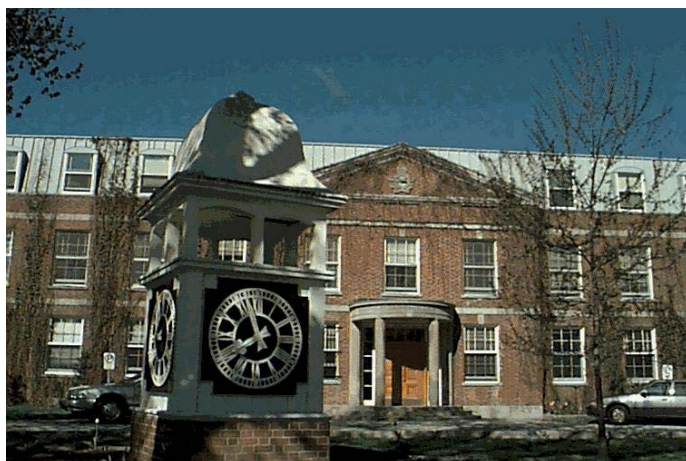


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## JOINT SURVEILLANCE CAPABILITIES TO OPERATIONALIZE

### CANADIAN SOVEREIGNTY IN THE ARCTIC

Major Marie-Claude Osmond

#### JCSP 40

#### *Exercice Solo Flight*

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## CANADIAN FORCES COLLEGE / COLLÈGE DES FORCES CANADIENNES

JCSP 40 / PCEMI 40

## EXERCISE SOLO FLIGHT/EXERCICE SOLO FLIGHT

**JOINT SURVEILLANCE CAPABILITIES TO OPERATIONALIZE CANADIAN SOVEREIGNTY IN THE ARCTIC**

By/par Major Marie-Claude Osmond

*This paper was written by a student attending the Canadian Forces College in fulfilment of one of the requirements of the Course of Studies. The paper is a scholastic document, and thus contains facts and opinions, which the author alone considered appropriate and correct for the subject. It does not necessarily reflect the policy or the opinion of any agency, including the Government of Canada and the Canadian Department of National Defence. This paper may not be released, quoted or copied, except with the express permission of the Canadian Department of National Defence.*

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*One of the most critical security issues now facing the Government is its ability to conduct surveillance of our vast territory, airspace and maritime approaches, and to respond to asymmetric threats. . . . The Government must improve how it gathers, tracks, analyzes, uses and shares information, particularly as it relates to the huge volume of air, land and sea activity within our areas of jurisdiction, and be better prepared to respond quickly and effectively to incidents. . . . The demands of sovereignty and security for the Government could become even more pressing as activity in the North continues to rise. . . . Air traffic over the high Arctic is increasing, and climate change could lead to more commercial vessel traffic in our northern waters. . . . Although the primary responsibility for dealing with issues such as sovereignty and environmental protection, organized crime, and people and drug smuggling rests with other departments, the Canadian Forces will be affected in a number of ways. There will, for example, be a greater requirement for surveillance and control, . . . Adversaries could be tempted to take advantage of new opportunities unless we are prepared to deal with asymmetric threats that are staged through the North.*

- Canada's International Policy Statement: A Role of Pride and Influence in the World Defence, 2005.

## **INTRODUCTION**

In accordance with the *Statement on Canada's Arctic Foreign Policy* Arctic Sovereignty is a priority.<sup>1</sup> It states that the Government of Canada is asserting its presence in the North ensuring we can protect and patrol the northern region. *Canada First Defence Strategy* (CFDS) states that climate changes are altering the environment and "[t]hese changes . . . could also spark an increase in illegal activity, with important implications for Canadian sovereignty and security and a potential requirement for

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<sup>1</sup> Department of Foreign Affairs, Trade and Development Canada, *Statement on Canada's Arctic Foreign Policy: Exercising Sovereignty and Promoting Canada's NORTHERN STRATEGY Abroad*, 1, last accessed 10 May 2012, [http://www.international.gc.ca/arctic-arctique/assets/pdfs/canada\\_arctic\\_foreign\\_policy-eng.pdf](http://www.international.gc.ca/arctic-arctique/assets/pdfs/canada_arctic_foreign_policy-eng.pdf).

additional military support.”<sup>2</sup> To assist with this, it also states that the Canadian Armed Forces (CAF) will have the capacity to conduct daily domestic operations in the North.<sup>3</sup> Despite these statements, the CAF is falling short of its mandate. The only current daily operations in the North are RADARSAT passes and a few Canadian Ranger missions. Given the vast land mass of the Canadian Arctic this far from covers our surveillance requirements. To ensure the CAF can meet this mandate a more robust surveillance mechanism must be procured to ensure we attend to our national interests in the Arctic.

This paper will describe future security/sovereignty threats in the Canadian Arctic including challenges due to climate change and the opening of waterways such as the Northwest Passage. Potential threats include increased transnational criminal shipping activity passing through the North, infringement on our sovereignty, claims on untapped natural resources, land disputes, and environmental threats. These threats could come from the air, the surface or the sub-surface environment and will require increased surveillance capabilities.

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<sup>2</sup> Department of National Defence, *Canada First Defence Strategy*, 6, last accessed 10 May 2014, [http://www.forces.gc.ca/assets/FORCES\\_Internet/docs/en/about/CFDS-SDCD-eng.pdf](http://www.forces.gc.ca/assets/FORCES_Internet/docs/en/about/CFDS-SDCD-eng.pdf).

<sup>3</sup> *Ibid*, 3.

Canada's present ability to monitor the North on a daily basis is insufficient. To accomplish this the Canadian Armed Forces requires an increase in surveillance capability to meet the Government's mandate. The paper will examine our current capabilities, identify gaps and propose future technologies for surveying all three environments through a 'system of systems' including satellite networks, unmanned air vehicles and underwater sensor systems.

## **ARCTIC CHALLENGES**

The Arctic is a vast territory making up 40% of Canadian land mass including 162,000 kilometers of Arctic coastline and encompasses 25% of the global Arctic.<sup>4</sup> Due to the nature of the harsh environment including weather conditions such as ice coverage on land and sea, high winds and extreme cold, this area has remained relatively uninhabitable and has been less of a concern for Canada. With recent trends in climate change there are now growing sovereignty concerns which Canada must address.

