Defense of North America from the Arctic

University of Southern California SHIELD Program

Viterbi School of Engineering Price School of

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Abstract

The importance of the Arctic to North American Defense has continued to grow in significance as an avenue for threats from Russia, China, Iran, and the Democratic People's Republic of Korea (DPRK). There is an urgent need to tackle the lack of energy, communications, and transportation infrastructure, all of which are necessary to enable next generation detection and defeat of these threats. Canada and Alaska represent more than one third of the global land mass above the Arctic Circle, however, less than half a percent of the United States and Canadian population lives in the Arctic. As a result of this extremely low population density, investment in key energy, communications, and transportation infrastructure that are taken for granted in other areas, are required to enable next-generation detection-and-defeat mechanisms for air and missile threats in the Arctic. While these challenges are not new, the return of strategic competition and advances in adversary technology, coupled with increased access to the Arctic as a result of climate change, has reinforced the importance of domain awareness in the Arctic. Additionally, investments in these critical infrastructure areas should provide dual-use benefits not only to the defense of North America, but also to northern residents, making such policy decisions a win-win prospect.

Keywords: Arctic, defense, energy, communications, transportation, infrastructure

Background

The Threat

Almost any missile attack from Russia, China, Iran, or DRPK is likely to have a trajectory that crosses the North American Arctic to reach a target in Canada or the United States (the notable exception being missiles launched from maritime platforms in the Atlantic or Pacific). As climate change progresses and global interest in and access to the Arctic increases, the opportunity for exploitation by adversaries exists. Increased commercial access to the Arctic through tourism, resource exploration and adventurism requires greater all domain awareness and increased requirement for services and the ability to respond to emergencies. This increased activity in the Arctic results in increased pressure on scarce energy, transportation, and communications infrastructure, complicating domestic surveillance and sovereignty monitoring, search and rescue, and daily life for Arctic inhabitants.

The Environment

The Arctic is a vast, resource rich, environmentally sensitive, and very sparsely populated region of the world, shared by eight countries – The United States, Canada, Denmark (Greenland), Iceland, Norway, Sweden, Finland, and Russia. Combined, Canada and the United States comprise approximately 30% of the circumference of the global Arctic measured at the Arctic circle. Alaska covers 1.732 million square kilometers (570,380 square miles) and is home to 730,000 people, slightly more than 0.2% of the United States population. Canada's Arctic territories cover 3.994 million square kilometers (1.542 million square miles) and approximately 200,000 people, which is approximately 0.5% of its total population. This vast territory and its harsh climate, combined with its extremely low population density, present a multitude of challenges for continental defense.

