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Journal of Arctic Security

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Dear and Distinguished Colleagues,

It is with great pleasure that I welcome you to the third volume of the Journal of Arctic Security, the flagship publication of the Ted Stevens Center for Arctic Security Studies. In an era of accelerating change, the Arctic has captured the world's attention, perhaps as never before. What was once a region perceived as remote and isolated is now at the forefront of geopolitical discourse, driven by a confluence of factors including easier access, growing economic interests, and intensified strategic competition. This increasing focus in the press and among policymakers underscores the critical need for informed, nuanced, and forward-looking analysis of the security and defense dynamics shaping across the High North.

The Stevens Center is proud to contribute to this vital conversation through our diverse range of publications and programs, with this journal serving as a key platform for advancing awareness and understanding of the complex challenges and opportunities facing the United States and our Allies across the Arctic region.

As you review this publication, please know, the Stevens Center is dedicated to building and supporting a network of security and defense professionals to advance collaborative solutions for the Arctic.

Our mission is rooted in the belief that a secure, stable, and prosperous Arctic requires a comprehensive understanding of the region in all its dimensions—from the geophysical to the geostrategic. Using the principals of innovation and experimentation, we at the Center strive to foster a "whole-of-community" approach, bringing together military and civilian practitioners, to share knowledge and develop practical solutions to shared security challenges. Our principal product are well prepared practitioners in Arctic security and defense...Americans, Allies, and partners.

The Journal of Arctic Security is a cornerstone of this effort. JAS complements our other Center publications, such as our Operational Analyses and Executive Briefs, as well as our wide array of educational courses and engagement seminars, by providing a forum for in-depth research and diverse perspectives on the most pressing security issues of our time...focused on the Arctic.

This journal, and the work of the Center as a whole, is committed to a holistic view of security that encompasses not only traditional defense matters but also the critical dimensions of the operational environment and human terrain, recognizing that economic, energy and the health of its environment are inextricably linked to regional stability.

This third volume of the Journal of Arctic Security continues our tradition of presenting rigorous, relevant, and thought-provoking discussions and analysis on a wide range of Arctic security and defense topics. The articles in this volume are intended to spark dialogue and critical thinking about the evolving character of warfare and strategic competition in the High North. Among the timely and important topics explored in these pages, you will find a detailed examination of icebreaking capacity in the Western Hemisphere. As the Arctic Ocean becomes more accessible, the ability to maintain a persistent presence, ensure freedom of navigation, and respond to crises depends on robust icebreaking capabilities. This article provides a crucial assessment of where we stand and the path we must forge to secure our interests in the region's maritime domain.

Another article delves into the innovative and operationally significant concept of landing C-130 aircraft on frozen lakes. This exploration of novel operational concepts is a testament to the ingenuity and adaptability required to project power and sustain forces in the world's most demanding environment. The ability to utilize frozen lakes as runways could revolutionize logistics and power projection in the high latitudes, offering new options for supporting both military and civilian activities in remote areas.

Furthermore, this volume includes a comprehensive review of Arctic command structures. As the strategic landscape evolves, so too must defense command-and-control arrangements. With the accession of Finland and Sweden to NATO, the Alliance's northern flank has been transformed, and it is imperative that we consider how to best plan, organize, educate, train and command forces to deter aggression and defend U.S. and Allied Arctic interests.

In sum, the articles contained in the Journal of Arctic Security not merely academic exercises; they are intended to inform policy, shape strategy, and ultimately, enhance our collective security in the Arctic. To be sure, the Journal of Arctic Security is a forum for practitioners, by practitioners, and we at the Stevens Center are proud to feature contributions from some of the leading thinkers and doers in the field of Arctic security.

As we look to the future, it is clear that the challenges facing the Arctic will only continue to grow in complexity and consequence. The increasing military activities of Russia and China in the region, the impacts of the evolving geophysical and human terrain, and the ever-present need to balance competition with cooperation...all demand our sustained attention and effort.

It is the sincere hope of the Ted Stevens Center that this volume of the Journal of Arctic Security will contribute to the ongoing dialogue and help to illuminate the path forward. A secure and prosperous Arctic is not a foregone conclusion; it is a future that must be built through collaboration, innovation, and a shared commitment to the rules-based international order.

I extend my deepest gratitude to the authors who have contributed their expertise to this volume, to the peer reviewers who have ensured the quality and rigor of their work, and to you, the reader, for your engagement with these critical issues. I am confident that the ideas and insights contained within these pages will help us to better understand and navigate the complex security landscape of the Arctic in the weeks, months, and years to come.

Warmest wishes and very respectfully, Church

Randy "Church" Kee, Maj Gen, USAF (Ret)

Director, Ted Stevens Center for Arctic Security Studies

Letter from the Editors

Dear JAS Readers,

With the release of this third edition of Journal of Arctic Security, the Ted Stevens Center for Arctic Security Studies is beginning to normalize publication processes, grow our readership, and expand the journal content. Director Kee aptly set the stage for your enjoyment of Volume 3 with a global perspective and a preview of the content that gives this edition value. This message will not duplicate his effort. Instead, this note serves as a window to the development of our journal as JAS continues to evolve in the Stevens Center's spirit of innovation and experimentation.

JAS has matured during a period of rapidly changing security challenges and perceptions of the Arctic. Critical attention to Arctic security and defense has continued to expand since the publication of our first edition in Summer 2023. There are changes in the Arctic security landscape that few could have predicted two and a half years ago. We have witnessed mounting evidence of Chinese and Russian ambitions in the Arctic, increasing Canadian and US commitment to protecting the northern approaches to North America, and growing European leadership of NATO's defense of the High North with the addition of Sweden and Finland to NATO. As the security environment changes, so will this journal.

In Volume 2 we added "Event Reports" with the intent to share insights from Arctic related events with our dispersed community of interest. Event Reports are intended to expand upon the collection of academic papers by increasing awareness of niche, far-flung, or invitation-only meetings that are consequential to Arctic practitioners.

In the same spirit of continuous improvement, this edition includes "Up for Debate," an Arctic security forum, to initiate involvement and discourse among Arctic scholars and practitioners. In the spirit of a forum, we will select responses for publication in subsequent JAS editions. The selected forum article may also spark social media responses.

You'll find Colonel Russ Vanderlugt's second JAS article, "Achieving Unified Command in the Arctic, Part II: Anticipating Arctic Futures" featured under the "Up for Debate" banner with an invitation to respond. Your thoughtful reflections based on your vantage are welcome. Your response may be a thoroughly researched manuscript for publication or merely a paragraph based on your personal experience. Forum responses should be aimed at synthesis and perspective that point toward new theories, ways of understanding, or research questions. We want to hear from scholars as well as busy defense professionals who represent experience from the field.

In future editions, we will continue to adapt the journal format and select research pertinent to our changing world. It's our sincere hope that the "Up for Debate" section of the journal gains the attention of our readers across the Arctic security community and enriches the body of knowledge we endeavor to grow. We look forward to hearing from you.

Eds. ~

Dear JAS readers,

This is the first iteration of a new section of the Journal of Arctic Security entitled “Up for Debate.” The double entendre—meaning both "a topic being posed for discussion" and "an individual being amenable to engaging in debate"—is intentional, as is the less strict academic tone it conveys. We hope the articles in this section will be provocative in the best way: that they will be thought-provoking and move you, the reader, to respond. Responses may be research-based, opinion pieces, or anecdotal contributions.

As we continue to support the growth of an Arctic security community of practice, we hope to capture the hard-earned knowledge and experience of practitioners who have learned to survive and thrive at these high latitudes. If, while reading the following article by COL Russ Vanderlugt, you are inspired to add to his argument, or *especially* if you disagree, please reach out to the Journal editors at TSC-JAS@groups.af.mil or on the TSC LinkedIn page (QR code below).

Eds. ~

To join the discussion, visit:
The Ted Stevens Center for Arctic Security Studies on LinkedIn

Achieving Unified Command in the Arctic, Part II: Anticipating Arctic Futures

COL Russ Vanderlugt, USA

Colonel Russ Vanderlugt serves as the Commander of the 11th Arctic Aviation Command at Fort Wainwright, Alaska. He holds a doctorate in Arctic and Northern History from the University of Alaska Fairbanks.

ABSTRACT:

Part I, Achieving Unified Command in the Arctic: The History of Alaskan Command argued that unity of command in Alaska and the Arctic is necessary for US homeland defense. It examined this concept by exploring the history of Alaskan Command (ALCOM) and its role in the Arctic, as well as illustrating lessons learned from the ebb and flow of unified command in and near the Arctic. Part I demonstrated how achieving unity of command in the Arctic remains a critical issue for U.S. national defense proposes that a joint force headquarters and Commander present in Alaska is central to this effort.

Part II, titled Anticipating Arctic Futures, opens the aperture beyond ALCOM's role in Alaska and explores the Arctic region more holistically. It builds upon the concept of unified command and the premise that the geostrategic significance of Alaska is what makes the United States an Arctic nation – and the principal key terrain that allows the US to act unilaterally in the Arctic's security environment. The Arctic is inextricably linked to homeland defense. In view of today's evolving Arctic security environment, Part II seeks to answer the questions: (1) how does the Arctic relate to the Indo-Pacific and western hemisphere, (2) how can unified command be best achieved in the region, and (3) how does introduction of the geopolitical term "Arcto-Pacific" impact the posture and security dialogue surrounding Alaska and the Bering-Chukchi Sea region? Finally, Anticipating Arctic Futures proposes near- and long-term alternatives for achieving unified command in the Arctic to include the formation of an Arctic Theater of Operations and establishing a distinct US Arctic Command. Both alternatives require viewing the Arctic as a distinctly cohesive global region possessing a unique and strategically significant identity.

CONNECTING THE ARCTIC SECURITY ENVIRONMENT TO THE INDO-PACIFIC AND WESTERN HEMISPHERE

The 2020s have witnessed increased military buildup and aggression across the globe. When the world answers the question of Ukraine following the Russo-Ukrainian War, and finds a solution to the security dilemma in the South China Sea, the Arctic will likely be the next region rising to the forefront of geopolitics in the 2030s. The Arctic was once an exceptional zone of peace but is progressively becoming a region of intense strategic competition, demanding global attention. In a post-Ukraine and post-Taiwan global security environment, China and Russia will increasingly turn their focus to the Arctic as their national bandwidth and military resources allow, posing new security challenges with global consequences.

The Arctic is undergoing drastic changes, and the evolution of threats is real. Recent cooperation between China and Russia equates to an increasing threat in, and through, the Arctic. Fundamentally, the Bering Sea region of Alaska and the Arctic is the only place within the North American homelands or approaches to the homeland where consistent, combined hard military power demonstrations occur. This is evidenced recently by combined Chinese-Russian bomber patrols off Alaska's coast, and Chinese and Russian naval and coast guard vessels holding joint military exercises in the Bering Sea, where Russia's military has increasingly operated near American fishermen (Guillot, 2025). Meanwhile, the opening of sea lanes in the Arctic continue to reduce maritime shipment times around the globe via the strategic Bering Strait for nations capable of operating in the Arctic. The ongoing effects of a changing operational environment emanating from the region continue to fuel Russian ambitions to control navigation and access along the Northern Sea Route as sea ice erodes (Bouffard et al., 2025). As access increases, the Arctic's rich resources – including fisheries, oil deposits, and critical minerals – will make the region vital for both commerce and competition.

While China and Russia continue to signal their growing alignment by demonstrating presence through joint exercises, patrols, and strategic coordination in the Arctic, North Atlantic Treaty Organization (NATO) expansion creates a dynamic counterpoint to the evolving geostrategic security environment. NATO Joint Force Command (JFC) Norfolk recently updated its command structure to integrate Finland, Sweden, and Denmark (JFC Norfolk, 2025). Of all countries present in the Arctic, though China cannot claim Arctic homelands, it continues to leverage its position and influence across the diplomatic, informational, military and economic spectrum, while seeking to access resources and promote governance favorable to its interests. It operates icebreakers and conducts dual civil-military research expeditions, including testing unmanned underwater vehicles and polar-capable aircraft. Russia possesses the largest Arctic territory and Arctic military presence on the globe, including strategic nuclear forces postured on the Kola Peninsula. Russia has also demonstrated capabilities for long-range conventional and nuclear strike missions, including Arctic transits of nuclear submarines.

Meanwhile, the Indo-Pacific remains America's priority theater. The 2025 National Security Strategy (NSS) states that the Indo-Pacific is and will continue to be the next century's key economic and geopolitical battleground (White House, 2025). This will require a vigilant posture in the Indo-Pacific and a focus on deterrence to prevent war in the region – specifically deterring a conflict over Taiwan by preserving military overmatch. The "Indo-Pacific" is a relatively recent addition to the security and foreign policy lexicon.[1] Japanese Prime Minister Shinzo Abe coined the term in 2007 to underscore linkages between the Pacific and Indian Oceans. In May 2018, Defense Secretary James Mattis officially renamed US Pacific Command (USPACOM) to US Indo-Pacific Command (USINDOPACOM) during the combatant command's change of command ceremony. This reflected the growing significance and continuity of the Indian Ocean region alongside that of the Pacific.

1 Occasionally, security rhetoric reverts to the older but more geographically inclusive term "Asia-Pacific" for the region now known more commonly as the Indo-Pacific.

Today the size and scope of USINDOPACOM's Area of Responsibility (AOR) is enormous, stretching from the west coast of the United States to India, and from the Arctic to Antarctica. The Indo-Pacific region comprises 38 nations that encompass over half of the earth's surface and are home to more than 50% of the world's population (USINDOPACOM, 2025). Two of the globe's three largest economies are based in the Indo-Pacific. The region includes seven of the world's ten largest militaries and United States mutual defense treaties with five nations. According to Admiral Samuel J. Paparo, Commander of USINDOPACOM, "The Indo-Pacific remains the world's center of gravity. If you were to choose the world's center of gravity 100 years ago, it would have been somewhere in east-central Europe. Today, it's squarely in the Indo-Pacific. For maritime commerce or strategic competition, here more than anywhere else, the future of the international order, the international order that directly benefits our strategic interests, our vital national interests, rest here" (Paparo, 2025).

It is clear from the 2025 NSS that for the Department of War (DOW) and US military, a hemisphere defense of the homeland in the western hemisphere is the top priority, coupled with the Indo-Pacific as the priority overseas theater with a forward force posture. Although the Arctic region is absent from the 2025 NSS, this is reflective of a broad hemispheric and core continental approach, rather than an omission. The NSS addresses the western hemisphere holistically, while the eastern hemisphere is divided into four parts that include three continents – Asia, Europe, and Africa – and one region and historical hot spot that does not fit neatly into any of the three – the Middle East. Therefore, it is not alarming that the NSS did not specifically call out the Arctic within the currently prioritized hemispheric and continental framework. The Arctic constitutes only about 4% of the globe: half in the western hemisphere (US/Alaska, Canada, Greenland), and the other half in the eastern hemisphere (the Nordic and Russian Arctic). The shift in the NSS from 2022 to 2025 instead facilitates a reframing of the North American Arctic as part of a broader western hemispheric zone of interest.

This reframing and renewed emphasis on the western hemisphere infers the growing significance and continuity of the Arctic alongside that of the homeland and Indo-Pacific. As U.S. forces focus on homeland defense and the Indo-Pacific, US Allies and partners elsewhere must take increasing responsibility for their own defense with critical but more limited support from American forces (NDS, 2026). One potential result may involve a strategic shift to the North Pacific and Arctic in the 2030s and beyond – resulting in a decreased or more balanced perspective on the South Pacific relative to the North Pacific and Arctic, where competition will continue to increase.[2] The United States is a Pacific nation, and – because of Alaska – the US is also an Arctic nation.[3] Therefore, in contrast to China, which does not have a geographic stake in the Arctic region, the United States can claim its identity as both an Arctic and Pacific nation. The Arctic represents a frontier area of the homeland, a seam and vulnerability. The Arctic is also potentially more vulnerable than the East or West Coasts – where the Atlantic and Pacific Oceans have historically served as a critical and strategic defense buffer for adversarial threats to North America's core continental landmass.[4] Therefore, given the homeland's proximity to threats in and through the Arctic, the Arctic layer is a primary concern within the western hemisphere and a frontline when viewed through the lens of homeland defense. In short, the Arctic is inextricably linked to Homeland Defense. This reframing and renewed emphasis on the western hemisphere infers the growing significance and continuity of the Arctic alongside that of the homeland and Indo-Pacific. As U.S. forces focus on homeland defense and the

2 This future state will be determined by China's goals in the South Pacific and the outcome of its currently expressed aim to gain control of Taiwan. Meanwhile, global focus on Arctic access and resources will likely accelerate in the circumpolar north.

3 The United States became a Pacific nation in 1846 when it gained Oregon Territory through a treaty with Great Britain. The U.S. became an Arctic nation in 1867 when it gained Alaska through a treaty with Russia.

4 To date, the oceans surrounding North America have shielded the United States from foreign invasion, allowing for relatively unhindered internal development since the Monroe Doctrine. This vast oceanic isolation has served as a protective "moat" for the Americas, forcing potential adversaries to surmount immense transoceanic supply chains and logistical challenges.

Indo-Pacific, US Allies and partners elsewhere must take increasing responsibility for their own defense with critical but more limited support from American forces (NDS, 2026). One potential result may involve a strategic shift to the North Pacific and Arctic in the 2030s and beyond – resulting in a decreased or more balanced perspective on the South Pacific relative to the North Pacific and Arctic, where competition will continue to increase. The United States is a Pacific nation, and – because of Alaska – the US is also an Arctic nation. Therefore, in contrast to China, which does not have a geographic stake in the Arctic region, the United States can claim its identity as both an Arctic and Pacific nation. The Arctic represents a frontier area of the homeland, a seam and vulnerability. The Arctic is also potentially more vulnerable than the East or West Coasts – where the Atlantic and Pacific Oceans have historically served as a critical and strategic defense buffer for adversarial threats to North America's core continental landmass. Therefore, given the homeland's proximity to threats in and through the Arctic, the Arctic layer is a primary concern within the western hemisphere and a frontline when viewed through the lens of homeland defense. In short, the Arctic is inextricably linked to Homeland Defense.

Prior to the recent release of the 2026 National Defense Strategy (NDS) in January, the speech by Secretary Hegseth at the Reagan National Defense Forum was the best refinement of NDS intent in terms of strategic guidance (Roque & Insinna, 2025; Hegseth, 2025). Now, publication of the 2026 NDS clearly outlines four lines of effort (LOEs) at the War Department: (1) Defend the U.S. Homeland, (2) Deter China in the Indo-Pacific Through Strength, Not Confrontation, (3) Increase Burden-Sharing with U.S. Allies and Partners, and (4) Supercharge the U.S. Defense Industrial Base.

The DOW's 2026 NDS LOE #1, "Defend the U.S. Homeland," directs an active and fearless defense of America's interests throughout the western hemisphere, which includes half of the Arctic. This involves both providing credible military options in the Arctic and guaranteeing U.S. freedom of action and commercial access to key terrain throughout the Arctic. The western hemispheric portion of the Arctic includes vast areas of key terrain, from Alaska to Greenland, which together guard the most direct approaches to North America from Asia and Europe along the 10 to 2 o'clock positions. Therefore, DOW's mandate involves prioritizing efforts to develop a comprehensive Golden Dome for America to defeat large missile barrages and other advanced aerial attacks along "great circle" approaches in the Arctic sector. DOW must simultaneously secure America's borders and maritime approaches throughout the western hemisphere – a large portion of which are in the Arctic, including the Bering Sea and its eastern corollary, the GIUK Gap.[5]

Protecting and defending the US homeland and the western hemisphere through "hemisphere defense" remains the #1 priority of the recently released 2025 NSS and 2026 NDS. Other national guidance documents such as the National Strategy for the Arctic Region (2022) and Implementation Plan for the National Strategy for the Arctic Region (2023) provide several strategic Arctic mandates, including exercise presence and development of capabilities for expanded Arctic military activity. The DOW Arctic Strategy (2024) emphasize peace, stability, and cooperation in the region with a focus on domain awareness, communications, and intelligence, surveillance, and reconnaissance capabilities. It also underlines the need for a concerted approach to preserve the Arctic as a stable region "in which the US homeland remains secure," but does not specifically address command and control (C2) in the Arctic. Specifically, US Arctic strategy and policy documents along with current

5 The GIUK Gap, or "G-I-UK," stands for the open ocean "gaps" between Greenland, Iceland, and the United Kingdom. This area forms a strategic maritime and naval choke point between the Arctic and North Atlantic Oceans, including portions of the Norwegian, Greenland, and North Seas.

DOW instructions, directives, and manuals do not address unified command nor current C2 complexities in the Arctic. Therefore, the changes needed to achieve unified command and "set requirements" in the Arctic will eventually need to occur through an update to the Unified Command Plan (UCP).[6]

The NSS's explicit emphasis on prioritizing core foreign policy interests includes a "Trump Corollary" to the Monroe Doctrine that prioritizes the western hemisphere – and, by its geographic inclusion, the North American Arctic – as the top US strategic concern. The NDS (2026), further refines the Trump Corollary to the Monroe Doctrine, or "Donroe Doctrine"[7] by stating that the Department of War will "restore American military dominance in the Western Hemisphere. We will use it [military dominance] to protect our Homeland and our access to key terrain throughout the region. We will also deny adversaries' ability to position forces or other threatening capabilities in our hemisphere."

This portion of the Donroe Doctrine applies directly to the Arctic. Alaska is, by US military doctrine,[8] key terrain within the western hemisphere and North America, just as the Bering Sea has proven to be a region where adversaries can position forces or threatening capabilities in the western hemisphere and hold the homeland at risk. Though Greenland is specifically called out in the NDS, Alaska may be omitted because the NDS regional callouts only include areas within the western hemisphere outside of sovereign US territory.[9] Therefore, the fact that Alaska or the Bering Sea are not called out does not negate their significance for homeland defense. On the other hand, the NDS clearly spells out that NATO and the European High North/Arctic are secondary in priority to defending the homeland and deterring China.

One of the challenges inherent in looking primarily at the western hemispheric portion of the Arctic is potential bifurcation at the top of the globe, resulting in an Arctic that is divided by eastern and western hemispheres. Though experts on the Arctic have long articulated major differences between the North American Arctic and the Nordic-Russian Arctic of Europe and Asia that further divide the region (Tingstad et al., 2025), to facilitate a comprehensive, unifying security construct for the region, American formation of a geopolitical term that connects the Arctic to the Pacific, the Arcto-Pacific, is urgently needed – before other nations take hold of such a concept for their own purposes (Kupriyanov, 2020). In addition, maintaining a favorable balance of military power in the Indo-Pacific by not allowing China to dominate the region is fundamental throughout the NDS, whether in the Indo-Pacific or Arcto-Pacific.

OLD WINE IN A NEW BOTTLE: BERINGIA AND THE ARCTO-PACIFIC

Alaska – and by political association, the United States – belongs to an emergent and broad circumpolar Arctic region. Amid an ever-changing security environment, the Arctic, or a portion thereof,

6 Setting requirements in a joint military context involves a formal, comprehensive, and structured process for identifying, validating, and prioritizing the needs and capabilities required to successfully execute joint plans and operations and achieve national security objectives within an acceptable level of risk.
7 This phrase originated in a New York Post article published on January 8, 2025, that included a front cover with the title "The Donroe Doctrine: Trump's vision for hemisphere." Following the raid in Venezuela, Operation Absolute Resolve, Trump referenced the phrase himself, though he did not invent the term.
8 Key terrain is "any locality, or area, the seizure or retention of which affords a marked advantage to either combatant" (Joint Publication 2.0, 2024).
9 When Greenland is mentioned in the NDS, it is only in immediate conjunction with other areas that are not part of the continental United States, including the Gulf of America and Panama Canal.

must remain tied to the priority theater in the Indo-Pacific to facilitate resourcing, force posture, and infrastructure development that anticipates the region's future. Alaska and the Arctic represent a strategically vital region for US homeland defense and Indo-Pacific operations, serving as the homeland's northern flank and its nearest point for projecting military forces to the Pacific and across Arctic. With increasing challenges from China and Russia, collaboration with Allies alongside investment in infrastructure and technology is essential to maintaining US dominance in both the Pacific and the Arctic. The Arctic Ocean, and the broader Arctic as a region, fundamentally influence the Indo-Pacific, specifically in and through the Bering Sea. A hyphenated geographic construct "Arcto-Pacific" is therefore essential to refer to the overlapping and more commonly understood regions of the Arctic and North Pacific along with adjacent portions of North America and Asia. This parallels the linkages between the Pacific and Indian Ocean: a broad "Indo" regional affiliation resulted in adaptation of a hyphenated Indo-Pacific. Similarly, the Arctic's regional affiliation and the hyphenated Arcto-Pacific reflect a growing significance and continuity of the Arctic region alongside that of the greater Pacific, and a potential future shift from south to north in the Pacific. In short, grouping of the Arctic and Pacific into an "Arcto-Pacific" construct presents a primary strategic lens through which to view U.S. unity of command and C2 modifications.

The region contained in the Arcto-Pacific is rapidly gaining attention as a discrete entity with a unique regional identity critical to global security. Centered on the Bering Sea and Strait, the Arcto-Pacific is where Asia meets North America and where the waters of the North Pacific mix with those of the Arctic. An examination of unified command in the Arcto-Pacific is needed to illuminate critical insights into the evolving dynamics of military organization and strategy in response to contemporary geopolitical imperatives. Rapid transformation driven by emerging security challenges and environmental changes in conjunction with increased militarization creates a pressing need to reassess and adapt the structural frameworks governing unified command near the top of the globe. Alternatives for unified command in the Arcto-Pacific present opportunities for structural changes that will enhance the effectiveness and responsiveness of military C2. Positioned between North America's ten o'clock position and Asia's corresponding two o'clock position, the Arcto-Pacific has critical strategical significance given current geopolitical and security threats. Conceptualizing geographic options for unified command across the entirety of the Arctic, including the Arcto-Pacific, sets the stage for subsequent examination by the Joint Staff during the periodic UCP review process.

Achieving unity of command in Alaska and the Arcto-Pacific requires comprehending its geographic and regional framework at the convergence of two of the world's continents and two of its oceans near the Bering Strait. Arcto-Pacific is merely a new term for an old reality: Beringia. Beringia connects Alaska's geologic and anthropological past prehistorically with Asia. Beringia is a geographic concept that emerged from the disciplines of anthropology, archaeology, and the earth sciences and is rooted in Indigenous cultures, languages, and histories centered on either side of the of Bering Sea and Bering Land Bridge. The Bering Sea, Bering Strait, Bering Land Bridge, and Beringia were named after the Danish-born Vitus Bering, who commanded two sailing expeditions commissioned by the Russian Czar across the region connecting Asia and America from 1725-1741.[10] The region known as Beringia received its name from the shallow Bering Sea that now spans the space between two continents – the extreme corners of northeast Asia and northwest North America. A majority of the Bering Sea floor was previously an exposed, dry plateau stretching between Siberia and Alaska. This land connection is called the Bering Land Bridge, encompassing a now underwater area the size of Alaska on either end of today's Bering Strait. During the Ice Age, the unglaciated Bering Land Bridge was the core of central Beringia.

As shown on the map below, the comprehensive Beringian landmass, an area roughly the size of Australia, stretched 3,000 miles from Canada's Mackenzie River to Russia's Lena River. Beringia is the only part of the Americas adjacent to Asia and the only area previously connected to it by a land

10 The concept and science behind "Beringia" – and the term itself – did not emerge until the late 1930s, when it was initially used to refer to the exposed continental shelf between Siberia and Alaska.

bridge. The former land bridge connecting Asia and North America at the margins of the Arctic and Pacific was part of a larger region that facilitated human migration and whose geographic continuity shaped the modern world. The Bering Sea region continued to be a geographically and culturally cohesive region until political divisions between Russia and the U.S. divided the resident population of Beringia.

Figure 1: The Arcto-Pacific, a proposed geopolitical concept based on the landmass of Beringia[11]

Central Beringia includes the former land bridge where the continental crust is now submerged underwater, represented by the whitish bathymetry encompassing the Bering and Chukchi Seas, and adjacent coastal plains of Asia and North America. Western Beringia extends from Russia's Verkhoyansk Range east of the Lena River to the Bering Strait, and from the Arctic Ocean to the Sea of Okhotsk, including Kamchatka. Eastern Beringia encompasses the ice-free zones of interior Alaska and adjacent areas of Canada within the Yukon drainage that were not covered by the massive continental glaciers during the Ice Age. It also includes the Aleutian Islands, Gulf of Alaska, and the northwest coast of North America.

Today, the islands and the maritime environment of the Bering Sea continue to connect Alaska to Asia and serve as the center of gravity for the Arcto-Pacific. Alaska possesses a vast coastline facing the North Pacific – the northern reaches of the world's largest ocean. This connects Alaska to Kamchatka, the Kurils, and Japan – along with the major Pacific archipelagos stretching out from

11 Map based on topography and bathymetry of the Arctic from the National Oceanic and Atmospheric Administration (NOAA, 1988).

Asia's eastern continental coast.[12] Therefore, both Asia-Pacific and Arctic influences upon Alaska contribute to its distinctiveness relative to the Arcto-Pacific. Timely conceptualization of the Arcto-Pacific by the United States will ensure protection of US interests in the Pacific and Arctic regions and should involve a vision of the Arctic that necessarily connects Alaska to its Asia-Pacific roots while protecting US homelands in North America. This is possible by mooring the new geopolitical term Arcto-Pacific to its anthropological predecessor, Beringia.[13]

GEOGRAPHIC CONCEPTIONS: THE WESTERN HEMISPHERE AND THE ARCTIC

Activation of US Army Western Hemisphere Command (USAWHC) on December 5, 2025, provided an operational warfighting theater command headquarters, ensuring American interests and security across the western hemisphere. USAWHC is the Theater Army supporting the Americas – including both U.S. Northern Command in North America and U.S. Southern Command in South America. Establishing a headquarters of hemispheric size necessitates a revitalized geographic and security perspective of both the scope of the western hemisphere and its relationship with the Arctic.

The western hemisphere is generally and geographically understood to comprise the landmass of the Americas. By technical definition, it includes an area formed by a great ellipse encircled by the prime meridian at Greenwich and the 180° meridian, dividing the earth into two equal "half spheres" – the western and eastern hemispheres.[14] However, this rather arbitrary division slices the westernmost parts portions of Europe and Africa into the western hemisphere, along with eastern tip of the Russian mainland, and cedes the Alaska's Aleutian Islands to the eastern hemisphere – among other complications. Therefore, scholars and practitioners often shift or truncate definitions of the western hemisphere to align political realities and continental geographic imperatives, effectively separating North and South America from Europe, Africa, Asia, and Australia. For example, an alternate conception of the western hemisphere involves shifting the great ellipse 20 degrees to the west, so that the 20th west and 160th east meridians become its boundaries.[15] This serves the purpose of focusing the western hemisphere more closely on the Americas, by excluding the European and African continental mainland, yet introduces several problems: (1) the 20th west meridian clips the northeastern tip of Greenland and (2) splits Iceland in half. Moreover, a boundary of the 160th east meridian is equally problematic: an additional portion of eastern Russia is pulled into the western hemisphere, including half of the Kamchatka Peninsula.

In the end, no technical hemispheric concept of the globe separating the western and eastern hemispheres is perfect, regardless of the meridians or points chosen. A compromise is represented by the International Date Line, which approximately follows the 180° meridian, but zigzags through the Bering Sea to facilitate continuity for both Asia and North America between Chukotka's Chukchi Peninsula and Alaska's Bering Sea and Aleutian Islands. A similar cartographic convention is possible by starting at the 11th west meridian in the Greenland Sea that includes Greenland and Ice-

12 The Arcto-Pacific is not an altogether new security framework. According to the 1953 UCP map revision, Alaskan Command's geographic area included a majority of the Arcto-Pacific / Beringia, including the North Pacific and Bering Sea regions, the Kamchatka Peninsula and Chukotka regions of Russia, all of Alaska, portions of western Canada, and a large slice of the Arctic Ocean (Vanderlugt, 2024).
13 The term Beringia was popularized by American geologist David M. Hopkins, who brought it into mainstream scientific and public use. Whereas Beringia is anthropological and rooted in the sciences, the hyphenated strategic term Arcto-Pacific is intended to be a more internationalist, geopolitical construct.
14 Any plane passed through the center of the earth will intersect its surface along a great ellipse or great circle resulting in two equal portions of the earth. For nontechnical purposes, "great ellipse" and "great circle" will be used interchangeably and represent a line of maximum circumference on an ellipsoid (like the earth) or a sphere, and the shortest path (geodesic) for navigation.
15 160° E longitude is the antimeridian or meridian opposite of 20° W longitude; likewise, the 180° meridian is the antimeridian to the Greenwich prime meridian at 0° longitude.

land; this necessarily requires a westward jag in the Atlantic to exclude mainland Africa and its associated islands. Regardless, a hemispheric concept combining this line with the international dateline would no longer be a great ellipse or a true hemisphere, but a truncated version that serves the purpose of focusing the western hemisphere on the North and South American continents and their associated islands. This "American hemisphere" focuses on the Americas.

Defining the Arctic is fraught with geographic problems similar to bounding the western hemisphere around the Americas, but on a smaller scale, and involves looking at the globe from the top as opposed to the side. This presents a somewhat unnatural or ahistorical perspective considering that for millennia Western map-makers have historically created maps emanating from human and political population centers rather than the sparsely populated Arctic. Once cartographers understood the earth was round, they created hemispheric maps – divided into western, eastern, northern, and southern hemispheres – which represented a logical and natural progression to comprehending two halves of the globe on a flat map. Hemispheric maps reflect a perceptual phenomenon: when a viewer looks at a spherical object such as a globe from any distance, only half a sphere or one hemisphere is seen. In theory, a sphere or globe can be split into an infinite number of hemispheric pairs. When handling a globe, the viewer naturally orients the globe's hemispheric position so that a particular point or region of interest is directly in the center, maximizing the surrounding contextual hemisphere in which it is located. Positioning the globe in this way is fundamental to understanding a point or region; on the contrary, positioning a globe with a point or region of interest at the periphery of the visible hemisphere is counterintuitive.[16]

A map of the northern hemisphere is thus centered on the North Pole and bound at 0° latitude by the equator, which serves as the great ellipse encircling the hemisphere. From a purely hemispheric perspective, the Arctic is a subset of the northern hemisphere, also centered on the North Pole, but bound by the Arctic Circle rather than the equator.[17] The Arctic Circle is the northernmost of five named latitudinal circles on the globe, and encircles the North Pole near the 66th north parallel at 66° 33.85' (66.56°) latitude north of the equator. The Arctic Circle is positioned to represent the southernmost latitude in the northern hemisphere where the sun remains continuously above or below the horizon for 24 hours at the summer and winter solstices, signifying the presence of the midnight sun and polar night. Thus, the Arctic Circle's latitude is determined by the Earth's axial tilt of around 23.44° relative to the sun (90° - 23.44° tilt = 66.56° latitude).

The angle of the sun relative to position on the globe are critical to understanding the Arctic's physical environment, yet the Arctic's widely held regional definitions are not merely the area circumscribed by the Arctic Circle. The region's political, military, economic and social aspects largely determine current definitions of the Arctic. Though some scholars have attempted to define a pluralistic Arctic through a "many Arctics concept" to account for its differing realities,[18] the Arctic must be viewed as a distinctly cohesive global region possessing a unique and strategic identity. The Arctic is a geographic area inhabited by people with a unique history, culture, and language who share fundamen-

16 When calculating a great ellipse using the prime meridian at Greenwich and the 180° meridian, the center of the western hemisphere lies in the Pacific Ocean, at the intersection of the 90th meridian west and the Equator among the Galápagos Islands.

17 Unlike the equator, the Arctic Circle is not a great ellipse or great circle whose plane passes through the center of the globe. Instead, the Arctic Circle is a "small circle" whose plane represents a fraction of a hemisphere. Widely recognized northern hemispheric projections of the Arctic, sometimes called polar projections, include Polar Stereographic, Azimuthal Equidistant, and Orthographic projections and are often limited to a small circle positioned at 55-60° N latitude to prevent distortion that occurs nearer to the equator.

18 Highlighting the complexity of driving factors and uncertainties influencing the future of the Arctic through a "many Arctics'' concept is counter to the geographic proximity, cultural, historical, and socio-economic linkages that unify the Arctic. The effect of dividing the Arctic into four sub-regions – i.e. Bering-Beaufort, Nunavut-Greenland, Barents, and Central Siberia (Tingstad et al., 2025) – runs contrary to achieving unified command in the Arctic.

tal continuities across high latitudes. Viewing the Arctic as a cohesive region acknowledges social, economic, and political dynamics impacting defense strategies and cooperation.

OTHER GEOGRAPHIC PERSPECTIVES

The continent of Africa and the formation of US Africa Command (USAFRICOM) in 2007 provides an analogy to problems of unified command in the Arctic, which is currently divided between three geographic combatant commands (Congressional Research Service, 2013, 2023; Watson, 2011; Cole et al., 2013). Prior to the formation of USAFRICOM, Africa faced challenges familiar in the Arctic, including a shared responsibility for the continent between three different unified commands – US European Command, US Central Command, and US Pacific Command – none of which had Africa as its primary concern.[19] This division made it difficult for the US to consistently prioritize or pursue security interests across a diverse and complex region. It also limited continuity in diplomatic roles using US military resources to enhance unified influence and access across the region. According to Richard Catorie (2000), who initially proposed unified command in Africa, "Unified command is the primary organization charged with protecting America's security interests in a geographic region of the world. It does this not only by managing US military resources in the region, but by building better security relations with the foreign countries in the region, endeavoring to build trust and 'habits of cooperation' that permit quick agreement and common action to resolve regional conflict. Assisting America's diplomats in building coalitions and maintaining alliances is thus a key role of the unified commands." In addition to performing purely military roles, combatant commanders of the unified commands play significant diplomatic roles by using military resources to enhance access and influence while communicating regularly with senior foreign civil and military leaders. Other organizations of the US government are arguably not manned or equipped to play a regional role of this magnitude (Catorie, 2000).

Given the Arctic is centered on an ocean rather than a continent like Africa, one approach toward achieving Arctic consistency involves categorizing the Arctic as a domain rather than a region, but this does not alleviate the problem of a necessary regional coherence or help define the Arctic's boundaries. An Arctic domain acknowledges an area that demands specialized resources, training, and understanding to operate effectively and may create synergy in Arctic-specific challenges and environmental characteristics. However, a so-called Arctic domain falls short of achieving the unity of command necessary for increased integration and coordination across the Arctic.[20] Unified command facilitates a whole-of-nation effort and optimization of US campaigning operations, activities, and investments with Arctic Allies and partners, specifically NATO.

NATO is in the process of shifting increased emphasis to the Arctic, reflecting a new regional alignment. In December 2025, NATO JFC Norfolk updated its command structure and integrated all Nordic countries under JFC Norfolk, including Finland, Sweden, and Denmark in the Command's Area of Responsibility (JFC Norfolk, 2025). JFC Norfolk remains NATO's newest and only operational warfighting headquarters in North America – and an example of a command structure that bridges the western and eastern hemispheres to ensure Allied cooperation and preparedness in both the North Atlantic and Arctic. JFC Norfolk's regional Area of Responsibility, Joint Operating Area-Northwest, previously included Iceland, Norway, and the United Kingdom. The move to expand shows how NATO is adapting its organizational structure and expanding its operational reach with the accession of Finland and Sweden. The evolving security environment demands that the Nordic Arctic can no

19 USEUCOM was responsible for the vast majority of the African continent, with USCENTCOM retaining the Red Sea countries and USPACOM retaining Madagascar.

20 Attempts to broadly define the Arctic as an all-encompassing "domain" – potentially involving any region on the globe with extreme cold weather or perhaps a place with mountains and ice – runs counter to the purpose of this paper, which is to articulate the Arctic as a discrete geographic place. Unlike the space and cyber domains, the Arctic is a circumpolar place on the globe.

longer be peripheral to the greater NATO Euro-Atlantic organizational construct, but central to planning, resourcing, capabilities, and exercises in the Arctic. This reorganization underscores NATO's commitment to collective deterrence in the Arctic.

US Atlantic Command once maintained boundaries that overlapped sea lanes in the North Atlantic and Arctic now contained by JFC Norfolk. Though it did not include all of the Nordic countries, US Atlantic Command included Greenland and Iceland, along with slightly more than half of the Arctic Ocean, split with USPACOM along a sector at 100° E and 95° W. Rather than divide the Arctic by an eastern/western hemispheric approach, this centered US Atlantic Command's Arctic portfolio on the Greenwich Prime Meridian running through the Norwegian Sea. Notably, this arrangement predated the creation of US Northern Command or Russia's inclusion in US European Command following 9/11, when the concept of "two Arctics" became more commonly bifurcated between the North American and Russian Arctic. The map below shows a pre-9/11 polar projection of how the Arctic divided between US Pacific Command and US Atlantic Command Areas of Responsibility.

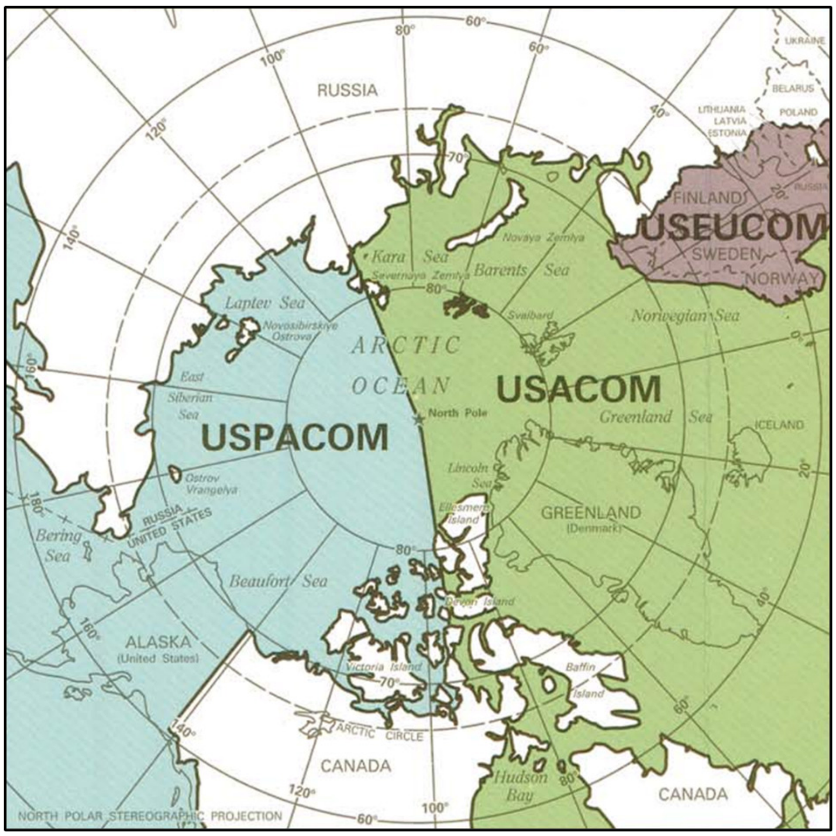

Figure 2: Combatant Commanders' Areas of Responsibility, 1996[21]

During the late twentieth and early twenty-first centuries, the Arctic Council attempted to clearly define an emergent Arctic identity within a broad circumpolar region. The most common internationally accepted definition of the Arctic is that adopted by the Arctic Monitoring and Assessment Programme (AMAP), a working group of the Arctic Council. In North America, this area generally includes the terrestrial and marine areas north of the 60th parallel. The figure below shows how, in

21 Map excerpt taken from The World with Commanders' Areas of Responsibility, based on unclassified data from the Unified Command Plan, 17 January 1996 (USGS, 1996).

the United States, this boundary includes all of mainland Alaska and the Aleutian Islands except Alaska's southeast panhandle below 60° N latitude (Murray, 1998). In Canada, this definition of the Arctic includes the Yukon, Northwest Territories, Nunavut, Hudson Bay, the tip the Labrador Peninsula in northern Quebec, and Greenland. In Europe, this includes Iceland and the Faroe Islands, along with Norway, Sweden, and Finland north of the Arctic Circle. In Russia, this includes the Murmansk region and Kola Peninsula, and most of Russia's northern provinces and districts above 62°N latitude.