The Canadian Arctic is rich in unexploited natural resources. These resources consist of mineral and hydrocarbons and more specifically reserves of oil and gas, diamonds, gold, tin and platinum all of which are garnering interest in Canada.<sup>5</sup> The Arctic is also the source of about 10% of the world's oil production and 25% of its gas production.<sup>6</sup> There are some contested land disputes in the North concerning Canada but they have remained relatively pacified. These include the Beaufort Sea between Alaska

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<sup>4</sup> Canada's Northern Strategy, "Exercising Our Arctic Sovereignty," last accessed 1 May 2014, <http://www.northernstrategy.gc.ca/sov/index-eng.asp>.

<sup>5</sup> Parliamentary Information and Research Service Publication PRB 08-07E, "The Arctic: Hydrocarbon Resources," 24 October 2008, last accessed 2 May 2014, <http://www.parl.gc.ca/content/LOP/researchpublications/prb0807-e.htm>.

<sup>6</sup> *Ibid.*

and Yukon which is thought to have a substantial resource base. The continental shelf is another area of contestation. What is contested is the fact that if states can prove their shelf goes beyond their 200 nautical mile Economic Exclusion Zone they “can claim control of the seabed and its resources for an additional 150 nautical miles . . . . A state with this zone has control of all activities that occur on or beneath the seabed.”<sup>7</sup> Arctic nations, including Canada and Russia, have been submitting their claims to the United Nations Convention on the Law of the Sea (UNCLOS) to lay claims on their continental shelves. In these times of increasing demands for natural resources and given climate change concerns, there are ever growing concerns which Canada must address in the future.

Another challenge that Canada may face is the opening of the Northwest Passage (NWP). This is one of Canada’s current sovereignty issues as it claims that the NWP is considered internal waters which would allow Canada to control who enters into these waters.<sup>8</sup> The United States and the European Union counter this stating that they believe it is considered international waters. Currently, it is relatively unnavigable throughout the majority of the year due to icing conditions. Recent data shows that the passage is becoming more navigable due to climate change. This route may become more appealing to shipping as it “will shorten the route for Europe-Asia shippers by 4,000 miles.”<sup>9</sup> As more shipping transits through these waters it brings with it many potential challenges for

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<sup>7</sup> Robert Huebert, “Canadian Arctic Sovereignty and Security in a Transforming Circumpolar World,” *Canadian International Council. Foreign Policy for Canada’s Tomorrow*, no. 4(July 2009): 3.

<sup>8</sup> *Ibid*, 6.

<sup>9</sup> Doug Stuck, “Canada warns US off claims to Arctic,” *Irish Times*, 2 January 2006.

Canadians. Terrorism, sovereignty infringements, security concerns all which will require surveillance to ensure we keep our territory and citizens safe.

The last challenge to be addressed is that of undetected incursions on our sovereignty from submarines including from friendly states. “It is no secret that U.S. submarines – and probably British, French and Soviet . . . vessels – have regularly used the Northwest Passage in the past and likely continue to do so.”<sup>10</sup> These are countries that have nuclear submarines which are able to transit under ice. What Canada should also be concerned with are states that own diesel submarines with air-independent propulsion (AIP) technology which allows them to conduct under-ice operations.<sup>11</sup> Many countries own diesel submarines and although their fleets may not currently be operational or have AIP technology, the fact that there is potential for their use cannot be overlooked. This issue is of concern both from a sovereignty and security perspective and Canada must ensure it is prepared to counter such challenges.

There are many proponents, such as Franklyn Griffiths a Professor Emeritus of Political Science at the University of Toronto and a prominent Canadian expert on Arctic issues, that dispute that the melting ice caps will lead to increased shipping, challenges in jurisdiction and require increased defence spending<sup>12</sup> but despite these opinions there are growing concerns in the Arctic. “Several trends suggest that many Arctic and non-Arctic

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<sup>10</sup> Michael Byers, *Understanding Sovereignty Disputes in the North: Who Owns the Arctic?* (Vancouver: Douglas & McIntyre, 2009), 75.

<sup>11</sup> Franklyn Griffiths, Rob Huebert, and P. Whitney Lackenbauer, *Canada and the Changing Arctic: Sovereignty, Security, and Stewardship*, (Waterloo: Wilfrid Laurier University Press, 2011), 105.

<sup>12</sup> *Ibid*, 3.

states are rebuilding their combat-capable forces in the Arctic.”<sup>13</sup> One of these states is Russia and with the current situation in the Ukraine Canada cannot discount potential aggression from them in the future. On 22 April 2014 Putin announced increased interests in the Arctic, especially concerning natural resources, he is reopening old military bases and is pushing to re-establish a surface/sub-surface force in the North. He stated that “. . . , we should strengthen the military infrastructure. Specifically, . . . a united system of naval bases for ships and next-generation submarines in our part of the Arctic.”<sup>14</sup> In the same article he reasserted their claim on the continental shelf requires careful attention. In addition, in accordance with a Reuter’s article dated 22 April 2014 “President Vladimir Putin said . . . that Russia should step up its presence in the Arctic and challenge other nations in exploring the world's largest untapped natural reserves.”<sup>15</sup> All these points touch on the challenges depicted above and demonstrate that there is cause for alarm.

In 2006 the Canadian government realized the potential issue in the North and “proposed expanding Canada's military presence, building new ice-breakers and creating an early-warning system to detect other ships, to enforce its claim of sovereignty.”<sup>16</sup> Other projects have also been introduced but since this announcement many initiatives have been delayed and the increased budget cuts could exacerbate this. It is imperative

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<sup>13</sup> Robert Huebert, “Canada and the Newly Emerging International Arctic Security Regime,” in *Arctic Security in an Age of Climate Change*, ed. James Kraska, 193-217 (New York: Cambridge University Press, 2011), 197.

<sup>14</sup> RT News, “Russia to create united naval base system for ships, subs in Arctic – Putin,” Edited time: April 22, 2014 16:39, last accessed 3 May 2014, <http://rt.com/news/154028-arctic-russia-ships-subs/>.

<sup>15</sup> Alexei Anishchuk, “Russia's Putin wants beefed-up presence in Arctic,” *Reuters*, 22 April 2014, last accessed 3 May 2014, <http://www.reuters.com/article/2014/04/22/us-russia-putin-arctic-idUSBREA3L1BN20140422>.

<sup>16</sup> Doug Stuck, “Canada warns US off claims to Arctic,” *Irish Times*, 2 January 2006.



that Canada continue to invest in these projects in order to be able to ensure our sovereignty is not infringed upon and that we are able to protect our citizens and land from potential threats.