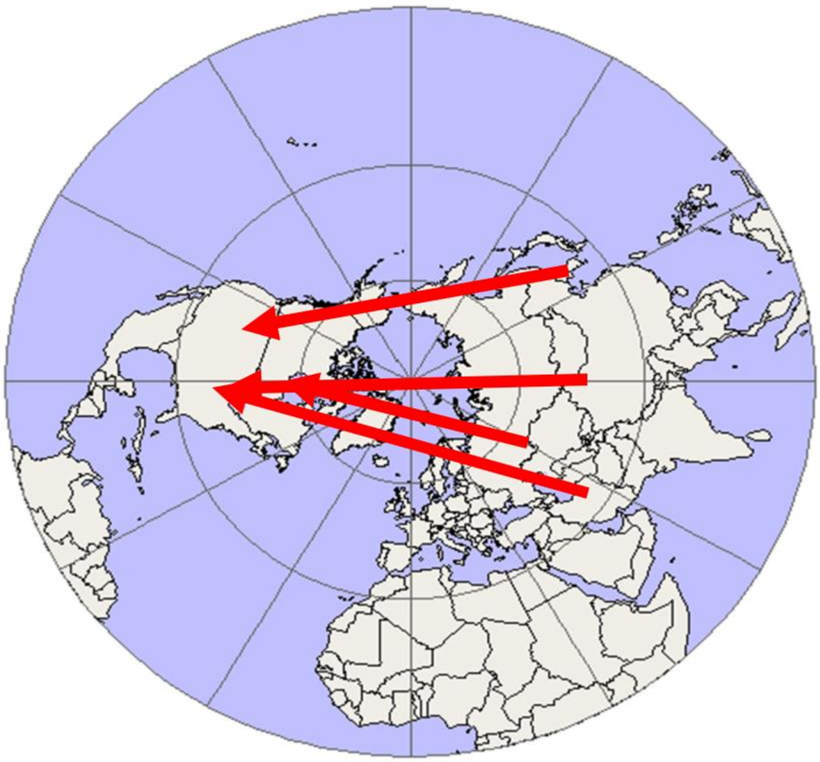

Figure 1. Polar Projection Map

Note. The Stereographic Projection map is considered an 'ancient' projection and was first used for polar star maps by Hipparchus, Ptolemy, and probably earlier Egyptians. Own work to overlay the trajectory arrows was inserted. From *Winwaed Blog Code and Commentary*, by Winwaed Software Technology, LLC, (https://www.winwaed.com/blog/2010/01/11/polar-maps-and-projections-part-1-overview/).

Due to geography, geometry, climate change, and the laws of physics, the importance of the Arctic to North American defense has continued to grow in significance, as a likely avenue of approach for missile threats from Russia, China, Iran, and DPRK. As shown in Figure 1, almost any missile attack from Russia, China, Iran, or DPRK is likely to have a trajectory that crosses the North American Arctic to reach targets in Canada and the U.S. Further, cruise missiles or other military incursions launched from ships, aircraft, or submarines are likely to traverse portions of the Arctic, depending on the launch location.

To detect and potentially defeat military threats to Canada and the U.S., there is an urgent need to tackle the lack of energy, communications, and transportation infrastructure needed to support defense and security activities in the Arctic. Investment in key energy, communications, and transportation infrastructure is required to enable next-generation detection-and-defeat mechanisms for air and missile threats.

Brief History

The end of World War II saw a significant power shift in the world, and this power shift was accompanied by advances in military technology. Previously, North America had been relatively well insulated from European or Asian adversaries due to geography. Improved aviation, navigation, and missile technology enabled long-range bombers equipped with atomic and nuclear weapons to strike directly at North America. Soviet bombers had the range to attack Canada and the United States via the shortest distance over the Arctic, and this led to a new military imperative to detect activity in the Arctic region that had, until the advent of the long-range bomber, been previously inhospitable to military operations in the land, maritime, and air domains.

During World War II, the United States rapidly improved infrastructure in Alaska to address the threat of the Japanese Empire in the Pacific. In the immediate post-war era, both Canada and the United States invested in mapping the Arctic and built airfields and other infrastructure to support increased military operations. Recognizing the importance of permanent inhabitants to sovereignty, Canada went so far as to permanently relocate Inuit people to new settlements at Grise Fiord on Ellesmere Island and Resolute on Cornwallis Island (Royal Commission on Aboriginal Peoples, 1994).

In the early 1950s, Canada and the United States agreed to start building a series of three radar lines to detect potential Soviet bombers operating in the Arctic. These were, from south to north, the Pinetree Line, the mid-Canada Line, and the Distant Early Warning (DEW) line. The DEW Line grew out of a study in the early 1950s by scientists at the Massachusetts Institute of Technology (MIT) who found that the United States and Canada were vulnerable to a Soviet air attack from across the North Pole (Rafferty, 2023). The DEW Line was made up of more than 60 staffed radar installations and extended about 4,800 km (3,000 miles) from northwestern Alaska to eastern Baffin Island. The network served as a warning system for the United States and Canada that could detect and verify the approach of aircraft from the Soviet Union (Rafferty, 2023). The DEW Line and other early-warning installations (the Mid-Canada and Pinetree radar lines) were effective components of deterrence against Soviet aggression during the Cold War.

Construction of this network of radar stations required significant investment in transportation, power, and data systems to support the logistics and command and control requirements to support operations, particularly in the mostly uninhabited high north.

The commencement of the space race in the 1950s led to the development of Intercontinental Ballistic Missiles (ICBMs), and further infrastructure investments in the 1960s to build large Ballistic Missile Early Warning Radars (BMEWS) (Library of Congress – BMEWS Geopolitical Significance, 1968) and the associated transportation, communications, and energy infrastructure to support them.

In 1958, Canada and the United States signed an agreement to create a bi-national command called North American Air Defense (NORAD – which later changed to North American Aerospace Defense), formalizing the relationship between the two nations. NORAD's mission is to conduct aerospace warning, aerospace control, and maritime warning for North America (NORAD, 2023).

