

Canadian  
Forces  
College

Collège  
des  
Forces  
Canadiennes



## EMERGING TRENDS IN SPACE-BASED COMMUNICATION TECHNOLOGY

Major Denise C.A. Sweet

### JCSP 47

#### Service Paper

##### 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, 2021.

### PCEMI 47

#### Étude militaire

##### Avertissement

Les opinions 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, 2021.



CANADIAN FORCES COLLEGE - COLLÈGE DES FORCES CANADIENNES

JCSP 47 - PCEMI 47  
2020 – 2021

SERVICE PAPER – ÉTUDE MILITAIRE

## **EMERGING TRENDS IN SPACE-BASED COMMUNICATION TECHNOLOGY**

By Major Denise C.A. Sweet

*“This paper was written by a candidate 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.”*

Word Count: 2,300

*« 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. »*

Nombre de mots : 2.300

# EMERGING TRENDS IN SPACE-BASED COMMUNICATION TECHNOLOGY

## AIM

1. As the world is rapidly becoming more technologically advanced, reliable and affordable global connectivity through space-based platforms is quickly becoming a reality. This paper will examine the emerging trend for super satellite constellations to provide global communication coverage and how this could be a game changer for the Canadian Armed Forces' (CAF) ability to enforce sovereignty in the north. The paper provides suggestions about how this new technology could be used and potential areas where the CAF should invest resources to ensure our Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance (C4ISR) enterprise is able to take advantage of this new technology.

## INTRODUCTION

2. The enforcement of Canadian sovereignty in the north has always been difficult due to the vast and unforgiving environment. Currently communication systems in the north are either unreliable or non-existent. With the reseeding ice pack in the Arctic, the Northwest passage is quickly becoming a viable trade route. It is also drawing attention from other nations on possible commercial endeavours with or without Canadian permission. These factors makes Canada's need to be able to operate and enforce sovereignty in the Arctic more pressing. This requirement for increased presence in the Arctic is a common theme throughout the Canadian Defence Policy, Strong, Secure and Engaged (SSE),<sup>1</sup> and reliable communications will be critical for any success.

3. This paper will first look at the gaps in current communication systems and how emergent space-based technology could fill these gaps. It will then examine areas where Canada could help influence the new domain to ensure the CAF can take advantage of the systems.

## DISCUSSION

4. One of the largest hurdles the CAF currently faces when operating in the north is the lack of reliable communication systems. Dependable communication systems are crucial to provide everything from situational awareness, search and rescue to early warning. The current lack of robust communication systems makes it difficult to enforce Canadian sovereignty in the north as we are unable to have a clear operational picture or have sufficient reach back capabilities for those operations that do occur.

5. The lack of sufficient communication infrastructure is not solely a sign of historical underinvestment in the North but also has fiscal and technological roots. Land based communication systems have significant infrastructure and maintenance requirements. One needs only to look at a cell phone coverage map of Canada to see where there is not a sufficient user base to justify the expense of building and maintaining the required cellular towers.<sup>2</sup>

---

<sup>1</sup> Canada, *Strong Secure Engaged* (Ottawa: Minister of National Defence, 2017).

<sup>2</sup> "Compare Canadian Coverage Maps from all Carriers," , accessed 30 Jan, 2021, <https://www.comparecellular.ca/coverage-maps/>.

6. Space-based communication technology can be used to solve this global coverage problem, but has historically had limitations. First, in order for a satellite to remain continuously over the same area of the Earth it must be in a geosynchronous orbit. Although this may seem convenient it prevents the satellites from being able to provide polar coverage.<sup>3</sup> This results in operations in much of Canada's arctic unable to use these assets. It is possible to use highly elliptical orbits for communication satellites as although they do not remain in the same place over the Earth, which complicates tracking from ground stations, they can provide long linger times over the poles. Unfortunately, this approach requires a constellation of satellites to provide continuous coverage which has historically proven to be extremely costly and compromises have resulted in significant coverage gaps.

