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# How Lunar-Based Operations Will Transform Pan-Domain Warfare

**Lieutenant-Colonel Gina Decarie**

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# How Lunar-Based Operations Will Transform Pan-Domain Warfare

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# HOW LUNAR-BASED OPERATIONS WILL TRANSFORM PAN-DOMAIN WARFARE

## AIM

1. The aim of this paper is to inform Commander Canadian Joint Operations Centre (CJOC) about the emerging trends and technology in space-based operations that might redefine the Canadian Armed Forces (CAF) in ways that seemed like science fiction merely a decade ago. These new trends are important to the CAF in a pan-domain environment, as the future of national defence may shift with an increasing importance of the space domain. This paper will discuss NASA's Artemis Program, focusing primarily on the implications of a lunar base and space objects placed in cislunar orbit. Drawing primarily from NASA publications, this paper will speculate on how these projects could impact humanity and how the novel use of space can transform modern warfare.

## INTRODUCTION

> *We can see no more clearly now all of the utility and implications of spaceships than the Wright brothers could see flights of B-29's bombing Japan and air transports circling the globe…*
>
> *- Project RAND, 1946.*

2. In 1946, a newly formed think tank, Project Research and Development (RAND), was commissioned by the United States (US) Army Air Force to investigate the feasibility of an Earth-orbiting satellite. This work, revolutionary of its time, coincided with the rise of the Cold War and subsequent research and development into intercontinental ballistic missiles (ICBMs). Project RAND concluded that the mechanics of an orbital satellite would be similar to that of an ICBM and therefore feasible, and that while its scientific use was clear, the military use of such technology was not.[1]

3. This historical anecdote is relevant to the contemporary use of space technology for three reasons. The first is the relative time aspect: only 77 years have passed since Project RAND concluded that an Earth-orbiting satellite would be theoretically feasible, to today, when global communications, economics, logistics, intelligence, and surveillance are among the capabilities dependent on satellite systems. The second is the unknown – although Project RAND was not able to quantify the military usefulness of satellites, they recognized that the enormous potential of space technology was unforecastable in contemporary terms; the same might be said of today's visions for the future use of space-based technology. Finally, the era in which the Project RAND report was published meant that the US was unwilling to cede any technological advancement that the Soviets might first exploit, a phenomenon that became the first space race.

[1] R. Cargill Hall, "Early U.S. Satellite Proposals," *Technology and Culture*, vol. 4, no. 4 (Autumn, 1963): 410-434.

During this space race, early funding was influenced by the US Department of Defense and without the military potential of satellites, the US may not have pursued the technology for purely scientific uses.[2]

4. Former US Deputy Assistant Secretary of Defense for space policy, Doug Loverro, contends that the first space race was not the one to the moon, but of the first military use of space, which the Soviets won with their first use of ICBMs and the launch of Sputnik in 1957.[3] This framed the use of space as a legitimate warfighting domain, and ongoing demonstrations of anti-satellite missiles demonstrate this posturing.[4] It is not since Neil Armstrong landed on the moon that Western nations have considered themselves in a space race against adversaries. However, while the US landed first on the moon, Russia first successfully landed probes on Venus and continued to demonstrate its mature space capabilities.[5] Since the end of the Cold War, a new space superpower has emerged: China. Absent from early space exploration efforts, China's impressive technological emergence has changed the calculus when considering a new, second space race.

5. A crewed mission to Mars by 2033 is a stated aim of the US Nautical and Aerospace Administration (NASA), and in order to meet this date, NASA intends first to establish a lunar base as a proof of concept by 2025. NASA Administrator Bill Nelson acknowledged that the aggressive timelines are challenging, and that the Chinese space program has advanced their lunar base planning much more quickly than previously anticipated.[6] The US, Russia, China, and India all have advanced space organizations with active programs for lunar exploration. India most recently joined the race to the moon, with a successful landing at the lunar South Pole in 2019.[7]

6. NASA's plan for the establishment of a lunar base is phased, with each phase starting with an uncrewed mission followed by a crewed one. A Lunar Gateway will first be placed in a near-rectilinear halo (NRH) orbit, capable of acting as a waypoint between Earth and the Moon. Lunar station equipment will be deployed from the Gateway to the south pole of the Moon, where the Artemis Program will establish its lunar base.[8] The

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[2] R. Cargill Hall, "Early US Satellite…, 106.