## **CURRENT CAPABILITIES**

Prior to ascertaining if Canada needs to invest in new capabilities in protecting and claiming sovereignty on our nation we must first address our current mandate in the Arctic and identify if we are meeting it with our existing capabilities. In accordance with *Canada's Northern Strategy* one of the four pillars is to exercise our Arctic Sovereignty.<sup>17</sup> It also states that we are firmly asserting our presence in the North protecting and patrolling the land, sea, and sky. CFDS has further identified a requirement to “[c]onduct daily domestic and continental operations, including in the Arctic and through NORAD”<sup>18</sup> Current Canadian surveillance capabilities fall short of this. The CAF conducts yearly Arctic sovereignty missions such as Operations NUNAKPUT<sup>19</sup>, NUNALIVUT (a joint Arctic sovereignty exercise)<sup>20</sup>, and NANOOK (a Whole of Government exercise).<sup>21</sup> In addition, the CAF recently added a new subordinate operation to their surveillance mission, Op LIMPID, called Op QIMMIQ which

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<sup>17</sup> Canada's Northern Strategy, “Exercising Our Arctic Sovereignty,” 9, last accessed 3 May 2014, <http://www.northernstrategy.gc.ca/sov/index-eng.asp>.

<sup>18</sup> Department of National Defence, *Canada First Defence Strategy*, 3, last accessed 10 May 2014, [http://www.forces.gc.ca/assets/FORCES\\_Internet/docs/en/about/CFDS-SDCD-eng.pdf](http://www.forces.gc.ca/assets/FORCES_Internet/docs/en/about/CFDS-SDCD-eng.pdf).

<sup>19</sup> National Defence and the Canadian Armed Forces, “Operation NUNAKPUT,” last accessed 3 May 2014, <http://www.forces.gc.ca/en/operations-canada-north-america-recurring/op-nunakput.page>.

<sup>20</sup> National Defence and the Canadian Armed Forces, “Operation NUNALIVUT,” last accessed 3 May 2014, <http://www.forces.gc.ca/en/operations-canada-north-america-recurring/op-nunalivut.page>

<sup>21</sup> National Defence and the Canadian Armed Forces, “Operation NANOOK,” last accessed 3 May 2014, <http://www.forces.gc.ca/en/operations-canada-north-america-recurring/op-nanook.page>.

encompasses surveillance and presence missions covering the Arctic AOR which totals 8,276,554 square kilometers.<sup>22</sup> “It includes . . . Hudson Bay and the Arctic Ocean and all Canadian territory north of the 60<sup>th</sup> parallel. It extends to the North Pole and includes Canada’s Exclusive Economic Zone to the West and East.”<sup>23</sup> These exercises/missions, although a step forward, are not continuously conducted throughout the year and do not meet our requirement for daily operations in the North. Additionally, Op NANOOK is conducted in the summer months because our current maritime fleet as well as some of our air fleets and land support are unable to conduct operations during icing and cold weather conditions experienced in the winter months.

Although any aircraft is capable of conducting surveillance missions, only the CP-140 Aurora and CH-124 Sea King are currently assigned this task as a primary role. The CP-140 is the only aircraft that conducts surveillance operations in the North on a fairly regular basis but is normally limited to the above operations or when tasked on a cued mission. Although the CP-140 is versatile and capable of conducting overland operations, maritime surface and sub-surface missions it is still limited in what it can achieve. These constraints include mission length, normally 10-12 hours, and crew day restrictions.<sup>24</sup> As the North is an extremely large area it must forward deploy to bases such as Yellowknife and Iqaluit to accomplish these missions especially if tasked in the high Arctic. If 24/7 operations are necessary, there would be requirements for additional aircraft, aircrews, technicians and logistical support which comes with increased financial costs. This would

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<sup>22</sup> National Defence and the Canadian Armed Forces, “Operation LIMPID,” last accessed 3 May 2014, <http://www.forces.gc.ca/en/operations-canada-north-america/op-limpid.page>.

<sup>23</sup> *Ibid.*

<sup>24</sup> Information comes from officers on JCSP 40 familiar with current CP-140 operations.

also leave the two coasts with reduced capabilities to conduct other routine operations. The CP-140 is therefore limited in their ability to conduct daily operations in the North.

The Canadian Rangers are another asset used for surveillance in the North but again they can only conduct limited operations due to their size of approximately 5000 members.<sup>25</sup> From a sovereignty and surveillance perspective they are tasked to conduct patrols, to conduct North Warning Site patrols, to report suspicious and unusual activities, to collect local data of military significance and to conduct coastal and inland water surveillance.<sup>26</sup> While the Rangers are extremely professional and are valuable to the CAF they are only able to conduct missions through ground operations and can only cover a small area of operations on a daily basis.

From a maritime surveillance perspective in addition to the CP-140 missions the Canadian Navy has multiple assets including the Halifax class frigates, the Iroquois-class destroyers, the Protecteur-class auxiliary oil replenishment supply ships, the Kingston-class Maritime Coastal Defence Vessels and the Victoria class submarines. All of these vessels have no capability to conduct operations in icing conditions. In order to operate in ice ships require a certain Polar Class (PC) rating. The new Arctic Off-Shore Patrol (AOP) vessels that Canada intends to procure are rated at a PC 5<sup>27</sup> which is capable of

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<sup>25</sup> Canadian Army, "About the Canadian Rangers," last accessed 3 May 2014, <http://www.army-armee.forces.gc.ca/en/canadian-rangers/about.page>.

<sup>26</sup> *Ibid.*

<sup>27</sup> Martin Shadwick, "Maritime Futures," *Canadian Military Journal* Vo. 8, no. 2, (Summer 2007): 81, last accessed 4 May 2012, <http://www.journal.forces.gc.ca/vo8/no2/doc/commenta-eng.pdf>.

year-round operation in medium first-year ice which may include old ice inclusions.<sup>28</sup> This is considered a low rating thus critics have dubbed it a ‘slushbeaker.’<sup>29</sup> Therefore the AOP may not meet all of Canada’s needs in the North. Our current submarine fleet is also unable to conduct operations under ice given that diesel electric submarines are required to surface in order to replenish its batteries. The AIP technology previously identified would allow our submarines to conduct such operations but this is currently not on the agenda for procurement.

