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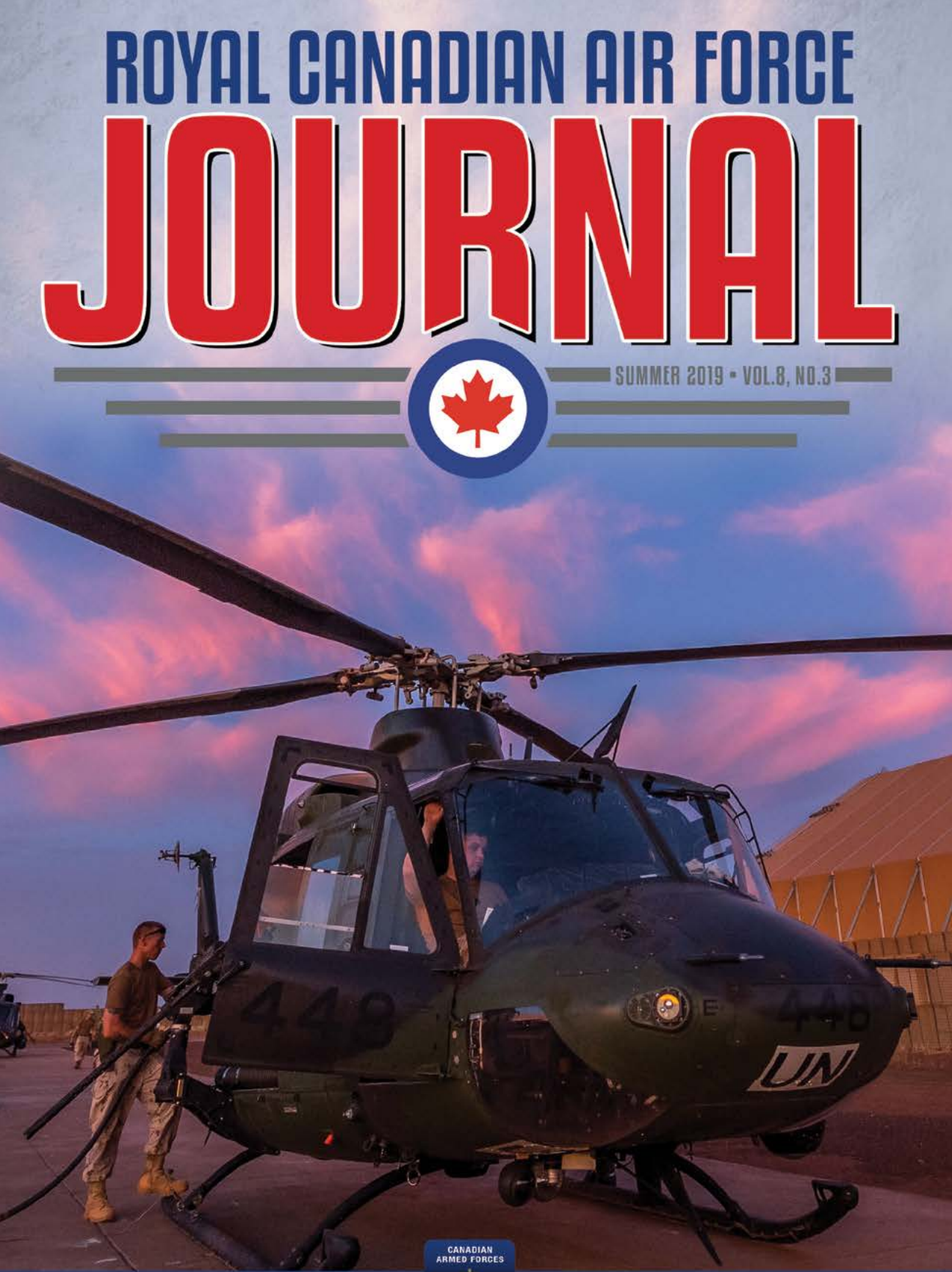

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The *ROYAL CANADIAN AIR FORCE JOURNAL* is an official publication of the Commander Royal Canadian Air Force (RCAF) and is published quarterly. It is a forum for discussing concepts, issues and ideas that are both crucial and central to air and space power. The *Journal* is dedicated to disseminating the ideas and opinions of not only RCAF personnel, but also those civilians who have an interest in issues of air and space power. Articles may cover the scope of air-force doctrine, training, leadership, lessons learned and air-force operations: past, present or future. Submissions on related subjects such as ethics, technology and air-force history are also invited. This journal is therefore dedicated to the expression of mature professional thought on the art and science of air warfare and is central to the intellectual health of the RCAF. It serves as a vehicle for the continuing education and professional development of all ranks and personnel in the RCAF as well as members from other environments, employees of government agencies and academia concerned with air-force affairs.

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ROYAL CANADIAN AIR FORCE JOURNAL

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The *ROYAL CANADIAN AIR FORCE JOURNAL (RCAFJ)* welcomes the submission of articles, book reviews and shorter pieces (which will be published in the Letters to the Editor, Points of Interest, Pushing the Envelope and Point/Counterpoint sections) that cover the scope of Air Force doctrine, training, leadership, lessons learned and Air Force operations: past, present or future. Submissions on related subjects such as ethics, technology and Air Force history are also invited.

JOURNAL SECTIONS

ITEM	WORD LIMIT*	DETAILS
LETTERS TO THE EDITOR	50–250	Commentary on any portion of a previous *RCAFJ*.
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POINT/COUNTERPOINT	1500–2000	Forum to permit a specific issue of interest to the RCAF to be examined from two contrasting points of view.

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EDITOR'S **MESSAGE**

This summer 2019 issue of the *Royal Canadian Air Force Journal* provides an assortment of articles that are sure to entice many an air power enthusiast. Furthermore, these articles were all taken from the Air and Space Power Operations Course (ASPOC) 1802, as they provide a coherent theme for this issue of the *Journal*: firstly, our junior officers are well suited to leading this organization into the future; and secondly, their breadth of knowledge is, quite literally, staggering. All this bodes well for the RCAF.

In "AI and the Kill Chain," Captain Deluce tackles the continuing challenges of autonomous systems within the kill chain; how we, the RCAF, need to consider where and if humans are required and the implications of those choices. How will the RCAF manage the planning and execution of military operations given the employment of these systems?

"RCAF Contributions to Space Debris Mitigation" by Captain Mahon argues that the RCAF should expand its space-debris-mitigation contribution by making additional investments in tracking systems for space debris and ensuring that it adheres to space-debris-mitigation measures in future space-asset projects. Our reliance on space-based assets from both the RCAF and national perspectives should drive our way forward on this issue.

As *Strong, Secure, Engaged* articulates, the RCAF and Public Services and Procurement Canada (PSPC) will be required to manage and deliver on these programmes. "RCAF Procurement" by Captain Gagne identifies that, with manning in both the RCAF and the PSPC project offices critically low, it is in the interest of both organizations to make efficient use of their human and financial resources.

"Towards a Greener Future" by Major Campbell argues that the "RCAF has a responsibility to reduce its impact on the environment, in particular its greenhouse gas (GHG) emissions, and that alternative jet fuels should be considered as a means of meeting this intent." Major Campbell addresses both the social and regulatory responsibilities of the RCAF as well as the impact that alternative fuels might have on operations.

Captain Deutsch examines Canadian claims to Arctic sovereignty in "Canada's Arctic Sovereignty and the Northwest Passage," from the perspective of both the United Nations Convention on the Law of the Sea and the international law of the sea. Critical to the review is the justification of declaring the Northwest Passage an internal waterway, and as I am sure you will agree, Captain Deutsch's approach answers some questions while raising others.

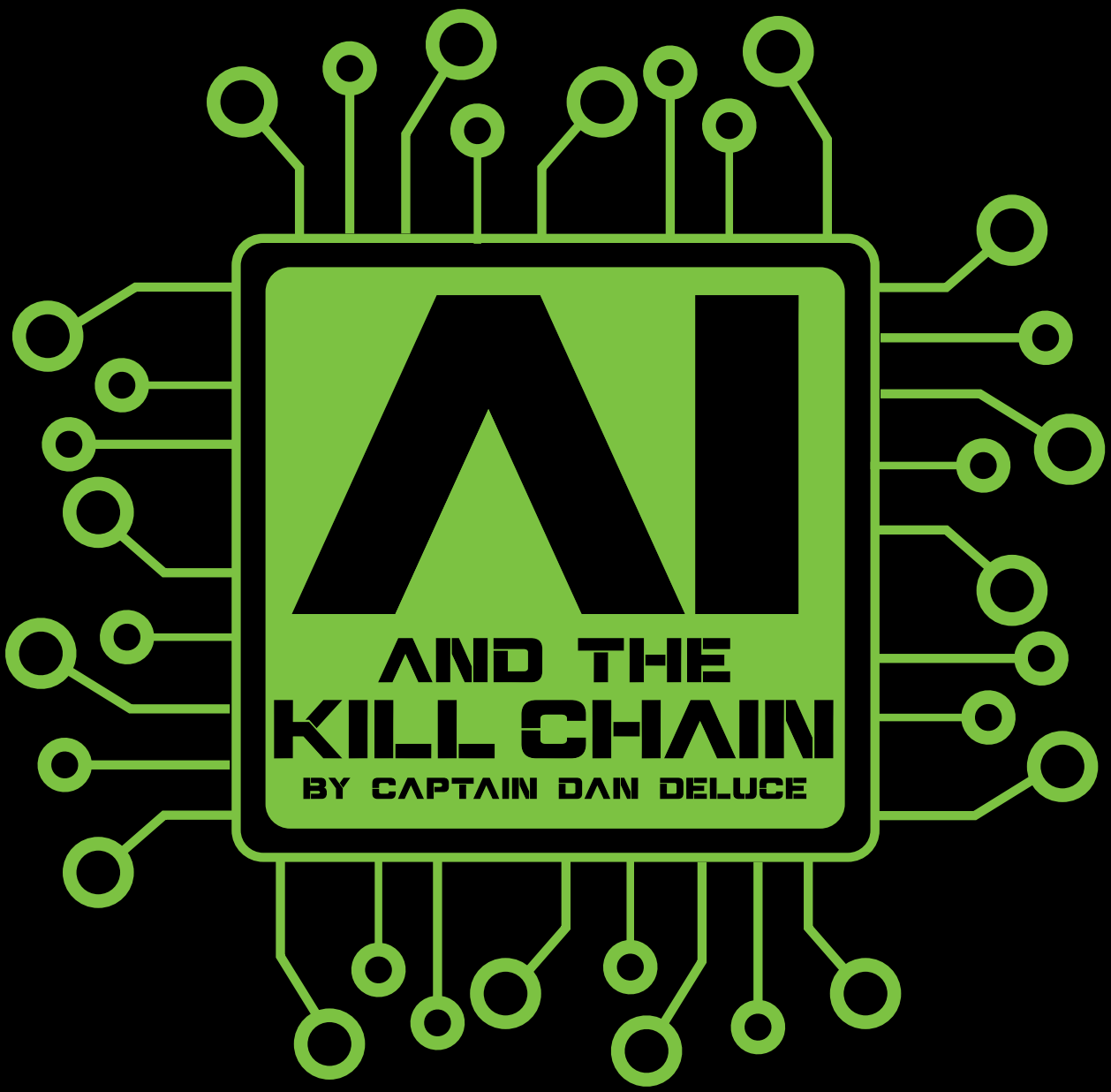
Captain Lafontaine delves into insurgency operations in "Airpower in COIN." Captain Lafontaine "defends the view that air power can significantly contribute to [counter-insurgency] COIN and underlines the conditions necessary for successful employment of air power in COIN operations."

Finally, in the "Points of Interest" article, Captain Millen, a graduate of ASPOC 1703, discusses his experience in taking ASPOC material from the classroom into the field through his experiences on Operation MALI.

Enjoy the read.

Sic Itur Ad Astra

Lieutenant-Colonel Doug Moulton, CD, MBA
Senior Editor


AI
AND THE
KILL CHAIN
BY CAPTAIN DAN DELUCE

Editor's note: This paper was written by a candidate attending the Air and Space Power Operations Course in fulfilment of one of the requirements of the course of study.

The use of lethal force on the battlefield is increasingly incorporating autonomous operations into the process of executing an attack (kill chain) and replacing the human element involved. The kill chain involves all the steps required to identify a target, dispatching a force to carry out the attack, the decision to strike, and the actual destruction of the target. The question arises as to where if at all the human element should be involved? The exponential growth in computational capacity available in smaller sizes allows more processing power to be carried on board unmanned systems. The availability of knowledge stored in the virtual space (combat cloud) has made access to additional information easier around the operating environment.[1] This enables tasks performed in the kill chain to be executed quicker and with more information than a human would be capable of processing.

The requirement of having a human in the later stages of the kill chain slows down the process and may inevitably be a losing strategy if employed against unconstrained systems of similar capabilities. In order to fully exploit the benefits of advances in artificial intelligence (AI) technology in combat with or against lethal autonomous weapon systems (LAWS), the Canadian Armed Forces (CAF) should allow for these systems to employ their effects without human control. This is not to say that the entire kill chain would be without human involvement, but rather that humans would be more involved in the creation, deployment, maintenance, and assigning of meaning to AI program operations.[2]

RUSSIAN PRESIDENT VLADIMIR PUTIN HAS DECLARED THAT "ARTIFICIAL INTELLIGENCE IS THE FUTURE. … WHOEVER BECOMES THE LEADER IN THIS SPHERE WILL BECOME THE RULER OF THE WORLD."

The nature of war is being challenged with the addition of machines capable of killing. The subject of autonomous weapons has created debate by subject experts in AI technology and robotics, leading to a call for the ban on the "further development of weaponized AI that could operate beyond meaningful human control."[3] They see the inclusion of LAWS as a threat to human existence, permitting wars to be larger in scale and faster than a human can comprehend. Allowing these systems to select and kill targets autonomously represents a new revolution in warfare.[4] Russian President Vladimir Putin has declared that "artificial intelligence is the future. … Whoever becomes the leader in this sphere will become the ruler of the world."[5] The pursuit of AI technology represents the new arms race, allowing its owner to be more efficient in operations. The risk of an adversary successfully incorporating this new technology into the kill chain creates significant strategic challenges.

Judgement day may have already passed as LAWS are currently being used around the world, although their use is primarily defensive in nature. It is easier to justify automatic autonomous weapons when it relates to self defence, as is the case for the United States (US) Navy with the Aegis Combat System, conceived because "humans were no longer quick enough to deal with the antiship-missile threat."[6] The idea that a human must be in the decision loop of a machine

is outdated and based on unfounded fears.[7] Instead, humans need to be the ones to define the decision loop of the machine. By doing so, CAF can incorporate the use of LAWS into the kill chain. The arguments for allowing LAWS to employ lethal force are: it can be accomplished within the Law of Armed Conflict (LOAC); it may provide some ethical advantages; and it will provide a significant tactical advantage.

In a heavily contested environment, it may not be always possible to have a human in the kill chain, not even through remote control. Allowing systems to operate autonomously provides the ability to transform higher-level intent and direction into actions without the need for external inputs.[8] AI enables LAWS to be able to learn from experiences, thereby adding new potential courses of action to their inventory to meet that intent.[9] This is important when the environment is dynamic and unstructured and, therefore, difficult for programming desired responses. Autonomy provides another means for self-protection and mission accomplishment in a cyber- and electronic-attack threat environment. The desired connectivity is also a factor in the design of LAWS, where in some cases restricted transmissions may be desired. The level of autonomy exercised by a system should be driven by the mission and the threat environment. It can be assessed by four factors: the frequency of interaction with a human, the tolerance for uncertainty of the environment, the flexibility to change its plan, and the ability to learn from its own actions.[10]

It is important to understand the factors that make a system autonomous to employ these systems responsibly. Humans are involved in the creation of these systems and, therefore; humans have the ability to design them with purpose and meaning. The definition of autonomy and AI are largely misunderstood and based on anthropomorphism: unintentionally giving human qualities to computer programmed systems.[11] In trying to replicate the cognitive functions of the human brain, AI technology is currently based on matching the outputs of computers with people, with less emphasis on differentiating the means to achieve the ends. The differences between the two highlight the potential vulnerabilities in humans and their computer counterparts. Understanding the strengths and weaknesses of humans and machines separately will allow employers of force to efficiently manage when and how to incorporate LAWS into the battlespace.

