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Protecting Canadian Space Capabilities: An Argument for Deterrence in the Space Domain

Lieutenant-Colonel Alan Jacula

JCSP 48

Exercise Solo Flight

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CANADIAN FORCES COLLEGE – COLLÈGE DES FORCES CANADIENNES

JCSP 48 – PCEMI 48
2021 – 2022

Exercise Solo Flight – Exercice Solo Flight

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PROTECTING CANADIAN SPACE CAPABILITIES: AN ARGUMENT FOR DETERRENCE IN THE SPACE DOMAIN

INTRODUCTION

Space has been described as an increasingly "congested, contested and, competitive" domain, which has become vital to both everyday lives as well as modern military operations.[1] As such, the Canadian Government, through the Strong, Secure, Engaged Defence Policy (SSE), identified the requirement for the Canadian Armed Forces (CAF) to defend and protect military space capabilities.[2] This SSE mandate is broad as the overall space enterprise is massive with a multitude of threats posed by natural hazards as well as the possibility of intentional attacks being aimed at ground stations, being carried out against space networks through cyber-attacks, and being targeted directly against space-based assets. With respect to hostile actions aimed directly at Canadian space-based assets, Canada must establish a robust deterrence system, built on a variety of mechanisms and capabilities organic to Canada as well as through international partnerships, to ensure adequate protection and security of military space-based capabilities as mandated by SSE. Through an examination of the current and potential space-based adversarial threats, along with an analysis of the challenges and risks associated with achieving an all-encompassing defensive posture, it will be shown

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[1] Innovation, Science and Economic Development Canada, *Exploration, Imagination, Innovation – A New Space Strategy for Canada* (Ottawa: Minister of Innovation, Science and Economic Development Canada, 2019), 5, 14; United States Space Force, *Space Capstone Publication - Space Power Doctrine for Space Forces* (Arlington, VA: United States Space Force, June 2020), 10; Department of National Defence, *Concept of Operations for the CAF Joint Space Program* (Ottawa: Department of National Defence, 2020), 5.

[2] Department of National Defence, *Strong, Secure, Engaged: Canada's Defence Policy* (Ottawa: Department of National Defence, 2017), 72.

that a deterrence approach is the best means to achieve the required protection of military space capabilities. Furthermore, the complexities associated with achieving deterrence across the broad spectrum of potential adversaries will demonstrate the requirement for a robust deterrence system encompassing credible, well communicated, active and passive mechanism and capabilities. Finally, an analysis of these various mechanisms and capabilities, along with Canada's objectives and requirements, will show that Canada must engage in the development and employment of organic passive and active deterrence mechanisms, while also leveraging and expanding international partnerships and alliances to maximize the effectiveness and global reach of the deterrence system.

Space-Based Threats and Protection Options

In order to determine the most effective means of defending and protecting an entity, such as Canada's space capabilities, it is paramount to understand the nuances of both the entity being protected as well as the potential threats against that entity. With respect to threats, the ability to directly attack space-based assets dates back to 13 October 1959, when the United States of America's (U.S) tested an air launched ballistic missile to demonstrate that a projectile could be aimed sufficiently close to an orbiting satellite to induce catastrophic damage.[3] Today, modern anti-satellite (ASAT) weapons broadly fit in to one of two categories; terrestrial launched direct ascent weapons, which travel on a suborbital trajectory before striking the intended space target, and co-orbital weapons, which are launched into orbit and remain there until maneuvered to strike their

[3] "Bold Orion Weapons System 199 (WS-199B)," GlobalSecurity.Org, Last modified 30 June 2016, https://www.globalsecurity.org/space/systems/bold-orion.htm.

target.[4] Co-orbital ASAT weapons, through rendezvous and proximity operations, can be maneuvered to either directly impact a target satellite or to position itself in such proximity that detonation of onboard explosives, or the activation of directed energy sources, will disrupt or destroy the target satellite.[5] These co-orbital devices complicate the threat spectrum as these ASAT weapons could remain in orbit for months or even years, appearing innocuous or going unnoticed, before being directed to attack their target.

Just as the ASAT technology has evolved over the years, so too have the list of potential adversaries possessing this technology. Russia developed ASAT capabilities shortly after the U.S's successful ASAT test, and have continued developing and amassing both direct ascent weapons as well as co-orbital weapons.[6] Furthermore, in 2017, China successfully tested a direct ascent ASAT missile against one of their own satellites and India followed suit with their own direct ascent ASAT weapon in 2019.[7] In addition to these nations, because ballistic missile technology forms the basis for many of these weapons, it can be assumed that North Korea and Iran are not far behind in having their own ASAT capabilities. As well, as space technology becomes less expensive and thus more accessible, non-state actors pose an increasing concern. Currently, the

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[4] Todd Harrison, Kaitlyn Johnson, and Makena Young, *Defense Against the Dark Arts in Space: Protecting Space Systems from Counterspace Weapons* (Washington, DC: Blue Ridge Summit: Center for Strategic and International Studies, 2021), 7.

