the CWO COE HEIMDALL initiative, ACT and EU innovation opportunities, and — where possible — EU defense funding instruments.

Photo: USMarines, along with NATO allies and partners, utilize a Norwegian Combat Vehicle 90 for overwatch during an assault on a compound, as part of a breaching and clearing mission with partner nations in preparation for Nordic Response 24 in Setermoen, Norway, on Feb. 7, 2024. Credit: APFootage via Alamy

Conclusion and Recommendations

NATO's long-term posture in the Arctic will increasingly rely on uncrewed systems as force multipliers that extend reach, enhance resilience, and reduce risk in a uniquely harsh and contested environment. As Arctic Sea routes open and competition accelerates, drones will become indispensable not only for Joint ISR and domain awareness, but also for security, deterrence, and defense across the High North.

Yet the path to effective integration of Arctic-ready drones will demand deliberate planning, sustained investment, and organizational adaptation. The alliance must treat the Arctic as a present security frontier, where rivals are already shaping conditions through military expansion, infrastructure development, and hybrid activities. Uncrewed systems cannot and will not fully replace traditional forces, but they will complement them and enable persistent presence, early warning, and rapid response across multiple domains.

The next decade is a decisive window of opportunity. NATO should build Arctic-specific capabilities and infrastructure; refine concepts for drone and counter-drone operations, and human-machine teaming; and close persistent gaps in communication, C2, and interoperability. By leveraging defense innovation ecosystems and new NATO/EU instruments, the alliance can field scalable and interoperable uncrewed systems suited to the High North. Those who act now — and align doctrine, infrastructure, sustainment, and force development — will shape a future Arctic security architecture capable of deterring and defeating emerging threats.

Recommendations for NATO and Individual Allies

To secure and defend Arctic-related interests, NATO and allies should align Arctic drone integration with broader efforts across capability, policy, and doctrine development, defense planning, and efforts related to resilience, innovation, defense investment, and procurement.

Technical Recommendations

- **Polar-hardened persistent ISR-T platforms:** Field interoperable, long-endurance aerial and maritime drones (notably UUVs) for wide-area surveillance.
- **Attritable tactical drones for forward operations:** Scale recoverable and expendable drones for tactical joint ISR, deception, and strike/denial missions for multidomain and dispersed operations.
- **Edge AI, autonomy, and resilient navigation:** Invest in onboard processing, edge computing, and multi-mode navigation suites (GNSS-resilient) to enable operations in communications-denied Arctic conditions.
- **Human-machine teaming, interoperability and processing, exploitation, and dissemination:** Standardize datalinks, software, and mission interfaces to enable seamless human–machine teaming across NATO, and accelerate high-bandwidth, low-latency PED pipelines (e.g., through automated fusion, AI data triage) to manage exponential sensor and targeting data.
- **Cold-weather sustainment and shared basing:** Build dispersed, mobile sustainment (repair, software support, energy-resilient systems) and reciprocal basing so that drones can operate seamlessly across allies — for example, an allied MQ-9B should be able to refuel/rearm at Andøya (NO), Aalborg (DK), or bases in Greenland**.** Leverage NSIP and other funding where possible.
- **Resilient navigation:** invest in autonomous systems with inertial, celestial, terrain-referenced, and magnetic systems along with autonomous fallback logic to sustain missions and operate independently of GNSS.
- **Hardened C2 and agile, secure communications:** Use encrypted, frequency-hopping, mesh networking, and directional links to maintain connectivity under EW. Integrate fiber-optic/tether options for short-range systems to preserve signal integrity.