[3] "Space Race in the 21st Century: Understanding Russia's Evolving Military Capabilities," YouTube video, 9:40, posted by Center for Strategic & International Studies, 29 June 2021, https://www.youtube.com/watch?v=4RO2KQDShzs.

[4] BBC News, "Russian anti-satellite missile test draws condemnation," last modified 16 November 2021, https://www.bbc.com/news/science-environment-59299101.

[5] NASA, "Venera 7," last accessed 21 January 2022, https://nssdc.gsfc.nasa.gov/nmc/spacecraft/display.action?id=1970-060A.

[6] "Media Briefing: NASA's Artemis Update," YouTube video, 15:20, posted by NASA Video, 9 November 2021, https://www.youtube.com/watch?v=AB7sSG2Rl9k.

[7] Prabhjote Gill, "With the Chandrayaan 2 launch, India's historic Moon mission has taken off," last modified 22 July 2019, https://www.businessinsider.in/isro-chandrayaan-2-india-moon-mission-launches-successfully-at-243-pm/articleshow/70328430.cms.

[8] NASA, "Gateway," last modified 21 December 2021, https://www.nasa.gov/gateway/overview.

South Pole is a vital location, where a large concentration of water is frozen in craters. This water is vital for the feasibility of a lunar base, to provide both drinking water and fuel through electrolysis.[9]

7. The US and India are not alone in their interest in the lunar South Pole. The Chinese National Space Administration (CNSA) and the Russian State Space Corporation (ROSCOSMOS) have announced a partnership and in June 2021 they jointly published the International Lunar Research Station (ILRS): Guide for Partnership. This publication outlines an action plan for reconnaissance missions between 2021 and 2025, with a view to undergo construction activities in 2030.[10] Like NASA, the CNSA plans to use this lunar base as a proof of concept and potential waystation for further space exploration, including a crewed mission to Mars in 2033.[11] Both the Artemis Program and the ILRS plan to explore the same region of the moon, and while the 1968 United Nations Outer Space Treaty prohibits military installations outside of Earth, the treaty annex that forbids lunar military activity remains unratified by the US, China, and Russia. At this point in time, it seems likely that both lunar programs will proceed without a formal agreement in place.[12]

**DISCUSSION**

*You can't look at that Earth … and say 'global' is sufficient enough for our perspective.*

- Lt. Gen. John Shaw, *Deputy Commander, US Space Command*

8. The first space race was a product of the Cold War, and signified a unified national desire on both sides of the war to outperform the other. NASA's space programs did more than simply land a human on the moon; through innovation and advanced engineering, the space program has produced novel items from freeze-dried food to transparent ceramics. The space race of the 21st century continues to innovate in many scientific and engineering domains, the products of which provide their country a technological and industrial advantage in a global market. Thus, whichever country first establishes a lunar base has a significant advantage in being the first to explore new resources and opportunities, and use them to further other goals in space.[13]

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[9] NASA, "Ice Confirmed at the Moon's Poles," last modified 20 August 2018, https://www.nasa.gov/feature/ames/ice-confirmed-at-the-moon-s-poles/

[10] Chinese National Space Administration, *International Lunar Research Station: Guide for Partnership* (Beijing: n.l., 2021), 4.

[11] Reuters, "China plans its first crewed mission to Mars in 2033" last modified 24 June 2021, https://www.reuters.com/business/aerospace-defense/china-plans-its-first-crewed-mission-mars-2033-2021-06-24/.

[12] Tara Copp, "If China and the US Claim the Same Moon-Base Site, Who Wins?" last modified 8 August 2021, https://www.defenseone.com/technology/2021/08/if-china-and-us-claim-same-moon-base-site-who-wins/184352/.

[13] Defense Innovation Unit, *State of the Space Industrial Base 2020: A Time for Action to Sustain US Economic & Military Leadership in Space* (Washington, DC: U.S. Government Printing Office, 2020), 11.