[5] Department of the Air Force, *Air Force Doctrine Publication 3-14 - Counter Space Operations* (Maxwell AFB, AL: Lemay Center for Doctrine, 2018), 1; Todd Harrison, Kaitlyn Johnson, Makena Young, Nicholas Wood, and Alyssa Goessler, *Space Threat Assessment 2022* (Washington, DC: Aerospace Security Project - Center for Strategic and International Studies, 2021), 3.

[6] Harrison, Todd, et al. *Defense Against the Dark Arts in Space: Protecting Space Systems from Counterspace Weapons*. . ., 1, 4.

[7] Justin Paul George, "History of anti-satellite weapons: US tested 1st ASAT missile 60 years ago," *The Week Magazine*. Last modified 27 March 2021. https://www.theweek.in/news/sci-tech/2019/03/27/history-anti-satellite-weapon-us-asat-missile.html.

technology to track satellites in orbit, including classified U.S. satellites, is readily available and through assistance from rogue states or by hiring the required expertise, the ability to launch direct ascent or co-orbital ASAT weapons is within reach of terrorist organizations.[8] In fact, the advances in miniaturized technologies have enabled the development of small, low cost, yet highly maneuverable and sophisticated, cube satellites (CubeSats) which due to their size and weight are relatively simple to launch into orbit.[9] This emergence of CubeSats in the space domain is analogous to the impact that drones have had on the air domain, where virtually anyone can now pose a threat through the employment of air power in the form of miniature, low cost, drone fleets. With several nations, as well as non-state actors, having the potential to utilize an ASAT weapon against space-based assets, Canada's military space capabilities must be protected from a diverse group of adversaries, with differing ideologies, morals, and motivations. This varied group of potential adversaries, combined with the wide range of ASAT weapons, generates a significant challenge as far as protecting and defending space capabilities.

In addition to the potential adversaries and their means of attack, the quantity of current and future assets requiring protection, combined with the vastness of the space domain, further exacerbate the challenges of protecting and defending space capabilities. Between purely Canadian assets, as well as alliance assets, the CAF relies on a large quantity of both government and commercially owned satellites, operating at various

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[8] Nina-Louisa Remuss, "The Need to Counter Space Terrorism – A European Perspective," *European Space Policy Institute Perspectives,* no. 17 (2009): 4-5.
[9] Michael Nayak. "CubeSat Proximity Operations: The Natural Evolution of Defensive Space Control into a Deterrence Initiative," *The Space Review*, 18 January 18 2016. https://www.thespacereview.com/article/2902/1.

orbits and performing various functions.[10] Currently, the government of Canada has authorized and licensed the operation of 33 active satellites and has approved an additional 16 licenses for satellites yet to be launched, many of which are dual-use serving both civilian and military needs.[11] As well, the CAF relies on the U.S.'s Global Positioning System (GPS) satellites for navigation, and Canada provided funding and support to the U.S.'s Wideband Global Satellite (WGS) system and their Advanced Extremely High Frequency (AEHF) system to ensure the CAF's ability to access and utilize these vital protected communications systems.[12] These satellite systems operate across the space domain from low earth orbit (LEO), at 180 to 2,000 kilometers above the earth, all the way up to geosynchronous orbit (GEO), at over 35,000 kilometers above the earth.[13] Even GEO satellites, which orbit in a fixed location relative to the earth, are still traveling over 260,000 kilometers every 24 hours.[14] Thus, with the range of the various orbits there exists a massive area requiring defence and an equally massive area for adversarial ASAT weapons to operate and potentially hide. Additionally, the number of assets requiring protection will likely grow significantly as Canada and other stakeholders look to capitalize on the benefits of employing larger constellations of LEO satellites rather than GEO satellites, such as improved bandwidth and better polar

