Expanding the Advantage: United States Navy Surface Ship Arctic Operability

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Synopsis

A maritime presence in the Arctic region is essential in the Great Power Competition with the Russian Federation and the People's Republic of China. This paper discusses US Navy Arctic policy and operational guidance, the US Naval Sea Systems Command Arctic Pack Up Kit prototype, the recent USS *Kearsarge* operations in the Arctic, the importance of ship crew training, and surface ship capabilities necessary to ensure mission success. The importance of operating in the extreme cold and unpredictable Arctic environment is crucial to our national strategic imperative of a secure and stable region. It is critical that US Navy ships can operate safely and effectively with capabilities that reduce the impact of topside sea ice accumulation and detect sea ice in the dark and in sea fog. Investments in these capabilities will enable US and allied naval forces to maintain enhanced presence and expand our competitive advantage in the Arctic Region.

Keywords: Arctic, Ice, High North, Operability, Great Power Competition

1. Introduction

The defeat of the Soviet Union in 1991 ushered in a new era. New countries emerged from the fall of communism, opportunities abounded for economic and social development, and old battlegrounds such as the Arctic faded into the background. Yet in so many ways the past is prologue, as the Russian invasion of Ukraine has demonstrated in brutal yet unsurprising fashion. Far to the North the Arctic region is once again a battleground between the world's most powerful nation-states, one in which their navies play an extremely important role. The frequency and duration of Unites States Navy surface ship operations in the ice-diminished waters of the Arctic region has increased in recent years. The Arctic is of critical strategic importance to the United States and the US Navy and its allies' ships must be capable of operating safely and effectively in this hostile environment of sea ice, sea fog, extreme cold, long periods of dark/diminished sunlight, ship topside icing, heavy seas and unpredictable weather.

This paper discusses US Navy Arctic policy and guidance, surface ship operational requirements and capabilities, near-term operator guidance and pack up kits, and ongoing scientific research and technology development including at-sea experimentation. The unique and challenging conditions of the Arctic region present an opportunity for innovation and new technology solutions that deliver capabilities necessary for surface ships to operate in this unforgiving maritime environment. The region is among the most challenging for operators on land, sea, and in the air, and some of the hardiest explorers in history have ventured past the Arctic circle, many never to return. Yet despite these enormous challenges many modern navies choose to risk Arctic operations. No other choice exists but to go North.

Author's Biography

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2. The Arctic Environment

"The North is not just a compass point but a state of mind. It has a geographical location and at the same time it exists wherever its call is felt." (McIntosh, 2019, p.1) This quote, from Nordic historian Christopher McIntosh in his new history of the region pays homage to the mythical quality of the Far North, as evoked by the Greeks, the Vikings and the polar explorers of the modern era. The quote also evokes the cold reality of the region. The Arctic is a harsh environment, requiring a mindset and psychology dedicated to survival, whether on land or at sea. The region challenges a human's natural limits, in terms of temperature, visibility, remoteness, and the availability of food and water.

Today the Arctic region has again become a battleground for Great Power Competition, as the United States, the Russian Federation, and now the People's Republic of China (PRC) work to situate themselves for dominance and access to its vast resources and strategic geography. During the Cold War the United States and the Soviet Union both made their presence at the top of the world a geostrategic priority, but more than 30 years after the Cold War ended, due to new technology and the realities of climate change, access and ownership of the Arctic has emerged as a key prize of the Great Powers. Even more so than during the Cold War, the Russian Federation has allocated enormous resources towards the development of the Arctic. In 2007 a Russian naval expedition planted its national tricolor flag on the seabed of the North Pole. (Honneland, 2016, p. 1) The PRC, despite no geographic connection to the region, as declared itself a "Near Arctic Power," and has also made investment and research in the Arctic a priority for its global ambitions.