9. The lunar South Pole is valuable for its concentrated frozen water deposits, and its position relative to the sun means that a lunar base will not undergo extended periods of darkness, important for power and light for machines and human inhabitants. Sunlight does not reach the crater depths at the South Pole, but scientists speculate that these craters could contain rare and valuable metal deposits that could be mined and returned to Earth.[14] Given the relatively small lunar surface area to mine and collect these deposits, any contested space may become a military responsible to protect. The exploration of the moon clearly has resource potential, but supporting objects in orbit could be a higher strategic value to military forces. The water, metals, and other resources that could be sent to Earth could also be used to resupply outer space stations in nearby orbit. The area of space between the Earth and the moon is known as 'cislunar,' and any Earth orbit higher in altitude from the Earth than the geostationary orbit that navigation and communications satellites use, is known as cislunar orbit. This means that any satellite in cislunar orbit has the proverbial 'high ground.'

10. NASA's Gateway, in NRH orbit, will circle the moon approximately every seven days and at its closest point in orbit to the moon, the Gateway will be stable enough to rendezvous with lunar rovers or objects arriving from cislunar orbits. The physics principle that makes this possible is known as Lagrange points, and of the five points that exist in the Earth-moon system, L1 and L2 are most relevant to this paper. At a Lagrange point, gravitational forces within a system are at an equilibrium and this is commonly called 'a parking spot in space.' Objects can be placed into a Lagrange point and they will stay there, or objects could be put into orbit around a Lagrange point. L1 is located between the moon and Earth, and L2 is located just beyond the moon toward outer space. In March 2019, the CNSA launched a communication satellite into an orbit around L2, the first of its kind, and its second in December 2021.[15] While L2 is behind the moon from the Earth's perspective, an orbit around L2 can have a persistent line of sight to Earth as well as the dark side of the moon. In this way, the CSNA can have constant communication with Earth and simultaneous control of its lunar probes that are currently exploring that area of the moon.

11. The use of higher orbits for Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance (C4ISR) is a proven concept with current Earth orbiting space objects. The lower the orbit, the easier and cheaper it is for satellite placement, and satellites can circle the Earth in less than two hours. However, the lower the orbit, the smaller the footprint the satellite has on Earth and the more contested that space is with other objects and debris. Higher orbit is expensive and technologically difficult to reach but has several advantages. One advantage of high earth orbits is their ability to communicate with each other. In a lower orbit, many satellites are required to

[14] Elizabeth Howell, "There's more metal on the moon than we thought," last modified 6 July 2020, https://www.space.com/moon-metal-mystery-clue-in-craters.html.

[15] Adrian Bell, "China launches second Tianlian II communication satellite," last modified 13 December 2021, https://www.nasaspaceflight.com/2021/12/second-tianlian-ii/.

create a network in order to have constant communication between them. In high orbits, the Earth does not obstruct inter-satellite communications and so less are required to ensure global coverage. Extrapolating this to cislunar orbits, the space between geostationary orbit and the moon is currently unoccupied, uncontested, and few satellites are required to maintain constant communication between them and form a network.[16] Cislunar orbits have the potential to change the C4ISR landscape, with sensors and antennas that can act as a relay between the moon and satellites in geostationary orbit.

12. Satellites in geostationary orbit are on the Earth side of the Van Allen belts, an electromagnetic (EM) shield that protects the Earth from harmful solar radiation. This shield enables life on Earth and its EM properties can make communications between the Earth and the moon challenging. With materials resupplied from a lunar base, supported cislunar objects could have more power than other objects in that space, meaning they have more power to illuminate conflict, resist jamming, and maneuver. In terms of protecting national assets, objects in cislunar orbit are currently difficult to track and predict due to the influence of the moon's gravitational pull. If adversarial satellites are better positioned at L1 or L2, or are more advanced in their ability to detect and attack friendly assets, the Artemis Program will not be successful and potentially trillions of public and private dollars in space investments could be destroyed. Having, maintaining, and defending objects in key cislunar orbits could prove critical to claiming the resources of the moon and beyond.

