National Defence Défense nationale

Canadian Forces College

Collège des Forces Canadiennes

Major Alexander Prentice

Three Solutions to Canadian Armed Forces Gaps in Intelligence, Surveillance, Target Acquisition, and Reconnaissance in Canada's Arctic

JCSP 47

Exercise Solo Flight

Disclaimer

Opinions expressed remain those of the author and do not represent Department of National Defence or Canadian Forces policy. This paper may not be used without written permission.

© Her Majesty the Queen in Right of Canada, as represented by the Minister of National Defence, 2022

PCEMI 47

Exercice Solo Flight

Avertissement

Les opinons exprimées n'engagent que leurs auteurs et ne reflètent aucunement des politiques du Ministère de la Défense nationale ou des Forces canadiennes. Ce papier ne peut être reproduit sans autorisation écrite.

© Sa Majesté la Reine du Chef du Canada, représentée par le ministre de la Défense nationale, 2022

Canada

CANADIAN FORCES COLLEGE – COLLÈGE DES FORCES CANADIENNES

JCSP 47 – PCEMI 47
2020 – 2022

Exercise Solo Flight – Exercice Solo Flight

Major Alexander Prentice

Three Solutions to Canadian Armed Forces Gaps in Intelligence, Surveillance, Target Acquisition, and Reconnaissance in Canada's Arctic

"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."

"La présente étude a été rédigée par un stagiaire du Collège des Forces canadiennes pour satisfaire à l'une des exigences du cours. L'étude est un document qui se rapporte au cours et contient donc des faits et des opinions que seul l'auteur considère appropriés et convenables au sujet. Elle ne reflète pas nécessairement la politique ou l'opinion d'un organisme quelconque, y compris le gouvernement du Canada et le ministère de la Défense nationale du Canada. Il est défendu de diffuser, de citer ou de reproduire cette étude sans la permission expresse du ministère de la Défense nationale."

THREE SOLUTIONS TO CANADIAN ARMED FORCES GAPS IN INTELLIGENCE, SURVEILLANCE, TARGET ACQUISITION, AND RECONNAISSANCE IN CANADA'S ARCTIC

The Canadian Armed Forces (CAF) current development of Intelligence, Surveillance, Target Acquisition and Reconnaissance (ISTAR) capabilities is critical for a restrained force to defend and exercise sovereignty while covering the vast area of operations in the Canadian Arctic. The distances involved in Arctic operations cannot be overstated, when the very limited potential footprint of available forces is considered. Strong, Secure, Engaged, Canada's Defence Policy (SSE) clearly states the need to bring joint capabilities together, including assets like land vehicles, radar, and satellites, to enable fusion of data for the ongoing intelligence preparation of the operating environment.[1] Efficient ISTAR is critical to provide data to enable commanders to best decide where their limited forces need to be deployed across the region in response to threats or other operational needs. Three significant ISTAR capability developments are ongoing within the CAF. The Polar-Over-The-Horizon Radar project will provide the Royal Canadian Air Force (RCAF) the land based surveillance necessary to provide situational awareness to allow commanders to respond to incursions in the air domain, and specifically in sovereign air space over the Arctic. The Grey Jay project will provide the space based surveillance to increase situational awareness in the multiple domains of air, sea, and land. And the Domestic and Arctic Mobility Enhancement project will enhance the Canadian Army (CA) ability to project warfighting elements forward and conduct armed reconnaissance tasks to provide intimate ISTAR data on the ground. The development of the Polar-Over-The-Horizon Radar, the Grey Jay microsatellite, and Domestic and Arctic Mobility Enhancement projects will provide the most significant support to the joint CAF ISTAR effort to cover gaps in air, land, and

[1] Canada. Strong, Secure, Engaged. Canada's Defence Policy. (Ottawa: Government of Canada, 2017), 64.

space-based surveillance and ground reconnaissance in the Canadian Arctic. With these three elements contributing to the joint ISTAR effort, commanders will have enhanced situational awareness in the future across multiple domains.