Between 1986 and 1992, Canada and the U.S. replaced the obsolete Cold War radar lines with the North Warning System (NWS). It was designed to detect air bomber threats from the Soviet Union traveling in a north-south direction (Charron, 2020). However, the NWS was based on 1970s technology designed to detect bomber-sized targets and has again become obsolete in the era of long-range, low-radar cross-section cruise missiles that can be launched outside radar detection range.

Advances in adversary capabilities have resulted in increasing complexity of the threat, which now ranges across all the military domains of land, air, maritime, space, and cyber. As a result of this threat landscape, defense of North America now requires what the Commander of NORAD and U.S. NORTHERN COMMAND (USNORTHCOM), General Glen VanHerck, calls all domain awareness (VanHerck, 2022). To achieve all-domain awareness, the appropriate network of sensors and their required data flows must be established.

All Domain Threats

Domain awareness can be achieved through an integrated network of sensors from the seafloor to space, including cyberspace, to detect, track, and deter potential threats (VanHerck, 2022). It is also vital to move quickly toward advanced space-based sensors capable of detecting hypersonic weapons, including hypersonic cruise missiles and other advanced systems designed to evade detection (VanHerck, 2022). These all-domain threats have advanced in sophistication since the Cold War and now span the sea to space, inclusive of cyber. Of particular concern in the sea are missile submarines and hypersonic weapons in space.

Domain awareness requires a layered sensing grid that provides persistent battlespace awareness from the seabed to space as well as cyberspace. As adversary capabilities continue to improve, timely and accurate information must be synchronized across all domains to counter adversary influence and actions (VanHerck, 2021). Canada and the United States need new sensors capable of dual-use data and information collection for military and civilian government agencies and allies in multiple domains, including land, space, maritime, and subsurface zones, in addition to the aerospace domain (VanHerck, 2022). Defense buildings and assets in Canada's Far North, including the North Warning System (NWS), use significant amounts of fuel for electricity and heating because of their remote locations and extreme cold conditions (Government of Canada, 2020). Since most fuel is delivered by air, it takes seven liters of fuel to deliver one liter of fuel to the site (Government of Canada, 2020). This traditional approach to the provision of energy in the Arctic is inefficient, carbon intensive, and lacks resilience.

The combined challenges of aging technology and energy sustainability are front and center in the defense of North America from the Arctic. Both Russia and China are increasing their activity in the Arctic. Russia's fielding of advanced, long-range cruise missiles capable of being launched from Russian territory, flying through the northern approaches, and seeking to strike targets in the United States and Canada, has emerged as the dominant military threat in the Arctic (Bouffard & Lackenbauer, 2021).

Current NORAD Modernization Plans

In June 2022, Canada and the U.S. announced NORAD modernization plans, outlining investments that will include new radar stations, command and control upgrades, additional air-to-air refueling aircraft, advanced air-to-air missiles for fighter jets, and upgrades to Canadian Armed Forces infrastructure in the North (Government of Canada, June 2022). Canada provides fighter aircraft on alert status to NORAD, operates three forward operating locations in Inuvik, Iqaluit, and Yellowknife to support fighter operations in the North, and it contributes to a layered defense network of radars and satellites (Bouffard & Lackenbauer, 2021). What does the U.S. provide?

In this model, NORAD has flagged All-Domain Awareness and Information Dominance as priority areas for investment. The Arctic thus fits within a system-of-systems that tracks competitor activities globally from the sea floor to orbit (and in cyberspace) through a network of sensors and systems that provide persistent and complete battle-space awareness. Accordingly, NORAD's integrated priority list includes Artic and Polar Over-the-Horizon radars (OTHR), polar communications through Proliferated Low-Earth Orbit satellites, and an improved Integrated Undersea Surveillance System (IUSS) (Bouffard & Lackenbauer, 2021).

While NORAD is responsible for air breathing threats, USNORTHCOM is responsible for ballistic missile defense (BMD). Canada has not signed on to the BMD program, complicating command and control (C2). Defense of North America in the future must address the full spectrum of integrated air and missile defense (IAMD). While the BMD policy and C2 aspects of this problem are outside the scope of this paper, future detect-and-defeat mechanisms must be fielded to improve deterrence.

Climate Change Concerns

The U.S. and Canada have immediate security concerns in the Arctic, where receding ice is making new natural resources and shipping lanes available (Colby & Delfeld, 2022). As the Arctic becomes more accessible, these adversary states are poised to conduct research, transit through, and engage in more trade in the region. Given the growing international interest and competition in the Arctic, continued security and defense of the Arctic requires effective safety and security frameworks, national defense, and deterrence (Bouffard & Lackenbauer, 2021).