Another issue with our naval fleet up North is that of resupply. This is not only the case in winter months but a year round dilemma. This is due not only to issues with our own supply ships but also the lack of infrastructure and limited resources available in the Arctic. It is hard enough getting supplies to northern communities let alone trying to resupply a large naval vessel. Our aging AORs are also an issue especially considering the recent fire on-board the HMCS Protecteur which will more than likely never sail again. This would leave Canada with only one resupply ship until they are replaced in 2019-20.<sup>30</sup> The new Joint Supply Ship (JSS) is delayed and will only be commissioned approximately 18 months after the decommissioning of the AORs which will further exacerbate the problem.<sup>31</sup>

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<sup>28</sup> Fisheries and Oceans Canada and Canadian Coast Guard, “Ice Navigation in Canadian Waters,” Revised August 2012, 22, last accessed 4 May 2014, <http://www.ccg-gcc.gc.ca/folios/00913/docs/ice-navigation-dans-les-galces-eng.pdf>.

<sup>29</sup> *Ibid.*

<sup>30</sup> The Canadian Press, CBC.ca “Arctic icebreaker delayed as Tories prioritize supply ships: Joint support ships won't be ready until old ones retired.” Last updated Oct 12, 2013 9:53 AM ET. Last accessed 4 May 2012. <http://www.cbc.ca/news/politics/arctic-icebreaker-delayed-as-tories-prioritize-supply-ships-1.1991522>.

<sup>31</sup> *Ibid.*

Given all the above issues from a naval perspective Canada is moving in the right direction but Northern operations will remain an issue and will not be robust enough to be able to sustain year round operations.

Another capability used by the CAF is the Polar Epsilon Project which utilizes the RADARSAT 2 system. Polar Epsilon came into full operation in August 2011 and was developed to provide improved Arctic surveillance to the CAF.<sup>32</sup> It uses synthetic aperture radar technology “to provide all-weather day/night surveillance in areas where other sensors are limited or unable to operate.”<sup>33</sup> It does have its limitations including the inability to “detect ballistic missiles, nor can it track small vessels or individuals.”<sup>34</sup> Additionally, it has a limited revisit time and if something is detected via satellite there is no ability to return to the area of interest until the next revisit time. It is therefore an enhancing feature in the North but must be used more as a cueing sensor for either a manned or unmanned vehicle which has the ability to continually track vessels of interest.

From an aerial surveillance perspective Canada is currently using the North Warning System (NWS). It comprises a chain of 47 unmanned radar sites, 11 long-range and 36 short-range, and was established to detect potential threats entering into North American airspace.<sup>35</sup> “It is part of Canada’s North American Aerospace Defense Command (NORAD) agreement with the United States (US), and an essential capability

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<sup>32</sup> National Defence and the Canadian Armed Forces, “ARCHIVED - Backgrounder - Polar Epsilon Project,” last accessed 4 May 2012, <http://www.forces.gc.ca/en/news/article.page?doc=polar-epsilon-project/hnps1uo5>.

<sup>33</sup> *Ibid.*

<sup>34</sup> *Ibid.*

<sup>35</sup> National Defence and the Canadian Armed Forces, “Backgrounder - North Warning System,” last accessed 4 May 2012, <http://www.forces.gc.ca/en/news/article.page?doc=north-warning-system/hgq87x9w>.

in our efforts to maintain Canada's sovereignty.”<sup>36</sup> Although it is extremely good at detecting objects coming into our airspace which our CF-188 fleet can then intercept, it only covers a limited area in the northern region leaving the remaining area vulnerable especially in the high Arctic. The estimated life expectancy of the radar sites is 2025<sup>37</sup> and NORAD is currently seeking not only to replace the NWS but also expanding its surveillance role especially in the Arctic. Although details of this initiative have not been publicized the project is called ‘NORAD next’ and is anticipated to be active in the 2025-2030 timeframe.<sup>38</sup> The project seeks not only to replace its aerial surveillance capability but also looks to expand into the land and maritime realms. In 2012 the Commander of NORAD was “specifically interested in ‘the modernization of the NORAD surveillance network to provide improved multi-domain coverage, particularly of the Arctic region.’”<sup>39</sup> Although there are no further details on this project a close eye must be maintained on this initiative when further studying Arctic surveillance to not duplicate effort especially in these times of financial constraints.

Although the CAF has an abundance of capabilities to conduct surveillance operations in the North none are capable of continually monitoring the entire Arctic region, especially the high Arctic, and certainly not on a daily basis. Currently the only asset capable of daily operations is the RADARSAT 2 system which only provides

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<sup>36</sup> *Ibid.*

<sup>37</sup> David Pugliese, “Canada-US-Eye-Arctic-Responsibilities-NORAD,” *Defence News*, 3 May 2014 - 03:45AM, last accessed 4 May 2014, <http://www.defensenews.com/article/20140503/DEFREG02/305030018/Canada-US-Eye-Arctic-Responsibilities-NORAD>.

<sup>38</sup> *Ibid.*

<sup>39</sup> *Ibid.*

information on a particular swath and mainly provides data from a maritime domain perspective. Additionally, it cannot easily revisit an area of interest if it identifies something out of the ordinary. The other system that conducts daily operations is the NWS but it is limited in area of coverage and only detects aerial contacts. From a sub-surface perspective our capabilities are extremely limited if almost non-existent. With the ever increasing potential threats that Canada could face in the Arctic a more robust surveillance system is required to meet our mandate.

## **POTENTIAL FUTURE CAPABILITIES**

Although there are a plethora of potential future options the CAF could examine only four will be expanded upon in this paper. These include the Joint Unmanned Surveillance and Target Acquisition System (JUSTAS) Project, the Northern Watch Technology Demonstration Project, Polar Epsilon 2 and the Polar Communication and Weather Mission. The following will expand on the capabilities these systems can bring to the CAF and how these can be integrated with our current capabilities in providing a layered surveillance system in the Arctic region.

The JUSTAS project is intended to provide persistent intelligence, reconnaissance, surveillance and target acquisition capabilities to provide decision makers with timely and accurate information. The project was originally split into two phases – Phase 1- domestic and international overland capability and Phase 2 – maritime

and arctic capability.<sup>40</sup> This was based on technical risks such as the ability to withstand the harsh northern environment and polar communications issues associated with the maritime and arctic capabilities. These risks have now been significantly reduced negating the requirement for a two-phased approach.<sup>41</sup>

From an Arctic perspective the current project will require the unmanned air vehicle (UAV) to be able to operate in a remote split operation mode when above 65N. Remote split operations requires the UAV to be launched and recovered using a line-of-sight mode. During transits and missions it will be controlled beyond line-of-sight through an operations center located at the main operating base using either ground systems or a satellite network.<sup>42</sup> The current draft Statement of Requirements states that it shall be able to operate using Iridium satellite communications above 65N for the command link.<sup>43</sup> As Iridium is publically owned there is no guarantee of its continued use. To ensure continual satellite communications are available Canada should invest in a government owned system and one such program will be discussed later.