7. Another factor that has limited the development of robust space-based communication systems with polar coverage in the past, is the space domain used to be only truly accessible to the governments of a few countries. Limited launch capabilities and high satellite development costs once made it so that satellites and their orbital parameters had to be optimised to get the most value out of limited platforms. Since there has historically been limited polar activity it is not surprising to see underinvestment in providing coverage to remote areas.

8. The restricted number of platforms does not only mean there is limited coverage, but that there is a limit on available bandwidth as well. With modern systems and practices requiring increased bandwidth it is not surprising that current space based systems are insufficient to keep up with demand. This bandwidth limitation is not just a concern in the arctic as it is not uncommon for the RCN to have communication outages even when operating in non-polar regions. This highlights the potential utility of this emergent technology, not only for northern operations, but for integration into the CAF's C4ISR spine for use in all future operations.

9. Fortunately for Canada, strong alliances and investments in space-based platforms with allies have granted access to military satellite communication platforms such as the Advanced Extremely High Frequency (AEHF) constellation for critical communications and the Wideband Global SATCOM (WGS) system for broadband data transfer. However, these platforms are both in geosynchronous orbits and therefore do not provide coverage over the polar regions.<sup>4</sup> They also have limited bandwidth capacity which, in a full spectrum warfare scenario, may not be sufficient to meet the communications requirements. In addition, although Canada did partially fund WGS-9 in order to be granted access to the constellation<sup>5</sup> we are not the owners and could be denied access if the US required more bandwidth for an operation.

10. Recent advancements in technology have lowered the cost of entry into the space domain opening the door for commercial space based platforms to be viable business

---

<sup>3</sup> "Geostationary Satellite Orbit, GEO," , accessed 30 Jan, 2021, <https://www.electronics-notes.com/articles/satellites/basic-concepts/geostationary-orbit-geo.php>.

<sup>4</sup> "AEHF Satellite Constellation," , accessed 25 Jan, 2021, <https://spaceflight101.com/spacecraft/aehf/>; "WGS – Wideband Global Satcom," , accessed 25 Jan, 2021, <https://spaceflight101.com/spacecraft/wgs-wideband-global-satcom/>.

<sup>5</sup> "WGS – Wideband Global Satcom,"

models. Commercial platforms like INMARSAT's, 14 satellites in geosynchronous orbit,<sup>6</sup> help to augment the bandwidth shortfalls of military satellites but still do not provide global coverage. Iridium on the other hand provides global coverage with its 66 satellite constellation in low earth orbit.<sup>7</sup> Iridium's use of a large constellation of satellites to provide reliable global coverage was made possible by increasingly affordable space technology and appears to be a trend we will see more of in the future.

11. As mentioned above, constellations of communication satellite seem to be the big trend in space based technology. However companies are no longer looking at small constellations of robust and expensive satellites to provide the coverage but super constellations, in low earth orbit, of inexpensive and mass produced satellites to provide the redundancy and bandwidth required for modern civilian and military operations. SpaceX's STARLINK and the Airbus and OneWeb joint venture are two examples of up and coming commercial endeavours that could provide the robust communications framework required for polar operations. Both OneWeb's proposed 900 satellite constellation<sup>8</sup> and STARLINK's over 12,000 satellite constellation<sup>9</sup> are promising to be able to provide global high speed, low latency internet connectivity.

12. Reliable arctic connectivity would not only make operating in the north easier and safer but it could enable more robust northern surveillance capabilities. Commercial high speed internet connectivity could be leveraged in the future as the communications backbone of northern operations. With increased foreign activity in the North it is crucial that Canada has the capability to monitor and operate in the arctic. Without adequate connectivity Canada runs the risk of not being aware of incursions in to its territory or being able to react to them. A robust communications network which leverages these future commercial solutions to link sensors would go a long way in enforcing Canadian sovereignty in the north.

13. The US department of defence has recognized the importance of improving northern communication capabilities and is reportedly seeking to spend \$130 million US dollars on northern communications experiments with STARLINK and OneWeb in 2021.<sup>10</sup> While it is unrealistic to assume the CAF will match the investments made by the US, the CAF should, at the very least, be looking to benefit from the lessons learned of these experiments. Much like the funding Canada provided for WGS, it would be prudent to invest in one or both of these emergent systems in order to secure usage and or even influence some of the technologies used. This could ensure the CAF and other government departments will be able to utilize the systems when they are operational.