In SSE, Canada's Arctic was assessed as a huge area, encompassing 75 percent of national coastlines and 40 percent of the total land mass of the country.[2] There is an enormous air domain surveillance challenge in this region and an ISTAR capability requirement for the CAF. The legacy solution is the North Warning System, which is still being maintained but is woefully outdated. The series of radar sights was designed for the Cold War threat of high altitude bombers and not the current stand-off range delivery systems, therefore a capability gap exists in North American Aerospace Defense Command (NORAD).[3] SSE directed that the Department of Defence (DND) collaborate with the United States to develop new technologies to improve Arctic surveillance, which included the renewal of the North Warning System.[4] The Polar-Over-The-Horizon Radar (POTHR) Project is the solution to provide the land based surveillance necessary to allow commanders to respond to incursions in the air domain, specifically the Canadian Air Defence Identification Zone (CADIZ) or our sovereign air space. These types of systems cannot be procured off the shelf, so Defence Research and Development Canada (DRDC) is heavily involved in developing high frequency (HF) radar technology, to be able to support the capability establishment. Specifically, DRDC is adapting HF sky-wave technology, which will have flexibility to be installed on inland sites, as opposed to the legacy coastal sites. The transmitted sky waves make use of ionospheric refraction several hundred

[2] Canada. Strong, Secure, Engaged…, 79.
[3] Sherman, J. NORAD lobbying for next-gen, over-the-horizon technology in north warning system modernization. InsideDefense.Com's SitRep (2021).
[4] Canada. Strong, Secure, Engaged…, 80.

kilometers above the Earth's surface.[5] This overcomes the issue of the Earth's curvature, which is a significant factor when the Arctic's vast area is considered. The desired system is predicted to be able to detect targets up to 50 million square kilometers in area and to a height of 30 kilometers.[6] Potentially, these targets can contribute to countering emerging hypersonic missile threats, although that is still to be proven. But POTHR must account for changes in atmospheric conditions, which fluctuate regularly. And Canada has an extra challenge as the auroral zone passes through the centre of the country or between 60- and 75-degrees latitude, where we commonly see the effects as the Northern Lights. The collisions of gaseous particles in the Earth's atmosphere in this zone with charged particles from the sun's atmosphere inhibits the POTHR picture. Therefore, DRDC is working on multi-dimensional POTHR solutions to nullify the impact of this phenomenon.[7] This is an example of home grown solutions in order to contribute to our collaborative agreement with the United States and NORAD. It also is an example of how the scope of our requirement, rivalled in the world only by Russian territory, demands unique solutions to be capable of adequate Arctic surveillance. Incrementally the Government of Canada (GoC) through DND must fund the development and infrastructure to test out the theories that underlie the systems, and then fund the systems and their installation after that technology is proven. An example is a contract awarded to Raytheon Canada for the construction of transmit and receive electronics for a study of POTHR detection at long range.[8] This type of protracted capability procurement requires a complicated investment strategy and

[5] Thayaparan, T. et al. "High-Frequency Ionospheric Monitoring System for Over-the-Horizon Radar in Canada," Institute of Electronics and Electrical Engineers Transactions on Geoscience and Remote Sensing 57 No, 9 (Sep 2019): 6372.
[6] Ibid., 6372.
[7] Ibid., 6373.
[8] Canada. DND. "Government of Canada announces contract awards for research and development in support of Arctic surveillance." Press Release (1 Feb 2019), 1.

vision, to deliver ISTAR assets in the end, and requires decades of coordinated effort along multiple technological fronts. In RCAF doctrine, OTHR systems fall under measurement and signature intelligence (MASINT) or scientific and technical intelligence that detects, locates, tracks, identifies and describes the unique characteristics of target sources. As POTHR systems are not yet fully developed or implemented, they are generically referred to as radar in doctrine.[9] Overall the development of POTHR systems will be a large upgrade of CAF ISTAR systems in the Arctic air domain.

