



Addressing Arctic Vulnerabilities

Lessons from Ukraine

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The Arctic is quickly becoming a theater of global competition—a development that has accelerated since Russia’s 2022 invasion of Ukraine. In order to protect critical undersea communications infrastructure, decrease intra-alliance dependency on U.S. space-based capabilities, and deter Russian gray-zone tactics, NATO-aligned Arctic states—the United States, Canada, Denmark, Finland, Iceland, Norway, and Sweden—must enhance situational awareness of these vulnerabilities. By applying lessons learned from the war in Ukraine on how technological advancements can shape military strategy and the operational environment, specifically with regards to resilient space capabilities, cost-efficient unmanned systems, and rapid procurement processes for evolving technological capabilities, Arctic states can improve both deterrence and potential warfighting in the region.

INTRODUCTION

Over the past two decades, and especially since Russia’s invasion of Ukraine in 2022, the Arctic has become increasingly characterized by competition rather than cooperation.¹ As described by Icelandic Prime Minister Bjarni Benediktsson in October 2024, “whether we like it or not, the Arctic is fast becoming a theater of global competition and militarization, and it is up to us to determine the parameters for developing this region.”² The Arctic security environment has changed politically, reflective of an increasingly competitive posture between a consolidated NATO bloc in the West and a belligerent Russia in the East.

Prominent among the political challenges facing NATO allies in the Arctic is addressing these changes materially. The issue is comprehensive and involves combining means in order to underpin deterrence—of both warfare and gray-zone actions—as well as to prepare for potential warfighting scenarios. In responding to these challenges,

Arctic states have an opportunity to learn from, and leverage, lessons from Ukraine on the role of technological development in contemporary warfare.

The Ukrainian battlefield has illustrated the strengths and limitations of several rapidly evolving technologies impacting the character of warfare. While some technological solutions have provided robust military advantages (e.g., the Starlink constellation) others have been caught in action-reaction cycles where advantages have been quickly neutralized by the adversary (e.g., certain configurations of drones or precision-guided artillery).³ These lessons are already influencing the strategies and force postures of Arctic states, including Russia.⁴

Any response to the changing Arctic security environment requires addressing several key concerns. The first is analyzing the vulnerabilities that impede the ability of Arctic states to credibly and capably both deter and fight in the High North. At least partially due to the absence

of an independent command, control, communications, computers, intelligence, surveillance, and reconnaissance (C4ISR) capability, situational awareness is a vulnerability of particular significance.⁵ Arctic states are instead dependent on vulnerable undersea communications infrastructure, or space-based capabilities that are relatively scarce and characterized by intra-alliance dependency on the United States.⁶ Additionally, Europe's reliance on Norway as an energy provider is vulnerable to Russian gray-zone tactics.⁷

The second concern is addressing these vulnerabilities, taking stock of which technological capabilities will make a difference and how lessons from the war in Ukraine can be efficiently applied to strategy and force postures. The most immediate priority to alleviate Arctic security concerns should be bolstering maritime domain awareness in the region, which directly impacts European energy security as well as nuclear security and deterrence by enhancing NATO's ability to detect, monitor, and respond to potential threats. Ukraine has demonstrated the utility and resiliency of advanced space capabilities and unmanned systems when used in nonpermissive environments. As Arctic geography already creates dependency on satellites, investing in space capabilities should be a main priority. Moreover, certain configurations of unmanned systems can cost-efficiently bolster both situational awareness and offensive options in Arctic security.

THE UTILITY OF SITUATIONAL AWARENESS IN THE ARCTIC

Harnessing benefits from technological development is particularly important given the ongoing geopolitical changes in the Arctic. Growing tension between NATO and Russia is likely to lead to increased naval activity in the High North, where vulnerable military, communications, and energy infrastructure is at risk of sabotage and interference. While China is unlikely to establish a significant presence in the Arctic, monitoring Chinese maritime traffic and their potential activities in building C4ISR ground infrastructure remains important.⁸ Monitoring Russian activity around its nuclear deterrent posture has been of particular consequence since the beginning of the war in Ukraine—in September 2024, Russian president Vladimir Putin announced changes to Russia's nuclear doctrine involving an “expansion” of its mission, although any substantial differences are yet to be revealed.⁹