As climate change is making the Arctic more accessible, the military threat is also changing. No longer is the threat just in the air from Russia; a focus on the seas is present as well. The Chinese People's Liberation Army Navy (PLAN) commissioned two new Type 272 icebreakers in 2016, which are the same size as the Canadian Harry DeWolf-class of Arctic and Offshore Patrol vessels. It is unclear how many more of these ice breakers the PLAN will build (Lackenbauer & Lalonde, 2019). China's existing icebreakers, Xue Long and Xue Long II, are ostensibly used for scientific programs, but many aspects of Chinese research benefit both academic and military missions. Their future missions are unknown (Doshi, Dale-Huang, and Zhang, 2021).

Further, climate change enables increased access to the Arctic through tourism, resource exploration, and adventurism. More people and activity in the Arctic results in increased pressure on scarce energy, transportation, and communications infrastructure, complicating domestic surveillance and sovereignty monitoring, search and rescue, and daily life for Arctic inhabitants.

Key Infrastructure Problems

Transportation

Much of the existing airfield infrastructure in the Arctic was built in the 1950s and is not capable of handling modern aircraft in terms of runway surface, length, and servicing capacities. Most coastal communities are resupplied during the short ice-free period via barges. There is almost no road infrastructure due to extremely low population density and in most locations is simply not feasible or economically viable.[1]

Road infrastructure is not feasible throughout the Arctic – its construction would require exorbitant sums of money and incur massive environmental and maintenance costs. Therefore, almost all transportation to remote communities relies on air, with some coastal communities having access to sea lift during the one or two summer months when ice conditions permit safe navigation. This lack of basic infrastructure complicates logistics and greatly increases costs.

Militarily, placing sensors in remote locations requires some type of transportation hub- typically for cargo aircraft to deliver payloads or a suitable means to offload from a maritime platform, as well as the energy sources required to power those sensors. Therefore, the ability to simply move things to strategically or operationally relevant locations is dependent on existing infrastructure. Traditionally, remote locations have been accessed by helicopter from the nearest fixed-wing airfield. Long distances sometimes require the use of fuel caches flown in by another aircraft. These fuel caches become “lily pads” for helicopters to operate. Distances are an enormous challenge.[2] For example, the straight-line distance between Eielson AFB, Alaska to Resolute Bay Nunavut is 2,200 km, or 1,375 miles. Most helicopters have a range of approximately 300 miles one way, or an operating radius of approximately 150 miles. Using helicopters or small, rugged fixed-wing aircraft and fuel caches requires numerous round trips to move large cargo (broken down into smaller manageable loads) and massive amounts of fuel to be effective, increasing fuel costs dramatically and reducing payloads. While current military

[1] Data gathered from multiple interviews with Department of National Defence experts and one of the authors’ own observations.

[2] Based on one of the authors’ experiences as a Royal Canadian Air Force helicopter pilot.

tiltrotor aircraft demonstrate increased speed and range over conventional helicopters, they remain subject to cargo capacity and fuel supply limitations.

Construction of larger airfields capable of handling longer range cargo aircraft is extremely expensive due to the costs of construction on difficult terrain,[3] but in certain use cases, this investment may be worth the effort. Improved hard surface all-weather runways in key communities may improve resilience by providing more options for forward basing of all types of military aircraft. However, conventional airports require large amounts of energy for airport navigation aids, passenger and cargo handling facilities, and sufficient fuel supplies to support those activities. Such a heavy logistics burden increases with the size of the facilities; in short, more airfield capabilities require more personnel to support them. More personnel requires additional work and housing space, food, fuel, and data, putting additional strain on already difficult supply chains. Therefore, construction of improved airfield facilities must be accompanied by investments in energy and other systems (water, sewage), housing, etc.

Despite the obstacles described above, in certain cases, dual-use infrastructure may be the preferred solution in some communities. An accommodations facility built to house a surge of transient or temporary military deployments may double as a community center with benefits to residents. Improved water, sewer, and energy infrastructure may incentivize other commercial opportunities in the area and encourage local economic activity, bringing yet more benefits to northern residents.