SSE has further defined satellites as tools for surveillance and reconnaissance in otherwise inaccessible areas in the Arctic, and vital for the CAF to secure northern approaches.[10] SSE further directs in Initiative 69 that defence research and development efforts prioritize studies that will further this technology to overcome the current operating environment challenges[11], paralleling OTHR development. To that end, DND awarded a contract to the University of Toronto Space Flight Laboratory (UoT SFL) to develop a prototype of a multipurpose microsatellite equipped with state-of-the-art sensor technology for air and maritime surveillance.[12] Project "Grey Jay", nestled under the All-Domain Situational Awareness Science and Technology Program, has been initiated to provide a space based solution to provide necessary ISTAR coverage in the multiple domains of air, sea, and land. The microsatellites are to be built on the UoT SFL "deviant" platform with the dimensions of 30 centimeters squared by

[9] RCAF. B-GA-401-002/FP-001 RCAF Doctrine Intelligence, Surveillance and Reconnaissance. (Ottawa: RCAF, 2017), 15.
[10] Canada. Strong, Secure, Engaged..., 71.
[11] Canada. Strong, Secure, Engaged..., 65.
[12] Canada. DND. Government…, 1.

forty five centimeters, and will launch together.[13] The technology combines multiple sensors on a constellation, in close formation at low orbit, which allows for the quick detection of surface or airborne targets.[14] Programmable data processing algorithms and tailored software, will provide the specific military data required to inform decision makers and planning during operations.[15] Unfortunately, due to the classified nature of space technology development, further military capability information is not available on open sources. But it is clear these assets would enhance the CAF capability to carry out surveillance from space, or the ISTAR activity that takes place by vehicles in orbit with payloads designed to observe the Earth.[16] Other than target detection capabilities, space ISTAR assets provide shareable satellite imagery, optimization of Global Positioning Systems, and Overhead Persistent Infrared (OPIR) which allows advance warning of ballistic missile launches anywhere around the world.[17] And although threat identification is a primary goal, the microsatellites will also gather information concerning the meteorological, hydrographic, or geographic characteristics of the terrain in the area of interest the potential commander is focused on.[18] This data will further develop the intelligence preparation of the operational environment, leading to better planning. Finally, with the development of microsatellites, a significant reduction in cost savings is found versus fielding conventionally larger arrays, such as the RADARSAT constellation, which has costs over $1 Billion or orders of magnitude more expensive.[19] So this is the gap that the development of

---

[13] Boucher, M. *DND Project Grey Jay will use the SFL Defiant Platform and Other new Details*. (SpaceQ Media Inc: 25 Feb 2019).
[14] UoT SFL. *Microsatellites: Gray Jay*. (UoT Institute for Aerospace Studies – SFL, 17 Jun 2020).
[15] Boucher, M. *DND Project…*
[16] RCAF. "Doctrine Note 17/01 Space Power." (RCAF Aerospace Warfare Centre, Trenton, 2017), 6.
[17] CA. "B-GL-352-001/FP-001 ISTAR Intelligence, Surveillance, Targeting Acquisition and Reconnaissance Volume 1 – The Enduring Doctrine." (CA Doctrine Centre, Trenton, Apr 2013), 4-17.
[18] Ibid., 6.
[19] Boucher, M. *Canadian Arctic Security Increasing with Acquisition of Three Satellites and Polar Radars.* (SpaceQ Media Inc, 6 Feb 2019).

microsatellites solve in the joint ISTAR system of systems, by increasing capability in the space domain through more efficient use of finite development and procurement funding. Potentially more systems can therefore be fielded, to ensure sustainability of the capability through redundancy. The CAF will be less reliant on fewer, extremely expensive, and vulnerable space vehicles, and therefore limit the effect of potential adversary ISTAR denial strategies. Microsatellites will surely help the CAF lift the fog of war from the Canadian Arctic, and increase the efficiency, capability, and robustness of joint ISTAR space assets.