Figure 3: Arctic boundaries based on AMAP definition (Murray, 1998)

Altogether, the Arctic Council's AMAP definition and boundaries for the Arctic provide a compelling context and comparison for the current UCP and unified command in the Arctic.

THE UNIFIED COMMAND PLAN AND ARCTIC FUTURES

Could Arctic futures involve unified command, with all armed forces operating under a single commander who directs forces in pursuit of a common purpose and mission? Currently, three geographic combatant commands (CCMDs) share responsibility within the Arctic: US Northern Command (USNORTHCOM), US European Command (USEUCOM), and US Indo-Pacific Command (USINDOPACOM). With Greenland shifting from USEUCOM to USNORTHCOM under a Presidential UCP reorganization in June 2025, USNORTHCOM now arguably retains nearly an equal "share" of the Arctic. This includes the entirety of the North American Arctic and a majority of the Bering Sea and the "western hemispheric portion" of the Arctic Ocean, including a keyhole cutout around the North Pole. USINDOPACOM retains a minority portion of the Bering Sea off the eastern littoral of Kamchatka, along with all assigned bases and forces in Alaska. However, Alaska remains within the USNORTHCOM AOR, as represented by the crosshatch below.[22] USEUCOM includes Iceland, the Faroe Islands, the Nordic Countries, and the balance of the Russian Arctic.

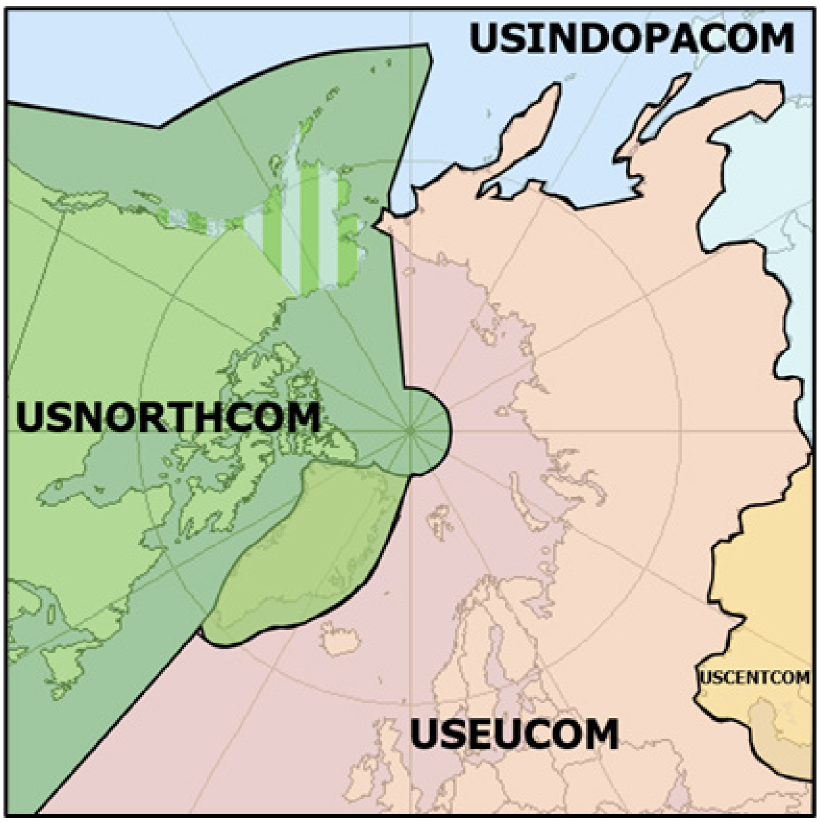

Figure 4: Current Geographic Combatant Command boundaries in the Arctic[23]

22 The allocation of Alaska's forces and bases to USINDOPACOM while Alaska itself remains in the USNORTHCOM AOR remains a challenge for C2. Alaska remains singular on the globe in this approach: an area that is in one combatant command but with its forces controlled by another combatant command.
23 This depiction approximates the recent inclusion of Greenland in the USNORTHCOM AOR (USNORTHCOM, 2025).

The UCP does not treat or approach the Arctic holistically; the Arctic continues to present the biggest global seams in the UCP. The current boundaries create a complex Arctic C2 environment, presenting challenges to the United States' ability to monitor and respond across the region. Meanwhile, NATO expansion and North American Aerospace Defense Command (NORAD) modernization, alongside increased China and Russian activities, create a security dilemma in the Arctic beyond the scope of the Arctic Council to adjudicate. Achieving unified command across the entirety of the Arctic to integrate and synchronize joint effects – including campaigning operations, activities, and investments – will enable employment of an Arctic-capable joint force trained and equipped to respond to crises or contingencies across the Arctic. [24]

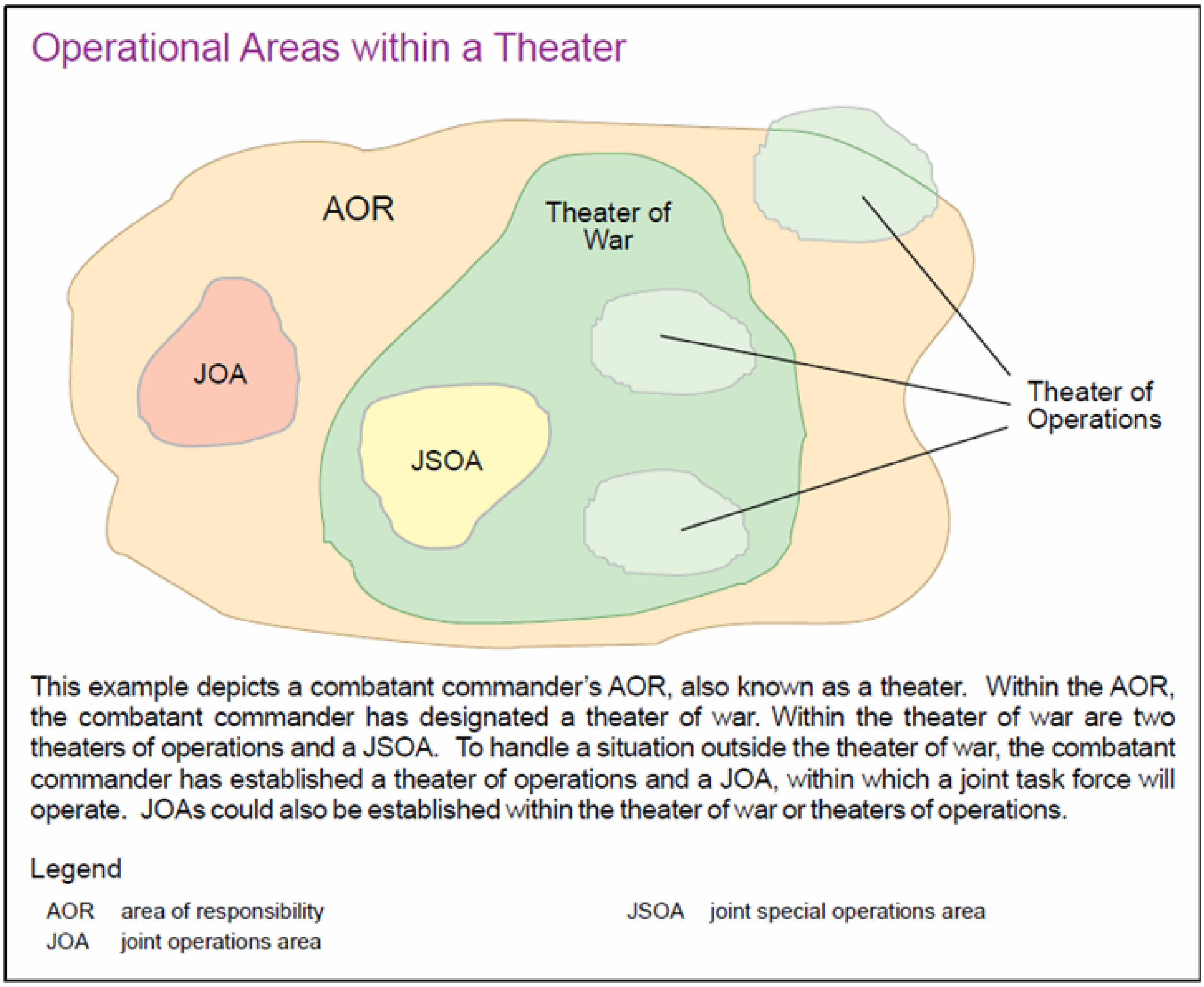

Figure 5: Operational Areas within a Theater (JP 3-0, 2022)

Given recent Presidential and DOW initiatives to consolidate and reduce military headquarters, the potential for a reduction in geographic combatant commands seems more likely in the near term than creation of a new one, especially for a portion of the globe that has not previously been the focus of a single command. Reducing combatant commands and a focus on the western hemi-

24 Key US Arctic capable forces and assets are described in the Arctic Strategies of each Service and are primarily centered in Alaska.

sphere could mean an opportunity for unified command in the Arctic, with both near-term and long-term alternatives. The near-term alternative does not involve any combatant command boundary changes and could be enacted through a phased approach beginning immediately. This alternative, establishment of an Arctic Theater of Operations, or ARCTO, involves utilizing and expanding current command structures and boundaries within the current UCP. As demonstrated in Part I, Alaskan Command (ALCOM) is a subordinate unified ("subunified") 3-star command reporting to USNORTHCOM and strategically positioned adjacent to the Arctic with responsibilities to campaign within the Alaskan Theater of Operations (AKTO). Potential exists to expand its current Alaskan Theater of Operations to encompass a larger geographic area, an Arctic Theater of Operations – thus serving as an operational-level Arctic command across the entire Arctic Region. Recent initiatives to leverage ALCOM and increase campaigning in the AKTO over the past several years underscore the potential of expanding this concept across the Arctic. Establishing an Arctic Theater of Operations per joint doctrine with boundaries acknowledged by all affected CCMDs provides continuity for military requirements and operations. A US joint force headquarters positioned adjacent to the Arctic and based in Alaska as a subunified Arctic Command under USNORTHCOM is also well-postured to serve as an interface with federal, state, local, and interagency partners in the Arctic.

A long-term alternative, in the 2030s, could involve either an expansion to include all of the ARCTO within a single combatant command's AOR (i.e. USNORTHCOM or a successor organization), or a division of the ARCTO to form a new combatant command as conditions merit or in time of need. Although assigning a single CCMD sole responsibility across the entirety of the Arctic on a permanent basis may be an attractive solution, the reality of achieving this endstate in the near term is unlikely. This is due to the hemispheric divide existing in the Arctic between the east and west, and opposing geopolitical forces acting upon the Arctic from North America and Eurasia. Keeping in line with this article's introductory and constructive nature, no exhaustive analysis regarding a Theater of Operations or combatant command boundaries is attempted beyond recommendations of broad potential structural alternatives, to provide senior decision-makers with hybrid solutions and cross-boundary alternatives throughout the UCP review process.

Continued study of Alaska and Arctic unity of command and C2 at the Joint Staff level in accordance with the phased biennial UCP review process is necessary given the combined and evolving threat of China and Russia in the region. Overall, unity of command in the Arctic will enable the DOW to:

1) Achieve a comprehensive operational design for domain awareness across the Arctic, impacting DOW's ability to monitor threats

2) Achieve comprehensive command and control across the Arctic, impacting DOW's ability to respond to threats

3) Achieve integrated and synchronized joint effects across the Arctic – including campaigning operations, activities, and investments (OAIs), that impact DOW's ability to employ an Arctic-capable joint force trained and equipped to respond to crises or contingencies

4) Assign primary responsibility for defining and setting requirements in the Arctic to a single CCMD

5) Refine the boundaries of a politically cohesive Arctic Theater of Operations to facilitate military operations across the Arctic with consensus from stakeholder CCMDs

ESTABLISHING AN ARCTIC THEATER OF OPERATIONS (ARCTO), A NEAR-TERM ALTERNATIVE

A near-term alternative for unified command in the Arctic involves maintaining the status quo boundaries of the current UCP, while expanding the Alaskan Theater of Operations (AKTO). This would entail a broader Arctic Theater of Operations (ARCTO) to transcend and overlap current CCMD boundaries. In this alternative, USNORTHCOM (or a successor organization) gains Arctic responsibilities without increasing its physical AOR.

An Arctic Theater of Operations is achieved through the doctrinal creation of a comprehensive, cohesive, and temporal Arctic Operations Area for military operations, or Arctic Theater of Operations. A theater of operations is a CCMD-level geographic area that can be designated by CCDRs, the SecWar, or the President. Per Joint Publication 3-0, *Joint Campaigns and Operations*:

> A theater of operations is an Operations Area (OA) defined by the CCDR for the conduct or support of specific military operations. A theater of operations is established primarily when the scope and scale of the operation or campaign exceeds what a JOA can normally accommodate. More than one joint force HQ can exist in a theater of operations. A CCDR may establish one or more theaters of operations. Different theaters will normally focus on different missions. A theater of operations typically is smaller than a theater of war but is large enough to allow for operations in-depth and over extended periods. Theaters of operations are normally associated with campaigns and major operations and *may cross the boundary of two or more AORs* [italics added]. (JP 3-0, 2022)

This last quality is what makes a theater of operations unique: an Arctic Theater of Operations can, by definition, overlap combatant command AORs – a necessary ingredient in the Arctic where boundaries from three CCMDs intersect. As illustrated in the graphic below, a theater of operations is the only doctrinal geographic construct (in times other-than-war) that facilitates operations across CCMD boundaries. It is a tool to "erase" CCMD seams and enable cross-AOR operations. Based on joint doctrine, Coordinating Authority (CA)[25] could be transferred at the CCMD level to the owner of the ARCTO. The primary use for this authority includes planning, campaigning, OAIs, and even contingency planning. It is designed to be a critical means for working through challenges across CCMD lines. Coordinating Authority is a corollary mechanism for a theater of operations, and a primary way at the DOW and Joint Staff level to retain unity of effort and unity of command.

A theater of operations can be perpetual if necessary, and can also include subdivisions, such as a joint operations area (JOA), for operations limited in scope or duration. An Arctic Theater of Operations – designed specifically to support Arctic military operations – is therefore appropriately sized relative to its associated Combatant Commander's Theater or AOR (a conglomeration of USNORTHCOM, USEUCOM, or USINDOPACOM). In this case, if the ARCTO is assigned to USNORTHCOM, the CCDR of USNORTHCOM can retain control of the entire ARCTO, or choose to assign subordinate joint force headquarters (a subunified command, i.e. ALCOM) for that purpose while remaining focused on the broader USNORTHCOM AOR. Since operations in the ARCTO would span CCMD boundaries and thus may expose gaps in C2, USNORTHCOM would leverage its subunified command to synchronize actions between AORs in the Arctic within the bounds of the ARCTO. Under this arrangement, USNORTHCOM would expand its current responsibility of advocating for Arctic capa-

25 Coordinating Authority (CA) is manifested through a commander or individual who has the authority to require consultation between the specific functions or activities involving forces of two or more Services, joint force components, or forces of the same Service or agencies but does not have the authority to compel agreement (Joint Publication 1, Volume 2, 2020). CA involves force employment, the near-term operationalization for forces to meet immediate challenges and execute campaign plans, and extends beyond the role of "proponent for" which is tied to longer term aspects of the Joint Strategic Planning System f*orce development and force design*.

bilities (DOW Arctic Strategy, 2024) by developing a more comprehensive and overarching responsibility of setting requirements within the Arctic – more clearly defined responsibility than advocating for Arctic capabilities. Though advocating and requesting resources for Arctic capability gaps is not new, the aspect of setting theater requirements for the Arctic is not found in national strategic or policy documents and should therefore be considered for codification in the UCP to ensure concurrence between the three stakeholder CCMDs and the Joint Staff. Moreover, a theater of operations can also become a theater of war for contingency plan activation, so it is resilient throughout various levels of campaign and contingency scrutiny.

Figure 6: Map of the Arctic (DOW Arctic Strategy, 2024)[26]

26 Note: the CCMD AOR boundaries near Greenland are dated. Greenland transitioned from USEUCOM to USNORTHCOM's AOR in June 2025.

One of the advantages of establishing an ARCTO in the near-term is it does not require AOR boundary changes in the UCP. A theater of operations that transcends current UCP boundaries is the logical first step toward unified command in the Arctic because this construct allows CCDRs a trial period. A trial period prior to crisis or conflict provides an opportunity to experiment and refine the boundaries of a unifying geographic space in the Arctic before full- or long-term implementation involving any AOR changes that place the entire Arctic under a single CCMD. Understandably, USEUCOM will be the least likely to initially accept an ARCTO because this CCMD serves to forfeit some (but not all) of its Arctic influence. For this reason, the Nordic countries were not included in the initially proposed ARCTO, but could be added as conditions warrant. On the other hand, USINDOPACOM only loses the western third of the Bering Sea to the ARCTO. The forces and bases in Alaska, an area of critical significance for homeland defense (Nahom and Vanderlugt, 2023), remain squarely stationed in the USNORTHCOM AOR and assigned to USINDOPACOM to be postured for the Pacific Theater. The global force management allocation plan could result in these forces responding to any location on the globe, including the Arctic, or alternatives involving Arctic capable Service-retained forces in Alaska through policies and procedures per global force management implementation guidance (JCS, 2024).

A second advantage for establishing an ARCTO involves the fact that the US already has a subordinate unified command task-organized under USNORTHCOM – essentially the nascent architecture of an "Arctic Command" – in Alaska, in a logical location and present on US soil in the Arctic. Though arguably under-resourced and under-manned for the task currently (Blume et al., 2024), ALCOM could serve as a nucleus for C2 of Arctic operations beyond Alaska and the AKTO. In this sense, the current AKTO could simply be expanded to include increasingly larger portions of the Arctic, with ALCOM assuming additional and proportional responsibilities and resourcing from USNORTHCOM.[27] Though other types of command relationships exist within combatant commands, such as joint task forces and single Service commands, subordinate unified commands offer specialized C2 for certain geographic areas of strategic or operation concern in a CCDR's AOR (US Forces Japan and US Forces Korea under USINDOPACOM provide two other examples). Indeed, experimentation and proposals for various command structures have occurred, including the US Coast Guard's Task Force Arctic and that of an Arctic Combined Joint Interagency Task Force, or CJIATF (Woityra & Thomas, 2025). The challenge with these organizations is they can lack a clear area of operations agreed upon by adjacent combatant commands, or adequate resourcing and support from Service Component Commands. The ARCTO and a subordinate unified command structure address these shortcomings.

One of the weaknesses of the current UCP is it lacks a clear definition of the Arctic within which to bracket the primary responsibility of setting theater requirements. Though the Arctic is duly invoked throughout the UCP document, as a region it is not clearly defined. This remains a challenge when clearly articulating the boundaries of the ARCTO. The US definition of the Arctic Region was originally codified in the Arctic Research and Policy Act (ARPA) of 1984 (15 U.S.C. § 4111).[28] This is the definition carried forward in the DOW's 2024 Arctic Strategy as illustrated by the Strategy's facer-map shown below.

27 For the expansion of this concept, i.e. establishment of a Western Hemisphere High Latitude Theater of Operations (HLTO), see section titled "Contrasting Views, Counterarguments and Hybrid Solutions" below.
28 According to 15 U.S.C. § 4111: "The Arctic means all U.S. and foreign territory north of the Arctic Circle and all U.S. territory north and west of the boundary formed by the Porcupine, Yukon, and Kuskokwim Rivers; all contiguous seas, including the Arctic Ocean and the Beaufort, Bering, and Chukchi Seas; and the Aleutian Island chain."

However, the Arctic as a region is not fully articulated merely by the area contained within the Arctic Circle. For military operations associated with the ARCTO, a more politically distinct definition is necessary – one that does not simply follow somewhat arbitrary lines of latitude (i.e. the Arctic Circle, at 66.56º N latitude) but leverages cohesive national, political, and military boundaries. An Arctic Theater of Operations (ARCTO) should include the following, as illustrated by the following map:

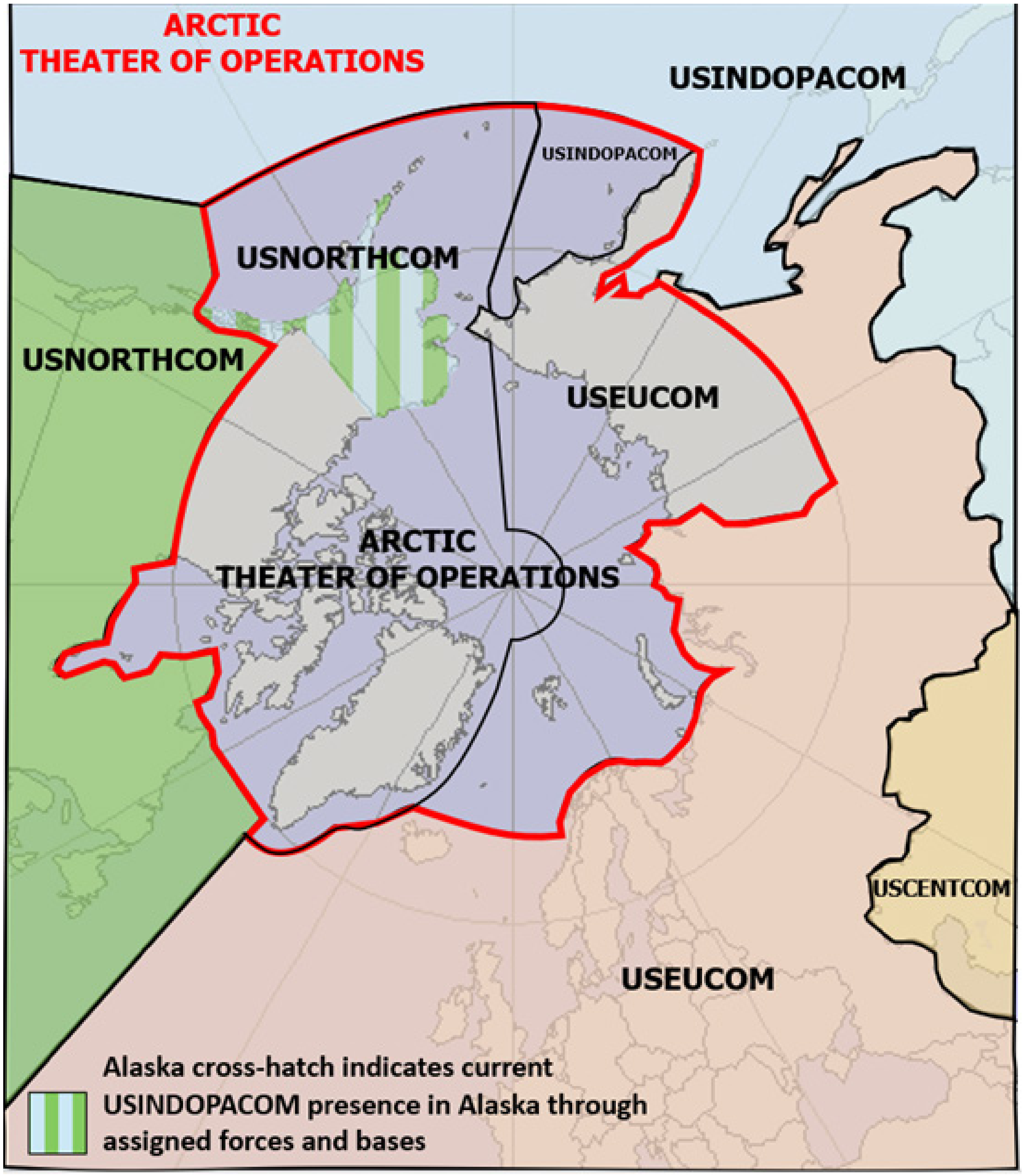

Figure 7: Proposed Arctic Theater of Operations (ARCTO)

1) The entirety of the Arctic Ocean and all islands within that body of water

2) The entirety of Alaska and its surrounding waters, as defined by USNORTHCOM's Alaskan Theater of Operations (AKTO), including the Aleutian Islands and Bering Sea

3) The entirety of Canada's JTF-North Arctic AOR[29]

4) The entirety of Greenland and Joint Arctic Command's (JACO's) AOR that encompasses Greenland and its surrounding waters[30]

5) All remaining areas included in the Arctic definition codified in 15 U.S.C. § 4111, except for the Nordic countries (Norway, Sweden, Finland, Iceland, and Denmark) and Russian mainland west of Russia's Eastern Military District and south of 60º N latitude (which remain in USEUCOM)

6) The entirety of Russia's Eastern Military District north of 60º N latitude, inclusive of the Kamchatka Peninsula

Under this definition, in the western hemisphere, the ARCTO follows 60º N latitude across the majority of the North American landmass, but includes all of Alaska and the Bering Sea. In the eastern hemisphere, the ARCTO follows 60º N latitude in Siberia and the Russian Far East, with the exception of Kamchatka's more southerly connection to Beringia. In the remainder of central and western Russia, the ARCTO's boundary follows the northern coast of western Eurasia, to include the coastline of the Nordic countries. It then connects across the North Atlantic via the Arctic Circle and includes the totality of Greenland.

Overall, establishing an ARCTO would involve specific responsibilities related to homeland defense, setting requirements, and military matters in the Arctic as assigned by the Commander, USNORTHCOM, who maintains overarching responsibility for planning, coordinating, integrating, synchronizing, assessing, and executing homeland defense operations within the USNORTHCOM AOR in concert with missions performed by the North American Aerospace Defense Command (NORAD). Though some responsibilities would be delegated to the subordinate unified command of the ARCTO, the Commander of USNORTHCOM would retain all overarching responsibilities associated with an AOR in the UCP as applied to the ARCTO. Therefore, within combatant command (COCOM) authority, the Commander of USNORTHCOM and NORAD – who historically has been the same individual – could serve as single point of contact on all operational military matters both within the USNORTHCOM AOR and beyond AOR boundaries within the Arctic Theater of Operations. This leverages the unique relationship between USNORTHCOM, NORAD, and homeland defense not found in other combatant commands adjacent to the Arctic. It provides a necessary Arctic buffer for development and implementation of the Golden Dome missile defense program from ten o'clock to the two o'clock positions – the northern sector of the North American homeland. It also provides opportunities to expand engagement with Arctic Allies and partners through NATO and NORAD, and increase campaigning and flexible deterrence options in the Arctic through combined exercises, presence, and training.

29 JTF-North's Arctic AOR includes Northwest, Yukon and Nunavut Territories bordered to the south by 60º N latitude, inclusive of Hudson, James, and Ungava Bays. The boundary extends east from Ungava Bay along 60º N latitude to the Canada/Greenland territorial water boundary, and follows this boundary to the North Pole. From the Pole, the boundary extends south along 141º W latitude, which divides Yukon Territory and Alaska.
30 The Greenlandic portion of JACO's AOR includes the Greenlandic Economic Zone and the Greenland Search and Rescue Region (SRR).

ESTABLISHING AN ARCTIC COMMAND (USARCTICOM), A LONG-TERM ALTERNATIVE

Establishing a new combatant command, an Arctic Command or "USARCTICOM," could represent a long-term Arctic futures alternative that facilitates unified command in the Arctic. By expanding the Alaska Theater of Operations to an Arctic Theater of Operations, (ARCTO) through a phased approach over approximately a decade, the ARCTO could be converted into a new geographic combatant command Area of Responsibility, i.e. USARCTICOM AOR. This AOR would include all areas of the ARCTO and could be further expanded to include the Arctic political entities previously excluded from the ARCTO (in order to facilitate a more seamless transition from AKTO to ARCTO), including the Nordic countries of Iceland, Norway, Sweden, and Finland and the Russian mainland north of 60º N latitude. The map below shows this later potential expansion of the ARCTO to include the Nordic countries and northern Russia.

Under this alternative, all three CCMDs that previously shared AOR space in the Arctic would lose portions of their territory. In this future state, USEUCOM would lose significant territory to USARCTICOM. USNORTHCOM would cede all territory above 60º N latitude, including Alaska, to the new Arctic combatant command. The forces (and bases) stationed in Alaska previously assigned to USINDOPACOM would be aligned as Arctic-capable forces for USARCTICOM – or could potentially be Service-retained – but would remain available for worldwide deployment. As the subordinate unified command is grown to fully accept responsibility for combatant command requirements, the red star on the map below indicates the likely headquarters location for a future US Arctic Command – near the same location as the current subunified Alaskan Command headquarters.

A variation of this alternative could include merely expanding USNORTHCOM's AOR to encompass the entirety of the Arctic, rather than breaking off the Arctic portion of the AOR and creating a separate combatant command. Another variation could involve retaining ALCOM's 3-star billet for the new combatant command, rather than elevating it to a 4-star billet. This would initially make USARCTICOM a "lesser" combatant command (a 3- versus 4- star command) but with its own discrete AOR, and provide an opportunity to gradually grow the currently existing subunified command to a 4-star combatant command as the operational environment evolves.

CONTRASTING VIEWS, COUNTERARGUMENTS AND HYBRID SOLUTIONS

The specifics of how to establish unified command in the Arctic will continue to be up for debate. This article does not attempt to propose the final word to this complex problem but rather serves to generate healthy and constructive dialogue regarding the future of Arctic Security and unified command. One goal is to encourage collaboration among CCMDs and the Joint Staff regarding the Arctic, and to generate strategic options, including that of other CCMDs (besides USNORTHCOM) "owning" the Arctic.

USINDOPACOM alternative. The option of transferring the entire Arctic region, including Alaska and the AKTO, to USINDOPACOM represents a contrasting view or counterargument to either the establishment of the ARCTO or a USARCTICOM. Transferring Arctic geography to USINDOPACOM could also include portions or combinations of the AKTO, including Alaska, and Russia's Eastern Military District aggregated under USINDOPACOM control. However, this would result in an expansion of USINDOPACOM's already extensive AOR space which currently includes over half of the globe, on top of the challenge of providing effective C2 in the Arctic from a tropical archipelago in the middle of the Pacific. A more satisfactory solution, in the near term, involves identifying the smaller portion of the Arctic that is directly linked to the Pacific as defined earlier, the Arcto-Pacific, to leverage resources, exercises, and infrastructure already supporting the Pacific.

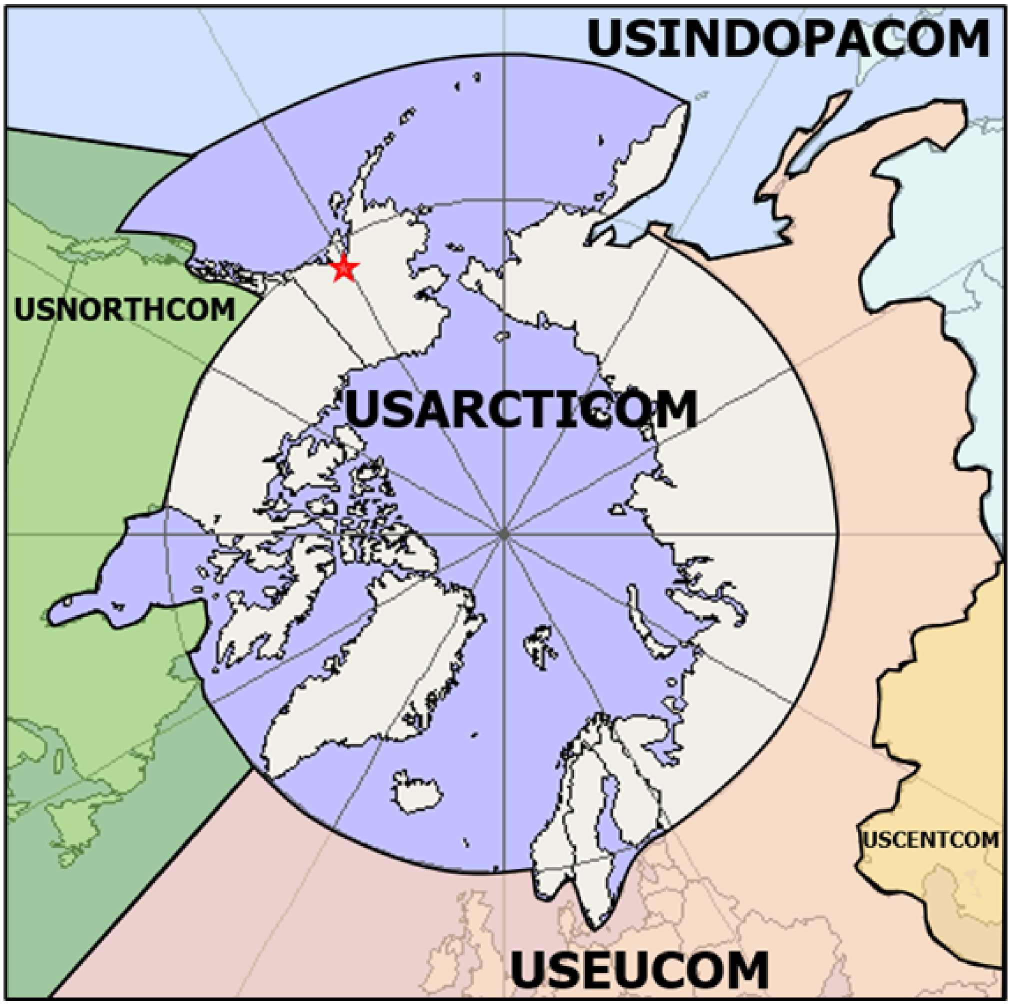

Figure 8: Proposed USARCTICOM and its associated AOR

USNORTHCOM alternative, and a High Latitude Theater of Operations (HLTO). A hybrid solution, while acknowledging the Arcto-Pacific's linkages of its assigned forces, infrastructure, and resources to USINDOPACOM, involves creation of an interim western hemispheric Arctic Theater of Operations – a bridging alternative between the currently established Alaskan Theater of Operations (AKTO) and the proposed cross-CCMD Arctic Theater of Operations (ARCTO). Establishment of this purpose-built and AOR-pure Western Hemisphere High Latitude Theater of Operations (HLTO) would include only that portion of the ARCTO in the current USNORTHCOM AOR. The HLTO, a theater of operations exclusively boundedNorth American Arctic within the western hemisphere, would include:

1) That portion of the Arctic Ocean within the current USNORTHCOM AOR

2) The entirety of Alaska and its surrounding waters, as defined by USNORTHCOM's Alaskan Theater of Operations (AKTO), including the Aleutian Islands and Bering Sea

3) The entirety of Canada's JTF-North Arctic AOR

4) The entirety of Greenland and Joint Arctic Command's (JACO's) AOR that encompasses Greenland and its surrounding waters

The HLTO differs from the ARCTO in that it would not include any portions of USINDOPACOM or USEUCOM within the Arctic. Therefore, the HLTO would exclude the western portion of the Bering Sea, the entire Russian Arctic, and the Nordic Countries (except Greenland, a self-governing territory of Denmark in North America). An advantage of the HLTO is its geographic simplicity: it merely includes the Arctic portion of the western hemisphere within the USNORTHCOM AOR. Like the ARCTO, the HLTO would follow 60º N latitude across most of the North American landmass and include all of Alaska and the Bering Sea.

A second advantage of the HLTO involves its rapid ease of implementation within one CCMD, an action by the USNORTHCOM Commander not requiring collaboration or concurrence of adjacent CCMDs. This could be accomplished in an incremental fashion: 1) establish the HLTO first, which is an expansion of the AKTO, with ALCOM providing C2 as a subunified command reporting to USNORTHCOM. 2) eventual implementation of the ARCTO, 3) establishment of a USARCTICOM *only if* the operational environment and threat conditions merit (USARCTICOM could initially be a 3-star billet given current constraints; however, ALCOM and USARCTICOM would eventually need additional resources and Service component support given a larger area and responsibilities to cover).

A third advantage is the HLTO would enable increased collaboration between Arctic Allies in North America, namely: Alaskan Command (a subunified command of USNORTHCOM) headquartered at Joint Base Elmendorf-Richardson; Canada's Joint Task Force – North headquartered at Yellowknife, Northwest Territories; and Greenland/Denmark's Joint Arctic Command headquartered at Nuuk, Greenland. Increased collaboration would facilitate unity of effort within OAIs, exercises, and campaigning across the North American Arctic.

The ability to project forces laterally across the western hemispheric Arctic[31] represents a fourth advantage and advances the recent intent of centralizing command structures in the west to facilitate homeland defense – as demonstrated by establishment of Western Hemisphere Command in late 2025. A disadvantage to the HLTO is that it does not ultimately solve the problem of unity of command in the Arctic, accounting for the seams where the eastern and western hemisphere meet in the Arctic, especially the strategic choke points of the Bering Strait and GIUK Gap. The Bering Strait and GUIK Gap represent vital naval choke points between the Arctic and Pacific Oceans, and the Arctic and Atlantic Oceans, respectively. The Bering Strait is a center of gravity (COG) and key strategic location for the Arcto-Pacific; the GIUK Gap, offers a similar COG in the European portion of the Arctic.[32] A significant element for unity of command in both locations hinges on who is responsible for the approaches to the Bering Strait and GIUK Gap, given they constitute significant hemispheric seams between CCMDs.[33] The GIUK Gap, specifically, is used by both NATO – which has recently intensified patrols in the region – and Russia, whose nuclear submarines based out of Murmansk traverse the Gap. This would seem to suggest a NATO, or USEUCOM, response in this portion of the Arctic.

31 For example, strategic airlift can cover the 2,000-mile distance from Joint Base Elmendorf-Richardson to Pituffik Space Base in approximately five hours, a distance shorter than either Pituffik to Washington DC, or Washington DC to Seattle.
32 Both Alaska and Greenland are also positioned along the path of significant "arc threats" that could reach the homeland by traveling great circle routes via air from Eurasia. Arguably, there may currently be a greater synergy of threats from China/Russia/North Korea via the 10 o'clock or Bering Sea approaches, than via Greenland at the homeland's 2 o'clock position.
33 The GIUK Gap's northern approaches present a problem for the proposed ARCTO concept, with unresolved seams where one could argue the areas due north of Murmansk and the Nordic states, including Svalbard and Novaya Zemlya, are more of a EUCOM NATO equity than related to USNORTHCOM or a subunified such as ALCOM within the ARCTO. Formation of a more comprehensive USARCTICOM with Arctic boundaries that include the Nordic States, Kola Peninsula, and encompass the entirety of the GIUK Gap addresses this issue.

USEUCOM alternative. Like the alternative of transferring the Arctic to USINDOPACOM, transferring the entire Arctic region to USEUCOM represents a scenario where USEUCOM would gain AOR space. Though this could address the specific problem of the GIUK Gap, it would also prioritize Europe and the eastern hemispheric portions of the Arctic over North America and the western hemisphere – which conflicts with recently published national strategic guidance that prioritizes the western hemisphere. USEUCOM will also likely remain NATO-centric in its orientation, rather than focused on defense of the US homeland, like its counterpart's mandate on the North American side of the GIUK Gap. The problem of the Gap therefore creates a natural tension between prioritization of a NATO-centric (USEUCOM or European) Arctic and a homeland defense-centric (NORAD and USNORTHCOM, or North American) Arctic. Moreover, viewing the Arctic exclusively through a NATO or "overseas" lens could involve increased national risk for the United States by diluting the prioritization of homeland defense (the Arctic contains US homelands and is therefore naturally aligned as a homeland defense priority). In short, the Arctic's inherent gravity to US homeland defense is why a comprehensive "Arcto-Atlantic" concept will not work; the Bering Sea and Alaska are far flung from USEUCOM and not priorities for organizations like JFC Norfolk.[34] Therefore, the USEUCOM or a similar NATO alternative is unlikely to effectively or comprehensively address unified command in the Arctic with homeland defense as the primary consideration.

Finally, the "do nothing" C2 alternative of merely keeping an enduring status quo in the Arctic is not sustainable and involves long term risk to mission and risk to force given the Arctic's evolving security environment and competing requirements elsewhere on the globe.[35] In addition, as articulated in Part I through examining the history of ALCOM, a bifurcated or trifurcated Arctic has proven to be an unsuccessful approach in Alaska and the Arctic. The United States will be increasingly challenged to execute its Arctic strategy in a divided Arctic, or within a region classified as "many Arctics." Many or multiple Arctics means the Arctic itself is undefined, resulting in a lack of deliberate examination of Arctic requirements and no plan of action or milestones that align with strategic national guidance documents. The trigger for a significant UCP rewrite in the Arctic will likely be a significant geographical shift in the operational environment or a major addition of tasks outside of current CCMD taskings. For example, new sea lines of communication and commerce lines such as along the Northern Sea Route through the Bering Strait along with commercial access to new resources in a region split between three CCMDs seems to indicate the necessity for geographic realignment of AOR boundaries. Russia currently has the highest concentration of military bases in the Arctic – this remains a fact even while the Ukraine War is occurring. The addition of Russian permanent infrastructure or even dual-use Chinese-Russian bases and infrastructure after Ukraine is resolved could also drive new taskings for UCP alignment under a single CCMD. In addition, increased access, basing, exercises, and military overflight by adversaries in the Arctic may invoke new tasks and create a demand signal that tips the scales toward clear contingency planning requirements in a region that currently has no standalone contingency requirements.

Ultimately, the solution may be the UCP AOR designation of an USARCTICOM, even if this seems currently untenable given consolidation and simplification of military headquarters based on hemispheric defense considerations. Creation of an Arctic combatant command will also meet headwinds due to competing priorities between NATO and USEUCOM equities versus those of a purely Arctic Command focused on unifying "all things Arctic" and serving as a critical homeland defense layer for USNORTHCOM. To be effective, a future USARCTICOM must solve the three-way CCMD problem currently existing in the Arctic, specifically in the Bering Sea portion of the Arcto-Pacific, and avoid transplanting the problem to other locations like the GUIK Gap and its approaches. A

34 Analyzing the likelihood of any NATO response in the North Pacific is beyond the scope of this article.
35 The United States' Arctic capable forces in Alaska are assigned to the Pacific. Should they be needed or called to respond in the Arctic, USINDOPACOM's boundaries within the Arctic are limited to the eastern portion of the Bering Sea only. Deployment and array of Arctic capable forces would need to be further prioritized and adjudicated.

new UCP construct within the Arctic must successfully gain and maintain domain awareness and maritime warning, with the ability to either handoff to USEUCOM/NATO (JFC-Norfolk) to flexibly respond, or potentially handoff to USNORTHCOM/NORAD to manage consequences if the threat is not deterred. The caution and challenge for any Combatant Command is to ensure problems are not pushed out of one AOR, just to have them resurface in another area on the globe.