Construction of dozens or even several such expanded airfield facilities may be prohibitively expensive. One innovative means to overcome this costly obstacle, while still

[3] An interview with an infrastructure project manager with Arctic experience estimates that construction in the Arctic is a minimum of 2-3 times more expensive than an identical facility in more populated areas. This situation is due to the difficulties of building on permafrost, lack of availability of heavy equipment, local building contractors, fuel, housing, etc.

maintaining the capability to install and service future detect-and-defeat mechanisms, could be to develop low environmental impact transportation mechanisms such as dirigibles that have a high degree of self-sufficiency. Transportation dirigibles currently under development, such as the Airlander (Airlander 10, 2023), do not require runway infrastructure to move heavy cargo loads since they can take off and land vertically and possess the range to operate in remote locations. While severe Arctic weather poses challenges to their use, this is true of any aircraft operating in the Arctic, and the inherent flexibility of dirigibles can drastically reduce the time and cost of emplacing sensors or weapons by removing the need to create new airstrips and the fuel supplies to support conventional aircraft operating from those airstrips. Dirigibles designed for Arctic operations could provide benefits that apply equally to cargo deliveries in support of northern communities or industry operating in remote Arctic areas, in addition to military uses.[4]

Communications

Sensors rely on the ability to communicate data back to C2 nodes. Polar communications pose problems in the Arctic because traditional military communications satellites are generally located in geosynchronous orbit and require line of sight to the transmitter and receiver. Due to the curvature of the earth and the laws of physics, geosynchronous satellites cannot cover polar latitudes above the Arctic Circle. Previous approaches to Arctic communications have used a series of microwave towers (The High Arctic Data Communications System – HADCS) (Government of Canada, 2018) to relay signals from above the Arctic Circle to a location at the Arctic Circle where line of sight can be achieved. This approach requires a large logistics effort to ensure fuel, generators, and continuously operating relay stations to ensure communications.

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[4] For additional information on the military uses of dirigibles, see USC Capstone Paper, *An Assessment of the Viability of Dirigibles in Support of United States Missile Defense and National Communications* by Lorenz, Snyder, and Wittenauer (2023).

Modern satellite communications networks typically use large constellations of low Earth orbit satellites. However, they are of insufficient bandwidth to carry large amounts of data economically or are not available at higher latitudes (Wideman, 2023). This necessitates an expensive constellation of highly elliptical orbit satellites, such as the Defence Enhanced Surveillance from Space Project (DESSP) as announced by Canada's NORAD modernization efforts (Government of Canada, 2022). Any future network of detection sensors of defeat mechanisms is critically dependent on the ability to send and receive data to C2 nodes.

However, adversary capabilities are such that complete reliance on space data transit poses risks, as demonstrated by both Russian and Chinese anti-satellite capabilities. This sole reliance on space can be mitigated using sub-marine and/or terrestrial fiber optic data pathways to augment commercial and military space capabilities.

Once again, investment in dual-use communications infrastructure benefits not only military operations in the Arctic, but also northern residents. Increased access to data enables an improved standard of living and commercial opportunities, while simultaneously providing enhanced domain awareness for military commanders.

Energy (Solar/Wind/Batteries, Small and Micro Nuclear)

Sensors and weapons require energy to operate and support onboard data collection and processing, and they must have connectivity to send and receive data to and from remote C2 nodes. In more populated regions than the Arctic, these sensors and weapons can be plugged into existing electrical grids or be serviced by relatively abundant fuel stations in many cases. These grids do not exist in the Arctic. Most Arctic communities are serviced by small scale micro grids.

An illustrative example of the energy challenges in the high north can be seen in the city of Iqaluit. As the capital of the Canadian territory of Nunavut, with a population of approximately 8,500 people, Iqaluit is the northernmost city in Canada, and it has a heavy dependence on imported supplies via sealift, as there are no roads or rail in the territory of Nunavut (Qulliq Energy Corporation, 2022). The city has a polar climate where average monthly temperatures are below freezing for eight months out of the year.

There are several renewable energy projects proposed in different parts of Nunavut, but the territory is a reminder of how much of a challenge the country faces in decarbonizing remote communities and providing access to a stable and economical supply of electricity. To this day, the territory remains almost completely dependent on importing diesel for electricity and heating as part of an energy system that is unaffordable, unreliable, and a major source of pollution. The simple notion of switching to cleaner energy is a mighty task with many obstacles (Bakx, 2022). Solar panels have limited utility because much of the Arctic receives no direct sunlight for months at a time. However, during the summer months, solar can provide a significant proportion of energy requirements, reducing overall carbon foot printing. Yet during the colder sunlit months, snow and ice cover can impede solar panel efficiency.