SSE was clear in directing the CA to acquire all-terrain vehicles in Initiative 43, specifically amphibious utility vehicles optimized for use in the Arctic environment.[20] Alpo K. Marttinen, a Finnish Colonel in World War Two, famously stated "all Arctic operations change into land operations even if they start airborne or seaborne"[21] and this is certainly true in the joint ISTAR effort. By CA doctrine, air reconnaissance is backed up by long-range ground-patrol operations, to confirm the location(s), strength and, where possible, the intentions of the adversary or element in question.[22] In response the CA needs to develop an updated capability to project land elements forward, to conduct armed reconnaissance and surveillance tasks, providing intimate ISTAR on the ground. Deployed soldiers on the ground can provide enhanced assessment and details in the area of interest, around the clock surveillance, and more importantly identify potential threats or activity, less constrained by more distant intelligence gathering assets. But they need a method to get there across harsh Arctic conditions, over and above light over snow vehicles (LOSVs), while bringing more capabilities and force projection to the area of operations. The legacy solution was the BV206 all-terrain tracked vehicle, which

[20] Canada. Strong, Secure, Engaged…, 37.
[21] Kattunen, J. "Future Mobility," *Military Review* 101, Iss. 4, (Jul/Aug 2021): 131.
[22] CA. B-GL-323-003/FP-001 Operations In Cold Weather. (Ottawa: Canadian Army, 2012), 8-1-2.

was projected to be replaced by 1998, but has lingered on until the present day. The DAME project is the CA developing solution for this gap, which is widening as the legacy vehicles parts and viability diminish, and the limited number of platforms are divested. For the specific ISTAR tasks of reconnaissance and surveillance, the project has identified the following critical capability requirements in the Canadian Arctic environment: ability to operate in as low as -46 degrees Celsius, self-sufficiency for 72 hours, and capacity to carry ten soldiers and two crew. By CA doctrine, the most common and likely sized land-based element to be projected into the Canadian Arctic to conduct ISTAR tasks is the reconnaissance platoon, which is well suited to four of the project vehicles.[23] Mobility is a key feature requiring the vehicle to be capable of off-road travel. In the Arctic this includes floating and swimming without preparation due to some of the unpredictability of terrain, climbing from water to ice, and ability to negotiate obstacles such as ice flows, crevasses, rivers, muskeg, rock, ice sheets, and gaps. Self-recovery, air deployable, 300 kilometer range, 50 kilometer per hour top speed, and towing capacity were also identified as the minimum capabilities in the Arctic environment.[24] Over snow has been identified as an important factor in Arctic conditions, balancing a low enough ground pressure to resist bogging down, while maintaining the required carrying and towing capacity.[25] A command post variant, able to communicate large distances and feed information back to the employing formation, is a key requirement to provide the data node that would connect to the joint ISTAR system of systems.[26] A larger vehicle that can protect the crew and reconnaissance personnel from the harsh elements in transit will allow fresher soldiers to carry out tasks once the

[23] CA. B-GL-394-002/FP-001 Ground Manoeuvre Reconnaissance. (Kingston: CA Army Doctrine Centre, 2013), 4-1-1.
[24] CA. DAME CA Force Development Working Group Record of Discussion (Ottawa 5-6 Nov 2019), 11.
[25] Kattunen, J. *Future Mobility*…, 138.
[26] CA. DAME…, 4.

area of operations is reached. These two key reasons are why LOSVs or snowmobiles, although well suited for reconnaissance, cannot fill the BV206 divestment gap alone. Currently the CA DAME project is in-line with other SSE initiatives and is in the definition stage of the process. The RCAF has joined in the project to meet their own specific needs and lessen the requirement for a parallel effort.[27] With the next phase being procurement and evaluation of potential platforms, multiple equipment manufacturers are interested in fulfilling the need.[28] With the procurement of a land vehicle, capable of getting to any land accessible area of interest in the Canadian Arctic and communicating once there, the CA will continue to contribute to the joint ISTAR effort. Intimate reconnaissance and surveillance capability on the ground will be provided while the secondary effect of projecting forces in the area of operations is achieved.