CONCLUSION

Anticipating Arctic futures to achieve unified command in the Arctic requires the United States to view its role in Alaska and the Arctic region holistically. The United States is an Arctic nation because of Alaska, and therefore Alaska must serve as the nucleus and entry-point for solutions to unified command amidst the Arctic's rapidly changing security environment. As a fundamental region within the western hemisphere, the Arctic is central to homeland defense and highly connected to the Indo-Pacific through Alaska and the Bering Sea, which serve as the Arctic's center of gravity. Unified command in the Arctic can be best achieved through a three-phased approach. First, the Arctic's relationship to the broader Pacific world must be immediately contextualized through the geopolitical construct "Arcto-Pacific." This can be accomplished now and directly impacts the Arctic's security posture by linking Alaska and the Bering-Chukchi Sea region to the priority forward theater of the Pacific. Second, a near-term alternative for achieving unified command in the Arctic involves establishment of an Arctic Theater of Operations (ARCTO), which expands the Alaska Theater of Operations concept to include the Arctic region without changing combatant command boundaries. This is not intended to be a call to militarize the Arctic or to initiate a dangerous escalatory spiral for an Arctic arms race. On the contrary, establishing a stronger US military presence through Arctic-capable bases and forces and effective command relationships facilitated by an ARCTO will be central to preempting strategic futures of the region. Finally, this article makes a case for the US pursuit of more centralized and integrated command and control (C2) relationships in the Arctic Region. It does not argue for US Arctic Command (USARCTICOM) now – or even in the next decade – but anticipates that the future state of the Arctic will require a unified command structure in the region. The operational environment and threats of today will be different ten years from now when an Arctic Command structure may be necessary. The United States must plan now for the threats of tomorrow. Ultimately, establishing a separate USARCTICOM in the late 2030s or beyond provides a long-term solution to inherent command and control challenges by enabling unified command in the circumpolar north through treatment of the Arctic as a distinctly cohesive global region possessing a unique and emergent strategic identity.

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Defending Arctic North America:

An IN, TO, and THROUGH Comparative Threat Analysis

By

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Recent strategic threat assessments reinforce that defending the North American homeland is a Canadian and American priority (VanHerck, 2022). Canada's Arctic Foreign Policy (GoC, 2024b), released in December 2024, complements the defense policy update Our North: Strong and Free (DND, 2024) published the previous April. These follow the Biden government's July 2024 release of the US Arctic Strategy (DoD, 2024), which completed a series of US strategic documents laid out in 2022 (Dean & Lackenbauer, 2024a). In both countries, the prioritization of defense strikes a different tone from the aspirations of the March 2016 Obama-Trudeau "U.S.-Canada Joint Statement on Climate, Energy, and Arctic Leadership," which focused on conservation, science-based decision-making, and incorporating traditional knowledge into this process to support strong Arctic communities built around sustainable economies (Prime Minister of Canada, 2016). Since that time, the changing operational environment, new and disruptive technologies, and "major geopolitical changes" driven by Russia's renewed invasion of Ukraine and growing Sino-Russian ties in the Arctic (DoD, 2024) have "rapidly redefining conflict and what it takes to be safe and secure" (DND, 2024), spurring renewed defense thinking in North America towards the Arctic.

This study provides comparative analysis of current Canadian and US Arctic threat assessments in selected strategic documents to interrogate defense thinking in a North American context. It applies the IN, TO, and THROUGH methodology (Lackenbauer 2021a) to Our North Strong and Free (ONSF) and Canda's Arctic Foreign Policy (CAFP) and then compares them to the DoD's Arctic Strategy. Analyzing these documents provides insight into the two countries' perceptions of Arctic security, illuminating synergies for possible cooperation and areas of possible divergence or disagreement. We also lay down a strategic policy baseline for the future, given the change of governments in both Washington and Ottawa since January 2025.

Both Canada and the US articulate common end states for the Arctic rooted in preserving regional stability in the face of growing strategic competition, advanced adversarial delivery systems, and a changing climate (GoC, 2024a, p. 5 and DoD, 2024, p. 1). The countries also share general similarities in where and how they will defend the Arctic. For example, their respective strategies call for cooperation with one another to secure the North American Arctic, primarily together through the binational North American Aerospace Defense Command (NORAD). Similarly, they both highlight working with other allies, primarily through the North Atlantic Treaty Organization (NATO), which reinforces Canada's pivot away from an earlier wariness to have the alliance adopt an explicit regional strategy. In both the North American and European subregions, Canada and the US position Russia as the principle geopolitical threat.

Despite these similarities, the Canadian and US Arctic security strategies are oriented differently. The US strategy is relentlessly international in its overall level of analysis, looking at how geopolitical forces outside the Arctic affect it and how the region can respond (see Dean and Lackenbauer, 2024a). In comparison, Canada's level of analysis is more domestic in orientation – an "inside out" approach that anticipates how proactive actions in the Arctic can calm the international system. Furthermore, while the US strategy parses the Circumpolar North into the distinct subregions of the European and North American Arctics, the Canadian strategy further breaks down the North American Arctic into its various avenues of approach, leading to a further delineation of threat and clarity of response. Ironically, while Canada explicitly references the categorization of IN, TO, and THROUGH threats in its policies, it does not apply the methodology with the same rigour as the US strategy (albeit implicitly).

Synthesizing American and Canadian threat perceptions of the Arctic yields a more comprehensive awareness of the region through a North American lens, clarifying where, how, and when threats will develop. This helps to focus local mitigation efforts on climate-induced threats IN the Arctic towards infrastructure and communities, better distinguish between the different threats TO the Alaskan and Canadian Arctic, and orient common responses to the shared aerospace threat THROUGH the region. This is reflected in American participation in the ICE Pact to produce ice-capable vessels for the United States Navy and Coast Guard (HS, 2024) as well as proposed Canadian participation in the Golden Dome to generate an all-domain defeat capability (Clark, 2025).

THREATS IN THE NORTH AMERICAN ARCTIC

ONSF, CADP, and the DoD Arctic Strategy all position changes in the operational environment as the primary threat IN the Arctic, particularly the North American Arctic (Government of Canada, 2024a, p. 13 and DoD, 2024, p. 5-6). CAFP states that "climate change is both the most pressing and the most proximate threat to Canada's security in the Arctic and the people who live there," (Government of Canada, 2024a, p. 13) further noting that "the Arctic [is] warming 4 times faster than the global average, causing significant impacts on natural and human environments" (Government of Canada, 2024a, p. 5). While acknowledging that the effects of these changes are wide-ranging and negatively impacting way of life in Arctic communities, the DoD Arctic Strategy remains focused on how they affect DoD's operating environment (DoD, 2024, p. 5). This maintains a clarity of purpose and focus that prevents the strategy from slipping into a tautology where climate change is a threat to everything, diluting policy responses to this threat IN the shared North American Arctic.

The DoD Arctic Strategy notes that much of the defense infrastructure in the North American Arctic was built during the Cold War. Subsequently, warming temperatures have begun causing "permafrost thaw and faster-than-anticipated rates of coastal erosion" (DoD, 2024, p. 5), threatening legacy infrastructure and placing additional demands on building and future-proofing new builds. Other effects include more forest fires in Alaska, which means fewer training days and greater response requirements on forces, thus affecting overall military readiness levels (DoD, 2024, p. 5-6). Increased uncertainty due to the changing environmental conditions in the North American Arctic puts greater demands on the Joint Force to operate in and from there, given that the region is "far drier, colder, and sparsely populated with minimal infrastructure" than the European Arctic (DoD, 2024, p. 6). These factors compound to make sustaining forces across the North American Arctic in remote operating locations "even more challenging" than elsewhere (DoD, 2024, p. 6).

ONSF elaborates on these challenges, positioning climate change as a primary driver of future requirements for the Canadian Armed Forces (CAF). The policy update notes that "extreme weather events are causing provinces and territories to call on our military much more often" (DND, 2024, p. v). Like the US Joint Force, the CAF already undertakes a wide range of missions, such as "conducting search and rescue, and assisting civil authorities when required," but calls for the military "to assist Canadians facing wildfires, floods, or other climate-related disasters" are increasing (DND, 2024, p. 24). The CAF thus needs “a more modern, mobile and effective tactical helicopter capability” to meet the demands for growing airlift capacity, along with “a mix of crewed and uncrewed aircraft” (DND, 2024, p. 25). ONSF promises that these new assets will “enhance our ability to respond to emergencies and disasters” (DND, 2024, p. xi). What the Canadian documents fail to note is how significant new platforms like the Harry DeWolf-class Arctic and Offshore Patrol Vessels (AOPV) already help address threats posed by environmental changes IN the North American Arctic, and how they can be used in future climate-related crisis.

Both US and Canadian documents attach timelines to changes in the operational environment. The DoD notes that the “Arctic may experience its first practically ice-free summer by 2030” (DoD, 2024, p. 2). In comparison, CAFP and ONSF posit that “by 2050, the Arctic Ocean will become an increasingly viable shipping route between Europe and Asia during the summer” (Government of Canada, 2024a, p. 5). This twenty-year window is important for planning future forces. The DoD Arctic Strategy emphasizes that “strategic significant maritime chokepoints such as the Bering Strait between Alaska and Russia” are becoming “more economically and militarily significant,” with more access producing an “elevated risk of accidents” and “environmental degradation” that heighten operational pressures on US forces in the North American Arctic. Greater contact with adversarial powers, particularly China and Russia, also raises the risk of “miscalculation” in the region (DoD, 2024, p. 2). The CAFP offers similar reasoning, elaborating that “with retreating sea ice and new technologies improving navigation and accessibility, foreign activity in the Arctic will continue to increase, bringing with it related safety, security and environmental challenges” (Government of Canada, 2024a, p. 13). CAFP concludes that climate-related impacts on natural and human environments “serve as threat multipliers because changing environmental conditions create additional opportunities for foreign adversaries and competitors to covertly or overtly operate in the Canadian Arctic” (Government of Canada, 2024a, p. 13).

Lackenbauer (2024) argues that it is important for analysts to consider specific domains (air, cyber, land, sea, and space), sectors of security (military, political, economic, environmental, and societal), time horizons, and other variables rather than assuming that a reduction in overall ice cover means greater accessibility writ large. Environmental change is not uniform across the Arctic and can produce unexpected effects on its different sub-regions. Both Canada and the US focus on shipping and the adverse effects that vessels bring with them – a topic often mischaracterized or blown out of reasonable proportion in the popular media. For example, the notion that “wildcat” miners will setup on Prince Patrick Island or plant an oil rig off the North Slope of Alaska without any kind of state approval is preposterous, as is the threat of some sort of full-spectrum military invasion of the North American Arctic. More helpfully, both countries delineate where this shipping threat could materialize in the Arctic. The DoD Arctic Strategy points out strategic chokepoints like the Bering Strait (DoD, 2024, p. 23), while CAFP observes that Russia “is looking to profit from climate change in the region and will continue promoting the development of the Northern Sea Route” (NSR), which runs along the northern coast of that country, “as a major international shipping route. Given the strategic importance Russia places on its Arctic region, Canada expects these activities will continue” (Government of Canada, 2024a, p. 7). This distinguishes the NSR from the Northwest Passage, which Canadian officials forecast will not see comparable shipping levels in the 2030-50 timeline (Government of Canada, 2024a, p. 5, 13).

While both countries’ strategies equate increased access with increased military threat, there are significant differences in anticipating when this could happen. For example, ONSF argues that “by 2050, the Arctic Ocean could become the most efficient shipping route between Europe and East Asia” (DND, 2024, p. v). A policy document such as this provides no references to source material, thus leaving it unclear whether this reference is to the transpolar route through the Central Arctic Ocean or the NSR. This speculative statement also downplays tremendous uncertainty in forecasting possible futures emanating from different climate models as well as assumptions about the economics and politics around these routes, should they become viable. Future threat assessments should incorporate more nuanced appraisals of the drivers of increased regional accessibility by domain and how these heighten the threat environment, as the US Army (2021) and Royal Canadian Navy (2023) strategies have done.

THREATS TO THE NORTH AMERICAN ARCTIC

Canadian and US Arctic strategies breakdown threats TO the North American Arctic into two general categories. This first is that Russia is an acute threat to the subregion, presenting a growing range of threats from below threshold cyber-attacks up to and including nuclear strikes. The second is that the PRC – as an outside actor to the region – is challenging the regional governance of the Arctic which could have negative implications TO the residents of the North American Arctic and beyond. However, both the Russian and PRC threats TO the North American Arctic are increasingly tied to thwarting the mobilization and deployment of the US Joint Force to overseas theatres.

Why both countries pose a threat TO the North American Arctic is that they are authoritarian regimes motivated – at a minimum – to undermine democratic norms and institutions in the region and as part of a larger global effort to their benefit (DoD, 2024, p. iii, 3-5). Completing the thesis that greater access means greater threat, CAFP emphasizes that “our adversaries aspire to a greater role in the region’s affairs. The physical threat of climate change is compounded by challenges from authoritarian states to the rules-based international order that Canada and its allies strive to uphold” (Government of Canada, 2024a, p. 4). Russia is a major actor in the Arctic, prioritizing the region second only to its “near abroad” (DoD, 2024, p. 4). While China is not a peer competitor in the Arctic and commentators often overstate its actual footprint in the region (Lackenbauer, Lajeunesse, and Dean, 2022; Edstrøm et al, 2025; Hulme, 2025), Beijing does have designs to “play a larger role in its regional governance” (DoD, 2024, p.3; also Kauppila and Kopra, 2025). Unlike Russia (which is repeatedly termed a threat), both Canada and the US deem China to be a geostrategic challenge but strongly imply that it could quickly become a threat to sovereignty and to the regional order (Dean and Lackenbauer, 2024b; DND, 2024, p. 8; and Government of Canada, 2024a, p. 7).

CAFP lays out how different parts of the Arctic face different threats. “The Arctic is a strategically important region for the defence of North America and the North Atlantic Treaty Organization’s (NATO’s) northern and western flanks,” the policy statement explains. “However, the defence architecture and threat picture differ across the circumpolar north” (Government of Canada, 2024a, p. 8). The division and assessment of the European and North American Arctics in the DoD Arctic Strategy paints a similar picture, confirming a consensus in both countries that Russia poses threats TO the European North across the security spectrum (Government of Canada, 2024a, p. 7 and DoD, 2024, p. 2, 4). The conventional military threat that Russia poses TO the North American Arctic is more limited in specific domains, given geographical distances, the absence of a land border, and the comparative risks of any attack on North America.

The DoD’s Arctic Strategy notes that the North American Arctic is home to “significant U.S. defense infrastructure” that is “vital to homeland defense” (DoD, 2024, p. 2). This infrastructure centers on two elements: 1) providing aerospace warning, aerospace control, and maritime warning capabilities to NORAD, and 2) supporting the air defense and expeditionary forces based in Alaska (DoD, 2024, p. 2). Russia poses threats TO the North American Arctic in both respects, with US Alaskan-based air defense and expeditionary forces oriented primarily to the Indo-Pacific and the pacing threat posed by China, and NORAD detection and communications infrastructure extending across the Canadian Arctic as well. Russia could seek to destroy or disrupt this critical infrastructure in the case of an armed conflict, meaning that both Canada and the US must deter and be prepared to defend against these kinetic threats TO the North American Arctic, so that Russian long-range fires cannot pass THROUGH it. While much of the strategies in this respect are oriented around the threat posed by Russia, the same logic holds for the PRC (see VanHerck, 2022; Dean and Lackenbauer, 2024b).

American strategy positions Russian forces as a threat TO critical military infrastructure, as that country "has a clear avenue of approach to the U.S. homeland through the Arctic" (DoD, 2024, p. 4), with Canadian strategic documents sharing this view (Government of Canada, 2024a, p. 7). Damaging North American aerospace and maritime domain awareness infrastructure "would hamper the U.S. military's ability to operate in the region" (DoD, 2024, p. 17) and undermine NORAD's ability to detect, deter, and defend threats to both homelands (DoD, 2024, p. 8). From an international level of analysis, the loss of this infrastructure means the Arctic could become "a strategic blind spot" (DoD, 2024, p. 17) for the US in its overall global awareness and integrated deterrence of threats passing THROUGH the Arctic (DoD, 2024, p. 9).

Supplementing these kinetic threats are more subversive "hybrid" or "gray zone" ones designed to undermine the resilience of communities across the North American Arctic (e.g. Kertysova and Gricius, 2023; Piché, 2024). CAFP explains that "disinformation and influence campaigns," seek to "exploit vulnerabilities" across Northern communities. This includes "malicious cyber operations" along with "espionage and foreign interference activities" to affect those across the sub-region and the governments, institutions and infrastructure that supports them (Government of Canada, 2024a, p. 8). These threats extend beyond the CAF's mandate and require not just a Whole-of-Government response by the federal and territorial governments but a Whole-of-Society effort that brings in the private sector, non-governmental organizations (NGOs), and other actors to generate awareness of and resilience to these threats.

While the PRC is not currently an Arctic power (Lackenbauer, Lajeunesse, and Dean, 2022), the strategies highlight that Beijing has announced its ambitions to become a "polar great power" by 2030 (Government of Canada, 2024a, p. 14 and DND, 2024, p. 4). Part of this aspiration involves building a "Polar Silk Road" as a spur of its global Belt and Road infrastructure program, which involves developing shipping lanes and exploiting natural resources such as oil and gas, critical minerals, and fish (Government of Canada, 2024a, p. 14 and DoD, 2024, p.3). Beijing is supplementing these economic aspirations with expanded military power projection capabilities that could be deployed to the Arctic. The US observes that People Liberation Army Navy (PLAN) and Air Force (PLAAF) assets demonstrate "the capability and intent to operate in and around the Arctic region through exercises alongside the Russian Navy" (DoD, 2024, p. 3). With marine scientific research and involvement in regional governance, the PRC showcases these capabilities and activities to normalize its presence in the region (DoD, 2024, p. 3; also, Millard and Lackenbauer, 2021; Eiterjord, 2024; Kossa, 2024).

The closest Canadian or US strategies come to presenting an explicit PRC threat TO the North American Arctic relates to governance (White House, 2022a, p. 45 and Government of Canada, 2024a, p. 2, 14). By undermining agreed to rules and norms amongst the Arctic states, the PRC could set the conditions to pose future economic, environmental, and societal threats TO the Arctic. For example, Chinese fishing fleets could engage in future illegal, unreported, and unregulated fishing, damaging the fragile food webs already under pressure by environmental change (White House, 2022a, p. 6). Similarly, poorly regulated mining of the "Arctic's significant deposits of in-demand minerals essential to key technology supply chains" could be a threat TO the Arctic environment. Such actions can have second order effects, posing "changes to traditional lifestyles" of various Arctic peoples (White House, 2022a, p. 6). While these scenarios remain speculative, both Canadian and US strategies posit that the PRC is undertaking dual-use scientific research across the Arctic that undermines international rather than regional law. While the PRC has the right to conduct research under the United Nations Law of the Sea Convention (UNCLOS), some of that research is clandestine in circumvention or contravention of these laws or is being collected and applied for military purposes as much as civilian ones (DND, 2024, p. 4). Given the nature of China's regime and its activities around the world, CAFP concludes that "China can be expected to use all the tools at its disposal to advance its geopolitical interests, including in the Arctic" (Government of Canada, 2024a, p. 14).

PRC threats TO the military defense of the North American Arctic are more implicit in Canadian and US documentation. US strategies anticipate that much of the possible PRC kinetic threat will be aimed at Alaska, particularly defense infrastructure and forces that provide power projection into the Indo-Pacific region. Along the coast of Alaska lays the boundary of two of six geographic Unified Combatant Commands of the U.S. Armed Forces: US Northern Command (USNORTHCOM) and Indo-Pacific Command (USINDOPACOM). The latter has an area of responsibility encompassing about half the earth's surface, stretching from "the west coast to the western border of India, and from Antarctica to the North Pole" (USINDOPACOM, 2025). By basing significant USINDOPACOM army, air, and space force assets in Alaska because of their proximity to Pacific theatres, the DoD Arctic Strategy explains that infrastructure in that state is "integral to the execution of Indo-Pacific operations as the northern flank for projecting military force from the U.S. homeland to that region" (DoD, 2024, p. 2; also Dean and Lackenbauer, 2024b). This builds on the National Defense Strategy, which emphasizes that the PRC "seeks to target the ability of the Joint Force to project power to defend vital US interests and aid our Allies in crisis or conflict" (DoD, 2022, p. 4) – thus making Alaskan bases a logical target, given that a Chinese move against Alaska would "exploit advantages in geography and time backed by a mix of threats to the US homeland and to our Allies and partners" (DoD, 2022, p. 5). Damaging core military infrastructure could also curtail US forces' ability to act in the North American Arctic, such as conducting "personnel recovery/search and rescue" (DoD, 2024, p. 10). The DoD Arctic Strategy implies that China could add to these kinetic threats to Alaska as it seeks to grow its presence across the circumpolar world (DoD, 2024, p. 3, 5).

Figure 1: PRC-Russia Joint Military Exercises 2022-24[1]

1 Source: (2024, September 24). Japan to Alaska: What's behind Russia-China joint military drills? Aljazeera. https://www.aljazeera.com/news/2024/9/24/japan-to-alaska-whats-behind-russia-china-joint-military-drills

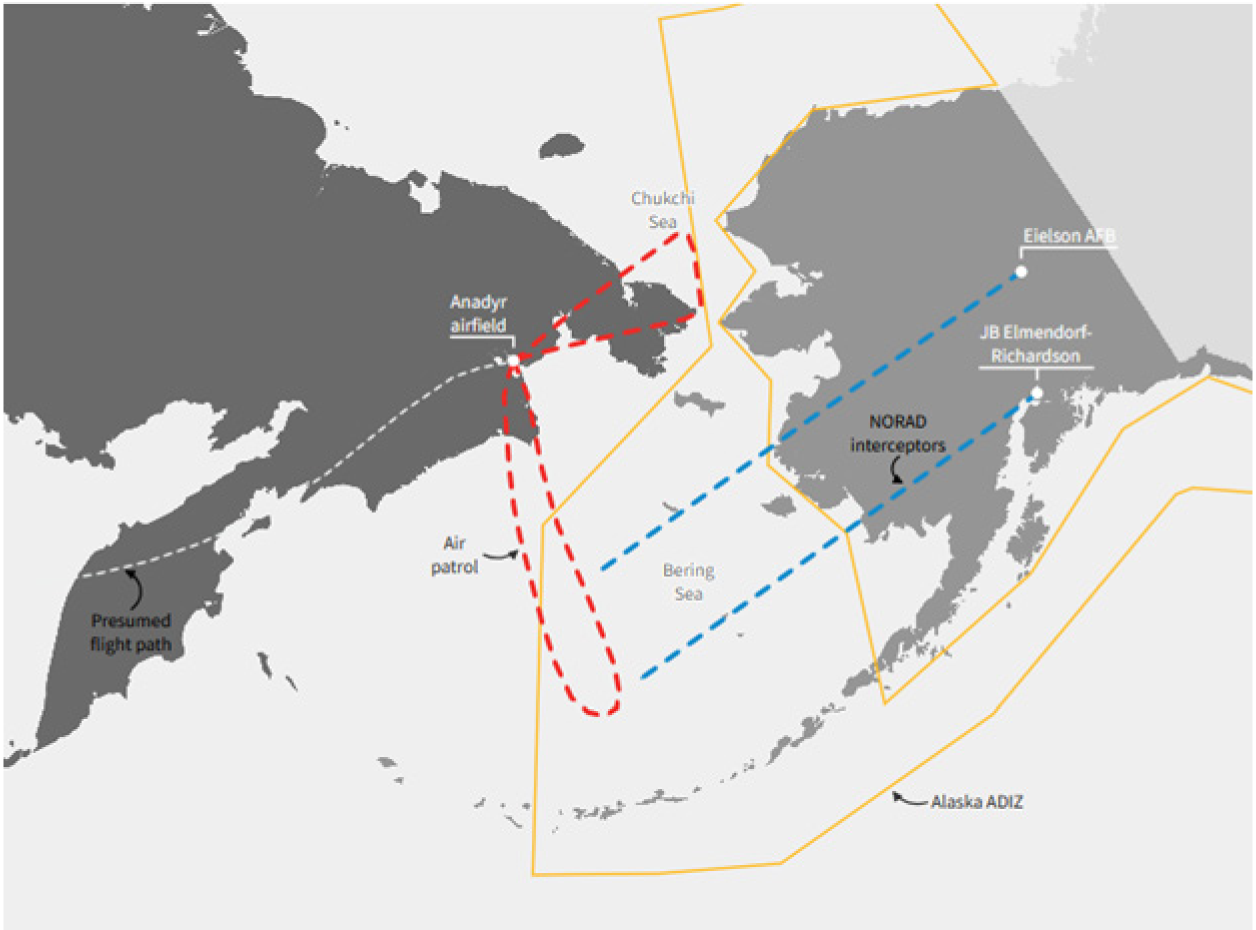

Figure 2: Approximate route of PRC-Russian bomber flight, 24 July 2024[2]

Both Canadian and US documents note that PRC military activity is concentrated around Alaska. To date, the Chinese military and coast guard has conducted military exercises in the Arctic with Russia, based on a 2022 Memorandum of Understanding (MOU) on regional cooperation between the two countries. 2022 and 2023 joint naval exercises were focused on the Bering Sea along the Aleutian Islands (see Figure 1). Joint PRC-Russia air exercises focus along Alaska's entire western coast (see Figure 2), with PRC and Russian ships operating along the Aleutian chain in summer 2024. These actions may be intended to check US power projection from Alaska (see Figure 1) as the northern flank of INDOPACOM (the area of focus for most PRC-Russia joint exercises) rather than as a vector of attack to penetrate Northern targets deep within the US and Canada (DoD, 2024, p. 5 and Government of Canada, 2024a, p. 7).

2 Source: Jon Feng. (2024, July 30). Alaska Map Shows Where Russian, Chinese Nuclear Bombers Circled U.S. Shores. Newsweek. https://www.newsweek.com/alaska-map-russia-china-nuclear-bomber-patrol-us-shores-1931944

The US National Defense Strategy notes that the PRC has at its disposal "a wide array of tools in an attempt to hinder US military preparation and response in a conflict" (DoD, 2022a, p. 5) or to employ in "complex escalation dynamics" (DoD, 2022a, p. 6). These range from nuclear weapons to conventional warheads delivered by expanding delivery systems, from intercontinental ballistic missiles to hypersonic vehicles to cruise missiles. Most of these weapons would be deployed as long-range fires from outside the Arctic, as part of the PRC's strategic posture "to project [its own] military power at greater distance" (DoD, 2022a, p. 4). PRC capabilities TO threaten the North American Arctic are not limited to the kinetic but also include cyber-attacks as well (DoD, 2022a, p. 5-6 and DoD, 2022b, p. 4).

By this logic, conventional PRC military threats TO the North American Arctic are more about preventing US power projection *from* Alaska into the Indo-Pacific than they are about territorial aggrandizement or contesting Canadian or American Arctic sovereignty, ownership of resources, and control of Arctic shipping lanes. While US strategic documents suggest an awareness that this is the case, the Canadian strategies are opaquer on the specific physical geographies in the North American Arctic that China (in collaboration with Russia) has identified and prioritized for joint exercises. Canada does not have these power projection capabilities in its Arctic. Alaska, as a nexus between the Arctic and the Indo-Pacific theatres with a strategically significant expeditionary military presence, represents a saliently different target for the PRC than the Canadian Arctic.

THREATS THROUGH THE NORTH AMERICAN ARCTIC

Canadian and US strategies position the North American Arctic as an approach THROUGH which air and aerospace long-range fires (and, to a lesser extent, maritime) threats are proliferating. Both countries acknowledge that "while the risk of military attack in the North American Arctic remains low" (Government of Canada, 2024a, p. 8), the "Arctic holds our northern approaches to the U.S." and Canadian homelands (DoD, 2024a, p. 8) that would be transited by "traditional" delivery systems such as bombers, ballistic, and cruise-missiles, as well as "emerging weapons systems that threaten broader North American" targets (Government of Canada, 2024a, p. 8). Each country's strategies explain that being able to detect and track – as well as defeat – these threats as far away as possible from their main population and industrial bases is "critical" to the shared homeland defense of North America (DoD, 2024a, p. 8).

Canadian and US strategies concur that there are two general types of kinetic threats THROUGH the North American Arctic. The first is the traditional threat of nuclear annihilation that has existed since the early Cold War (DND, 2024, p. 7-8 and DoD, 2022b, p. 4). The second are below-the-nuclear-threshold attacks at the hearts of both Canada and the US that would seek to disrupt and delay mobilization in the event of war elsewhere in the world, buying time for an aggressor to achieve their military goals (DoD, 2024, pp. 4, 17, and DND, 2024, p. 34; also O'Shaughnessy and Fesler, 2020). These two threats setup a deterrence dynamic that moves away from mutually assured destruction (MAD) towards increasingly flexible responses. While many strategists argue that this flexibility bolsters the credibility of deterrence, others argue this credibility comes at the expense of increasing the risk of great power war and strategic escalation (Kaplan, 1991, Kahn and Jones, 1960, and Brodie, 1959).

Canadian and US strategies frame Russia as the primary kinetic threat THROUGH the Arctic. ONSF observes that "despite battlefield losses in Ukraine, Russia remains highly capable of projecting air, naval and missile forces... through the Arctic to threaten North America" (DND, 2024, p. 7). The document elaborates that ""Russia continues to modernize and build up its military presence in their Arctic... It is highly capable of projecting air, naval and missile forces both in and through the broader Arctic" (DND, 2024, p. 4). Similarly, the US National Security Strategy observes that the PRC "is accelerating the modernization and expansion of its nuclear capabilities." This includes establishing "a nascent nuclear triad" enabling "a high degree of survivability, reliability, and effectiveness" that "could provide the PRC with new options before and during a crisis or conflict" (DoD, 2022b, p. 4).

Given the ballistic paths for some of these delivery systems, threats THROUGH the North American Arctic are growing in scope, providing more flexible options to the PRC in the event of conflict in the Indo-Pacific or to Russia if conflict erupts in Europe.

By modernizing their strategic delivery systems that could be used to launch limited attacks, the PRC and Russia pose a heightened threat THROUGH the North American Arctic. Canadian and US documentation presents Russia as the primary source of these threats, with the DoD Arctic Strategy arguing that Russia "could use its Arctic-based capabilities" to project THROUGH the North American Arctic onto a wide-range of targets in the lower 48 states as part of an attempt "to hold the U.S. homeland" at risk and/or threaten American ability to project power elsewhere (DoD, 2024, p. 4). This same logic holds for the PRC, with its growing nuclear forces being supplemented "with a broader set of kinetic and non-kinetic capabilities, including cyber, space, information, and advanced conventional strike" (DoD, 2022b, p. 4 and DND, 2024, p. 8). Subsequently, the DoD frames these threats THROUGH North American approaches as threats to international rather than Arctic regional security. Canadian strategic documents do not provide a similar level of clarity.

Both Canadian and US Arctic strategies state that the countries can no longer rely on geography for protection – although we disagree, given that this has been the case since the dawn of the nuclear age. Too often, these generalizations are hyperbolic. Neither the PRC nor Russia have or will have the ability to "invade" the North American Arctic akin to Ukraine or potentially Taiwan, let alone THROUGH it. Rather, the North American Arctic is a conduit for aerospace attack – a threat that has existed for over seventy years (Eyre, 1987; Jockel, 1987, 2007). Both Canadian and US strategies agree that this aerospace threat is proliferating, involving new delivery systems that could lower the threshold for an attack using conventional warheads. Rather than continuing the Cold War logic of simply deterring general nuclear attack, successive NORAD/USNORTHCOM commanders have highlighted the threat of limited "below-the-threshold" attacks on the North American allies (Charron and Fergusson, 2022). Such attacks are more likely to occur because of conflict erupting either in the Indo-Pacific or Europe, not from a conflict originating in the Arctic or owing to regional dynamics. Nevertheless, the risk of global "spillover" places additional emphasis on building new sensors across the North American Arctic to detect, track, and weapon systems to defeat limited threats and better deter miscalculation or escalation to general nuclear war.

Canada should prioritize its contributions to detecting, deterring, and if necessary, defeating these THROUGH threats. For Canada this means proceeding with NORAD modernization plans, especially with layering awareness over the 10 to 2 o'clock arc (Charron, 2025). Awareness architecture not stationed in the Arctic like the Arctic Over-the-Horizon Radar (Government of Canada, 2025) will improve domain awareness to counter TO threats, while other projects like the Polar Over-the-Horizon Radar (Government of Canada, 2024a) will push awareness beyond the North Pole and support "information dominance" and "decision superiority" (VanHerck 2021). Canada's acquisition of the F-35 Lightning II and contributions to integrated air and missile defense, including potential contributions to the Golden Dome initiative (Bouffard et al, 2025; Pugliese, 2025), will contribute substantively to layered sensors and control over the Arctic approaches to the shared North American homeland.

CONCLUSIONS

Analyzing American and Canadian threat perceptions of the Arctic together facilitates a more comprehensive and nuanced awareness of the threats facing the region. IN threats are an excellent example, with documents providing locations, means, and timelines in which these threats are likely to develop. While changing environmental conditions in the Arctic have multifaceted implications for national security (e.g. Frazier, 2024; Lackenbauer and Barnes, 2025), adaptation is the only response possible to environmental change IN the region given that mitigation strategies are global in scope (and thus beyond the IN, TO, and THROUGH framework). Canadian and US threat assessments indicate a 5-to-25-year period in which to adjust to changes IN the Arctic, emphasizing the importance of community-level solutions as well as enhancing the resilience of defence infrastructure in the region.

The major difference between the allies is that Alaska faces a significant threat TO it, owing to the power projection capabilities stationed there. By contrast, Canada has chosen not to base expeditionary capabilities in its Arctic and thus does not face the same threat. Accordingly, simply transplanting the strategic threats TO the American Arctic to the Canadian Arctic distorts Canada's efforts to address the more acute kinetic threats THROUGH and IN its Arctic region. The question might shift to how Canada can help defend Alaska from threats TO it. For example, could Canada provide ice-capable ships like the AOPVs and Coast Guard icebreakers to Alaskan waters in the near-term (Chan, 2025 and Lajeunesse, 2025), while helping to kickstart American shipbuilding of ice capable vessels through the ICE Pact over the medium to long-term?

We contend that, in detecting and defending against THROUGH threats, Canada should continue to align its Arctic defence efforts with the US to confront common threats. There is a long history of binational cooperation in confronting the aerospace threat THROUGH the American and Canadian Arctics, with new nuclear and conventional long-range fires warranting NORAD modernization. Canadian and US threat assessments concur that this will require a continuous process of updating and increasing detection and tracking capabilities, and assessing layered systems for gaps and seams in coverage that could be exploited by adversaries fielding new weapons. It should be kept in mind that these THROUGH threats are not Arctic regional challenges but are international in scope. Accordingly, they are about increasing the credibility of general deterrence and thus preventing international conflict from breaking out and spilling over into North America.

Our analysis also calls into question the larger narrative embedded in both country's threat assessments suggesting that greater access to the Arctic due to environmental change is driving greater threats to the region. The key challenges THROUGH and TO the Arctic, we suggest, have less to do with environmental change than technological change and the spillover of conflict from strategic competition elsewhere. By more coherently categorizing threat drivers and articulating the strategic environment through Canadian and American documents, we have sought to provide a framework that identifies and defines common problems and points towards shared solutions. Converting greater geostrategic clarity into operational and tactical guidance (Bouffard and Rodman, 2021), the North American allies can work towards achieving "holistic, integrated, and interoperable defence of the continent" (Rodman, 2020) and maintaining competitive advantage at a time of heightened strategic competition and uncertainty.

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Contemporary Icebreaking Capacity in the North American Region:

Detailing the Present State of Affairs and Challenges to be Confronted

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INTRODUCTION

As ice levels in the Arctic[1] recede (Thoman et al., 2023), shipping routes related to the wider region under discussion continue to experience heightened focus by numerous state governments worldwide (O'Rourke, R., 2025), as well as by certain influential stakeholders in shipping and environmental affairs (Arctic Council - Navigating the Future of Arctic Shipping, 2021). With less ice, crossing the Arctic Ocean in service of maritime transport demands is becoming an increasingly attractive option, based on the lesser distances involved when compared with other more 'conventional' routes (Rodrigue, J.P., 2020). Specifically, the Northwest Passage (NWP) of North America and Northern Sea Route (NSR) of Eurasia can be effectively utilized by the maritime industry to bypass traditional, longer routes which often rely on costly and restrictive Panama or Suez Canal transits (Sheehan et al., 2021). This naturally directs a spotlight onto the most critical vessel for capitalizing on this change: the icebreaker (Morley, J. P., 1962). The significance of this type of vessels (icebreaker) becomes apparent from the need to reduce navigational risk through traditionally treacherous waters based on increased shipping volume (Drewniak et al., 2021). Unfortunately, as nations with jurisdiction claims in the Arctic Ocean attempt to effectively meet this challenge by amplifying their icebreaking fleets, it is evident that execution of such enhancements often tends to fall short of recognized needs (Drewniak & Dalaklis, 2018).

Since most Arctic nations have expectations that their governments have a primary, if not exclusive, role in maintaining or opening these sea routes,[2] development of icebreaking fleets is influenced less by natural market forces and more by availability of public funding, capacity, and political will or prioritization. Through analyzing these constraints more closely, it is evident that a commonly shared factor limiting success is the lack of expertise in overcoming the unique design requirements of polar vessels. As asserted by U.S. Representative Brian Baird in a 2008 Congressional hearing on

1 Although icebreaker operations in the Antarctic are discussed tangentially, this effort focuses primarily on the Arctic region.
2 One of the U.S. Coast Guard's (USCG) 11 statutory missions is "Polar, Ice and Alaska Operations", and Canada's Oceans Act gives the Minister of Fisheries, Oceans, and the Canadian Coast Guard responsibility for providing "icebreaking and ice-management services".

maritime transportation, "icebreakers are extraordinary vessels. They are absolutely essential. They are not easy to make. They are not easy to operate. They are not easy to maintain. And they are not cheap. But the consequence of not making them, maintaining them and operating them is far more expensive" (US Congress, 2008).

Accordingly, after highlighting the significance of the icebreaker and unique requirements to their design and construction, the aim of this paper is to assess the current status and causes for delay in development of the North American fleet by focusing more closely on the United States and Canada as case studies . [3] In pursuit of the above, it is important to note that any current numbers or classifications of national icebreakers are referenced from the U.S. Congressional Research Service (CRS) synthesis of data gathered by both the U.S. Coast Guard and "publicly available estimates" (O'Rourke, R., 2025). To be included in these estimates, and in order to deploy similar standards for selection, vessels must be "capable of independent Arctic or Antarctic operations," and are "selected and organized based on IACS [International Association of Class Societies] Polar Class notation." Consequently, these numbers often omit many of the smaller, lower-classed icebreakers that do not have sufficient icebreaking capabilities (propulsion less than 10,000 brake horsepower and minimally ice-strengthened hulls) to be considered suitable for vessel escort operations in polar waters. What follows next will provide pertinent historical background, technical details, regulatory requirements, and political processes; all instructive toward painting a broad picture of the development of current icebreaker fleets and how they are expected to progress in the years to come.

THE VALUE OF ICEBREAKERS

In 1898, the first modern, oceangoing icebreaker, Yermak, was commissioned by the Russians to assist in freeing icebound merchant vessels, as well as to conduct hydrological and meteorological observations of the Arctic. Throughout its long history, this asset was also used as an escort vessel in the Baltic Sea during World War I and later to evacuate stranded polar explorers from a research station before ultimately decommissioning in 1963 (Davydovska et al., 2021; Eger C., 2015). Yermak heralded a century of flourishing icebreaker development globally and marked the beginning of an ever-evolving range of missions assigned to these vessels. Since that time, ice depletion in the polar regions has boosted the conceivable value for icebreakers as the phenomenon leads to an escalation of general maritime activity in both volume and variety (Arctic Council - "Arctic Shipping Update: 37% Increase in Ships in the Arctic Over 10 Years", 2024). Consequent amplified mission functions include defense and security, support for resource extraction, and use as platforms to assist in search and rescue operations (Drewniak et al., 2018).

Some may assume that decreased levels of ice coverage simply result in a corresponding decrease in demand for vessels to break ice. However, further investigation reveals the reverse is true. While overall ice coverage is certainly decreasing, the ice thickness in some areas may still increase, thereby expanding the unpredictability of navigating in such regions (Hodges, P., 2015). The waters of the Canadian Arctic Archipelago (CAA) and the NWP are more at risk for this phenomenon, as multi-year ice (MYI), versus first year ice, is more likely to increase in mobility from the Arctic Ocean and drift to form thicker deposits than what typically accumulates within the CAA. More significantly, less ice coverage leads to increased opportunities for a multitude of vessel activities, including the general viability of the NSR and NWP as shorter alternate routes for trans-oceanic voyages (Haas & Howell,

3 The vast majority of the content related to this analysis was accumulated during 2024; permission to use the latest statistics of the USCG (2025) in relation to the issue under investigation was also formally secured. An effort to capture the latest state of affairs was made during the successive blind peer-review rounds. The authors acknowledge that there is a certain reliance on Internet sources, but this option was viewed as the best way to capture the most recent information available. Needless to mention, further developments on the wider field under examination are still on-going and a decision to select a specific cut-off date was made in order to facilitate the smooth processing of all relevant information that is changing at a rapid pace.

2015). The steady aggregate reduction of ice has led to a surge in commercial vessel traffic in the Arctic regions over time. According to data collected by the Protection of the Arctic Marine Environment (PAME) working group under the Arctic Council, unique ships entering the Arctic, as defined by the Polar Code,[4] rose from 1,298 in 2013 to 1,628 in 2019; an increase of 25% (Hreinsson, H., 2020). Further, when looking at the metric for total number of unique vessels in transit through the Northwest Passage specifically, between 2016 and 2022, there was a 35% increase (157 to 212) (Reynolds, C., 2023). Notably, the NSR has a significantly greater number of Arctic ports along Russia's coastline (Figure 1) that make shorter transits (often with the same vessels) more common. These ports also serve to support a growing export industry, such as the recent construction of the Yamal Liquified Natural Gas (LNG) facility in the port of Sabetta in 2019. This alone accounted for 19 million tons of LNG production in its first year of operation along with the majority of shipping traffic in the NSR in 2020 (Rigot-Müller, 2022). Conversely, the NWP, including the Northern slope of Alaska, contains no adequate deep-water ports or accompanying support resources, resulting in the impracticality of brief voyages. However, plans are presently underway, with a U.S. Army Corps of Engineers contract of $399.4M USD awarded to Kiewit Infrastructure West Co., to complete the initial phase for the first U.S. Arctic deep-water port in Nome, Alaska. Construction is anticipated to commence in 2026 with completion projected for 2029. (Thorsson, E., 2025).