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[10] Department of National Defence, *Concept of Operations for the CAF Joint Space Program . . .,* 5,7.
[11] Innovation, Science and Economic Development Canada, *Satellite Services - Authorized and Approved Canadian Satellites*, Accessed on 11 April 2022, https://www.ic.gc.ca/eic/site/smt-gst.nsf/eng/sf01879.html.
[12] Elinor Sloan, "Communications Satellites in Canadian Security Policy: History and Prospects," *International Journal* (Toronto) 76, no. 2 (2021): 214-215.
[13] National Aeronautics and Space Administration, *Catalog of Earth Satellite Orbits*, Accesses 8 April 2022, https://earthobservatory.nasa.gov/features/OrbitsCatalog#:~:text=The%20semi%2Dsynchronous%20orbit%20is,hours%20to%20complete%20an%20orbit.
[14] United States Space Force, *Space Capstone Publication - Space Power Doctrine for Space Forces*. . ., 6.

coverage.[15] With space being such a vast and remote domain, with an ever-growing quantity of assets, developing an effective defensive framework is challenging and resource intensive.

There exists a school of thought that total space defence and security is the best method to ensure protection of space assets, however, this approach requires a level of space control similar to that of air superiority or air supremacy used in the context of air control.[16] Furthermore, this theory relies largely on the achievement of near complete situational awareness of the space domain along with the ability to limit the total number of space-based assets to a small quantity of well defended, highly maneuverable, satellites to ensure total security.[17] As discussed, the vastness of space and the growing number of assets in space work counter to the concept of achieving an everlasting state of space superiority or supremacy. Even arguments in support of the space control approach highlight the unlikely ability to ever achieve complete situational awareness in the space domain. [18] U.S. space doctrine also highlights a concern with attempting to achieve high levels of space control, as these efforts can hinder the national infrastructure and communication networks of other nations.[19] Finally, the build-up of weapons for an all-encompassing defensive system could lead to an undesirable arms race, with nations reacting, and over-reacting, to the defensive posture being taken by their adversaries.[20]

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[15] Elinor Sloan, "Communications Satellites in Canadian Security Policy: History and Prospects," . . ., 215-219.
[16] Russell Rumbaugh, *What Place for Space: Competing Schools of Operational Thought in Space* (Arlington, VA: Aerospace Corporation, Centre for Space Policy and Strategy, 2019), 4-5.
[17] Ibid.
[18] B.T. Cesul, "A Global Space Control Strategy," *Air and Space Power Journal,* 28 no. 6, (2014): 72.
[19] United States Space Force. *Space Capstone Publication - Space Power Doctrine for Space Forces*. . .,30.
[20] Brad Townsend, "Strategic Choice and the Orbital Security Dilemma," *Strategic Studies Quarterly*, Spring (2020): 87.

This form of arms race would ultimately be counter to the SSE mandate, as the increase in adversarial weapons in space and the heightened tensions between nations would actually decrease the overall space security situation. Given the challenges and potential risks associated with achieving the level of space control required to ensure total defence of space-based assets, Canada must focus on an alternative approach to ensuring protection of military space capabilities.

Contrary to a defence focused posture, which assumes an attack will occur and thus ensures adequate defences against that inevitability, a deterrence posture is developed such that potential adversaries will be influenced away from attacking and thus security and protection can be achieved with a reduced defensive footprint.[21] In this sense, deterrence is a force multiplier as the total protection provided to an entity can greatly surpass the actual defensive capabilities put in place.[22] Thus, from a space perspective, a level of protection can be achieved across the domain without actively defending the entirety of space. These aspects of deterrence make it particularly well suited to meet the security challenges posed by the space domain, without being exorbitantly expensive or prohibitive to other nations, and with a reduced risk of provoking a costly and dangerous arms race. In addition, an added benefit to focusing on deterrence is that many of the mechanisms required to achieve deterrence also provide a

[21] Ronald Kessel, "The Positive Force of Deterrence – Estimating the Quantitative Effects of Target Shifting," *NATO Undersea Research Centre* (La Spezia, Italy, 2010), 1-2. https://ieeexplore-ieee-org.cfc.idm.oclc.org/stamp/stamp.jsp?tp=&arnumber=5730250&tag=1
[22] Ibid.

level of defensive protection and benefits in the event that an attack was still to occur despite the deterrence measures in place.[23]

Thus, due to the vastness of space and the overwhelming quantity of current and future assets requiring protection, coupled with a growing threat base, the force multiplier effects of deterrence make it the best approach to achieve the SSE mandate of defending and protecting Canada's military space capabilities. With a focus on deterrence, Canada is most likely to achieve the SSE mandates without unwittingly entering a costly and dangerous arms race while also ensuring an ability to protect against adversarial attacks should they still occur. Deterrence is a complex strategy though, which requires a robust framework, particularly to be effective in the massive space environment and against the myriad threats identified.

