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Key Points

The advanced missile threats posed by Russia and China today are more acute than ever, and North America's Arctic approaches remain the most likely avenue for attacks against the U.S. homeland.

The United States once posessed a robust network of early warning radars and other sensors that met the task of deterring, preparing for, and countering attacks from Soviet attacks during the Cold War, but this system is now outmoded, aging, and not fit to the task of meeting today's missile threats.

Against the singular Soviet threat, the level of U.S. collaboration via U.S. NORTHCOM and NORAD with allies and NATO partners was more than sufficient, but these established working relationships must now grow and strengthen to address modern threats.

The larger scope of today's more sophisticated missile threats requires a modernization and recapitalization of U.S. northern tier defenses. This includes far greater integration and information sharing with U.S. and NATO Arctic nation allies.

A successful upgraded Arctic defense enterprise must deter missile threats, ensure rapid awareness of advanced airborne threats, give decisionmakers sufficient time to react and respond, and set the conditions to defeat adversaries if required.

Homeland Sanctuary Lost: Urgent Actions to Secure the Arctic Flank

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Abstract

Russia and China have spent the past three decades developing and fielding advanced weapons capable of striking the U.S. homeland. Today, their nuclear and non-nuclear missile technologies can hold vital centers of gravity at risk from thousands of miles away. Both military and civilian targets are more vulnerable to aerial attack than ever before. The advent of operational hypersonic missiles is especially concerning, given that a Russian aircraft launching one of these weapons could strike New York or Washington, DC, in less than 60 minutes. Additionally, cruise missiles—which are available in high numbers and at a low cost—can transit thousands of miles, evade existing radars, fly unpredictable flight paths, and deliver disastrous effects. The current devastation of major Ukrainian cities serves as a warning of what the United States could face in a future conflict. Nowhere is the country's exposure to attack more acute than from its Arctic approaches—the most direct corridor through which both Russia and China could strike the United States.

America has dealt with similar threats before. The Cold War saw the United States install and operate extensive arrays of early warning systems to ensure advanced detection of Soviet bomber aircraft across the Arctic region. However, those systems no longer operate or have aged out. Moreover, Cold War threats, while significant, were simpler and more predictable. Modern systems are far more diverse, dynamic, and more difficult to detect. U.S. Arctic domain awareness (ADA) capabilities and capacity are woefully insufficient to meet today's threats. A modern, effective enterprise must detect, track, and analyze military movements and other activities in real-time by using a variety of air, surface, and space sensors that collect and share information from multiple domains. Golden Dome is a major part of this solution. It is time for the nation to rebuild its northern tier defenses.

At a macro level, addressing the vulnerabilities tied to ADA includes improving the overall sensor network, enhancing information sharing between organizations, and promoting Arctic nation collaboration. A successful upgraded enterprise will deter Russia and China, ensure rapid awareness of advanced airborne threats, give decision-makers sufficient time to react and respond, and set the conditions to defeat them if required.

"My key priority remains improved domain awareness in the approaches to North America… Our core missions, to include defending critical defense infrastructure, require USNORTHCOM and NORAD to see and respond to threats through a globally integrated layered defense extending as far from our shores as possible."

-Testimony of General Gregory Guillot, U.S. Air Force, Commander, U.S. NORTHCOM and NORAD[73]

Introduction

As the military aggression of adversarial regimes around the world has escalated over the past five years, creating new types of threats that U.S. national security policy must address, defense and government leadership have made it clear that homeland defense is a priority. And, given the difficulty of defending against attacks through the Arctic, the Department of Defense (DOD) must take this approach more seriously than it has to date in the post-Cold War era. High north sea lanes are increasingly navigable thanks to ice melt and global temperature increases, which are driving increased high-value economic activity in the Arctic. The region is a favorable trade route because it is ideally located at the intersection of Europe, Asia, and North America. Arctic routes promise to serve as the gateway to these regions and represent the most direct path between them all. Warmer temperatures also allow new access to natural resources. China and a resurgent Russia recognize these trends and are opportunistically positioning themselves with an increased security focus on the Arctic region. This is driving an uptick in their military activities, which increases the potential for friction and conflict. Both adversaries now seek to hold U.S. targets at risk during any potential major conflict, and the most direct way to attack them remains across the Arctic. It stands to reason that the defense of America's Arctic approaches will continue to hold strategic value in deterring peer aggression.

U.S. national leaders are also tracking these realities, and a general bipartisan consensus exists regarding the need for an increased security focus on the high north. That is why multiple recent administrations have published several Arctic strategy documents calling for a "monitor-and-respond" approach for Arctic stability. Most recently, the Trump administration signaled an increased focus on the high north threat through initiatives like Golden Dome and hailing the significance of regions like Greenland. Meeting the administration's homeland defense expectations brings numerous challenges, but bolstering Arctic security will be essential to any plan for reducing the risk of attacks on the continental United States. This initiative must restore adequate levels of domain awareness, deter, and ultimately, if required, defeat an aerial attack.

Unfortunately, ever since the end of the Cold War, Arctic security has received insufficient budget priority. We now face a reality where the Arctic threat is surging, but we lack the necessary situational awareness to identify, track, and target offensive military capabilities in the region. The U.S. Air Force currently relies on outdated ground-based sensors that are decades old to deliver these critical effects.

"Major geopolitical changes are driving the need for this new strategic approach to the Arctic, including Russia's full-scale invasion of Ukraine, the accession of Finland and Sweden to the NATO alliance, increasing collaboration between the People's Republic of China (PRC) and Russia, and the accelerating impacts of climate change."

-Secretary of Defense Lloyd Austin
2024 Department of Defense Arctic Strategy[74]

Meeting the national defense imperative for a robust Arctic defense hinges on three main lines of effort. First, greater Arctic domain awareness requires fielding an improved sensor architecture with air-, surface-, and space-based sensors. Layered sensing is required to adequately cover the vast Arctic expanse and provide sufficient radar fidelity. In its most basic form, the sensor network would comprise a surface-based over-the-horizon radar (OTHR), a space-based radar, and a robust and flexible fleet of piloted and uninhabited aircraft. Second, the DOD must aggressively promote information exchange between governmental departments and military commands. Policy and technical hurdles impede the timely sharing of information, subsequently reducing domain awareness. These impediments must be identified and removed. Third, Arctic domain awareness requires seamless collaboration with the other Arctic nations. Increasing the number of military exercises with these countries and improving interoperability will advance America's security posture to the north.

The United States once fielded its most advanced sensing and integrated interdiction network along its northern tier during the Cold War. Leadership recognized the seriousness of Soviet threats and built the kill chain it needed to address them, necessarily including partners with shared interests in the region. It is time to reclaim this first-rate defensive capability, reaping its deterrent and protective benefits for U.S. homeland defense.

The Cold War Model: The North American Air Defense Command (NORAD)

Some 75 years ago, the United States faced an existential threat from the Soviet Union through the Arctic. Nuclear-armed long-range Soviet bombers threatened the continental United States, exposing new vulnerabilities. The response was historic, bringing the United States and Canada closer than ever to form a new bi-national military command and deploy a network of radar sensors aimed at the most likely avenue of attack—the Arctic. The establishment of the North American Air Defense Command (NORAD) ushered in high levels of information exchange and military system interoperability. The command relied on sensors capable of detecting Soviet bombers armed with gravity bombs, which would have to fly attack routes penetrating deep into Canadian and U.S. airspace to deliver their ordinance. It developed a command-and-control network that shared information fast enough to respond to the inbound aircraft. A close bi-national relationship, a robust radar network, and an ability to exchange and share information at a speed relevant to military decision makers formed the basis of this successful North American air defense across the Arctic domain. While NORAD's now-older systems lost relevancy facing new 21st-century threats, a brief look into its history illuminates how these systems came together in defense of North America and provides principles for shaping a modern North American defense.

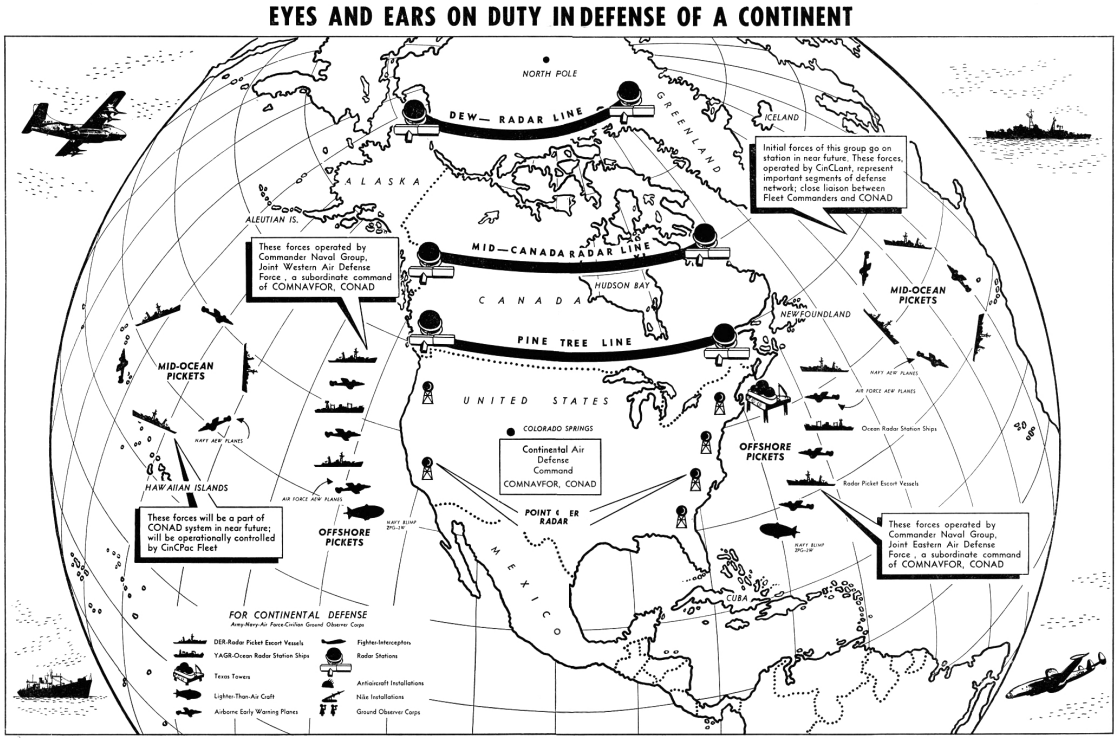

Figure 1: Map of components to U.S. North American Air Defense Command in 1956.