Commanding (or programming) LAWS requires an understanding of the limitations of the technology in relation to the task or mission within the context of the operating environment. This presents a challenge in the case of AI technology where "the very interdependence, complexity and flexibility of the system that allows it to perform complex mission sets may result in unpredictable and unintended lethality."[12] In traditional, large-scale, mechanized battles, it is easier to distinguish between combatant and non-combatant, as is required within LOAC and the principle of distinction.[13] There is a real possibility that LAWS will fail when confronted with more complex mission sets in obscure war environments if allowed to target and kill autonomously beyond their capabilities. Current image recognition software can be "spoofed" in ways that are fundamentally different from the way humans are misled. But in both cases, deception complicates the matter of targeting.

The possibility of unintended and unpredictable collateral damage leads to questions regarding the responsibility level and the acceptable tolerance level for these errors. Someone must be accountable to operate LAWS with the autonomous use of lethal force within the confines of the LOAC. This is a difficult task considering the unpredictable nature of AI, and creates a "responsibility gap" in that possibly no one is considered responsible.[14] According to the targeting rules in the International Humanitarian Law, Article 57, "those who plan or decide upon an attack must exercise due diligence to avoid or minimize civilian causalities."[15] The responsibility would therefore lie with the commanders who decide to employ LAWS. The commander must act with

due diligence and in good faith to be protected within existing laws if unintended collateral damage occurs.[16] This due diligence requires a thorough understanding of the technology, the mission, and the operating environment. By employing LAWS, the commander is exercising the decision to kill by assigning a mission, setting limits in time and space, and designing rules of engagement by which the lethal force is authorized.[17]

The LOAC dictates that the use of force requires proportionately. This is the responsibility of a military action not to cause excessive damage to civilian lives or property in relation to the military advantage to be gained from that action.[18] The assessment of proportionality requires an understanding of the importance of strategic goals in relation to the human costs involved. This is arguably impossible for LAWS because it appeals to human reason, common sense, and shared human values and, therefore; it requires a human to make that judgement.[19]

"MUST A ROBOT BE PERFECT IN ITS COMPLIANCE WITH INTERNATIONAL LAW, OR SIMPLY MUCH BETTER THAN HUMANS?"

Such a judgement, based on the expected collateral impact, would have to be made before employing the system, with the commander again being responsible for the outcome. There is possibly some shared accountability with the manufacturer, the designers, and the programmers, as well.[20] If the system were tampered with at some point, or a cyberattack occurred, it could complicate the matter further.[21] An investigation would have to determine where and how the judgement was made in error. Although assigning legal liability would be a challenge, there is an accountability chain that could be examined if sufficient evidence were preserved.

This leads to a discussion of the legal and moral tolerance levels to be applied to LAWS. "Must a robot be perfect in its compliance with international law, or simply much better than humans?"[22] If the moral tolerance level is strict, then it follows that the legal tolerance will also be strict and requires someone to always be accountable.[23] With a strict tolerance, any failure is impermissible, and the possible costs may make the project undesirable.[24] Machines will never be perfect, and setting the tolerance level too high risks discarding a technology that has the capability of outperforming humans in the use of lethal force. As discussed earlier, the morality of the use of lethal force for self-defence is easily accepted; the attacker, however, gives up the right not to be targeted. Where the risk of collateral damage is low (such as in sparse environments), the use of LAWS might also be more ethically acceptable. If one side has access to the technology and the other does not, this would be an unfair advantage in which only one side has the benefits. This would imply that the tolerance level is dependent on the situation.

The idea of being targeted and killed by a machine is terrifying in much the same way as it must have felt when tanks were first introduced onto the battlefield. Furthermore, "militaries that can successfully develop and utilize them [AI systems] will experience a dramatic increase in fighting power relative to those that cannot."[25] It is important to remember that there is a human element behind the machine. The weapon is just an extension of the will of the combatant. In the

case of LAWS, it allows humans to fight from an increased distance with less risk of the loss of life. Fighting against any superior capability and innovative weapon system will invoke feelings of fear, and in the case of LAWS, the capability is not limited by human physiology and is itself incapable (presently) of feeling emotions. This may just be the cold reality of the future of warfighting. What difference does it make to the person in an exploding submarine whether the torpedo was fired by a human or by a LAWS? Having said that, it is apparent that in many cases we are already far removed from the intimate nature of warfighting. If we reject an emerging technology for emotional reasons we could put our people and forces at significant strategic risk.[26]

It could even be considered unethical to send a human into a high-risk scenario to complete a task that a machine would be more capable of completing.[27] This notion implies that the value of a human life is worth more than a machine. There may be other costs associated with the possible loss of a new technology to the enemy. An adversary might also see the unequal value given to a machine as a way to challenge the commitment of the force, such as by destroying the machine, knowing its value to be less.

An example of this occurred during the lead-up to the 2008 Russian conflict with Georgia when four Georgian remotely piloted aircraft (RPA) were shot down.[28] The international condemnation of Russia would have been higher if the aircraft had contained humans. Both countries were condemned by the UN investigation that followed.[29] It is possible that LAWS will be easy targets knowing that the consequences of destruction are viewed as less severe. Would the situation have been different if the RPA were capable of autonomous self-defence and destroyed Russian threats that were manned? The autonomous defensive mode of the US Navy Aegis system discussed earlier is used to defend the ship and the people on board and not so much itself. There are currently no ethical rules governing the use of machines in warfare, either against humans or machines. In the same way that a military would defend stationary equipment from destruction, a machine should be capable of self-defence, if possible.

EMERGING TECHNOLOGIES ARE NOT THE DANGER. AS ALWAYS, FAILURE OF HUMAN IMAGINATION, OPTIMISM, ENERGY, AND CREATIVITY IS THE DANGER.

Now the tactical situation becomes a little different. It would not take long for LAWS to cease being easy targets. A human averages 200–300 milliseconds to react to simple stimuli, while a machine can select and execute manoeuvres with millions of corrections in the same time.[30] In the near future, autonomous AI systems will be able to move faster and employ more force with more precision than manned platforms.[31] Allowing machines to employ lethal force will enable them to react faster to get inside the decision-making cycle of the adversary to gain tactical advantage. The use of smaller autonomous machines could be networked into a coordinated swarm formation to overwhelm an adversary with numbers and superior manoeuvrability.[32] "Processes and decisions in automated war will become so swift that residual human interference means an unacceptable military disadvantage."[33] The human element of the kill switch would still exist because of the commander's choice to employ the AI system.

The willingness to employ LAWS in this way could provide strategic benefits as a valuable deterrent asset, not unlike weapon systems involved in integrated air defence with area denial surface-to-air missiles.[34] In an offensive situation, the use of LAWS not only represents a tactical advantage but also may minimize friendly causalities and lower the risk of unintended collateral damage.[35] Robotic technology represents a faster, more efficient warfighting ability that is unimpaired by stress, fatigue, or limited cognitive abilities.[36] Allowing LAWS the ability to make kill decisions capitalizes on the benefit of this emerging technology and gives a significant tactical advantage.

AT SOME POINT AN INTELLIGENCE THAT SURPASSES THAT OF HUMANS MIGHT FIGURE OUT A WAY OF CIRCUMVENTING OUR CONTROL, AND THIS COULD LEAD TO DEVASTATING CONSEQUENCES FOR OUR SPECIES.

The risk of an emerging technology presents challenges in the adaptation of the culture that will inherit it. In a democratic society that wishes to minimize the risks of war, LAWS offer a more efficient method of fighting.[37] However, in a time of exponential rates of technological change, it becomes increasingly difficult for society and culture to adapt.[38] The strategic and military advantages of embracing new technology make it unlikely that meaningful constraints can be imposed.[39] Calls for the ban on the development of autonomous weapons may fuel the debate and enable more thinking on their potential use. In many cases, warfighting is already accomplished at a distance by the use of LAWS. As the technology becomes smarter, society should also become smarter by allowing kill decisions to be made by a more efficient means.

The responsibility inherent in military operations when making decisions that lead to a loss of life represents the human nature of war. This responsibility lies at the very heart of the use of force. Autonomous weapons challenge the premise of humanity in warfare. In the advent of space technology and worldwide connectivity, the battlespace has become global. This does not absolve the responsibility of making good decisions with the use of lethal weapons. "Emerging technologies are not the danger. As always, failure of human imagination, optimism, energy, and creativity is the danger."[40] This larger battlespace offers benefits to all adversaries, and geographical distance can no longer be considered protection from retaliation.

The idea of a larger battlespace for adversaries without the use of autonomous weapons may be inspiration to execute guerrilla tactics and possibly terrorist attacks on their enemy's home front.[41] The unfair advantage granted to the users of LAWS may force the unequipped adversary to operate by non-traditional methods "justified" by the view that LAWS are unfair and dishonourable and, therefore, subversive to traditional rules of warfare. The very benefits of using superior killing machines on the battlefield, then, could have unintended consequences of greater risk to civilians and other targets on the home front.

The shape and complexity of the battlespace continues to change and presents questions regarding the applicability of the LOAC. With the rapid technological change that has occurred in the last several decades, it may be time to revisit the rules of war and/or to develop an acceptable code of conduct for the use of robotics in war. While the use of LAWS arguably can be accomplished

within the existing laws, it would be beneficial to have defined specifics in relation to robotic warfare. Just because we can operate a certain way does not mean that it is the right way. By lowering the risk of the loss of human life in the immediate vicinity of the fight we are possibly inviting risks in other forms. War could increase in frequency if it is viewed as easier to conduct with robots. AI technology may also prove useful in strategic decision making or in an advisory role. At the heart of the debate is how AI can be controlled. At some point an intelligence that surpasses that of humans might figure out a way of circumventing our control, and this could lead to devastating consequences for our species.

The employment of lethal force could be better executed by autonomous weapons so long as humans continue to design and employ them with purpose. Allowing AI to make kill decisions could improve the tactical effectiveness of CAF. Humanity is the guardian of AI technology and its use. This requires an increased understanding of the limitations of AI technology and where it can be reasonably employed in an ethical manner. There is also the possibility that the distinction between human and artificial intelligence will become less with advances in human-AI interfaces.[42] Humans and robots must evolve together to most efficiently fight together. In all cases, responsibility for the use of lethal force remains with the persons designing and employing it. The human element is never totally removed from decisions in the conduct of war. AI just makes the kill chain a little more efficient.

Captain (Capt) Dan "Delouse" Deluce is an instructor pilot with 419 Tactical Fighter Training Squadron in Cold Lake, AB. Capt Deluce is originally from Toronto and joined the Canadian Forces in 2010 as a direct entry officer with a BA in Chemical Engineering from the University of Toronto. He graduated the Fighter Pilot Course in August 2015 and was employed with 409 Tactical Fighter Squadron for three years, serving as a combat qualified element lead and tactical instructor pilot on the CF18. Capt Deluce was deployed to Romania as part of Operation REASSURANCE in the fall of 2017 as an alert pilot for the NATO Air Policing Mission. In summer 2018, he started his current position as an instructor pilot with 419 Squadron.

ABBREVIATIONS

AI	artificial intelligence
CAF	Canadian Armed Forces
Capt	Captain
LAWS	lethal autonomous weapon system
LOAC	Law of Armed Conflict
RPA	remotely piloted aircraft

NOTES

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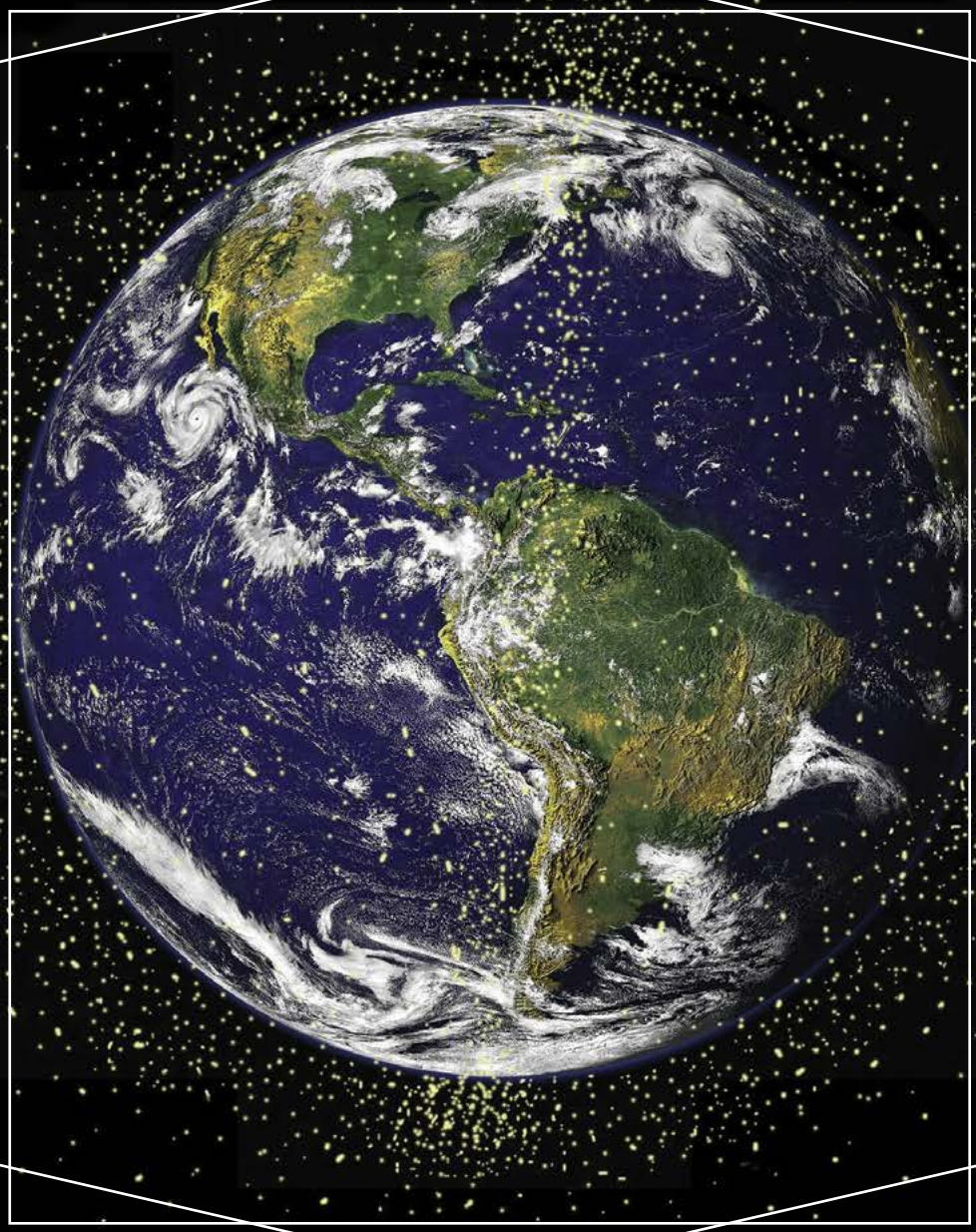


ROYAL CANADIAN AIR FORCE CONTRIBUTIONS TO SPACE DEBRIS MITIGATION

BY CAPTAIN N. J. K. MAHON

Editor's note: This paper was written by a candidate attending the Air and Space Power Operations Course in fulfilment of one of the requirements of the course of study.