Defence Research and Development Canada (DRDC) conducted a study analyzing JUSTAS requirements in the Canadian Arctic to evaluate speed and endurance requirements. Three mission types were analyzed of which two were pertinent to surveillance missions. These were the ability to track a vessel in the NWP and the ability

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<sup>40</sup> Department of National Defence, *Draft Statement of Operational Requirements Joint Unmanned Surveillance and Target Acquisition System Version 2.0*, 20 April 2012, 3.

<sup>41</sup> *Ibid*, 3.

<sup>42</sup> *Ibid*, 6.

<sup>43</sup> *Ibid*, 9.



to conduct point surveillance on a small area.<sup>44</sup> In the tracking scenario it was identified that 100% coverage was impossible with one UAV but in 94% of the cases trialed 100% tracking was possible with two UAVs. In the point surveillance scenario it was assumed that the area had to be surveyed for a two week period. Once again in order to obtain 100% time on station two UAVs were required.<sup>45</sup> Despite the requirement for two UAVs this is still a vast improvement to the CP-140's abilities in the North.

Notwithstanding the UAV's improved capabilities there are still issues with its use that would have to be taken into consideration. Firstly, air traffic control approval to fly UAVs in the North could be problematic in the beginning. In accordance with the Canadian Aviation Regulations "No person shall operate an unmanned air vehicle in flight except in accordance with a special flight operations certificate or an air operator certificate."<sup>46</sup> These certificates are approved on a case by case basis and the operators must prove they understand air regulations. Although this should be less of an issue for military operators there is still hesitance to have unmanned vehicles operating within controlled airspace especially in higher density traffic. Given that we are currently not operating UAVs it may take time before we are given approval to fly in controlled airspace once we commence operations.

Another issue is that there are presently few UAVs capable of flying in harsh weather conditions. One that the Harper government was considering buying in 2012 was

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<sup>44</sup> Defence Research and Development Canada, *3553-1 (DRDC CORA) ANALYSIS OF JUSTAS REQUIREMENTS IN THE CANADAIN ARCTIC*, October 2012, 2.

<sup>45</sup> *Ibid*, 5.

<sup>46</sup> Justice Laws Website, "Canadian Aviation Regulations SOR/96-433 article 602.41", 16 April 2014, 536, last accessed 4 May 2014, <http://laws-lois.justice.gc.ca/PDF/SOR-96-433.pdf>.

the Polar Hawk.<sup>47</sup> The Polar Hawk is a high-altitude long-endurance (HALE) UAV which flies at 60,000 feet, ranges over 22,000 kilometers and stays airborne for more than 33 hours at a time in all weather conditions.<sup>48</sup> Advantages of flying at that altitude is that it would be well clear of other air traffic which could make it easier to get approval for a flight operation certificate and it would normally be clear/above adverse weather conditions. That said, the disadvantage is that although the system would likely have state of the art equipment such as synthetic aperture radar to gain contacts it would not be able to obtain visual identification, if required, through cloud layers nor would it be prudent or cost effective to descend in order to do so. Another potential disadvantage of the Polar Hawk is cost.

The JUSTAS project is currently examining options for what type of UAV CAF will procure. Whether it is Polar Hawk or some other UAV we must ensure the project continues. There are advantages to their use compared to manned aircraft that must not be neglected. UAVs can fly longer hours and there is a reduced risk in threat environments owing to lack of aircrew. Additionally, the deployed footprint is vastly reduced as it would only require launch and recovery crews and some technicians at a forward operating base. The aircrew and mission controllers would be based at the main operating base reducing costs on deploying crews that would be required for manned aircraft to conduct the same missions.

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<sup>47</sup> CBC News, "Arctic surveillance by unmanned planes proposed: U.S. defence contractor pitches drones to patrol Northwest Passage," Last Updated: Jun 01, 2012 12:33 PM CT, last accessed 5 May 2014, <http://www.cbc.ca/news/canada/north/arctic-surveillance-by-unmanned-planes-proposed-1.1185790>.

<sup>48</sup> Canadian Manufacturing, "Northrop Grumman, L-3 pitch Polar Hawk UAV for arctic use," 30 May 2012, last accessed 5 May 2014, <http://www.canadianmanufacturing.com/manufacturing/northrop-grumman-l-3-pitch-polar-hawk-uav-for-arctic-use-65313>.

Another future capability that is currently being experimented on by DRDC is the Northern Watch Technology Demonstration Project. The project is designed to “develop and demonstrate a capability to conduct unattended, persistent, local-area surveillance of an Arctic chokepoint, . . . , on the Northwest Passage.”<sup>49</sup> The project objectives include the capability to conduct 24/7 persistent local-area surveillance of air, maritime surface and sub-surface objects for up to 365 days and the ability to operate the sensor systems remotely.<sup>50</sup> One of the unique features of this project compared to most is that it addresses sub-surface surveillance which the CAF currently lacks, other than the CP-140, in an icing environment. From an aerial surveillance perspective the project will attempt to track transpolar, local and military traffic that will be transiting through the surveillance coverage area.<sup>51</sup> The project will also assess the ability to detect, track and classify surface contacts and using acoustic arrays it will determine if it can detect submerged objects such as submarines, unmanned underwater vehicles and towed devices.<sup>52</sup> If this technology proves to be effective it would benefit the CAF. Having an unmanned system capable of conducting surveillance in all three environments would be cost effective in the long run.

There are some disadvantages to the system. Firstly, it is only testing local-area surveillance as wide-area surveillance was not within the scope of the project.<sup>53</sup> If the

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<sup>49</sup> Bruce McArthur, Defence Research and Development Canada – Atlantic, “Northern Watch System Concept V2.0,” July 2012, iii.

<sup>50</sup> *Ibid.*

<sup>51</sup> *Ibid.*, 8.

<sup>52</sup> *Ibid.*

<sup>53</sup> *Ibid.*, 6.

concept is proven this could certainly be a follow-on project. Secondly, acoustic arrays are affected by environment conditions such as ice, precipitation, winds which increase ambient noise making it more difficult for detection.<sup>54</sup> That said, the CAF is highly interested in a system capable of detecting sub-surface contacts and has indicated to DRDC that this is their highest priority objective for this project.