Icebreakers are a necessary element to lessen the initial navigational safety risks as more shippers choose to operate in these regions and help to ensure stability and consistency of such changes over the long-term. Additionally, although it has been in existence in some form or another since the early 19th century, Arctic tourism has been on the rise in the last 40 years. Notably, 1984 marked the first successful cruise through the NWP by MS Explorer[5], while Quark Expeditions offered cruises onboard Russian icebreakers to the North Pole in 1991, and Crystal Serenity recently made news in 2016 as the first large cruise vessel to make the same NWP transit (with ticket prices starting at $22,000 USD) (Cajaiba-Santana et al., 2020). In summary, due to both the unpredictability of ice distribution throughout the polar regions as well as the rising trend of vessel traffic, the reliance on existing icebreakers and the need for additional, capable platforms will only intensify.

UNIQUE DESIGN REQUIREMENTS FOR ICEBREAKERS

HULL FORM AND CONSTRUCTION

The general population of vessels operating in polar regions encounter multiple environmental forces that are destructive to a ship's hull and structures. These forces include both low air temperatures, as well as global and local structural loads encountered from sea ice (Canadian Coast Guard - Ice Navigation in Canadian Waters, 2022). The effects of such forces are of significantly greater consequence to icebreakers since they are purpose-built for icebreaking operations versus merely operating in regions where such conditions may be encountered. Consequently, the required design standards are understandably more rigorous. Simply stated, the traditional method for breaking ice involves the ship forcing its bow on top of the ice and breaking it through the sheer magnitude of its weight (Morley, J.P., 1962). To achieve this, the vessel must have the correct bow shape (typically described to be "spoon-like") to slide up the ice, sufficient propulsion to achieve the necessary momentum to get there, thick, high-strength steel to resist hull damage, and, finally, enough weight

4 PAME describes that neither they, nor the Arctic Council, have a unique definition for "Arctic" and, consequently, use the geographic bounds detailed in the International Code for Ships Operating in Polar Waters (Polar Code). It is worth noting that there are significant differences between this region and the area encapsulated by the Arctic Circle.

5 To avoid confusion for the non-experienced reader, the vessel under discussion was initially named "Lindblad Explorer" (until 1985). However, after the previously mentioned NWP transit, there was a name change to "Society Explorer" (1985), and then finally to "Explorer" in 1992.

(displacement) to produce the downward force to break the ice. For the bow, this necessitates stark design tradeoffs since the required blunt surface contrasts with the typical "U" or "V" shapes that are employed for better ship handling and efficiency.

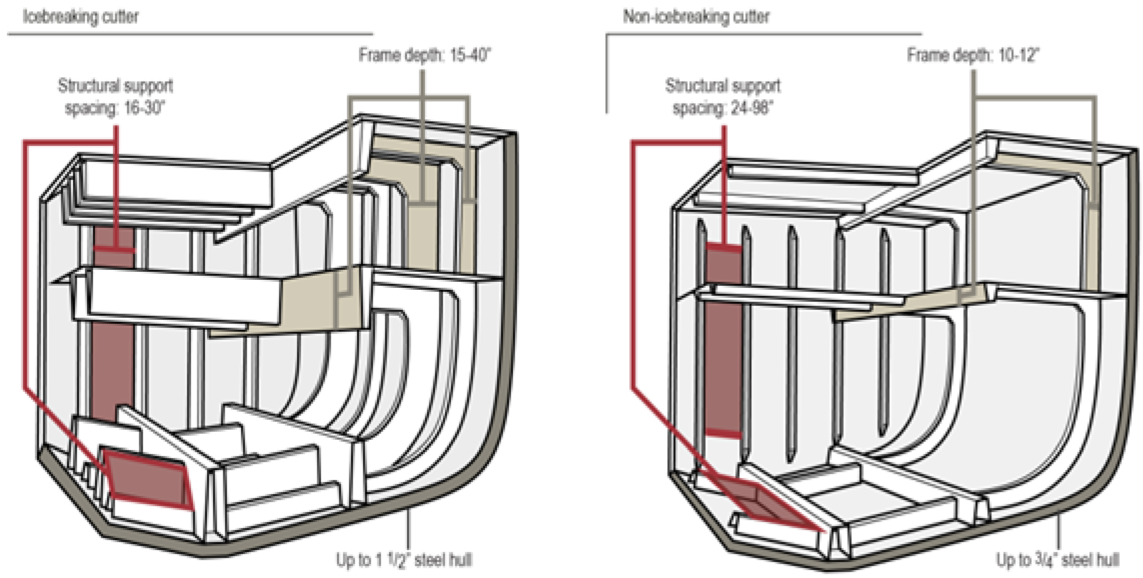

Figure 1 Notional Icebreaker Design Frame Elements Versus Non-Icebreaker[6]

Additionally, one of the biggest costs for construction is the specialized steel needed for both the shell plates on the hull and the supporting frames. Such steel must have higher strength for more demanding loading conditions and resistance to brittle fracture at low temperatures, especially in the hull region above the waterline (Canadian Coast Guard - Ice Navigation in Canadian Waters, 2022). As such, the metal undergoes a significantly more laborious heat treatment process and is consequently not commonly used in standard shipbuilding. Further, throughout the "ice belt" (the region of the ship around and below the waterline), shell thickness requirements are often double that of standard vessels, and support frames must be deeper and spaced closer together (U.S. Government Accountability Office (GAO), 2023). Representative differences between the scantlings of an icebreaker versus a non-icebreaker can be seen in Figure 2. Satisfying these criteria for a given ship adds cost and complexity to an already arduous endeavor. In order to understand the practical demands for design and construction, it is instructive to investigate the standards and requirements commonly applied to such vessels.

Of the approximately 116 icebreakers currently active worldwide, 94 of them (81%) are government-owned and operated vessels (GAO, 2023)[7]. Of the remaining vessels, many are more of a public/private hybrid consisting of government funding to an otherwise independent operator. As such, it is mostly up to each nation to determine the standards these ships will be built to since they fall outside of most international requirements. It is of interest to note that, while SOLAS Chapter XIV Regulation 2.5 states that its safety measures for ships operating in polar waters do not apply to "ships owned or operated by a Contracting Government," it also clarifies that those ships are "encouraged to act in a manner consistent, so far as reasonable and practicable, with this chapter" (SOLAS, 2020). This implies that, while not strictly bound by international convention or treaty, it is a sound

6 Source: GAO Analysis of US Coast Guard Informationm, GAO-23-105949

7 Numbers attained through referencing data generated by the U.S. Coast Guard Polar Coordination Office, updated July 15, 2025.

practice for member states to follow the standards found in the International Code for Ships Operating in Polar Waters (Polar Code), which was adopted by the International Maritime Organization in November of 2014, when constructing any new vessel intended for operation in polar waters. Some of the extra requirements beyond SOLAS that are found in the Polar Code include unique structure, machinery, firefighting and navigation safety standards (Polar Code, 2016).

Notably, ship structures and machinery requirements incorporate the International Association of Class Societies (IACS) Unified Requirements for Polar Class Ships. This standard provides the detailed prescriptions necessary for achieving appropriate Polar Class (PC) notation ranging from the most rigorous PC 1, "Year-round operation in all polar waters" to the more permissive PC 7, "Summer/autumn operation in thin first-year ice which may include old ice inclusions." These notations take into account satisfaction of both hull form and propulsion power standards, but apply to all ships "constructed of steel and intended for independent navigation in ice-infested polar waters" (IACS, 2016). However, the standard also includes specifications for achieving the "Icebreaker" notation which, in addition to meeting the other relevant PC requirements, includes the mandate to have "powering and dimensions that allow it to undertake aggressive operations in ice-covered waters" (IACS, 2016). While this may seem like a vague addition, there are also several areas within the standard where the "Icebreaker" notation carries further demands. This includes hull shape requirements for the stern, higher design loads used in determining minimum shell plate thickness, lower permissible stress for longitudinal strength of the hull, higher anticipated blade force magnitude and number of ice load cycles for design of the propeller, and higher torque relief requirements for steering gear systems (IACS, 2016). All of these unique demands necessitate more intensive design and construction processes, specialized training and materials, and, consequently, a substantial price tag.

PROPULSION

Within the bounds of the previously stated design requirements for propulsion, icebreakers must employ system types that maximize performance within an unforgiving operating environment. They must produce above-average power output while also satisfying high demands on fuel endurance to permit operation in regions with limited refueling facilities. Traditional steam turbines burning fossil fuels comprised the initial prevalent technology for icebreakers, which ultimately gave way to diesel-electric, being first used on the Swedish vessel Ymer, in 1933 (Riska K., 2011). Propulsion systems on icebreakers today typically include diesel engines, gas turbines, or steam turbines with nuclear reactors, with the majority of these prime movers transferring their power through electric transmission to either fixed or controllable pitch propellers. Interestingly, many platforms are now also adopting azimuthing pod propulsion motors to provide better maneuverability, backing power, and eliminating the need for standard rudders which are vulnerable components to damage from sea ice (Canadian Coast Guard - Ice Navigation in Canadian Waters, 2022). Further advancements also include the emergence of LNG as a fuel. In 2016, Finland's new PC4 classed vessel, Polaris, became the first icebreaker to operate with an LNG powered engine (The Maritime Executive, 2019). Efforts are still being made to provide suitable LNG bunkering stations along Finland's coast to reduce operational pauses, but as the infrastructure improves, LNG can be used as a cleaner alternative to standard fuel oil. In spite of such improvements to technology for maneuverability and emissions, the perennial problem of limited range associated with use of hydrocarbons remains.

The benefits of employing nuclear power generation for icebreaker propulsion should not be discounted. It serves a two-pronged objective of increasing ship endurance in remote regions, while simultaneously reducing harmful emissions in highly sensitive ecosystems (Dalaklis D., 2019). Ever since the first nuclear-powered icebreaker, Lenin, was launched in 1957 by what was then the Soviet Union, Russia has maintained the status as the only country to have built or operated such vessels. They later made news in 1977 with the nuclear-powered icebreaker Arktika being the only ship to have reached the geographical North Pole (Josephson, P.R., 2014), and today (according to USGC's relevant statistics) Russia operates a fleet of 58 icebreakers (of various size/capabilities), of which nine are nuclear. In all that time, many countries have entertained the possibility of using nuclear propulsion, but only China has set in motion tentative plans for construction; although scarce information on their progress is available outside of their state-owned nuclear corporation soliciting bids for technical consultancy for the project in 2018 (Eiterjord, T., 2023). While the United States Navy, in addition to the navies of several other developed nations, has long maintained a nuclear fleet of submarines and aircraft carriers with an impeccable safety record[8], the U.S. has avoided incorporation of the same technology for icebreakers. This resistance can be attributed mainly to the lack of equivalent expertis and resources within the United States Coast Guard (USCG) and insufficient political will to overcome such gaps with necessary investments of time and money in the midst of a multitude of competing priorities. However, as the technology for nuclear power generation improves, both in terms of safety, cost and efficiency, the longstanding opposition against this alternative i likely to wane.

CURRENT ICEBREAKING CAPABILITIES

As outlined previously, this study is primarily focused on the United States and Canada as representative nations laboring to augment their presence and impact in the Arctic through updates to their respective icebreaker fleets. What follows will provide a snapshot of the status of these fleets, with a focus on gaps each government should attempt to rectify in the future.

UNITED STATES

The Icebreaker program in the United States is managed by the U.S. Coast Guard. The progress of that program has been subject to much discussion and criticism over the last few decades due to the unsuitability of this particular fleet to currently execute all of its intended missions. In addition to icebreaking, these vessels are tasked with supporting eight of the remaining ten statutory missions of the Coast Guard. Among these are search and rescue, protection of marine resources and law enforcement. Within the polar regions specifically, USCG icebreakers must perform and facilitate scientific research and defend U.S. sovereignty and economic interests. Previous missions throughout USCG history have also included mail delivery and health care for native Alaskan populations (U.S. Treasury Department, 1962).

Currently, the United States operates only three Arctic-capable icebreakers, two of which are quite advanced in age. These include the heavy[9] polar icebreaker, Polar Star, delivered in 1976, the medium polar icebreaker, Healy, delivered in 2000 (National Research Council, 2006) and the medium polar icebreaker, Storis, delivered in August of 2025 after the Coast Guard purchased and converted the previously named Aiviq from Edison Chouest Offshore (Blenkey, N., 2025). Polar Star was commissioned two years before its sister ship, Polar Sea. However, Polar Sea experienced a catastrophic engine casualty in 2010 and remained at berth in Seattle for several decades where it was used only to supply parts for Polar Star until ultimately transferring to a Navy reserve fleet in 2024. In 2006, Polar Star reached the end of its originally projected 30-year life span, but decommissioning has not

8 As per a 2020 U.S. Department of Energy report, the U.S. Navy currently operates a total of 98 nuclear reactors on 79 submarines and aircraft carriers. To date, they have accumulated over 7,100 reactor-years since the inception of the program in 1955 and not experienced an “adverse effect on human health or on the quality of the environment” since 1960. Available online at : https://www.energy.gov/sites/default/files/2021-07/2020%20United%20States%20Naval%20Nuclear%20Propulsion%20Program%20v3.pdf
9 In this context, a “heavy” icebreaker is defined in the U.S. as “ships that have icebreaking capability of 6 feet [1.83 meters] of ice continuously at 3 knots and can back and ram through at least 20 feet of ice,” compared to a “medium” icebreaker that is capable of breaking through 4.5 feet [1.37 meters] of ice continuously at 3 knots.

been an option due to the lack of a suitable replacement. At that point, it was temporarily taken out of service based on various technical problems, including degraded electrical motors. Following costly repairs, it successfully resumed operations in late 2012.

One of its most essential demands is completing the annual trip to resupply the U.S. McMurdo Station in Antarctica. This has been referred to as "Operation Deep Freeze" ever since the program first began with the construction of the research station in 1955. Notably, this was initially carried out with three icebreakers (Glacier and Edisto operated by the U.S. Navy and Eastwind operated by the Coast Guard) and today comprises a multi-agency effort which receives support from the Navy, Air Force and Army, all in support of the National Science Foundation (NSF), the lead agency for the U.S. Arctic Program (Kikkert, P., 2021). This is a taxing journey under ideal circumstances, and is even more harrowing for a single vessel with over 40 years of service. Consequently, after each such mission, Polar Star must immediately undergo critical, in-port maintenance to ensure its readiness for the same deployment the following year. Polar Star recently completed its 28th trek to McMurdo in April of 2025 (USCG, 2025), but to maintain this current trajectory in coming years is not sustainable and is putting Operation Deep Freeze at risk.

Healy, on the other hand, is 24 years younger, but still in need of a service life extension project (SLEP) to continue operations. The Coast Guard has issued a Request for Information (RFI) for interested contractors to begin in 2026 and prolong work in a phased approach over a five-year period. Assuming all goes well, Healy can be expected to operate until such a time as it is replaced by the forthcoming Polar Security Cutters. As detailed in the following section, this delivery timeline is still tentative. Regardless, as an icebreaker with lesser capabilities (when compared with those vessels previously described as heavy), Healy does not maintain the same icebreaking power as Polar Star, and, consequently, is primarily used for scientific research and various auxiliary missions.

Of note, there are also two vessels that are operated for the NSF, which maintains these ships independently while directing research goals for the other Coast Guard operated platforms. These vessels include Nathaniel B. Palmer, and Sikuliaq, although there was a third, Laurence M. Gould, whose service contract recently expired without renewal by the NSF in 2024. Furthermore, Nathaniel B. Palmer may face a similar fate since the NSF's budget request for 2026 includes a line item to terminate its lease due to rising costs (Voosen, P., 2025). Even if all three vessels continued to operate, they have significantly less icebreaking capacity and are thereby limited in their usefulness beyond their intended missions. For example, the largest of the three, Nathaniel B. Palmer, was often used to resupply Palmer Station (both icebreaker and station named for the same Antarctic explorer), another U.S. research station which is located north of the Antarctic Circle close to the farthest point on the Antarctic Peninsula (NSF, 2024). However, based on its maximum icebreaking capacity of 3 feet (0.91 meters) at 3 knots, it is not able to proceed further south and cannot be used to reach McMurdo Station. Following consideration of the status and characteristics of each U.S. icebreaker, none of them are truly equipped to fulfill the role of icebreaking in the wider Arctic region. If the United States truly desires to capitalize on the changing ice conditions, in addition to maintaining their obligations in support of Antarctic research stations, their efforts in funding and executing construction of a new fleet must be accelerated.

CANADA

It is impossible to analyze the development of the Northwest Passage without understanding the capabilities and future outlook of the Government of Canada. Canada has by far one of the longest coastlines in the world, of which approximately 75% (162,000 kilometers) is in the Arctic (Transport Canada, 2023). Accordingly, this country currently maintains the second largest fleet of icebreakers (after Russia). Their icebreaker program is similarly executed primarily by the Canadian Coast Guard (CCG), but the Royal Canadian Navy also maintains a moderate but expanding fleet of smaller capacity icebreakers to address more security-focused missions.

In total, the government of Canada currently maintains a fleet of 16 active icebreakers that are capable of independent Arctic or Antarctic operations. Of these, ten are operated by the CCG and six by the Navy. Of the ten in the CCG fleet, two are classified as "heavy" icebreakers, the flagship Louis S. St. Laurent and Terry Fox, and eight are classified as "medium" (CCG - Icebreaking Fleet of the Canadian Coast Guard, 2022). A graphical representation including the icebreakers of Canada and the United States, produced by the U.S. Coast Guard, can be referenced in Figure (3). Canada also operates eight, "light" icebreakers and two air cushioned vehicles with icebreaking capability, but these did not meet the brake horsepower (BHP) criterion developed by the USCG, a minimum of 10,000 hp, that was employed for the purposes of this study. Similar to the USCG icebreakers, the larger, polar-capable Louis S. St. Laurent and Terry Fox have surpassed their intended service lives with launch dates of 1968 and 1983, respectively.

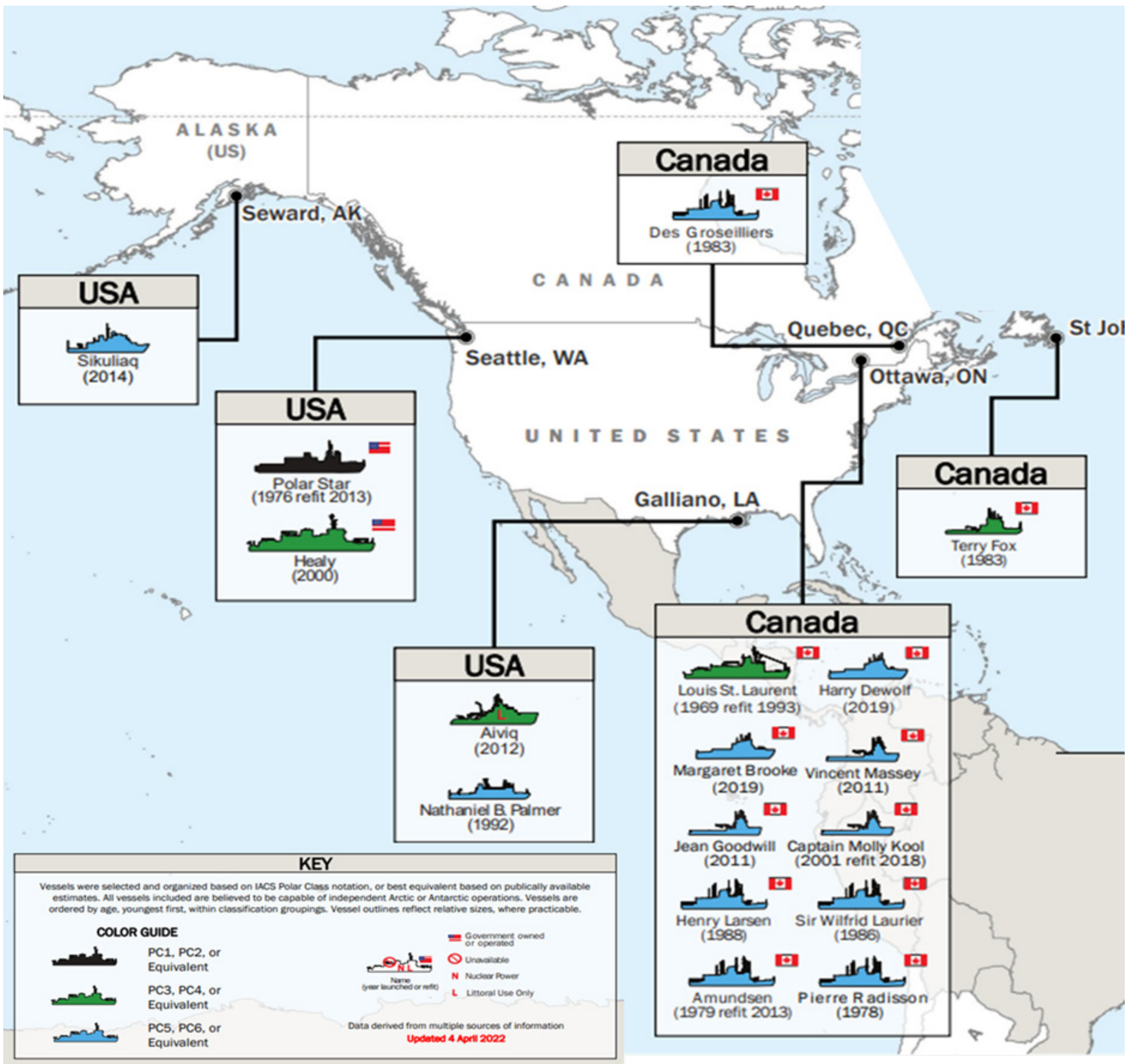

Figure 2 Homeports of Major Polar Icebreakers[10]

10 Source: USCG Polar Coordination Office (Cropped by the authors from the original, to highlight Canadian and US vessels exclusively)

When Louis S. St. Laurent was first completed, while it was considered the fifth of Canada's heavy icebreakers, it was the first one purpose-built for operation primarily in the Arctic and was therefore the largest and most powerful to date (Nossal, K. R., 1987). It was initially constructed with a steam-electric propulsion system and was noted to have a less-than-optimal cruising range of 16,000 nautical miles (nm) prior to its conversion to a more-efficient diesel-electric plant in the 90's. It can now operate for 28,000 nm, or roughly 120 days, before refueling; but is still eclipsed by the massive range of the newest Russian nuclear icebreakers, Yakutia, Arktika, Sibir and Ural, which can theoretically last seven years after stocking reactor fuel and are instead limited to six months by their on-board provisions (Russelprom Website, 2024). Louis S. St. Laurent still maintains the designation as the CCG's most capable icebreaker with a total brake horsepower of over 27,000 (CCG - Icebreaking Fleet of the Canadian Coast Guard, 2022) and designation of Arctic Class 4.[11]

The only other existing Canadian icebreaker with the "heavy" designation is Terry Fox, which is slightly newer, but just over 40 years old with an equivalent Arctic Class 4 rating despite its smaller power output of 23,000 BHP. It was initially privately owned and used for Arctic resource exploration prior to being leased and ultimately sold to the Canadian Coast Guard in 1994. Now, in addition to icebreaking, it is used for search and rescue, environmental response, and scientific research, including the resupplying of various Arctic stations (CCG - Canadian Coast Guard Ship Terry Fox Vessel Life Extension Contract Awarded, 2022). Most recently, Terry Fox was dispatched in June of 2023 for Operation Pacer Goose to help resupply of the U.S. Pituffik Space Base (formerly Thule Air Force Base before it was renamed after the creation of the Space Force) in Northwestern Greenland. Like Operation Deep Freeze, Operation Pacer Goose occurs annually when the ice is thinnest and is executed in conjunction with the U.S. Military Sealift Command and Defense Logistics Agency. Remarkably, they recently completed this operation for the 71st consecutive year (Sykes L., 2023). Of further interest, on its way to Greenland, Terry Fox was briefly involved (along with three other vessels in the Canadian fleet) to assist with the joint search for the Titan research submersible that tragically went missing while looking for the wreckage of Titanic 900 nm east of Cape Cod, Massachusetts (USCG, 2023).

Five of Canada's recently commissioned icebreakers are operated by the Royal Canadian Navy (RCN) with the most recent addition joining the ranks in July of 2025. Frederick Rolette, William Hall, Harry DeWolf, Margaret Brooke, and Max Bernays are part of the new Harry DeWolf class Arctic and Offshore Patrol Ships (AOPS) which, upon planned completion in 2027, will consist of six vessels for the Navy and two for the Coast Guard (Wertheim, E., 2023). The RCN's six vessels are intended to protect the sovereignty of Canadian Arctic and internal waters, as well as perform various cooperative international missions. Each is named after RCN heroes throughout history and will also be affiliated with Canada's six northern Inuit regions (Government of Canada, 2025). The ships have been designed based on one of the only other Navy-operated icebreakers, Norway's Svalbard, are lightly armed, and are rated at Polar Class 5 with over 12,000 BHP from twin diesel electric propulsion. The RCN and CCG have demonstrated noteworthy capacity to cooperate within a common theater with a wide array of ice strengthened vessels maintaining distinct missions between the two organizations. However, despite maintaining the world's second largest fleet of oceangoing icebreakers, the Louis S. St. Laurent and Terry Fox are still the only platforms truly equipped to be workhorses in some of the thickest ice regions of Canada's Arctic. Regrettably, they are still limited to only operating in certain zones depending on the seasons throughout the year and are long overdue for relief from newer, more powerful successors.

11 "Arctic Class" is a different icebreaking designation system than the "Polar Class" from IACS and is based on a vessel's icebreaking capabilities to maintain continuous headway of 3 knots through ice of a given thickness, per Canadian Regulations. This system is used by the Canadian Coast Guard to determine what regions a vessel can navigate in during various seasonal ranges. The ratings span from 1 to 10, where a hypothetical Arctic Class 10 vessel could operate in all zones, all year long.

FUTURE PLANS FOR ICE BREAKER FLEET AUGMENTATION

UNITED STATES

In order to address their preparedness gaps in the polar regions, the Coast Guard received approval to fund the construction of three new heavy polar icebreakers, dubbed Polar Security Cutters (PSCs), from its 2013 appropriations. The original plan was to secure funding at a later date for an additional three Arctic Security Cutters (ASCs), filling the role of medium polar icebreakers. Despite this mix of PSCs and ASCs, the overall program is referred to as the Polar Security Cutter Program and was initially marketed by Commandant Schultz as the "6-3-1 Strategy." This refers to the intent to build at least six new icebreakers, where three are heavy, and one is started immediately. Gradually, from official testimony given in April, June and November of 2023, the Coast Guard increased its desired fleet to include a total of eight to nine new polar icebreakers, of which four to five should be heavy and four to five medium vessels. This was the result of a "fleet mix analysis" which was intended to incorporate needs for all classes of vessels within the USCG and anticipate the ideal makeup based on mission requirements. As of March 2025, the total estimated procurement cost of the first PSC is approximately $2.4 Billion USD, over 2.5 times greater than the initial 2019 estimate of $925 Million. (O'Rourke, R., 2025). Delivery of the first PSC was originally projected for 2024 and has frequently been adjusted until its most recent projection of 2030 (O'Rourke, R., 2025). Although the contract was awarded in April of 2019 to the Pascagoula, Mississippi based shipyard, Bollinger Mississippi Shipbuilding (known as VT Halter Marine Inc. prior to purchase by Bollinger), construction did not officially begin until May of 2025, although 8 prototype modules were cut in 2023.

The first PSC will be built using a "parent design," which is typically employed to eliminate risk inherent to the process of developing an entirely novel design. This parent design is borrowed from the anticipated German icebreaker, Polarstern II, developed by Ship Design & Consult (SDC). Interestingly, construction of the Polarstern II, which is intended to replace the 42-year-old original Polarstern, has also not yet begun, as they have been plagued by similar budget challenges. Plans for the vessel were originally announced in 2010 with an expected delivery date of 2016; however, it wasn't until June of 2022 that funding for the project was officially approved by the German Bundestag and now is projected to enter service in 2030 (Alfred-Wegener-Institute, 2024). Regardless, it has had time to undergo sufficient scrutiny and analysis to merit consideration as a "mature" design, theoretically streamlining the overall process. The USCG's version will be dubbed Polar Sentinel (Figure 4) and will be followed by Polar Bear and Polar Glacier. Polar Sentinel, as currently planned, will be 460 feet in length with diesel-electric propulsion totaling a brake horsepower of over 45,200, and designed to break ice between 6 and 8 feet thick. Notably, its displacement should total 22,900 tons, which is nearly 10,000 tons greater than the Polar Star it intends to replace, but its propulsion power is nearly a quarter less. It is expected to make up for this lower power through a unique hull form and novel, higher-efficiency arrangement of one centerline propeller in conjunction with two rotating podded propulsors.

Figure 3 Model of Halter (Bollinger) Design for Polar Sentinel[12]

In response to the growing anxiety over the delayed production of this first vessel, the Coast Guard also sought funding for an auxiliary program to acquire a Commercially Available Polar Icebreaker (CAPI). Rather than risk non-fulfillment of essential missions, this was deemed a quicker solution meant to bridge the gap resulting from current construction delays. The idea was previously rejected as an option until it was proposed as part of an Unfunded Priority List (UPL) for FY22, and ultimately requested within the FY24 budget for $125M USD (O'Rourke, R., 2025). Unfortunately, there were very few U.S. built vessels to choose from and any purchased icebreaker could not commence service until undergoing potentially time-consuming modifications to meet USCG requirements. Consequently, in response to an official Request for Information (RFI) for available candidates, on March 1, 2024 the USCG issued a special notice affirming their intent to "solicit for a Firm-Fixed-Price contract to Offshore Service Vessels, LLC to acquire and service a domestically produced, commercially available icebreaker with the objective to provide an operational surface asset capable of projecting U.S. presence in the Arctic" (USCG, 2024). Offshore Service Vessels, part of Edison Chouest Offshore, owned one potential candidate that fit the bill; the icebreaking tug, Aiviq. Aiviq was built in 2012 and operated primarily by Royal Dutch Shell oil company for its ill-fated oil exploration and drilling operations off the Arctic coast of Alaska, which were abandoned in 2015. Particularly, Aiviq became famous in news cycles when, in the course of towing the Mobile Offshore Drilling Unit (MODU), Kulluk, in December of 2012, it experienced engine casualties during heavy weather. After successful attempts to repair the engines that had reportedly been fouled with contaminated fuel, their resumed towing efforts were not enough to counter the 35-45 knot winds, and Kulluk ultimately grounded off the coast of Kodiak Island. Fortunately, the U.S. Coast Guard had previously evacuated all 18 crewmembers from the vessel, and only four sustained injuries.

In spite of this unfortunate history, Aiviq has gone on to conduct noteworthy work in frozen seas. After concluding its tenure with Shell, Aiviq was chartered by the Australian Antarctic Division and

12 Source: Cropped version of photograph accompanying Peter Ong, "USGC's polar security cutters to receive mark 38 mod 4 guns," Naval News, April 21, 2022. The article credits the photograph To Naval News at the Sea Air Space Exposition 2021.

embarked on several voyages to facilitate expedition team changeovers and vessel refueling in the region. The platform met the USCG's specifications for icebreaking with its PC3 designation, with the ability to break three feet of ice at three knots and operate for 60 days without resupply. Aiviq was officially purchased in December of 2024 and renamed Storis, in honor of the Coast Guard's former "Galloping Ghost of the Alaskan Coast" which had been decommissioned in 2007 after 64 years of service (O'Rourke, R., 2025). The new Storis completed its inaugural patrol north of the Bering Strait in October of 2025 and returned to its temporary berth in Seattle, with plans for transfer to a permanent homeport in Juneau, AK in 2026 (The Maritime Executive, 2025). The essential question for success will be highly dependent on the extent of required modifications to become fully compatible with the USCG fleet, with a series of structural changes over the next five years (O'Rourke, R., 2025).

Finally, the USCG has begun implementation of a service life extension program to ensure the Polar Star can continue until at least the delivery of the second Polar Security Cutter. Necessary improvements and refurbishments to the vessel have been budgeted to cost a total of $75M USD, or $15M annually over five years. As of September 2025, the vessel has completed its fifth and final stage, which included overhauling primary and auxiliary propulsion systems, refurbishing heating, ventilation and air conditioning and replacing all three propellers (USCG, 2025). Such upgrades, especially those of phases four and five, could mean that this well-seasoned vessel may not see retirement until it reaches the ripe old age of 53 years.

Within the Presidential Memorandum on Safeguarding U.S. National Interests in the Arctic and Antarctic Regions issued by President Donald Trump on June 9th, 2020, one key directive was for the Coast Guard to conduct an assessment that evaluates "Defensive armament adequate to defend against threats by near-peer competitors and the potential for nuclear-powered propulsion." Then Commandant Admiral Karl Schultz later responded in a speech to the Surface Navy Association's annual symposium that "we've moved off the nuclear-powered breaker. That capability – the ability to operate that in the Coast Guard – that just doesn't exist nor can we build out to that with all the demands on our plate" (Shelbourne, M., 2021). This determination harkens back to a similar decision, nearly 60 years earlier, when U.S. Representative Herbert Bonner had exhausted multiple attempts to champion a funding bill for nuclear icebreakers. After the last attempt received a presidential veto due to its hefty $60 million USD price tag, Bonner settled for a bill requesting three traditional icebreakers and a $500 thousand USD feasibility study to determine if nuclear propulsion was a necessary feature. Ultimately, the need for a feasibility study, along with the funding of new conventional icebreakers, was rejected based on more immediate requirements of new, non-icebreaking, Coast Guard vessels (Kikkert, P., 2021). Clearly, there has been a long-standing recognition and desire in the U.S. Government to explore the benefits of nuclear-powered icebreakers, but action requires anticipating those long-term benefits with significant financial investment.

Further details into the decision expressed by Commandant Schultz were not made public, but reference to the clear lack of nuclear capability within the Coast Guard can be understood, since, unlike the U.S. Navy, they have never operated any nuclear-powered vessels and, consequently, do not possess the expertise or ability to provide proper training in the area. With obstacles to building new icebreakers already at a nearly insurmountable level, the desire to avoid unfamiliar propulsion technologies is reasonable. Incorporating nuclear power within the foreseeable future may first require reaching a level of relative comfort with an active and effective fleet of icebreaking vessels.

In a January 2022 Military Times opinion piece, a former member of the U.S. Presidential Commission on Arctic Research, Dr. Julia Nesheiwat, assessed the inability for the Coast Guard to support a nuclear vessel and proposed the option of "working with the Department of the Navy to authorize the purchase of an icebreaker under the jurisdiction of the U.S. Navy," further explaining that this would "not only expand the Navy's mission to include patrolling of the far North but could also lead to involving NATO forces in the region," thereby signaling "America's willingness and readiness to defend its northern territories and those of its allies" (Nesheiwat & Mathewson, 2022) . The U.S. Coast Guard and Navy directly working together towards icebreaking missions may have temporarily end-ed with the transfer of the USS Glacier and USS Edisto to Coast Guard service in 1965, but they have since shared resources and cooperated in many relevant missions. In addition to the joint effort to resupply McMurdo in Antarctica each year, the Navy and Coast Guard also collaborate in managing the Polar Security Cutter Program following the establishment in 2017 of an integrated program office. This office is led by a USCG program manager, and relies on embedded Navy personnel to serve as the main contracting authorities, providing expertise in acquisition, engineering and design (GAO, 2023). While this was a step in the right direction, it may be time to fully revive cooperation within the icebreaking mission as a whole to ensure the United States can fully benefit from the existing nuclear propulsion technology knowledge base.

CANADA

In addition to the three AOPS currently under construction for their Navy and Coast Guard, Canada is developing a vessel, Arpatuuq (previously planned to be named John G. Diefenbaker), that will be of similar size and capacity to Polar Sentinel and is intended to replace Louis S. St. Laurent. This project was initially announced in 2008 with an accompanying budget of $1.3 billion Canadian Dollars (CAD) and a delivery target of 2017. In 2021, despite not beginning construction on Arpatuuq, plans were altered to build a total of two new polar icebreakers, with a combined cost of $7.25 billion CAD, and delivery of both in 2030. The Arpatuuq construction contract was awarded to Seaspan in Vancouver and the second vessel, Imnaryuaq, will be built by Davie in Quebec [13] and can eventually be used to replace Terry Fox (Pugliese D., 2022).

STX Canada Marine maintains the design contracts for both vessels and is working in conjunction with Aker Arctic of Finland. These vessels are intended to surpass the size of Louis S. St. Laurent and incorporate modern shipbuilding technology and propulsion systems to facilitate a broader range of missions for the CCG (Stewen C., 2024). Notably, Seaspan Shipyards awarded a contract on March 9, 2024 to ABB to implement a propulsion system with a single fixed shaft line and twin azimuthons propulsors, like what is planned for the USCG´s Polar Sentinel (ABB, 2024). Both vessels will be built to the IACS Polar Class 2 standard, will include helicopter flight decks and hangars, moon pools to deploy research equipment, and facilities for a remotely piloted aircraft system. In addition to traditional icebreaking missions, these ships are also intended to complete scientific research and provide support to Canada's northern settlements, including indigenous populations (Seaspan, 2023).

Prompted by concerns over the delayed construction of the polar icebreakers, Canada sought commercially available, interim icebreakers to ease the burden on the existing fleet, similar to the efforts the United States recently pursued. Interestingly, this plan initially included assessing the feasibility of purchasing the same Polar Class 3, U.S. vessel, Aiviq, to meet Arctic demands, but was later abandoned. Yet, under the moniker "Project Resolute," in 2018 the Canadian Government tasked Davie Shipyard with purchasing and retrofitting three, smaller "medium interim icebreakers" for $912.5 million CAD. Accordingly, in October of 2022, the last of the three Polar Class 4 vessels, Vincent Massey, was successfully completed and joined sisters Molly Kool and Jean Goodwill in active CCG service. These vessels were previously built in Norway in 2000 and frequently contracted out to augment the Swedish Maritime Administration's fleet (CCG - Canadian Coast Guard Ship Vincent Massey joins the icebreaker fleet, 2022).

The Canadian Coast Guard also briefly entertained the idea of using nuclear propulsion for a new icebreaker. In 1979, ten years after Louis S. St. Laurent was in operation, there were plans underway for the "Polar-10" project; named for the anticipated ability to break through ten feet of ice at three knots (corresponding to Arctic Class 10). The need for a vessel with this level of power was based on

13 In March of 2025, following adoption of the Icebreaker Collaboration Effort (ICE) Pact between the U.S., Canada and Finland, Davie announced it would begin construction of Imnaryuaq at the Helsinki Shipyard in Finland. Approximately 30% of the work will be completed in Finland before the hull is towed to Quebec for completion (Woityra, 2025).

the desire to capitalize on resource development in one of the harshest regions of Canada's Arctic waters. To achieve this capability, nuclear was seen as the only option since diesel for a vessel of sufficient size would require establishing several new northern fuel depots (Nossal, K. R., 1987). Ultimately, the CCG was authorized to employ a hybrid propulsion arrangement including both nuclear and gas turbine power (Brigham, L. W., 1986). Theoretically, this would have permitted a refueling frequency of once every three or four years at a southern (south of the Arctic Circle) facility. The plan eventually lost steam, both literally and figuratively, based on several factors. At the time Canada possessed no nuclear technology for marine applications and therefore looked to France to provide the installation. Further, there was no regulatory framework yet established, and such a framework would need to be created in parallel with the vessel itself. The final dissolution came when industry projections shifted away from Arctic resource development in 1981, thereby eliminating the immediate need for the Polar-10. To date, no additional attempts at nuclear icebreakers have been pursued publicly (Nossal, K. R., 1987).

DELAYS ATTRIBUTED TO UNIQUE DESIGN CHALLENGES

The United States and Canada are not alone in their frustrated efforts to develop the next generation of icebreakers. Other nations with ageing fleets that have made public plans to construct replacements include Germany, Sweden and Chile. Of note, Australia recently had some success in replacing its 34-year-old Aurora Australis with the newly christened Antarctic research vessel, Nuyina, in 2021 (Ervin, 2020); and China has had similar fortune with the 2019 Xue Long 2 (or Snow Dragon 2), which will augment the 31-year-old original Xue Long (Nikulin, M., 2021)[14]. Delays in all of these endeavors can be attributed to common themes that will be discussed once again through the representative examples of the United States and Canada.

UNITED STATES

As detailed in the 2025 Coast Guard Polar Security Cutter Program Background and Issues Report for Congress, there are multiple reasons given for delays in beginning construction, and consequently delivery, of the first Polar Security Cutter. One such reason, provided in a March 2023 press report, is attributed to the need for completing the critical design review which is dependent on adequate "design maturity" (O'Rourke, R., 2025). Since the Coast Guard is employing the use of parent design (through Germany's planned Polarstern II), one may assume that the task of achieving design maturity is less daunting. However, many changes to the parent design were required to meet the specific operational needs of the U.S. Coast Guard, such as proper helidecks to accommodate USCG helicopters. These changes were significant enough to necessitate further research in minimizing risks regarding technology, design, cost and schedule. Furthermore, even after new design modifications were determined, incorporation of those changes was not executed properly, resulting in ripple effects of complications. According to a July 2023 Government Accountability Office (GAO) report, the vessel's damage control deck was originally located too low in the ship on the design plans. This resulted in the need to move the deck higher up to meet damage stability requirements in case of flooding; however, the shipyard neglected to adjust the new height of the deck location accordingly. This oversight affected many other dimensions of the ship, including multiple tanks for fuel and potable water (GAO, 2023).

Moreover, in addition to COVID-19 impacts and design complexity and changes, a major contributing factor to Polar Sentinel delays is attributed to the recognition that "U.S.-based designers and shipbuilders generally lack experience designing and building polar icebreakers." This may be an understatement as the United States has only constructed four oceangoing icebreakers in the last

14 As of December 2024, China's fleet has also welcomed Tan Suo San Hao as its first scientific research vessel designed for global deep-sea exploration which is also rated as a Polar Class 4 icebreaker.

45 years. Additionally, shipbuilding in the United States in general has significantly decreased in that same period of time. The U.S. Maritime Administration reported that between 2015 and 2020, United States shipyards produced an annual average of only 19 deep draft vessels and structures. In 2020, only 15 were delivered, of which 14 were for the Navy or Coast Guard and only one was intended for commercial purposes (Maritime Administration, 2021).

For the more pressing issue of challenges with design complexity, the GAO report highlighted the unique building materials required for icebreakers of this size; namely, a steel alloy known as EQ-47. Per the American Bureau of Shipping (ABS) Rules for Materials and Welding, the "Q" designation corresponds to "extra high strength steel," versus "higher" or "ordinary" strength varieties[15]. The GAO Report further validates that this particular alloy is used for its high strength properties and resilience in low temperatures. However, due to the rarity of its use in standard shipbuilding, the plate thicknesses required, and specialized welding procedures, it is difficult to find welders with the necessary training and skill to work with the material effectively. Further, as previously referenced through Figure 2, frames around the ice belt must be placed closer together, which exponentially increases the time and complexity for welding in these more confined spaces.