The White House has already identified C4ISR capabilities as essential to its Arctic ambitions. Reflecting its “monitor-and-respond” global posture as outlined in its

National Defense Strategy, the United States asserts a general readiness to respond to threats in the Arctic along with its regional allies, yet highlights two focal points: the Arctic (1) houses various early-warning and intelligence, surveillance, and reconnaissance (ISR) capabilities, and (2) acts as the U.S. northern flank in carrying out Indo-Pacific operations.¹⁰ In the strategy's implementation plan, the first strategic objective is improving the understanding of the Arctic operating environment, particularly emphasizing the bolstering of space capabilities and maritime domain awareness.¹¹

The strategic utility of an Arctic presence is considerable for early warning purposes. Its geographical location makes the Arctic an important vantage point for monitoring potential ballistic missile launches and other airborne threats.¹² Russia and the United States—with its allies—depend on Arctic infrastructure for their early warning systems, both through ground-based radars and ground stations for satellite communications (SATCOM). Russia and China are increasingly collaborating in developing defense technology, decidedly prioritizing space and new technologies, and it is with Russia's cooperation that China is seeking to develop and deploy its own early warning infrastructure.¹³

More broadly, with their increasing dependence on space-based capabilities for advanced warfare, states seeking global or Arctic regional coverage for their space systems are reliant on ground infrastructure in the Arctic due to its latitude-restricting coverage.¹⁴ The Arctic is also an ideal location for this type of infrastructure. Particularly for states with ambitions of global space-power projection such as the United States and China, this incentivizes a growing physical presence in the Arctic to support developing space infrastructure, including dual-use projects.¹⁵ China has advanced its global space capabilities drastically in recent years, and reports have emerged that Russia is becoming reliant on Chinese satellite imagery of Ukraine.¹⁶ Moreover, the geopolitical tension between NATO and Russia heightens the risk for assets such as Norway's K-SAT satellite station on Svalbard and the space-launch capabilities in Andøya, Norway, and Kiruna, Sweden.¹⁷

VULNERABILITIES IN ARCTIC SECURITY

Addressing several vulnerabilities in particular would effectively bolster Arctic security. While most European NATO members already agree with and have begun to answer the need for a general increase in defense expenditure—

particularly in naval power for Arctic states—since February 2022, there remain points of weakness.

Arctic geography is vast and remote, making it hard to establish and maintain a comprehensive surveillance and communications network. A cold and rugged climate subject to rapid environmental changes, including in ice conditions, make the Arctic a challenging operating environment and constrains options for building robust infrastructure.¹⁸

In the absence of a redundant communications network, long-range communications in the Arctic primarily rely on undersea cables, a dependency that is a vulnerability.¹⁹ Undersea cables offer little resistance to sabotage, acting as low-hanging fruit for an adversary to exploit through physical damage, cyberattacks, or espionage.²⁰ For zones like Svalbard, which is dependent on two fiber-optic cables for outside communications, the situation is precarious. A loss of both cables would carry strategic implications, as transmissions to and from the K-SAT satellite station—the world’s largest satellite ground station and of strategic importance to satellites in polar orbit—would effectively be lost.²¹

Svalbard’s fiber-optic cable dependence was tested in January 2022 when one of the cables was cut, rendering the archipelago entirely reliant on reserve capacity from its one remaining cable. Although the cause of the incident remains unconfirmed, Russian trawlers were spotted by the cable shortly beforehand.²² Similarly, in April 2021, a 4.3-kilometer section of an undersea cable outside the Norwegian coast disappeared, with no information on how or on the actors involved.²³ In addition, while outside of Arctic territory, the 2022 Nord Stream Pipeline sabotage in the Baltic Sea strongly resembled the Svalbard incident.²⁴ With all of these incidents left unattributed, albeit doubtlessly caused by human interference, they reflect both the vulnerability of critical subsea infrastructure as well as the need for maritime situational awareness in the Arctic.