A complimentary capability to this project is that of unmanned underwater vehicles. This paper will not delve into to details as this is still extremely new technology but there is an abundance of work being done on such systems. The United States Navy is invested in this technology as outlined in their Unmanned Undersea Vehicle (UUV) Master Plan which identifies intelligence, surveillance and reconnaissance and anti-submarine warfare as their top priorities.<sup>55</sup> In addition, although only conceptual at this time, DRDC is also investigating under-ice UUVs which would work between fixed points where they would dock recharge their batteries and upload data.<sup>56</sup> This technology should continue to be investigated for future surveillance considerations by the CAF.

Another initiative that must continue to progress is Polar Epsilon 2 (PE 2). While the original Polar Epsilon exploits data from the RADARSAT 2 system PE 2 will use the new RADARSAT Constellation Mission (RCM) scheduled to replace RADARSAT 2

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<sup>54</sup> *Ibid*, 14.

<sup>55</sup> Department of the Navy United States of America, "The Navy Unmanned Undersea Vehicle (UUV) Master Plan," November 9, 2004, xvi, last accessed 6 May 2012, <http://www.navy.mil/navydata/technology/uuvmp.pdf>.

<sup>56</sup> E-mail David Hazen/Major Osmond, Subject: NW, Sat 4/5/2014 5:41 PM.

which is expected to be launched in 2018.<sup>57</sup> “The three-satellite configuration will provide complete coverage of Canada's land and oceans offering an average daily revisit, as well as daily access to 95% of the world to Canadian and International users.”<sup>58</sup> Additionally, the system will provide up to four passes per day in the North and several passes per day over the Northwest Passage which is an improvement from RADARSAT 2.<sup>59</sup>

Another RCM feature which will vastly enhance maritime surveillance is the availability of Automatic Identification System (AIS) on the space segments.<sup>60</sup> AIS “is a vessel tracking system that automatically provides updates on a vessel’s position and other relevant ship voyage data. . .”<sup>61</sup> This will allow operators to correlate contacts transmitting on AIS with those identified using the synthetic aperture radar negating the need for visual identification.

The last initiative to be discussed is that of polar communications which have been challenging in the past. Many CAF assets are using the Iridium satellite system to communicate in the North and this is one of the reasons that the JUSTAS project negated the need for the two-phased option. Despite this, Iridium does not have large enough data rates required for advanced technologies that the CAF intends on procuring such as

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<sup>57</sup> Canadian Space Agency, “RADARSAT Constellation,” last accessed 6 May 2012, <http://www.asc-csa.gc.ca/eng/satellites/radarsat/>.

<sup>58</sup> *Ibid.*

<sup>59</sup> *Ibid.*

<sup>60</sup> Canadian Space Agency, “Components and Specifications,” last accessed 6 May 2014, <http://www.asc-csa.gc.ca/eng/satellites/radarsat/components.asp>.

<sup>61</sup> Canadian Coast Guard, “Automatic Identification System (AIS),” last accessed 11 May 2012, <http://www.ccg-gcc.gc.ca/eng/CCG/Maritime-Security/AIS>.

JUSTAS. Connectivity for C4ISR systems is a growing concern and guaranteed access to high-capacity satellite communications will be required in the near future.

Current satellite systems are in a geosynchronous orbit leaving the high Arctic with limited secure, reliable and high capacity communications.<sup>62</sup> There is a current initiative called the Polar Communications and Weather Mission which is being conducted by the Canadian Space Agency in concert with the Department of National Defence, Environment Canada and other supporting Government departments. One of the main objectives of the project is to provide reliable 24/7 high data rate communications capabilities and during its initial concept phase it proved that two high elliptical orbit satellites could provide this coverage in the Arctic.<sup>63</sup> On 1 November 2013 the Canadian Government released a Request for Information indicating they are moving forward on the project.<sup>64</sup>

Many capabilities have been described thus far and it is apparent that no one system, current or future, can meet the demands of conducting surveillance in the high Arctic on its own. Additionally, many of our current capabilities will become obsolete between 2020-2030 timeframe and the CAF must look ahead at viable options to meet our mandate of operating in the North on a daily basis.

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<sup>62</sup> Canadian Space Agency, "Polar Communication and Weather mission (PCW)," last accessed 6 May 2014, <http://www.asc-csa.gc.ca/eng/satellites/pcw/>.

<sup>63</sup> *Ibid.*

<sup>64</sup> Marc Boucher, "Polar Communications and Weather Satellite Project One Step Closer to Reality," *Space Ref Canada*, Posted November 1, 2013 12:42 PM, last accessed 6 May 2012, <http://spaceref.ca/missions-and-programs/canadian-space-agency/polar-communication-and-weather-mission/polar-communications-and-weather-satellite-project-one-step-closer-to-reality.html>.

A viable solution for CAF to meet its requirements in the Arctic is via a layered approach. The CAF does not have enough assets to conduct all missions and those we do have are in high demand. A layered approach would allow CAF to pool its resources to meet the demands of the taskings assigned to them. Given the vast amount of territory to cover in the North this concept is even more important as our current resources have limitations when operating in the North.

Our current naval assets have extremely limited abilities to operate in icing conditions. The CP-140 fleet can and does operate in the North but their transit, on-station times, crew limitations, etc. are not conducive to conducting extended 24/7 operations in the North. Canada is in a much better situation from an aerial surveillance perspective with NORAD and the North Warning system but it too requires replacing in the near future. It is anticipated that 'NORAD next' will be a robust solution as it is a bi-national agreement with the United States and given their concerns for security it is highly unlikely that it will not meet Canada's requirements.

Manned systems require a large deployed footprint when operating in the North especially from an air perspective. Utilizing unmanned systems will reduce the footprint compared to manned systems. In the case of UAVs it will also reduce the wear and tear on our current fleets which could extend their life expectancy.

To alleviate some of these issues a tiered approach to surveillance should be investigated. In the near term Canada should continue using RADARSAT 2 and investing in the follow-on RCM upgrade with integrated AIS. This will vastly increase maritime surveillance in the North. Continued cooperation with NORAD and the North Warning

System including the 'NORAD Next' initiative is imperative from an aerial surveillance perspective. From the land standpoint the Canadian Rangers must continue to be employed and if possible expanded upon. These three assets should be utilized as our core surveillance resources and if an activity of a suspicious nature was to arise cued surveillance assets such as the CP-140, CF-188, naval assets, submarines etc. should be deployed to investigate.