Apart from the specific design and construction challenges encountered for icebreakers, it is also valuable to note the impact of high costs of shipbuilding in the United States. Calculations conducted using data from the U.S. Maritime Administration's Office of Shipbuilding Costs compared the average construction price for Jones Act compliant U.S. built oceangoing merchant vessels with prices for equivalent vessels in foreign shipyards. The results indicated that U.S. vessels were 268-285% more costly to build than their average foreign counterpart (Pagel et al., 2019). Military vessels in the United States are governed by different requirements, but the cost comparisons can end up being even more unbalanced. For example, the current projection for Polar Sentinel is $2.4 Billion USD, which includes shipbuilding costs, government furnished equipment costs, and post-delivery costs (O'Rourke, R., 2025). In contrast, Australia's new icebreaker, Nuyina, was completed for $528 Million AUD (approximately $344 Million USD) and, although it has many differing systems and capabilities that prevent it being a perfect comparison, it has a greater overall displacement, length and combined engine output than what is anticipated for the Sentinel (Australian Government, 2022). Nuyina was also built along the Black Sea in Romania by Damen Shipyards, a Dutch company.

The United States is currently restricted by law from constructing a vessel for the Armed Forces in a foreign shipyard without an exception granted by the President for national security.[16] Assuming that an exception could be granted, in 2017 Mr. Stefan Lindstrom, Finland's Los Angeles-based Consul General claimed that a Finnish shipyard could complete a polar icebreaker for the U.S. in under 24 months for roughly $235 to $258 Million USD (Yereth R., 2017). While that estimate may not be completely accurate, it further serves to draw attention to the stark difference in shipbuilding costs. This reality serves to raise the stakes for the USCG in achieving accurate design maturity prior to cutting steel in order to avoid costly mistakes. It helps to explain why, despite leveraging a mature design from Polarstern II, the Coast Guard continues to examine the effects of necessary service-specific alterations to the existing design with an abundance of caution.

Against this backdrop, the trilateral Icebreaker Collaboration Effort ("ICE Pact") between the United States, Canada, and Finland, which was announced on July 11, 2024 and formalized by an Memorandum of Understanding (MOU) on November 13, 2024, seeks to pool demand signals, share

15 ABS Rules for Materials and Welding, Part 2, July 2022: The "E" in EQ-47 is a grade of composition that can withstand a lower test temperature, corresponding to - 40 degrees Celsius, for the Charpy V-Notch impact test, and 47 is the yield strength in kilograms per square millimeter.

16 This restriction is independent from the prohibition contained within the Merchant Marine Act of 1920 (Jones Act) which applies only to merchant vessels. The Coast Guard specifically is restricted under 14 U.S.C. 1151, and the Armed Forces as a whole are restricted under 10 U.S.C. 8679.

design knowledge, and expand industrial capacity through structured information exchange, workforce development, and options for coordinated production of Arctic and polar icebreakers (DHS, 2024; Public Services and Procurement Canada, 2025; Reuters, 2024; Wilson Center, 2024). While the pact does not itself constitute a procurement decision and U.S. statutory constraints on foreign construction of Armed Forces vessels still apply, it provides a policy framework that could allow the USCG to leverage Finnish design expertise and Canadian yard capacity in ways that compress schedules and reduce risk in design maturation through common standards and iterative learning across programs (DHS, 2024; Public Services and Procurement Canada, 2025). In practical terms, the ICE Pact may narrow the longstanding cost and schedule differentials highlighted above, not by "offshoring" a U.S. cutter, but by orchestrating modular cooperation, reciprocal supplier networks, and workforce pipelines that raise productivity across all three industrial bases (DHS, 2024; Reuters, 2024).

CANADA

It was 2008 when then Prime Minister Stephen Harper first announced that Canada was initiating plans to replace Louis S. St. Laurent with a new heavy icebreaker, John G. Diefenbaker (now known as Arpatuuq). In spite of this, 17 years later, construction has not yet commenced beyond prototype blocks (Axworthy, T. S., 2023). A November 2016 update attributed delays to a scheduling conflict, without further elaboration, within the Seaspan Vancouver shipyard resulting in a projection of completion in the early 2020s (Berthiaume, L., 2016). In 2021, following the news that Canada's Polar Icebreaker Project would now plan for construction of two vessels versus just one, the Office of the Parliamentary Budget Officer released a fiscal analysis to help arrive at the previously referenced $7.25 billion estimate. A close reading of this analysis sheds light on other potential causes for delay. The report describes that, in contrast to naval vessels, costs for large polar icebreakers are quite difficult to predict since there are very few existing ships of "similar specifications and capacities" (Office of the Parliamentary Budget Officer, 2021). It further elaborates that the only ships that match the mission and size are "legacy vessels" over 40 years old, such as Louis S. St. Laurent and the USCG's Polar Star. Essentially, this hints at the challenge of not only developing accurate cost projections, but also tapping into the knowledge and skilled workforce necessary to construct modernized versions of scarce and outdated predecessors. Moreover, at the end of 2023, the Government of Canada issued a report summarizing the year's activities related to their overall National Shipbuilding Strategy. In this, they listed their common challenges spanning all vessel types, noting delays resulting from "the global pandemic and supply chain disruptions, as well as workforce shortages, increased costs (partially due to inflationary and supply chain pressures), commodity pricing and geopolitical tensions" (Government of Canada - 2023 year in review: National Shipbuilding Strategy, 2024). While this can reasonably account for recent setbacks, amplifying information explaining the 2008-2021 lull is difficult to find.

Furthermore, as with the U.S. Coast Guard, one of the latest reasons given for the delay has been the difficulty in sourcing the hardened steel needed to build icebreakers of this capacity. In this case, the steel in question is listed as "EH50" (Pugliese D., 2022). As with the EQ-47 steel sought for Polar Sentinel, the "E" designation relates to a particular grade which is held to a standard for lower temperature testing thresholds (-40 degrees Celsius). Although the "H" indicates it is only higher strength steel versus "extra" high strength steel, the number 50 refers to the yield strength which is slightly higher than that of EQ-47. All in all, both listed grades contain similar properties and are uncommon in standard vessel production. Other problems given during House of Commons questioning to the CCG included the determination of helicopter type to deploy on the icebreakers and also the capacity of the chosen shipyards to complete the work (Pugliese D., 2022). Since two different shipyards, Seaspan and Davie, must construct the polar icebreakers on parallel timelines, expectations that the vessels will be sufficiently similar to avoid operational complications may prove to be an increased challenge for ongoing communications. It has yet to be seen if this will result in further setbacks or, alternatively, create extra incentives through competition for each shipyard to keep pace with the other.

CONCLUSIONS

Demand for icebreakers in the Arctic (and Antarctic regions) is expected to intensify in coming years. In response, it is imperative that stakeholder administrations, along with the shipbuilding industry, leverage intelligent and farsighted plans to remove barriers to construction, amplify international partnerships, and maximize efficiency and effectiveness of essential resources. All eyes are on the United States and Canada in particular to promote stability in the Arctic. Furthermore, amplifying maritime trade efficiency in the wider region can have positive ripple effects on consumer costs and human flourishing across the globe. Progress of this variety cannot be achieved without capable icebreakers to assist in eliminating unnecessary safety risks in treacherous, icy waters. However, both the U.S. and Canada have historically been committed to building such vessels domestically, and were therefore subject to the drastically higher costs that must follow from that decision. This study did not investigate the value of such policies since it deployed an out-of-scope approach, but it is evident that significantly lower costs can be achieved from foreign partners which could then alleviate many of the impediments stalling mission success.

Incentives to build up icebreaker fleets of North American Arctic states are not on par with those from Russia and others along the Northern Sea Route. This is simply a matter of dissimilar geography-based realities that result in the NSR being a preferable means of joining the Atlantic and Pacific Oceans for commercial traffic in comparison to the NWP (less year-round ice for one). Furthermore, Russia has significant industry and infrastructure investments along their northern coast, including the Yamal LNG facility. By way of contrast, primary economic drivers for shipping traffic in the NWP include tourism and resupply of isolated communities. While there are clearly many future commercial opportunities, such as oil and gas exploration, these are dependent on supporting infrastructure that is not presently available. Consequently, if the governments of Canada and the United States want to strengthen their presence in the Arctic for security and sovereignty purposes, independent of economic incentives, they will need to continue pressing the case for icebreaker construction as a funding priority and simultaneously find novel ways to decrease unreasonable associated costs.

As early as 1988, the United States and Canada had already signed a treaty on Arctic cooperation based on shared interests in the region. This agreement cited a need to "facilitate navigation of their icebreakers," and "develop and share research information" from those icebreakers [17] . Nevertheless, it is important to note that this agreement was not merely a straightforward accord, but rather a diplomatic solution to the 1985 Polar Sea controversy[18] and the broader debate over whether the Northwest Passage should be considered an international strait or part of Canada's territorial waters. Capitalizing on the incumbent advantages associated with economies of scale is one avenue to reduce required spending.

To this end, the policy commitments outlined in the ICE Pact MOU present promising developments in international collaboration. Following formalization of the ICE Pact and further discussions with Finland's President Alexander Stubb, President Trump released a Presidential Memorandum providing the needed exemption to the foreign shipyard restriction for a period of four years. This memorandum further outlines the intent to build up to four Arctic Security Cutters abroad and directs development of a plan to on-shore the necessary expertise to build future icebreakers domestically (White House, 2025). Coupling this outcome with Canada's plan to split construction of their second heavy icebreaker between Finnish and Canadian shipyards represents a pragmatic shift to-

17 For text of the treaty see the following: "Agreement Between the Government of Canada and the Government of the United States of America on Arctic Cooperation," Treaty 101701, January 11, 1988, available online: <https://www.treaty-accord.gc.ca/text-texte.aspx?id=101701>.
18 The United States sent the fledgling Polar Sea through the Northwest Passage from Greenland to Alaska without first seeking the approval of Canada. Canada saw this as a violation of their sovereignty, but the U.S. maintained that the transit was through an international waterway.

wards balancing domestic interests with the economic benefits of multinational partnerships.

While it is true that icebreakers comprise distinctive construction requirements that challenge the capacity and infrastructure of even the most experienced shipbuilding nations, this fact alone is insufficient to justify further delays. The growing interconnectedness of the globe offers unique opportunities for information sharing and cooperation to remove such barriers. All countries, not just so-called Arctic nations, can experience benefits from decreased shipping transit times, resource exploration and scientific polar research. Consequently, maximizing use and safety within Arctic waters must be a shared goal of every nation. So long as governments are expected to maintain control over icebreaking operations in lieu of industry alternatives, this goal must be achieved through further treaties, capacity building initiatives and loosening of decreasingly effective protectionist policies and regulations.

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Pacing the Polar Shift:

Reshaping US-NATO Strategy in a Contested Arctic[1]

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ABSTRACT

The Arctic is rapidly re-emerging as a central arena for strategic competition amid accelerating climate change and shifting geopolitical dynamics. Once governed by the "low tension" principle, the region now witnesses deepening cooperation between Russia and China across economic, political, and military spheres. This paper critically examines the nature and limits of Sino-Russian coordination in the Arctic, assesses Russia's Arctic militarization and economic strategy, and analyzes China's expanding regional footprint. It finds that while the partnership is pragmatic rather than fully aligned, it poses a significant challenge to US and NATO interests. The analysis identifies critical shortcomings in current NATO and US Arctic strategies, including command fragmentation, capability gaps, and insufficient infrastructure for sustained polar operations. The paper argues for a recalibrated Western approach centered on developing a unified NATO Arctic strategy, investing in Arctic-capable forces and infrastructure, and strengthening regional partnerships. It concludes that proactive measures today are essential to preserve Arctic stability, deter authoritarian coercion, and ensure that the Arctic remains a domain governed by international law rather than strategic rivalry.

1 Disclaimer: This paper represents the views of the authors and does not represent the views of the Department of Defense, or the Department of the Air Force.

The Arctic is undergoing a profound transformation in both its geopolitical and environmental landscapes. Rapid climate change is melting polar ice at an unprecedented rate, opening new sea lanes and access to long-frozen resources. The region is warming more than three times faster than the global average, hastening the prospect of an ice-free Arctic summer by as early as 2030 (Department of Defense [DoD], 2024). These changes create new opportunities for commerce and development while intensifying great-power competition in a once-stable theater. The United States and its NATO allies now face a "contested Arctic," where strategic rivals are seeking to shape the region's future, necessitating a recalibration of policy to compete and avoid conflict. The US strategy envisions an Arctic region that remains "peaceful, stable, prosperous, and cooperative," acknowledging the rising strategic competition driven by Russia's aggression and China's ambitions (White House, 2022). Achieving this vision will demand a coordinated US-NATO approach that keeps pace with the polar shift in climate and security dynamics.

THE CHANGING ARCTIC ENVIRONMENT

The physical environment of the Arctic is changing more rapidly than predicted, driving its newfound strategic significance. The Arctic is the fastest-warming region on Earth, heating at approximately three to four times the global rate (DoD, 2024). The US Department of Defense warns that the Arctic's warming is "rapidly reshaping" the operating environment, with dramatic impacts on ice, weather, and infrastructure (DoD, 2024). Scientists project that the first practically ice-free summer in the Arctic Ocean will occur by around 2030, a scenario once considered unthinkable (DoD, 2024). The loss of multiyear sea ice is already increasing the viability of Arctic maritime transit routes and access to untapped undersea resources. For example, the Northern Sea Route along Russia's coast and the Northwest Passage through the Canadian archipelago are becoming seasonally navigable, shortening intercontinental shipping distances and attracting commercial interest. NATO officials note that melting ice is "creating new sea routes that would shorten navigation times," fundamentally altering global trade patterns (NATO, 2023).

These environmental shifts carry significant strategic implications. The Arctic is estimated to hold 13% of the world's undiscovered oil and 30% of its natural gas in technically recoverable deposits (US Energy Information Administration [EIA], 2012). Melting ice and advancing technology make these rich hydrocarbon and mineral reserves more accessible, spurring interest from Arctic states and outsiders alike. At the same time, increased human activity, such as shipping, energy exploration, and tourism, in harsh Arctic conditions raises the risk of accidents, environmental disasters, and search-and-rescue emergencies (White House, 2022). The changing climate also poses significant threats to Indigenous communities and fragile ecosystems, introducing security challenges such as coastal erosion, permafrost thaw, damage to infrastructure, and even wildfires in sub-Arctic regions (DoD, 2024). In short, climate effects are both "creating... new economic opportunities" in the Arctic and "bringing additional challenges," as the White House observed, ranging from resource rushes to greater potential for disputes over navigation and environmental protection (White House, 2022). As never before, this confluence of opportunity and risk has drawn global strategic attention to the Arctic.

RUSSIA'S MILITARIZATION OF THE ARCTIC

Russia has moved aggressively to bolster its position in the evolving Arctic as the nation with the most extensive Arctic territory and coastline. Over the past decade, Moscow has significantly expanded its military presence in the Arctic, broadly modernizing Arctic bases and forces. According to the US Arctic strategy, Russia has refurbished and upgraded numerous Soviet-era installations across its High North, deploying new coastal and air defense missile systems, modernizing airfields, and fielding more capable submarines in Arctic waters (White House, 2022). Russia's Northern Fleet, based on the Kola Peninsula, remains a linchpin of its strategic deterrent; this region hosts a significant concentration of nuclear second-strike forces and advanced missiles that can threaten the

United States and Europe (DoD, 2024). Notably, the Pentagon assesses that Russia's Arctic capabilities "have the potential to hold the US homeland and Allied territory at risk," underscoring the High North's role in Russian defense strategy (DoD, 2024). In recent years, Russia has even established a new Arctic joint strategic command to command and coordinate its expanding Arctic footprint (White House, 2022). These investments are backed by an ambitious fleet of icebreakers that dwarfs the United States; Russia operates over 40 icebreaking vessels (including several nuclear-powered), whereas the US has only two functional polar icebreakers in service (DoD, 2024). This dominant icebreaker fleet enables Russia to patrol its Arctic domain and escort commercial shipping along the Northern Sea Route year-round, reinforcing its bid to control Arctic maritime access (DoD, 2024).

Moscow has also updated its strategy documents to elevate the Arctic as a core priority. In 2023, President Vladimir Putin approved a new Foreign Policy Concept, which for the first time explicitly designates the Arctic as a top-tier strategic region, second only to the "near abroad" of former Soviet republics (Ukaz Prezidenta Rossiyskoy Federatsii ot 31.03.2023 N 229, 2023). This reflects Russia's view of the Arctic as vital to its national interests, both for security and economic development (Ukaz Prezidenta Rossiyskoy Federatsii ot 05.03.2020 N 164, 2020; Ukaz Prezidenta Rossiyskoy Federatsii ot 26.10.2020 N 645, 2020). Indeed, the Kremlin's Arctic policy emphasizes the development of the Russian Arctic zone (e.g., new ports, the Yamal LNG mega-projects, and mineral extraction) and the instrumental use of international cooperation to support these domestic goals (Ukaz Prezidenta Rossiyskoy Federatsii ot 05.03.2020 N 164, 2020; Ukaz Prezidenta Rossiyskoy Federatsii ot 26.10.2020 N 645, 2020). To protect its stakes, Russia has asserted expansive interpretations of its jurisdiction: it claims authority over large portions of the Northern Sea Route beyond what is permitted under UNCLOS, demanding that foreign vessels seek Russian permission and even threatening the use of force against ships that do not comply with its "excessive maritime claims" along the route (Postanovleniye Pravitel'stva Rossiyskoy Federatsii ot 18.09.2020 N 1487, 2020; DoD, 2024). Such moves have raised concerns that Moscow intends to constrain freedom of navigation through an emerging Arctic seaway that, by international law, should remain open to global transit (White House, 2022).

An increasingly assertive behavior has accompanied Russia's military buildup. Even as its war against Ukraine rages, Russia continues to conduct Arctic military exercises and bomber patrols, at times in tandem with China. In 2022 and 2023, Russian Navy ships conducted drills alongside China's PLA Navy in waters off Alaska's coast, an unprecedented display of joint presence near US territory (DoD, 2024). Moscow has also engaged in lower-level harassment around the Arctic, from GPS jamming to aggressive overflights near NATO airspace (DoD, 2024). These activities signal that Russia is prepared to challenge Western interests in the far north. NATO's leadership warns of "increased competition and militarization in the Arctic region, especially by Russia," marking a break from the previous era of Arctic cooperation (NATO, 2023). In response to Russia's aggression in Ukraine and its bellicose Arctic posture, the seven other Arctic states (Canada, the Kingdom of Denmark, Finland, Iceland, Norway, Sweden, and the United States) jointly paused all Arctic Council meetings with Russia in March 2022—effectively freezing the primary forum for Arctic diplomacy (Global Affairs Canada, 2022). They cited Russia's "flagrant violation" of fundamental principles and the "grave impediments to international cooperation, including in the Arctic," caused by its invasion of Ukraine, as reasons for halting business as usual (Global Affairs Canada, 2022).

In short, Russia's actions have shattered much of the cooperative veneer of Arctic relations. The Arctic is now a theater of heightened tension: Moscow is fortifying its northern frontier and staking broad claims to the region. Meanwhile, NATO nations are reinforcing their Arctic defenses and suspending partnerships with Russia. Any US-NATO strategy for the contested Arctic must start with this new reality: a militarized, assertive Russia in the High North.

CHINA'S EMERGING ARCTIC AMBITIONS

Although China has no Arctic territory, it has declared itself a "Near-Arctic State" and is increasingly active in Arctic affairs (State Council Information Office of the People's Republic of China [SCIO; Guówùyuàn Xīnwén Bàngōngshì], 2018). Both economic and strategic calculations drive Beijing's interest. In 2018, after being granted Observer status in the Arctic Council, China released its first Arctic policy White Paper, outlining its plans to integrate the Arctic into its global Belt and Road Initiative via a "Polar Silk Road" – developing Arctic shipping routes to connect Asia and Europe (SCIO, 2018). The document contended that, as a major trading nation, China has a stake in the Arctic's future and hopes to work with all parties to build this Polar Silk Road through infrastructure investment and trial voyages (SCIO, 2018). In line with this vision, Chinese state enterprises have invested in Arctic natural resources (such as Russian LNG projects on the Yamal Peninsula). They are pursuing infrastructure partnerships that could facilitate Arctic transit.

China has steadily expanded its scientific and operational footprint in the Arctic. It maintains a research station in Svalbard (Norway) and has conducted frequent scientific expeditions using its growing icebreaker fleet. The People's Liberation Army Navy (PLAN) commissioned its first domestically built heavy icebreaker, Xue Long 2, in 2019, joining the older Xue Long; China now operates three polar-capable icebreakers, including one dedicated to research (DoD, 2023). Under the banner of science, China has engaged in dual-use research activities in the Arctic, for instance, deploying unmanned submersibles and sensors during research cruises that could have both military and intelligence applications (White House, 2022). Top US officials have cautioned that even ostensibly civilian research could support future Chinese military deployments, such as submarine operations in Arctic waters (Pompeo, 2019). China's military presence in the Arctic remains limited, but Beijing is clearly "seeking to bolster its operational expertise in the Arctic" and incrementally increase its regional presence (DoD, 2023). Beijing signaled its intent to shape Arctic governance norms in its favor in the 2018 White Paper, which asserted that non-Arctic states have rights in the region's global commons and called for a "shared future for mankind" in the Arctic (SCIO, 2018).

Another aspect of China's Arctic foray is its growing diplomatic and security collaboration with Russia in the far north. In recent years, Beijing and Moscow have drawn closer on Arctic matters, committing to deepen military mutual trust and cooperation, expand joint exercises, and regularly organize joint maritime and air patrols (People's Republic of China and Russian Federation [PRC-RF; Zhōnghuá Rénmín Gònghéguó hé Éluósī Liánbāng], 2023), such as the third joint naval patrol conducted in the Western and Northern Pacific waters in July-August 2023 (Ministry of National Defense of the People's Republic of China [MND PRC; Zhōnghuá Rénmín Gònghéguó Guófángbù], 2023). Isolated from Western investment due to sanctions, Russia has turned to China for capital and partnership to develop Arctic energy projects; a significant portion of Russia's natural gas production now comes from its Arctic fields, and China is a key purchaser and financier, according to US assessments (DoD, 2024).

This symbiotic relationship suggests that China could gain greater access or even a quasi-stake in Russia's Arctic Sea routes and infrastructure in exchange for economic support, aligning with joint goals to promote cooperation on developing and utilizing Arctic routes (PRC-RF, 2023). Indeed, Chinese officials have expressed interest in utilizing the Northern Sea Route for commercial purposes. According to US analysis, such Sino-Russian collaboration in the Arctic "continues to increase" across economic and military domains (DoD, 2024). Western strategists worry that a more active China–Russia axis in the Arctic could complicate the security environment, as both nations have an interest in diluting Western influence there. At the same time, China has been careful to present itself as respecting the sovereignty of Arctic states while quietly asserting that the Arctic's transnational challenges (climate change, shipping, fisheries) implicate global interests (SCIO, 2018).

China's Arctic strategy is characterized by a gradual yet deliberate approach, marked by the expansion of scientific research, investment in energy and shipping ventures, and norm-building to legitimize its role, all under the self-proclaimed status of a "Near-Arctic State." For the US and NATO, China represents a new kind of Arctic actor with vast resources and global strategic ambitions, but lacking Arctic geography. As China's regional footprint grows, any comprehensive Western Arctic strategy must account for Beijing's influence, ensure that Arctic governance remains rules-based, and guard against any future Chinese military uses of the region. While Russia poses an immediate military threat in the Arctic, China's long-term entry as an Arctic stakeholder subtly reshapes the strategic calculus in significant ways.

US AND NATO RESPONSES IN A CONTESTED ARCTIC

For much of the post-Cold War period, NATO lacked an explicit Arctic security strategy, instead deferring to individual member states to manage the region. The Arctic was viewed as a peripheral theatre that did not require a dedicated NATO role, as tensions remained low (NATO, 1991, 1999, 2010). Unlike the Baltic Sea or the Mediterranean, NATO has not established a regional command structure or regular exercises specific to the Arctic Ocean.

Several factors have historically limited NATO's involvement in the Arctic. First, not all Arctic states were NATO members until recently: Finland and Sweden were partners but not protected under Article 5, while the essential Arctic player, Russia, was theoretically a partner in forums like the Arctic Council. Canada, a founding NATO member with vast Arctic territories, has often been cautious about a NATO role in its Arctic, preferring bilateral defense with the US through NORAD and fearing that internationalizing Arctic security could dilute its sovereignty (Government of Canada, 2019). These dynamics have led to a somewhat fragmented approach: Arctic security has been handled through national strategies (DoD, 2019; Government of Canada, 2019; Norwegian Ministry of Defence, 2020) and bilateral arrangements rather than a coherent NATO policy (NATO, 2010). Indeed, as the Arctic Institute's Alina Bykova (2024) noted, "NATO currently has no official Arctic policy nor a command devoted to northern affairs," calling this lack of focus "problematic" in light of rising challenges.

However, with Russia's more aggressive posture and China's entry, NATO's stance has been evolving. In NATO's 2022 Strategic Concept, the Alliance highlighted the Arctic for the first time as an area of strategic importance. It warned that Russia's capability to disrupt Allied reinforcements and freedom of navigation in the High North posed a strategic challenge. It also expressed concern about the "deepening strategic partnership" between Russia and China (NATO, 2022). These points signaled that NATO's strategic planners now view Arctic security through a 360-degree lens, recognizing threats from the north as part of the broader competition with authoritarian great powers. The accession of Finland (2023) and Sweden (2024) to NATO has effectively turned the Baltic and Nordic Arctic into NATO territory. NATO Secretary General Jens Stoltenberg explicitly welcomed these new Arctic members, noting that with them aboard, "seven out of eight Arctic nations" are in NATO, and stating NATO has a responsibility to defend all Allies in the region, affirming in a joint speech with then-Canadian PM Justin Trudeau that, "NATO will defend its interests in the Arctic (and is) responsible for protecting all Allies, including the seven in the Arctic." (Stoltenberg, 2022).

Concrete steps have been taken to bolster NATO's regional footprint. In response to Russia, NATO has begun to increase its military presence and exercises in the Arctic. In recent years, large-scale exercises such as Trident Juncture 2018 (NATO, 2018) and Cold Response 2022 in Norway (NATO, 2022) have brought tens of thousands of NATO troops into Arctic conditions to practice reinforcing Norway and high-latitude warfighting. Joint naval groups have operated in the Norwegian Sea and even the Barents Sea to signal freedom of navigation (NATO Allied Maritime Command [MARCOM], 2020). The US reestablished its 2nd Fleet (US Navy, 2018), and NATO established a new Atlantic Command (JFC Norfolk) with responsibilities that include the "High North" to ensure Atlantic-Arctic Sea lanes remain secure (NATO, 2021). Allied maritime surveillance of the GIUK gap and North Atlantic has intensified since 2022, anticipating that Russian subs from the Arctic would surge in a crisis (Stoltenberg, 2022).

Despite this progress, critical shortcomings persist in NATO's Arctic posture. One significant gap is in the integration of command and control (C2) and strategy. With Finland and Sweden joining, NATO's northern flank stretches from Alaska via Canada (albeit the Alliance does not formally cover Alaska (NATO, 1949, Art. 6)) to the European Arctic Norway/Finland. Command responsibilities are split: the US and Canada cover the North American Arctic through NORAD, while NATO's European command (SHAPE) covers the European High North (North American Aerospace Defense Command [NORAD], n.d.; NATO Allied Command Operations [ACO], n.d.). There is concern about "seams" in command. As Commander Rachael Gosnell and CSIS's Benjamin Jensenthat (2024) incisively argue, NATO should "reexamine command and control in the north" and possibly establish a dedicated NATO Arctic Command to ensure unity of effort. Currently, no single NATO commander focuses exclusively on the Arctic (ACO, n.d.), raising the risk of fragmented responses (Gosnell & Jensenthat, 2024).

Another gap is capability shortfalls in extreme cold-weather operations (NATO Parliamentary Assembly [NATO PA], 2023). Outside a few countries, such as Norway, NATO forces have relatively limited experience in the unique Arctic environment, characterized by extreme cold, permafrost, darkness, polar navigation challenges, and auroral interference with communications (NATO PA, 2023). Additionally, NATO lacks specialized assets such as heavy icebreakers or all-weather Arctic communications (NATO PA, 2023). Allied militaries have taken steps to address the operational malaise; for instance, the US Army reactivated an Arctic brigade (11th Airborne Division) in Alaska (US Army, 2022) and published an Arctic Strategy emphasizing training and materiel for cold regions (US Department of the Army, 2021). The US Navy and Marine Corps have resumed Arctic exercises such as ICEX and increased maritime patrols (US Navy, 2024). Still, as experts point out, communications and domain awareness in the far north remain weak (Gosnell & Jensenthat, 2024). The polar regions are notorious for experiencing satellite communication blackouts and navigation errors due to their proximity to the magnetic pole. NATO does not yet have a dedicated Arctic satellite system. Furthermore, under-ice anti-submarine warfare is a niche skill that has atrophied since the Cold War, necessitating that NATO relearn how to track Russia's under-ice submarines and cope with a changing acoustic environment due to melting ice (NATO PA, 2023). These are not insurmountable issues but, as a 2023 NATO Parliamentary report warned: Alliance forces must be better equipped for Arctic conditions or risk ceding advantage to Russia's seasoned Arctic units (NATO PA, 2023), which will require investment in "tailored systems, training, and tactics" for the Arctic (US Department of the Army, 2021).

The most glaring operational shortfall is a lack of physical icebreaking and logistics capabilities for sustained Arctic operations. As noted, Russia operates dozens of icebreakers, while NATO nations have only a handful (owned mainly by the US and Canada, plus a few in Scandinavia) (O'Rourke, 2024). This means that NATO forces cannot maneuver in ice-covered waters or respond to incidents in high-latitude seas (O'Rourke, 2024). The US Coast Guard's lone heavy icebreaker is over 40 years old (US Coast Guard [USCG], n.d.), and new Polar Security Cutters will not be fully operational until the late 2020s (O'Rourke, 2024; USCG, n.d.), while Canada's icebreaker fleet is similarly aging (Office of the Auditor General of Canada, 2023). Although Europe's NATO members like Norway and Denmark have some ice-capable patrol vessels (Norwegian Armed Forces, n.d.; Danish Ministry of Defence, n.d.), they lack heavy icebreakers (O'Rourke, 2024) (though Finland maintains a strong commercial icebreaker fleet for the Baltic (Arctia Ltd., n.d.) and is now adding limited capability). Without sufficient icebreaking support, NATO warships or supply ships could be constrained seasonally, and until new assets come online, this remains a vulnerability.

In terms of strategy documents and doctrine, NATO lacks a unified "Arctic Strategy"; however, the Alliance has started incorporating the Arctic into its planning (NATO, 2022). For example, the 2023 US-led Trident Juncture 2023 exercise scenario reportedly involved Arctic contingencies. With Finland and Sweden in mind, NATO's new regional plans (approved in 2023) presumably account for Nordic Arctic defense (NATO, 2023). Nevertheless, NATO as a whole could benefit from a clear, publicly articulated Arctic policy. Such a policy should define NATO's objectives, e.g., ensuring the

Arctic remains stable and conflict-free, assuring Allies' territorial defense (particularly Norway, the Baltic Sea, and the North American Arctic), safeguarding freedom of navigation, and contributing to disaster response as needed. Additionally, NATO's policy must outline its stance vis-à-vis Russia and China in the Arctic, drawing red lines against aggressive moves and offering dialogue on risk reduction. Currently, NATO's messaging on the Arctic tends to be reactive, emphasizing a response to Russian buildup rather than a proactive vision (NATO PA, 2023).

NATO's current Arctic approach is necessary but insufficient. It has made significant strides by acknowledging threats, integrating new members, and increasing deterrence. Nevertheless, it lags behind Russia in deployed capabilities and China in long-term regional economic engagement. The U.S., for its part, has updated its Arctic strategies. The 2022 US National Strategy for the Arctic Region (The White House, 2022) and the 2024 DoD Arctic Strategy (2024) explicitly recognize the connection between climate change, Russian aggression, and Chinese ambitions as factors creating a more contested Arctic. The DoD strategy (2024) emphasizes building "critical capabilities" to operate in the Arctic and identifies the PRC as the pacing challenge and Russia as the acute threat in the region. In 2022, the US appointed an Arctic Ambassador-at-Large to elevate diplomatic attention (US Department of State, 2022). These national efforts are essential building blocks, but without a coordinated NATO framework, there is potential for overlap or gaps; for instance, US-Canada defense upgrades under NORAD may not directly assist Nordic European surveillance, and vice versa.

POLICY RECOMMENDATIONS FOR THE US AND NATO

Addressing the convergence of Russian and Chinese activities in the Arctic will require concerted action by the United States and NATO to ensure the Arctic remains stable and free from coercion.

DEVELOP A UNIFIED NATO ARCTIC STRATEGY AND COMMAND STRUCTURE

NATO should formalize its commitment to the Arctic by crafting an official regional strategy document endorsed by all Allies. This strategy must define NATO's core interests in the Arctic and articulate how the Alliance will defend them in coordination with partners. A central element should be acknowledging the "deepening strategic partnership" between Russia and China (NATO, 2022) as a strategic concern and outlining a deterrence posture against hostile activities. To implement this and eliminate command seams, NATO should establish a dedicated Arctic coordination center or command as a full-fledged NATO Arctic Command (ARCCOM) or a more networked Joint Task Force. With Finland and Sweden in NATO, the Alliance can reevaluate the division of responsibilities between the North American and European theaters. One option is to expand the remit of Joint Force Command Norfolk (which already covers the North Atlantic and GIUK gap) to explicitly include Arctic operations and ensure close integration with NORAD for North American Arctic contingencies (NATO PA, 2023). Another complementary step is to set up a NATO Center of Excellence for Arctic Security, which could be hosted in a member country like Norway or Canada. This COE would harness regional expertise, develop cold-weather doctrine, and facilitate exercises and training. By institutionalizing Arctic security within NATO's command structure, the Alliance demonstrates its resolve and enhances unity of effort, thereby reducing the likelihood that Russia could exploit any Allied coordination gaps in a crisis.

INVEST IN ARCTIC-CAPABLE FORCES AND INFRASTRUCTURE

NATO and the US must significantly enhance the capabilities necessary for military operations in the challenging Arctic environment. This begins with addressing the icebreaker gap. The US should accelerate the construction and deployment of its Polar Security Cutters and consider interim solutions (such as leasing icebreakers from allies or the private sector) to ensure more than two functional icebreakers this decade. Other NATO nations with icebreaking needs (Canada, Norway, Denmark/Greenland) could pool resources, possibly through a NATO-EU initiative, to guarantee adequate icebreaking support for joint operations and logistics. Additionally, Arctic infrastructure on Allied soil must be improved. This includes upgrading airfields in Alaska, Canada, and Northern Europe to accommodate heavy aircraft in extreme cold (e.g., heated hangars and de-icing facilities); developing at least one deepwater port in the US Arctic (the proposed port of Nome in Alaska (US Army Corps of Engineers [USACE], 2020)) capable of hosting naval and coast guard vessels; and pre-positioning fuel and supplies in key Arctic locations for rapid response. Communications infrastructure is critical: NATO should invest in dedicated polar-orbit satellite communications and PNT (positioning, navigation, timing) assets to ensure connectivity above 70° north. The US could expand programs like Enhanced Polar System satellites and collaborate with Canada (investing in Arctic surveillance satellites) to establish a resilient network. Similarly, enhancing domain awareness is paramount – more long-range radar and sonar systems are needed to monitor Arctic airspace and waters. Canada and the US have already committed ~$38 billion to modernize NORAD's early-warning systems (with new over-the-horizon radar and sensors); these efforts should be fully funded and, where possible, integrated with NATO's Integrated Air and Missile Defense architecture so that data (like the detection of Russian bombers or missiles over the Arctic) is shared Alliance-wide in real time.

Another aspect is equipping troops for Arctic warfare. As Commander Gosnell (2024) cautioned: "[t]he Arctic is not a pickup game", it demands focused preparation. NATO should ensure that most of its rapid reaction forces receive specialized training and gear for extreme cold-weather conditions. This could mean expanding programs like the Norwegian-led winter warfare training (where Allies send units to train annually) and creating an Arctic Operations training center. Specialized equipment, vehicles that operate on ice and deep snow, Arctic-proven drones, and polar survival gear should be procured. For example, the US Army's new Cold Weather All-Terrain Vehicle (CATV) program can be a model for other Allies operating in northern Scandinavia. The aim is for NATO forces to excel in the Arctic rather than treat it as an exotic deployment. Equipped and appropriately trained, Allied units will be far more credible in deterring adventurism.

To demonstrate capability and resolve, NATO should significantly increase the frequency and scale of its Arctic exercises. While exercises like Cold Response and Dynamic Mongoose have been valuable, they should be broadened. NATO could establish a recurring marquee exercise focused on Arctic defense, akin to how "Baltops" exists for the Baltic Sea (NATO PA, 2023). For instance, an annual "Arctic Guardian" exercise, rotating between North America and Europe, could involve multi-domain scenarios, such as defending Norway's Finnmark region from incursion, escorting convoys across the Atlantic-Arctic route, or responding to a simulated attack on Arctic undersea cables. Such drills would allow the Allies to practice reinforcement under Arctic conditions and coordinate the region's naval, air, and ground forces. Further, NATO should incorporate Article 5 scenarios in the Arctic into its contingency planning – for example, how the Alliance would collectively respond if Russian forces (or a "little green men" hybrid scenario) threatened Svalbard or if Chinese "fishing vessels" conducted hostile action to regional deep-sea infrastructure (as seen with 2024 Balticconnector incident (Standish, 2024)).

In peacetime, NATO can maintain a more persistent presence in the Arctic. This might involve establishing a rotational NATO maritime patrol in the Norwegian Sea/Barents, perhaps expanding the UK-led Joint Expeditionary Force (JEF) activities with Nordic nations. Additionally, as seasonal conditions allow, NATO could periodically send a surface naval group through the Fram Strait towards the Arctic Ocean to assert navigational rights (ensuring respect for UNCLOS but not Russia's excessive NSR claims). Allied submarines should continue to train under ice (as U.S., UK, and French subs do in ICEX exercises) (US Navy, 2024). Coast Guards of Arctic Allies (U.S., Canada, Denmark, Norway) can coordinate more effectively on presence missions, as many Arctic scenarios (such as search and rescue or managing increased shipping) fall under the purview of Coast Guards. A forum for Coast Guard cooperation under NATO aegis could be beneficial. The underlying message of a stepped-up presence and exercises is deterrence through readiness – convincing Moscow and Beijing that NATO will "stand up for [its] shared values and the rules-based international order" even in remote Arctic waters (Stoltenberg, 2022).

STRENGTHEN COLLABORATION WITH ARCTIC PARTNERS AND INSTITUTIONS

The US and NATO should leverage all available partnerships to strategically manage the Arctic. This means working hand-in-hand with non-NATO Arctic states. With Sweden and Finland as members, NATO can draw on their substantial Arctic expertise, including Finland's experience in winter warfare (Finnish Defence Forces, n.d.) and Sweden's space surveillance capabilities from Kiruna (Swedish Space Corporation [SSC], n.d.), and integrate them fully into planning. NATO should also ensure Canada's full engagement; as one of the original Arctic powers, Canada's stance is pivotal. Ottawa has sometimes protected sovereignty, but the Ukraine war spurred Canada to invest billions in NORAD and Arctic defense (Government of Canada, 2019; Department of National Defence [DND], 2022). NATO must support and complement, not duplicate, these efforts. For instance, while NORAD covers air defense, NATO could assist with anti-submarine warfare in the Labrador Sea or with deployments to Greenland, if needed.

Furthermore, a proactive partnership with Indigenous Arctic communities (such as Alaska Native peoples, including Canada's Inuit, the Sámi in Northern Europe, and other groups across the Arctic) should be integral to NATO's posture. As the region's primary inhabitants and long-term stewards, these communities possess invaluable local knowledge and direct observational capacity, which are crucial for enhancing domain awareness and resilience. NATO and its member states should establish formal consultative mechanisms and support community-based initiatives – for example, integrating local observation networks (such as the Canadian Rangers or similar community programs) into broader domain awareness frameworks to help monitor environmental shifts and report unusual activities. Consistent with stated US national goals to consult, coordinate, and partner with Indigenous communities on infrastructure development and disaster response preparedness (The White House, 2022), such collaboration offers practical benefits for defense and security (e.g., local insights for SAR, infrastructure siting, early warning). This approach also projects a responsible, cooperative Arctic stewardship model based on mutual respect, contrasting with Beijing and Moscow's purely extractive and expansionist approaches.

Internationally, as the Arctic Council stalls, alternative avenues, including those involving Russia and China, are needed to maintain dialogue and establish norms. The US and its Allies could consider convening an "Arctic Security Dialogue" outside of NATO, perhaps as a Track 1.5 forum, to discuss risk reduction with Russia and transparency measures. This is challenging in the current geopolitical climate, but planning for post-conflict re-engagement is prudent (e.g., naval IncSea agreements in the Arctic or notifications of major exercises to avoid miscalculations). Engaging China is also essential; while NATO has no direct forum with China on Arctic issues, member states can utilize bilateral channels to address these concerns. If circumstances allow, China should be encouraged to re-engage in Arctic Council working groups to maintain its connection to cooperative behavior – something Beijing itself views as important (SCIO, 2018). The United States, through the State Department and its new Arctic Ambassador, should coordinate closely with Nordic allies to present a unified front to China: welcoming cooperation on climate and science while firmly rejecting any unlawful or destabilizing actions (illicit surveillance or dual-use facility buildups).

MAINTAIN A BALANCED APPROACH – SECURITY WITH STABILITY

Finally, while strengthening deterrence, the US and NATO must also avoid escalating the Arctic into a full-blown militarized standoff. Policy must be measured, and cooperation with China and Russia in areas of mutual concern should be prioritized. For example, any NATO Arctic Command could also have a mandate for confidence-building, such as conducting unclassified climate change monitoring or engaging in joint emergency response drills that could include Russia when relations improve.

The United States and NATO should continue to support scientific and environmental initiatives in the Arctic, demonstrating that security preparations do not preclude cooperation on shared challenges. For instance, NATO could contribute to ecological security by offering capabilities for oil spill cleanup or search and rescue that benefit all Arctic nations. This soft-power approach can help counter any Chinese narrative that NATO is "militarizing" the Arctic for hegemonic purposes. Instead, it should be framed as protecting the openness and rule of law in the Arctic, which benefits smaller states and the international community at large.

Collectively, these recommendations form a comprehensive response, strengthening military deterrence and preparedness, addressing vulnerabilities, and integrating efforts among allies and across multiple domains. By implementing them, the US and NATO would send an unambiguous message that, while they welcome peaceful cooperation in the Arctic, they will firmly oppose any attempt by Russia and China to dominate or destabilize the region.