Wind power has the potential to augment solar as a renewable, year-round power source, but wind can be intermittent. Furthermore, wind turbines must be capable of operating in areas with significant snow and ice accretion. Traditional electrical deicing equipment, such as the type used on commercial aircraft can be utilized, but it further reduces the efficiency of wind turbines. Additional materials research is underway to improve the efficiency of solar and wind power (Government of Canada, 2020).

Another area that shows promise in the widespread adoption of renewable energy sources is battery technology. Off-grid small sensor packages can be powered by a combination of solar, wind, and batteries. However, extreme weather conditions and long periods of darkness put strain on the reliability of batteries as gap-filler energy sources, and additional technology improvements are needed for arctic applications (Government of Canada, 2020).

A potential solution to renewables or reliance on fossil fuels is the use of Small Modular Nuclear Reactors (SMNRs). The use of SMNRs could provide a reliable, clean source of energy to supply communities with power instead of using diesel generators. Likewise, SMNRs could be used to power small sensor or weapons packages in the vicinity of larger communities or to power sensors like a large radar installation, such as the Polar Over the Horizon Radar (P-OTHR) where there is no other suitable sustainable power source.

For applications requiring less power than provided by a SMNR, the development of micro nuclear power plants shows great promise. Micro nuclear molten salt reactors can be packaged into units the size of a standard 40-foot shipping container and could be used to power sensor packages such as tethered airships or future directed energy weapons (Lambert 2022).

Since the operating requirements for both remote military uses as well as remote civilian or commercial activities are very similar, sustainable energy innovation is a high-payoff, dual-use technology with benefits for all these users.

Infrastructure Investment Benefit Overlap

Relations with Indigenous populations and governments are critically important in this environmentally and culturally sensitive region. Therefore, solutions that can meet defense and security objectives that also improve the lives of Arctic residents are more likely to receive policy support from a 'whole of government' perspective. Most energy, communications, and transportation problems apply equally to military and civilian use.

The challenges of transportation, energy, and communications are not unique to the military. Upgraded airfield infrastructure can benefit both the community and surrounding area as well as military users. Longer all-weather runways capable of accommodating military transport or fighter aircraft can also benefit the community through improved airline service, transportation of goods, and access to health care and other services. Improved communications infrastructure (either space-based or terrestrial) can improve access to e-commerce, online medical consultation, and connectivity with the world as well as serving military C2 purposes. Improved sustainable energy sources are central to enable both transportation and infrastructure requirements.

Table 1 outlines some of the potential military solutions that would provide benefits to the civilian population.

	Potential Military Solutions	**Civilian Population Benefits**
Energy	Investments in non-diesel alternatives Reduced supply chains Reduced carbon footprint	Sustainable alternate energy sources Improved community resilience Reduced carbon footprint
Transportation	Upgrades to existing airfield infrastructure Investment in cargo dirigibles	Improved airline service Improved transportation of goods Improved access to health care and other services
Communication	Space-based data on commercial systems Sub-marine and terrestrial fiber cables	Improved access to e-commerce Online medical consultation Connectivity with the world

Table 1. Potential Military and Civilian Benefits from Infrastructure Upgrades in the Arctic

Future Detect and Defeat Mechanisms (Sensors, Weapons, etc.)

Given the above discussion, investments are required to establish the infrastructure network needed to detect and queue defeat mechanisms. This situation is not about strategic forces preparing to fight over Arctic territory or resources; rather it is about building capabilities to address core security requirements from and in the Arctic (Lackenbauer & Lalonde, 2019). The existing networks of the BMD system and the current network of NWS and Upgraded Early Warning Radars (UEWR), as well as the planned Arctic and polar OTHRs and network of Crossbow sensors, must all be enhanced and complemented through an integrated all-domain solution to more rapidly detect, deter, and if required, defeat threats to North America. The current and planned capabilities are an important element of a layered defense of systems to defend North America from attack. Nevertheless, systems like the U.S. BMD system and its interceptors primarily located at Fort Greely Alaska, underscore the strategic importance of the entire region and its inextricable links to the global security balance (Lackenbauer & Lalonde, 2019).