Source: U.S. Navy, *All Hands Magazine*, September 1956, pp. 32–33.

Building an adequate air defense network in the middle of the 1950s was not easy, but, given the threat of nuclear-armed bomber aircraft, it was necessary. This mirror's today's threat environment, in which precise Russian missiles hold U.S. elements of national power at risk. While 1950s Soviet weapons lacked precision, they could mass effects instead. This prompted the United States and Canada to develop an integrated defense command focused on air early warning and coordinated air defense.[1] Their combined efforts resulted in the operation of 138 radar sites with roughly 800 aircraft tasked for air defense.[2] The mission was to detect and then intercept Soviet bombers as far north and as far away from North American population centers as possible. Armed with nuclear gravity bombs, Soviet aircraft were required to penetrate deep into Canadian and U.S. airspace to reach their targets, providing NORAD systems the opportunity to identify, track, target, and ultimately prevent the completion of a successful Soviet air strike. Adequate domain awareness was key, and it required the use of multiple radar sites across Canada and the United States.

As the Soviet threat evolved, so did NORAD. Adding to an already formidable long-range bomber capability, the Soviets began deploying their nuclear intercontinental ballistic missiles (ICBM) and submarine-launched ballistic missiles (SLBM) in the 1960s. The United States and Canada now faced a prolific nuclear ballistic missile threat. NORAD's limited capability to defeat these missiles shifted its focus from air defense to deterrence. Unlike the bombers, which could be detected and then intercepted, NORAD lacked the capability to intercept missiles. However, it remained responsible for their detection. NORAD's mission to detect inbound missiles underpinned the U.S. deterrent posture, safeguarded Strategic Air Command's nuclear retaliatory capabilities, and ensured adequate response time to counter any attack.[3] This response time was a crucial element of the mutually assured destruction (MAD)

strategy. NORAD maintains the important responsibility of detecting and tracking ballistic missile launches using a system of surface- and space-based sensors today, and, over the past 20 years, the United States fielded capabilities to intercept ballistic missiles threatening America's West Coast. Despite these advances, important gaps remain.

By the end of the 1970s, the Soviet threat evolved further still. Previously armed with gravity bombs, Soviet bombers were now capable of carrying stand-off air-launched cruise missiles (ALCM). This new capability was significant because it eliminated the requirement for their aircraft to fly over their intended targets. Soviet bombers could launch long-range nuclear missiles from over 1,000 miles away, outside North American airspace. This development simultaneously eliminated NORAD's requirement for radars located within the continental interior and increased the range requirements for radars located on the northernmost Canadian and Alaskan coastlines. Since the radars were unable to detect the small, low-altitude ALCM missiles, the radars needed to detect the bombers prior to weapons release. Radar search patterns had to extend deep into the northernmost Arctic airspace to accomplish this. The main radar system, the North Warning System, was upgraded in the 1980s to best detect the new threat.

The end of the Cold War and the 1991 collapse of the Soviet Union drastically reduced the fear of nuclear attack. Russia and the United States signed the Strategic Arms Reduction Treaty (START) and reduced their nuclear arsenals by 25 percent. Focus began shifting away from aerial attacks from Arctic approaches. Fears of Russian attack only continued to wane following the sobering attacks of September 11, 2001. National focus shifted to support the wars in Afghanistan and Iraq. Homeland defense capabilities capable of addressing the high north threat continued to atrophy. Homeland defense radar upgrades were a low priority and received no substantial technical upgrades for over 30 years.

However, while the United States focused on sustaining combat operations in the Middle East and Central Asia, China and Russia doubled down on developing new, sophisticated weapons and increasing their presence across the Arctic. Many national security experts flagged these risks, but ongoing Middle East combat operations dominated budget and policy decisions throughout the early 2000s.

The United States and Canada now face a stark new reality across the Arctic. The threat has advanced. China and Russia are committed to increased regional presence. However, America's systems used to monitor these threats are outdated and woefully inadequate to provide necessary situational awareness and early warning for commanders to present options at the strategic, operational, and tactical levels. Most importantly, they lack the credibility necessary to deter first-mover hostile actions. This must change. Robust investment and appropriate policy guidance are required to reset America's defensive measures in the high north.

Increasing Threats from Russia & China

Russia and China's motivations for increased Arctic presence are tied to three main variables: a desire to hold the continental United States at risk driven by peer competition trends, increased access to Arctic natural resources, and time-saving maritime Arctic trade routes. These realities have prompted both Russia and the People's Republic of China (PRC) to boost their military, commercial, and scientific Arctic activities with the aim of gaining an advantage and strengthening their strategic foothold. U.S. leaders recognize these movements and are sounding the alarm. In October 2024, for

"The threat of attack by ballistic, hypersonic, and cruise missiles, and other advanced aerial attacks, remains the most catastrophic threat facing the United States."

-The White House
Iron Dome for America Executive Order[75]

example, then-Chairman of the Joint Chiefs of Staff General C.Q. Brown explained, "We are seeing more and more activity where Russia and [the] PRC are working together, and the Arctic is the most recent area that we're seeing that. It's something we all need to be paying attention to."[4]

Russia's Arctic military activities are particularly troubling. Tupolev bombers and ultra-quiet nuclear-powered submarines frequently conduct mission rehearsals for strikes on North America in areas outside the North American Aerospace Defense Command's radar coverage.[5] In 2022, Russian naval doctrine raised the Arctic region to its highest priority, and President Vladimir Putin directed the construction of more than 475 military facilities across the region. These Russian installations are protected by a multilayered network of sensors and defense systems to ensure their ability to generate military effects on U.S. mainland targets.[6] The Russian Northern Fleet poses a significant threat in and of itself. Roughly two-thirds of the Russian Navy's nuclear strike capabilities are harbored in the Barents Sea, allowing a direct and mostly undetectable path to North America and Europe. In July 2024, the Russian Navy exercised its Barents Sea capabilities with missile cruisers, attack submarines, and minesweepers.[7] Their demonstrated commitment to the region is undeniable. Also in 2024, for the thirteenth year in a row, the Russian Northern Fleet embarked on a two-month maritime exercise in Arctic waters that included combat maneuvers, anti-submarine operations, and general protection of Arctic sea lines of communication operations.[8]

Russia is not alone in its focus on the high north, though. China's foray into Arctic activities covers a spectrum of both civil and military activities, including scientific research, trade agreements, public diplomacy, infrastructure investments, and increased military presence.[9] In July 2024, their military activities caught worldwide attention due to their close coordination with Russian forces in the region. A joint bomber task force comprising two Russian Tu-95 strategic bombers and two Chinese H-6 strategic bombers penetrated the Alaskan Air Defense Identification Zone (ADIZ). This was the first time China and Russia conducted a joint air patrol near Alaska and the first time the two countries launched aircraft from the same Russian airfield. The task force was also unique in that it demonstrated a close relationship between the two air forces that had not been demonstrated before. While the Russian Ministry of Defense claimed a "new area of joint operations," U.S. Senator Daniel Sullivan (R-Alaska) branded the exercise one of "authoritarian aggression" and an escalation.[10]

Importantly, increased Chinese maritime activities have also caught the attention of national security leaders across the board. While serving as U.S. Coast Guard commandant, Admiral Linda Fagan commented that the Coast Guard typically would identify a single Chinese research vessel in the Arctic in a year, but 2024 saw five.[11] Former U.S. NORTHCOM Commander General Glen VanHerck, USAF (Ret.) observed, "The PRC is applying all instruments of national power to enhance

"For decades, NORAD has relied heavily on the North Warning System arrayed along the Arctic coasts of Canada and Alaska to detect potential airborne threats to North America. It is clear that our competitors possess long-range strike capabilities that could be used to attack the United States and Canada from outside the detection range of legacy sensors."

-General Glen VanHerck[76]

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its Arctic influence, expanding initiatives such as the Polar Silk Road."[12] China's Arctic maritime activities are not all civil, either. In 2024, the PRC expanded its maritime military force projection capabilities. Chinese surface combatants deployed to the Bering Sea for the fourth straight year and operated within cruise missile range of critical infrastructure throughout Alaska.[13] Though a specific impetus for this increased level of activity is unknown, China's general ambitions to hold U.S. targets at risk during a potential attempt at expansion through aggression and the rising threats to U.S. and allied forces' security remain clear.