Satellites and their capabilities have changed the world and day-to-day life of modern society in more ways than most people realize. The world is reliant on space-based assets for weather forecasting, research, precision navigation and timing, communications, television, military applications and much more. Satellites provide unique benefits due to their orbits, including reach and persistence; however, they are costly, impractical to maintain and relatively fragile. Since the beginning of the use of space, Earth's orbits have become increasingly polluted space, with debris from breakup events, used rocket bodies, defunct satellites, mission-related debris and natural objects.[1] The space-debris issue has become so significant that of approximately 21,000 objects tracked in orbit, only 1,800 are operational satellites.[2] In addition to these 21,000 tracked objects, there are smaller pieces that cannot be tracked but still pose significant risks to satellites—an estimated 166 million pieces of small debris.

Since the beginning of the use of space, Earth's orbits have become increasingly polluted space, with debris from breakup events, used rocket bodies, defunct satellites, mission-related debris and natural objects.

The Canadian Armed Forces (CAF) and the Royal Canadian Air Force (RCAF) in particular have significant interest in space both for day-to-day operations and for future capabilities described in the *Strong Secure Engaged: Canada's Defence Policy* (*SSE*). These current and future capabilities are threatened by the significant and increasing hazard of space debris, and mitigation action must be taken to continue the use of space. Space-debris mitigation considerations are essential for any user of space, and a global effort is necessary to manage and improve the issue.

The current space-debris mitigation approaches include object tracking, component shielding, active-debris removal and mitigation policies. Any of these options should not be considered in isolation, and a combination of tracking, shielding and policy, in particular, is necessary in any space endeavour. As an organization heavily reliant on reliable and safe access to space, the RCAF should expand its space debris mitigation contribution through further investment in space debris tracking systems and adhere to space debris mitigation measures in future space asset projects. Reliance on space-based assets is shared by almost every modern country on Earth, and the issues transcend government and military disagreements, just as space issues have for many years.

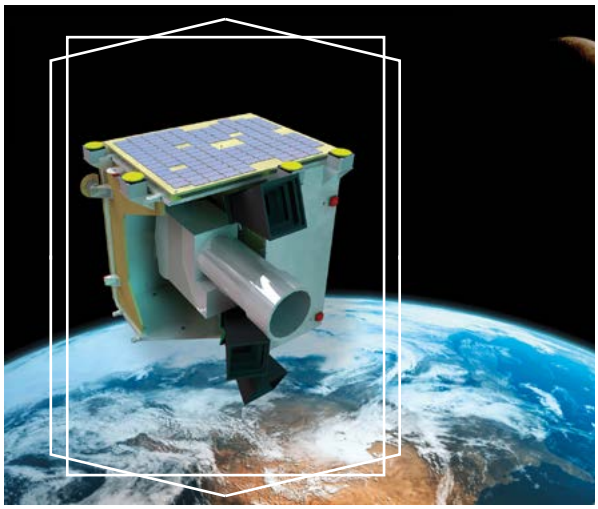
Canada has been a spacefaring nation since the launch of Alouette 1 in 1962, as the space race began in the early years of the Cold War. Canada was the third nation to design and construct a satellite and, around this time, the Canadian government provided direction to the Department of National Defence (DND) and the RCAF, in particular, to begin formalizing their military space agenda.[3] Since Canada's introduction to space, the world has changed to become heavily reliant on satellite assets in orbit around the Earth. CAF is a daily user of a wide range of satellite capabilities, including weather and environmental monitoring, precision navigation and timing, global communications,

space research, ground imaging, intelligence gathering and more.[4] These capabilities have become essential to conducting daily missions, and the availability of these effects has been mostly taken for granted. Enemy antisatellite weapons and effects are a consideration, but they pose only one part of the threat to the RCAF's satellite reliance. Space debris has been accumulating in orbit since the beginning of the space race, through launch debris, natural breakups, power-pack explosions and intentional actions such as the antisatellite test with the Fengyun-1C weather satellite by the Chinese in 2007.[5] While mitigation measures have been developed and implemented, the problem continues to be one of the primary concerns for satellite mission designers, planners and users.

CAF is a daily user of a wide range of satellite capabilities, including weather and environmental monitoring, precision navigation and timing, global communications, space research, ground imaging, intelligence gathering and more.

Space debris is considered to be anything in orbit other than functioning satellites. The amount of space debris has increased steadily since the first satellite was launched into orbit, and as more satellites are launched, broken and decommissioned, the amount of space debris continues to increase. The physics of an object in orbit around Earth means that any object is moving at great speed, and even tiny particles can hold enough energy to cripple large satellites.[6] As the amount of space debris continues to increase, the safer orbits are being constricted and becoming increasingly congested, requiring shielding techniques and active orbital manoeuvres to mitigate the effects of space debris. Research has been conducted on the destructive effects of space debris on satellites and the International Space Station, while unintentional research (e.g., paint chips causing impact craters on shuttle windows during orbital missions) adds proof to the issue. When debris is detected in proximity of the space station, the crew is often required to take shelter in the emergency evacuation capsule in case debris impacts the station and causes a significant pressure leak or structural damage.[7]

The RCAF relies on many aspects of space and is thus vulnerable to the potential destructive effects of space debris. In the worst-case scenario, a Kessler Syndrome[8] event would cripple most networks, degrade a significant portion of communications, destroy the ability to conduct space-based intelligence, surveillance and reconnaissance and disable anything reliant on a global positioning system.[9] A Kessler Syndrome event is an extreme example but is not impossible, particularly with the constant addition of satellites and increase in debris in orbit. Large portions of the RCAF's space-based capabilities are provided on behalf of other nations and companies, but the RCAF currently operates SAPPHIRE and a portion of RADARSAT, both capabilities that contribute to the security of Canada and the RCAF's space-based assets. *SSE* includes guidance for several new space-based assets including RADARSAT-2, a new surveillance-of-space asset, narrowband and wideband communications and non-space-based assets that rely on space capabilities to function, such as remotely piloted systems and the search and rescue network.[10] All of these missions must be designed with space-debris considerations, including shielding for small debris, the ability to manoeuvre to avoid large pieces and mission planning for safer orbits. These options all increase launch cost by requiring heavier shielding or propellants, or they reduce the payload to offset the increase in other weights.



Launched in 2013, Sapphire is Canada's first operational military satellite. An orbital traffic controller, Sapphire monitors thousands of pieces of space debris, detects man-made objects in orbit, and provides data to the U.S.-led Space Surveillance Network dedicated to preventing satellite collisions.

IMAGE: MDA Corporation

Given the importance of satellites, several space-debris-mitigation techniques have been deployed and more are being developed to assist in limiting and improving the issue. The Space Surveillance Network (SSN) is a combined network of sensors throughout the world and in orbit that use radar, optical and laser sensors to monitor and search for any objects in Earth's orbit. The network is controlled by the United States Air Force (USAF) and fuses various sensors with advanced modeling techniques to maintain an accurate picture of everything detectable in orbit.[11] The RCAF currently contributes to this network through SAPPHIRE, a space-based surveillance-of-space satellite. SAPPHIRE is in low earth orbit and monitors debris and satellites in outer orbits. By contributing to this network, USAF provides Canada with access to the information it has collated from the network of sensors, which allows planning and reaction to possible space-debris collisions with the RCAF's space-based assets. SAPPHIRE is currently operating beyond its design life.

The RCAF currently has a programme soliciting bids for the construction and launch of Surveillance of Space 2, which will add another sensor and more capability to the SSN through participation in the global effort to monitor Earth's orbits.[12] This contribution should be closely followed with a second system that expands on the capabilities of Surveillance of Space 2 by concentrating on orbital altitudes and inclinations that have limited monitoring in the SSN. As Surveillance of Space 2 is not finalized, the coverage gaps cannot be identified; however, the volume of the orbital planes around Earth makes it impossible to monitor them all with one asset. Contributing to the SSN will aid in maintaining access and provide Canada with the space situational awareness required for debris avoidance and overhead intelligence satellite information. Expanding the capabilities and coverage of the RCAF's space-surveillance assets would also ensure continued situational awareness if access to the SSN were compromised or denied. Australia recently contracted a portion of its space-surveillance project for similar reasons, in the form of a ground-based optical system at a cost of approximately Aus$80 million.[13]

Contributing to the SSN currently helps negotiate access to the surveillance network; however, if the political landscape changes, there is the possibility that Canada and the RCAF will lose the ability to access this network. Without a Canadian-controlled sensor network, the limited orbital view of SAPPHIRE would not be able to ensure complete coverage and could leave Canadian space assets vulnerable to space debris.[14] The network provides more than situational awareness to space debris; it also provides telemetry information on the functioning satellites that is required to maintain the accurate position of Canadian-controlled satellites and information for when other

countries satellites are overhead. Australia has recognized the potential shortcomings of the reliance on the network and has begun developing the capability to be partially self-reliant on its own systems. Australia is augmenting its current radar surveillance with enhanced capabilities to monitor satellites and debris in all levels of Earth's orbits. Similar to Canada's situation, the investment is to ensure that Australia can continue a meaningful contribution to the SSN while also ensuring independent mission assurance for domestic interests.[15]

Access to the SSN does not mitigate space-debris avoidance by countries who do not have access to the network nor possess their own space-surveillance capability. The shared reliance on—as well as safety of—space assets generally ensures that potential collision data is shared with countries of interest, but the decision to share it is controlled by the United States (US) or by other counties with integral sensor capabilities. With an RCAF-controlled space-surveillance network, Canada would have an increased independent ability to share potential collision information with countries that the US may be unwilling to work with.

Tracking and monitoring space debris only provide situational awareness, with the mitigation measures being to place satellites into less-congested orbits and manoeuvre them around space debris, both actions requiring consideration and compromises with planning and payload. The orbits with less space debris are becoming congested, and new debris caused by collisions can put debris into orbits currently considered to be relatively safe.[16] Planning to manoeuvre satellites around space debris affects the useful payload and life span of the satellites, as the weight used for extra propellant is at the expense of greater mission payload. As the propellant runs out, the ability to move the satellite is hindered, making it impossible to move the satellite out of the path of space debris should a potential collision be detected.

Shielding is another method currently used to mitigate the damaging effects of space debris to satellites. It is required on mission-critical portions of satellites for protecting them from small, untrackable space debris as well as micrometeorites. Shielding is optimized to ensure a high probability of survival for predicted impacts throughout a satellite's design life. As a space-debris-mitigation measure, shielding is essential; however, it is not an area to which the RCAF can significantly contribute. Shielding is already part of every satellite design, with numerous agencies and scientific organizations conducting research on lighter and stronger shielding as well as on the optimization of its placement on the satellites.[17] Extensive modelling is completed for each satellite and mission to ensure more vulnerable portions have increased protection and less vulnerable areas have reduced shielding to save weight. In one example, the weight penalty for one lid on a satellite component made of high-strength aluminum was two kilograms to ensure maximum survivability.[18] A two kilogram weight penalty becomes particularly significant when combined with other shielding requirements and the trade-off is considered against other functional components or launch costs. Millions of untrackable microparticles are spread throughout Earth's orbits, leaving shielding as the only currently viable option to protect space-based assets. The significant velocity of objects in orbit suggests that collisions with small objects can be very high energy, particularly with satellites orbiting in the opposite direction to the debris. The high-energy impact potential of space debris means that it would be impractical to shield satellites completely against anything larger than microparticles. Accurate tracking and warning of larger debris from space surveillance networks allow manoeuvrable satellites to avoid collisions with larger debris that shielding cannot withstand.

Active debris removal is the inevitable next step in space-debris mitigation.[19] Comparable to many polluted environments on Earth, human intervention is required to return Earth's orbits to near-natural states. All objects in orbit will eventually fall back to Earth given enough time, but for

The first major experiment in active space-debris removal was launched from the International Space Station recently as a combined European effort.

higher-altitude and faster-moving debris it can take hundreds of years. A complete stop of all rocket launches would not prevent the increase and spread of space debris, as collisions of objects in orbit would continue to create more pieces.[20] To ensure safe use of Earth's orbits by any nation, the removal of space debris must be a serious option. The first major experiment in active space-debris removal was launched from the International Space Station recently as a combined European effort. The satellite was equipped with several payloads, each testing a different method to remove debris.[21] A successful test has been conducted with a target piece of debris. The general concept of active debris-removal missions is to locate space debris and force it to deorbit. The methods to deorbit space debris include attaching drag devices, collection, electro-magnets, laser pulses and special foams.[22] Active debris removal is very technical and requires the satellite to be able to navigate, detect objects, manoeuvre and stay in range to accomplish the desired effect. This method must be pursued, although it is going to be expensive to develop and launch and will require numerous satellites to cover significant portions of Earth's orbits. Active debris removal will take time to start making a difference but cannot be delayed, as the space-debris problem will get worse without it.

Active debris removal has potential political implications, particularly if developed and deployed by a military organization. The capability to deorbit a functional satellite is made possible with active debris-removal satellites, and giving control of this capability to a military could allow its employment for military means. China and Russia are both developing and possibly testing active debris-removal satellites, with local commentary and western perspectives inferring that these nations could use these satellites to deorbit other countries' space assets.[23] This mitigation technique is better suited to multinational scientific organizations whose allegiance is not to a particular country and whose primary objective is science. The RCAF can advocate for the development and deployment of these technologies but should not be involved with the projects to avoid the potential perception of military employment.

Pieces departing the rocket launches and entering Earth orbit continue to contribute to the issue of space debris. Many international organizations and governments have recognized the need to eliminate further debris being placed in orbit and have adopted space-debris mitigation policies. Guidelines have been created and agreed to by most spacefaring nations, including the United States, Japan, Russia and China. International policies are also created by the European Space Agency (ESA) and the United Nations (UN). The UN policy includes seven guidelines:

(1) limiting debris released during operations;

(2) minimizing the potential for breakup;

(3) limiting the potential for a collision;

(4) avoiding intentional destruction;

(5) reducing the potential for stored-energy breakup;

(6) limiting launch-vehicle orbital stages in low earth orbit; and

(7) limiting launch-vehicle orbital stages in geosynchronous earth orbit at the end of missions.[24]

The RCAF should ensure that any company contracted to design and launch CAF space assets follows these guidelines. In addition to these policies, an end-of-life plan should be considered to deorbit satellites at the end of their missions. Many of these policies require some compromise for payload, launch cost and design life, but the mitigation of space debris is essential through all means possible to avoid a continually worsening problem. As a mitigation technique, limiting the RCAF's contribution to the problem sets a positive example for other space missions and ensures the RCAF does not contribute debris that may affect Canadian assets or those that CAF relies on.

With the extensive global reliance on space, every country will have to contribute to space-debris mitigation if they intend to continue operating in space and relying on space-based capabilities. Space debris is a significant problem for satellites in orbit, with heavy consequences that require extensive resources to mitigate. Solutions have been developed to address the issue of space debris, including tracking and manoeuvres, shielding, active-debris removal as well as policies to reduce future debris. Simple mitigation measures should be encouraged for any space launch, such as planned end of life deorbit and launch components that are designed to deorbit and stay in larger pieces after a launch.

As an organization heavily reliant on space for a wide range of operations, the RCAF must recognize the fragility of space-based assets and develop the independent ability to safeguard current and future space assets. The RCAF should develop and enhance a Canadian-controlled space-sensor network and follow space-debris mitigation policies in all space endeavours.

As a current contributor to the tracking of space debris with SAPPHIRE, a second project in process—Surveillance of Space 2—will increase sensor coverage and aid in assuring access to the SSN. Accurate monitoring helps plan satellite orbits for safer areas, alerts operators to potential collisions and provides time for satellites to be manoeuvred away from larger debris.