14. There appears to be a growing trend for militaries to leverage commercial services. This may be due to shrinking defence budgets, or it could be due to government procurement systems being unable to keep pace with industry. Either way the CAF does

---

<sup>6</sup> "Inmarsat," , accessed 25 Jan, 2021, <https://www.inmarsat.com/en/about/technology/satellites.html>.

<sup>7</sup> "Iridium Technology ," , accessed 25 Jan, 2021, <https://www.iridium.com/>.

<sup>8</sup> "OneWeb Satellites," , accessed 25 Jan, 2021, <https://onewebsatellites.com/>.

<sup>9</sup> "Starlink," , accessed 25 Jan, 2021, <https://www.starlink.com/>.

<sup>10</sup> "Starlink," ; "U.S. Military to Cooperate with SpaceX to Overcome Arctic Communication Blackout," last modified 26 Feb, accessed 25 Jan, 2021, <https://www.highnorthnews.com/en/us-military-cooperate-spacex-overcome-arctic-communication-blackout>.

not have the resources or political will to build a military communication system capable of providing adequate northern coverage. Even the US has recognised this is not feasible and has instead decided to invest early in commercial companies to ensure their emergent technology will meet the operational needs of their military.

15. The trend of using large satellite constellations to provide global coverage is not limited to communication satellites. There are also commercial satellite imaging companies like Planet which uses a constellation of over 150 satellites to image the entire globe daily.<sup>11</sup> Access to this amount of up to date information combined with robust communications systems could be used to monitor Canadian territory and position our limited forces in areas where they will have the greatest effect. However, although there are no upfront development costs to Canada to use commercial satellite services there can be significant subscription costs that one must balance when looking at commercial solutions.

16. From a national defence perspective, there are several problems that an increased reliance on commercial space based satellite solutions present. Firstly, since services are provided by a company looking to profit the services may not just be available to allies. Therefore, adversaries could have access to the same systems which would make it easier for them to find ways to deny us usage. One way to counter this is through early involvement with companies so agreements can be put in place on who can buy services. This of course comes at a cost and is not always an option. Another potential issue is that you lose control of the system and may not have a say in when outages occur. There is also a concern that a company may not be supportive of a government's military operation and refuse to provide a service. These potential stumbling blocks are why it is important to ensure critical services are protected by detailed and binding contracts as well as having access to backup systems, even if they are less robust.

17. Unfortunately, even a binding contract will not prevent a loss of service if a commercial venture fails to be profitable. There is currently massive investments being made in space-based systems but with this comes risk. OneWeb already overstretched itself in the race to provide global high speed internet coverage, filing for bankruptcy in March 2020.<sup>12</sup> Although the company was saved, it demonstrates the importance of investing in a company with a good business model or you could risk losing a critical capability. Much like with other trade, defence and especially the Canadian defence industry is not large enough to support companies on its own. However, defence investments can potentially make the difference for a new company to be able to break into the market.

18. Another concern with this new technology is that the thousands of satellites will further congest the space environment. As satellite technology becomes more accessible for states and commercial enterprises, the congested and contested nature that currently exists is only going to get worse. Therefore, this technology will not only be important for

---

<sup>11</sup> "Planet Imagery and Archive: Global Monitoring, Daily Insight," , accessed 25 Jan, 2021, <https://www.planet.com/products/planet-imagery/>.

<sup>12</sup> "How OneWeb's \$1 Billion Bankruptcy Rescue Changes the Competitive Landscape for Elon Musk's Starlink," last modified 10 Jul, accessed 25 Jan, 2021, <https://www.cnn.com/2020/07/10/onewebs-bankruptcy-rescue-changes-the-competition-for-elon-musks-spacex-starlink.html>.

future operations, but it also demonstrates the growing need for the CAF to understand the space domain so as to leverage it appropriately and defend against future threats.