Evolving Missile Threat

Missiles transiting through the Arctic stand as the most prominent threat to the U.S. homeland from a defense vantage point. As then-Assistant Secretary of Defense John Plumb testified in 2024, "As the conflicts in Ukraine and Israel, as well as operations in the Red Sea, have demonstrated, missiles are the principal means by which our competitors and their proxies seek to gain strategic, operational, and tactical advantages."[14] Plumb highlighted the tie-in to airpower as a delivery means for many of these missiles: "Adversaries are developing, fielding, and integrating more advanced air and missile capabilities into their strategies in order to favorably shape the course of a potential crisis or conflict. These air and missile capabilities pose an expanding and accelerating risk to the U.S. homeland, U.S. forces abroad, and our Allies and partners."[15] The Trump administration continues to hold concerns regarding this combined air and missile threat. They are the primary driver behind the Iron Dome Executive Order, signed January 27, 2025. Modeled after Israel's Iron Dome, Golden Dome raises the priority of homeland defense and calls for the resourcing of a next-generation missile defense shield.[16] This is an Arctic-centric mission, given that the Arctic is the most likely vector of attack.

The conventional missile threat has grown for a long time, and now the increased enhanced lethality, improved precision, and proliferating numbers pose a greater threat to the U.S. homeland than, potentially, the Cold War Soviet nuclear missile threat. The 2020 Ballistic and Cruise Missile Threat Report substantiates the conventional threat concern: "Numerous types of ballistic and cruise missiles have achieved dramatic improvements in accuracy that allow them to be used effectively with conventional warheads."[17] Missile ranges also continue to increase. Consider the Russian Kh-101/102, which has a range of nearly 2,000 miles, a distance equivalent to flying from Atlanta to Los Angeles.[18] Even more shocking than the increased missile precision and range is the unchecked missile proliferation across active 21st-century battlefields. In the ongoing Russian war on Ukraine, from September 28,

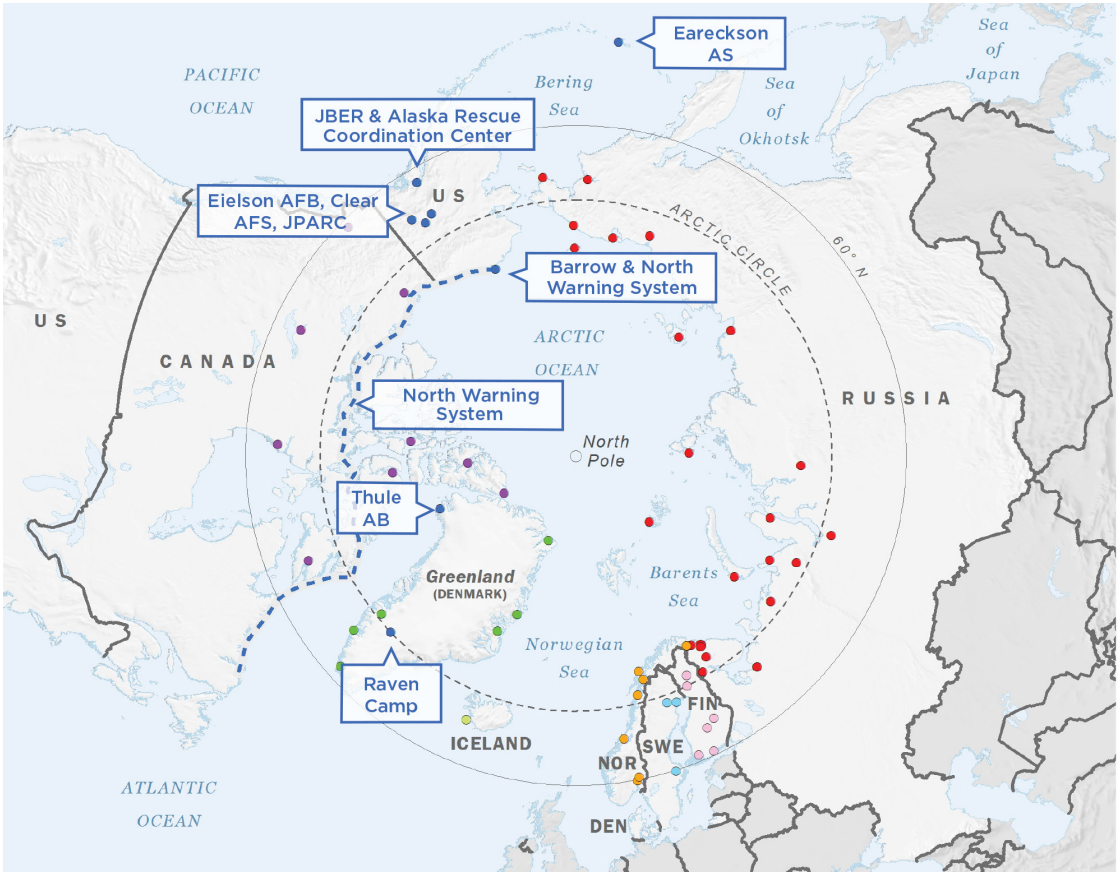

Figure 2: Military facilities in the Arctic region (United States, Canada, Russia, Denmark/Greenland, Norway, Sweden, Finland, and Iceland).

Source: National Geospatial-Intelligence Agency, from the *Department of the Air Force Arctic Strategy*, 2020.

2022, to September 1, 2024, Russia launched a total of 11,466 missiles.[19] They used 36 various missile types, including a combination of ballistic missiles, cruise missiles, and long-range one-way attack drones. They are not limited to domestic production, either, with the international market, most notably Iran, contributing to their offensive magazine depth.

However, unlike in the Cold War, several options for missile defense are viable today. For instance, Israel, with U.S. assistance, defended against mass Iranian air and missile attacks, the most prominent of which occurred in April and October 2024 and in June 2025. Iran targeted Israel with huge salvos of over 300 ballistic and cruise missiles, sometimes erroneously termed "armed drones," the scale of which stressed the capabilities of Israel's defensive systems.[20] Ultimately on both occasions, Israeli and U.S. defensive efforts demonstrated the utility of an effective missile defense shield by intercepting an overwhelming majority of the incoming projectiles.[21] This required the ability to find, fix, track, and target the threats involved. An effective command and control enterprise was also crucial in orchestrating such a complex defensive effort.

Foundational to Israel's success was its modern layered missile defense radar systems. They field several types, including the ELM-2084 multi-mission Super Green Pine radar system.[22] These new-type electronically scanned phased array radars provide advanced early warning against updated airborne threats. Without this type of situational awareness, successful missile intercepts, like those in April and October 2024, or those in June 2025, are not possible. This is why the lack of radar coverage across the Arctic is especially troubling for U.S. homeland defense.

Technical Challenges to Domain Awareness

As the threats continue to mount from and through the Arctic, the U.S. capability to detect modern threats wanes. Outdated sensors cannot cover the ranges needed, nor do they have the capability to detect newer-type threats: they require modernization. Commander of U.S. Northern Command General Gregory Guillot recently testified, "You can't defeat what you can't see, and the adversaries have an increasing capability of reaching us and threatening us from ranges beyond what some of our current systems can detect and track."[23] General Guillot's predecessor, General VanHerck, added, "The North Warning System, when it was designed, it was certainly state of the art. Today, it's a picket fence that [hard-to-detect] missiles can navigate their way through."[24]

The North Warning System (NWS) is the backbone of North American airborne early warning. Constructed in the late 1980s, it comprises 47 radar sites across northern Canada and provides an important radar feed into NORAD situational awareness.[25] Designed to detect high-flying non-stealth aircraft, the line of radars can detect aircraft over 100 miles away at altitudes up to 100,000 feet.[26] But, low-flying, stealth, long-range cruise missiles and drones have the ability to evade the system.

The NWS was designed to detect bomber threats from the Soviet Union traveling from north to south; it is simply not prepared to deal with modern 21st-century air threats.[27] The radar's lack of range allows strike aircraft the opportunity to remain out of radar coverage while launching their missiles. Russian bombers are currently able to take off from an Arctic base, fly over the North Pole, launch a salvo of cruise missiles at North America, and return to Russia undetected. As missiles flew toward North America, they would approach the NWS radar sites with specific missile flight paths that lower the odds of detection. Low-altitude routes could avoid NWS radar sites for more than 70 miles beyond their maximum 100-mile detection range due to terrain masking. Reduced radar cross sections (i.e., stealth characteristics) would further decrease the probability of missile detection. Aside from air-launched cruise missiles, NWS radars also lack the ability to detect and track advanced hypersonic missiles. Ideally, an NWS replacement would detect modern threats, including cruise missiles, hypersonic missiles, and small drones.

In many cases, non-military sensors and radars provide important data to NORAD's radar system to create a more comprehensive common operating picture (COP). Following the 9/11 attacks, the Federal Aviation Authority (FAA) made deliberate efforts to maximize the sharing of data between civilian radar facilities and NORAD.[28] With over 90 percent of Canada's population living within 150 miles of the American border, Arctic infrastructure, as with people, is sparse. Where much of the continental U.S. is covered by various radar systems, much of Canada's vast expanse is outside radar range, even a dead zone for radio communication.[29] Unlike the United States, where a network of civil sensors used for weather and civilian aviation collect tremendous amounts of data, the same networks do not exist across the vast Canadian expanse. Alternative networks of sensors are required.

In some cases, space-based systems provide important capabilities across the Arctic. Though some satellites face challenges reaching the most northern Arctic latitudes, in many cases, they can provide important communications links and intelligence, surveillance, and reconnaissance (ISR) resources when no other options exist. These instances make satellites an important part of improving Arctic domain awareness. Geostationary satellites are inaccessible due to the Earth's curvature. Their orbits are designed to focus on Earth's middle latitudes. Similarly, most low-Earth orbit (LEO) constellations do

not reach beyond the Arctic Circle because their inclinations are optimized for commercial customer markets in more temperate latitudes. Despite the challenges, space-based capabilities continue to evolve and promise to improve Arctic domain awareness in the future to ultimately fill an important gap in an integrated and layered Arctic defense strategy.