By expanding and enhancing Canadian space-surveillance capabilities, the RCAF can help ensure access to the SSN into the future and maintain a capability in case access is ever limited or cut off. Space-surveillance assets are not capable of tracking small space debris, making shielding an essential component of any space asset. Shielding as a part of satellite designs is heavily researched and tested by the scientific community and is already in use by satellite designers, limiting the effective contribution the RCAF could make. Tracking, manoeuvres and shielding mitigate the space-debris issue but do not contribute to improving the situation.

Active space-debris removal is the inevitable next step to space-debris mitigation and is essential to return the orbital environment to its original state and ensure safe use of Earth's orbits for satellites. The military and political implications of active debris removal make it difficult for the RCAF to contribute to this method. A militarily developed and controlled active debris-removal satellite can be viewed as a weapon in space, capable of targeting and manipulating other functioning satellites. This approach is better suited to multinational scientific communities, especially as the technology is still being developed and tested. Any space launch, including those of debris-removal satellites, has the potential to contribute further debris if mitigation policies are not followed.

Space-debris mitigation policy has been published and agreed to by many nations in the world and compliance should be an essential requirement for any RCAF satellite contract. Space debris will continue to be an issue for any nation's space assets, and a global effort to mitigate space debris is essential. The RCAF and most of Earth's modern-day society rely on space assets for a wide range of services and the relative safety of these assets should not be taken for granted, particularly given the situation where the problem cannot remedy itself.

Captain Mahon enrolled in the Canadian Forces in 2009 and went on to complete a degree in Civil Engineering at the Royal Military College of Canada. Following graduation in 2013, he was posted to Moose Jaw for pilot training, receiving his wings on the CF Bell 412 in 2015. Captain Mahon was subsequently posted to 423 where he participated in RIMPAC 2016, the RCAF UK (United Kingdom) Public Duties, and deployed to Operation IMPACT as a Mission Support Officer. Captain Mahon is currently the Deputy Operations Officer at 423 Squadron and fills the role of 12 Wing Electronic Warfare Officer while preparing for his Cyclone training course. He is also continuing work towards an MBA at the University of Fredericton.

ABBREVIATIONS

CAF	Canadian Armed Forces
DND	Department of National Defence
ESA	European Space Agency
RCAF	Royal Canadian Air Force
SSN	Space Surveillance Network
USAF	United States Air Force

NOTES

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RCAF PROCUREMENT: CANADIANIZATION IS NOT THE BEST FIT FOR CANADA

BY CAPTAIN ALYSSA M. GAGNÉ, CD, MA, CAPM

Editor's note: This paper was written by a candidate attending the Air and Space Power Operations Course in fulfilment of one of the requirements of the course of study.

Strong, Secure, Engaged: Canada's Defence Policy[1] (*SSE*) outlines the expectation that the Canadian Armed Forces (CAF) will remain strong at home, secure in North America, and engaged in the world. Further, it explicitly states the scope of Canada's missions at home and abroad. To enable these functions, this defence policy is "costed," meaning it allocates funds over the next twenty years to provide CAF the capabilities required to match the domestic and expeditionary missions assigned. Figure 1 shows that approximately half of these funds are directed toward the Royal Canadian Air Force (RCAF), as *SSE* outlines thirteen new projects for the RCAF.[2] Over the next twenty years, the RCAF and Public Services and Procurement Canada (PSPC) will administer these and existing projects in various stages. Manning in both the CAF and Department of National Defence (DND) project offices administering these procurements is critically low.[3] Therefore, it is in the interest of the organization to make efficient use of both its human and financial resources to procure the right capabilities in a timely manner. Efficient and effective procurement ensures that ageing fleets are not operated beyond their projected life expectancy, which would put a drain on operations and maintenance budgets; but, more importantly, efficient and effective procurement ensures that the RCAF can meet the future threats per *SSE*.

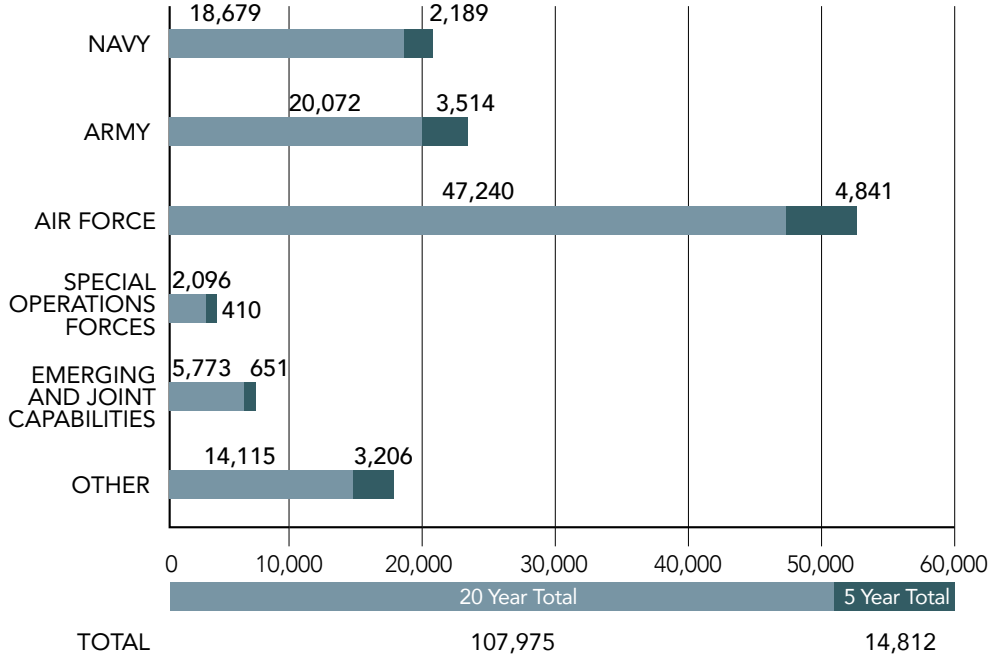

Figure 1. Capital expenses on an accrual basis by domain ($millions)[4]

To maximize the efficiency of the RCAF's procurements, it is important to understand what the best practices are and to apply them swiftly to ongoing and upcoming capital projects. Doing so will ensure that the RCAF can contribute to the Canadian defence strategy's goal of procuring the right equipment, at the right time, at the right cost, while stimulating the economy.[5] As such, an examination is needed of the time, cost, capability, and industry growth to review RCAF

procurements over the last twenty years that have reached "implementation" to determine what, if any, best practices can be gleaned. These best practices together with project management and economic theory can provide considerations for the RCAF about ongoing and future procurements.

Authors such as Nossal and Williams are correct in their acknowledgement that RCAF procurement woes are not uniquely Canadian, nor can they be traced to a single causal factor. This paper seeks to address issues within the process itself where the RCAF may have influence, while acknowledging the inherent complexities and other issues, such as Canadian public perception, politicization of certain acquisitions, and the accountability structure for defence procurement, among many others.[6] The RCAF would better serve itself to take a commercial off-the-shelf (OTS) procurement-strategy approach as opposed to selecting a product, then introducing modifications unique to Canada. Proper capability selection would deliver Canadians the right balance of capability set out in *SSE* within the framework of the Canadian defence strategy.

To demonstrate this, OTS procurements will be contrasted with new development and "Canadianized" projects. OTS is defined, as Rudd did, to include equipment that is in service in another country's armed forces; that is, equipment with an established production line, needing only minor modifications to ensure interoperability with existing or allied assets. New development is the opposite—it involves a new design to be drawn, produced, tested and implemented for the first time. "Canadianization" represents the grey area in between, where an existing platform is used but extensive modifications are required before the capability can be brought into service.

An examination of RCAF procurements over the last twenty years, spanning both Liberal and Conservative Governments, will determine what is optimal in said procurements. Some of these are regarded by the media as successes and some are widely publicized as failures. The four cases to be studied do not attempt to provide a generalizable sample but rather a starting point to study the trends and possible best practices within the RCAF procurement process. The tables below show time, cost, capability, and industry growth data for the procurements of the CC130J, CH148, CC177 and CH147F respectively.

CC130J – Non-Competitive, OTS			
	Expected	Actual	Variation
Time[7]	2010	2010	6 months ahead of schedule
Capability	OTS	OTS	Nil
Cost [8]	3.1B$	3.1B$	Nil
Industry Growth	100% IRB	350M IRB[9]	Ongoing

Table 1. Procurement of the CC130J

CC177 – Non-Competitive, OTS			
	Expected	Actual	Variation
Time	2007	2007	Nil
Capability	OTS	OTS	Nil
Cost[10]	2B$	2B$	Nil + extra CC17711
Industry Growth	100% IRB	66% IRB 795 M12	Ongoing

Table 2. Procurement of the CC177

CH148, Competitive (LCC), Canadianized[13]			
	Expected	Actual	Variation
Time	2005[14]	2015	+ 10 years
Capability	OTS[15]	Canadianized [16]	
Cost	3.1B$[17]	3.2B$[18]	Re-baselined after 700M$ overrun[19]
Industry Growth	100% ITB	General Dynamics, L3 Technologies, ITB[20]	Ongoing

Table 3. Procurement of the CH148

CH147F Non-Competitive, Canadianized[21]			
	Expected	Actual	Variation
Time	2008[22]	2013[23]	+ 5 years
Capability[24]	OTS	Canadianized	
Cost[25]	2B$	4.9B$*	+0.2B$
Industry Growth	100% ITB	L3 Technologies, Raytheon[26]	Ongoing
* Original value miscommunicated to government, did not include in-service support (ISS) 0.2B$ increase overall			

Table 4. Procurement of the CH147F

Any of the indicators that either met or positively exceeded the expected metric in that category are represented in green while red represents shortfalls. This particular analysis examines variations from original values. One could argue that this fails to account for any project with inflated starting values due to lack of competition. However, for simplicity, this aspect, although also worthy of examination, is suppressed for this study.

The small sample above is comprised of two OTS procurements, two Canadianized procurements, and no new developments. On most indicators, the OTS acquisitions were more successful. OTS purchases inherently have less risk; therefore, project management theory would predict less variation in time, cost, and capability.[27] Risk, as referred to above, is defined as the "likelihood of failing to achieve the functionality and manufacturability within given budgetary and time limits."[28] The project management theory and the risk definition address time, cost, and capability, but do not account for industry growth, all of which will be examined in turn.

The case study of recent acquisitions (Figure 1) finds that time is the aspect most sensitive to procurement type. As proposed by project management theory, an increase in the complexity of an acquisition such as going from an OTS to a Canadianized purchase also has an impact on time, cost, and scope.[29] The most pronounced effect of such increased complexity appears to be the variation of a project schedule. Further to this, an aggregate study of Norwegian acquisitions also found that "OTS projects perform better when it comes to completion of the projects according to the initial schedule compared to development projects."[30] It is important to note that schedule delays in a project are often linked to increases in both opportunity costs, such as unused infrastructure and real costs. Real costs are incurred with the increased spending on human and material resources toward the continuation of expensive and time-consuming maintenance on older platforms.

It is difficult to argue for Canadianized or new development projects as functions of reduced delivery time, as OTS has proven both theoretically and in practice to deliver more quickly. However, an OTS model does not eliminate schedule risk—the RCAF's order may be prioritized behind that of other countries, resulting in a longer delivery period. Further, any time savings resulting from this method may be offset by increased unit costs. Overall, any alteration of an OTS product to Canadianize it poses a risk to the schedule. An otherwise proven design being significantly altered will require additional engineering and development.[31] Additional engineering and development requirements are likely to result in both increased delivery time and cost.

Any discussion of project schedule cannot be isolated from a corollary discussion of project cost. In the same manner that Canadianization of an existing product increases schedule risk, it also, theoretically, and in our case study, increases project cost. While the variation in the cost of OTS purchases is lower, it is often argued that the per-unit prices of OTS platforms are higher than with a product with multi-source competition. For instance, the CC177, the CC130J and CH147F were purchased without holding a competition.[32] While the variation in project cost from start to finish was low, the price paid was high.

Conversely, economies of scale support an OTS model for lower per unit costs. A country like Canada may not, by itself, have the market power to negotiate lower prices and special customizations;[33] whereas, buying into an OTS solution with our allies can provide an interoperable capability at a reasonable price. A good example of the exploitation of this model is the United States' development of the F-35 programme.[34]

If pursuing a non-OTS model of acquisition, opting instead for Canadianization, new processes and engineering need to be created to suit local industrial capability and environmental factors. While the initial per unit cost under a non-OTS model may be less, the Canadianization adds risk to the budget due to new servicing, engineering and processing requirements.[35]

When looking at the iron triangle of project management, the quality of work or, for our purpose, the capability delivered is constrained by time, cost and scope. One could argue that an increase in time and cost is worthwhile if it delivers a capability that serves the RCAF's unique requirements in a Canadianized model.

Canada's unique geopolitical and economic circumstances may preclude OTS capabilities from other countries that suit our region. Further, because of Canada's low defence spending compared to our allies (approximately 1.3% of gross domestic product [GDP] versus the NATO-recommended 2%),[36] Canada does not have the resources to purchase a range of distinct platforms to satisfy the spectrum of capabilities set out by *SSE*. Therefore, the RCAF may need to buy a single platform and alter it to perform a wide set of unique capabilities. If this premise is accepted, Rudd argues that a new development project still offers less time, cost, and scope-risk than Canadianization. However, a strictly Canadian solution brings forth its own challenges. Purchasing a unique capability requires integral and distinctive support in terms of maintenance, documentation, safety programmes, etc. While these can be incorporated into the purchase contract, military resources will still have to be expended to validate these upon receipt, as well as to extensively test and evaluate the platform and its capabilities in the operational environment. An ongoing example of these challenges is seen with the CH148 implementation, which Sloan argues should have been treated as a developmental programme. Further to these challenges, the RCAF cannot draw upon an international network of aviation corporate knowledge or a worldwide supply and distribution system to enable their custom-built capabilities. A large base of users helps mature a capability by uncovering defects early and completing appropriate upgrades.[37] With effective manning low across most RCAF trades,[38] the RCAF cannot afford to be conducting project management functions within its operational lines.

OTS plus minor customization may seem like a natural sweet spot for the RCAF. The literature reviewed for this analysis, while on two separate sides of the new development versus OTS issue, reach consensus that OTS plus customization—or Canadianization—is the least favourable solution. Canadianization initially masks the risks inherent to developmental initiatives—subsequent variations in cost and time are not forecast and impede project progress. If a new development is deemed necessary, it should be procured according to that process.[39] The 2010 Fall Report of the Auditor General admonishes the practice of minimizing project complexity as it relates to both the CH148 and CH147F: "the full extent of the modifications were not initially presented to decision makers."[40] This resulted in a complex, customized purchase sold as a low-risk, OTS procurement.

A CH148 Cyclone helicopter moves into position over the flight deck of Her Majesty's Canadian Ship (HMCS) Montreal, for deck evolutions on April 20, 2016, off the coast of Nova Scotia. Photo: Leading Seaman Dan Bard, Formation Imaging Services, Halifax, Nova Scotia

An aforementioned aspect of the capability debate to consider is the uniqueness of RCAF requirements. Does the RCAF require significantly different platforms than our allies when, doctrinally,[41] the core roles these platforms enable are quite similar? Table 5 displays the RCAF's doctrinal core capabilities. NATO's air doctrine states that joint air power roles are counter-air, attack, air mobility, and contribution to joint intelligence, surveillance and reconnaissance.[42] These mirror the RCAF's doctrinal capabilities. The NATO doctrine goes on to highlight the importance of interoperability and integration. Perhaps the Canadianization we require can take place within our own training and employment rather than by custom tailoring platforms. Keeping in mind fundamentally similar air doctrine and the importance of interoperability and integration,[43] acquiring platforms similar to those of our allies increases the RCAF's capability when operating as part of a coalition.