Beyond its military investment Russia has taken advantage of the physical changes wrought by climate change to increase its access to economic resources. Prior to the Ukrainian-Russian War, Russia's northern Arctic territories account for 20% of its total GDP and 10% of its exports, but with greater Arctic investment Moscow could likely increase these numbers. (Eumer, Sokolsky, Stromki, 2021, p. 4) Beyond the opportunities for increased hydrocarbon and energy exploitation, operating a viable Northern Sea Route (NSR) has been a major goal of Russia for centuries. From 1910 to 1915 the Russian Navy authorized a series of ice breaking expeditions to chart the route after Russia's disastrous defeat in the Russo-Japanese War of 1904-05. (Starokadomskiy, 1976, p. xiii) Long a Russian dream, this route may nearly be within reach. In 2017 a Russian oil tanker sailed from East Asia through the NSR above Siberia to Europe, completing the journey in only 19 days, as compared to the usual 48 days through the Strait of Malacca and the Suez Canal. If warming trends continue the NSR has the potential to dramatically shorten shipping routes within the Northern Hemisphere.

To seriously challenge Russia and its Arctic ambitions, as well as those of the PRC, Western navies must enhance their warships' operational capability in the region. But modern naval warships, with a few exceptions, are not equipped for such conditions. When operating at the high latitudes modern surface warships must contend with a host of operational threats, including the effects of sea ice on ship stability and sensors, floating sea ice presenting a hazard to navigation and the ship structure, unreliable radio communications and gyro compass readings, and extremely poor visibility. These challenges to ship operations do not take into account secondary requirements such boat launch and recovery, replenishment at sea, and even avoiding marine mammals in Arctic waters, to say nothing of the unforgiving temperatures that can lead to hypothermia. See Figure 1.

Figure 1: Arctic environment

3. US Arctic Policy

All this means that the United States, particularly its naval forces, must adapt to operate successfully in the Arctic. To explain how the United States Navy plans on improving Arctic operability, it is useful to review a summary of current US government guidance and strategy on the region. The available government publications on the Arctic region are enormous and often overlapping, and each US military branch maintains its own jurisdictional expertise. The United States Army, for example, has a long history of Arctic operations and maintains the Northern Warfare Training Center (NWTC) in Fort Wainwright, Alaska. Similarly, the US Army's Cold Weather Manual, FM 31-70, is considered a classic in Arctic survivability and training. Yet in the 21st century joint warfare publications are among the most critical in determining current US Navy Arctic strategy. Chief among these are three documents from the Joint Requirements Oversight Council, or JROC. The JROC is headed by the Vice Chairman of the Joint Chiefs of Staff, currently Admiral Christopher Grady, the former head of the US Fleet Forces Command, and is tasked with assisting the Joint Chiefs with policy guidance and assessing military capability and performance in a variety of joint missions.

The first of the primary Arctic related documents is the JROCM 107-17, also known as the Initial Capabilities Document (ICD) for Arctic Maritime Home Defense (AMHD). As the US Navy is the lead DoD component of this effort, this document is primarily concerned with naval exercise deployments in the Arctic region. Fundamentally the "JROC recommends further analysis be conducted to consider a broad range of solutions across the joint force in the ice diminished waters of the Arctic. This analysis should consider all solutions whose capabilities pace the future threat of the Arctic region." (JROCM, 2017, p.1) Overall, this key memorandum pushes for innovative solutions to support surface ship deployment in the Arctic and recommends taking advantage of the increased access to the region due to climate change.

Two other primary JROC memorandums concerning Arctic related naval matters are the JROCM 099-18, the Initial Capabilities Document (ICD) for Future Surface Combatant Forces, and JROCM 043-20, "ICD for the Arctic Maritime Homeland Defense-Logistics." The first of these, released in September 2018, is entitled "Initial Capabilities Document for Future Surface Combatant Force." Although not specifically dealing with the Arctic region, this is a key strategy for modernizing the Navy's surface combatant force to integrate both manned and unmanned surface vessel that will "keep pace with technological advances throughout the vessel's services lives." (JROCM 099-18, 2018, p. 1). JROCM 043-20, released in May 2020, identifies gaps in Arctic logistics, most notably the lack of afloat refueling at sea in Arctic waters.