U.S. Arctic Strategy: Built on Improved Domain Awareness & Bolstered by Partnerships, Cooperation, & Integration

The critical need for much more robust Arctic domain awareness is one that, while unaddressed, is well understood. The Arctic national security imperative is broadly recognized across both political and military communities, leading to important updates to the U.S. National Strategy for the Arctic Region in 2022 and the Department of Defense Arctic Strategy released in 2024. The U.S. Air Force similarly outlined an Arctic strategy in 2020. Each document recognizes the Arctic's increasing strategic value and identifies Arctic domain awareness as the cornerstone to regional security. The strategic guidance also coalesces on the critical role played by Allied and partner nations across the region and the importance of military exercises to ensure operability and credible joint capabilities.

The 2022 National Strategy established four overall pillars to ensure a peaceful, stable, prosperous, and cooperative Arctic region—security, environmental protection, economic development, and international governance.[30] The first pillar, security, touts its number one objective as "improve our understanding of the Arctic operating environment." Key to this effort is investing in modernized domain awareness to detect and track airborne and maritime threats, including NORAD modernization.[31] The updated DOD Arctic strategy, citing increased Chinese and Russian activities, supplements and supports this parent document, by declaring Arctic domain awareness as the strategy's top priority.[32] "By continuing to invest in sensors, intelligence, and information-sharing capabilities, DoD will enhance our understanding of the Arctic operating environment as well as our ability to manage risk."[33] Improving Arctic domain awareness is the clear path to reducing risk and making the nation more secure.

The 2020 Department of the Air Force Arctic strategy, despite preceding these strategies, echoes them. The number one Air and Space Force line of effort in this strategy is "vigilance." The Department of the Air Force will pursue this vigilance by investing in missile warning and defense and command, control, communications, and intelligence, surveillance, and reconnaissance (C3ISR).[34] Similar to its parent DoD document, the Air Force strategy recognizes the importance of investing in Arctic domain awareness as the first step toward shoring up vulnerabilities to the north, but it also prioritizes cooperation with Allies and partner nations, stating, "Alliances and partnerships represent key strategic advantages for the United States in the Arctic."[35]

U.S. strategic guidance is clear: the keys to maintaining an advantage are domain awareness and international partnerships. The challenge that now remains is prioritizing investment into homeland defenses, including the sensors and systems required to achieve adequate levels of Arctic domain awareness. Shoring up international relationships with Arctic nations is an effort that, likewise, cannot be ignored. While the list of critical regions to U.S. national security is long, Arctic nation relationships must be at the top of the list. No organization is more appropriate to strengthen security relationships with NATO Arctic nations than NORAD.

"For decades, NORAD has relied heavily on the North Warning System arrayed along the Arctic coasts of Canada and Alaska to detect potential airborne threats to North America. It is clear that our competitors possess long-range strike capabilities that could be used to attack the United States and Canada from outside the detection range of legacy sensors."

-Testimony of General Gregory Guillot, U.S. Air Force Commander, U.S. NORTHCOM and NORAD[77]

NATO / NORAD / USNORTHCOM Seams

Successful security operations in the Arctic require clear lines of authority. The Arctic is one of the few strategic regions of the world currently not assigned to a unique U.S. geographic combatant command. Three geographic COCOM theaters merge in the Arctic. These include the Indo-Pacific Command, Northern Command, and European Command. The U.S. Unified Command Plan (UCP) assigns the preponderance of responsibility for the Arctic region to USNORTHCOM. It also designates USNORTHCOM as the Department of Defense's advocate for Arctic capabilities.[36] Arctic security certainly extends beyond North America with the NORTHCOM commander explaining, "as inter-reliance between allies and partners grows increasingly vital to ensuring a secure and open Arctic, USNORTHCOM and NORAD gain strength and capability from our military partnerships."[37]

When the United States faced the Soviet threat in the 1950s, it formed NORAD, a bi-national command focused on the defense of North America. This agreement minimized seams between the United States and Canada and improved the Arctic security posture in several ways. Ground-based radars could be forward positioned, reducing the chance of strategic surprise and allowing for timely intercepts of airborne threats before entering U.S. airspace. Information and intelligence were shared more easily, and command and control friction was reduced by placing the entire North American Arctic domain under the command of a single bi-national NORAD commander. Just as the U.S.–Canada bi-national relationship improved the Arctic security posture, so does a close NORAD–NATO relationship.

The United States' Arctic security posture benefits greatly from a close working relationship with NATO's Arctic nations. Politically, working together as a block of Arctic nations strengthens their collective policy positions. At a more tactical level, NATO nations on the Scandinavian Peninsula monitor Russia's military operations from a most advantageous position. These nations also maintain formidable military capabilities ideally suited for the unforgiving Arctic environment. Most importantly, close U.S. coordination with the NATO Arctic nations, as with Canada in the NORAD arrangement, breaks down communication and command and control seams, ensuring overall security objectives across the region.

NATO's ties to the Arctic are stronger than ever, with the addition of Sweden and Finland into the Alliance raising the priority of Arctic security matters. Over the past couple of years, the European Arctic nations—Denmark, Finland, Norway, and Sweden—developed the Nordic Air Power Concept, bringing their four Air Chiefs together to develop capabilities together

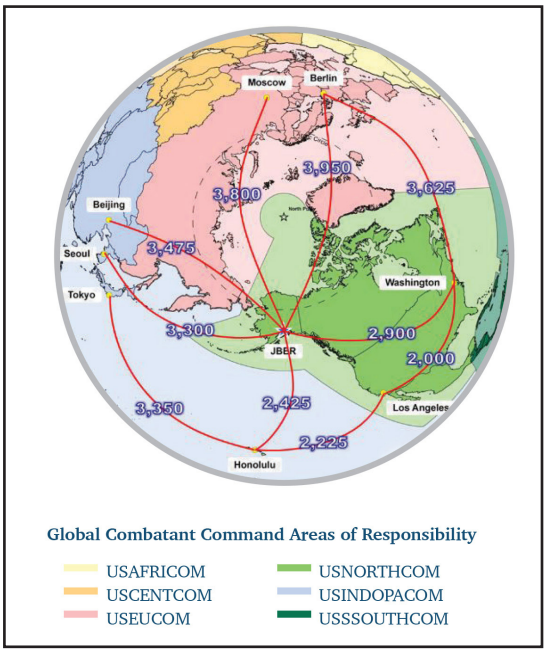

Figure 3: Arctic perspective of Combatant Command AORs. Distances to select capital cities from Joint Base Elmend are in nautical miles.

Source: NORAD/NORTHCOM, from the *Department of the Air Force Arctic Strategy*, 2020.

and act as "one air force."[38] Recently, the Chairman of NATO's Military Committee, Admiral Robert Bauer, articulated the importance of the Arctic by highlighting the creation of NATO's new Regional Plan North. He stated the plan will ensure that "NATO's force posture supports Arctic operations and provides greater Arctic defence coherence."[39] A NATO Regional Arctic Report added, "taken together, climate change, growing global interest in the Arctic, and a renewed geostrategic competition between major powers are all unfolding against the backdrop of an increasingly stressed international system, which demands that NATO brings the Arctic to the forefront of Alliance thinking."[40]

NATO's command structure was established in the early 2000s and ensures effective command and control of NATO Arctic. Divided into three main areas of operation, NATO assigns a Joint Force Commander to lead each of the three regions based in Brunssum, Naples, and Norfolk. NATO's Arctic region is commanded by the Joint Force Commander (JFC) Norfolk. Two 24/7 Combined Air Operations Centers (CAOC) monitor European airspace and provide domain awareness—Uedem and Torrejon. CAOC Uedem, located in Germany, monitors the Arctic. Its area of responsibility spans from Poland's southern and eastern borders across Europe over to the United Kingdom and up to the northern tip of Norway. To streamline NATO's Arctic air defense efforts, the Supreme Allied Commander Europe (SACEUR) is seriously considering the creation of a third NATO CAOC located in the Arctic.[41] Utilizing command and control structures optimized for Arctic operations increases deterrent value against regional threats, increases NATO focus on the Arctic, and improves information flow tied to Arctic security.

Multiple command and control seams merge within the Arctic. These seams include three U.S. Combatant Commands and two multi-national commands—NORAD and NATO's JFC Norfolk. This unusually high number of command fault lines makes information-sharing between the multiple organizations exceptionally challenging. Former NORAD Commander General Glen VanHerck stated, "[The Chinese balloon incident] is a failure of multiple intelligence, and [Department of Defense] agencies. I should not get surprised by something that's coming into my area of responsibility… Anybody who knows about it should pass that on. It shouldn't be less than 24 hours' notice." [42] Information exchange seams within the Department of Defense delayed the handoff of a slow-moving threat. Future threats traveling at greater speeds only compound the challenge. The Department of Defense must make deliberate efforts to maximize the flow of relevant information into and out of NORAD to improve the Arctic security posture.

"Command modernization initiatives, including the establishment of a layered system of sensors such as space-based Airborne Moving Target Indicator (AMTI), Over-the-Horizon Radar (OTHR), the E-7 Wedgetail, and Integrated Undersea Surveillance System (IUSS), remain critical to continental defense in order to detect, track, and prosecute adversary submarines, aircraft and surface vessels, as well as inbound missiles."