RCAF Functions	Capabilities		Roles, Missions, Activities
Command Sense Act	Core	Control of the Air	Counter Air (OCA, DCA, Air Defence)
			Area of Operations Management (Airspace Control, Nav Systems, Air C2)
		Air Attack	Counter Land (CAS, Interdiction)
			Counter Sea (ASW, ASUW)
		Air Mobility	Airlift (Strategic and Tactical, Aeromedical Evacuation)
			Air-to-Air Refuelling
			Search and Rescue (Personnel Recovery)
		Intelligence, Surveillance and Reconnaissance	Collect, Process, Disseminate (Early Warning, RAP)

Table 5. RCAF capabilities, roles, missions, and activities[44]

Defence procurement authors, such as Williams, argue that the RCAF needs to source some purchases from Canadian companies only to grow and maintain key capabilities at home.[45] Rudd would echo this sentiment as it relates to the shipbuilding strategy. Both would contend that these acquisitions should remain competition based, but the acquisition of CAF capabilities should also strive to stimulate the Canadian industrial base. These authors' visions of Canadian procurement do not support an OTS strategy but rather a new Canadian development or a Canadianization strategy to allow Canadian companies easier access to the market. The balance between advancing Canadian industry and equipping the military at the best possible price is an art as much as a science. The aforementioned authors would rightly contend that Canadian companies do not stand a chance in the global market if they have not won "in their own backyard."

Canada's defence procurement policy[46] emphasizes the importance of industry growth within defence procurement. With this in mind, new developments and Canadianization offer avenues to include Canadian businesses looking to participate in the defence industry. The stimulus from Canadian defence contracts can give companies the footing they need to expand into wider markets.

However, if the goal is to stimulate Canadian industry enough that it is competitive in the global market, the past and present defence procurement strategies are not optimal. Any mechanism forced upon the free-market economy causes deadweight loss.[47] The *Defence Procurement Strategy*[48] assigns disproportionate weighting to Canadian firms. This artificially increases demand for the product. Other factors being equal, this leads to a shift away from the free-market equilibrium and a deadweight loss[49] that will be shared between the consumer and the producer. Conversely, stimulating Canadian firms at the research-and-development stage to ensure they are competitive for Canadian and other contracts will give them best access to both the Canadian and international markets. Capabilities stimulated by "buy-Canadian" strategies such as shipbuilding can lead to waxing and waning between contracts that is difficult for the industry and economies it supports.[50] This does not speak directly in favour of either procurement strategy, OTS or Canadianized acquisitions, but weakens the argument that OTS purchases are worse for Canadian industry. Instead, Canada can focus on making Canadian companies competitive at home and abroad. This argument is echoed by Burgess and Antill: that the "best way to help small defence firms, as we have in Canada, isn't to create a dependency but rather to establish a level playing field removing barriers to entry and growth for firms of all sizes, reinforcing competition."[51]

The question should not be about which method of procurement most stimulates industry growth, but whether influencing this part of the procurement is the best lever to use to stimulate real growth that Canadian firms can bring to other markets. In sum, when considering the amount of projects *SSE* has given the RCAF against how many missions it is required to fill, it is imperative that the RCAF draws on best practices from project management and economic theory, as well as those we can glean from within the organization.

In line with the procurement strategy goal (to acquire the right capabilities in a timely, cost-efficient manner that also stimulates Canadian industry), the analysis of recent acquisitions and theory finds that while some particular instances may require a new development, OTS solutions offer less risk, which usually translates into lower costs and shorter delivery times. Conversely, the Canadianization of platforms leads to time and cost penalties. In terms of capability, new developments may be required in some areas; but, again, Canadianization does not deliver the best results in terms of the product maturity, support, and economies of scale. OTS procurements offer a proven product with less developmental risk, along with a worldwide system from which to draw parts and information. Finally, in terms of industry growth, Canadianization does offer Canadian firms more access to defence contracts. However, artificially increasing demand for Canadian products within our own market does not best serve the customer or the business if the firm is not competitive on its own merit. Rather, if industry growth is a priority, it should be stimulated in earlier stages to ensure that Canadian firms can compete at home and abroad.

Overall, there may be some niches where a new development is the best solution to meet the RCAF's requirements. However, given the doctrinal similarities between us and our allies, OTS platforms can exploit economies of scale and of interoperability, decrease delivery time and cost, and increase use of a capability. Therefore, the RCAF can optimize its procurements by avoiding Canadianized capabilities in favour of OTS options that will deliver to Canadians the right balance of capability set out in *SSE* within the framework of the Canadian defence strategy.

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ABBREVIATIONS

Air C2	air command and control
ASW	antisubmarine warfare
ASUW	antisurface warfare
CAF	Canadian Armed Forces
CAS	close air support
Capt	captain
DCA	defensive counter-air
DND	Department of National Defence
GDP	gross domestic product
IRB	industrial and regional benefits
ISS	in-service support
ITB	industrial and technological benefits
LCC	life cycle cost
Nav	navigation
OAG	Office of the Auditor General
OCA	offensive counter-air operation
OTS	off-the-shelf
PSPC	Public Services and Procurement Canada
RAP	recognized air picture
RCAF	Royal Canadian Air Force
SSE	*Strong, Secure, Engaged: Canada's Defence Policy*

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TOWARDS A GREENER FUTURE:

Complex Considerations of Alternative Jet Fuels

By Major J. M. Campbell, CD

Editor's note: This paper was written by a candidate attending the Air and Space Power Operations Course in fulfilment of one of the requirements of the course of study.

Over the past two decades, it has become increasingly difficult to deny the negative impact humans have on the environment. National and global news cycles frequently focus attention on climate change and, consequently, the future of humankind. The realm of national defence is not exempt from environmental considerations either. In fact, *Strong, Secure, Engaged: Canada's Defence Policy* (*SSE*) gives the Department of National Defence (DND) and the Canadian Armed Forces (CAF) a clear call to action when it says: "Climate change threatens to disrupt the lives and livelihoods of millions around the world. It also presents us with an urgent call to innovate, to foster collective action, to work hand-in-hand with like-minded partners around the world to meet this threat and beat it, rather than stand passively by."[1]

For the Royal Canadian Air Force (RCAF), greenhouse gases (GHGs) emitted by military aircraft are a key environmental issue. To understand the magnitude of the problem of GHGs, we can look to the fact that globally, the civil aviation sector is one of the main emitters of GHGs, accounting for approximately 2.5% of global GHG emissions: roughly equivalent to the seventh biggest national polluter in the world.[2] These data do not include the world's military air forces; however, it is fair to assume that their inclusion would only increase the volume of aviation emissions. Furthermore, increased demand for aviation will likely lead to a related increase in emissions without active mitigation.[3] From a CAF perspective, many of Canada's recent expeditionary operations (both domestic and international) rely heavily on the use of air power resources; continuation of this operational trend will likely equate to increased emissions if mitigating actions are not taken.

The use of alternative jet fuels is frequently highlighted as a viable means of significantly reducing GHG emissions; however, a closer look at the arguments for and against the use of alternative jet fuels reveals that opinions on the subject remain quite divided. Questions abound about the realistic sustainability of alternative jet fuels and about their actual environmental benefits. But, based on an analysis of relevant data, this paper will contend that the RCAF has a responsibility to reduce its impact on the environment, in particular its GHG emissions, and that alternative jet fuels should be considered as a means of meeting this intent.

A CC150 Polaris Airbus from 437 Transport Squadron in Trenton provides air-to-air refueling to CF18 Hornet fighter aircraft from 409 Tactical Fighter Squadron in Cold Lake, Alberta.

To argue these points, this paper will first assert that the RCAF does in fact have social and regulatory responsibilities to reduce its environmental impact and that other organizations are working towards the same, and then it will conduct an analysis of the arguments both for and against a switch from conventional to alternative jet fuels for the RCAF. Given that there is an incredibly wide range of alternative fuels currently being produced and trialed for various aviation uses, the term "alternative fuel(s)" will be used generically for the remainder of the paper to refer to all non-fossil fuels from varying biomass sources. However, where the analysis requires more granularity, specific fuels and fuel-production methods will be cited accordingly, and the term "alternative jet fuels" will be used as necessary to differentiate from other forms of alternative fuels not appropriate for jet engines.

A key part of analysing the benefit of a switch to alternative fuels as part of a valid RCAF environmental strategy is first demonstrating that the RCAF has a responsibility to reduce its environmental impact. To argue responsibility, this paper will first explore the social context in which the RCAF operates, the policies to which the RCAF needs to adhere and the example of similar organizations. To begin, socially, there are a number of indicators that confirm the RCAF's environmental responsibilities. In a qualitative research study of Canadian environmentalists, Stoddart et al. show that 76.3% of respondents believe government leadership should be responsible for dealing with climate change,[4] which would indicate that the public expects all federal departments to do their part to combat climate change. In a broad review of the implications of climate change on CAF, Lieutenant-Commander (LCdr) Ray Snook identifies a number of valuable considerations. He points out that there are significant financial consequences to climate change for DND, given that ongoing depletion of non-renewable energy resources will go hand-in-hand with cost increases.[5] He also identifies the preponderance of high-power engines used in military operations as a key challenge to limiting our environmental impact and he speaks to the likelihood that future CAF operations will be linked to the global consequences of climate change, such as severe weather events.[6] Ultimately, Snook's position that "inaction equates to gross irresponsibility" is reasonable.[7] Hence, it is reasonable to conclude that the RCAF has a social responsibility to reduce its environmental impact, including its GHG emissions.

From a policy perspective, a review of current Canadian environmental policies and regulations demonstrates that the Government of Canada (GC) is also particularly interested in reducing departmental GHG emissions as part of a larger national environmental strategy. This expectation extends down to the RCAF level within DND. The Federal Sustainable Development Strategy (FSDS) sets a target for reduction of "GHG emissions from federal government buildings and fleets by 40% below 2005 levels by 2030, with an aspiration to achieve it by 2025."[8] As an overarching document, the FSDS lays out broad GC goals and specific targets for some government operations; however, it doesn't specify targets for military aircraft fleets or platforms in any way. To determine how these broad goals translate into specific RCAF responsibilities, additional examination of two departmental-level documents is necessary: *SSE* and the Defence Energy and Environment Strategy (DEES).

SSE acknowledges that DND is responsible for more than half of the GC's GHG emissions and commits the department to the previously mentioned goal of a 40% reduction in GHG emissions from 2005 levels by 2030.[9] Again, this target of 40% reduction explicitly excludes military fleets, but *SSE* does mandate the examination "of alternative energy options and their potential use for operations,"[10] which can be taken to include military fleets. Similarly, the Defence Construction Canada (DCC) report mentioned above references a 2014 Defence Operational Energy Targets document, which indicated that by 2016, CAF should have determined the certification process to be used to determine the suitability of "drop-in" alternative fuels for tactical platforms and vehicles.[11]

However, DEES, published in 2017, only generically references certification processes and neither sets specific goals related to use of alternative fuels for military platforms, nor demonstrates that certification processes are in place.[12] What is perhaps more telling is the fact that the legacy Hercules (CC130H) is the only aircraft in CAF's current fleet that has even been tested with an alternative fuel and that the test was conducted over six years ago (in May 2012) with no indication that alternative fuels have been utilized since, despite the test being an initial success.[13] Essentially, *SSE* and DEES set lofty goals related to GHGs but don't reference or perpetuate previous specific targets related to RCAF fleets and alternative fuel certification processes.

In light of the current lack of RCAF-specific goals, one positive piece of policy is the Innovation for Defence Excellence and Security (IDEaS) programme introduced in *SSE* and further elaborated on in the Defence Investment Plan. Launched in 2018, this competitive process presents defence and security challenges to Canada's innovation community and includes alternative fuels in the list of specific areas open to advanced research and development.[14] So while the RCAF may not have a direct mandate for future use of alternative aviation fuels, policy makers are clearly still leaning in that direction.

A final litmus test for gauging organizational responsibility is to consider what other organizations, with a similar focus, are doing to deal with the same problems. The International Civil Aviation Organization (ICAO) and the United States (US) Department of Defense (DoD) are two good examples to consider. ICAO has formally recognized that climate change could have major cost implications for the air transport industry; thus, it recently passed Resolution 393, which sets out a system for addressing GHG emissions stemming from civil aviation.[15] In the US, the DoD is already using biodiesel in administrative and other non-deployable vehicles and, despite a lack of national regulations for military fleets, the US Army, United States Navy (USN),

A member of the CC130 Hercules crew helps the local refueling crew hook up to the aircraft at the airfield in Gao, Mali, Operation PRESENCE - Mali, on July 10, 2018.

US Marine Corps and US Air Force (USAF) have their own programmes that are "geared toward reducing dependence on the use of fossil fuels in tactical weapon systems, such as aircraft, combat ships and vehicles, and supporting equipment."[16] In fact, USAF is many steps ahead of the RCAF in that it has certified all aircraft that utilize JP-8 to fly on available alternative-fuel blends (typically a 50/50 blend of conventional and alternative fuels) with the exception of the F-22 and the F-35.[17] However, despite publishing specific goals in 2011 to have all aircraft flying on 50% alternative-fuel blends by 2016, there is no evidence that USAF has achieved this goal.[18] Given the budget and fleet size of USAF, its lofty goals are not surprising; however, it should be duly noted that even USAF isn't looking to be a leader on alternative and biomass fuel production. Rather, it is taking a wait-and-see approach and allowing the industry to develop naturally to a point where it can be capitalized on in a more cost-effective manner.[19] These examples highlight that the RCAF is not alone as an aviation-centric organization concerned with its environmental impact and seeking means of reducing GHG emissions.

Based on social expectations, policy requirements and the example of similar organizations, it is clear that the RCAF does have a responsibility to consider alternative fuels as part of a broader environmental strategy.

Based on social expectations, policy requirements and the example of similar organizations, it is clear that the RCAF does have a responsibility to consider alternative fuels as part of a broader environmental strategy. Given this, the next step is to review arguments in favour of using alternative fuels to reduce the environmental impacts of military aviation and, specifically, to reduce GHG emissions.

First, alternative fuels may be able to address general concerns related to price stability and supply security for aviation fuels.[20] These may be especially important considerations for military aviation, given that "adversaries increasingly target energy as a centre of gravity."[21] Furthermore, as our allies and the civilian aviation industry begin to adopt various alternative fuels, they may eventually become a more common, or even the primary, fuel source available at civilian airports and allied air bases from which the RCAF may wish to operate. In those cases, our ability to utilize drop-in[22] alternative fuels for our aircraft fleets will become critical for security of supply on expeditionary operations and may push the RCAF to be more forward thinking.[23] Fluctuation in the cost of conventional fuels based on the cost of crude oil was also an early driver in the push for both civil and military aviation organizations to consider alternative fuels.[24] So, while the current cost of oil may be a far cry from heights it soared to in the past decade, it is well understood that any significant increase in the cost of oil causes military fuel budgets to skyrocket; hence, it is reasonable to seriously consider any fuel source that is more cost-stable. While the price of alternative fuels is not currently competitive with conventional fuels, the price of conventional fuels is expected to continue to rise over the next 20 years, and there is reason to be hopeful that alternative fuels will become less expensive in the coming years as well.[25]

Investment in alternative fuels from early adopters may help push the technology to be more price competitive. One example of this type of investment is the USN Great Green Fleet— a carrier strike group deployed to Exercise RIMPAC in 2016.[26] It is arguably the largest military example

of alternative-fuel use, its ships and embarked aircraft having utilized primarily alternative fuels for the duration of the deployment. The concept for the Great Green Fleet was developed based on sky-high oil costs experienced in 2008 (up to $147/barrel, compared to the more recent $60–80/barrel range).[27] In relation to this impressive feat, Lieutenant Alaina Chambers of the USN argues that one of the key benefits of this type of forward-leaning action by the military is that even relatively small investments in alternative fuels—when compared to the global use of conventional fuels—may have significant potential to drive technology development in a growing industry where some of the challenges of mass production are currently insurmountable and cost-prohibitive.[28] While alternative fuels may not be able to provide price stability at this juncture, future industry growth should help achieve that goal.