Beyond these more specific Joint publications, the sea services have been the beneficiary of a profound shift in Arctic policy in recent years, which has been reflected in the volume of official documents relating to Arctic operability. Chief among these is the new "A Blue Arctic," a Department of the Navy Strategic Blueprint for the Arctic released in 2021. This bold strategy dictates a renewed focus for the US Navy in the High North, emphasizing the importance of an American naval presence in the region. Laying out a comprehensive strategy, the publication authors warn, "Without sustained American naval presence and partnerships in the Arctic region, peace and prosperity will be increasingly challenged by Russia and the PRC, whose interests and values differ dramatically from ours." The "Blue Arctic" strategy focuses on three main priorities: building a more capable Arctic naval force, modernizing and investing in existing capabilities, and evaluating improvements in overall Arctic presence and familiarity, including the US industrial shipbuilding base. Knowledge of the changing Arctic, such as improved hydrographic survey in ice-diminished waters will be critical for future deployments in the region. (US Navy Publication "The Blue Arctic: A Strategic Blueprint for the Navy, 2021, p. 2)

Complementing the new Navy "Blue Arctic" strategy is a broader US Department of Defense "Geostrategy of the Arctic." The document states that the "DoD's desired end state for the Arctic is a secure and stable region in which US national security interests are safeguarded, the US homeland is defended, and nations work cooperatively to address shared challenges." Like the Blue Arctic strategy this directive outlines three main strategic objectives: building Arctic awareness, enhancing Arctic operations, and strengthening the rules-based order in the Arctic. To accomplish all this both the US Navy and the US Coast Guard must build on recent successes and increase operations above the Arctic circle by maximizing participation in multinational exercises, including Operation

Arctic Edge and Dynamic Mongoose. Concurrently the US Marine Corps, long neglected in Arctic exercises, will increase its participation in multi-lateral exercises such as Dynamic Mongoose and Joint Viking.

Additional guidance strongly informs US Navy Arctic policy. One is the recent Naval Sea Systems Command Arctic Integrated Flag Oversight Board decision for a three-tier approach to surface ships that includes 1) Arctic mission preparation, 2) innovative technology insertion, and 3) fortification and ice hardening of existing ships. Lastly is the US Navy's Arctic Operational Guidance/Cold Weather Bill. This document outlines guidance on how to maneuver US Navy warships in ice infested waters and inform operators on the nature of sea ice in the marginal ice zone. As the guidance makes clear, however, "US Navy Surface Warships are not designed to accommodate ice going loads." Although extremely detailed, the guidance places strong limitations on just where and how US Navy warships can operate in the Arctic region. (ATP-17, Chapter 11.1)

4. Challenges Associated with Arctic Operations

Although it is obvious that the US Navy has become focused on the Arctic in its words, this must be matched by deeds. A coherent strategy for achieving sustained surface warship Arctic presence relies on a balance of warfighting, open water mobility and Arctic hardening of its surface fleet. During the Second World War the US Navy's approach was to build the *Wind* class icebreaking destroyers, powerful combatants that also had exceptional polar capabilities for their time. Their design was strong but also rather flawed. The *Wind* class overmatched the uncertainty of unpredictable ice loads by compromising ship speed and agility. A better balance can be achieved though increased confidence in detecting the presence of ice in a seaway, identification of ice properties, and the steady and dynamic impulsive loading for identified ice type, size and thickness at a given ship's speed.

Today instead of armed icebreakers the US Navy relies on existing technologies and ship designs that can be adapted better to Arctic use. The limitations of detecting sea ice using onboard ship sensors is well established problem. By far the most important electronic navigation tool in the Arctic, as it is around the world, is radar. It seems without doubt that history's most famous maritime encounter with ice, the sinking of the RMS *Titanic* in 1912, would have very likely been avoided if even a primitive surface radar system had been available. Over the past century radar technology has improved exponentially, and capable radar systems are installed on nearly all oceangoing vessels around the world.

Yet in the Arctic even radar his significant limitations, and sea ice has unique characteristics that defy even the most sophisticated radar system. The evolution from visual sightings of ice to radar, sonar and then electro-optical sensors has gained little real improvement for ice smaller than icebergs or bergy bit size due to unique characterization of the Arctic environment and the difficulty in discriminating small ice floes hidden inside surface waves. (ATP 17, NATO Arctic Manual, 2022, Chapter 12.7) In short radar <u>can</u> detect large icebergs, but smaller bergs and growlers capable of causing damage even to ice strengthened ships pose a significant problem. (ATP-17, Chapter 11.1) See Figure 2. While huge improvements in iceberg and large sea ice detection and tracking have been made using airborne and now space-based systems much more work needs to be done in developing an ability to detect smaller profile pieces of ice. (NATO Cold Weather Report, 2015, Paragraph 5.7) Currently, these efforts are concentrated on the downstream processing of radar returns to better 'tune' modern radars to display ice more effectively.