## **CONCLUSION**

19. The ability to operate in the north is quickly becoming critical as warmer temperatures make the area more accessible and interesting for exploitation. With the northwest passage opening for shipping traffic and potential commercial viability of resource exploitation in the north, Canada needs to be able to have situational awareness of northern activities and be able to respond to major incidence, incursions and illegal activities in the north. A major roadblock to being able to safely operate in the north is the current unreliable nature of communication and navigation systems north of 65 degrees latitude. Emergent super satellite constellations have the potential to be a cost effective solution to obtaining reliable communications in the arctic.

20. Super satellite constellations such as Starlink and OneWeb are promising to provide reliable, global coverage of high speed internet through the use of affordable, mass produced satellites placed in low earth orbit. These systems will eliminate the northern communications dark spots and could be exploited to gain better situational awareness of activities in Canada's northern regions. Possessing a clear picture of what is going on in the North will be game changing for protecting Canadian sovereignty.

21. Despite the clear benefits to future arctic operations there are also some potential drawbacks that will need to be considered as communication becomes easier in the north. Since the service will be affordable and commercially available, it is likely to stimulate more commercial activity in the north, further increasing the need for the CAF to be able to effectively operate in the arctic. There are also environmental concerns due to the further congestion of the space environment from thousands of new satellites. Despite concerns the creation of these constellations is already approved and underway so it would be ill-advised for the CAF not to take advantage of the capability as it comes online in the future.

## **RECOMMENDATIONS**

22. In light of the information this service paper presents, the following are recommendations on how the CAF should approach the communication issues in the north.

- a. The CAF should leverage industry to provide a commercial solution to the northern communication problem;
- b. Work with the US to leverage lessons learned from the US's northern communications experiments that it is conducting with industry;
- c. Ensure the C4ISR spine of the future force will be able to utilize the high speed commercial satellite communications systems; and
- d. Investigate ways to leverage this emergent technology to improve connectivity and available bandwidth not only in the north but for all operations.

## BIBLIOGRAPHY

Blau, Patrick. "AEHF Satellite Constellation." Accessed 25 Jan, 2021.

<https://spaceflight101.com/spacecraft/aehf/>.

Blau, Patrick. "WGS – Wideband Global Satcom." Accessed 25 Jan, 2021.

<https://spaceflight101.com/spacecraft/wgs-wideband-global-satcom/>.

Canada. *Strong Secure Engaged*. Canadian Defence Policy. Ottawa: Minister of National Defence, 2017.

Compare Cellular. "Compare Canadian Coverage Maps from all Carriers." Accessed 30 Jan, 2021. <https://www.comparecellular.ca/coverage-maps/>.

Electronics-notes. "Geostationary Satellite Orbit, GEO." Accessed 30 Jan, 2021.

<https://www.electronics-notes.com/articles/satellites/basic-concepts/geostationary-orbit-geo.php>.

Humpert, Malte. "U.S. Military to Cooperate with SpaceX to Overcome Arctic Communication Blackout." Accessed 25 Jan, 2021.

<https://www.highnorthnews.com/en/us-military-cooperate-spacex-overcome-arctic-communication-blackout>.

Inmarsat Global Limited. "Inmarsat." Accessed 25 Jan, 2021.

<https://www.inmarsat.com/en/about/technology/satellites.html>.

Iridium. "Iridium Technology ." Accessed 25 Jan, 2021. <https://www.iridium.com/>.

OneWeb. "OneWeb Satellites." Accessed 25 Jan, 2021. <https://onewebsatellites.com/>.

Planet Labs Inc. "Planet Imagery and Archive: Global Monitoring, Daily Insight."

Accessed 25 Jan, 2021. <https://www.planet.com/products/planet-imagery/>.

Sheetz, Michael. "How OneWeb's \$1 Billion Bankruptcy Rescue Changes the Competitive Landscape for Elon Musk's Starlink." Accessed 25 Jan, 2021.

<https://www.cnn.com/2020/07/10/onewebs-bankruptcy-rescue-changes-the-competition-for-elon-musks-spacex-starlink.html>.

SpaceX. "Starlink." . Accessed 25 Jan, 2021. <https://www.starlink.com/>.