Deterrence Mechanisms and Capabilities in the Space Domain

To validate the requirement for a robust deterrence system, built on a variety of mechanisms and capabilities, the theory of deterrence and how to practically apply it to the space domain will be examined. Deterrence theory, dating back to the Cold War and early studies by Dr. Glenn Snyder, provides two approaches to deter an adversary: deterrence by denial and deterrence by punishment.[24] The former being based on an adversary's perception of an inability to achieve their desired gains while the latter relies on the ability to inflict punishment on an adversary in response to any unwanted actions.[25] Although different in their approaches, Dr Snyder describes both methods as

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[23] Michael J. Mazarr, "Understanding Deterrence," *RAND Corporation*, 2018, 2. https://www.rand.org/content/dam/rand/pubs/perspectives/PE200/PE295/RAND_PE295.pdf.
[24] Glenn H. Snyder, "Deterrence and Power," *Journal of Conflict Resolution*, 4 no. 2 (1960), 163.
[25] Ibid.

being "a function of the total cost-gain expectations of the party to be deterred."[26] With the multiple potential adversaries within the space domain, there is a plethora of possible motives and cost-gain expectations. Thus, to ensure deterrence across this spectrum of adversaries, Canada must leverage both deterrence by denial as well as deterrence by punishment approaches. As well, for the deterrence to be effective, it must adhere to the "three Cs of deterrence", which are: capability, credibility, and communication.[27] This means that Canada must ensure that the deterrence system is comprehensive and includes the required capabilities to deter and that those capabilities are communicated in such a way that the potential adversary is aware of them and views them as credible threats when performing their cost-gain analysis.

Deterrence by denial, with respect to ASAT attacks, can be achieved by either active methods of reducing the adversary's ability to successfully engage a satellite or by passive means to ensure that even with a successful engagement the capability which the satellite provides is not jeopardized and thus the adversary does not achieve their desired outcome. Mission assurance strategies, although not necessarily developed with deterrence as a primary objective, generate the required passive resiliency to ensure that capabilities will be maintained even after an ASAT strike, thus providing a level of deterrence by denial.[28] Employing complete duplications of space-based systems to achieve redundancy can be cost prohibitive, but mission assurance strategies can still

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[26] Glenn H. Snyder, *Deterrence and Defence – Towards a Theory of National Security* (Princeton Legacy Library, Princeton New Jersey, 1961), 10.
[27] Bryan Boyce, "Twenty-First Century Deterrence in the Space War-Fighting Domain - Not Your Father's Century, Deterrence, or Domain." *Air and Space Power Journal*, 33 no. 1, (2019): 35.
[28] Dean Cheng and John Klein, "A Comprehensive Approach to Space Deterrence," *Strategy Bridge*, March 31, 2021. https://thestrategybridge.org/the-bridge/2021/03/31/a-comprehensive-approach-to-space-deterrence.

achieve acceptable levels of resiliency by employing disaggregated systems where each satellite only performs one mission set or through distributed constellations comprised of several satellites as opposed to single satellites which represent a single point of failure.[29] This level of resiliency greatly increases the cost required for an adversary to inflict significant damage or eliminate a complete capability, as it requires multiple ASAT attacks on multiple satellites to achieve the desired effect. In addition to the increased costs associated with launching multiple attacks, the more attacks launched by an adversary, the greater probability of the adversary being identified and thus exposing themselves to an increased chance of facing follow on punishment.[30] Therefore, to achieve deterrence, space-based systems need be designed, or retro-fitted, to be sufficiently distribution and disaggregation that a single ASAT attack will have nearly no impact on the overall capability being provided.

In addition to improving resiliency within space-based systems, for ample deterrence the overall resiliency of capabilities should be diversified beyond just the space domain. For example, maintaining alternative Intelligence, Surveillance, and Reconnaissance (ISR) capabilities is a method to deter attack on ISR space-based satellites.[31] Although satellites have many advantages for ISR, including the ability to fly over any territory with no requirement for over-flight permissions or facing threats from air defence systems, in the midst of a conflict an ISR aircraft, with sophisticated signals

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[29] Harrison, Todd, et al. *Defense Against the Dark Arts in Space: Protecting Space Systems from Counterspace Weapons*. . ., 11-12.
[30] Mark Reither, "Brandishing Our Air, Space, and Cyber Swords - Recommendations for Deterrence and Beyond," *Air and Space Power Journal*, 31 no. 4, (2017): 107-108.
[31] Jaganath Sankaran, "Limits of the Chinese Antisatellite Threat to the United States," *Strategic Studies Quarterly* 8, no. 4 (Winter, 2014): 30-32.

intelligence and electronic warfare capabilities, can pose a greater risk to an adversary.[32] This fact means that directing efforts towards destroying an ISR space-based asset will likely not meet an adversary's cost-gain expectations if they know that equal, if not better, ISR capabilities will still be employed against them through aircraft. Thus, maintaining alternative means of conducting core military functions such as ISR and secure communications, and promoting the capabilities of these diversified systems, will reduce the probability of an attack on space-based assets.[33] Therefore, to ensure effective deterrence, resources need to be directed to developing and improving various terrestrial based systems to ensure that regardless of any adversarial actions in the space domain, capabilities are maintained through alternative means.