Figure 2: CG 60 operating in ice infested waters

Beyond detection in the Arctic the availability of cold weather lifesaving gear is of critical importance. Most warships do not have lifeboats and rafts that will ensure survival of personnel in extreme cold. Hypothermia will quickly take the lives of nearly all crew members forced to abandon ship in extreme Arctic conditions. (ATP 17, 2022, Chapter 9.9) Yet even in more moderate conditions, with air and sea temperatures just below the freezing mark, long term survival is unlikely. Frozen drinking water, the buildup of carbon dioxide inside enclosed rafts, the lack of insulation, and the inability to warm Sailors adequately all make survival problematic. Of special concern is the fact that modern surface combatants rarely train on how to use their lifesaving gear, a factor made all the more important in the Arctic where only a few minutes can mean the difference between life and death. (APT 17, 2022, Chapter 9.9)

Simple and relatively inexpensive solutions exist that can mitigate some of these conditions, and modern and survivable life rafts are available that greatly increase the chances of survival. However, the best of these Arctic capable lifeboats are expensive, and most modern navies are unable to afford their higher cost. Furthermore, they would likely require ship structural modifications and could not be easily applied to existing surface combatants. Yet if the US Fleet and other navies are to operate successfully and routinely in the Arctic funding and upgrades must accompany the allocation of resources.

Another concern for surface ships operating at high latitudes is the problem of topside ice accumulation. As with every car on the road, ice needs to be removed from the decks and upper works in order for a ship to operate a ship safely. See Figure 3. Warships capable of flight operations which have accumulated heavy amounts of ice and snow topside are often unable to launch and recover aircraft. Gained from centuries of experience navies and coast guards around the world have developed several time-tested techniques for ice removal, such as ice scrapers and baseball bats. Due to changes in propulsion preferences, however, one technique is no longer readily available. In previous decades steam lances fed by ship's boilers was a viable option, but today few surface ships utilize this form of propulsion. (ATP 17, 2022, Chapter 5.7)

Figure 3: Topside ice accumulation on a DDG 51

Beyond improvements to ship design and construction, adequate and improved Arctic training must be emphasized for future deployments in the High North. Robust and effective training programs for 'ice pilots" exist among several NATO members including Canada, Denmark and Norway, as well as soon near members Finland and Sweden. The United States Coast Guard also has a training program for icebreaker operators. However, despite the availability of these programs few US Navy officers have had the opportunity or time for such training. Last year a US Navy Surface Warfare Officer was embarked on the recently commissioned Canadian Arctic & Offshore Patrol Ship (AOPS) HMCS Harry DeWolf, a new armed icebreaker capable of long-range patrols in the High North. This deployment took the ship through the Northwest Passage and circumnavigated North America, providing invaluable training in both long rang navigation and ice piloting. Taking advantage of such training opportunities with our Arctic allies will be of critical importance.

To better prepare for Arctic operations the US Naval Sea Systems Command (NAVSEA) has developed a prototype Arctic Pack Up Kit (PUK). This kit can be repurposed for nearly any surface warship class and contains a variety of components to improve Arctic operability. Although the components would vary by ship class, the core equipment would include Cold Weather Personal Protective Equipment (PPE) clothing, night vision binoculars, High Intensity Searchlights, and cold resistant lithium batteries. Other components would likely include ice melt chemicals, portable space heaters, in-port ice management bubblers, and Rigid Hull Inflatable Boat (RHIB) engine lube oil heaters. The PUK is designed to be highly adaptable, however, and other components such as steam lances or other cold weather gear will be identified and included in future cold weather deployments.