-Testimony of General Gregory Guillot, U.S. Air Force Commander, U.S. NORTHCOM and NORAD[78]

Streamlined Information Sharing

If information dominance is a pillar of homeland defense, an essential prerequisite to this dominance is streamlined information flow. Tracking the activities of multiple adversary weapon systems across the vast Arctic expanse requires a complex information and intelligence network that necessarily works across governmental and international borders and involves dozens of separate organizations. As changes occur in the environment and threats emerge, relevant information must be properly analyzed and then provided to decision makers throughout the NORAD chain of command in order to take appropriate action.

This principle is well-recognized. The DOD Arctic Strategy states, "DoD will explore options to expand collaboration with Federal interagency partners and improve information sharing with Arctic Allies and partners."[43] General Guillot likewise asserts, "Addressing threats from long-range missiles, cyberattacks, and uninhabited aerial systems requires close coordination and collaboration with a host of interagency, international, and DoD partners, and USNORTHCOM and NORAD are ideally situated to serve as the synchronizer and integrator for that crucial whole-of-government enterprise."[44] However, many impediments retard the flow of information, reducing the overall security posture across the region. Some impediments are policy-based, others are technical in nature. Regardless, they must be identified and removed. Several lines of effort will be required to realize these necessary improvements and reach the needed technical and policy solutions.

New technologies are squeezing more information from existing sensors and systems than ever before. Where human operator-led analysis and observation might fall short, machines can analyze incomprehensibly large data sets to improve overall threat detection capabilities. Pathfinder is one current NORAD program in development that uses machine learning to analyze data streams from multiple military and non-military commercial and government systems.[45] This technology combs large sets of data collected by the NWS to identify patterns and potential target tracks that a human operator alone cannot decipher.

Airborne threat data can also be obtained from sensors not originally designed for national defense. Civilian air traffic control radars collect tremendous amounts of real-time data that, when fused with other sources, enhance national security. In the wake of 9/11, NORAD integrated internal Canadian and U.S. civil radar feeds into their common operating picture for improved situational awareness.[46] A similar arrangement with Eurocontrol, the organization responsible for controlling civilian air traffic across the European continent, could improve NORAD's Arctic domain awareness. Their air

traffic radars extend into the Arctic Circle over Iceland and the Scandinavian peninsula.[47] Eurocontrol maintains a Memorandum of Cooperation with NATO, but that relationship does not currently extend to NORAD. Further integration of existing Arctic radars like these into NORAD's common operating picture is an important step in growing domain awareness.

One of the most important lines of effort aimed at breaking down information stovepipes, however, remains military exercises. DoD's Chief Digital and Artificial Intelligence Office (CDAO) has hosted exercises aimed at improving information sharing for years. Termed Global Information Dominance Experiments, or GIDE for short, these exercises originated at USNORTHCOM in 2020 under General Glen VanHerck's leadership. He explained, "I'm a firm believer that [someone], in the future, with the right data, at the right time, will win, whether that be in crisis, … in conflict, or day-to-day competition."[48] GIDE experiments aim to break down information-sharing barriers between regional COCOMs and governmental departments, proliferate all relevant sensor data, and frame threats using a more holistic perspective. Experiments conducted in 2020–2022 demonstrated the advantage of eliminating intelligence stovepipes, moving data to a shared information cloud, and integrating systems across multiple COCOMs and international partners.[49]

The 2025 GIDE experiments will "test new communications strategies, but also how well the Defense Department can adjust its procedures and policies for information sharing, a long-time obstacle to faster operations."[50] While there is still a lot of work to do to free up data silos in the Pentagon, GIDE and other joint all-domain command and control initiatives have made notable progress toward better interoperability of systems.[51]

However, the challenges to information sharing extend beyond U.S. borders. International coalition and partner nation information sharing requirements add additional layers of complexity. From a technical perspective, respective countries typically operate on separate and distinct computer networks. Politically, countries wrestle with releasability policies governing the sharing of classified information across these computer networks. For example, the United States uses the classification Secret NOFORN to restrict information to U.S.-eyes only. International alliances and data sharing agreements can address these issues by creating networks capable of sharing information across borders with appropriate classification labels. NATO extensively uses its NATO-SECRET system, and NORAD uses several systems to transmit classified information across bi-national NORAD command and control nodes. Yet, classified information is seldom shared between NATO and NORAD. The two organizations do not typically share military exercises or operations, and when secure communications occur, it's often simply on a secure Battlefield Information Collection and Exploitation System (BICES) telephone line.[52] NATO and NORAD do not share a common operating picture, they operate at different classification levels, and they retain very few means of secure communications between the two organizations. As activity in the Arctic increases, these gaps must be addressed to permit the timely sharing of classified threats.

Layered Arctic Domain Sensors and Command and Control

There are no simple answers to securing the homeland, but any solutions must sufficiently prioritize airborne threats. That is why NORAD is the cornerstone of U.S. homeland defense, charged with detection, validation, and warning of attack against North America by aircraft, missiles, or space vehicles.[53] It operates 24 hours a day, 7 days a week, keeps watch over the entirety of

North America, and operates several regional operations centers across Canada and the United States to ensure layered and redundant command and control. Importantly, NORAD faces far more advanced threats and a more complex national security environment than when it predominantly focused on a unilateral Soviet threat.

NORAD's main operations center is the NORAD/NORTHCOM Command Center, or N2C2 for short, in Colorado. N2C2 is where information and intelligence ultimately coalesce for the NORAD commander's consideration. The faster the data arrives, the more time available to decide how to best react and employ forces. The more complete the data, the better quality a decision is likely to be. Data quality depends on a robust set of air-, surface-, and space-based radars and sensors that continually search for inbound threats the instant they can be detected. Redundant communications nodes are also needed to ensure that the data collected can be processed and fused into actionable information, then disseminated to decision makers. The penultimate goal is to empower timely command and control across the entirety of North America to address airborne threats.

Airborne threats, especially cruise missiles, are important to counter because they can hold important targets at risk, are hard to detect, and are not as likely to aggressively escalate a conflict as would an intercontinental ballistic missile, especially one armed with a nuclear warhead. As events in Ukraine prove, there are tremendous sensitivities tied to perceived nuclear escalation. The use of cruise missiles would also drive a sizable holdback of U.S. forces to address homeland defense demands. This would cause a net reduction of the capacity for power projection abroad—something especially useful for an enemy hoping to minimize the availability of U.S. forces to counter their aggression across the globe. The benefit is obvious in the context of a Chinese invasion of Taiwan or a Russian attack on a member of NATO. Consequently, adversaries are growing their cruise missile forces such that the sheer numbers overcome Cold War-era U.S. missile defenses.

The scale and scope of this modern threat environment demand that a northern tier defense begin with a layered sensor network feeding command centers and decision makers. Turning robust domain awareness into necessary and appropriate responses to various threats relies on a set of cascading steps. First, sensors need to scan to detect objects at range. From there, tracks must be established to determine the vector, potentially intimating the intent of the asset in question. For example, an airborne asset flying along a border is different than one crossing a border and flying toward a populated area. If the asset in question appears to have hostile intent, it is deemed a threat and must be targeted for interception, which may include a kinetic kill. There is no single system that executes these functions. Instead, it takes a variety of technologies on the surface, in the air, and in space to engage collaboratively. Each domain capability has respective advantages and weaknesses, but the goal is to field a combined set of surface-, air-, and space-based sensors that eliminate gaps in data or information and provide timely domain awareness and command and control.

Urgent Need For Early Warning

Accelerated E-7 acquisition is more important now than ever, given the current Airborne Early Warning and Command System (AWACS) struggles. Fighting a meager 55 percent mission-capable rate, AWACS need replacement not just due to their outdated radar.[79] The old airframe has become unsustainable with replacement parts in short supply. These geriatric aircraft are flying beyond their expected lifespan with little relief in sight.

Given the vast expanse of the Arctic, detecting and tracking targets is no small task. Over-the-horizon radars provide a formidable capability for detection and tracking. The sensors outperform traditional radars by providing much greater detection ranges and covering larger volumes of airspace. Existing OTHR systems can detect targets at distances between 600 and 1,800 nautical miles.[54] These systems are best suited to threat detection and tracking, as they lack the necessary fidelity to execute the targeting function.

Due to the size and complexity of the program, the OTHR program will take years to develop and require the support of both the United States and Canada. Most experts agree that defending such vast expanses of terrain from advanced missile threats requires OTHR. In 2022, the U.S. Missile Defense Review stated, "modern over-the-horizon radar capabilities are essential to improving warning and tracking against cruise missile and other threats to the homeland."[55]

Both Canada and the United States are working toward OTHR implementation. Canada committed $6.9 billion in new technologies to modernize their surveillance systems. They specifically highlighted the importance of OTHR and satellites in their 2022 national defense strategy.[56] Their plan is to deploy two separate arrays of OTHR systems—the Arctic OTHR located along the U.S.–Canada border and the Polar OTHR located much further north near the Arctic Circle.[57] Combined, they will provide an unprecedented improvement over the existing North Warning System with radar search areas extending out thousands of miles, enabling the ever-critical early threat detection that affords commanders sufficient time for threat reaction.

U.S. efforts to field the OTHR are also moving forward, but at a slightly slower pace. The U.S. Air Force leads OTHR program development and informed Congress in 2024 that procurement would be delayed due to an update in their acquisition strategy.[58] Any additional budget delays now threaten to push the 2031 initial operation date of the system, even though replacing the NWS with OTHR as soon as possible must remain a priority effort to detect threats at sufficient range to allow decision makers time to react.