Redundancy in military capabilities and mission assurance, although effective when the adversary's objective is focused on the destruction of a particular military capability, will not necessarily deter all potential aggressors. A terrorist organization, for example, may have the aim of generating publicity or fear by simply demonstrating that they can actually strike a space-based target.[34] Another challenge with terrorist motives, and those of more extreme states, is that they may not necessarily be deterred by the prospect of international backlash or by the potential of their actions disrupting global economies, in fact these outcomes may be the goal of their actions.[35] The successful employment of a co-orbital or direct-ascent ASAT weapon by an extremist group,

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[32] Ibid., 32-33.
[33] Michael P. Gleason and Peter L. Hays, "Getting the Most Deterrent Value from U.S. Space Forces," *The Aerospace Corporation - Center for Space Policy and Strategy*, October 2021, 5. https://aerospace.org/sites/default/files/2020-10/Gleason-Hays_SpaceDeterrence_20201027_0.pdf
[34] Gregory D. Miller, "Space Pirates, Geosynchronous Guerrillas, and Nonterrestrial Terrorists - Nonstate Threats in Space," *Air and Space Power Journal*, 33 no. 3, (2019): 40.
[35] Ibid., 34,40.

however, would very likely require a support network including either state actors, private companies, or individual specialists, and these groups are often more easily persuaded through deterrence by punishment.[36] Therefore, ensuring a credible and effective attribution system is in place and thus increasing the threat of follow-on punishment will deter many entities from aiding extremist organizations in their ASAT endeavors. Attribution of space attacks is difficult, however, due to the remoteness of space as well as the growing amount of space debris and congestion which results in difficulty distinguishing accidental collisions from those of intentional ASAT attacks.[37] These attribution challenges reduce the credibility of any deterrence by punishment approach and thus must be addressed. Therefore, to deter the full spectrum of adversaries, the deterrence system must include the capabilities to reduce the probability of an ASAT weapon successfully striking a satellite while also ensuring a credible means to attribute the attack to the perpetrator, as well as to those who assisted the perpetrator, for follow-on punishment.

Given that one of the arguments for a deterrence versus total defensive posture is to reduce the potential of provoking an arms race, it is imperative that any defensive systems developed to reduce the probability of a successful attack are clearly distinguishable from offensive weapons.[38] This requirement is further amplified by the fact that Canada has committed to promoting the responsible use of space and has emphasized the importance of focusing defensive measures on those which are non-

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[36] Nina-Louisa Remuss, "The Need to Counter Space Terrorism – A European Perspective,". . ., 5.; Matthew Kroenig and Barry Pavel, "How to Deter Terrorism," *The Washington Quarterly* 35, no. 2 (Spring, 2012): 24.
[37] Dean Cheng and John Klein, "A Comprehensive Approach to Space Deterrence."
[38] Brad Townsend, "Strategic Choice and the Orbital Security Dilemma," . . ., 66-67.

debris generating.[39] With these factors, any active deterrence by denial system designed to prevent a successful ASAT strike must not involve weapons or mechanisms which eliminate potential threats by causing catastrophic damage through direct impact, as this tactic could be seen as an offensive capability and would also generate hazardous space debris. Employing large numbers of small satellites for improved situational awareness, specifically ones capable of conducting rendezvous and proximity operations against potential co-orbital ASATs, is a solution to this restriction as these assets will provide advanced warning of possible attacks while also providing improved identification capabilities for future attribution.[40] These small satellites are described as "guardian" satellites by Dr. Michael Nayak of the United States Air Force, who envisions them as being employed around high-value targets and during times of heightened threat levels in order to "image the interceptor, perform orbital tracking, deliver responsive intelligence regarding the source of the attack, and provide a post event battle damage assessment" while contributing greatly to overall deterrence through the "protective security function of the Guardian, the high likelihood of failure for hostile actions and subsequent negative consequences."[41] These small satellites could also be developed to capture potentially threatening co-orbital ASATs, as this technology is reported to have been employed by China with one of their small satellites being fitted with a robotic arm for proximity and rendezvous operations with other Chinese satellites.[42] In order to translate these capabilities into a complete deterrence system, however, the denial and attribution