CONCLUSION

The Arctic is entering a new era as a strategic theater in which the old patterns of cooperative governance and benign neglect can no longer be taken for granted. The growing cooperation between Russia and China in the region, though not without limits, heralds a significant shift in the balance of power and the challenge set facing NATO and the United States. Russia's military dominance in the High North and China's expanding economic presence have begun to overlap in ways that could undercut Western interests and freedom of action. This tandem, an authoritarian great-power condominium in the Arctic, poses a multifaceted threat that is strategic (impinging on alliance defense plans), military (through increased capabilities and operations), and economic (via control of resources and sea lanes).

Against this backdrop, NATO and the US can no longer treat the Arctic as a secondary priority. The analysis presented herein critically examines NATO's current Arctic strategy and finds it lacking in certain respects, primarily due to the absence of a formalized policy, dispersed command arrangements, and capability gaps that have developed over years of underinvestment. Encouragingly, steps are being taken, but more needs to be done to bring coherence and adequate resources to Arctic security before the Western regional position becomes completely untenable.

The recommendations provided serve as a roadmap for a robust and responsible Arctic strategy. Implementation will not be cost-free; it requires a strong political will, adequate funding, and sustained attention at the highest levels. However, the cost of inaction or underreaction could be far greater. If NATO and Washington neglect the Arctic, they risk it becoming a region dominated by adversarial powers, where the rules may be rewritten by force or coercion. Given the rapid changes underway, time is of the essence. Investments in polar capabilities take years to yield results (e.g., icebreaker construction or satellite launches), so decisions made in the next few years will shape the strategic balance in the Arctic for decades.

Ultimately, the goal of a reinvigorated NATO-US Arctic strategy is not to militarize the region for its own sake, but to preserve the Arctic as a stable, open, and governed domain. Strength through unity and preparedness will be the surest way to deter aggression and ensure that the Arctic remains a zone of peaceful cooperation for all Arctic states and peoples. A more assertive Western posture, backed by clearly demonstrated capabilities, will also pressure Russia and China to calibrate their behavior, ideally steering them toward cooperation rather than confrontation in the long run. As the Vilnius Summit Communiqué (2023) succinctly noted, "We call on the PRC to play a constructive role... [but] we will stand up for our shared values and the rules-based international order." Nowhere is this commitment more tested than in the Arctic, the new frontier of great power competition.

In conclusion, the future of the Arctic as a strategic space will be defined by choices made today. NATO and the United States can shape that future to reinforce peace, deter malign actors, and ensure that the Arctic does not become a vacuum exploited by those who would threaten the Alliance. By adopting a clear-eyed, proactive strategy, as argued in this paper, grounded in unity and credible deterrence, the West can rise to the challenge of growing Sino-Russian cooperation in the Arctic. Doing so will safeguard not only the interests of Arctic allies but also the broader principle that, even as the ice melts, no single bloc will dictate the Arctic's destiny—it will remain governed by law, not by force.

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Security-Centered Science Diplomacy:

A Proposed Framework for Future US-Russian Collaboration in the Arctic

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ABSTRACT

The Arctic's rising strategic importance and intensifying geopolitical competition require a fundamental reassessment of traditional science diplomacy frameworks. Historically, US Arctic science diplomacy emphasized environmental cooperation, exemplified by initiatives such as the International Geophysical Year (1957–1958) and the Arctic Environmental Protection Strategy (1991). While these efforts fostered collaboration, they were not designed to address today's operational, strategic, and informational threats—including contested territorial claims, expanding military activity, and critical infrastructure vulnerabilities.

The 2024 drone strike on Murmansk—the first act of armed conflict in the Arctic since World War II—marked a turning point, illustrating that the region is no longer insulated from global security dynamics. In this evolving environment, US strategy must adopt a security-centered science diplomacy framework that integrates scientific engagement with deterrence planning, domain awareness, and mission assurance.

This model requires support from institutions that operate across scientific and security domains. US entities are well positioned to lead by fostering international partnerships, advancing dual-use research, and supporting regional expertise. Precedents such as the Arctic Military Environmental Cooperation (AMEC) demonstrate that even under geopolitical strain, targeted technical collaboration can mitigate shared risks and support strategic stability.

While formal US-Russia cooperation remains largely prohibited as a result of Russia's 2022 invasion of Ukraine, Track II diplomacy provides a viable mechanism for sustaining communication, reinforcing shared technical norms, and reducing uncertainty in politically constrained contexts. Informal scientific engagement—particularly in public health preparedness, maritime safety, and environmental monitoring—can reinforce deterrence objectives while maintaining US freedom of action in the Arctic.

INTRODUCTION

The Arctic has become a focal point of strategic competition due to its vast resource potential, expanding operational relevance, and increased military interest among global powers. As access improves, Arctic states and external actors are seeking to secure national interests through control of emerging sea routes, critical mineral deposits, and energy reserves. These contested spaces have heightened the importance of legal frameworks, infrastructure readiness, and domain awareness. At the same time, gaps in coordination among Arctic states and inadequate multilateral frameworks for security and scientific cooperation complicate efforts to maintain regional stability and deter escalation.

For decades, the Arctic was regarded as a geopolitical buffer—an exceptional space seemingly insulated from great power rivalry and conflict. This notion of "Arctic exceptionalism" shaped regional diplomacy, emphasizing cooperation over confrontation (Lackenbauer & Dean, 2020). Yet this framing both underestimated the region's growing strategic value and overestimated the durability of cooperative norms (Chevalier, 2024). As geopolitical tensions have intensified, the foundations of Arctic exceptionalism have steadily eroded (Shvets & Hossain, 2022). Russia's invasion of Ukraine in February of 2022 marked the formal unraveling of that vision (Vasovic, 2022). When Ukraine responded to Russia by launching a drone strike on Murmansk in 2024—the first instance of armed conflict in the Arctic since World War II—this action definitively shattered the notion of Arctic exceptionalism, demonstrating that the region is no longer insulated from instability and conflict occurring in other regions (Staalesen, 2024; Umland, 2024).

The breakdown of Arctic exceptionalism has exposed critical gaps in the existing diplomatic toolset, particularly in managing operational risk and maintaining regional coordination. Effective situational awareness and strategic communication rely on scientific and technical data—much of which remains inaccessible without Russian participation. At the same time, continued engagement with Russia poses legal, policy, and political dilemmas. The central question now facing US and allied Arctic policy is whether, and how, scientific collaboration can be deliberately leveraged to support strategic objectives. This paper contends that integrating scientific engagement into a security-centered diplomatic framework is essential to strengthening deterrence and regional stability.

US SCIENCE DIPLOMACY OF THE PAST

The United States has long employed science diplomacy as a tool to advance stability and mitigate risk in the Arctic. Early efforts recognized that shared scientific interests—particularly in the physical and environmental domains relevant to navigation, communications, and infrastructure—could help reduce tensions between geopolitical rivals. A foundational example is the International Geophysical Year (IGY) of 1957–1958, during which the US and the Soviet Union conducted joint Arctic research despite Cold War hostilities (Goodsite et al., 2016). These efforts demonstrated that technical cooperation on polar conditions could serve broader strategic purposes, including trust-building and the promotion of stability in contested regions.

Following the IGY, US Arctic science diplomacy evolved through a series of bilateral and multilateral initiatives aimed at improving operational understanding of Arctic systems. Agreements with key Arctic partners such as Canada and Norway, as well as continued technical exchanges with the Soviet Union, enabled collaboration on oceanography, ice dynamics, and geophysical processes relevant to both civil and defense applications—including early-warning systems, environmental monitoring, and submarine navigation (e.g., AMEC, the North Warning System, and Barents Sea acoustic studies (Woods Hole Oceanographic Institution, 1991)). The US also contributed to global atmospheric research efforts, such as the Global Atmospheric Research Program (GARP), to enhance its predictive capabilities in the Arctic—critical for operational planning and early warning systems (Goodsite et al., 2016).

A major step toward institutionalizing cooperation came with the 1984 Arctic Research and Policy Act (ARPA), which established the US Arctic Research Commission (USARC) and provided a framework for coordinating national research priorities. While primarily focused on scientific advancement, ARPA also emphasized national security considerations and resource management, highlighting the Arctic's strategic value (Eigner, 2023). This dual-purpose orientation shaped US participation in the 1991 Arctic Environmental Protection Strategy (AEPS), a platform that enabled information sharing among Arctic states on cross-border risks. Although its core mission emphasized environmental concerns, the AEPS also functioned as a mechanism for confidence-building during a period of renewed interest in the High North (Goodsite et al., 2016; US Department of State, n.d.).

These cooperative mechanisms laid the foundation for the Arctic Council, established in 1996, which continues to serve as a key forum for scientific and technical collaboration. However, its deliberate exclusion of military and security issues has created a gap in regional governance—highlighting the demand for complementary mechanisms that operate at the intersection of scientific collaboration and strategic coordination (Chevalier, 2024; Shvets & Hossain, 2022). As geopolitical tensions intensify, it has become increasingly clear that traditional science diplomacy—focused primarily on environmental or academic goals— must evolve to address emerging defense and deterrence needs. Doing so will require mechanisms that link technical collaboration to strategic coordination without undermining the region's stability.

EMERGING CHALLENGES

The Arctic is increasingly defined by shifting geopolitical dynamics and intensifying competition for strategic advantage. Access to newly viable shipping routes, expansive energy reserves, and critical mineral deposits has elevated the region's value for Arctic and non-Arctic states alike (Keil, 2014; VanderZwaag, Vorobev, & Koubrak, 2022). These actors are pursuing long-term influence over transit corridors, seabed claims, and resource control—placing strain on cooperative frameworks that were not designed to manage security dilemmas (Marsili, 2022). The involvement of non-Arctic states, including China, further complicates the regional order and raises questions about future norms, freedom of navigation, and the durability of existing governance institutions (Diaconu, 2019).

The Arctic Council, while instrumental in advancing scientific and civil coordination, is not structured to address issues tied to sovereignty, deterrence, or force posture. As a result, its ability to manage disputes or mitigate escalation is limited (Shvets & Hossain, 2022). For example, the 2018 Agreement to Prevent Unregulated High Seas Fisheries in the Central Arctic Ocean exemplified successful coordination among Arctic and non-Arctic stakeholders, yet such agreements remain confined to resource conservation and monitoring (Fisheries and Oceans Canada, 2021). Meanwhile, overlapping territorial claims—including Russia's assertions over the Lomonosov Ridge and the US extended continental shelf (ECS) submission in 2023—illustrate how legal processes under the United Nations Convention on the Law of the Sea (UNCLOS) are struggling to resolve complex jurisdictional disputes (Chevalier, 2024).

These pressures are compounded by growing militarization. Russia has increased the size and capability of its Arctic-based forces, expanded its dual-use infrastructure, and intensified exercises near key chokepoints and contested areas (Marsili, 2022). In response, other Arctic nations, including the United States, have revised their Arctic strategies and begun enhancing their defense postures to counterbalance adversarial positioning. NATO's presence in the region is also expanding, altering the strategic calculus for both Arctic and non-Arctic actors (Diaconu, 2019). The convergence of civilian and military activity elevates the risk of miscalculation and accidental escalation in a region previously characterized by low tension (Eigner, 2023).

The deployment of nuclear-powered assets further complicates the security environment. Russia's use of floating nuclear power stations and nuclear-powered icebreakers represents not only a technological investment but also a strategic signal. The presence of nuclear reactors in remote and logistically challenging environments increases the risk of accidents, contamination, or dual-use ambiguity. Without dedicated agreements to regulate the deployment and oversight of such systems, tensions over safety, access, and sovereign claims are likely to intensify (Goodsite et al., 2016).

Together, these developments illustrate the insufficiency of traditional diplomatic mechanisms in addressing the region's evolving threat landscape. While scientific diplomacy remains a valuable tool, it must be linked to broader strategic objectives, including mission assurance, operational coordination, and deterrence. Without an integrated approach that merges scientific insight with security planning, the Arctic will remain vulnerable to unmanaged escalation and strategic surprise.

TOWARD SECURITY-CENTERED SCIENCE DIPLOMACY IN THE ARCTIC

While traditional Arctic science diplomacy has emphasized collaborative research and environmental monitoring, evolving geopolitical dynamics demand a shift toward security-centered science diplomacy—a framework that explicitly integrates scientific engagement with defense planning and strategic risk management (Eigner, 2023; Goodsite et al., 2016). Existing institutions such as the Arctic Council have played a valuable role in relationship-building and advancing regional technical knowledge, but they deliberately avoid security-related issues. This exclusion has created a strategic gap at a time when the Arctic's geopolitical salience is rising (Chevalier, 2024; Shvets & Hossain, 2022).

Scientific cooperation remains an essential tool for managing shared risk, particularly where technical data and operational coordination converge. Areas such as mission assurance, early warning systems, and environmental monitoring offer meaningful opportunities for collaboration that directly support security objectives. Yet scientific engagement alone is insufficient to address the full scope of emerging strategic challenges. Bilateral and multilateral initiatives must also confront operational concerns—ranging from maritime safety and emergency preparedness to vulnerabilities in dual-use infrastructure. By framing scientific collaboration as a component of strategic risk reduction, states can enhance regional stability without requiring full political alignment. To be effective in today's contested environment, science diplomacy must be explicitly integrated with defense planning and deterrence strategies—reducing uncertainty, improving crisis response, and sustaining communication channels among states with diverging interests (Diaconu, 2019).

While Track II diplomacy offers a useful avenue for informal scientific engagement under political constraints, security-centered science diplomacy encompasses a broader spectrum of cooperation—ranging from ad hoc exchanges to formalized technical agreements and defense-informed research initiatives. This framework recognizes that durable strategic coordination requires both informal communication and structured institutional support.

A compelling precedent within this broader framework is the Arctic Military Environmental Cooperation (AMEC) initiative, launched in 1996 by the United States, Norway, and Russia. AMEC focused on managing radioactive waste from decommissioned Russian submarines, but its broader significance lies in its success at fostering trust and operational coordination on issues with both environmental and strategic consequences. The initiative established pathways for data sharing, hazard mitigation, and technical standard-setting—outcomes directly relevant to defense planners and civilian authorities alike (Goodsite et al., 2016).

AMEC's success demonstrates that narrowly scoped, security-informed technical collaboration is possible even during periods of strained political relations. Its model—grounded in shared operational interests—offers a useful template for future mechanisms aimed at managing the Arctic's increasingly contested spaces. In a region where escalation risks are growing and strategic misperception is a constant danger, mechanisms that bridge scientific capability and security imperatives will be essential to preserving regional stability (Eigner, 2023).

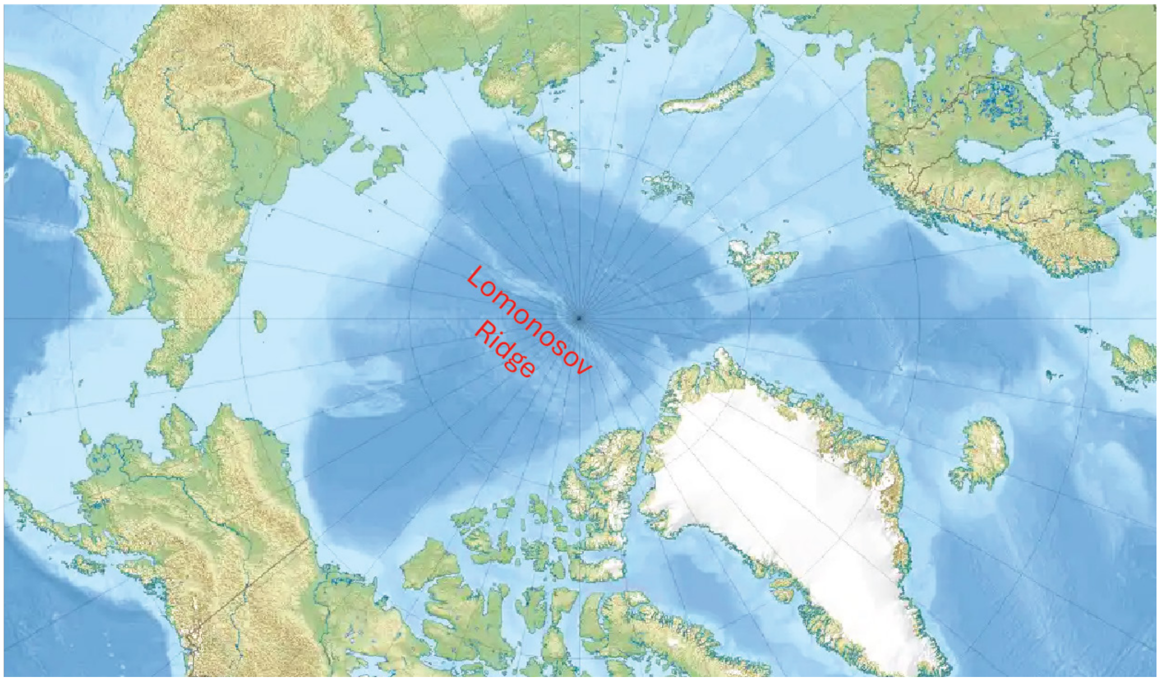

Figure 1: The Lemonsonov Ridge

TRACK II PATHWAYS AND US-RUSSIAN COLLABORATION OPPORTUNITIES

The suspension of bilateral channels, including the US-Russia Presidential Commission's working groups after 2014 and the Arctic Council's pause in working group activities following Russia's invasion of Ukraine, underscores the fragility of science diplomacy in the face of international mistrust and rising strategic competition (Shvets & Hossain, 2022). These breakdowns have created intelligence and monitoring gaps in areas critical to US and allied mission planning, including maritime traffic, undersea activity, and infrastructure safety across vast sections of the Russian Arctic. For operational forces tasked with maintaining presence and readiness in these environments, such information gaps directly affect situational awareness and decision-making under pressure—placing greater emphasis on adaptability and tactical judgment at the operator level.

While formal diplomatic engagement remains constrained, Track II diplomacy presents a pragmatic alternative for maintaining essential communication and reducing operational uncertainty (Eigner, 2023). Informal scientific exchanges can sustain contact on issues such as nuclear safety, maritime navigation standards, and basic public health infrastructure—particularly in sparsely monitored or politically sensitive areas. Though such exchanges may not restore strategic trust, they can reduce misperception, promote technical consistency, and serve as informal early-warning channels during periods of elevated risk. For both uniformed and civilian personnel, the continuation of technical dialogue reinforces a culture of vigilance and competence under ambiguous conditions.

In this context, emerging biosecurity risks associated with increased Arctic shipping present additional opportunities for narrowly-scoped cooperation. The introduction of marine pathogens via ballast water or contaminated hulls—particularly in the Bering and Chukchi Seas—could severely disrupt shared fisheries, undermine food security, and destabilize key export markets. As Arctic shipping volumes grow, especially along the Northern Sea Route, the likelihood of pathogen transmission—accidental or otherwise—rises accordingly. Recent research highlights the growing risk of pathogen introduction through vessel traffic (Bell et al., 2019) and points to additional dangers stemming from the release of ancient microbes through thawing permafrost (Revill, 2024). Scientific coordination in this space would directly support mission assurance and reinforce maritime safety norms in contested transit corridors—offering risk reduction without requiring political alignment.

Joint public health preparedness exercises, for example, could further strengthen Arctic mission assurance by improving coordination across dual-use infrastructure systems and enhancing civilian defense planning. These efforts not only bolster logistical readiness but also reinforce a warrior ethos grounded in adaptability, vigilance, and the protection of vulnerable populations in contested operational environments. In a region defined by harsh conditions and limited infrastructure, planning and responding together makes everyone more effective- it improves short-term operations, ensures we are ready for emergencies, and strengthens our ability to prevent conflicts in the long run.

In the current security environment, science diplomacy must be viewed not as a substitute for defense planning but as a complementary tool for regional stability and risk mitigation. Informal scientific engagement offers one of the few viable pathways for reducing uncertainty and maintaining strategic awareness—even in the absence of formal diplomatic consensus.

CHALLENGES OF SECURITY-CENTERED DIPLOMACY

Implementing a security-centered approach to Arctic science diplomacy presents structural and geopolitical challenges. Russia's ongoing war in Ukraine has severely strained its bilateral and multilateral relationships, including longstanding scientific partnerships with the United States and allied Arctic nations. These disruptions serve as a reminder that scientific collaboration, while valuable, remains vulnerable to broader strategic breakdowns (Vasovic, 2022; Umland, 2024; Shvets & Hossain, 2022). The Cold War-era International Geophysical Year (IGY) of 1957–1958 demonstrated that limited cooperation can persist under high tension, but such efforts depend on shared interests and narrowly scoped objectives—conditions increasingly difficult to sustain in the current geopolitical climate.

Track II diplomacy offers one possible avenue for preserving essential communication despite geopolitical volatility. Historical models such as the Pugwash Conferences —informal meetings between scientists and policymakers during the Cold War—highlight the potential for informal, expert-driven engagement to reduce strategic misperception and keep technical channels open (Eigner, 2023; Rotblat, 1999). However, while these engagements can mitigate operational risk, they are inherently limited in scope and authority. This underscores the need for institutional mechanisms that formalize technical collaboration in support of strategic objectives.

A second challenge lies in coordinating the diverse objectives of Arctic stakeholders. The eight Arctic states, numerous non-Arctic actors with regional ambitions, Indigenous communities, and international organizations each bring distinct priorities—ranging from resource access and defense readiness to legal sovereignty and civil infrastructure development. Multilateral cooperation is further complicated by asymmetries in military posture, intelligence capabilities, and strategic intent (Marsili, 2022; Diaconu, 2019). While models such as the Antarctic Treaty System offer useful lessons in governance, the Arctic's higher density of national interests, proximity to critical infrastructure, and growing military activity make replication of that model inconceivable.

Perhaps the most pressing challenge is ensuring that defense imperatives are integrated into Arctic cooperation without compromising stability. As strategic access expands, so too does the risk of miscalculation. The increasing tempo of military exercises, forward basing, and surveillance activity raises the possibility of escalation in a domain where cold weather, limited communications, and vast distances already strain operational coherence (Keil, 2014). Ensuring clear rules of behavior and maintaining dialogue through both formal and informal channels are essential to preserving freedom of maneuver while avoiding unintended conflict.

Security-centered diplomacy will require persistent coordination, professional restraint, and a clear articulation of shared interests among competitors. It will also demand institutions and mechanisms capable of balancing deterrence with the discipline and predictability necessary to reduce risk in a strategically vital region.

CONCLUSION

The Arctic is rapidly emerging as a contested and strategically significant operating environment. Long-standing assumptions about the region's insulation from global conflict no longer hold. As geopolitical tensions deepen and military activity expands, the tools of traditional science diplomacy—built around cooperation and environmental coordination—are no longer sufficient to protect US interests or ensure regional stability.

The United States has historically used scientific collaboration to manage shared risk and improve coordination in the Arctic. Frameworks such as the Arctic Research and Policy Act and participation in multilateral initiatives have helped build relationships and reduce uncertainty. However, these mechanisms were not designed for today's competitive security environment, where dual-use infrastructure, contested legal claims, and persistent presence now define the strategic landscape.

Moving forward, US Arctic strategy must integrate science diplomacy into a broader framework of deterrence and defense cooperation. This includes leveraging scientific exchanges to support mission assurance, increase domain awareness, and reinforce communication channels during periods of geopolitical strain. Informal mechanisms, such as Track II diplomacy and technical collaboration on public health, logistics, or maritime safety, can contribute meaningfully to operational preparedness.

Security-centered science diplomacy will not eliminate competition in the Arctic, but it can shape the terms of engagement, reduce the risk of miscalculation, and support US strategic objectives. Rather than treating science diplomacy as a neutral or apolitical endeavor, it should be employed as a deliberate tool to reinforce deterrence, mission assurance, and domain awareness. As the region grows more complex and unpredictable, diplomatic tools that bridge technical expertise and defense planning will be essential to deterring strategic miscalculation, preserving US freedom of action, and ensuring stability in the increasingly contested High North.

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Understanding The Arctic Research and Policy Act and its Implications for US Security and Defense in the Arctic

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INTRODUCTION

While the US status as an Arctic nation commenced in 1867 with the agreement with Imperial Russia to transfer Russian America to the US, US attention and active engagement with the Arctic remained limited and largely punctuated by security crises, the economic aspirations of the gold rush, and development of a burgeoning fishing industry. World War II and the Japanese occupation of Alaskan territory followed by Soviet Cold War threats to and through the Arctic required a major influx of military personnel, massive infrastructure development, wide ranging operations, and detailed contingency training. It was also necessary to develop close and continuing defense cooperation in the North American Arctic which led Canada and the US to form the North American Air Defense Command (NORAD) in 1957[1]. Additionally, NATO, formed in 1949, did include Arctic security but largely left the implementation of security plans to NATO's Arctic members. So, US cooperation in the Arctic remained largely binational and focused primarily on defense requirements. The US did propose an international Arctic treaty to promote transportation and communication during World War II and in the late 1960s promoted cooperation in science, economic development, environmental protection and health through a "Northlands Compact." At the time, these proposals found no traction amongst the other Arctic nations and the US continued to lack a national level policy on the Arctic (Leighton, 1994).

Nonetheless, by the early 1970s, a number of factors drove US President Richard Nixon to issue National Security Decision Memorandum (NSDM)144 addressing the lack of a coherent and comprehensive US Arctic Policy. This memorandum elucidated a national policy that protected vital security interests while supporting sound and rational development of the Arctic while minimizing adverse environmental effects as well as promoting mutually beneficial international cooperation. However, despite these clear and formidable statements, the mechanisms to coordinate and fund research to support these policies were not fully constructed at the time (A United States Commitment to Arctic Research, 1982).

1 Later update to the North American Aerospace Defense Command

In the ensuring years, multiple factors proved conducive in passing a law addressing Arctic research deficiencies. The Arctic Research and Policy Act of 1984 mandated the mechanisms that could actively address critical Arctic research requirements. This included the very definition of the US Arctic[2], US defense and security requirements, the health and welfare of Arctic communities and implications for the greater US population, the balance of environmental preservation and economic development, infrastructure development and international cooperation in Arctic research.

Driven by economic, socio/cultural, environmental, security and international factors, the enactment of the Arctic Research and Policy Act of 1984 ushered in a far more coherent and comprehensive US approach to the Arctic. Through the two new bodies it created, the US Arctic Research Commission and the Interagency Arctic Research Policy Committee (IARPC), ARPA has promoted public engagement, prioritized research, fostered international partnership, contributed to vital infrastructure development, and supported homeland security and defense requirements.

ECONOMIC DRIVERS

From President Nixon's 1971 memorandum to enactment of ARPA in 1984, several factors converged to create the momentum necessary to propel the new law across the finish line. The 1968 discovery of oil at Prudhoe Bay, Alaska, bolstered Alaska's potential economic significance but remained contingent on developing suitable transport and distribution capabilities. The proposed pipeline to Valdez floundered under environmental controversy and Alaska Native claims on the requisite lands. The negotiation and passage of the Alaska Native Claims Settlement Act (ANCSA) in 1971, the largest such act in US history, had myriad consequences, one of which was the formation of Native-owned corporations which have been, and continue to be, hugely impactful. ANCSA did hasten acculturation and change but also empowered many Native people and several of these corporations are among largest and most prosperous in the US (Haycox, 2020). With the Settlement Act in place, and the 1973 OPEC oil embargo imposing fuel shortages across the US, the pipeline received presidential authorization. (Nilsson, 2018). Oil development in Alaska helped broaden momentum for a national Arctic policy to encompass defense as well as economic and energy security interests.

SOCIO/CULTURAL DRIVERS

For the Inuit on whose lands the oil development was taking place, this conferred deep environmental and traditional livelihood implications. By 1977, the inaugural meeting of the Inuit Circumpolar Conference (ICC),[3] not only showcased the growing political power of the Inuit at a national level but provided a strong international presence in circumpolar Arctic policy (Nilsson, 2018). The ICC benefitted from the path already trod by the Alaska Federation of Natives whose formation in 1967 had demonstrated the political power that such a voice and platform could wield (Claus and Slotnick, 2011). Thus, the ICC became a robust advocate of land rights, maintaining traditional lifestyles, sustainable development and environmental stewardship. In the early 1980s, when concrete discussions commenced on developing a US Arctic research policy, both the ICC and Inuit leaders supported its implementation but only with the assurance of Inuit participation.

During the June 1983 House Subcommittee on Science, Research and Technology hearings on the proposed Arctic Research and Policy Act, Mayor Eugene Brower of Alaska's North Slope Borough

2 Section 112 of the Arctic Research and Policy Act (ARPA) of 1984 defines the Arctic as follows: "As used in this title, the term "Arctic" means all United States and foreign territory north of the Arctic Circle and all United States territory north and west of the boundary formed by the Porcupine, Yukon, and Kuskokwim Rivers [in Alaska]; all contiguous seas, including the Arctic Ocean and the Beaufort, Bering, and Chukchi Seas; and the Aleutian chain."

3 The ICC was later renamed the Inuit Circumpolar Council.

along with ICC president Hans-Pavia Rosing emphasized that Inuit participation was essential due to unique and indispensable knowledge. They wanted to ensure the Inuit should not be disenfranchised from decisions impacting the long-term future of their homeland (Inuit Request Role in Arctic Research, 1983, Rasmussen, 1983). Rosing pointed out, "For a nation to stumble into its arctic regions, into areas fragile in their environment—without appropriate technology derived through adequate research—will endanger the subsistence lifestyle and the culture of the Native inhabitants of the Arctic, who will be there long after the oil rigs are removed and the mine shafts closed" (Inuit Request Role in Arctic Research, 1983, p. 4). At the July 1983 Third General Assembly, the ICC adopted a resolution calling on the US Congress to guarantee Alaskan Inuit participation in any US Arctic research policy enactments (Principles and Elements for a Comprehensive Arctic Policy, 1989, The ICC Resolutions – in brief, 1983). ICC delegates stressed that while southerners often viewed the Arctic as a frontier and focused on availing themselves of its resources, to the Inuit, the Arctic is a homeland. Protecting their subsistence culture was of paramount importance and the ICC wanted to ensure any national Arctic policy addressed this concern (Rasmussen, 1983).

Mayor Brower, while advocating for the nascent Arctic Research and Policy Act, addressed the Alaska Science Conference in December 1983. He pointed out that to maximize energy resources while minimizing adverse industrial impacts, a comprehensive national policy would be required. This policy, he explained, needed to include all fields of science with a holistic approach towards all components of the Arctic ecosystem as well as long term environmental, cultural and health effects (Directions of Northern Science, 1983). Brower further highlighted concerns over issues such as oil spills, Arctic tanker movement, and impact on marine animals which could lead to "irreparable harm...to our land, our water, and our subsistence resources" (Reagan signs Arctic Science Bill into Law, 1984, p. 3).

ENVIRONMENAL DRIVERS

While concern for the environment was an essential component of ICC advocacy, sustainable development, along with continued Native access to engage in subsistence activities and maintain traditional culture, were equally significant. This sometimes clashed with the wider environmental movement in the 1970s. During this period, environmental concerns found a far wider audience and advocacy. Although the passage of ANCSA benefitted from both the Civil Rights Movement and rising environmentalism and had united myriad interests to ensure its passage, the idea of Alaska as a pristine wilderness as advocated by many environmentalists did not resonate with many who called the Arctic their home (Haycox, Alaska: An American Colony, 2020).

Across America, increasing environmental awareness and activism drove a series of actions to preserve and protect the US's land, air and water. The Wilderness Act of 1964 defined wilderness and set aside 50 million acres. This was later expanded to 109.5 million, half of which is in Alaska. In 1969, the National Environmental Policy Act (NEPA) established guidelines for federal agencies to ensure environmental sensitivity in conducting their business. It also formalized a Council on Environmental Quality to advise the president. President Nixon established the Environmental Protection Agency in Dec 1970 and conferred on it the authority to monitor environmental impact to the landscape, built environment, and watercourses (Haycox, Arctic Policy of the United States: An Historical Survey, 2020). Other acts included the National Marine Mammal Protection Act (1972), the Coastal Zone Management Act (1972), the Endangered Species Act (1973), the Fishery Conservation and Management Act (1976), the National Forest Management Act (1976) and the Ocean Pollution Planning Act (1978). Thus, environmentalists and the environmental movement helped to shift the view of many from Alaska as the last frontier to the last wilderness and Alaska became an environmental battlefield (Haycox, Alaska: An American Colony, 2020).

The impetus of increased environmental awareness and successful legislation prompted President's Carter's efforts to set aside environmentally sensitive lands in Alaska. These efforts had to be balanced with development and subsistence interests and the compromise became the Alaska

National Interest Lands Conservation Act (ANILCA), enacted in 1980. The battle over withdrawal of lands, which Carter initially sought through use of the 1906 Antiquities Act, raged for many years until President Reagan's 1980 election helped drive the compromise that led to Congress passing ANILCA. This was the most comprehensive land and environmental act in US history and set aside 104 million Alaskan acres as national parks, fish and wildlife refuges and forests. The amount of US land in parks and refuges doubled with the passage of this act. (Haycox, Alaska: An American Colony, 2020). President Carter called it his most "important act and legacy as president." (Haycox, Alaska: An American Colony, 2020, p. 6043). Most importantly for the future Arctic Research and Policy Act of 1984, ANILCA mandated a coordinated Arctic research program (Inuit Request Role in Arctic Research, 1983).

INTERNATIONAL AND SECURITY DRIVERS

Due to the circumpolar nature of the Arctic, a coordinated Arctic research program could only succeed with international cooperation as an integral component. Both Mayor Brower and ICC President Rosing had long highlighted the importance of international cooperation in the Arctic. They stressed that the Arctic's fragile environment along with the circumpolar connections of the Inuit people necessitated a national policy that integrated international cooperation. They bemoaned the great disparity between Antarctic and Arctic funding, particularly considering the huge human impact of actions in the Arctic and urged that it be remedied (Inuit Request Role in Arctic Research, 1983). Furthermore, Mr. Rosing stressed the need for circumpolar international cooperation, pointing out that oil spills and air pollution do not respect national boundaries (Rasmussen, 1983).

Given both Inuit concerns and the broader geopolitical context, a lack of US Arctic leadership and substantive Arctic policy appeared an increasingly perilous omission in the international arena. Lincoln Bloomfield's 1981 Foreign Affairs article entitled "The Arctic: Last Unmanaged Frontier," explored this problem. Arctic oil and gas extraction begun in the 1970s and the promise of further oil and gas finds had increased the economic value of the Arctic to the US. Rising tensions with the USSR and a bumpy patch in relations with Canada increased anxiety about security and lack of coherent policy in the Arctic. Bloomfield took Arctic nations' governments to task for their lack of action in establishing a consistent Arctic forum and negotiating Arctic treaties to address transnational issues in the Arctic space. The single exception signed by Arctic states was the Polar Bear Treaty of 1973. In fact, Bloomfield pointed out that transarctic diplomacy was "pioneered not by the six governments of the adjacent states, but by a nongovernmental "transnational" association, the Circumpolar Conference of Alaskan, Canadian and Greenlander Inuit (ICC). With his experience as a political scientist at MIT and service on the National Security council from 1979-80, Bloomfield felt that other Arctic nations such as the USSR and Norway firmly grasped the strategic military significance of the Arctic while Americans did not. He quoted the Norwegian State Secretary for Foreign Affairs, Johan Jorgen Holst who stated, "The Northern region constitutes a flank area from the point of view of defending Central Europe. At the same time the area occupies a central balance of deterrence." Economic activity, which Bloomfield expanded beyond oil and gas to shipping and mining combined with increased security needs, drove a concomitant need for transnational scientific and environmental collaboration.

ARPA TAKES SHAPE

In the early 1980s, harnessing the synergy of converging economic, socio/cultural, environmental, international and security factors, Senator Frank Murkowski constructed a successful campaign for an Arctic Research policy. He built on longstanding efforts to produce one begun by Senator Bob Bartlett in the 1960s (Reagan signs Arctic Science Bill into Law, 1984) A 1981 Alaska Division of the Association for the Advancement of Science report also bolstered his efforts. The report called for a US Arctic science policy and emphasized the US's diminished position among the other Arctic nations. The report noted this was due to piecemeal attention and uncoordinated Arctic research and meant the US lacked ability to engage effectively in the Arctic. The report pointed out that future energy development and US claims to resources on the extended continental shelf depended on international engagement. All of this stood in stark contrast to Soviet capacity in the Arctic. Thus, US security in the economic and defense realms depended on developing an effective and coordinated Arctic policy to include provisions for international collaboration. With Murkowski's support, the findings in this report would be translated into legislative action (Nilsson, 2018). Senator Murkowski submitted his first Arctic Research and Policy Act bill in 1981.

Senator Murkowski garnered the support of Inuit leaders such as Mayor Brower by including firm environmental protection and incorporating Inuit participation. However, convincing Congress required integration of security and foreign policy concerns. World War II and Cold War military threats had generated support for military technological and infrastructure development in the Arctic but no comprehensive statement to guide US research and policy there (Nilsson, 2018). In arguing for increased focus and spending for Arctic research and policy priorities, Sen Murkowski pointed out the strategic position, significance for defense of the US and valuable energy resources. Of all circumpolar countries, only the US lacked a national institute, laboratory or other central organization dedicated to sustained planning and support of Arctic research. He chided the US government for the "disgraceful" lack of an ice worthy vessel for research that necessitated using Soviet research vessels for US federally funded research. Incorporating economic concerns into his exhortation for action, he pointed out that sufficient research should precede industrial development. He explained that lack of prior research led to considerable overspending on the Trans-Alaska oil pipeline construction. In addition, he advocated for better research to play a role in preserving northern societies and the important role of those in the North in supporting and participating in research (Inuit Request Role in Arctic Research, 1983).

Alaska's congressional delegation was not alone among government entities concerned about the lack of an Arctic policy. ANILCA's Section 1007 had directed the Secretaries of the Interior, Defense and Energy to review and make recommendations on the need for redirecting US Arctic research policy. Thus, the US Departments of Defense, Interior and Energy requested a report from the Polar Research Board of the National Research Council analyzing the state of US Arctic research. The 1982 report determined that "a policy guided comprehensive Arctic research plan" (p.2) was required. The report highlighted deficiencies in planning, implementing and funding Arctic research due to the bifurcation between federal agencies, the State of Alaska and private groups. The report recommended that US government science policy should establish a commitment to support scientific research in the Arctic to fulfill government responsibility for national economic, technical, social, and resource development, environmental protection, cultural well-being, defense and national security, and international cooperation in the Arctic. This report concluded that President Nixon's NSDM 144 intentions had been left unfulfilled and supported Alaska Senator Frank Murkowski's efforts to pass the Arctic Research and Policy Act (A United States Commitment to Arctic Research, 1982).

ARPA ENACTED

All of these components--economic, socio-cultural, environmental, international cooperation and defense and security--effectively integrated into Senator Murkowski's proposed bill on Arctic Research and Policy, propelled the legislation to fruition in the US Congress by 1983. Securing the support of President Reagan who disliked legislation establishing regional policies, took additional time. However, he recognized the value for strengthening the US position in the Arctic and signed the Arctic Research and Policy Act (ARPA) into law on 31 July 1984. ARPA now defined the Arctic in a clear and broader context.

This extended the reach of ARPA's ability to deploy funds and strategic facilities in a wider area. It required the establishment of the US Arctic Research Commission (USARC) to promote Arctic research and recommend policy and an Interagency Arctic Research Policy Committee (IARPC) to develop the research policy, assist interagency coordination, and review and comment on federal research programs in the Arctic. Part of IARPC's remit was to develop a five-year plan to implement

Arctic research policy. Furthermore, ARPA designated the National Science Foundation (NSF) as the lead agency responsible for implementing the Arctic research policy. Importantly, ARPA set up mechanisms to coordinate Arctic research among federal and state agencies and private industry. ARPA established national policy, priorities and goals and a federal plan for basic and applied research on the Arctic to include natural resources and materials, physical, biological and health sciences and social and behavioral sciences (Reagan signs Arctic Science Bill into Law, 1984).

In 1990, Congress amended the Arctic Research and Policy Act of 1984. This increased the number of Arctic Research Commissioners appointed by the President of the United States from five to seven voting members. The composition of the Commission now included four members from academic or research institutions; two members from private industry undertaking resource development in the Arctic; and one member from among the Indigenous residents of the US Arctic. The Director of the National Science Foundation remained as an ex officio member. Due to the geopolitical changes between 1984 and 1991, the amendment also removed references to the Soviet Union. Additionally, it updated reporting requirements to a biennial statement of goals and objectives with respect to Arctic research to guide the IARPC. Finally, it changed the nature of suggestions to recommendations (United States Senate, Committee on Governmental Affairs, 98th Congress, 1st Session. Report No. 98-159, 1983; To Amend the Arctic Research and Policy Act of 1984 to Improve and Clarify its Provision: Report of the Committee on Governmental Affairs, United States Senate, 1990). IARPC has grown over the years to now include 18 agencies, departments and offices, with the director of the NSF serving as chair (Weingartner & Orttung, 2019).

Once APRA was signed into law, the appointed members of the commission began their work and produced their first annual Report to the President and Congress in October 1985. An important aspect of their work was educating senior political leaders on the value of Arctic research. The titles of the first four annual Reports to the President and Congress sound like a primer to educate policy makers on the fact of and implications for US Arctic connections. Reflecting the lack of Arctic awareness amongst senior US government officials, the US Arctic Research Commission selected the following titles: U.S. on the Arctic Rim, The United States: An Arctic Nation, Entering the Age of the Arctic: Opportunities and Obligations of an Arctic Nation, and Arctic Research for an Arctic Nation. These titles alert the reader to the geographic reality of the U.S's Arctic status, the implications of this status and the critical role of Arctic research.

Reports outlined priorities, described the development of functions and structures and listed key work of the commission. The very first report, U.S. on the Arctic Rim set the stage in the Fall of 1985 by justifying ARPA and the creation of the Arctic Research Commission. The report stated, "It is in the national interest of the United States to support scientific and engineering research in all pertinent fields to implement its national policy" (U.S. on the Arctic Rim, 1986, p 1). Later reports noted that, "There is but limited recognition as yet to the crucial role of the Arctic in national security and economic well-being," (The United States: An Arctic Nation, 1987, p 26) and increased knowledge was essential for sage decisionmaking on the US Arctic future. The 1987 report emphasized that the US must position itself "to take its rightful place as a leader among the Arctic nations of the world." (Entering the Age of the Arctic, 1988, np). The work of the Commission began with both political and public awareness of the US status as an Arctic nation and then expanded into developing a deeper understanding of the roles and responsibilities that Arctic nationhood should entail and promoting US leadership among Arctic nations.