Space-based radar systems could supplement the OTHR capability with an additional layer of threat detection and tracking, but many believe the technology to be years away from operational relevance. Most notably, Airborne Moving Target Indicator (AMTI) promises to one day detect and track airborne threats using sensors in space. As with OTHR, space-based sensors will likely contribute primarily to the detection and tracking portion of the kill chain, due to data fidelity.

The U.S. Space Force and the Space Development Agency (SDA) are organizations charged with operating space systems and fielding future ones. Both have plans to advance capabilities relevant to Arctic domain awareness. The Space Force already operates several systems that provide missile launch warnings and space-based communications. Moving forward, AMTI remains a priority Space Force effort. Providing the ability to detect and track airborne aircraft using sensors in space would truly be a revolutionary capability that could cover areas much greater than any surface- or air-based radar system.

Details surrounding space-based AMTI systems remain closely held, but former Vice Chief of Space Operations General Michael Guetlein forecasts space-based AMTI capabilities to start coming online in the early 2030s.[59] In 2023, the Air Force Scientific Advisory Board conducted a study on the feasibility of space-based radar, but those results have not been made public. Though many technological hurdles remain,

recent advancements in small satellites and the exponential growth of proliferated low-Earth orbit (LEO) satellites potentially bring this capability within reach. One issue catching the attention of experts pertains to access to the electromagnetic spectrum. Some have expressed concern that commercial 5G's use of S-band 3.1-3.45 GHz may conflict with space-based radar.[60] Issues such as these run the risk of further delays in what is a very technologically advanced and important program.

Where surface and space-based radar data are not targeting-quality, the airborne layer affords options that bring increased fidelity for establishing tracks and generating targeting data. These systems are also available now—a key consideration given that OTHR and space-based AMTI are still in development. These aircraft include the E-3 Airborne Early Warning and Command System (AWACS) and its successor, the E-7 Wedgetail. They carry early warning radars capable of detecting targets at distances of several hundred miles.[61] Though these airborne radars lack the range of surface or space-based systems, they can fill gaps in degraded data, bring flexibility in sensing options, and have the ability to cover unexpected avenues of attack.

Uninhabited aerial vehicles (UAV) can also complement manned aircraft in the airborne early warning mission. Aircraft such as the MQ-9 and RQ-4 can fly higher and longer and be equipped with numerous sensors capable of collecting radar and other data. Their lower operating costs and smaller number of crew members allow several aircraft to operate at the same cost as a single E-3 or E-7 aircraft. Importantly, using uninhabited aircraft to extend the number and spread of sensors does not preclude the need for E-3s or E-7s, but instead can free them up to focus more on their critical battle management roles.

One drawback to existing medium/high altitude long endurance (MALE/HALE) aircraft is their limited electrical

Aircraft Flexibility

Aircraft provide unmatched flexibility to the Arctic domain awareness mission. Their integration precludes the creation of a northern tier Maginot Line, the infamous French defensive posture outmaneuvered by the Germans at the start of World War II. An entrenched land-based perimeter of surface radars constantly faces the reality of harsh Arctic weather, routine maintenance upkeep, and the threat of attack, any of which could result in a vulnerability and be exploited by the enemy. Aircraft can deploy to and operate from different airfields around the globe, can immediately reposition while airborne, can stay aloft for over 24 hours, and carry an assortment of sensors capable of multi-spectral awareness optimized for an assortment of targets. Northern tier airfields across the United States and Canada are valuable real estate. Basing aircraft further north increases time on station by reducing flight transition time between the airbase and the air patrol area. MQ-9s have proven they can move airfields given their light logistics footprint. In the 2022 Exercise Valiant Shield, the launch and recovery element swapped airfields in under 20 hours using less than two standard pallet loads of equipment. But flexible aircraft payloads could also improve Arctic domain awareness. The Air Force RQ-4 Block 30 fleet is being completely re-instrumented from electro-optical and signals intelligence to collect missile telemetry data for hypersonic testing across thousands of miles. Additional payloads are possible. While famous for full-motion video capabilities, the MQ-9 successfully employed multi-spectral intelligence collection and fusion during the 2021 Exercise Northern Edge. The E-7 Wedgetail, based on a Boeing 737 airframe, brings unmatched ability to onboard additional size, weight, and payload as it continues to evolve. The flexibility and capability of these aircraft promise to provide a key component to a multi-layered Arctic domain awareness architecture.

power output. The E-7 is based on a Boeing 737 class aircraft, which puts out 360 kVA total and can carry upward of 40,000–50,000 lbs of payload.[62] MQ-9s and RQ-4s put out 25-45kVA, and carry a substantially smaller payload of 2,000–5,000lbs.[63] Less power equates to less radar range, and less payload equates to fewer and smaller sensors than aircraft with more powerful engines. But what these aircraft lack in power, they make up in mass and endurance. Combined, piloted and uninhabited aircraft provide unmatched flexibility and important detection and tracking capabilities that complement surface- and space-based systems. In its entirety, a system of surface, air, and space sensors provides the redundancy needed to counter extreme weather, vast distances, and a determined enemy threat.

Beyond the collection architecture, equally important is the ability to move threat data to a command and control node for decision and immediate action. Air and space systems also support this critical capability. Effective command and control is essential for domain awareness and for orchestrating a timely and appropriate response to inbound threats. Arctic command and control requires combining sensor data across an extremely wide region, so it must be supported by an extensive communications system. Given the lack of infrastructure across most of the Arctic, air and space systems are critical to this data transport.

Satellites operating in highly elliptical orbits (HEO) best serve customers in the high north and bring important capabilities to future military operations, most notably improved communications. Space Norway, in partnership with the U.S. Space Force, recently launched the Arctic Satellite Broadband Mission (ASBM) satellite into a HEO orbit to fill some of the resident communications gaps.[64] Prior to ASBM, uninhabited aircraft such as the RQ-4 Global Hawk struggled to operate north of the Arctic Circle due to its dependence on geo-stationery communications satellites. Geostationary satellites are unusable north of the Arctic Circle due to interference by the Earth's horizon. Capabilities like ASBM improve Arctic communications while enhancing command and control architectures.

SDA continues to push the technological boundaries with the rapid development and deployment of the Proliferated Warfighter Space Architecture (PWSA). Over the next few years, PWSA will provide data relay and missile warning and tracking. Ultimately, it will be the space backbone for command and control with low-latency data transport, sensor-to-shooter connectivity, and tactical satellite communication direct to relevant battlefield nodes around the world.[65]

In addition to space systems, aircraft like the E-3 and E-7 provide an essential Arctic command and control function. NORAD's fixed regional command centers rely on extensive communications systems to monitor for incoming threats. Any communications interruptions could sever the vast network of sensors from the regional command centers, resulting in a loss of control over defensive operations. These dynamic defensive counter-air scenarios require networked and redundant command and control systems, for which the E-7 aircraft was specifically designed. The E-7 co-locates air battle managers with its powerful air-to-air radar, providing a proven intermediate-level command and control node capable of monitoring a large swath of airspace with decision makers immediately tied to the aircraft. The E-7 collects threat data, presents it to an onboard decision-maker, and then provides an extensive suite of radios allowing timely communication of any subsequent directives. For instance, once a threat is

detected, it might be appropriate to vector a fighter aircraft for intercept. Once fielded, the E-7 provides a flexible command and control node in addition to an optimally positioned powerful radar within the battlespace. These are both important enhancements to Arctic domain awareness.

Arctic domain awareness relies on multiple systems; no single system, no matter how capable, provides an adequate radar picture by itself. Success demands a teamed approach. The combination of space, surface, and air sensors reduces vulnerabilities and eliminates coverage gaps. It is not an either-or question with these systems; a robust capability requires all components. Threat data collected by these systems must feed a flexible and responsive command and control system with multiple nodes connected by redundant communications paths. Any adequate command and control system would comprise command nodes located both on the ground and in the air, connected by communication systems across the air, surface, and space.

Conclusion

A review of the Arctic security situation reveals a concerning vulnerability to homeland defense. Inadequate domain awareness leaves the United States open to strategic attack. China and Russia's continued proliferation of precise long-range conventional aerial weapons, their desire to hold our strategic interests at risk, and their increasing Arctic activities make the situation dire. Reducing this threat will require a combination of efforts centering on improved domain sensing, improved information exchange, and international partnerships.

Improved domain sensing rests on a layered set of systems comprising surface, air, and space capabilities. None of the systems is independently sufficient for the epic task of providing Arctic domain awareness, so each component is complementary to the others. The cornerstone of domain awareness is the OTHR surface-based NWS replacement. Of all the recommended components, this system brings the most capability in the shortest time frame. The airborne components bring the greatest flexibility and survivability. The uninhabited MQ-9 and RQ-4 aircraft are ideally suited for the surveillance mission, given their high operating altitudes and long endurance. The E-7 has the greatest air-to-air radar capabilities and serves as an independent command and control node. Finally, the space-based component to domain awareness, while the most technologically immature capability, could, with sufficient investment, eventually replace the need for complex ground-based OTHR systems.

Equally important to a layered sensing architecture is an efficient information sharing enterprise encompassing DOD, state, and federal institutions, as well as pertinent foreign entities. This holistic intelligence and information conglomeration must break down stovepipes resulting from both technical and policy barriers. DOD's Chief Digital and Artificial Intelligence Office (CDAO) certainly plays an important role in reducing the number of information stovepipes within the Department, but, moving forward, a CDAO-like office above the DOD level is required to ensure information flow between governmental departments and partner nations. The Department of Transportation, Homeland Security, and Eurocontrol are all prime examples of organizations that routinely handle information pertinent to Arctic domain awareness and require seamless ties to NORAD's common operational picture.