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[39] Department of National Defence, *Strong, Secure, Engaged: Canada's Defence Policy. . .,* 71.
[40] Michael Nayak, "Deterring Aggressive Space Actions with Cube Satellite Proximity Operations," . . ., 95-96.
[41] Ibid., 98.
[42] Todd Harrison, Kaitlyn Johnson, Makena Young, Nicholas Wood, and Alyssa Goessler, Space Threat Assessment 2022 (Washington, DC: Aerospace Security Project - Center for Strategic and International Studies, 2021), 28.

abilities of these small satellites would have to be made public through a communications plan. The exact disposition of these guardian satellites at any given time could still remain secret, and their precise activities would be based on a flexible response posture dictated by intelligence and threat levels, similar to the way that naval and air power is employed today.[43] Employing small guardian style satellites, with a flexible response posture, would bolster the deterrence by denial while not unnecessarily escalating tensions through the deployment of offensive weapons. Furthermore, with the increased situational awareness and improved forensic capabilities, these assets could provide the attribution needed to ensure credible follow-on punishment is possible.

From this analysis, in order to deter adversaries from engaging space-based assets, there must be resiliency in the space capabilities through disaggregation and distribution, along with diversification beyond the space-domain. Furthermore, to deter against more extreme actors, a level of active deterrence by denial combined with improved deterrence by punishment must be achieved through employing active guardian satellites to improve situational awareness and provide advanced warning of attacks, while also improving identification, tracking and forensic technology for follow-on attribution. Thus, a robust deterrence system, encompassing these active and passive elements, must be employed to ensure deterrence across the variety of potential adversaries who could threaten Canadian military space capabilities.

Organic and Partnered Approaches to Achieving Deterrence

[43] Bryan Boyce, "Twenty-First Century Deterrence in the Space War-Fighting Domain - Not Your Father's Century, Deterrence, or Domain." *Air and Space Power Journal*, 33 no. 1, (2019): 46; Michael Nayak, "Deterring Aggressive Space Actions with Cube Satellite Proximity Operations," . . ., 98.

The final aspect to examine is which of these aforementioned mechanisms and capabilities must be entirely organic to Canada and which must Canada rely on allies and partners to achieve. The Canadian space program is heavily integrated with the space programs of other nations and the continued integration and development of international space partners is identified as an objective within Exploration, Imagination, Innovation – A New Space Strategy for Canada.[44] As well, specific to defence, the joint Deputy Minister and Chief of Defence Staff Initiating Directive for Space Operations states that "collaboration with allies and partners is essential to influencing the responsible use and protection of the space environment and is key to deterring potential adversary plans and intentions."[45] Thus, there is no question that an overall deterrence system will rely on strong international partnerships, however, this does not mean that Canada can simply rely on these partners to provide all the required deterrence capabilities and mechanisms. In the early 2000s, due to Canada's limited defence spending in the space domain at the time, along with differing space policies, the relationship with the U.S. from a space perspective was fragile and ultimately the U.S. limited Canada's access to their space-based assets and data.[46] This scenario highlights the potential risk if Canada is not an active partner and contributor to space protection. Thus, for Canada to establish and maintain partners in their quest for deterrence, they must be viewed as a credible and value-added ally in the overall deterrence framework.

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[44] Innovation, Science and Economic Development Canada, *Exploration, Imagination, Innovation – A New Space Strategy for Canada, . . .,10-11, 16.*

[45] Department of National Defence, *Initiating Directive for Space Operations* (Ottawa: Deputy Minister of National Defence and Chief of Defence Staff, 2020), 11.

[46] Andrew B. Godefroy, "Is the Sky Falling? Canada's Defence Space Programme at the Crossroads," *Canadian Military Journal* 1, no. 2 (Summer 2000), 55.