The same vulnerabilities can be applied to Arctic petroleum infrastructure. As Norway has become the largest petroleum supplier in Europe—in tandem with European states reducing their reliance on Russian energy—the Nordic country’s strategic importance as an exporter has greatly increased. The security dimension of energy production has become more visible. This also makes Norwegian energy infrastructure in Arctic waters an increasingly attractive target for Russian sabotage.²⁵ Furthermore, Norway has recently permitted exploration of mineral extraction further into the Arctic, which may lead to additional geopolitical

importance for the Norwegian continental shelf.²⁶ Additional maritime infrastructure incentivizes increased awareness to safeguard these assets against potential threats.

While space-based communication is the most capable alternative to undersea cables, the Arctic is hampered by significant shortcomings in satellite capabilities. Conventional SATCOM from geosynchronous orbit is unstable or unusable in large parts of the Arctic due to limited coverage above 70 degrees latitude.²⁷ As a result, satellite coverage in the Arctic largely relies on satellites in polar or highly elliptical orbits. Currently, Arctic SATCOM mainly encompasses narrowband frequencies with constrained data rates and high latency, thereby limiting functionality. The United States possesses military satellites with encrypted communications, such as the Enhanced Polar System, but the existing pool of Arctic satellite capabilities is insufficient for current operational requirements.²⁸ The accuracy of precision, navigation, and timing (PNT) systems, such as GPS, is also limited in the Arctic, causing potential challenges for precision-based munitions and navigational awareness.²⁹ Even with fully functional PNT systems, Arctic states can still expect Russian GPS-jamming as an asymmetric tool to impact states’ abilities to utilize advanced munitions and vehicles.³⁰

Aside from SATCOM, bolstering situational awareness depends on continuous and accurate ISR (intelligence, surveillance, and reconnaissance) over the vast Arctic region, which is only achievable through a foundation of space-based ISR.³¹ While aerial capabilities such as P-8 reconnaissance aircraft and unmanned aerial vehicles (UAVs) may supplement localized ISR, these capabilities have insufficient range and speed to cover the vastness of the Arctic geography.³² Similarly, sea-based capabilities, including Coast Guard vessels and sea-based drones, face limitations in range and operational endurance, making it challenging to ensure comprehensive coverage without the support of space-based systems.³³

The issue of C4ISR infrastructure in the Arctic also touches upon a broader problem for European NATO allies: dependency on U.S. capabilities for C4ISR in Europe. The absence of an independent C4ISR capability has been highlighted as a key factor in why Europe cannot defend itself.³⁴ This dependency is particularly acute given the current political direction of the United States, which heralds a shift toward prioritizing domestic concerns and reducing international military commitments, potentially including NATO obligations.³⁵ Aside from concerns regarding NATO cohesion, intra-alliance dependency on U.S. C4ISR sys-

tems weakens the credibility of alliance-level deterrence. A disproportionate amount of NATO's C4ISR capabilities belonging to the United States may lead adversaries to see these assets as primarily the country's, rather than NATO's. This may lower the threshold of an adversary targeting, for example, U.S. satellites in polar orbit, which would severely impact the situational awareness of state actors in the High North dependent on U.S. C4ISR patronage, more than it would impact the United States itself.³⁶

APPLYING LESSONS FROM UKRAINE IN THE ARCTIC

The war in Ukraine has demonstrated how technological development has shaped military strategy and the operational environment. To the surprise of many, the use of capabilities such as drones, non-kinetic warfare, missile defense, hypersonic missiles, and advanced space capabilities has been combined with tactics from early stages of military development including trench warfare. The balance between offensive and defensive advantages has been dynamic as asymmetric capabilities have neutralized high-value platforms before often becoming neutralized themselves as the adversary adapts.³⁷ Accordingly, not all advanced technological capabilities have been transformative, and some lessons stand out more than others in their relevance to the Arctic.

A key facet of warfare in Ukraine has been the ability of Ukrainians to retain a functional C4ISR infrastructure in a nonpermissive operating environment. Despite attacks against its terrestrial communications infrastructure, cyberattacks, and jamming against satellites, Ukraine has persisted in utilizing resilient and adaptive capabilities—chiefly unmanned systems and satellite data—to maintain situational awareness and to coordinate military operations. Impressively, it has done so largely within a digitalized defense framework.³⁸ This is a substantial, broader lesson for NATO allies facing the fundamental challenge of leveraging technological hegemony against adversaries with tools to asymmetrically offset their technological advantages.