Finally, European nations ideally located on Russia's Arctic front door offer important partnership opportunities. European countries on the Scandinavian peninsula offer significant insights into Russian military activity with their front-row view of the

adversary, in addition to their deep cultural understanding. These countries routinely collect critical information on Russia that should directly feed NORAD's intelligence assessment and common operational picture. Despite recognition of this partnership's importance, few touchpoints presently exist between NORAD and the Joint Nordic Air Command. Deliberate DOD efforts could alleviate this shortfall.

Policy Recommendations

1. Defend the homeland and deter strategic attack against the United States. This is the number one strategic priority of the new presidential administration and the DOD. Despite the rapid advance of adversary conventional weapons capable of holding the United States at risk, North American continental defense has remained a lower priority than warfighting abroad for decades. Years of relative inattention yielded a weak set of capabilities to protect the homeland. Historically, America aimed to fight our nation's wars on foreign lands to boost domestic security. While this is a fundamentally sound principle, it does not abrogate leaders from robust domestic security investments. This strategy fell short following the historic air attacks of December 7, 1941, and September 11, 2001. We risk another strike on U.S. targets if we do not heed the warning of growing hostile adversary actions and their advancing technological means.

Increasing levels of Chinese and Russian Arctic activity in recent years demand a special focus on upgrading and maintaining domain awareness in the north. The proliferation of long-range precision-strike missiles increases the likelihood of future aerial attacks on the homeland. Current threat detection means built for the Cold War are no longer adequate, given the capabilities of advanced adversary technologies. Former NORAD Commander retired General Glen VanHerck highlighted these concerns: "The North Warning System, when it was designed, it was certainly state of the art. Today, it's a picket fence that missiles can navigate their way through."[66] A panoply of modern threats, including long-range cruise missiles, drones, hypersonic missiles, and fractional orbital bombardment systems, demands a more capable warning enterprise. The Department of Defense must budgetarily prioritize systems that can directly defend the homeland by deterring and defeating multiple means of aerial attack.

President Trump's Golden Dome executive order provides clear guidance to prioritize U.S. homeland air and missile defense acquisition efforts. Senator Sullivan and Senator Cramer's 2025 Iron Dome Act provides a key step toward manifesting the president's vision. Fulfilling this executive guidance begins with improving aerial and maritime domain awareness. Because missiles targeting the United States could be launched from the ground, sea, or air, domain awareness must extend as far north as possible, ideally to detect enemy ships, submarines, or aircraft prior to launching their salvo of missiles. This should occur through a layered air-surface-space sensor network to minimize coverage gaps across the vast Arctic expanse. The data collected by the network must then seamlessly combine with data already circulating throughout NORAD's communications networks to inform a robust common operating picture across the command's multiple command and control nodes. A dynamic and ubiquitous information sharing network with reach across America and between agencies and partner nations ensures maximum decision space for senior-level leaders.

2. Accelerate the fusion of all-source data to enhance Arctic domain awareness. The 2023 Chinese balloon incursion into U.S. airspace exemplified the chasms permeating America's national security enterprise,

especially when it comes to the timely exchange of information between involved agencies, commands, and departments. A shared common operating picture is essential to alleviate the challenge of maintaining custody of individual targets across seams between geographic combatant commands.

NORAD has long known it faced an information stovepipe problem, so it hosted a series of Global Information Dominance Experiments to try to improve data flows. These efforts focused on a NORAD priority: expediting the processing and sharing of information between combatant commands, allies, partners, and the interagency community. The experiments have grown over the years and are now run by the DOD's CDAO. In addition to breaking down information stovepipes, they also aim to improve joint all-domain command and control, while implementing artificial intelligence tools to facilitate processing larger amounts of data and improve senior leader decision-making.

This speaks to a priority of former NORAD Commander General Terrence O'Shaughnessy, who highlighted that the U.S. military must aggregate multiple sensors and information systems to move beyond traditional stovepiped systems in the high north. That ecosystem needs to fuse information from as many sources as possible as quickly as possible—air, surface, space, and sub-surface sensors—to attain what he termed "predictive analysis." This real-time fusion of data from multiple nodes provides decision-makers with a distinct advantage over their adversaries. The concept is well understood, but, as multiple field commanders observe, and as the GIDE experiments highlight every year, fusing sensor data and connecting disparate computer networks is difficult to execute, especially seamlessly. Moreover, technical and policy roadblocks often restrict information sharing.

Solving this set of challenges is not easy. The Department of Defense must impose integration across the joint community in service-specific systems and mandate that combatant commands integrate between commands. DOD must continue to support the GIDE experiments and expand them to include international partners and NATO. DOD must also fund U.S. NORTHCOM and NORAD's FY 2025 leading unfunded priority—"foundational information technology"—to provide a secure and resilient information environment for all NORAD's strategic efforts. Along these lines, DOD's Maven Smart System shows promise. It ties headquarters together across combatant command boundaries while also tying together information across discrete information domains at different classification levels.[67] DOD must further expand investment into programs that facilitate this type of information exchange.

A critical piece of the Golden Dome architecture must be rapid information exchange. Defending the entirety of the homeland requires getting as far "left of launch" as possible. Timely information exchange across the whole of government will be essential. As the bureaucratic structure responsible for building the Golden Dome is formed, it must contain an office like CDAO that breaks down information silos across the entire federal government and not just within the Department of Defense. This office must identify policy and technical barriers to data and intelligence sharing while accelerating the adoption of data, analytics, and artificial intelligence.

3. Configure Sky Range UAVs for dual-use homeland defense aerial surveillance. Homeland defense is too important for single points of failure, which is why NORAD commanders consistently profess the importance of a layered sensor network to provide domain awareness. The Space-based airborne moving target indicator

effort shows tremendous technological promise, but it is years away from operational relevance and will likely not have the acuity of air- and ground-based radars. Existing long-endurance medium-high altitude uninhabited aircraft offer a promising near-term solution to Arctic domain awareness. These systems are available, and crews are highly experienced in their operation.

An inventory of readily available UAVs exists at the Grand Sky section of Grand Forks Air Force Base in North Dakota to support the Test Resource Management Center (TRMC). The center operates an extensive fleet of MQ-9s and 27 RQ-4s. These aircraft are primarily tasked to monitor hypersonic weapons testing, but the time between tests presents an opportunity for the aircraft to support additional activities. Additional domain awareness activities, importantly, would be possible. Facilities involved with this mission are already in use at several missile defense radar sites across the Pacific and serve in similar capacities, supporting both missile defense and missile testing activities.

Adding payloads like an airborne moving target indicator radar capability could supplement the Arctic domain awareness mission. MQ-9s could carry a host of external collection pods, which could consist of electro-optical, infrared, and radio frequency payloads to monitor Russian airfields and aircraft at extremely long ranges. The relatively small logistical footprint of the MQ-9 enables forward deployment of the aircraft to airfields across Canada. Forward basing far north would decrease transit time and increase the aircraft's loiter time and mission effectiveness in monitoring the threat. RQ-4 aircraft would require modification, but with some investment, an internal electronically scanned phased array radar would allow search ranges out to 200 nautical miles for airborne threats. Currently, a similar radar capability is found on the MQ-4C Triton Navy variant of the RQ-4. The 30-hour RQ-4 loiter time provides unmatched persistence from a high-altitude aircraft. Overall, the TRMC's aircraft offer a cost-effective, strategically located, flexible, and responsive sensing capability that can help to increase detection and tracking of air and missile threats deep into the Arctic region.

4. Lead international commitment to E-7 Wedgetail acquisition. Former Air Combat Command commander General Kenneth Wilsbach recently said, "It starts with the E-7. Having domain awareness is important. [The reason] why we need the E-7 so badly is because our current fleet of E-3s are challenged remarkably, just getting them in the air."[68] The U.S. Air Force had to delay its AWACS aircraft recapitalization plan for decades because the service did not have sufficient budgetary resources. These same budget pressures caused the U.S. Air Force to divest more than half of its E-3 inventory without any replacement. The original AWACS inventory numbered 33 aircraft. Today, that number stands at only 16. With a 55 percent aircraft availability rate, this takes an already small inventory and cuts the number of available aircraft down to roughly eight.

Despite the critical state of the E-3 fleet and the unquestioned importance of the air superiority mission, the Air Force recently announced the cancelation of the E-7 program, causing many experts to scratch their heads in disbelief. Retired Lieutenant General David Deptula characterized the decision as, "a costly and strategic blunder."[69]

Cancelation of the E-7 program places the United States in a precarious situation, given the age of the existing AWACS fleet and the lack of any other suitable replacement. Maintaining the aging AWACS aircraft through the mid-2030s is projected to cost nearly $10 billion. Prospects to transition to a space-based AMTI capability face significant technical challenges involving engineering, testing, and fielding an operationally

relevant capability. The transition could take decades, and its integration with the air battle management function is unclear. Finally, proposals for five Navy E-2 Hawkeye aircraft to replace the fleet of AWACS fall significantly short of meeting theater air battle management requirements across the multiple combatant commands.[70] Moreover, the E-2 lacks the range, power, and crew capacity for air battle managers that the U.S. Air Force requires, especially in geographies such as the Western Pacific. The risk associated with program cancelation is simply too high, and Pentagon leadership should reconsider terminating the E-7 program.[71]

Absent U.S. E-7 aircraft, substantial requirements exist for allies and partners to supplement this important mission. Heightened tensions in the European or Pacific theaters would rapidly increase battlespace situational awareness demands across vast expanses of airspace. Just as U.S. homeland defense would require multiple 24/7 airborne early warning combat patrols to closely monitor the most likely avenues of attack, the same would apply overseas. Airborne early warning aircraft minimize strategic miscalculation, strengthen defensive posture, and provide a flexible deterrent, but 24/7 presence and long stretches of adversarial border require large numbers of aircraft to maintain adequate coverage. To date, many countries have already acquired E-7 aircraft with more in the process of acquisition. Australia, South Korea, and Turkey already fly a total of 14 aircraft. NATO and the United Kingdom are in the process of acquiring an additional nine aircraft.