One example of recent US Navy operations in the Arctic comes from the USS *Kearsarge* (LHD-3), a large deck amphibious landing ship that deployed to Northern Europe and the Mediterranean in the spring. During their deployment the USS *Kearsarge* sailed north of Norway and encountered Arctic conditions that tested the large ship and her crew, with the unpredictable weather and snow conditions often dictating operations. One junior officer onboard the *Kearsarge* had this to say about the experience: "Weather gets a vote. When you're having to coordinate ops [operations] in the High North, you have to be ready for weather to shift that plan many times over. Weather is predictable and unpredictable at the same time, it can be awesome one moment and a blizzard the next!" She went on to describe other operational challenges, such as the curvature of the Earth at high latitudes, exposure times for Sailors topside, and the need for extremely detailed planning. (Jordan, 2022, p. 1)

NATO and partner nations, especially the Scandinavian countries and New Zealand, have been active in improving their capabilities and addressing standards for non-ice strengthened naval vessels, and commissioning Offshore Patrol Vessels and auxiliaries capable of operations in ice. Under NATO sponsorship, a research and technical demonstration effort is underway in the Advanced Vehicle Technology area focused on sea ice collision prediction and risk mitigation. In another effort, NATO's Ship Design Capability Group has a specialist team concentrating on polar ship design and safety that has participated in the update to the NATO Arctic Manual (ATP 17) which is the tactical publication for conducting operations in polar regions.

5. Areas for Future Research

As the US Navy and its allies continue to increase the frequency and duration of their surface deployments in the Arctic region it is imperative that maritime nations invest in science and technological capabilities to further sustained operations beyond the summer months in the Northern Hemisphere. As previously noted, a great threat to surface ship operability is the danger of small "chunks" of sea ice at night or in heavy fog, a very common condition in the Arctic. In 2017 the US Navy and Coast Guard demonstrated the Passive Millimeter Wave (PMMW) imaging sensor on the USCG *Healy*. Funded by the US Navy's Office of Naval Research (ONR), the after-action report on the test concluded that "the sensor proved capable of identifying ice floes at detection ranges in heavy fog, defining the horizon and water line in varying visibility conditions, and performing harsh weather conditions, including freezing temperatures, sea swells, high winds and rain." (US Navy PMMW Report, 2017, p. 2). Technologies such as the PMMW imaging sensor may be able detect small pieces of floating ice or ice floes, even in the most challenging visibility conditions. See Figure 4.

Figure 4: PMMW imaging sensor demonstrated in USCG HEALY

Another operational challenge, topside ice accumulation, may also have a partial new technological solution. Extra weight from topside ice accumulation can burden a ship and result in extreme rolling. The capability to predict and monitor topside ice accumulation would increase safe ship stability and significantly lower the likelihood of personnel and equipment casualties. Investment in advanced low friction hull coatings could also reduce the impact of sea ice accumulation on ship hulls at or below the water line and minimize effects of sea ice loading. See Figure 5.

Figure 5: Sea ice loading on the hull of a DDG 51

6. Conclusion

The United States is an Arctic nation, and after decades of largely ignoring the region, US Navy surface ships are once again focused on the High North. This challenging environment represents both risks and opportunities for the world's navies and must be addressed with sufficient resources. By relying on its previous Arctic experience and employing new, innovate technologies, the US Navy surface Fleet will conduct a broader range of missions in the Arctic Region. See Figure 6.

Figure 6: Arctic Region

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References

Allied Tactical Publication (ATP) 17, NATO Arctic Manual, U.S. Government Publication.

Honneland, G. 2020, *Russia and the Arctic: Environment, Identity, and Foreign Policy*, Bloomsbury Publishing.

Joint Requirements Oversight Council Manual (JROCM) 107-17, 2017, U.S. Government Publication.

Joint Requirements Oversight Council Manual (JROCM) 099-18, 2018, U.S. Government Publication.

Joint Requirements Oversight Council Manual (JROCM), 043-20, 2020, U.S. Government Publication.

Jordan, S. 2022, Interview with the author.

McIntosh, C. 2019, *Beyond the North Wind: The Rise and Fall of the Mystic North*, Weiser Books, Newburyport, MA

Rumer, E., Sokolsky, R. Stronski, P. 2021, “Russia in the Arctic: A Critical Examination” Carnegie Endowment for International Peace

Starokadomskiy, L.M. 1976, *Charting the Russian Northern Sea Route*, Montreal, McGill-Queen’s University Press

U.S. Navy “A Blue Arctic: A Strategic Blueprint for the Navy”, 2021, U.S. Government Publication

U.S. Navy Passive Millimeter Wave Report (PMMW), 2017, U.S. Government Publication