Fielding ISTAR capabilities across the breadth of the Canadian Arctic with relatively limited resources and assets to the size of area, requires a coordinated joint effort from the CAF, supported by DRDC, industry, academia, and other governmental organizations to develop technologically efficient solutions. As threats evolve over time and legacy systems age out, gaps in capability appear, exacerbated by technologically complex and lengthy procurement processes in order to solve unique challenges when operating in the Arctic. Two critical gaps no longer adequately fulfilled by the aging Northern Warning System and BV206 vehicles, along with the need to increase space based ISTAR capability, have been identified in SSE in relation to Canadian Arctic defence. Arguably the development of POTHR, the Grey Jay microsatellites, and DAME projects are the most significant capability procurement files currently ongoing in

[27] DAME project status was confirmed at the Director Land Requirements (DLR) Senior Review Board, in Ottawa, 24 Sep 2021.
[28] Ibid.

the CAF. They all have the potential to contribute to the joint ISTAR system of systems, in order to carry out the CAF mandate to defend Canada, and specifically the Canadian Arctic, while fulfilling NORAD commitments. Collectively, the description of these projects and the gaps they are intended to fill in defence demonstrate how ISTAR capabilities are a joint CAF responsibility to develop in the face potential emerging and legacy threats.

BIBLIOGRAPHY

Boucher, Marc. Canadian Arctic Security Increasing with Acquisition of Three Satellites and Polar Radars. SpaceQ Media Inc, 6 Feb 2019. Accessed at: https://spaceq.ca/canadian-arctic-security-increasing-with-acquisition-of-three-satellites-and-polar-radars/.

Boucher, Marc. DND Project Grey Jay will use the SFL Defiant Platform and Other new Details. SpaceQ Media Inc, 25 Feb 2019. Accessed at: https://spaceq.ca/dnd-project-grey-jay-will-use-the-sfl-defiant-platform-and-other-new-details/

Canada. Strong, Secure, Engaged. Canada's Defence Policy. Government of Canada (GoC), Ottawa, 2017.

Canadian Army. *B-GL-323-003/FP-001 Operations in Cold Weather*. Canadian Army Doctrine Centre, Kingston, Aug 2012.

Canadian Army. *B-GL-352-001/FP-001 ISTAR Intelligence, Surveillance, Targeting Acquisition and Reconnaissance Volume 1 – The Enduring Doctrine*. Canadian Army Doctrine Centre, Kingston, Apr 2013.

Canadian Army. *B-GL-394-002/FP-001 Ground Manoeuvre Reconnaissance*. Canadian Army Doctrine Centre, Kingston, Apr 2013.

Canadian Army. *Northern Approaches: Army Arctic Concept 2021*. Canadian Army Doctrine Centre, Kingston, 2013.

Canadian Army. Domestic Arctic Mobility Enhancement Canadian Army Force Development Working Group. Ottawa, 529 November 2019.
Reference Type: Record of Discussion

Canada. Department of National Defence. *Government of Canada announces contract awards for research and development in support of Arctic surveillance*. Ottawa, 1 Feb 2019.
Reference Type: Press Release

Karttunen, Jari J. Future Mobility. Military Review; Fort Leavenworth Vol. 101 (4) ,Jul/Aug 2021: 133-140.

Machi, Vivienne. *United States, Canada Studying Options To Replace Arctic Early Warning Radars*. National Defence, Arlington, Vol. 103 (777), Aug 2018: 26-27.

Royal Canadian Air Force. *B-GA-401-002/FP-001 Royal Canadian Air Force Doctrine Intelligence, Surveillance and Reconnaissance*. Royal Canadian Air Force Aerospace Warfare Centre, Trenton, 2017.

Royal Canadian Air Force. *Doctrine Note 17/01 Space Power*. Royal Canadian Air Force Aerospace Warfare Centre, Trenton, 2017.

Sherman, J. NORAD lobbying for next-gen, over-the-horizon technology in north warning system modernization. InsideDefense.Com's SitRep, 2021. Accessed at: https://www.proquest.com/trade-journals/norad-lobbying-next-gen-over-horizon-technology/docview/2563672209/se-2?accountid=10524.

Thayaparan, T. et al. High-Frequency Ionospheric Monitoring System for Over-the-Horizon Radar in Canada, Institute of Electronics and Electrical Engineers Transactions on Geoscience and Remote Sensing Vol. 57 (9), Sep 2019: 6372-6384.

University of Toronto. Microsatellites: Gray Jay. University of Toronto Institute for Aerospace Studies – Space Flight Laboratory, 17 Jun 2020. Accessed at: https://www.utias-sfl.net/?p=3105.