SPACE AND COMMERCIAL ACTORS

Space has been an essential domain for Ukraine's C4ISR capabilities. From the conflict's prelude onwards, the combination of open-source and classified data from both military and commercial satellites has provided Ukraine with a persistent military advantage.³⁹ While most terrestrial communications and situational awareness infrastructure

in Ukraine has been subject to interference, space-based capabilities have largely endured. Aside from ISR, space has enabled precision-guided munitions, resilient SATCOM, and the maintenance of command and control. This is an essential lesson for any potential adversary to Russia, which relies on offsetting technological advantages through non-kinetic capabilities such as cyber-jamming and electronic warfare. Advanced space capabilities, particularly redundant systems in low Earth orbit, have proven highly resilient when facing non-kinetic counterspace attacks. In a nonpermissive Arctic security environment, reliance on space may both address existing vulnerabilities and counter Russian asymmetric capabilities.

There are, however, three significant caveats regarding the lessons learned from space systems in Ukraine. First, as highlighted by space policy expert Michael Gleason, having advanced space capabilities is necessary but insufficient to create a persisting military advantage. As he argues, Ukraine has done a far better job than Russia in integrating space-enabled data at operational and tactical levels through ground stations and data networks.⁴⁰ This shows the need for a comprehensive infrastructure, including ground-based capabilities, to utilize space effectively. This applies as much in the Arctic as in Ukraine if not more so, given the scarcity of ground-based space infrastructure in the Arctic.

Second, the resiliency of certain space systems varies depending on its specifications. Satellites in geosynchronous orbit and medium Earth orbit—such as U.S. early warning satellites and GPS, respectively—are much more vulnerable to counterspace attacks than satellites in low Earth orbit.⁴¹ In Ukraine, space-derived advantages have mainly come from satellites in low Earth orbit with high redundancy. In particular, the Starlink constellation has proven both numerically and technologically resilient to cyberattacks and electronic warfare.⁴² Indeed, in many parts of Ukraine, Starlink has been the only non-Russian SATCOM option still functioning. In contrast, PNT systems such as GPS have been persistently jammed, constraining Ukraine's ability to utilize precision-guided munitions.⁴³ The implication of this caveat is that advanced satellite systems in low orbit with high redundancy will be important to emulate for other regions, such as the Arctic, while PNT systems such as GPS will likely remain vulnerable in their current configurations.

Third, a significant portion of space capabilities in Ukraine have been commercial. Aside from companies like Maxar and Hawkeye 360, Starlink has been the biggest

commercial contributor to satellite services in Ukraine.⁴⁴ On the one hand, this has showcased the innovation of the commercial space sector, which has led to demonstrable advantages. On the other hand, dependency on commercial actors, and particularly on Starlink, may be disadvantageous in the long term. In regions like the Arctic with a state-centric demand, requirements involving encryption and software may diverge with commercial interests aimed at a broader user base. There are also risks relying on satellites with off-the-shelf hardware.⁴⁵

For Starlink specifically, there are severe risks relating to the company's owner. Elon Musk's personal interests have allegedly led to restrictions on how Starlink is used in Ukraine, and Musk has reportedly had regular contact with Putin—possibly influencing the former's decisionmaking process. Sources have further described Putin requesting Musk deny Taiwan access to Starlink on behalf of Chinese president Xi Jinping.⁴⁶ Russian troops using Starlink have also been reported, raising further questions on the system's reliability.⁴⁷ Many reports on Musk and Starlink remain unconfirmed. There is a discernable pattern of accounts, however, sowing doubt on the credibility of Musk's services if they are to be used counter to his personal convictions or interests. In the Arctic, Starlink would be integrated into a C4ISR posture opposing Russia. Therefore, Starlink's role in Arctic security should be constrained. Instead, Arctic states should work to emulate the advantages of Starlink in Ukraine by developing redundant satellite systems—including ground-based infrastructure—tailored to states' security preferences.