In the mid-term, Canada must procure a UAV capable of operating in the Arctic, continue with the AOP project, the polar communications initiative and keep a close eye on the developments of the Northern Watch Technology Demonstration Project. As the AOPs are being procured for Arctic operations they could become one of our core surveillance assets in the North along with those identified above. To ensure constant coverage the ideal would be to use the UAVs in a persistent manner in the Arctic. If cost savings is an issue it need not be utilized on a daily basis but could be employed as a cued assets alleviating resources such as the CP-140 from increased wear and tear and allowing them to continue with other taskings.

In the long-term if the Northern Watch Technology Demonstration Project is successful the CAF should invest in procuring this system especially given its potential for persistent surveillance capability in all environments. The systems should be placed at strategic chokepoints to ensure we maintain on our sovereignty especially from a sub-surface perspective. Additionally, the option of procuring UUVs should be considered if and when this technology has been proven in the Arctic.



With the increased advances in technology all these options will require a central repository for the vast amounts of data being collected. It is therefore imperative that Canada invest in a data fusion center to collate and disseminate data. Decision makers will need information in a timely manner and one central location for all data will ensure they receive the most up-to-date information available.

## **CONCLUSION**

The Canadian Arctic is an extremely massive area encompassing 40% of our land mass and remains virtually uninhabited leaving it open to threats on our national sovereignty. Canada must ensure it is prepared to detect these threats. Some of the challenges facing our sovereignty include climate change which is opening up the Northwest Passage allowing increased shipping conceivably from terrorist groups who could infringe on our security. The Arctic is also rich in unexploited natural resources which could become contentious especially once all countries have submitted their claims regarding the continental shelf to UNCLOS. Lastly, Canada should be concerned with possible intrusions on our sovereignty from undetected submerged contacts.

These challenges come with a growing cause for alarm. Russia has shown an increased interest in the Arctic, their claims on the continental shelf could contradict our own and their recent escalation in violence against the Ukraine demonstrates that they are willing to use aggression to achieve their aims. It is therefore imperative that Canada put forethought on Arctic surveillance. To ensure Canada protects its sovereignty a persistent capability to monitor the Arctic is necessary. The CAF's current capabilities fall short of providing the CFDS mandated daily operations in the North. While daily aerial

surveillance is conducted through NORAD and the NWS there are still area gaps that the system does not cover. Maritime and land surveillance are limited to RADARSAT 2 passes, Canadian Ranger missions, and the occasional surveillance missions by the CP-140. None of these are capable of robust daily operations in the Arctic.

The CAF is invested in multiple projects such as JUSTAS, the RADARSAT Constellation Mission and the Northern Watch Technology Demonstration Project which are focused on providing persistent capabilities in the North. These initiatives must continue but they cannot on their own constantly cover the entire Arctic. A layered surveillance capability using multiple systems will allow Canada to achieve a more robust surveillance capability able to operate in the North on a daily basis. This layered approach should incorporate current and future capabilities as they become available.

The use of multiple systems will require some type of data fusion center to ensure decision makers can receive and process information in a timely manner. Canada cannot afford to operate in stovepipes which could cause unnecessary duplication of efforts. New capabilities will have more advanced technologies with vast amounts of information requiring real-time download to the center. To do this, Canada must continue investing in the Polar Communications and Weather Mission to guarantee we have constant high data rate communications in the entire Arctic.

The Harper government is committed to Arctic and the CAF must endeavor to do their part in protecting our nation and our citizens from possible threats that could infringe on our sovereignty.

## BIBLIOGRAPHY

- Anishchuk, Alexei. "Russia's Putin wants beefed-up presence in Arctic." *Reuters*, 22 April 2014. Last accessed 3 May 2014. <http://www.reuters.com/article/2014/04/22/us-russia-putin-arctic-idUSBREA3L1BN20140422>.
- Boucher, Marc. "Polar Communications and Weather Satellite Project One Step Closer to Reality." *Space Ref Canada*. Posted November 1, 2013 12:42 PM. Last accessed 6 May 2014. <http://spaceref.ca/missions-and-programs/canadian-space-agency/polar-communication-and-weather-mission/polar-communications-and-weather-satellite-project-one-step-closer-to-reality.html>.
- Byers, Michael. *Understanding Sovereignty Disputes in the North: Who Owns the Arctic?* Vancouver: Douglas & McIntyre, 2009.
- Canada. Defence Research and Development Canada. *3553-1 (DRDC CORA) ANALYSIS OF JUSTAS REQUIREMENTS IN THE CANADAIN ARCTIC*. October 2012.
- Canada. Department of Foreign Affairs, Trade and Development Canada. *Statement on Canada's Arctic Foreign Policy: Exercising Sovereignty and Promoting Canada's NORTHERN STRATEGY Abroad*. Last accessed 10 May 2014. [http://www.international.gc.ca/arctic-arctique/assets/pdfs/canada\\_arctic\\_foreign\\_policy-eng.pdf](http://www.international.gc.ca/arctic-arctique/assets/pdfs/canada_arctic_foreign_policy-eng.pdf).
- Canada. Department of National Defence. *Canada First Defence Strategy*. Last accessed 10 May 2014. [http://www.forces.gc.ca/assets/FORCES\\_Internet/docs/en/about/CFDS-SDCD-eng.pdf](http://www.forces.gc.ca/assets/FORCES_Internet/docs/en/about/CFDS-SDCD-eng.pdf).
- Canada. Department of National Defence. *Canada's International Policy Statement: A Role of Pride and Influence in the World DEFENCE*, 2005. Last accessed 11 May 2014. [http://web.archive.org/web/20050425004233/http://www.forces.gc.ca/site/reports/dps/pdf/dps\\_e.pdf](http://web.archive.org/web/20050425004233/http://www.forces.gc.ca/site/reports/dps/pdf/dps_e.pdf).
- Canada. Department of National Defence. *CONCEPT OF OPERATIONS Joint Unmanned Surveillance and Target Acquisition System*. 30 June 2013.
- Canada. Department of National Defence. *Draft Statement of Operational Requirements Joint Unmanned Surveillance and Target Acquisition System Version 2.0*. 20 April 2012.
- Canada. Department of National Defence. *Statement of Operating Intent Joint Unmanned Surveillance and Target Acquisition System Version 1.0*. 30 June 2013.
- Canada's Northern Strategy. "Canada's Northern Strategy: Our North, Our Heritage, Our Future," (Ottawa: 2009), last accessed 11 May 2014, <http://www.northernstrategy.gc.ca/cns/cns.pdf>.