A current area where Canada must continue to be an active contributor is in space situational awareness, which has been shown to be crucial to both deterrence by denial and deterrence by punishment. Currently, Canada is a significant participant to global space situational awareness (SSA) initiatives through their Sapphire satellite, which is a system that Canada's allies have come to rely on as part of the overall SSA enterprise.[47] Sapphire was launched in 2013, with a minimum five year design life, and in 2016 the CAF intended to replace the satellite by 2022 noting that not implementing a replacement would "be a considerable loss in capability for conducting SSA" and "may result in a loss of confidence in Canadian commitment to SSA."[48] Now, in 2022, the Sapphire replacement is not expected to be delivered until the 2028/2029 timeframe.[49] Given how crucial situational awareness is to the overall deterrence system, and since this is a capability that Canada has become relied upon for, this is an area where Canada must continue to develop and deliver. As well, the Exploration, Imagination, Innovation – A New Space Strategy for Canada, states Canada's desire to grow their domestic space industrial base and to enhance space security and sovereignty.[50] To achieve this aim, Canada needs to take a leading role, among international partners, to enhance space situational awareness capabilities. Furthermore, to truly be a leader in this field, Canada should invest in research and development of guardian style satellites to leverage the benefits which these active systems bring to both deterrence by denial as well as

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[47] Charity Weeden, *Strong, Secure, Engaged in a Threatened Space Domain (*Calgary: Canadian Global Affairs Institute, 2018), 4. https://www-deslibris-ca.cfc.idm.oclc.org/ID/10096593.
[48] Michel Lalumiere and Jeff Dooling, briefing to The Canadian Association of Defence and Security Industries, "CAF Space Projects," April 2016, slide 14.
[49] Department of National Defence, *Defence Capabilities Blueprint – Surveillance of Space 2*, Accessed on 14 April 2022, http://dgpaapp.forces.gc.ca/en/defence-capabilities-blueprint/project-details.asp?id=1920.
[50] Innovation, Science and Economic Development Canada, *Exploration, Imagination, Innovation – A New Space Strategy for Canada*, . . .,14, 16.

deterrence by punishment through improved attribution. Thus, with Canada's desires to grow their space industry while enhancing space security and given the impacts which strong SSA, attribution, and denial capabilities have on overall deterrence, Canada must develop and field this technology organically and use it to contribute to global deterrence initiatives, ensuring they are a value-added partner in space security.

Another mechanism which Canada must take responsibility for and ownership of is the resiliency within their own space-based systems. This is an area which Canada has already embraced with the Royal Canadian Air Force (RCAF) recently releasing their Strategy for Space Mission Assurance, which "aims to achieve enhanced resilience of mission-critical [defence space enterprise] assets and capabilities."[51] The RCAF intends to improve mission assurance by conducting a risk assessment of threats and vulnerabilities and then developing optimized solutions to mitigate those risks.[52] Some of these solutions will include the development of backup equipment and redundancies as well as measures specific to space architecture including the use of distributed systems with multiple nodes vice single nodes, disaggregation of various capabilities into separate platforms, and diversification to include multiple platforms performing the same mission set in multiple ways.[53] Once this RCAF guidance is translated into tangible improvements in mission assurance, and the results are communicated, space-based capabilities will be afforded improved protection through deterrence by denial. As the CAF also relies on U.S. and allied space assets, however, this is an area where Canada

[51] Department of National Defence, B-GJ-120-000/FP-001, *RCAF Strategy for Space Mission Assurance*, (Ottawa, Ontario, Canada: Department of National Defence, 2022), 8, 13.
[52] Ibid., 10.
[53] Ibid., 13.

must also work with and support their allies to ensure that all mission critical systems that the CAF relies on have the requisite resiliency to achieve effective deterrence.

An area where Canada cannot achieve effective deterrence alone is that of deterrence by punishment which requires that international norms and legal policies be in place to make the risk of punishment a credible threat. Through the United Nations' (UN) Outer Space Treaty, space is to be considered a neutral territory used for peaceful purposes, with no state being able to lay claim to any portions of it, thus satellites can freely transit through space.[54] Each nation is to register all objects launched into space from their territory with the UN and are responsible for any damage caused by an object launched from their territory into space, however, aside from this damage liability aspect, there are no specific norms or standards related to maintaining a safe operating distance between satellites or criminal repercussions for intentional malicious actions.[55] Having norms and accepted international standards, along with clearly identified penalties and punishments, contribute to ensuring potential adversaries understand what is, and is not, acceptable and fully appreciate the consequences of their potential actions.[56] As well, the overall registration process has gaps as instances exist where ownership and control is transferred between various nations throughout the life of a satellite without the UN registration being updated.[57] Additionally, there are occurrences where the launching

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[54] United Nations, General Assembly, *Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies*, 2222 (XXI) (New York, 19 December 1966).
[55] United Nations, General Assembly, *Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies*, 2222 (XXI) (New York, 19 December 1966); United Nations, General Assembly, Convention on International Liability for Damage Caused by Space Objects, 2777 (XXVI) (New York, 29 November 1971).
[56] James P. Finch and Shawn Steene, "Finding Space in Deterrence: Toward a General Framework for "Space Deterrence," *Strategic Studies Quarterly* 5, no. 4 (Winter, 2011): 13.
[57] Upasana Dasgupta, *Reconciling State Practice of in Orbit Satellite Transfer with the Law of Liability and Registration in Outer Space* (Montreal: Faculty of Law McGill University, 2018), 58-69.