UNMANNED SYSTEMS

Maintaining a persistent C4ISR infrastructure in nonpermissive conditions necessitates the integration of several essential enablers. Drones have amassed attention throughout the fighting in Ukraine, allowing asymmetric strike capabilities and serving as enablers of ISR and target detection.⁴⁸ Accordingly, drones have played important roles in providing situational awareness in difficult conditions. To be sure, there are constraints in drone-centric warfare. The “cheap mass” afforded by unmanned systems provides resiliency and flexibility, and most drones are cheaper than their countermeasures. However, as naval analyst Joshua Tallis argues, limitations in speed, power, and size make drones complementary to, rather than a replacement for, missiles—particularly in naval warfare, as would be relevant in the largely maritime Arctic context.⁴⁹

Drone warfare also has implications for the development of integrated air and missile defense systems (IAMDs). The war in Ukraine has demonstrated the advancement of IAMDs, such as the National Advanced Surface-to-Air Missile System (NASAMS), Patriot Missiles, and the S-300, with neither side having gained air superiority.⁵⁰ However, as reflected by the 2023 Chinese balloon incident, advanced sensors quickly become ineffective when faced with something for which they are not designed to look.⁵¹ In Ukraine, developing IAMDs that can cost-efficiently counter drones has been challenging.⁵² As drones will remain an essential part of contemporary warfare, this challenge will extend to Arctic states seeking to both integrate drones into their military structures and to prepare countermeasures.

Integrating drones involves two main challenges. First, the general lessons of Ukrainian drone-warfare—how the drone niche can complement and enable other foundational capabilities—must be applied to the Arctic geography and temperature, demanding requirements for durability and range.⁵³ Norway's scarce drone pool is more suited to Middle Eastern rather than Arctic conditions.⁵⁴ Notably, all Scandinavian countries have recently announced plans to progressively integrate drones into their military structures, and Norway and Denmark have begun cooperating in maritime Arctic drone surveillance.⁵⁵

Second, modelling Ukraine's rapid acquisitions of drones, which has enabled quick reconstitution of its capabilities, requires a comprehensive overhaul of most Arctic states' acquisition structures. Currently, long procurement cycles risk drone purchases becoming technologically outdated by the time they arrive.⁵⁶ More streamlined and responsive acquisition processes are needed to adapt to the changing security environment.

RECOMMENDATIONS: APPLYING LESSONS ON ARCTIC VULNERABILITIES

There are important lessons to be learned from how unmanned systems and space capabilities have been utilized in Ukraine, and that these lessons can apply in other theatres, including the Arctic. However, there remain significant caveats and nuances that are important for applying these lessons constructively in such a different environment. Simply investing in higher quantities of drones and satellites is insufficient for significantly bolstering situational awareness in the Arctic. These capabilities must be

tailored to the geographical and technological needs of the region. The following policies are recommended to operationalize the lessons from Ukraine going forward.

1. Bolster Arctic situational awareness through resilient space capabilities.

Space capabilities are poised to fill important gaps in Arctic C4ISR architecture. Additions in SATCOM could provide meaningful improvements to meager existing communications infrastructure. While not necessarily providing a 1:1 replacement for undersea fiber-optic cables, investments in SATCOM would add layers of redundancy and reduce the vulnerabilities associated with reliance on undersea cables. Similarly, space-based ISR would bolster situational awareness and amplify Arctic states' abilities to secure undersea networks, as well as reduce the risk of hostilities being unattributable.

While the advantages of Starlink in Ukraine make the proposition of directly utilizing Starlink in the Arctic for security purposes appear intuitive, there are significant uncertainties that make the proposition less attractive, including a risk of insecure encryption and uncertainties regarding the interests of Elon Musk. Accordingly, emulating the advantages of Starlink—predominantly through high numbers of satellites in low Earth orbit—in developing new satellite systems is preferable to relying on Starlink directly.

The European Union's proposed Infrastructure for Resilience, Interconnectivity and Security by Satellite (IRIS²) constellation is the closest realistic alternative to Starlink, but the project is limited in scope and unlikely to become a serious competitor.⁵⁷ This reflects the historic difficulties of security collaboration in a European framework, which are understandable considering European political fragmentation. Nonetheless, in light of European security interests currently threatened by Russia, the potential straining of transatlantic relations due to an inward-focused United States, and the possibility of a SpaceX technological monopoly in space, there are broad incentives for consolidating European security interests.