Defense Policy and Planning Recommendations

- **"Arctic Eyes" mechanism:** Explore creating a "minilateral" intelligence-sharing framework ("Arctic Eyes" or "NATO 7 Eyes") to coordinate domain awareness, joint ISR, and threat monitoring.
- **Arctic drone capability strategy:** Establish a NATO-coordinated, short-term (0–6 year) development plan aligned with Science and Technology Organization and NATO military authorities to accelerate Arctic drone delivery.
- **C2 and integration frameworks:** Develop Arctic-adapted command and control protocols for tasking, delegation, and ROE; ensure uncrewed systems drone integration into multi-domain operations (C4ISR, IAMD, logistics, targeting).
- **Civil-military coordination:** Harmonize drone operations with Arctic air and maritime traffic systems for domain awareness, SAR, and environmental monitoring; use NORDEFCO's "accessible airspace" agreement to expand UAV mobility.
- **Digital integration and human capital:** Align uncrewed systems' architectures with NATO's digital transformation (Federated Mission Network, AI/ML, cyber resilience) and train personnel for autonomy management and human-machine teaming in Arctic environments.
- **Integrate Arctic drones into NATO defense planning:** Embed Arctic drone roles in regional defense plans and the next NATO Defence Planning Process cycle, beginning with 2027 Political Guidance and 2028 Minimum Capability Requirements, leading to apportioned capability targets.
- **Align national defense planning:** Ensure that allies incorporate Arctic drone priorities into national force goals, modernization programs, and industrial strategies.
- **Adopt a threat- and user-driven approach:** Define drone requirements through continuous testing, operator feedback, and iterative design to maintain flexibility and operational relevance.

Military Recommendations

- **Modular Arctic drone units:** Establish specialized, multidomain drone formations with embedded EW and counter drone capabilities, supported by interoperable C2 constructs for autonomous operations.
- **Training and experimentation:** Develop NATO-wide cold-weather drone training curricula and expand Arctic operational trials under JFC Norfolk and ACT, leveraging COEs to align standards and doctrine.

- **Rules of engagement, C2, and coordination:** Define Arctic-specific ROE, escalation thresholds, and coordination protocols with civilian actors to ensure safe and lawful drone employment.
- **Doctrine and concept development:** Task Cold Weather Operations COE and related COEs (e.g., C2, CJOS, IAMD, maritime security) to advance doctrine covering:
  - Layered Arctic joint ISR and multi-domain awareness.
  - Integration of uncrewed systems into dispersed, low-comm C2 nodes.
  - Area security, SAR, logistics, and medical support.
  - Drones as sensors/effectors in distributed targeting networks (e.g., swarms for ASW, ASuW, air and maritime interdiction operations, and IAMD/C-UxS).
  - Human-machine teaming for offensive and defensive operations.
  - Uncrewed systems-EW coordination to avoid spectrum fratricide and mitigate enemy electronic warfare.

Procurement and Innovation Recommendations

Accelerate Arctic drone acquisition: Leverage NATO's Rapid Adoption Action Plan (RAAP) to speed Arctic drone procurement, testing, and integration through agile evaluation, verification, and validation processes.

Expand multinational procurement tools:

- NSPA and OCCAR pre-approved vendor consortia;
- Framework contracts for modular Arctic platforms (including through NATO High Visibility Projects);
- Targeted co-investment among Arctic allies in priority systems such as JISR UAVs, maritime drones, and hybrid-electric logistics drones;
- Employ contractor-owned/operated (COCO) schemes to deploy capabilities rapidly and bypass bureaucratic delays.

Boost Arctic innovation and R&D: Increase funding for cold-weather technologies and exploit NATO innovation mechanisms — DIANA, the NATO Innovation Fund, etc. — to prototype and field-test Arctic-capable drones.

Leverage EU innovation and defense investment instruments: Utilize EUDIS and HEDI for dual-use innovation, and access EU defense financing tools (EDF, SAFE, EDIRPA, and EDIP) to scale Arctic drone projects where eligible.

Mobilize private capital: Create NATO measures to attract venture investment in Arctic-relevant technologies by de-risking early operational testing, incentivizing military end-user experimentation, and simplifying procurement pathways.