An additional benefit of alternative fuels over conventional fuels is surety of supply, given that alternative fuels can be derived from a wide variety of renewable resources (customarily referred to in the alternative-fuel community as feedstocks) and produced in a wide variety of ways. For example, currently there are two ASTM (an international standards organization[29]) certified pathways for drop-in alternative jet fuel production (Fischer-Tropsch and hydro-processed esters and fatty acids [HEFA][30]), and ASTM is reviewing five additional production pathways for qualification.[31] Eventually, this will provide industry with options to produce alternative fuels from "a very broad range of feedstocks and waste streams, using a broad range of technologies."[32] Variety in feedstock and technology selection is likely to lead to improved surety of supply over non-renewable, petroleum-derived fuels. An additional benefit to the military of having multiple potential sources of drop-in fuel is that alternative-fuel-production facilities "need not be located in the same places where conventional refineries are located."[33] In an ever-changing operational environment, where agility matters, the ability to diversify production and supply chains can provide a distinct strategic and operational advantage.

The benefits of alternative fuels addressed above do not relate directly to environmental considerations, aside from addressing an inevitable future requirement to find a renewable fuel source to replace dwindling fossil fuels. If the goal of using alternative fuels is strictly to reduce the environmental impacts of military aviation, reduced GHG emissions are typically highlighted as the key benefit of alternative fuels. Most scientific studies of alternative fuels look at them from a life-cycle perspective, meaning they evaluate the total GHGs emitted during the fuel life cycle minus the carbon sequestered or offset during the life cycle.[34] Many take the theoretical stance that alternative fuels produced from biomass are greener by virtue of the fact that they produce fewer carbon dioxide (CO2) emissions across their entire life cycle.[35] However, much of the improvement in CO2 emissions depends on the specific production method and feedstocks used.[36] For example, Feng et al. conducted studies to determine if a coal biomass to liquid (CBTL) alternative fuel is sufficiently "greener" than conventional JP-8 currently used in USAF jet fleets, meaning fewer GHGs are emitted throughout the fuel life cycle. They determined that as long as a minimum of 10% biomass is used in the CBTL process, then the CBTL alternative fuel is a worthwhile green investment for USAF, when the entire life cycle of the fuel is considered.[37] Similarly, Bartis and Van Bibber point out that "any significant differences in life cycle emissions are associated with differences in how the alternative fuels are produced."[38] For example, they conclude that life-cycle GHG emissions for alternative fuels would be near zero for 100% biomass feedstocks (where there are no land-use implications that would alter the carbon capture from other sources); however, if coal alone is the feedstock, emissions are only 10–15% less than conventional fuels and a coal/biomass feedstock combination yields GHG emissions better than coal alone but not as good as biomass alone.[39] The calculations and considerations necessary to make these determinations are complex and demonstrate that, while there is definitely potential for reduced GHGs with the use of alternative fuels, care needs to be taken to carefully select feedstocks and feedstock proportions to actually realize a benefit.

Another interesting and potentially positive consequence from the adoption of alternative fuels is the potential for decreased production of contrails. First, it is generally accepted that one of the specific benefits of alternative fuels produced through both the HEFA and Fischer-Tropsch methods (from biomass) is a reduction in emissions of soot and sulfur oxides, and potentially nitrogen oxides, even where CO2 emissions are not significantly reduced.[40] Second, it is generally accepted that contrails "influence Earth's climate" by helping to trap heat in the atmosphere, which leads to elevation of the surface temperatures.[41] Fahey and Lee, taking a scientific perspective on aviation and climate change, use these two facts to demonstrate that the decreases in soot production of alternative fuels can be expected to equate to fewer contrails, which may ultimately equate to a reduced environmental impact from alternative fuels. In this way, a switch to alternative fuels could help reduce GHGs even if the reductions in combustion emissions themselves are not significant.

Decreases in soot production of alternative fuels can be expected to equate to fewer contrails, which may ultimately equate to a reduced environmental impact from alternative fuels.

The information presented above demonstrates the numerous arguments pointing to the use of alternative fuels as a legitimate way ahead for both civil and military aviation; however, along with these positive impacts, there is also evidence of multiple unintended negative environmental impacts related to their use that need to be considered. For example, some researchers have identified the potential for expanded environmental impacts on soil contamination and groundwater contamination when using alternative fuel as compared to their conventional counterparts. Specifically, Goltz et al. note that "adding ethanol to petroleum appears to slow the biodegradation rates of hazardous BTEX compounds; furthermore, contaminants exist for long periods and travel greater distances than predicted by prior modeling."[42] This particular finding is potentially concerning in the case of leaks and/or spills from underground pipelines, and more research is required to determine the extent of the risks involved.

Biofouling is another identified concern with alternative fuels that stems from the fact that, although alternative and conventional fuels have very similar combustion characteristics, they do not have the same chemical compositions.[43] Because of this, researchers at the US's Air Force Institute of Technology have documented cases of biofouling, which occurs when there is microbial growth wherever fuel is, including in aircraft structures themselves. Biofouling can pose an increased risk of corrosion of aircraft parts as well as a potential health risk to maintainers who come into contact with these microbes.[44] This is significant, given documentation that a crash of a USAF B-52 in 1958 was caused by clogging of screens due to microbial contamination.[45] Biofouling also occurs with conventional fuels; however, it has been sufficiently mitigated over the years through the use of fuel additives. As increased proportions of alternative fuels are introduced into fuel blends, there is potential for a related increase in operational risk without proper mitigation.[46] And while a crash related to microbe growth is likely a worst-case scenario, it certainly represents a risk that should not be taken lightly.

Research also demonstrates that the production methods for various alternative fuels are not equal and the environmental impacts of any given fuel-production method may vary based on location of production. Csonka et al. demonstrate this through a discussion of freshwater use in

production of alternative fuels. In one location, requirements for fresh water in fuel production may not be problematic; however, if the same production process is utilized in an area where fresh water is in short supply, the environmental and resulting socio-economic impact on the region may be far more detrimental.[47] There is additional evidence that cultivation of certain biofuel feedstocks risks undermining food security around the globe. If feedstock crops overtake food crops it could be cause for serious concern for "the more than 800 million food-insecure people … who live on less than $1 per day and spend the majority of their incomes on food."[48] Expansion of feedstock crop areas may also require "conversion of marginal land, rainforest and wetlands to arable land."[49] The negative impacts of this type of land-use conversion could completely offset the environmental benefits of the alternative fuels produced, specifically when it comes to the net carbon benefits of biomass feedstocks. Ultimately, the overall effect of a massive aviation-industry switch to alternative fuels could have serious unintended environmental consequences stemming from the additional pressures placed on various ecosystems. Captain "Ike" Kiefer of the USN describes the use of alternative fuels as a catch-22, whereby yields from uncultivated biofuels would meet only a fraction of the energy needs of the US, but increasing yields through cultivation would use more energy than it would create.[50] More specifically, he argues that the "pursuit of biofuels creates irreversible harm to the environment, increases greenhouse gas emissions, undermines food security, and promotes abuse of human rights."[51] While some of the specific data points and analyses done by Kiefer have been questioned by scientific experts in the field, he does raise some legitimate concerns about alternative fuels that deserve at least a modicum of attention from policy makers.[52] Undoubtedly, alternative fuels carry their own environmental and operational risks and may not be, at the moment, as "green" as some environmentalists might have us believe.

Task Force-Mali members transport fuel barrels while setting up a Forward Area Refueling Point during Operation PRESENCE -Mali, on February 16, 2019.

The current policies governing the RCAF aircraft fleet are clear: there is no mandated requirement for the RCAF to consider aircraft emissions as the GC and DND move to reduce GHG emissions before 2030, nor are there policies mandating the use of alternative fuels. Additionally, the scientific literature on alternative fuels is extensive but also highly technical in nature. It is easy to understand how the general public, and even air power professionals, could be uncertain about the role that alternative fuels should or should not play in CAF and RCAF environmental policies. Furthermore, it is clear that the technology necessary for mass production of alternative fuel is still rapidly developing. As the DCC report for 1 Canadian Air Division headquarters noted, there are numerous projects ongoing in the industry that all have the potential to produce breakthroughs that could ultimately make large-scale, affordable and sustainable production as well as use of alternative fuels feasible for both civilian and military aviation.[53] It is also important to note that much of the research for this paper was taken from USAF-centric sources, and while it remains valuable, the fundamental differences in size between USAF and the RCAF will undoubtedly affect how the RCAF transitions to future energy sources for its aircraft fleets.

Ultimately, there is no evidence to indicate that early adoption of alternative fuels by the RCAF will lead to a significant reduction in GHG emissions. There are, however, numerous other possible options for the RCAF to consider, which will likely lead to reduced fuel consumption and, hence, reduced GHG emissions. Any future consideration of the use of alternative fuels over the longer term and on a larger scale within the RCAF must be holistically considered to ensure that such use does not jeopardize the GC's strategic vision of Canada as a world leader from an environmental social standpoint. Still, it is likely prudent for the RCAF to move towards certifying certain aircraft fleets for alternative fuels, even if there is no immediate plan to switch to those fuels on a larger scale. Doing so will ensure that we are operationally prepared to accept drop-in alternative fuels as they begin to proliferate across the aviation industry.

SSE states that "military operations and environmental protection and stewardship are not mutually exclusive."[54] The RCAF must seriously consider how it can reduce GHG emissions from aircraft fleets; however, considering GHG emissions alone as a reason for early adoption of alternative fuels is extremely short-sighted. Careful monitoring of technological developments in the alternative fuels industry, while remaining cognizant of the complicated trade-offs of some biofuel feedstocks and working to implement other short-term fuel reduction strategies is the most prudent and necessary approach. In this manner, the RCAF will be able to meet the expectations of CAF, the GC and the Canadian public in a responsible and cost-effective way.

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ABBREVIATIONS

ASTM	American Society for Testing and Materials
CAF	Canadian Armed Forces
CBTL	coal biomass to liquid
CO2	carbon dioxide
DCC	Defence Construction Canada
DEES	Defence Energy and Environment Strategy
DND	Department of National Defence
DoD	Department of Defense
FSDS	Federal Sustainable Development Strategy
GC	Government of Canada
GHG	greenhouse gas
HEFA	hydro-processed esters and fatty acids
ICAO	International Civil Aviation Organization
RCAF	Royal Canadian Air Force
USAF	United States Air Force
USN	United States Navy

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CANADA'S ARCTIC SOVEREIGNTY AND THE NORTHWEST PASSAGE:

SOVEREIGNTY FOREMOST OR ENHANCED GLOBAL STRATEGY?

BY CAPTAIN JACLYN DEUTSCH

Editor's note: This paper was written by a candidate attending the Air and Space Power Operations Course in fulfilment of one of the requirements of the course of study.

Global warming and the resulting melting of Arctic ice has begun to open up the Arctic waterways to more transiting vessels; consequently, many Arctic nations are submitting legal claims to portions of Arctic territory in order to prepare themselves in a legal, maritime-law context and in a national-security context. Canada is one such nation. The Arctic is an area of great concern:

> Canadians have an emotional attachment to the North. The majority of Canadians live in an urban setting within one hundred kilometers of the [United States] US border. Canadians, however, look to their wilderness as a source of pride and reserve a sentimental place for the North in their hearts. Rugged and austere conditions define Canadians.[1]

In 2013, the Government of Canada filed a submission to the United Nations (UN) in regards to the continental shelf in the Atlantic Ocean. This submission also included preliminary findings regarding the continental shelf in the Arctic, an area that Canada continues to research in preparation for an additional claim submission to the UN. Canada is justified in its current Arctic sovereignty claim to include the Northwest Passage according to the United Nations Convention on the Law of the Sea (UNCLOS). However, the Northwest Passage does remain a contested waterway, particularly in the eyes of the US.

In this regard, questions remain: Is the Law of the Sea codified or is it just a series of assumptions passed down over time? Should the Northwest Passage be designated internal waters as Canada claims or an international strait as the US claims? Finally, how does Canada's sovereignty over the Northwest Passage (or lack thereof) impact Canada and North America as a whole, from a continental-security perspective?

A series of governmental policies, international maritime laws, and multinational agreements define the geopolitical situation in the Arctic. In addition to UNCLOS, the bulk of Arctic legal considerations were developed by two specific organizations: the Arctic Council and the International Maritime Organization (IMO). UNCLOS came about in 1982. It is important to note that the US, while in attendance at the convention, and having since adopted the treaty as customary maritime law and for the most part followed its practices, did not sign or ratify it. UNCLOS set the framework for national sovereignty, the right of usage and passage in maritime zones as well as the protection of natural resources.

The Arctic Council consists of a group of nations who all have a vested interest in the Arctic. The member nations include Canada, the US, Denmark, Finland, Sweden, Norway, Iceland, and the Russian Federation. The predominant focus points of the Arctic Council are "environment and indigenous protection, chemical and pollution regulation, search and rescue, and the need for cooperation."[2]

IMO, established in 1948 in concurrence with the UN, is an international organization that regulates maritime law. The mission of IMO is to ensure that maritime shipping—through international cooperation—follows safe, secure, and environmentally sound practices.[3] The combination of laws and policies as outlined by UNCLOS, the Arctic Council, and the IMO all contribute to the legal basis for Canada's sovereignty claims in the Arctic, with one of the most specific legal arguments based on geography.

The geography of the Arctic can be quite complex, with designations such as territorial seas, continental shelves, and exclusive economic zones all contributing to any one country's claim to a part of the territory. Canada's claims in the Arctic centre on its Arctic Archipelago. According to UNCLOS, the definition of an archipelago is: "a group of islands, including parts of islands, interconnecting waters and other natural features which are so closely interrelated that such islands, waters and other natural features form an intrinsic geographical, economic and political entity, or which historically have been regarded as such."[4] There is no dispute as to the validity of Canada's sovereignty over the Arctic Archipelago in regards to its land claims.[5] The contentious discussion centres on the waterways contained within the archipelago. Typically, maritime zones will be defined by looking at a country's coast at low tide; however, when a coastline is made up of numerous inlets and bays, it is permissible to use a straight baseline method as defined in Article 47 of UNCLOS.[6] Canada has claimed that this straight baseline around its Arctic Archipelago then designates the waters contained therein as internal waters. Internal waters can be described as "any waters that lie inland of the territorial sea (bays, inlets, harbours, etc.) and are subject to the full sovereignty of the coastal state with no associated right of innocent passage through them."[7] This claim, and how it applies to the Northwest Passage, is the most significant portion of Canada's Arctic sovereignty claim to be challenged by other nations.

THE MELTING ARCTIC ICE IN THE NORTH IS STEADILY MAKING WAY FOR THE NORTHWEST PASSAGE TO BECOME A MAJOR ROUTE FOR THE INTERNATIONAL SHIPPING COMMUNITY.

The predominant nation that has a significant interest in the designation of the Northwest Passage is the US, which has consistently argued that the Northwest Passage is an international strait and that a right of innocent passage for international shipping exists. In order for the waters of a territorial sea to be classified as an international strait, two components need to exist: a geographical component and a functional component. The geographical component is defined as "an area of water that joins two areas of high seas. A well-known example is the Malacca Strait joining the Indian Ocean with the South China Sea. The functional component is that the strait must be used for international navigation."[8] This designation of the Northwest Passage as either Canadian internal waters or as an international straight is central to determining the validity of Canada's current claims for Arctic sovereignty.