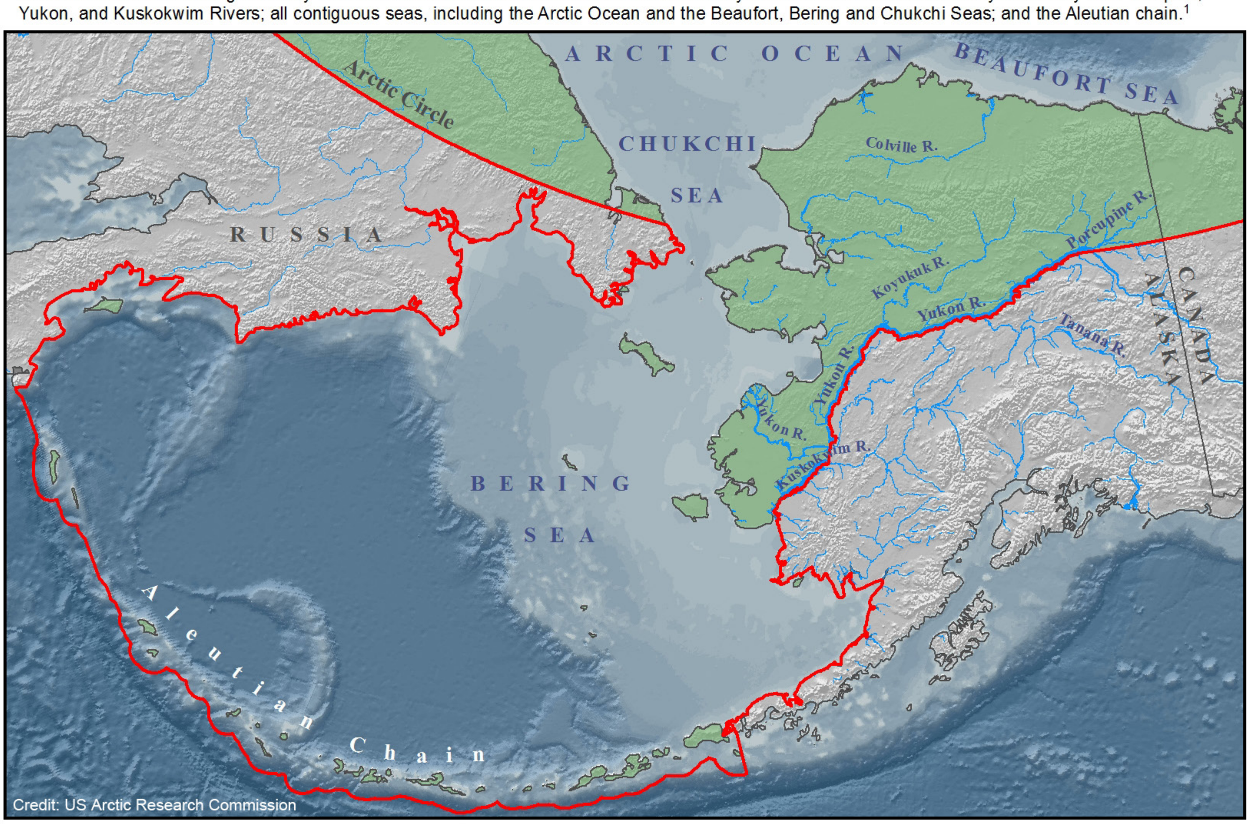
The Commission increased interaction with a wide variety of stakeholders in Alaska to include the governor, legislators, Native leaders, industry, the USCG and military stationed in Alaska and thus in 1987 opened an office in Anchorage. To support the work of the commission, it set up a group of 24 scientific and engineering advisors, The commission's work included three to four public meetings a year with at least two of them in Alaska. These focused on hearing local concerns, educating the public about the Commission's work and publicizing the work of the Commission through interaction with the press and interviewers. Additionally, members of the Commission visited various locations in Alaska to better understand current work both in the scientific and commercial/industrial fields. In addition to its yearly reports, the Commission also published ad hoc reports and by 1990 had reported on issues such as the role of sea ice in Arctic ecosystems, a survey of Arctic engineering research, a report on Arctic logistics and access and a report on international agreements for research.

To promote mutually beneficial international cooperation, the Commission participated in a 1988 meeting in Stockholm which secured an agreement to establish an International Arctic Science Committee. Focused on science matters concerning Arctic seas, atmosphere, space and people, the International Arctic Science Committee (IASC) convened its first conference in Leningrad in December 1988. Five hundred scientists from 15 countries attended (Entering the Age of the Arctic: Opportunities and Obligations of an Arctic Nation, 1988, Arctic Research for an Arctic Nation, 1989). The USSR's General Secretary, Mikhail Gorbachev, had paved the way for this meeting with his 1987 Murmansk speech in which he stated, "The scientific study of the Arctic is of immense importance for the whole of mankind. We have a wealth of experience here and are prepared to share it" (Arctic Research for an Arctic Nation, 1989, p. 18). Now celebrating its 35th anniversary, IASC's Fourth International Conference on Arctic Research Planning is scheduled for March 2025. The conference will consider Arctic science, the Arctic in global affairs and the most urgent knowledge gaps and research priorities going forward.

In the 1990 report, the Commission reflected on its first five years focused on promoting Arctic research and acknowledged the need to expand oil and gas exploration in the US Arctic to strengthen

Arctic Boundary as defined by the Arctic Research and Policy Act (ARPA)

All United States and foreign territory north of the Arctic Circle and all United States territory north and west of the boundary formed by the Porcupine, Yukon, and Kuskokwim Rivers; all contiguous seas, including the Arctic Ocean and the Beaufort, Bering and Chukchi Seas; and the Aleutian chain.[1]



Acknowledgement: Funding for this map was provided by the National Science Foundation through the Arctic Research Mapping Application (armap.org) and Contract #0520837 to CH2M HILL for the Interagency Arctic Research Policy Committee (IARPC).
Map author: Allison Gaylord, Nuna Technologies. May 27, 2009.
1. The Aleutian chain boundary is demarcated by the 'Contiguous zone' limit of 24-nautical miles.

US economic strength. The Commission also acknowledged the value of fish stocks to the US economy. Additionally, the report identified the need to increase national competitiveness of the US in the Arctic regions which necessitated increased research on Arctic global connections. With 50% of the total US coastline located in Alaska, the commission recognized that securing this area represented an important national security concern. (Arctic Research in a Changing World, 1991). The Commission also underscored their role in propelling the US beyond merely Arctic nation status and into a key role as an Arctic leader in the 21st century (Arctic Research in a Changing World, 1991). This reflected the comments from the Chairman, published in the 1988 report, that stated, "knowledge of the Arctic, competitiveness in the Arctic, and leadership in the Arctic are three fundamental national goals" for the commission to focus on and help US to enter the 2000s as a preeminent leader in the Arctic (Arctic Research for An Arctic Nation, 1989, p. 3).

INCREASING NATIONAL SECURITY CONCERNS

Increased accessibility in the Arctic prompted the Arctic Research Commission to urge greater attention to National and Homeland Security Issues. Their 2003 Report on Goals and Objectives for Arctic Research highlighted unprecedented high latitude transits through the Northwest Passage and Northern Sea Route which presaged long term consequences in a more accessible Arctic. More access in the Arctic meant the US needed to develop new concepts and systems to protect the Arctic Ocean and US coastline. This included research to assist in development and enhancement of Arctic capable defense systems and equipment. Due to these concerns, the Arctic Research Commission was increasing distribution of its report to the Department of Defense Military Service Secretaries, the Department of Transportation and the Department of Homeland Security (Report on Goals and Objectives for Arctic Research, 2003).

Starting in the mid 1990s as the Arctic Research and Policy Act helped generate greater knowledge and capabilities for US engagement and leadership in the Arctic and federal action built on President Nixon's 1971 NSDM 144 as well as a 1983 National Security Decision Directive 90 (NSDD90) which had reaffirmed the 1971 statement (Leighton, 1993-1994). The end of the Cold War offered greater potential for international cooperation in the Arctic which was reflected in a 1994 Presidential Decision Directive/NSC-26 on Arctic and Antarctic Policy. The Directive still acknowledged the importance of security and defense to protect against attack across the Arctic, control US borders and carry out military operations in the region. It did, however, note the potential for greater collaboration and coordination on Arctic matters. (PDD-26 U.S. Polic on Arctic and Antarctic Regions, 1994). In this spirit, the US signed an agreement with Japan to establish the International Arctic Research Center (IARC) at the University of Alaska in 1999. The purpose of the center was to leverage American and Japanese expertise in wide ranging Arctic research to develop useful, actionable science on the Arctic. (About IARC, 2025). The US also held its first chairmanship of the Arctic Council from 1998-2000.

The Arctic received presidential attention with the 2009 Presidential Directive 66/Homeland Security Presidential Directive 25 (NSPD 66/HSPD 25). It emphasized compelling US interests in the Arctic to include national security and homeland security and addressed the need for scientific study to advance these interests. International governance, the extended continental shelf and boundary issues, international scientific cooperation, maritime transportation and economic issues, including energy, were all identified as important Arctic issues to address (Changes in the Arctic: Background and Research for Congress, 2024).

In the mid 2000s an increased focus on developing effective Arctic policy led the establishment of multiple entities with polar and Arctic responsibilities. This included the creation of an assistant director of Polar Sciences within the Office of Science and Technology Policy, as well as an Arctic Executive Steering Committee to enhance coordination of national efforts in the Arctic. This entity operated within the National Security Council to coordinate actions of federal agencies, state, local and tribal government, business and on-profit section that impact the US Arctic (Weingartner and Orttung, 2019).

During this time, IARPC became a White House working group of the National Science and Technology Council[4] which helped elevate Arctic policy issues on the federal level. Importantly, in order to enhance US Arctic engagement, the US released its first National Strategy for the Arctic Region in 2013. This led to the first DOD Arctic Strategy in 2016 followed by service specific strategies. These documents reflected themes from earlier national security documents to include national security issues, protecting the Arctic environment, managing natural resources and international cooperation. (Weingartner and Orttung, 2019, Changes in the Arctic: Background and Research for Congress, 2024).

US international engagement in the Arctic also ramped up in the mid 2000s. In 2011, for the first time a US Secretary of State represented the US at the Arctic Council. At this meeting, the Arctic Council members signed an agreement on Search and Rescue (Secretary Clinton: Travel to Nuuk, Greenland for Arctic Council Ministerial). From 2015-2017, the US began its second chairmanship of the Arctic Council. During this period of US Arctic leadership, the Council issued the Arctic Climate Impact Assessment while working with the International Arctic Science Committee. Also, the US promoted human health with the International Circumpolar Surveillance, a disease surveillance system led by the US Center for Disease and Prevention. The US committed numerous scientific groups and organizations to both initiatives by the Council (Haycox, Arctic Policy of the United States: An Historical Survey, 2020, 2456-247). In 2019, the US Secretary of State identified the Arctic as a "geopolitically significant arena" for power and influence and identified a "new era of strategic engagement." In a 2019 Arctic Council meeting, the US also pushed back against the Chinese declaration that it was a "near-Arctic nation" in an effort to discredit Chinese attempts to gain a greater foothold in the Arctic (Paul, 2023).

By contributing to the Arctic priorities listed in the 2022 National Security Strategy and those from the new National Strategy for the Arctic Region (NSAR), ARPA helped promote security and defense goals. While the NSAR described US desire for an Arctic region that is "peaceful, stable, prosperous and cooperative," it importantly listed security as its first pillar with focus on actions to deter threats to the US homeland and to Allies and a commitment to protect the American people and defend US sovereign territory (Congressional Research Service, 2024). A key aspect of this is understanding the Arctic operational environment through domain awareness and Arctic communications and federally funded Arctic research can facilitate development in these realms (Report on the Goals and Objectives for Arctic Research 2023-2024). For example, the 2023-24 USARC Report on Goals and Objectives for Arctic Research identified work in unmanned aircraft systems (UAS) optimized to work in extreme northern environmental conditions. The ArcticX22 exercise demonstrated this capability to provide surface situational awareness operating beyond the line of sight. The report highlighted UAF's Alaska Center for Unmanned Aircraft Systems Integration (ACUASI), whose focus is on Arctic and sub-Arctic regions as one of the top drone research programs in the US. Additional work focused on improving fiber optic cable capabilities to provide better communication to remote Alaskan locations. This communication capability is critical for military forward operations. Optimizing development of dual use technology is both a force multiplier and a cost saver (Report on the Goals and Objectives for Arctic Research 2023-2024).

On the economic side, the USARC report identified the value of investigating opportunities for Arctic economic development to include critical minerals and advancing better understanding of Arctic marine operations, the implications of the Northern Sea Route and its links to oil, gas and minerals. The report also identified small-scale nuclear power as an emerging topic. The report noted Russia's

4 The Office of Science and Technology Policy (OSTP) was established in 1976 to advise the president and other executive agencies on science policy. Nestled under OSTP, the National Science and Technology Council (NSTC) was established in 1993 and chaired by the President with cabinet secretaries and agency heads with science and technology responsibilities. In 2010, IARPC became part of NSTC which provided it a more direct link to the executive branch.

already existing floating nuclear power plant in the Arctic and joint Chinese and Russian efforts to develop additional nuclear power capability. Governmental, industry and university research efforts are aimed at building on US Air Force efforts to deploy a nuclear microreactor at Eielson AFB, Alaska to consider expansion of such power sources in the US Arctic (Report on the Goals and Objectives for Arctic Research 2023-2024).

NATIONAL SECURITY IMPLICATIONS OF ARPA

As addressed in the NSAR under strategic objective 2.3, it is imperative to understand ongoing changes in the Arctic environment and anticipate future changes. The NSAR makes clear the role of USARC in developing and recommending policy, and establishing research plans, as well as IARPC's role in coordinating and guiding research on the Arctic (National Strategy for the Arctic Region, 2022). DOD Directive (DODD) 4715.21 states the necessity of ensuring DOD can retain operational advantage under all conditions. Thus the DOD requires effective research to make informed decisions, train and equip a force able to operate in extreme weather, construct and maintain infrastructure to support military operations in changing conditions, provide supply chain survivability and innovation in austere locations, and enhance adaptation through collaboration with other federal agencies, Congress, US Allies and partners and other stakeholders (Climate Change and Adaptation: Department of Defense, 2023).

In recent years, the DOD has also increased its focus on the Arctic by establishing the Ted Stevens Center for Arctic Security Studies, as well as an Arctic Strategy and Global Resilience department within the Office of the Secretary of Defense. Additionally, the US established the position of Ambassador-at-Large for the Arctic Region and appointed the first Ambassador in 2024 (Congressional Research Service, 2024) DOD also issued an updated Arctic Strategy document in 2024. Increased security concerns, strategic competition and focus on energy issues means that Arctic research and policy initiatives are increasingly relevant for DOD operations.

These efforts are important for DOD due to the need for planning and investment in mitigating changes to the Arctic operational environment that would affect military capabilities.

Both the US military and the Arctic science community share the need to better understand the Arctic and new discoveries through collaborative efforts can yield substantive results. ARPA enshrines this collaboration and continues the legacy of Cold War projects such as collection of ice cores in Greenland that are yielding new data even today.

In a recent example of the value of such collaborative research, scientists traveling aboard the US Coast Guard icebreaker Healy discovered a volcano like structure in the ocean floor over 500 meters high. This collaboration between the U.S. National Science Foundation, the National Oceanic and Atmospheric Administration, the University of New Hampshire, and the USCG is part of a project called the Alaska Arctic Coast Port Access Route Study. It is examining unchartered waters in the Chukchi and Beaufort Sea to survey a corridor proposed by the USCG for a preferred vessel route from the US-Canada border to Utqiagvik. Using equipment on the Healy, the scientists worked to create detailed images of the sea route to include objects along the ocean floor. With the potential for increased economic value of shipping in and through the Arctic, as well as the military's need to operate effectively in the same area, such collaborative efforts serve both military and civilian purposes. A NOAA participant commented that "The coordination and partnerships during this mission fill critical gaps in the region for all waterway users and provide a foundation for safe navigation in the Arctic" (Rosen, 2024).

In October 2024, the USARC supported a Geologic Hydrogen Workshop at the University of Alaska Fairbanks. This workshop focused on pursuing the potential for use of Alaskan geologic hydrogen to augment US energy sources. Geologic hydrogen gas is created in the Earth's subsurface. Alaska's geology is conducive to its existence, and it would likely be located in areas associated with crucial strategic and precious minerals. The workshop brought together scientists, energy experts, the private sector, Alaska Native Corporations and state and federal policymakers, including the White House Office of Science and Technology Policy (Boyce, 2024)

With the economic importance of Arctic fish stocks and unwelcome Russian and Chinese maritime activity in Arctic waters, both US military presence and increased knowledge of the maritime environment through scientific research are imperatives the US should not neglect. The impetus for Arctic research in this area supported the development and construction of the R/V Sikuliaq. This 261 foot oceanographic research ship, one of the most advanced university research vessels in the world, is able to operate in moderate seasonal ice and break ice up to 2.4 feet thick. It is owned by the NSF and operated by UAF's College of Fisheries and Ocean Science. Commissioned in March 2015, it has been used by both US and international scientists (About R/V Sikuliaq, 2024).

Through the work of the USARC, the US engages with international Arctic experts. USARC and IARPC support US participation in Arctic Council research and helped facilitate US Chairmanship of the Arctic Council in 1998-2000, 2015-2017 and will in 2031-33 when the US holds the position again. Both USARC and IARPC also supported US participation in the 4th International Polar Year in 2007. USARC proposed research priorities and IARPC adopted two of them as federal agency IPY priorities for 2007. This included creating the framework for an Arctic Observing Network and focus on social science concerns to include Indigenous cultures and languages (United States Arctic Research Commission Annual Report Fiscal Year 2007).

Currently, USARC and IARPC are supporting planning for the 5th IPY from 2032-2033. This will be an international, coordinated multi-year activity. Planning is ongoing and the project phase will commence in 2026 and continue through 2033. The IPY is facilitating cooperation among countries, disciplines, programs and knowledge systems to develop actionable information, promote polar science communication, and enact educational activities and public engagement. This work can inform polar region decision makers as well as build and deepen Arctic partnerships (Initial Concept Note International Polar Year 2032-33, 2023).

Over the past 40+ years, ARPA has bolstered US security in the Arctic through significant research and initiatives. This work has spanned a wide range of activities from developing undersea sensors, to operating and sustaining remote research stations, to making the case for new more powerful icebreakers. Twenty-five years' worth of mapping data that the USARC brought to Congress enabled the US in December 2023 to claim the seafloor regions in the Extended Continental Shelf. Asserting US sovereignty over this area confers important security and economic benefits.

CONCLUSION

With USARC's mission to develop and recommend US Arctic research policy to the President and Congress and build cooperative links in Arctic research within the federal government, with Arctic residents, the State of Alaska, researchers and international partners, its work can yield solutions to address national security and DOD warfighting requirements to enable effective US operations in the Arctic operational environment.

ARPA's 1988 report highlighted three fundamental goals to promote the US as a leader in the Arctic. These included knowledge of the Arctic, competitiveness in the Arctic and leadership in the Arctic. The mechanisms put in place by the Arctic Research and Policy Act of 1984 have been key to addressing these goals. However, much work remains to be done. While US policy makers and DOD have recognized the value of the Arctic and continue to enhance US capabilities to engage, operate, protect and project in the Arctic, US public perception of the US as an Arctic nation is lacking. The results of a 2019 survey published in Zachary Hamilla's paper, The Arctic in US National Identity (2020), indicated a decline in the percentage of Americans who view the US as an Arctic nation. Almost 30% of Americans fully disagreed that the US was an Arctic nation, while only 13% fully agreed that the US was an Arctic nation. This highlight the need to garner wider public recognition of the strategic and economic importance of the Arctic to the US as a whole.

Acknowledging the strong foundation of ARPA, Senator Lisa Murkowski recently introduced the Arctic Research and Policy Amendments Act of 2024. She pointed out ARPA now requires additional evolution to ensure US leadership going forward. Her amendment calls for broadening ARPA's scope to more comprehensively support the Arctic's increased role in national and homeland defense and strengthening sustained funding of research on Arctic impact on global systems. Additionally, the amendment would establish an annual award for excellence in Arctic research and expand the US Arctic Research Commission to include an Alaskan appointed governor of Alaska. Senator Murkowski urged her colleagues to "wake up to the fact that this is the age of the Arctic" and the US needs "to be the leader in the Arctic space." (Senator Murkowski Introduces Arctic Research and Policy Amendments Act of 2024).

With continued threat from adversaries in the Arctic and the growing Arctic capabilities that the CCP is developing in the Indo-Pacific region, the US must be a leader in the Arctic to ensure the security and safety of its citizens. Otherwise, the US will find itself relegated to catch up with other Arctic powers who have made the Arctic a greater priority. ARPA has and will continue to provide vital research to enhance US defense capabilities in the Arctic and promote US leadership in the Arctic.

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Operational Viability of Arctic Lake Ice:

Ice Growth and Runway Feasibility at Teshekpuk Lake, Alaska

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ABSTRACT

Arctic lake ice is experiencing profound changes due to climate-driven variability, with significant implications for infrastructure, transportation, and security operations in northern Alaska. This study assesses the operational feasibility of using Teshekpuk Lake, Alaska's largest Arctic lake, as a winter runway for LC-130H aircraft. Through a combined approach of ground-penetrating radar (GPR), ice drilling, satellite telemetered thermistor arrays, and Sentinel-1 synthetic aperture radar (SAR) imagery, we evaluated ice thickness, growth patterns, and surface hazards during winter 2020. Results showed rapid black ice formation under minimal snow cover, with ice thickness increasing from 43 inches (1.1 m) in mid-January to 55 inches (1.4 m) by early February—reaching the threshold required for LC-130H landings. Sentinel-1 SAR imagery provided complementary insights into ice surface conditions, such as potential hazards associated with lake ice pressure ridges. Importantly, when viewed against long-term records of Arctic lake ice thickness, it appears that modern ice growth is approaching critical thresholds for the safe operation of LC-130H's, as lake ice is typically not attaining the same thickness as observed historically. These changes present growing challenges for Arctic logistics and security operations that rely on thick, stable lake ice for transport corridors and runways. Our findings highlight how climate-driven variability in ice growth and snow cover influences runway viability, raising critical considerations for Arctic security operations. This work underscores the need for integrated, real-time ice monitoring to ensure safe Arctic logistics and informs broader strategies for adaptation and resilience in rapidly changing polar environments. The findings contribute to ongoing discussions on Arctic security and align with the mission of the Journal of Arctic Security to explore the intersection of science, security, and sustainability.

INTRODUCTION

The Arctic is undergoing rapid environmental transformation, with implications for national and global security (Goodman et al., 2021). The rapidly changing Arctic has become a focal point for scientists and policymakers (Schlosser et al., 2022; Steindal et al., 2021). With significant implications for both local communities and global systems, the physical and climatic processes occurring in this region are of strategic importance (Ford et al., 2021, 2015). Arctic lake ice is experiencing significant changes in duration, thickness, and growth patterns due to climate-driven variability (Huang et al., 2022; Woolway et al., 2020; Zhang et al., 2021). Rising air temperatures have led to later freeze-up in the fall and earlier ice breakup in the spring, shortening the ice-covered season (Newton and Mullan, 2021; Zhang et al., 2021). Warmer conditions also impact ice growth rates, as well as increased snowfall that insulates lake surfaces, reducing the formation of strong, load-bearing black ice (Block et al., 2019; Culpepper et al., 2024b; Woolway et al., 2020). These shifts have critical implications for infrastructure, transportation, and security operations, as thinner and less stable ice increases risks for overland travel and aircraft landings (Povoroznyuk et al., 2023). Long-term monitoring using field measurements, remote sensing, and climate modeling is essential to understanding and predicting these changes, ensuring safe Arctic operations amid a shifting Arctic climate (Saros et al., 2023).

The LC-130H ski-equipped “Hercules” is a crucial aviation asset for maintaining U.S. presence and supporting national interests in the Polar regions (Wallwork and Wilcoxson, 2006). In the Arctic, LC-130H’s off-airport capabilities are critical for supporting logistics, emergency response, and security operations in some of the world’s harshest and most rapidly changing environments (Gryc, 1985; Reed, 1958). With maintained airfields often separated by hundreds of miles, frozen lakes can offer the primary landing surfaces for activities during winter months (Barnes, 1960). In fact, maintained frozen lakes and rivers were used as landing strips in 1945 during the US Navy’s exploration of the Petroleum Reserve No. 4 (PET 4), with surfaces ~ 3,000 (~900 meters) by 100 (~30 meters) feet that were maintained by a tractor. One strip on a lake near Umiat, Alaska was utilized by cargo planes such as C47s (R4Ds) flown by Naval Air Transport Service (Reed, 1958). In another example, LC-130H aircraft were used during oil and gas exploration activities in the National Petroleum Reserve in Alaska between 1977 and 1982 (Figure 1; Gryc, 1985). The requirements at the time were a runway that extended for 6000 feet (1.8 kilometers) with at least 4 feet (1.2 meters) of ice thickness for freshwater conditions and 4.5 feet (1.4 meters) for brackish water conditions below the ice (Gryc, 1985).

As northern winters become shorter and warmer, traditional assumptions about frozen lakes as reliable landing surfaces are increasingly uncertain (Dauginis and Brown, 2021; Dong et al., 2022; Rantanen et al., 2022). Hence, operational safety increasingly depends on accurate and timely assessment of ice strength, thickness, and variability, prior to any landing. Ideal landing surfaces are composed of black ice, which is formed by freezing of undisturbed lake water and has a superior load-bearing capacity than white ice, which can be formed from refrozen overflow, snowfall on open water, or in areas of high lakebed methane production (Anthony et al., 2021; Block et al., 2019; Culpepper et al., 2024b). Pressure ridges, snow drifts, cracks, and structural weaknesses pose significant risks and should also be avoided (Daley, 2021; Kozlov et al., 2023). Studying lake ice growth rates, stability under dynamic loads, and real-time monitoring techniques are essential to ensuring safe and effective Arctic air operations.

This study aligns with the Journal of Arctic Security (JAS) mission to explore the nexus of science, security, and sustainability. We conducted a mission on Teshekpuk Lake, Alaska’s largest Arctic Lake, during the winter of 2020 to assess the feasibility of its ice conditions to support repeated landings of an LC-130H aircraft during a two-week period. This research integrates synoptic in situ measurements, near real-time data transmission, and remote sensing imagery to evaluate the feasibility of landing an LC-130H on frozen lakes in the 21st century Arctic, providing critical insights for military, scientific, and logistical applications in Arctic environments. This research contributes to understanding the operational and environmental challenges of the Arctic, providing actionable insights for infrastructure planning, security strategy development, and climate adaptation.

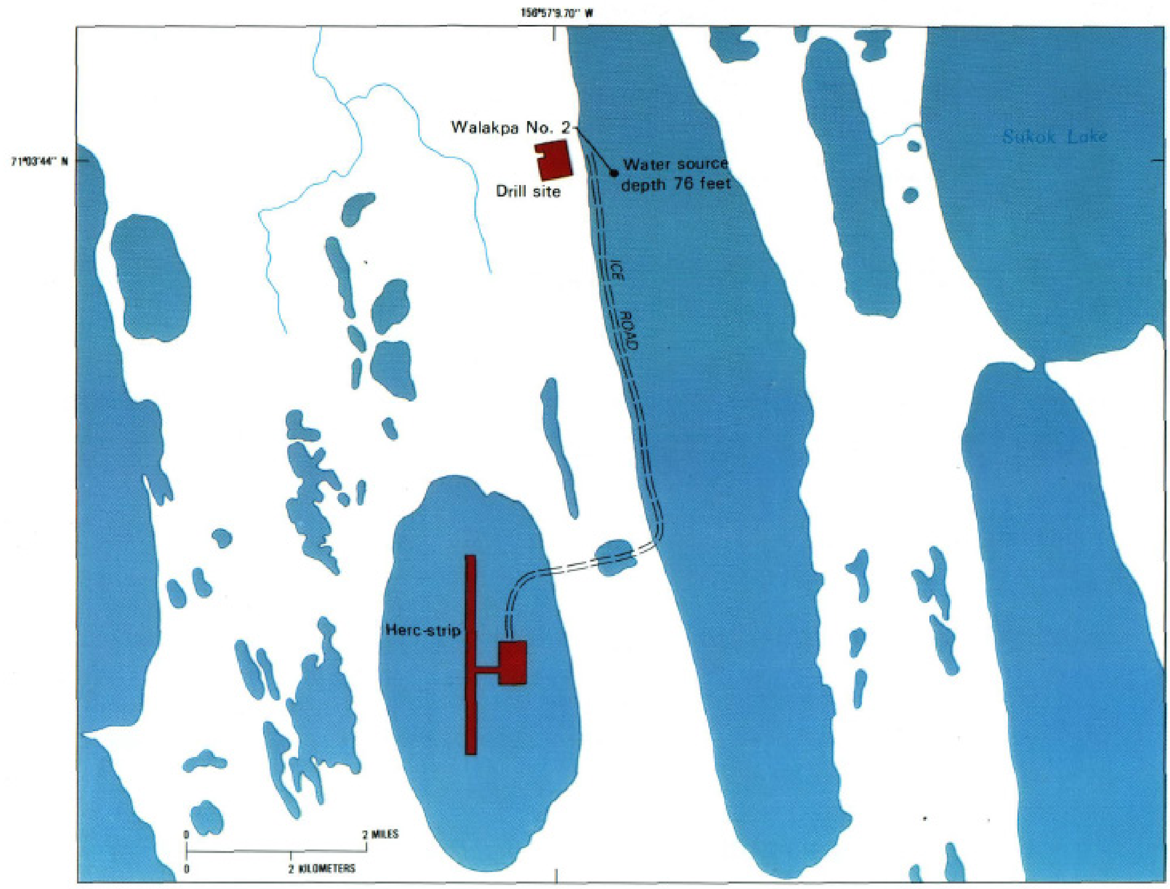

Figure 1: LC-130H ice runway locations. LC-130H provided contractors working in the NPR-A between 1977 and 1982 with the high-volume, high-tonnage capability necessary to transport drilling and construction equipment during field operations.

LANDING AN LC-130H ON FROZEN LAKES: REQUIREMENTS AND CHALLENGES

Landing an LC-130H aircraft on a frozen, ice-covered lake presents unique challenges and requires meticulous planning to ensure operational safety. One of the critical factors is the minimum ice thickness necessary to support the maximum takeoff weight of the aircraft (~155,000 lbs/70,000 kg). When operating in the Arctic, LC-130H aircraft require ice runways that extend for 6,000 feet (1.8 kilometers) and have ice thicknesses that range between 42 inches (1.1 meters) and 55 inches (1.4 meters), depending on the under-ice water salinity (Gryc, 1985; Planning and design of roads, airbases, and heliports in the theater of operations, 1968). If repeated landings are required, the minimal conditions to build and maintain the ice runway might increase (Wang et al., 2025; White and McCallum, 2018).

Black ice, known for its superior strength and transparency, offers an ideal surface for such operations compared to weaker, white ice (Culpepper et al., 2024b). The recommended runway length for an LC-130H on ice is approximately 6,000 ft (1.8 km), depending on the payload and environmental conditions (Gryc, 1985; Wallwork and Wilcoxson, 2006). Runway preparation would typically involve clearing snow to expose the black ice surface and creating a level, compacted snow-covered runway for aircraft operations (Abele, 1990; Talalay, 2024). Special equipment, including snowplows and graders, may be used to create a smooth and debris-free surface. Monitoring weather and ice conditions is crucial throughout the operation, as sudden temperature fluctuations can affect the integrity of the snow and ice surface, impacting runway performance. Additionally, continuous communication and logistical coordination are necessary to manage the operational complexities of Arctic environments. These carefully engineered ice runways not only enable strategic and tactical operations but also provide critical support for emergency responses and resource delivery in remote Arctic regions (Wallwork and Wilcoxson, 2006). Key hazards include the potential for pressure ridges, snow drifts, and underlying cracks, all of which can compromise the structural integrity of an ice runway (Ashton, 2011; Leppäranta, 2023). Pressure ridges form due to thermal stress and ice movement, creating uneven surfaces that pose risks to aircraft during takeoff and landing (Dionne, 1979; Parmerter and Coon, 1972; Rangel et al., In Review). Snow drifts can obscure ice conditions, requiring thorough reconnaissance and preparation before runway establishment. Ground-penetrating radar (GPR), ice drilling, and remote sensing are essential tools for assessing ice thickness and identifying potential hazards (Annan et al., 2016; Culpepper et al., 2024a; Talalay, 2024).

STUDY AREA AND METHODOLOGY

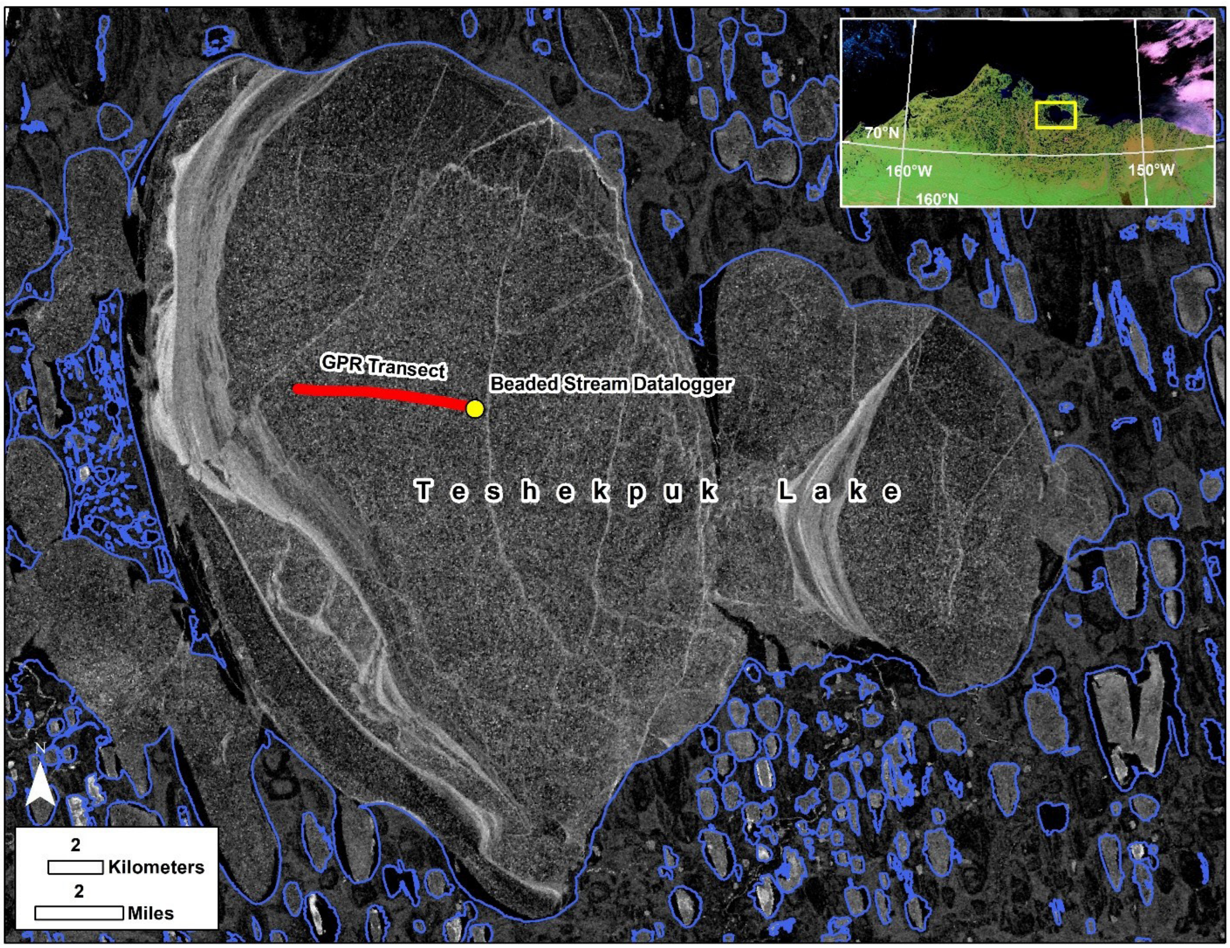

Figure 2: A Sentinel-1 SAR satellite image from 02 January 2020 showing lake ice conditions and the location of the satellite telemetered BeadedStream datalogger (yellow dot) and the GPR transect (red line). The linear white features in Teshekpuk Lake indicate white ice or substantial fractures and pressure ridges; otherwise, ice conditions on Teshekpuk are interpreted as black ice. The inset in the upper right shows the location of Teshekpuk Lake in northern Alaska and the blue polygons overlying the SAR image indicate lakes that are larger than 25 acres (10 hectares).

Teshekpuk Lake is the largest lake on the North Slope of Alaska, covering approximately 330 square miles (850 square km). Situated at a low elevation of less than 6.5 feet (2.0 meters) above sea level, the lake has a maximum depth of 23 feet (7.0 meters) and a watershed area of 1,050 square miles (2,700 square km). It remains ice-covered for 275 to 315 days each year, reflecting the region's extreme Arctic climate (Jones, 2019.). Teshekpuk Lake is primarily fed by Kealok Creek and drains through the Mayugiaq River, which connects it to the Beaufort Sea. The lake and its surrounding wetlands serve as critical habitat for migratory birds, the Teshekpuk Lake Caribou Herd, and various fish species, supporting both ecological diversity and Indigenous subsistence activities (Borough and Barrow, 2007; Liebezeit et al., 2011; Wilson et al., 2012). As climate-driven variability accelerates permafrost thaw and alters hydrological processes, Teshekpuk Lake remains a focal point for Arctic research and conservation efforts (Teshekpuk Lake Observatory, 2025).

Sentinel-1 SAR imagery from 02 January 2020, supported field planning by identifying areas interpreted as black ice, indicating potential locations of lake ice pressure ridges, and guiding the alignment of the GPR transect as well as the placement of the satellite-telemetered ice thickness datalogger and thermistor string. Our field team conducted ice measurements at Teshekpuk Lake from 10-13 January 2020. Activities included traversing ~80 miles (~130 kilometers) from Utqiagvik to Teshekpuk Lake under extreme weather conditions, with wind chills reaching -50°F (-46°C), to establish a base camp at the Teshekpuk Lake Observatory. Ice thicknesses and snow depths were recorded using direct drilling and GPR surveys, producing more than 25,000 data points. The ice/water interface was picked using a human-guided automated algorithm in the post processing software ReflexW (Sandmeier Geophysical Research, Karlsruhe, DE). GPR picked data were calibrated to a series of five drilled ice thickness holes that were gauged with a weighted tape measure (Kovacs Inc., Roseburg, OR). The drilled measurements ensured accuracy in thickness assessments, demonstrating the effectiveness of combined methodologies. We installed a near real-time satellite telemetered BeadedStream datalogger with a temperature cable with thermistors spaced at 0 inches (0.0 meters), 8 inches (0.2 meters), 16 inches (0.4 meters), 24 inches (0.6 meters), 32 inches (0.8 meters), 39 inches (1.0 meters), 43 inches (1.1 meters), 51 inches (1.3 meters), 55 inches (1.4 meters), 59 inches (1.5 meters), 63 inches (1.6 meters), 67 inches (1.7 meters), 71 inches (1.8 meters), 75 inches (1.9 meters), and 79 inches (2.0 meters). An air temperature sensor and a sonic snow depth sensor were also installed and connected to the datalogger at the central lake location. The use of a BeadedStream data logger provided continuous temperature profiles, allowing for near real-time tracking of ice growth from January through the planned airborne campaign in mid-February and further into mid-May.

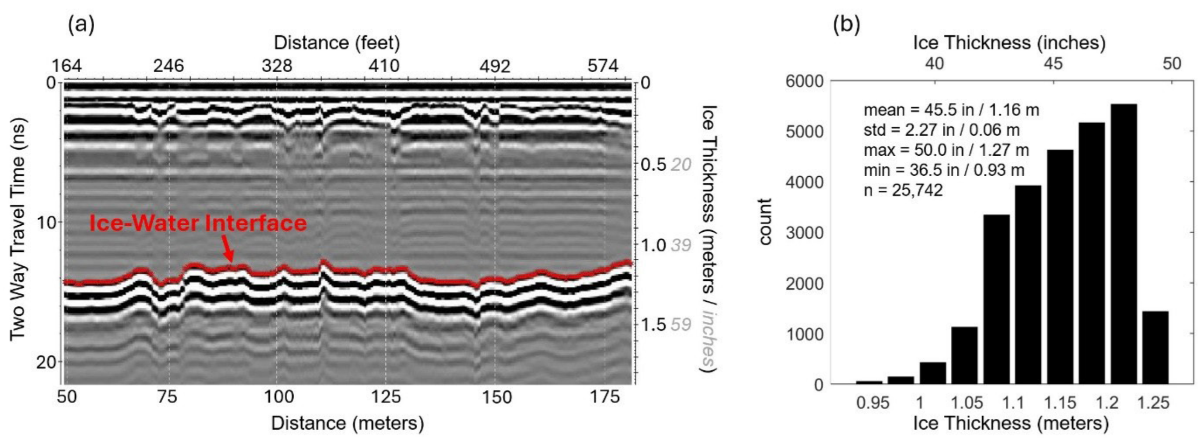

Figure 3: (left) Example showing a GPR radargram and the post-processed base of the ice in red. (right) Histogram of GPR measured ice thickness (shown in inches and meters) along the 4 mile (6.4 kilometer) long GPR transect.

RESULTS

ICE GROWTH PATTERNS AND VARIABILITY

Air temperatures during the study period ranged from -13°F to -50°F (-25°C to -46°C), driving rapid freeze-down of the lake ice. The thermal properties of black ice, combined with low snow cover, created conditions for accelerated ice growth. Ice thickness averaged 45.5 inches (1.2 meters) during the 11 January survey and reached 51 inches (1.3 meters) by 01 February, at growth rates of 0.44 inches/day (1.1 to 1.7 cm/day). The minimal snow cover and the presence of black ice and sustained cold air temperatures facilitated rapid ice growth during the study period. At the time, we estimated that if the current rate of lake ice growth continued into February, ice thickness would have reached the required 55 inches (1.4 meters) by 10 February at the location of the sensor site in the middle of Teshekpuk Lake. However, the average air temperature between 1–7 February was colder than the prior two weeks (-32°F (-36°C)). The sustained cold spell contributed to more rapid ice growth, increasing from 51 inches (1.3 meters) to 55 inches (1.4 meters) in just six days, or an average increase in ice thickness of 0.66 inches/day (1.7 cm/day).

Analysis of the GPR data against ice thickness in drillholes revealed a local GPR wave velocity of 0.171 ± 0.002 m/ns, which was used to convert the radar travel time observations to ice thicknesses. Comparison against an additional validation ice thickness in a drillhole indicated accuracy within 2.4 inches (6.1 centimeters), confirming its reliability for lake ice monitoring. Observations of wind-blown snow sastrugi conditions on the lake ice highlighted minor surface irregularities less than 1 inch (2.5 cm), ensuring the feasibility of using Teshekpuk Lake for operational activities. The integration of remote sensing and field measurements demonstrated the value of multi-modal approaches for studying Arctic ice dynamics.