states have minimal knowledge of the assets being launched, such as in the case where a private company, from a different nation, launches a satellite on behalf of a third party country.[58] As satellites become smaller with new technology, significant quantities of satellites will be contained in a single launch vehicle, making this process of registration and accountability even more complex. Thus, these existing gaps in current policies and procedures must be rectified to allow for a credible system of deterrence by punishment. Canada, as an advocate for the responsible use of space, should work with international partners to garner support to have more robust international norms and treaties developed, with strong deterrence language against those who violate the rules or aid others in violating the rules.

Finally, as previously identified, deterrence is based on the potential adversary's cost-gain analysis, thus the effectiveness of a deterrence strategy is based on the adversary's perception of the deterrent. Therefore, Canada must work with international partners to demonstrate the various deterrence capabilities and send a united deterrence message, ensuring all adversaries perceive these threats as credible and substantial. Large scale, international, military exercises play a substantial role in deterrence by showcasing national capabilities, interoperability, and also demonstrating commitments and partnerships among nations.[59] To this end, Canada must continue to support and participate in counter-space military exercises and wargames such as the Schriever

[58] Upasana Dasgupta, *Reconciling State Practice of in Orbit Satellite Transfer with the Law of Liability and Registration in Outer Space . . .*58-69.
[59] Danylo Kubai, "Military Exercises as a Part of NATO Deterrence Strategy," *Comparative Strategy* 41, no. 2 (2022): 155-156.

Wargame hosted annually by the United States.[60] These forms of exercises provide an opportunity to communicate the various deterrence capabilities which Canada and their partners possesses while also establishing credibility by demonstrating the effectiveness of their denial and attribution systems. These efforts of communicating the deterrence mechanisms, in partnership with allies, will greatly increase an adversary's perception of the costs associated with launching an attack, resulting in heightened deterrence, and thus improving the overall security situation.

Therefore, for Canada to ensure a capable and credible deterrence posture, they must strengthen the resiliency of their own space capabilities, while also supporting their allies in strengthening their systems, particularly those which Canada relies on for core military functions. Furthermore, to be a value-added partner and to meet industrial and technological objectives, Canada must upgrade and enhance their contribution to situational awareness and the development of active deterrence mechanisms, including those with tracking, identification, and forensics abilities to improve space attribution. By advocating for stronger international laws and norms with respect to space, and leveraging the improved attribution capabilities, Canada can strengthen the credibility of deterrence by punishment. Finally, Canadian deterrence mechanisms and their commitment, and that of their allies, to protect space must be emphasized through participation in international military exercises, showcasing global denial and attribution capabilities. With this approach, Canada will be seen as a serious, value-added,

[60] Tyler Whiting, United States Air Force, "Schriever Wargame: Critical Space Event Concludes," news release, 4 November 2020. https://www.spoc.spaceforce.mil/News/Article-Display/Article/2404914/schriever-wargame-critical-space-event-concludes.

contributor to global space security, able to establish and maintain vital international partnerships, bolstering the overall deterrence system.

CONCLUSION

The vastness of space, coupled with the various ASAT threats posed by diverse and emerging adversaries, means that a robust deterrence focused approach comprised of both organically Canadian mechanisms and capabilities as well as those achieved through international partnerships, is a requirement to meet the SSE mandate of protecting Canadian military space capabilities. The near impossibility of achieving total security and defence in space, combined with the resource intensity of that endeavor as well as the risks it poses with respect to sparking an arms race, makes a deterrence approach the best method to achieve protection for space-based assets. This deterrence system must be robust, encompassing credible active and passive capabilities, designed to deter both by denial as well as by punishment, to ensure effectiveness across the broad spectrum of potential space adversaries. Deterrence requires reliance on international partners, however, and to establish and maintain these required partnerships, as well as to accomplish Canada's own goals of developing their industrial and technological capacities, Canada must maintain and develop organic deterrence capabilities, such as those related to mission assurance and in the areas of situational awareness. Furthermore, Canada must work with their allies to ensure clear international policies are established and communicated and that consequences for infractions are well understood and credible. Establishing this robust, all-encompassing, deterrence approach will position Canada in the best possible way to protect space-based capabilities from the known adversaries and threats of today as well as those which will emerge in the years ahead.

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