Two historical events help define both the Canadian and the US positions on the designation of the Northwest Passage: the Corfu Channel case of 1947, and the voyage of the *Polar Sea* in 1985. The International Court of Justice (ICJ) was established in 1945, and the Corfu Channel case was the first public international law hearing that the ICJ oversaw. The case was a dispute between the United Kingdom of Great Britain and the People's Republic of Albania. Albania asserted that the Corfu Channel was part of their territorial waters and Great Britain argued that it was as an international strait. Even though there were relatively small amounts of international maritime traffic through the Corfu Channel, the ICJ ruled that those small amounts of traffic were sufficient grounds for the Corfu Channel to be designated an international strait.[9] Another historical event of

significance was the voyage of the *Polar Sea* in August 1985. The *Polar Sea* was a U.S. Coast Guard icebreaker that sailed from Greenland to Alaskan waters using the Parry Channel and the Prince of Wales Strait. In doing so, the *Polar Sea* traversed the Northwest Passage. The significance of this event is that the US did not ask permission of Canada before entering the Northwest Passage.

In January 1988, the US and Canada finalized an agreement on Arctic cooperation, wherein two key clauses were established:

> The Government of the United States pledges that all navigation by the U.S. icebreakers within waters claimed by Canada to be internal will be undertaken with the consent of the Government of Canada. Nothing in this agreement of cooperative endeavour between Arctic neighbours and friends nor any practice thereunder affects the respective positions of the Governments of the United States and Canada on the Law of the Sea in this or other maritime areas or their respective positions regarding third parties.[10]

The Corfu Channel case and the voyage of the *Polar Sea* are frequently referenced as compelling evidence supporting both the Canadian and the US positions on the Northwest Passage.

The Arctic Ocean is difficult to traverse, with icebreakers being a requirement to cross it. However, it does have incredible economic potential as a major shipping lane, as it will shorten the distance from Europe to Asia by roughly 4000 miles (6500 kilometres) by allowing vessels to avoid the longer Panama Canal route.[11] The melting Arctic ice in the North is steadily making way for the Northwest Passage to become a major route for the international shipping community. In anticipation of this increased maritime traffic flow, it is in the best interests of both Canada and the US to officially determine the designation of the Northwest Passage as either internal waters or an international strait.

The Government of Canada consistently makes two arguments to support its position that the Northwest Passage is an internal waterway: by virtue of historic title, and the straight baseline method as outlined in UNCLOS. The historic title claim allows a nation to "supersede purely geographical considerations in claiming sovereignty."[12] The conditions for historic title to exist are: exclusive exercise of state jurisdiction, a long lapse of time, and acquiescence by foreign states. The consensus is that Canada's argument that the Northwest Passage be designated internal waters by virtue of historic title is weak at best since the ICJ refused to ascribe any weight decisively to the historic rights claimed by the parties in the Gulf of Maine case in 1985.[13]

A stronger case can be made for the straight baseline method as previously referenced. The straight baseline method is thought by some to be strong enough to satisfy international law, allowing Canada to declare the Northwest Passage as internal waters and thereby to regulate activities and to enforce laws there.[14] However, UNCLOS declares that "a State cannot close an international straight by declaring straight baselines."[15] Since Canada was a party to UNCLOS in 1982 and established the straight baselines around the Arctic Archipelago in 1986, it has been argued that the "international legal right to claim jurisdiction over international shipping in these waters is unlikely to withstand an international challenge."[16]

The American concern for continental security could make the Canadian claim "more palatable politically and legally"[17] if the US believed that North America's northern perimeter would be strengthened by Canada's control of the Northwest Passage.[18] However, the US has long promoted the navigational freedom of the seas around the world, in direct conflict with Canada's desire to maintain sovereignty over the Passage. The US believes it to be an international strait, and, while UNCLOS could not solidify a definition for what constitutes an international strait, the Corfu Channel case is frequently referenced in this regard.[19] In order for a body of water to be considered an international strait, it needs to meet geographical and functional criteria. The geographical criterion is met if the Northwest Passage joins one area of the high seas to another. Since the Northwest Passage links the Davis Strait to the Beaufort Strait, the geographical condition is met;[20] therefore, "a sea route through the Northwest Passage might be regarded in law as an international strait through which there would also be a right of passage that would be more onerous for the coastal state than the right of innocent passage in the territorial sea."[21]

IF THE NORTHWEST PASSAGE IS OFFICIALLY DECLARED AN INTERNATIONAL STRAIT, CANADIAN AND AMERICAN CONTINENTAL DEFENCE POLICIES WOULD NEED TO BE ADAPTED TO THIS NEW DESIGNATION.

While it is universally accepted that the Northwest Passage meets the criteria for an international strait from a geographical perspective, it is the functional criterion that is more challenging. The functional criterion requires that "a strait must have been a useful route for international maritime traffic, as evidenced mainly by the number of ships using the strait and the number of flags represented,"[22]and that criterion fails when applied to the Northwest Passage. Donat Pharand had further argued that "by no stretch of the imagination could the Northwest Passage be classified as an international strait and that those who maintain that the Passage may be so classified obviously confuse **actual use** with **potential use**."[23] [emphasis in original] While it's true that the Northwest Passage presently only sees a limited amount of maritime traffic—and then only with the support of an icebreaker—the US and Europe both continue to argue that the Passage is an international waterway, and "the Americans have always maintained that the International Court of Justice's ruling in the Strait of Corfu case is applicable for the Northwest Passage."[24] This argument gains in strength as global warming continues to melt the Arctic ice.

If the Northwest Passage is officially declared an international strait, Canadian and American continental defence policies would need to be adapted to this new designation. It may well be in the best interests of both nations to "find a practical, bilateral, narrowly defined solution that recognizes Canada's sovereignty claims, while at the same time addressing the United States' continental security concerns."[25] In addressing continental security concerns, a provision of UNCLOS describes transit passage as a freedom of navigation and overflight that "may be exercised by all ships, including warships in general and submarines in particular in their **normal mode of navigation**. More specifically, if the Northwest Passage were internationalized, submarines of all States (Russian as well as American) would be completely within their navigational rights under the ice."[26] [emphasis in original] Very little is currently known about submarine transit in the Arctic,

Her Majesty's Canadian Ship MONCTON sits at anchor in Pond Inlet, Nunavut, during Operation QIMMIQ on August 21, 2015.

although "if they have been frequent and without Canadian knowledge or consent, then it might be possible to show that the Northwest Passage has been 'used for international navigation' and that in practice submarines have been exercising a right of transit passage."[27]

This appears to lend credence to the US position that the Northwest Passage is an international strait, with the caveat that the term used for "international navigation" in theory means "capable of being used for international navigation."[28] As it stands, the US has had nuclear submarines patrolling the Arctic for purposes of security and reconnaissance since the 1960s. These submarines can stay submerged without resurfacing for up to 90 days,[29] in contrast to Canada's four submarines that "are not capable of submersion under the Arctic ice, rendering MDA [maritime domain awareness] and security awareness of the Canadian territory inefficient and a weak point in securing Canadian Arctic presence."[30]

In addition to American and Russian submarine traffic in the Arctic, a Chinese research vessel visited Tuktoyaktuk in 1999. While the Canadian embassy in Beijing was aware that the Chinese vessel would be arriving, local officials in Tuktoyaktuk were unaware and quite surprised when the vessel did arrive in port. The voyage of this Chinese research vessel, undetected by local authorities, demonstrates Canada's limited ability to carry out maritime surveillance in the Arctic.[31] This Chinese research vessel, *Xuelong*, has since made three more Arctic expeditions into Canadian waters, in 2003, 2008, and 2010.[32] It has also been argued that "the security threats to the North are now expected to come in the form of more commercial traffic rather than from an invasion by an opposing military."[33] So, one can assess that the Northwest Passage is already being used somewhat liberally by submarines and other vessels and that the number of vessels is only likely to increase with the effects of global warming and that Canada's continental-defence strategy in the Arctic needs to be adjusted to reflect this increase in maritime traffic.

Photo taken from Her Majesty's Canadian Ship SUMMERSIDE as it sails off the coast of Eclipse Sound, Nunavut, past an iceberg during Operation NANOOK 13 on August 19, 2013.

In conclusion, Canada's sovereignty claims regarding the Arctic Archipelago are justified from a land-claim standpoint, without question. The Northwest Passage, however, is more complex. It appears to be universally understood that the melting of the Arctic ice will open up the Northwest Passage to more maritime vessels and that the transiting of the passage by those vessels is inevitable. With that in mind, Canada's sovereignty claim to the Northwest Passage is not necessarily incorrect, but ill advised. From a continental security perspective, the Northwest Passage should be designated an international strait to induce an American military response and/or presence.

Also, it is unlikely that the US will relinquish its stance on the Northwest Passage as an international strait because that designation impacts their global maritime interests and overall position regarding freedom of the seas. Mathieu Nolin argues that "it is in the US's interest to have a broad interpretation of what qualifies as an international strait in order to promote freedom of the seas in similar straits in different parts of the world."[34] Canada's continued assertion that the Northwest Passage is internal waters could have such a domino effect and set a negative precedent.

Accepting the reality of security and precedent-setting concerns need not displace environmental concerns. While allowing for the full participation of the US in the Arctic, following the model of the Straits of Malacca case could "open the door to widespread international recognition of Canada's status as a strait state and attract support for appropriate measures to protect the Arctic ecosystem, ensure Canadian security and sovereignty, and promote safe navigation through designated routes."[35] Accepting that "continued reliance on strictly legal argument is likely to result in a stalemate in regards to the Passage,"[36] it is imperative that the US and Canada work together to develop a mutually beneficial solution. Ultimately, the consensus it that the maritime traffic through the Northwest Passage is poised to steadily increase with the melting of the Arctic ice, and that Canadian and American surveillance platforms are ill-equipped to maintain adequate awareness of activity in the North. It is therefore recommended that Canada and the US reach a binational agreement for the legal designation of the Northwest Passage, as well as an applicable surveillance and law enforcement presence in the Arctic, which would simultaneously ensure continental security and protect freedom of the seas worldwide.

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ABBREVIATIONS

ICJ	International Court of Justice
IMO	International Maritime Organization
UNCLOS	United Nations Convention on the Law of the Sea

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AIR POWER IN COIN: AN INSTRUMENT OF POLITICS

BY CAPTAIN P. L. LAFONTAINE, BBA, MA

Editor's note: This paper was written by a candidate attending the Air and Space Power Operations Course in fulfilment of one of the requirements of the course of study.

The West has a long history of fighting insurgencies with air power, and the prevalence of this form of conflict shows no sign of diminishing. Recent counterinsurgency (COIN) operations include the fight against the Taliban in Afghanistan and the fight against the Daesh in Iraq. Despite the prevalence of COIN operations, both air doctrines and capabilities are largely tailored for conventional warfare. Perhaps a consequence of this lack of attention is the absence of agreement on the roles and contributions of air power in COIN. The literature stresses the importance of a whole-of-government approach to COIN; however, the effectiveness of "hard" military power in such conflict is not clear, and there are specific debates around the contributions that air power can make in COIN. Some critics of using air power to fight insurgencies went as far as calling its use counterproductive.[1]

This paper defends the view that air power can significantly contribute to COIN and underlines the conditions necessary for successful employment of air power in COIN operations by answering three main questions. First, what are the fundamental characteristics of insurgencies? Understanding the fundamental characteristics of insurgencies is critical to effectively employ air power in COIN and to assess its contribution. Second, can air power make a significant contribution to COIN when employed in a support role? More specifically, what contributions can air power make when used in an airlift and in an intelligence, surveillance and reconnaissance (ISR) role? Third, can air power contribute to COIN operations when used in a kinetic role? To answer these questions, both historical pieces of evidence and theories are presented while giving special considerations to recent technological advances.

To understand the contribution of air power in COIN operations, some key terms must be defined. First, the term "insurgency" has been used interchangeably with many other terms in the literature (at times incorrectly): "small wars," "irregular warfare," and "guerrillas."[2] The difficulty of categorizing and defining "insurgencies" in a common and precise fashion may be due to the constantly evolving nature of conflicts. Insurgencies evolve with time, and from their rise to their fall will move left and right on the spectrum of conflict; however, some core characteristics remain. Moore simply defines "insurgency" as "a protracted violent conflict in which one or more groups seek to overthrow or fundamentally change the political or social order in a state or region through the use of sustained violence, subversion, social disruption, and political action."[3]

Moore then defines COIN has "an integrated set of political, economic, social, and security measures intended to end and prevent the recurrence of armed violence, create and maintain stable political, economic, and social structures, and resolve the underlying causes of an insurgency to establish and sustain the conditions necessary for lasting stability."[4] COIN is by nature reactive, often forming only after the insurgency has gained enough strength to meaningfully challenge the social and political order. COIN can involve a single country or a coalition of multiple nations, as seen recently with the global coalition against the Daesh in Iraq and Syria. Regardless of its size, COIN will primarily aim to end violence, restoring order and establishing and nurturing the fundamental conditions necessary to prevent a reoccurrence.

Insurgencies have characteristics that are particularly important to keep in mind for the effective employment of air power. Various authors have published work detailing and explaining the core characteristics of insurgencies. Of note is the work of Ringmose et al., which details five characteristics of insurgencies: the territory, the tactics, the centre of gravity, the means and time.

The first characteristic is the asymmetric significance of territory between the insurgents and counterinsurgents.[5] This asymmetric significance of territory plays in favour of the insurgents. The insurgents are not particularly responsible for any part of the territory; they are free to abandon their posts and to relocate elsewhere, individually or in small clusters. These small isolated cells of resistance make them and their line of supply difficult to identify and is a challenge for the counterinsurgents. In contrast, the counterinsurgents are responsible for the territory and for the protection of the population. Abandoning any part of the territory is likely to be seen as the government's inability to protect its population, which consequently weakens its legitimacy.

The second characteristic is the tactics of the insurgents,[6] as observed by Drew: "Guerrilla tactics are the classic ploy the weak use against the strong."[7] The counterinsurgents generally possess a larger force, are professionally trained, and are more technologically advanced than the insurgents. This imbalance of power forces the insurgents to use guerilla-warfare tactics. They aim to be fluid, evasive and unpredictable on the battlefield, carrying out sporadic attacks like suicide bombing and roadside improvised explosive devices (IEDs) at the time of their choosing. They are intertwined with the population and may use non-combatants, like children, as human shields, which make them difficult to identify, isolate, and target. The tactics of the insurgents reduce the relative significance of a stronger force and can prove challenging even for a largely superior force.

The third characteristic is the centre of gravity.[8] The centre of gravity for both the insurgents and counterinsurgents is the "hearts and minds"[9] of the population. The insurgents need the support of part of the population, or at least their submission, to alter the political and social order. The larger the proportion of the population that is in support of the insurgency movement, the easier it becomes to control and subvert the rest of the population. The counterinsurgents also fight

to win the hearts and minds of the population by taking actions for the host-nation government to regain its legitimacy. To do so, they not only need to end the violence but also need to remove the conditions that led to the rise of the insurgency by promoting civic engagement and economic development.[10] This has direct implications for the employment of air power in COIN operations and translates into the extreme care in the application of force.