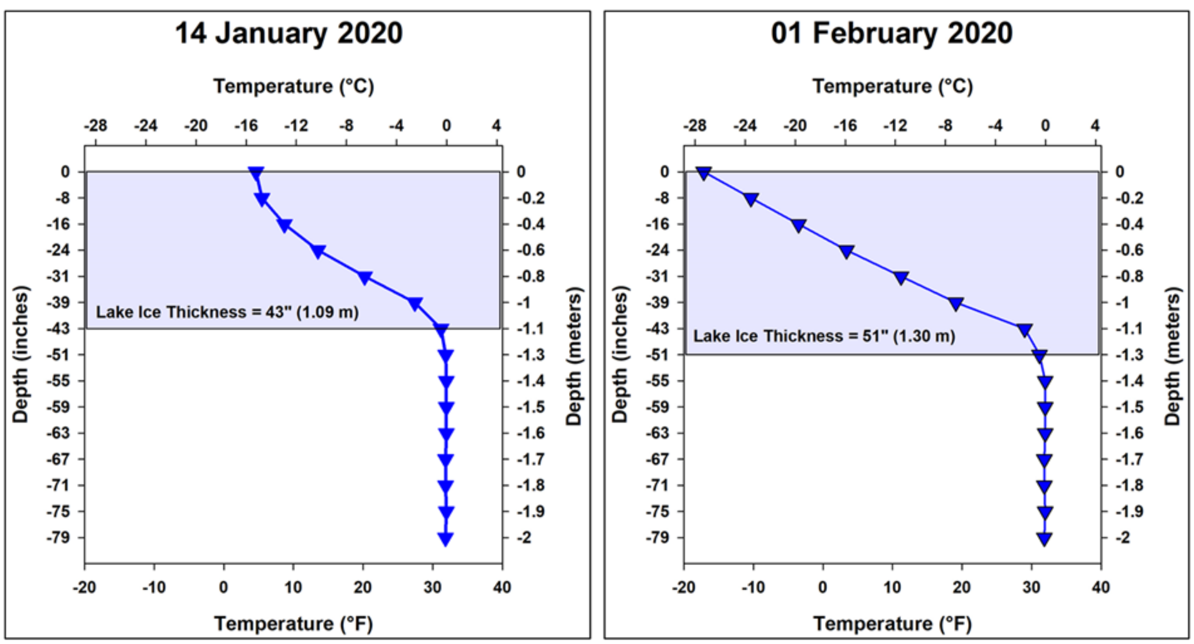

Figure 4: Inferred ice thickness and growth based on vertical temperature profile on 14 January 2020 (left) and 01 February 2020 (right). The ice grew from 43 inches (1.1 meters) to 51 inches (1.3 meters) during this period at a rate of 0.44 inches (1.1 cm) per day.

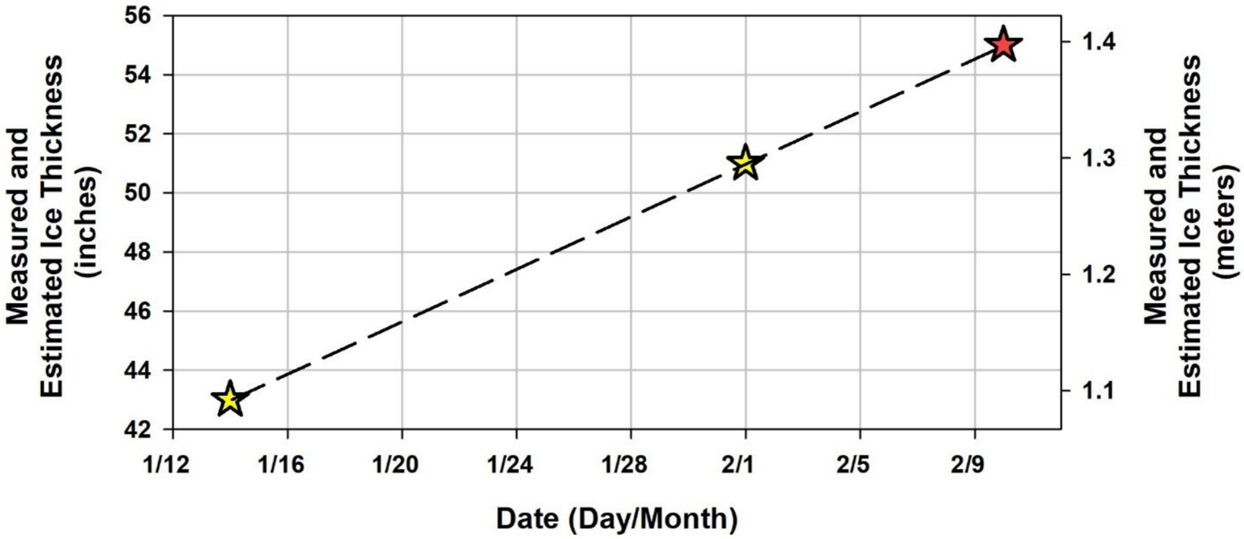

Figure 5: Estimating lake ice growth to 55 inches (1.4 meters) (red star) based on a linear extrapolation of ice thickness measurements on 14 January and 01 February (yellow stars). If the current rate of lake ice growth had continued, the ice thickness would have reached 55 inches (1.4 meters) by 10 February (red star) at the location of the sensor site in the middle of Teshekpuk Lake.

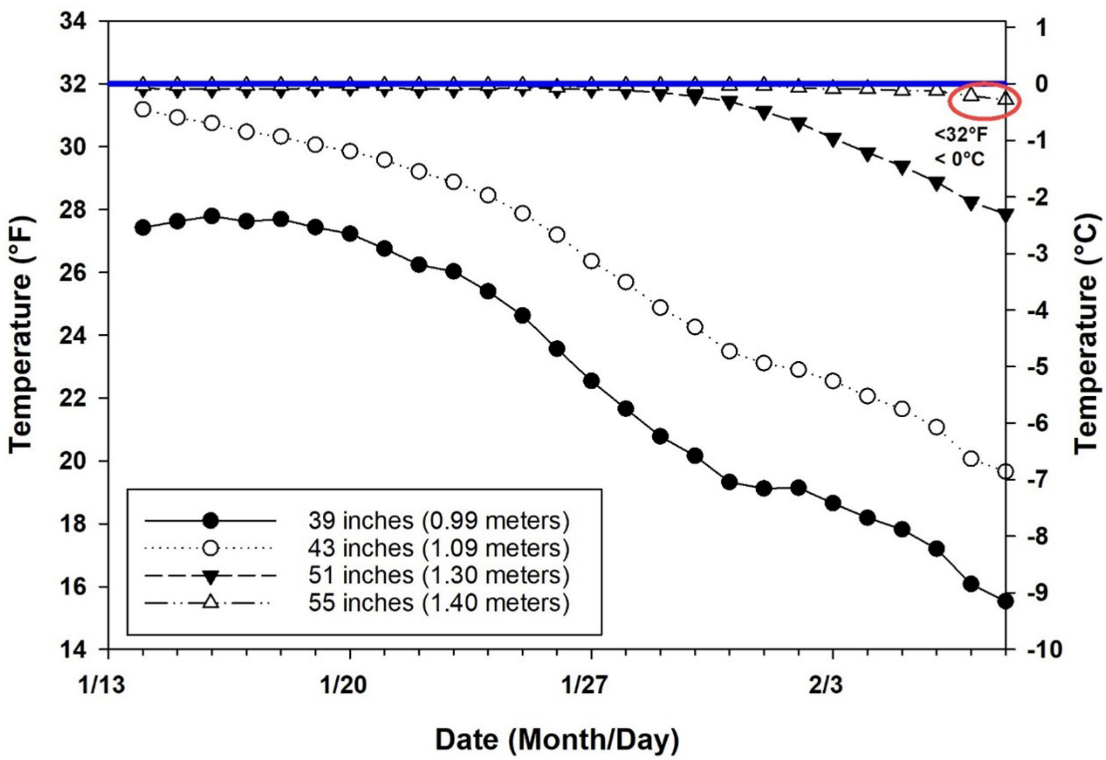

Figure 6: Daily plot of temperatures measured from a depth of 39 inches to 55 inches (1.0 meters to 1.4 meters) below the ice surface between 14 January and 7 February. The point in time when the temperature at a given depth drops below the freezing mark indicates likely ice formation. The temperature sensor located at 55 inches (1.44 meters) from the surface most likely froze into the ice around February 6th.

DISCUSSION

IMPACT OF CLIMATE VARIABILITY ON ARCTIC LAKE ICE FORMATION

Climate-driven variability has had a profound impact on the timing and thickness of lake ice formation across the Arctic (Huang et al., 2022; Prowse et al., 2011; Woolway et al., 2020; Zhang et al., 2021). Rising air temperatures, delayed onset of freezing conditions, and alterations in precipitation patterns have all contributed to significant changes in ice growth. Historically, by late April to early May, many lakes in the Arctic Coastal Plain of Alaska regularly exceeded the 55 inches (1.4 meters) threshold generally required to safely land an LC-130H aircraft; however, over the past two decades, both the Arctic Coastal Plain and Foothills regions have experienced winter conditions that have limited lake ice growth to less than 55 inches (1.4 meters) by the end of the winter, leading to increasing instances of lakes not reaching safe landing conditions, particularly during the early winter period. Notably, 2020, when our observations were made, stands out as an anomalously cold year in the 21st century, with thicker ice growth across both regions. The pattern of thick lake ice growth prevailed on the Arctic Coastal Plain in 2021 as well (Arp et al., 2023), highlighting annual variability in the lake ice growth patterns that would benefit from near real-time observation networks in northern Alaska. These patterns underscore growing challenges and unpredictability for ice-supported aviation operations in northern Alaska.

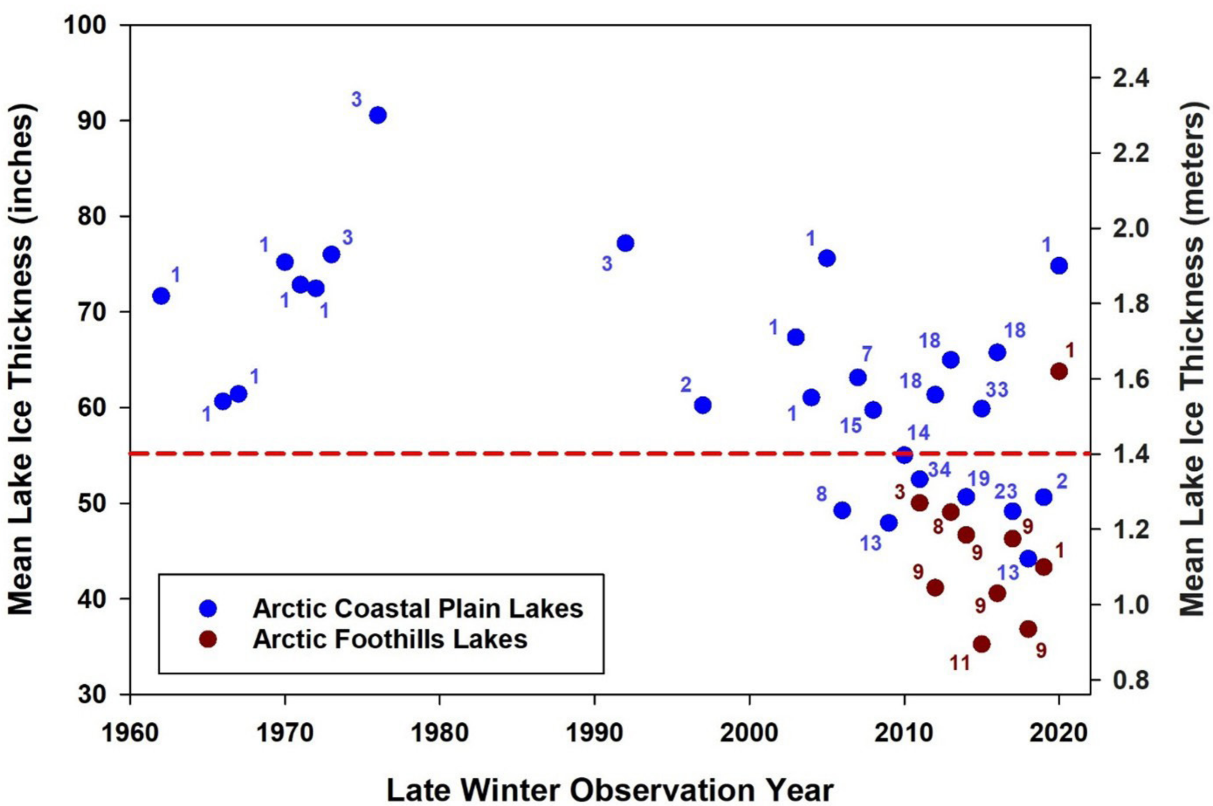

Figure 7: Mean late-winter lake ice thickness observations (in inches and meters) for Arctic Coastal Plain lakes (blue circles) and Arctic Foothills lakes (red circles) from 1962 to 2020. The red dashed line (55 inches / 1.4 meters) marks the minimum ice thickness generally required to safely land an LC-130H aircraft, and the color-coded numbers indicate the number of lakes with observations in a given year. Data collection and synthesis were supported by two NSF-funded projects (CALON and ALISS; Arp, 2024) and the 2019–2020 Arctic Foothills lake ice data are available from Toolik Field Station.

Teshekpuk Lake exemplifies shifts in lake ice growth patterns in northern Alaska, with recent observations indicating thinner maximum winter ice thickness and earlier ice-off timing compared to historical records. Delayed ice formation and thinner ice growth likely reduces the overall duration of the ice-covered season, which has critical implications for both ecological systems and human activities (Jones et al., 2009). Shorter ice seasons limit the time available for safe transportation routes and ice-dependent operations, increasing logistical challenges in remote Arctic regions (Arp et al., 2020, 2019; Culpepper et al., 2024a). Furthermore, thinner ice poses higher risks for infrastructure and vehicles, including snowmachines and aircraft. The insulating properties of an increase in winter snowfall exacerbate these issues by limiting ice growth (Alexeev et al., 2016). Increased snowfall during early winter, often linked to warmer and wetter atmospheric conditions, creates a natural thermal insulation that inhibits the formation of thicker and stronger ice. This has been observed at Teshekpuk Lake, where snow-covered areas show reduced ice thickness.

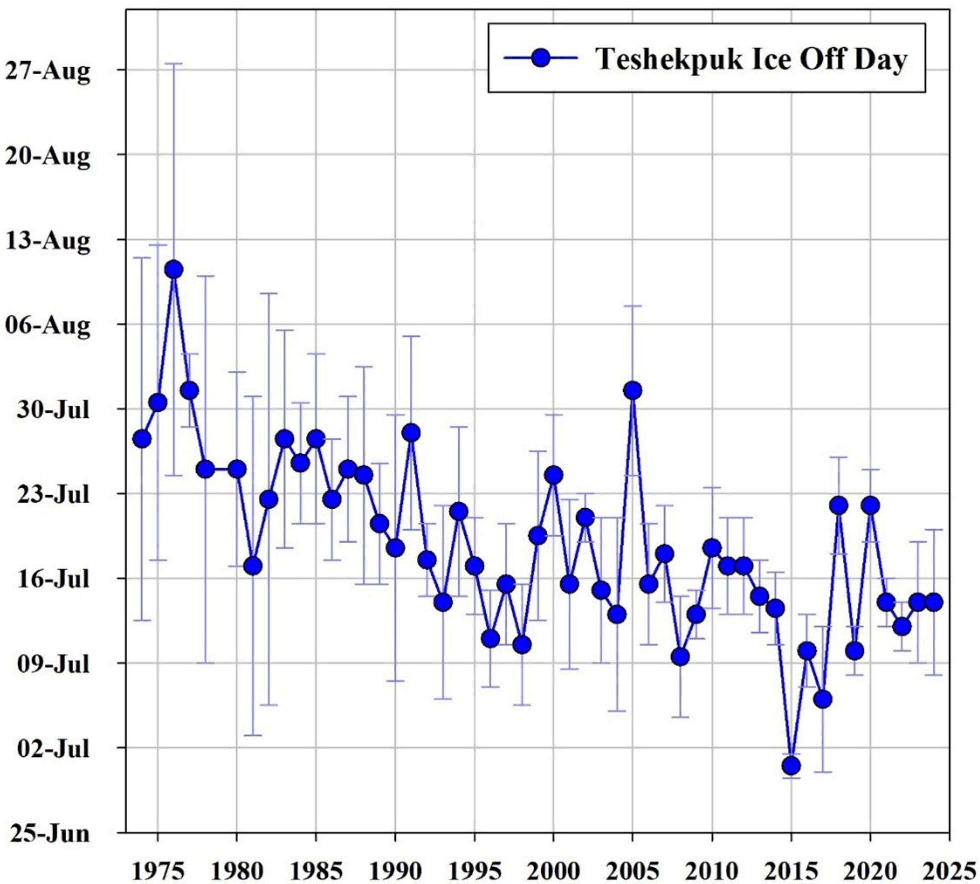

Figure 8: Annual timing of lake ice-off for Teshekpuk Lake, Alaska, from 1974 to 2024. Points represent the mean estimated ice-off day for each year, with vertical bars indicating uncertainty in estimation based on the availability of cloud-free optical satellite imagery. Over the 50-year record, there is a clear long-term trend toward earlier ice-off dates, shifting from late July and early August in the 1970s and 1980s to early- to mid-July in 21st century. This trend reflects regional warming and shorter ice-covered seasons, with important implications the operational window for ice-supported activities in Arctic Alaska.

CLIMATE-DRIVEN VARIABILITY, GEOPOLITICAL CHALLENGES, AND ARCTIC LOGISTICS

Figure 9: A field photo of the 6-13 foot (~2-4 meter) high Teshekpuk Lake ice pressure ridge that typically extends ~75 miles (~120 kilometers) across the frozen lake surface. The pressure ridge typically begins to develop in late December to early January but most actively grows to attain its maximum height around early May.

Our findings underscore Arctic lakes, and Teshekpuk Lake in particular, as a critical site for understanding Arctic environmental changes and their implications for security. As Senator Lisa Murkowski has highlighted, the 'Arctic represents a strategic frontier with rapidly evolving challenges that demand innovative scientific and operational responses' (Murkowski, 2023). As Arctic lake ice maximum thickness continues to diminish, access to remote areas increases, raising the stakes for natural resources exploration, infrastructure development and maintenance, domain awareness, safety, and security. This study directly addresses these concerns by advancing foundational research on lake ice growth and observations of hazards associated with pressure ridging, which are vital for understanding and adapting to the region's changing conditions. By integrating fieldwork with remote sensing and modeling, this research provides actionable insights for infrastructure resilience, disaster preparedness, and security strategy planning. Furthermore, the data collected from Teshekpuk Lake contributes to a broader understanding of Arctic systems, supporting national and global efforts to mitigate the impacts of climate-driven variability and protection of critical resources in the region.

Better-informed logistics over the shorelines of the Arctic will be instrumental in mitigating risks associated with these rapid changes. Reliable data on ice thickness, snow cover, and freeze-thaw cycles, such as that provided by this study, supports safer transportation routes and more efficient deployment of resources (Culpepper et al., 2024a; Dawson et al., 2017). Furthermore, the integration of remote sensing technologies and in situ measurements enables real-time monitoring, allowing decision-makers to adapt quickly to changing conditions. Future research should focus on enhancing remote sensing capabilities, such as higher spatial and temporal analysis of SAR imagery, to provide real-time data on ice runway conditions, and acquiring GPR data before, during, and after LC-130H flight operations to evaluate changes in the ice properties (Culpepper, Joshua et al., 2025). Enhanced observation and improved modeling of ice strength under dynamic loads and the integration of predictive tools for ice behavior will further support the safe and effective use of frozen lakes as operational runways in Arctic regions (Ashton, 1986; Babaei et al., 2016; Gribanov, 2020). These tools are essential for developing adaptive strategies to mitigate the impacts of climate-driven variability on Arctic lake ice and the associated security and operational challenges.

Geopolitical competition in the Arctic also demands enhanced domain awareness and improved infrastructure resilience to ensure safe and sustained operations in an increasingly contested and rapidly changing environment (Pollock Miriam et al., 2020b, 2020a). Understanding the physical properties of lake ice, such as its load-bearing capacity and vulnerability to fractures, provides critical information for establishing operational bases, constructing temporary runways, and supporting overland supply chains. Detailed knowledge of ice thickness, strength, and growth dynamics directly informs risk assessments and operational planning, helping to prevent accidents and infrastructure failures in extreme Arctic conditions (Culpepper et al., 2024a). By contributing to the foundational understanding of Arctic ice dynamics, this research provides actionable insights that are vital for navigating both the climate-driven transformations and the geopolitical pressures reshaping the region, ultimately supporting more resilient and informed decision-making in Arctic environments.

IMPORTANCE OF UNDERSTANDING LAKE ICE PRESSURE RIDGES

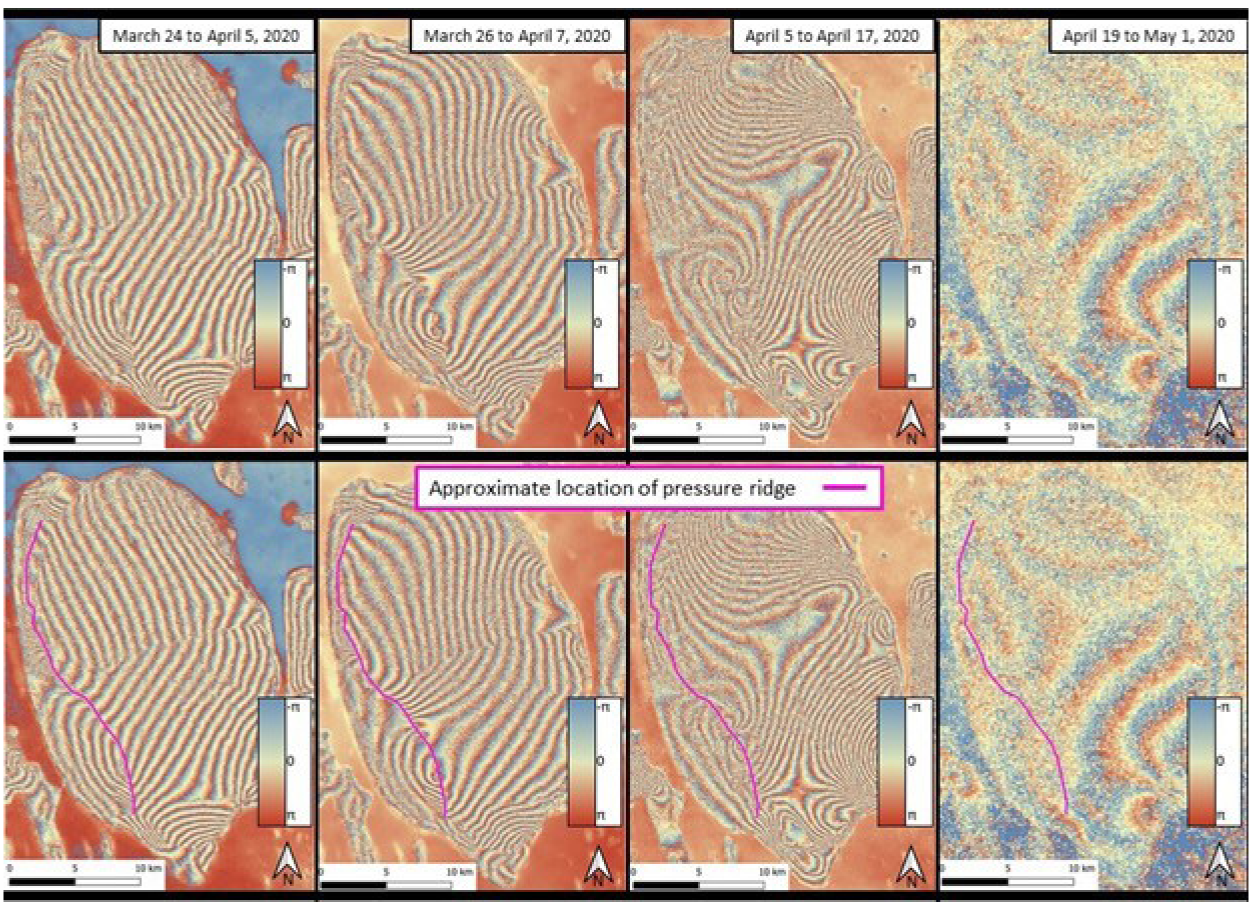

Figure 10: Interferograms of Teshekpuk lake in March to May, 2020 showing the approximate location of the pressure ridge (pink) and the ability to resolve deformation of the lake ice due to pressure ridge development.

Pressure ridges on lake ice pose a significant hazard to vehicles and aircraft operating in Arctic environments. These ridges, formed by the dynamic movement and fracturing of ice sheets under thermal stresses, can reach heights that compromise the safety of overland travel and airstrip operations. In the context of Teshekpuk Lake, the identification and monitoring of pressure ridges are essential for planning secure travel routes and establishing safe operational zones. GPR, Sentinel-1 SAR, and drone imagery can be instrumental in mapping and tracking these features, providing actionable data to mitigate risks (Rangel et al., In Review). For example, Sentinel-1 InSAR can be used to identify obstacles such as pressure ridges. InSAR has been used extensively to measure deformation in landfast ice and estimate ice stability (Dammann et al., 2019, 2018; Fedders et al., 2024; Meyer et al., 2011). InSAR provides measurements of relative phase change to the satellite in a single look direction with a spatial resolution of ~150 feet (~46 meters) and a current temporal resolution of 12 days (ASF Staff, 2020). Adjacent pixels with similar phase change values collectively form fringes. Fringe orientation, patterns, and spacing can be interpreted as different modes of deformation and amount of deformation or activity (Dammann et al., 2016). Coherence (defined on a scale from 0 to 1) is a measurement of correlation between phase values in a pixel window and is used to establish the quality of the interferogram (Werner et al., 2000). Incoherence can result from a change in the surface scattering layer such as melt or large deformation processes such as ridging (Kristenson, 2023). Discontinuities in phase gradient are interpreted as fractures or ridges, across which relative motion is ambiguous (Gao et al., 2023).

Sentinel-1 InSAR Interferograms of Teshekpuk Lake from March-May 2020 show the location and timing of the pressure ridge. Fringe patterns are consistent with ridging. Decorrelation and phase discontinuity are present at the ridge location, indicating high relative deformation. Fringe patterns are consistent with ridging with decorrelation and phase discontinuity at the ridge location, indicating high relative deformation. Measuring the timing of ridge formation with InSAR is confined by the 12-day temporal resolution but is consistent with ground observations in the spring. Measuring activity across an entire frozen season on Teshekpuk Lake is unreliable due to the lack of stable surface reflectors on the lake before substantial snow cover. The limited coherent interferograms in December 2020 and January 2021 show lower activity with fringe patterns consistent with low thermal strain. Across multiple years (2020-2022), increased activity around April and May is observed, consistent with ground accounts of pressure ridge activity and location associated with warming conditions in the latter part of the spring season (Rangel et al., In Review). Better understanding the physical processes driving pressure ridge formation is essential for predicting their occurrence and mitigating associated risks. This includes studying the interactions between thermal gradients, ice stress, and snow loading. Enhanced modeling approaches that incorporate these variables will be critical for operational planning and infrastructure design in Arctic regions. Future research should focus on the temporal dynamics of pressure ridge formation and their mechanical properties to enhance predictive capabilities and ensure the safety of critical Arctic operations.

LINKAGES TO THE JAS MISSION

The findings of this study strongly align with several themes highlighted in Volume 1 of the Journal of Arctic and Climate Security Studies (JACSS). Specifically:

- Climate variability and Environmental Security: As discussed by multiple contributors in Volume 1, including Dalton (2023), the rapidly warming Arctic necessitates adaptive strategies to address climate-driven changes. This study contributes by detailing the impact of climate-driven variability on lake ice dynamics, a key factor in understanding broader environmental transformations in the Arctic.

- Operational and Strategic Challenges: VanHerck (2023) emphasized the importance of domain awareness and infrastructure resilience in Arctic operations. This research provides actionable insights into the physical conditions of Arctic lake ice, aiding operational planning and infrastructure development.

- Data Integration and Technology: The use of Sentinel-1 SAR imagery and GPR data aligns with Hursch (2023) advocacy for leveraging advanced technologies to enhance Arctic domain awareness. The integration of field and satellite data in this study demonstrates a successful application of this principle.

- Interdisciplinary and International Collaboration: As noted in the introduction to Volume 1, fostering cross-sectoral coalitions is essential for addressing Arctic challenges. This research integrates academic and operational expertise, embodying the collaborative spirit encouraged by the Ted Stevens Center for Arctic Security Studies.

These connections underscore the relevance of this study to ongoing discourse in Arctic security and climate research, emphasizing its contribution to the themes and objectives of JACSS Volume 1.

CONCLUSION

This study demonstrates the critical role of collecting field-based lake ice observational datasets during synoptic surveys as well as through near real-time data tracking platforms to ensure the feasibility of Arctic lake ice runways, particularly for large-scale operations such as repeat LC-130H landings. Field measurements at Teshekpuk Lake confirmed rapid ice growth rates, driven by minimal snow cover and the high thermal conductivity of black ice, which allowed for the formation of a structurally strong frozen surface by early February 2020. The integration of satellite telemetered temperature loggers, GPR, and Sentinel-1 SAR imagery provided high-resolution data in near real-time on ice growth trends, validating that the required 55 inches (1.4 meters) ice thickness threshold was met prior to any potential field operations. This research highlights the importance of real-time ice monitoring, as climate-driven variability continues to alter freeze-up timing, ice growth and stability, and seasonal to annual variability across the Arctic. Future Arctic operations, whether for military logistics, scientific missions, or emergency response, will increasingly depend on adaptive ice monitoring strategies and enhanced predictive capabilities.

Beyond operational feasibility, this study underscores the broader implications of climate-driven variability on Arctic infrastructure and security. As Arctic ice conditions shift, historically reliable ice runways may become less predictable, increasing the risk of logistical challenges, transportation failures, and loss of life. The ability to accurately assess ice thickness and strength, detect hazards like pressure ridges, and predict future ice conditions is essential for maintaining safe and efficient

Arctic operations. Moving forward, continued investment in satellite-based ice monitoring, coupled with in situ validation and remote sensing techniques, will be essential for securing Arctic logistics in a rapidly changing environment. The findings of this study contribute to ongoing discussions on Arctic climate security, infrastructure resilience, and operational preparedness, aligning with the mission of the Journal of Arctic Security (JAS) to explore the intersection of science, security, and sustainability.

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Event Report

Arctic Warfare:

Strategic Imperatives and the Case for Enterprise Synchronization

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Arctic warfare has emerged as a critical focus in global military strategies, necessitating robust capabilities in training, equipment, and logistics. The Arctic region, once remote and largely inaccessible, is now at the forefront of global security concerns due to its strategic importance and a changing geopolitical landscape (White House, 2022a; 2022b). Despite individual advancements by various military services, efforts remain insufficiently aligned. To unify initiatives and drive coherent outcomes, the Department of Defense (DoD) should designate the Ted Stevens Center for Arctic Security Studies (TSC) as the Global Synchronizer within the bounds of its mission-serving as a neutral convener and secretariat. Service-level integrators would set Arctic priorities and standards, and an Arctic Coordination Cell (chartered under NDAA Section 911) would synchronize implementation across Services and CCMDs (114th Congress, 2016; White House, 2022a; 2022b). This event report examines the strategic imperatives of Arctic warfare, the geopolitical context, and funding constraints, and proposes targeted solutions, policy reform, establishment of an Arctic Coordination Cell to translate service priorities into joint execution, and enhanced joint and interagency collaboration to achieve consistent, DoD-wide synchronization and innovation.

GEOPOLITICAL SIGNIFICANCE IN THE ARCTIC

The resurgence of Great Power Competition (GPC) further underscores the Arctic's significance, echoing Cold War era strategic rivalries between the United States and the Soviet Union. Today's GPC centers on influence, access, and military capability, often tied to territorial claims and resource exploitation (GAO, 2016; White House, 2022a). Russia has been assertive in its Arctic ambitions, militarizing the region and asserting control over the Northern Sea Route (White House, 2022a). Meanwhile, the People's Republic of China (PRC) is identified in the 2022 National Defense Strategy as the United States' most consequential strategic competitor and pacing challenge, expanding its global logistics and basing footprint to enable greater power projection (White House, 2022b). Furthermore, U.S. strategy and scientific assessments indicate that diminishing Arctic Sea ice is opening additional maritime routes and access to previously unreachable resources, heightening geopolitical friction among Arctic and near-Arctic states (White House, 2022a). Authoritative analyses conclude that strategic competition in the Arctic is not solely about resources, but equally about influence, access, and power projection (GAO, 2016).

STRATEGIC IMPERATIVE

Looking ahead, continuous adaptation and innovation constitute a strategic imperative for navigating the dynamic Arctic landscape and ensuring national security in an era marked by strategic competition and technological advancement (Lynch, 2020; Mahnken, 2017). Addressing this imperative requires a comprehensive approach that integrates military, economic, and diplomatic strategies to counter the growing influence of rival powers in the Arctic (Jacoby & Shaw, 2016; GAO, 2016)

CHALLENGES IN COORDINATION AND FUNDING

Efforts to prioritize Arctic warfare encounter inherent challenges within governmental structures, particularly in funding allocation and organizational priorities. Annual government funding is aligned to specific appropriations and programs, constraining flexibility for innovative initiatives. Reprogramming is limited by appropriations law and DoD budget execution rules (Congressional Research Service n.d.; DoD n.d.; White House, 2022b). Office of Management and Budget (OMB) Circular A-11 further structures budget formulation and execution processes that shape timing and flexibility (n.d.). In practice, portfolio choices must align with Planning, Programming, Budgeting, and Execution (PPBE) timelines and applicable reprogramming thresholds to avoid Anti-Deficiency Act exposure and maintain fiscal discipline (Congressional Research Service n.d.; DoD n.d; OMB, n.d.). Moreover, each major military command contends with competing mission priorities, complicating access to additional funds or resources for Arctic-focused projects. This financial rigidity hinders adaptation to the rapidly changing Arctic environment, where specialized equipment, infrastructure, and training are increasingly urgent. The 2022 National Defense Strategy emphasizes the need for agility and rapid adaptation to meet evolving threats and fiscal constraints (White House, 2022b).

The Arctic's harsh environment presents unique challenges that differ significantly from other theaters of operation, requiring specialized training and equipment. The National Strategy for the Arctic Region stresses aligning resources, manpower, and planning efforts within a coherent competitive strategy (White House, 2022a; 2022b). Achieving these demands requires logistical adaptation and policy adjustments to ensure forces are prepared to operate in extreme conditions. To remain competitive, the United States must employ resources more effectively and efficiently through integrated planning and coordinated execution (White House, 2022a; 2022b).

One key challenge is the lack of a cohesive policy framework tailored to Arctic warfare. Current approaches are often fragmented, with different branches pursuing their own Arctic priorities without sufficient coordination, leading to redundancy, inefficiency, and missed opportunities for joint initiatives and resource sharing. Overcoming this fragmentation requires deliberate institutional design and sustained political and financial support, enabled by strategic agility and joint governance mechanisms (Long, Robinson, & Jones 2017; Lynch, 2020).

CALL FOR ENHANCED COORDINATION AND POLICY REFORM

Given these geopolitical dynamics and institutional constraints, clear enterprise-level coordination is required to convert strategy into sustained Arctic readiness and interoperability.

First, reprioritization and strategic alignment are essential. The government should realign resources toward Arctic warfare, minimizing redundancy and maximizing efficiency across military services. This includes investing in specialized training, developing equipment tailored for cold-weather operations, and modernizing logistics and infrastructure to sustain distributed operations at range. Minimizing redundancy is fundamentally an institutional problem: fragmented authorities, service-centric budget lines, and parallel requirements processes incentivize duplicative efforts, slow decision-making, and misaligned investments. Addressing this requires enterprise mechanisms that enforce unity of effort, common standards and interoperability targets, joint portfolio reviews to rationalize overlapping programs, shared training and test ranges, consolidated procurement pathways for Arctic kits, and outcome-based performance metrics tied to resourcing, anchored by service-level integrators who set standards and priorities, synchronized by TSC within its mission, and implemented through an Arctic Coordination Cell (Lynch, 2020).

Second, joint and international integration must be strengthened. Establishing joint, interagency, and international partnerships is essential for enhancing communication, standardization, and sharing best practices. The Arctic is a global concern, and no single nation can address its challenges alone. Collaboration with NATO allies and Arctic partners (e.g., Canada and Norway) should be deepened to ensure a unified approach to Arctic security (White House, 2022a; 2022a; GAO, 2016). Centralizing Arctic strategy execution through a dedicated platform or cell can streamline coordination, improve intelligence and resource sharing, and accelerate collaborative innovation (White House, 2022a; 2022b).

Third, policy agility is required to respond to evolving geopolitical dynamics and technological advancements. Flexible policy frameworks empower leaders to adopt proactive measures against global competitors; in the Arctic, this means adapting rapidly to new threats and opportunities arising from the operational environment, technological innovation, or geopolitical shifts (Lynch, 2020: White House, 2022b).

Fourth, establish an Arctic Coordination Cell under NDAA Section 911 to serve as the central hub for synchronizing Arctic initiatives across all military services and agencies. Recommendation: charter the Arctic Coordination Cell as a Deputy Secretary-led Office of the Secretary of Defense (OSD) cross-functional team, with OSD-Policy (Assistant Secretary of Defense for Strategy, Plans, and Capabilities, ASD(SPC)) as the proponent and Joint Staff J5 (Strategy, Plans, and Policy) as the operational deputy, and designate U.S. Northern Command (USNORTHCOM) as the supported Combatant Command (CCMD) with U.S. European Command (EUCOM) and U.S. Indo-Pacific Command (INDOPACOM) in supporting roles to enforce unity of effort and reduce duplication. Pursuant to Section 911, the charter should define supported/supporting relationships, decision rights, data-sharing requirements for a common Arctic readiness dashboard, and outcome-based metrics reported to senior leadership and Congress (114th Congress, 2016) . Service-level integrators set priorities and standards and adjudicate cross-portfolio tradeoffs; TSC synchronizes within its mission as a neutral convener and operational secretariat; Services and CCMDs retain execution and force readiness responsibilities. This entity would foster better resource allocation and joint efforts, streamline Arctic readiness, and facilitate collaboration with international partners. During the Arctic Edge 2024 exercise, joint forces collaborated with interagency partners to address operational gaps, experiment with new tactics and processes tailored to Arctic challenges, and share best practices across services and agencies, demonstrating the value of synchronized implementation.

EVENT REPORT: ARCTIC EDGE 2024 FTX—AFTER-ACTION NARRATIVE

Arctic Edge 2024 provided practical insights into training, equipment, performance, and joint synchronization in extreme conditions. Integrated collaboration across services and agencies improved outcomes in the Arctic's extreme conditions. Early acclimatization and targeted training, Arctic Resiliency Training (ART) and Below Zero Medicine (BZM) reduced preventable injuries. To institutionalize these gains, formalize and extend ART (two nights) and adopt a two-tier BZM (non-clinicians and clinicians), supported by an advance, comprehensive gear list and a central cold-weather clothing issue to ensure uniform readiness. Synchronized all-hands in-briefs and recurring joint training repetitions are needed to align experimentation objectives and improve interoperability. Where communication gaps persisted, outcomes varied and timelines slipped; in one case, a mass-casualty lane expected to take about 10 minutes required approximately 45 minutes in snow and ice because cold-weather gear, triage demands, and terrain conditions increased complexity. This underscores the need to standardize joint processes and expand cold-weather practice. Equipment performance was a recurring constraint-cumbersome sleds, unreliable portable oxygen systems, and shelters vulnerable to snow load-pointing to Arctic-specific research, development, testing, and evaluation (RDT&E) and realistic cold testing to field lighter, more stable sleds; better-insulated, reliable oxygen systems; and rapid-setup shelters with clear casualty access. Codified Arctic Tactics, Techniques, and Procedures (TTPs) and cold-weather Tactical Combat Casualty Care (TCCC), including Military Working Dogs, and integrated into pre-exercise training, and an Arctic theater entry requirement for all personnel will reduce avoidable risk and enhance readiness. To avoid parallel efforts and align exercises, standards, and investments with strategy, the military services and designated combatant commands should integrate training, experimentation priorities, equipment portfolios, and interagency/allied inputs under Joint Staff and OSD policy guidance. Service-level integrators set priorities and frameworks; TSC supports as the Global Synchronizer within its mission-acting as a neutral convener and educator without operational authority-and the Arctic Coordination Cell synchronizes cross-service implementation. Observations should be documented and made readily accessible and shareable across all services through a common repository to ensure easy access and cross-service learning.

ROLE OF THE GLOBAL SYNCHRONIZER AND THE TED STEVENS CENTER

A lead entity in the role of a Global Synchronizer is required. Designate the Ted Stevens Center for Arctic Security Studies (TSC) as the Global Synchronizer within the bounds of its mission, serving as a neutral secretariat and convening venue; service-level integrators set Arctic standards and priorities; the Section 911 Arctic Coordination Cell implements across Services/CCMDs, interagency, and allied partners (114th Congress, 2016; White House, 2022a; 2022b). At the Annual Security Conference, a breakout session highlighted the practical benefits and opportunities of this approach: cross-service discussion of priority gaps and draft common training standards; identification of duplicative efforts; a preliminary joint roadmap linking exercises, experimentation, and resourcing; commitments to shared data and lessons-learned repositories; and deeper coordination with interagency and allied partners. These takeaways support continued use of the Ted Stevens Center for Arctic Security Studies in its proper role-as an educational and convening venue that connects stakeholders and curates' lessons-while coordination of Arctic operations and standardization/enforcement of readiness remain the responsibilities of the services, Joint Staff, and designated combatant commands under department-level authorities.

CONCLUSION

Arctic warfare stands as a critical frontier in modern military strategy, shaped by Great Power Competition and rapid environmental change (GAO, 2016; White House, 2022a; 2022b). Sustained U.S. advantage will depend on policy agility, disciplined resourcing, and enterprise-level unity of effort (114th Congress, 2016; White House, 2022a; 2022b). To that end, DoD should designate the Ted Stevens Center for Arctic Security Studies as the Global Synchronizer within the role of its mission; empower service-level integrators to set priorities and standards; and employ an Arctic Coordination Cell to translate policy into joint standards, exercises, and portfolio rationalization across Services/CCMDs and interagency/allied partners (114th Congress, 2016; White House, 2022a; 2022b). These steps minimize redundancy, maximize efficiency, and accelerate innovation, enabling DoD to lead in Arctic operations and navigate the region's complexities with coherence and speed in the 21st century. Progress should be tracked through measurable outcomes, including shared Arctic readiness metrics, a common Arctic readiness dashboard, and portfolio rationalization milestones reported quarterly to senior leadership and Congress (114th Congress, 2016).

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The *Journal of Arctic Security*, the flagship publication of the Ted Stevens Center for Arctic Security Studies, is committed to innovation and excellence in Arctic defense education, relevant practitioner-focused research, and collaboration with America's Arctic security Allies and partners. The *Journal of Arctic Security* is a forum for interdisciplinary intellectual exchange in the spirit of innovation, experimentation, education, analysis, and engagement.

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