Ukraine's successful use of space capabilities is not solely attributable to Starlink but rather has included an array of smaller satellites in low Earth orbit. Technological developments have enabled

broader uses for smaller satellites which, in tandem with lowering launch costs, can bolster Arctic C4ISR architecture. A broader space-based sensor network enables various capabilities, including precision-strike weapons and fighter jets, thereby supporting both deterrence and warfighting objectives. There are examples in the Arctic to build on, including the recent Arctic Satellite Broadband Mission (ASBM)—while not constituting smaller satellites, ASBM nonetheless represents an important step in leveraging space capabilities for Arctic security objectives.⁵⁸ Additionally, newly built spaceports in Andøya and Kiruna may facilitate small satellite launches from Northern Scandinavia.

2. Prioritize unmanned systems that cost-efficiently complement Arctic security needs.

Unmanned systems have the potential to play an important role in Arctic security. Sea-based and air-based drones can supplement conventional maritime and aerial capabilities in gathering Arctic situational awareness, particularly in the maritime domain. As attack capabilities or close air support, as seen in Ukraine, drones can complement long-range missiles by providing an asymmetric strike option. However, since the Arctic geography and climate vastly differ from the Ukrainian, the unmanned systems used in Ukraine may be largely incompatible with Arctic territory. Range requirements differ depending on uses, but for situational awareness purposes, for example, drones should ideally withstand high range in low temperatures.

As discussed, a major factor behind successful drone warfare in Ukraine has been the cost-efficiency of drones, which further enables scalability and strength in numbers. Given the constraints of Arctic geography, the current availability of unmanned systems that cost-efficiently fulfill the above-mentioned criteria is limited. Northrop Grumman's MQ-4C Triton is the most frequently mentioned aerial high-altitude long-endurance drone alternative for Arctic states. While systems such as the MQ-4C Triton would certainly bolster maritime domain awareness, they do not accurately exemplify the benefits of drone warfare as demonstrated in Ukraine. Instead, they represent high-value targets vulnerable to asymmetric

warfare.⁵⁹ This is not necessarily detrimental to Arctic states' national security objectives, but harnessing the benefits of drone warfare as seen in Ukraine requires a different line of thinking.

Ukraine has shown how cheaper platforms in higher numbers can make a difference in high-intensity warfare against Russia. Therefore, Arctic states should be cautious of putting all of their eggs in one basket: Rather than opting for fewer numbers of expensive drones, which do not capture the military-technological advantages of evolving drone capabilities, the Arctic should choose instead to adopt many less-expensive variations. More on that trade-off in the recommendation below.

3. Facilitate the rapid procurement of evolving technological capabilities.

The Ukrainian battlefield has demonstrated the ability of both sides to adapt to emerging capabilities, particularly in unmanned systems. In many cases, adaptation has negated persistent military advantages, and important capabilities have quickly become neutralized and replaced. This reflects the trade-off in most capabilities with “affordable mass”—rapid advantages in high-intensity warfare until their inherent vulnerabilities become known and exploited. Despite the trade-off, being able to procure commercial capabilities on a large scale will pay off in future conflicts. Doing so, however, requires a bureaucratic apparatus capable of rapidly acquiring and integrating military capabilities.

As discussed, this is not currently the case for most Arctic states. Neither the United States nor Nordic countries currently have sufficiently flexible procurement structures.⁶⁰ In order to face this challenge, national military establishments must enhance their abilities to adapt to the changing military-technological environment; should they

do so, as shown in Ukraine, the benefits can be significant. Managing the challenge of facilitating flexible procurement structures can be eased through cooperation with other Arctic states. A streamlined Nordic approach, for example, could promote interoperability, scalability, and cost-efficiency. This could also actualize cooperative frameworks such as Nordic Defence Cooperation (NORDEF) to a greater extent, while lowering the threshold of investing in other assets, such as space-based C4ISR capabilities, that would benefit all Nordic countries. Whether this is feasible, however, partially rests on the ability of Arctic states' military establishments to adapt to changing security needs. ■

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