- Canada's Northern Strategy. "Exercising Our Arctic Sovereignty." Last accessed 1 May 2014. <http://www.northernstrategy.gc.ca/sov/index-eng.asp>.
- Canadian Army. "About the Canadian Rangers." Last accessed 3 May 2014. <http://www.army-armee.forces.gc.ca/en/canadian-rangers/about.page>.
- Canadian Coast Guard. "Automatic Identification System (AIS)." Last accessed 11 May 2012. <http://www.ccg-gcc.gc.ca/eng/CCG/Maritime-Security/AIS>.
- Canadian Manufacturing. "Northrop Grumman, L-3 pitch Polar Hawk UAV for arctic use." 30 May 2012. Last accessed 5 May 2014. <http://www.canadianmanufacturing.com/manufacturing/northrop-grumman-l-3-pitch-polar-hawk-uav-for-arctic-use-65313>.
- Canadian Space Agency. "Components and Specifications." Last accessed 6 May 2014. <http://www.asc-csa.gc.ca/eng/satellites/radarsat/components.asp>.
- Canadian Space Agency. "Polar Communication and Weather mission (PCW)." Last accessed 6 May 2014. <http://www.asc-csa.gc.ca/eng/satellites/pcw/>.
- Canadian Space Agency. "RADARSAT Constellation." Last accessed 6 May 2012. <http://www.asc-csa.gc.ca/eng/satellites/radarsat/>.
- CBC News. "Arctic surveillance by unmanned planes proposed: U.S. defence contractor pitches drones to patrol Northwest Passage." Last Updated: Jun 01, 2012 12:33 PM CT. Last accessed 5 May 2014. <http://www.cbc.ca/news/canada/north/arctic-surveillance-by-unmanned-planes-proposed-1.1185790>.
- Coates, Ken S., P. Whitney Lackenbauer, William Morrison, and Greg Poelzer. *Arctic Front: Defending Canada in the Far North*. Toronto: Thomas Allen Publishers, 2008.
- E-mail David Hazen/Major Osmond, Subject: NW, Sat 4/5/2014 5:41 PM
- Fisheries and Oceans Canada and Canadian Coast Guard. "Ice Navigation in Canadian Waters." Revised August 2012, 22. Last accessed 4 May 2014. <http://www.ccg-gcc.gc.ca/folios/00913/docs/ice-navigation-dans-les-galces-eng.pdf>.
- Griffiths, Franklyn, Rob Huebert, and P. Whitney Lackenbauer. *Canada and the Changing Arctic: Sovereignty, Security, and Stewardship*. Waterloo: Wilfrid Laurier University Press, 2011.
- Huebert, Robert. "Canada and the Newly Emerging International Arctic Security Regime." In *Arctic Security in an Age of Climate Change*, edited by James Kraska, 193-217. New York: Cambridge University Press, 2011.

- Huebert, Robert. "Canadian Arctic Sovereignty and Security in a Transforming Circumpolar World." *Canadian International Council. Foreign Policy for Canada's Tomorrow*, no. 4 (July 2009).
- Martin, Antoine. "U.S. Expands Use Of Underwater Unmanned Vehicles." *National Defense NDIA's Business and Technology Magazine*, April 2012. Last accessed 6 May 2012. <http://www.nationaldefensemagazine.org/archive/2012/April/Pages/USExpandsUseOfUnderwaterUnmannedVehicles.aspx?PF=1>.
- McArthur, Bruce. Defence Research and Development Canada – Atlantic. "Northern Watch System Concept V2.0." July 2012.
- National Defence and the Canadian Armed Forces. "ARCHIVED - Backgrounder - Polar Epsilon Project." Last accessed 4 May 2012. <http://www.forces.gc.ca/en/news/article.page?doc=polar-epsilon-project/hnps1uo5>.
- National Defence and the Canadian Armed Forces. "Backgrounder - North Warning System." Last accessed 4 May 2012. <http://www.forces.gc.ca/en/news/article.page?doc=north-warning-system/hgq87x9w>.
- National Defence and the Canadian Armed Forces. "Operation NANOOK," last accessed 3 May 2014. <http://www.forces.gc.ca/en/operations-canada-north-america-recurring/op-nanook.page>.
- National Defence and the Canadian Armed Forces. "Operation NUNAKPUT." Last accessed 3 May 2014. <http://www.forces.gc.ca/en/operations-canada-north-america-recurring/op-nunakput.page>.
- National Defence and the Canadian Armed Forces. "Operation NUNALIVUT." Last accessed 3 May 2014. <http://www.forces.gc.ca/en/operations-canada-north-america-recurring/op-nunalivut.page>.
- Parliamentary Information and Research Service Publication PRB 08-07E. "The Arctic: Hydrocarbon Resources." 24 October 2008. Last accessed 2 May 2014. <http://www.parl.gc.ca/content/LOP/researchpublications/prb0807-e.htm>
- Pugliese, David. "Canada-US-Eye-Arctic-Responsibilities-NORAD." *Defence News*, 3 May 2014 - 03:45AM. Last accessed 4 May 2014. <http://www.defensenews.com/article/20140503/DEFREG02/305030018/Canada-US-Eye-Arctic-Responsibilities-NORAD>.
- Shadwick, Martin. "Maritime Futures." *Canadian Military Journal* vo. 8, no. 2. (Summer 2007): 81-82. Last accessed 4 May 2012. <http://www.journal.forces.gc.ca/vo8/no2/doc/commenta-eng.pdf>.

Stuck, Doug. "Canada warns US off claims to Arctic." *Irish Times*, 2 January 2006.

The Canadian Press, CBC.ca "Arctic icebreaker delayed as Tories prioritize supply ships: Joint support ships won't be ready until old ones retired." Last updated Oct 12, 2013 9:53 AM ET. Last accessed 4 May 2012.  
<http://www.cbc.ca/news/politics/arctic-icebreaker-delayed-as-tories-prioritize-supply-ships-1.1991522>.

United States. Department of the Navy United States of America. "The Navy Unmanned Undersea Vehicle (UUV) Master Plan." November 9, 2004, xvi. Last accessed 6 May 2012. <http://www.navy.mil/navydata/technology/uuvmp.pdf>.