13. The US Defense Innovation Unit (DIU) published a report in July 2020 that outlines the state of the space industrial base and the role of the US military in cislunar operations. One recommendation from this report is that the US should pursue an information sharing collaboration similar to the Five Eyes agreement, to strengthen supply chain providers and focus on counterintelligence activities. This report goes on to recognize that the US investment into cislunar activities require a secure and stabilizing military presence.[17] For Canada's part, the Canadian Space Agency (CSA) has committed to provide external robotics to the Gateway in the form of Canadarm3, which will be vital to operating and maintaining the Gateway, particularly during its uncrewed phases. CSA is contributing to lunar exploration and the Artemis Program with the development of the Lunar Exploration Accelerator Program (LEAP), which will see a Canadian lunar vehicle exploring a polar region of the moon by 2026.[18] A Canadian astronaut will also be on the

[16] Amanda Miller, "Cislunar Space," last modified 7 October 2021, https://www.airforcemag.com/article/cislunar-space/.

[17] Defense Innovation Unit, *State of the Space Industrial*…21-22.

[18] Canadian Space Agency, "Canada's Role in Moon Exploration," last modified 12 Novemer 2021, https://asc-csa.gc.ca/eng/astronomy/moon-exploration/canada-role.asp.

Artemis 2 mission as one of four astronauts to take part in the first crewed mission to the Gateway.[19]

14. In addition to the national strategic implications of establishing a lunar base, NASA has also stated that a lunar base could be used to open the moon for private payload deliveries. Recent years have seen NASA partner with private industries such as SpaceX, Blue Origin, and Boeing to co-develop technologies that further space exploration.[20] The commercialization of near-Earth space has begun with space tourism and the development of pharmaceuticals in micro-gravity conditions. Breakthroughs in cancer treatments and vaccines have been made as a result of experiments on the International Space Station, and permanent labs in micro-gravity conditions could prove a renaissance for drug development.[21] Industrial complexes on Earth stand to benefit from lunar bases that can send mined resources 'down well,' meaning that the gravitational pull of Earth can be used to send resources from the moon to lower-Earth orbits with minimal energetic requirements. The future implications of a developed lunar base can be speculated at length, from long-term human habitation, agricultural development, and as a waystation for deeper space exploration. What is clear today however, is that the moon and cislunar space are becoming objects of great power competition; even if world governments or militaries were not engaged, private industry would press for first mover advantage.

[19] Elizabeth Howell, "Canadian astronauts will start flying to the moon in 2023 with NASA's Artemis missions," last modified 16 December 2020, https://www.space.com/canadian-astronauts-artemis-moon-missions

[20] Defense Innovation Unit, *State of the Space Industrial*…35-36.

[21] Shimon Amselem, "Remote Controlled Autonomous Microgravity Lab Platforms for Drug Research in Space," *Pharmaceutical Research*, vol. 36, no. 12 (Dec 2019): 1-15.

## CONCLUSION

15. Much like the RAND report predications for satellites in 1947, the military implications of a lunar base and persistent cislunar orbits cannot be fully predicted. NASA's Artemis Program starts with the Gateway, which will launch its first mission within the next three years. Canada's commitment to this program is threefold: robotics, an astronaut, and a lunar vehicle. These investments underscore that Canada's success in space operations is heavily dependent on NASA's successes. Lunar bases are valuable for scientific research, resource extraction, and commercialization. From a military perspective, lunar bases are areas that may require physical protection, if limited resource areas become contested. However, the most valuable aspect of a lunar base may become its ability to resupply objects in cislunar orbits, which would extend supply chains into space and allow these objects to retain an orbital high ground. Without this high ground, NASA and its partners, including Canada, risk the loss of national assets in space.

16. The first space race was largely binary, between the US and Russia, during which time both countries obtained significant experience in satellite and outer space operations. Relative newcomers like China and India may lack this operational experience, but in the case of China, a partnership with Russia might prove symbiotic. Russia could provide decades of experience, knowledge, and experts in the space domain, while China's wealth and technological superiority creates a powerful union. The space race of the 21st century seems to be centered on the moon and cislunar orbits, and will perhaps culminate with the first human to walk on Mars. With several significant space programs planned for implementation within the next three years, what seems certain at this time is that how humans will perceive space is poised to irrevocably change.

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