Glossary

Acronym	Meaning
AEW	Airborne Early Warning
APKWS	Advanced Precision Kill Weapon System
ALRE	Aircraft Launch and Recovery Equipment
ACT	Allied Command Transformation
APSS	Alliance Persistent Surveillance from Space
ASW	Anti-submarine warfare
ACTUV	Anti-Submarine Warfare Continuous Trail Unmanned Vessel
ATR	Automatic Target Recognition
BMS	Battle Management Systems
BLOS	Beyond Line Of Sight
CASEVAC	Casualty Evacuation
CMRE	Centre for Maritime Research and Experimentation
CCA	Collaborative Combat Aircraft
C2	Command and Control
C4ISR	Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance
COTS	Commercial Off-The-Shelf
CONOPS	Concept of Operations
COCO	Contractor-Owned/Contractor-Operated
CARD	Coordinated Annual Review on Defense
Counter-ISR-T	Counter-Intelligence, Surveillance, Reconnaissance, and Targeting
C-UxS	Counter-Unmanned Systems
CUI	Critical Undersea Infrastructure
DARPA	Defense Advanced Research Projects Agency
DIANA	Defense Innovation Accelerator for the North Atlantic

DSRB	Defense Security and Resilience Bank
DOTMLPFI	Doctrine, Organization, Training, Materiel, Leadership and Education, Personnel, Facilities, and Interoperability
HEDI	EDA's Hub for EU Defense Innovation
EO/IR	Electro-Optical/Infrared
EW	Electronic Warfare
CDP	EU Capability Development Plan
EUDIS	EU Defense Innovation Scheme
EDF	European Defense Fund
EDIP	European Defense Industry Program
EDIRPA	European Defense Industry Reinforcement through common Procurement Act
F2T2EA	Find, Fix, Track, Target, Engage Assess
FPV	First-Person View
FLOT	Forward Line of Own Troops
GNSS	Global Navigation Satellite System
GIUK	Greenland-Iceland-United Kingdom
GMTI	Ground Moving Target Indicator
HEIMDALL	Harnessing Emerging Technologies and Innovations for Multi-Domain Capability Development in the Arctic Littoral Landscape
HALE	High Altitude Long Endurance
HMT	Human-Machine Teaming
INS	Inertial Navigation System
IAMD	Integrated Air and Missile Defense
ISR	Intelligence, Surveillance, and Reconnaissance
NATO STANAG 4748	JANUS Underwater Communications Protocol
JISR	Joint Intelligence, Surveillance, and Reconnaissance
MPA	Maritime Patrol Aircraft

MALE	Medium Altitude Long Endurance
MCM	Mineral-Countermine Warfare
COE CWO	NATO Centre of Excellence for Cold Weather Operations
NISRF	NATO Intelligence, Surveillance, and Reconnaissance Force
NSIP	NATO Security Investment Program
NSPA	NATO Support and Procurement Agency
AISF	NATO's Accelerating Interoperability and Standardization Fund
NCIA	NATO's Communications and Information Agency
NDPP	NATO's (four-year) Defense Planning Process
RAAP	NATO's Rapid Adoption Action Plan
NORAD	North American Aerospace Defense Command
NATO	North Atlantic Treaty Organization
NSR	North Sea Route
NORDEFCO	Nordic Defense Cooperation
OCCAR	Organization for Joint Armament Co-operation
PGMs	Platinum Group Metals
PED	Processing, Exploitation, Dissemination
RIMPAC	Rim of the Pacific Exercise
SATCOM	Satellite Communications
SLOCs	Sea Lines of Communications
SAR	Search and Rescue
SAFE	Security Action for Europe
SHORAD	Short Range Air Defense
SIGINT	Signal Intelligence
SWaP-C	Size, Weight, Power, and Cost
SME	Small and Medium-sized Enterprise
ROE	Strict Rules Of Engagement

SSBN	Ship, Submersible, Ballistic, Nuclear
SBAD	Surface-Based Air Defense
TTPs	Tactics, Techniques, and Procedures
UI	Underwater Infrastructure
UxVs or UxS	Uncrewed and Autonomous Vehicles
USVs	Uncrewed Surface Vehicles
UUVs	Uncrewed Underwater Vehicles
UAVs	Unmanned Aerial Vehicles

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