Technology has advanced over the past 50+ years. U.S. and Canadian adversaries have built up their arsenals, and the existing North American solution has not kept pace. All told, some 640 ballistic missiles loaded with more than 1,700 nuclear warheads are potentially aimed at North America. Another 580 warheads exist on air-launched cruise missiles on bombers, and the emerging and growing inventory of hypersonic missiles and long-range sea-launched cruise missiles must be added to the missile threat. However, the current ground-based, mid-course interception defense (GMD) system is only designed to protect North America from a limited ICBM threat from the DPRK (and possible other future small state arsenals) – in other words, less than three percent of the ballistic missile threat is in the GMD sights (Regehr, 2021).

This BMD system can be augmented by the Aegis shipborne system, which uses the Standard Missile-3 (SM-3), an intermediate-range, three-stage missile that launches its warhead, a non-explosive "kinetic kill" vehicle, into space where it is designed to collide with and destroy oncoming warheads (Regehr, 2021, p. 3). To do that, the ship launching the interceptor would have to be correctly positioned within range of the oncoming warhead near the American coast – as one commentator has noted, "it would have to be in the right place at the right time, the kind of good fortune that could hardly be counted on" (Regehr, 2021, p. 3).

North America's heightened focus on threats of conventionally armed Russian and Chinese cruise and hypersonic missile systems, against which GMD has no capability and which are considered not to be amenable to nuclear deterrence, has spawned the SHIELD (Strategic Homeland Integrated Ecosystem for Layered Defense) strategy – a key feature of which is, again, to launch pre-emptive attacks on cruise missile platforms (aircraft and ships) to destroy the "archer" before its "arrows" can be launched (Regehr, 2021, p. 4).

Aegis BMD ships are extremely expensive assets that are not capable of covering the approaches to North America on a year-round basis. Accordingly, a network or series of networks of distributed autonomous sensors, linked to a robust Joint All-domain C2 network, in turn linked to future weapons systems, provides the best chance of an effective integrated air and missile defense (IAMD) system.

Future sensors, such as signals intelligence packages to detect aircraft, balloons, dirigibles, and cruise missiles, multispectral optical sensors, passive bi-static radar sensors, and others, combined with planned projects such as arctic- (A-OTHR) and polar-over-the-horizon radars (P-OTHR) are likely to provide the most comprehensive all-domain situational awareness of the Arctic.

This pervasive situational awareness can then permit future defeat mechanisms, such as directed energy weapons and kinetic interceptors to defeat missile threats before they reach the more densely populated areas of North America. However, to enable a robust network of sensors and defeat mechanisms, transportation, communications, and energy infrastructure are required.

Policy Recommendations

Key considerations must be navigated, as solutions are recommended. Current and past trends illustrate that the United States is in full support of any integrated defense solution when it comes to the matter of protecting national security. However, defense and security challenges may be insufficient to secure the required investments to detect, deter, and defend against adversaries. Therefore, investment in dual-use technologies that benefit both military and civilian requirements are more likely to receive broad political and societal support. This condition may be particularly true in the case of Canada, which traditionally spends less on defense and security than the U.S. Dual-use technologies that reduce the impact on the environment, improve benefits to Indigenous populations and local communities are more likely to succeed.

Given NORAD's role in the defense of North America, the NORAD command team also emphasizes the distinct concept of risk mitigation, which implies a much broader range of protection options in support of deterrence-by-denial. Determining appropriate risk mitigation requirements under the auspices of NORAD requires key policy decisions and guidance from Washington and Ottawa about what the Command is expected to defend against attack – and deciding what risks should be left to civilian departments and agencies to manage (Bouffard & Lackenbauer, 2021).

This process entails cultural and procedural change within the Canadian Department of National Defence (DND), the U.S. Department of Defense (DOD), NORAD, and USNORTHCOM, as well as carefully coordinated planning across U.S. combatant commands and Canadian Joint Operations Command (CJOC) to overcome the limitations of the current region-by-region approach to national defense (Bouffard & Lackenbauer, 2021).

Conclusion

Canadians and Americans must continue in a collaborative and mutually reinforcing relationship to address threats to North America and to ensure the security and prosperity of both nations. Given the increasing importance of the Arctic as a more accessible region rich in resources and commercial opportunities, increased access and activity provide opportunities for exploration by adversaries. Therefore, investments in crucial energy, communications, and transportation infrastructure are essential to enhance the ability to surveil, control, and defend the region, which in turn enhances collective security and ensures the security and prosperity of North America. If this can be done in a way that also improves the lives of Arctic residents, everyone wins.

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