Moving forward, the United States must fund the U.S. Air Force E-7 program. The capability is essential for homeland defense and Arctic domain awareness. Additionally, the United States should continue to press NATO to increase its E-7 purchase above its current six aircraft. NATO's existing fleet of 15 AWACS aircraft requires significantly more aircraft than another six to provide a similar replacement capability. The E-7 could potentially help Canada meet the security challenges of its vast territorial expanse, commitment to NORAD, and recognized gaps in aerial domain awareness. E-7 purchases could also help Canada raise its national defense spending from its current level of 1.24 percent of Gross Domestic Product (GDP) closer to the NATO minimum of 5.0 percent.

5. Accelerate modernization and replacement plan for the Northern Warning System. During its 67-year history, NORAD has largely relied on an interconnected series of ground-based radars to provide early warning of aerial attacks. Upgraded most recently in the 1980s, the Northern Warning System was designed to detect and track Soviet long-range bombers approaching from the North Pole. In 2021, Canada and the United States released a joint statement on a NORAD modernization effort that promised to replace the NWS with the more advanced OTHR as soon as possible. Although timely replacement of the NWS with the more capable OTHR remains a key component of Arctic domain awareness, to date, the Department of Defense has failed to resource NWS recapitalization. In 2024, while General Gregory Guillot, NORAD's current commander, testified that OTHR would "significantly enhance domain awareness in the air," the Air Force informed Congress of its intention to delay the planned FY 2024 sensor upgrade project in favor of higher priority projects. However, OTHR must remain a priority effort to rebuild Arctic domain awareness. Its ability to detect low-altitude and long-range targets, its relative cost-effectiveness, and its continuous operational coverage make it a critical asset for North American air defense. While space-based radar holds great promise, many capabilities are years away, and OTHR provides unique advantages in terms of detection, coverage, and adaptability for defending against regional airborne threats.

Meanwhile, in 2022, Canada announced a $38.5 billion twenty-year NORAD modernization plan. The plan includes acquisition and deployment of an OTHR system that covers from the U.S.—Canada border to beyond the Arctic Circle. Radar site preparation has already begun. The system is planned to meet initial operating capability in 2028. Because the OTHR will remain an integral piece of a layered domain awareness system, the United States must also increase budget priority for this system to allow immediate acquisition and deployment in a minimum time.

6. Accelerate fielding of space-based Arctic domain awareness capabilities. Since the original fielding of the Northern Warning System, space-based capabilities have greatly expanded and offer important opportunities to improve domain awareness. Continued investment remains paramount. The Arctic's vast expanse and lack of basic infrastructure increase the attractiveness of space-based capabilities. Looking forward, the continued migration of sensing and communications capacity provides a critical piece to the Arctic domain awareness architecture.

The ability to detect and track airborne targets using satellites, otherwise known as airborne moving target indicator, is an important manifestation of space-based sensing. Details surrounding space-based AMTI systems remain closely held, but General Michael Guetlein, former Vice Chief of Space Operations, forecasts space-based AMTI capabilities to start coming online in the early 2030s. Though many technological hurdles remain, recent advancements in small satellites and the exponential growth of proliferated LEO satellites bring this capability closer each day.

The disaggregation of sensors across hundreds to thousands of satellites provides the ultimate high-ground and an unmatched field of view, but requires high-speed and dependable communications to be effective. Often referred to as the "transport layer," satellites must seamlessly transmit data between themselves and down to Earth-based ground receivers. Satellites the size of school buses are being replaced by micro-satellites no larger than mini refrigerators, creating resilient communications networks encircling the planet. The continued proliferation of space-based communications enhances Arctic security by providing alternative data pathways across a region lacking basic infrastructure.

The U.S. Space Force and the Space Development Agency (SDA), charged with fielding and operating future space systems, continue to work to improve homeland security and reduce the risk of attack. However, they require programmatic commitment for the continued development of their technologies for an Arctic defense.

7. Create a new Assistant Secretary of Defense responsible for "Arctic Security." The Office of the Secretary of Defense for Arctic and Global Resilience Office requires a refocus on strictly Arctic defense and deterrence matters. Its current umbrella of responsibilities includes protecting the U.S. homeland and allied interests in the Arctic region; managing oceans policy and the freedom of navigation program to uphold the maritime rules-based order; addressing strategic resilience risks, including critical minerals and energy security; and ensuring DOD maintains innovation advantages in strategic competition. This broad portfolio detracts from the goal of deterring and defeating attacks through the Arctic.

Given the current administration's focus on warfighting and homeland defense, a revamped office focused on U.S. Arctic defense policies is not only fitting, but also much needed. This entails establishing an Assistant Secretary of Defense responsible for Arctic Security to lead an office with three objectives. First, the office would plan, program, and support data sharing and secure sufficient domain awareness from the

seafloor to space. Second, it would support the development of deep partnerships with appropriate allies, partners, and the NATO alliance. Finally, the office would aid the services in prioritizing training and equipping for Arctic environmental conditions.

U.S. NORTHCOM commander General Guillot explained the basic principle of domain awareness in his February 14, 2025, testimony to Congress: "You cannot defeat what you cannot see."[72] Homeland defense relies first and foremost on domain awareness. A new Arctic security office must advocate for a multi-layered network of sensors and break down the inter-agency policy barriers that prevent the timely sharing of information and intelligence. In addition to the Department of Defense, many traditional security-focused agencies collect time-sensitive information that contributes to domain awareness—the Department of Homeland Security, National Security Agency, Federal Bureau of Investigation, and U.S. Coast Guard. This office must ensure that respective policies do not prevent the sharing of information across common bureaucratic boundaries.

Arctic domain awareness requires close partnership with Canada, the United Kingdom, and other European Arctic nations. Sweden, Norway, Finland, and Denmark have kept a watchful eye on Russian activity for decades. Their shared national security priority has been Arctic domain awareness since the end of World War II. Recent NATO expansion has only increased focus on Arctic security. The Arctic Council is one of the few international organizations solely focused on Arctic issues, but it avoids military matters by decree. This opens an opportunity to shape security policies and improve coordination and cooperation across the region for mutual benefit. Combined military exercises, shared intelligence agreements, and cohesive systems of sensors spanning across Arctic nations improve collective defense through the improved domain awareness that underpins denial and deterrence activities. Shared collective defense is also strengthened by multinational interoperability of fielded military forces.

With a proven record of performance in the harshest Arctic weather conditions, NATO Arctic nations set the standard for cold-weather operations. U.S. military forces benefit from this training. First, training equipment and personnel are forced to overcome the real-world hostile Arctic environment. Second, as multi-national forces collaborate, they improve interoperability and gain regional expertise. And finally, maintaining a routine military presence enhances deterrence and demonstrates commitment to the region's security. The DOD Arctic Security office must continue to direct and encourage multi-national military training exercises across the region.

8. Foster NATO's Arctic focus and direct partnership with NORAD. Immediate proximity to Russia drives Norway, Sweden, and Finland to keep a close eye on all Russian military activity within the Arctic Circle. Most recently, security concerns prompted them to combine their air forces, establish a Joint Nordic Air Command, and lay out a vision for common defense under the Nordic Defense Cooperation. Each country fields formidable military capability and has kept busy integrating into NATO's evolving Regional Defense Plans. Over its 75-year history, NATO has always stressed the importance of interoperability. Integrating 32 countries into a collaborative force takes deliberate effort, and an important piece of interoperability is the ability to share timely information between countries and among military headquarters. Historically, NATO and NORAD have maintained few touchpoints and hosted few combined exercises aimed at integrating the two organizations. Given the low levels of military Arctic activity in the past, there was little need for coordination. Today's rising Arctic threat now requires immediate attention to this vulnerable seam.

Despite the recent addition of two new NATO Arctic nations, NATO has done a formidable job of minimizing command-and-control seams. However, a prominent seam remains between NATO and NORAD. The two commands report through separate international chains of command and operate using separate computer networks and classification systems. Breaking down these stovepipes requires deliberate action to ensure the timely sharing of Arctic information and intelligence.

NATO's Air Component Commander signaled intentions for the creation of an additional Combined Air Operations Center focused on Arctic operations in September 2024. Creating this command and control node would go a long way to help meet NATO's defensive requirements. It would serve as an ideal connection for NORAD into NATO's Arctic domain awareness ecosystem, and as a distant eastern front-door to homeland defense threats. It took NORAD years to break down policy barriers to ensure the timely sharing of sensitive information between Canada and the United States. A similar effort to break down policy barriers to allow the timely sharing of information between NORAD and NATO is required. Without this real-time information-sharing conduit, NORAD faces an unacceptable information void to its east. Just as Alaska's proximity to Russia provides immediate awareness of Russia's Arctic activities, NATO's Scandinavian peninsula provides the same. Formation of the Joint Nordic Air Command and the future NATO Arctic CAOC provides an ideal opportunity for NORAD to conduct information-sharing exercises and interoperability discussions aimed at the Arctic countries, focused on the immediate Russian threat. ✪

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