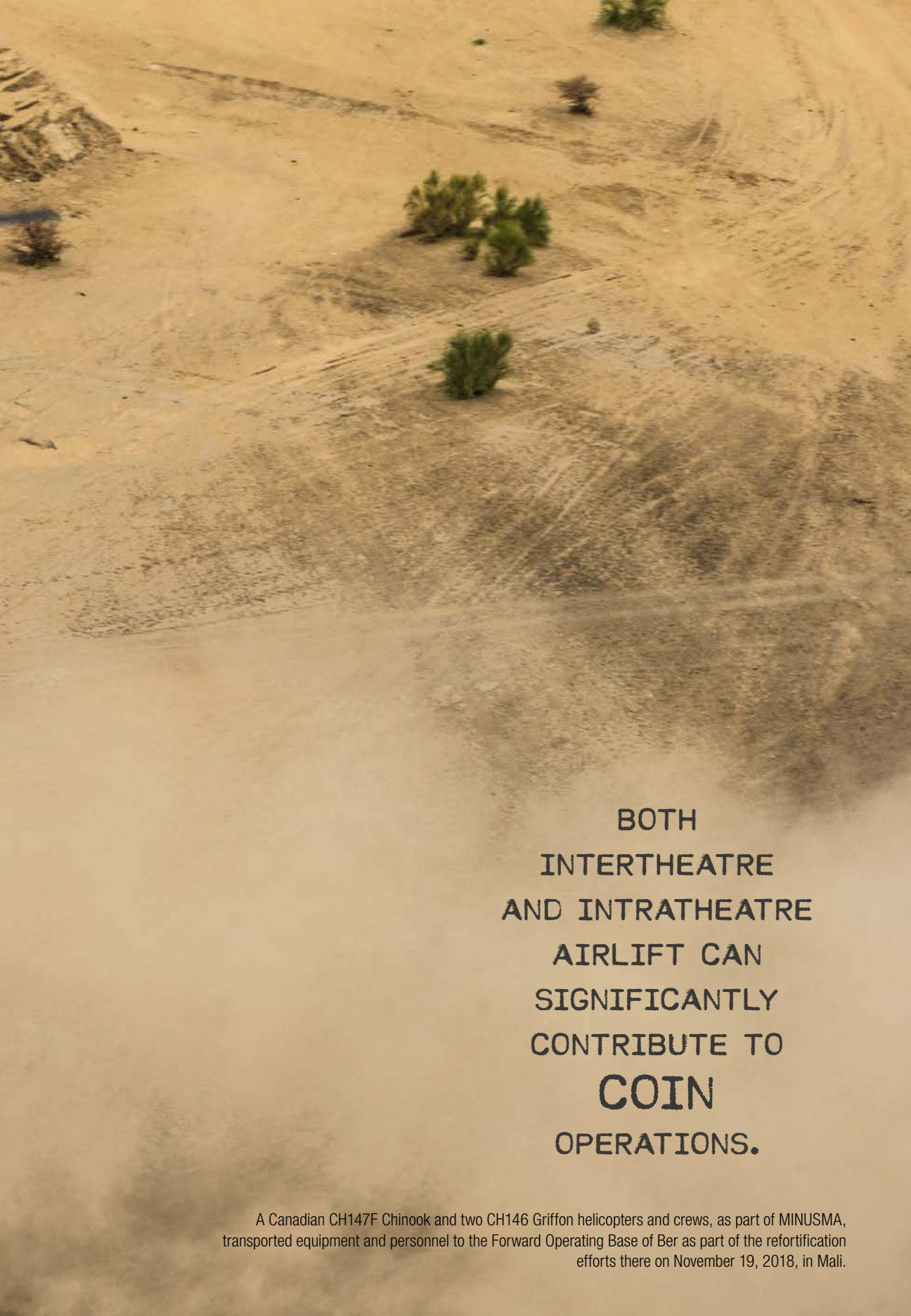
The fourth characteristic is the means.[11] An insurgency is at its core a political struggle which cannot be fought with military power alone. As described by Corum and Johnson, COIN should include military, political, and economic activities to attain a political goal.[12] While conventional warfare also requires the employement of various means to achieve the aim, military power is normally at the forefront. In COIN operations, however, military power arguably plays a smaller role and should be seen as an "instrument of politics."[13]

Lastly is the significance of time in insurgency warfare. Insurgencies are protracted conflicts, and time tends to play in favour of the insurgents.[14] As Drew puts it, "Time, however, becomes a two-edged sword in the hands of an insurgent, and both edges cut into support for the government."[15] Insurgencies do not need a major military victory; a sporadic tactical victory will often suffice to maintain relevance and continue to erode the government's legitimacy.[16] Moreover, a long, drawn-out war tends to erode public support for the counterinsurgents on their home front, their "staying power," as described by Baltrusaitis.[17] Additionally, due to the complex and technical nature of air operations, prolonged conflicts are costly and frustrating for Western military powers.[18] The insurgents aim to deny COIN the opportunity for a decisive victory. In its absence, COIN has no choice but to fight a long and costly war.

Air power has been employed in both kinetic and non-kinetic roles during past COIN air campaigns. Two non-kinetic roles are particularly important in COIN: airlift operations and ISR operations.

Airlift operations can be divided into intertheatre and intratheatre airlifts. Both intertheatre and intratheatre airlift can significantly contribute to COIN operations. Intertheatre airlift provides the ability to rapidly move a large amount of troops and materiel over large distances.[19] While COIN and conventional warfare are quite different at the tactical level, the role of strategic airlift in both types of conflicts is essentially the same.[20] In both cases, strategic airlift plays a vital role in sustaining the war effort; it is a force enabler critical for the initial deployment, long-term sustainment, and re-deployment of COIN campaigns.

Similarly, intratheatre airlift proves valuable for COIN operations. Intratheatre airlift provides the ability to transport people and materiel far into the territory in a timely manner, which could prove difficult using ground transport. The Vietnam War is evidence of the intratheatre airlift contribution to the COIN effort: "At the peak of the airlift effort, in 1968, U.S. [United States] Air Force theatre transports lifted an average of nearly 3000 tons of cargo and almost 10,000 passengers per day within Vietnam alone."[21] In comparison to other means of sustainment, airlift is generally safer and more effective in COIN. Ground means of transportation are generally more susceptible to guerrilla-type tactics like roadside IEDs and suicide bombing. Moreover, because insurgencies are normally spread out in hard-to-reach pockets of resistance, distance and terrain can be challenging for ground means of transportation. The enabling element of the intratheatre airlift capability is the relative air superiority normally enjoyed by the counterinsurgents, at least at higher altitudes. While the small arms, anti-aircraft artillery (AAA) and man-portable air defence systems (MANPADS) threats are still generally present in COIN operations, they are not insurmountable. One downside



BOTH INTERTHEATRE AND INTRATHEATRE AIRLIFT CAN SIGNIFICANTLY CONTRIBUTE TO **COIN** OPERATIONS.

A Canadian CH147F Chinook and two CH146 Griffon helicopters and crews, as part of MINUSMA, transported equipment and personnel to the Forward Operating Base of Ber as part of the refortification efforts there on November 19, 2018, in Mali.

of being overly reliant on airlift in day-to-day operations is that it can become cost prohibitive over a protracted conflict; however, what is lost in "treasure" is arguably saved in "blood." It is difficult to argue against the added value of airlift in COIN operations and again, as pointed out by Owen and Mueller, the role of airlift in COIN operations is not fundamentally different from its role in conventional warfare.[22]

Air power also contributes to the COIN efforts with airborne ISR capabilities. COINs are intelligence-intensive operations, largely because of the difficulty of identifying the combatant from the non-combatant, combined with the criticality of avoiding civilian casualties. Airborne ISR assets can meaningfully contribute to meet this intelligence requirement. Airborne ISR assets generally have freedom of movement over the insurgents' territory; they can observe large areas from a unique point of view, and if sufficient air assets are available, can maintain constant surveillance of the enemy.

However, airborne ISR has limitations that are magnified by guerrilla tactics. First, it is particularly vulnerable to concealment, camouflage, and deception. One recent example of this was the use of vast underground tunnel systems built by the Daesh in Iraq.[23] Still, while such tactics are effective against airborne ISR assets, the insurgents cannot stay underground forever. Moreover, the use of air power arguably forced the Daesh to divert their effort from primary war-waging activities to tunnel building. Second, the view from the air does not give the complete picture. As pointed out by Corum and Johnson, airborne ISR can determine ground movement of personnel, but may not be able to determine why they are moving.[24] While it is true that air observation cannot meet the intelligence requirement on its own, it provides a unique perspective. Each form of intelligence collection has its own set of strengths and weaknesses; hence, the importance of not relying on only one source of intelligence, and the requirement for fused intelligence.

Air power is highly dependent on technology, and technological advances continue to increase the effectiveness of airborne ISR operations. Recent technological advances such as the rise of unmanned aerial vehicles (UAVs) has increased the effectiveness of airborne ISR. Large UAVs, such as the MQ-1 Predator, can remain on-station for an extended period of time with an endurance in excess of 24 hours. Dunlap describes this technological leap as a "persistence revolution."[25] Moreover, UAVs are generally more covert than the larger manned platforms and can be fitted with various sensors. Another example of how technology can contribute to ISR in COIN is the advance in imagery, notably the ARGUS-IS system developed by Defense Advanced Research Projects Agency (DARPA) and BAE-systems. [26] The ARGUS-IS can provide high definition imagery of a 4-mile (6.4-km) diameter area, in high definition, with a single unit. However, better technology often comes with increased cost and system complexity and is not always the answer, as argued by Corum and Johnson: "There is an important role for the low-tech aspect of airpower in small wars."[27] The context and specific situation dictate the appropriate level of technology. There is a general agreement in the literature that the non-kinetic use of air power can make a significant contribution to COIN operations; however, the same cannot be said for the kinetic use of air power.

The kinetic contribution of air power to COIN has been hotly debated for some time, both at the practical and theoretical levels. Drawing on evidence from recent conflicts and theory, the kinetic use of air power can indeed make a meaningful contribution to COIN operations.

Reflecting on the necessity for the counterinsurgents to win the hearts and minds of the population, it is easy to comprehend how the misuse of kinetic air power can be counterproductive. In a recent study using empirical data of air strikes during the Vietnam War, Dell and Querubin estimate that the "bombing of civilian centres increased the military and political activities of

the communist insurgency, weakened local governance, and reduced non-communist civic engagement."[28] It is worthwhile to point out that precision guided munitions were not available during the Vietnam War and that imprecise and even indiscriminate bombings arguably contributed to excessive civilian casualties. Moreover, during the Vietnam War, the U.S Army employed a search and destroy approach which was not conducive to winning the hearts and minds of the population. The U.S Army's approach at the time was more along the lines of "get the people by the balls and their hearts and minds will follow."[29]

Since the Vietnam War, COIN doctrine has evolved considerably, which arguably contributes to a more effective kinetic employment of air power in COIN. In 2007, the U.S Army and Marine Corps released their field manual on COIN in which Appendix E is dedicated to the use of air power. The manual stresses the importance of minimizing civilian casualties, but also stresses that it is important to "weigh collateral damages against the consequences of taking no actions."[30] Moreover, as accurately pointed out by Baltrusaitis,[31] collateral damage is not unique to air power, and as argued by Dunlap, the use of ground forces to replace the kinetic role of air power would result in increased collateral damages.[32] Moreover, air power carries a relatively lower risk to one's casualties compared to ground forces, making it a politically sensible solution.[33]

Supportive of the doctrine which stresses the need to avoid collateral damages are the advances in technology and the use of "smart bombs" in COIN operations. This ability to discriminately target the insurgents supports the idea that kinetic air power can meaningfully contribute to COIN operations.[34] However, the ability to take out targets with pinpoint accuracy is only one part of the equation; the targets still need to be accuratly identified and isolated from the population COIN is trying to help. As Clodfelter puts it, "Lethal airpower against insurgents works well **only** when they can be isolated from the sea of population in which they prefer to swim."[35] [emphasis in original] Consequently, high weapon accuracy is only beneficial to COIN if combined with accurate, complete and timely intelligence so that the enemy can be eliminated without harming either the friendly forces or the population.

Despite technological and doctrinal advances, a recent empirical study on the impact of air strikes in Afghanistan concludes that "air strikes markedly increase insurgent attacks relative to non-bombed locations for at least 90 days after a strike," and that "civilian casualties play little role in explaining post-strike insurgent responses."[36] Supportive of Lyall's conclusions are the views of Walsh, based on results from a study on the use of drones in Pakistan.[37] In both cases, there is an increase in insurgent attacks post-air strike, leading to more instability. Both authors argue that this is likely caused by pressures on the insurgents to demonstrate to the population their ability to fight back, their resolve, and consequently, their relevance and legitimacy. However, it is important to underline some of the limitations with the empirical and quantitative approaches used by Walsh and Lyall. First, it is often difficult to access quality data during wartime. Second, while the studies from Walsh and Lyall do link the air strikes with increased insurgent activities for up to 90 days, they do not attempt to explain the longer-term impacts of these air strikes on the strategic goal of the COIN campaign. Third, Walsh and Lyall demonstrated the correlation between the air strikes and post-insurgent attacks, but not causation. Lastly, it is difficult to understand the second- and third-order effects of these air strikes on the insurgents without comparing the consequences of doing nothing. While Walsh and Lyall's studies on air power in COIN can provide insights, the above-mentioned limitations should be considered.

Air power is inherently dependent on technology. Intuitively, better technology should translate into better results in COIN operations, but is it the case? The evidence in the literature on the

LETHAL AIRPOWER AGAINST INSURGENTS WORKS WELL ONLY WHEN THEY CAN BE ISOLATED FROM THE SEA OF POPULATION IN WHICH THEY PREFER TO SWIM.

Corporal Venessa Larter conducts a presence patrol in the Village of Spin Kalacheh, Afghanistan.

effectiveness of drones is mixed. The use of drones has been portrayed by some as being the silver bullet in fighting insurgencies. One key strength of drones is that they combine persistent ISR capability with precision-strike capability in one platform. The packing of these capabilities into one platform makes it a valuable asset that can contribute throughout the targeting cycle. However, some critics of drones assume that they cause an excessive amount of civilian casualties, while others argue that drone strikes are simply counterproductive.[38] Plaw and Flicker conclude the opposite in a study of civilian casualties from drone strikes in Pakistan. Their results show that drone strikes, when compared with other types of force, have a lower or comparable ratio of civilian casualties per combatant.[39]

In a survey in Pakistan, only 16.2% believed that drones kill militants only, while 47.8% believed they largely kill civilians, and 33.1% believed they kill both militants and civilians.[40] And as argued by Kilcullen, "popular perceptions and rumor are more influential than the facts and more powerful than a hundred tanks."[41] It is crucial to keep in mind that COIN operations "are inherently political"[42] in the assessment of the kinetic air power effects. In this context, the real measure of effectiveness should not be seen as the number of militants killed, or a ratio of militants killed per civilian casualty, but the effect of these air strikes on the larger strategic goals of the campaign. Perception on the ground is key, and as described by Sluka,[43] drone strikes can create a "siege mentality" and a sense of injustice, which in turn fuel the insurgency. In a fight to win the hearts and minds of the population, a drone-centric approach to COIN is perhaps not optimal, but is arguably effective if part of a larger strategy.

Air power should be employed jointly with other military disciplines such as information operations, which can greatly influence the perception on the ground in favour of the counterinsurgents. Moreover, having native "boots-on-the-ground" can be seen in a positive light by the local population, as their presence can help with security, stability, and to maintain the host-nation government's legitimacy. The joint approach to COIN has been stressed by many, including Meilinger, who articulate that air power combined with special forces, native ground forces, and overwhelming ISR can generate outstanding results.[44] The joint military aspect is crucial, but COIN should not be seen as a military-only effort. The military is one aspect of an effective COIN strategy, which should include political, social and economic elements in support of the larger political goal.[45] While the importance of having a multifaceted strategy in COIN is clear, one must remember that the military aspect is essential in re-establishing the security and relative peace required to implement the subsequent social, economic and political measures.

Despite the prevalence of COIN operations in recent history, both air doctrine and capabilities are still largely focused on conventional warfare. Moreover, the roles that air power should play in COIN and its potential contributions to the COIN campaigns are still debated. However, air power can meaningfully contribute to COIN operations in both support and kinetic roles. Insurgencies have unique characteristics that shape the employment of airpower in COIN. The non-exhaustive list includes the significance of territory, tactics, centre of gravity, means and time. While they are all important characteristics to keep in mind during COIN campaigns, the centre of gravity is of critical importance. The centre of gravity is the hearts and minds of the population for both the insurgents and counterinsurgents. Consequently, air power must be employed in a way that is conducive to winning the support of the population and re-establishing the legitimacy of the host-nation government.

Air power can make a significant contribution to COIN when used in a support role. Intertheatre and intratheatre airlift operations can be very effective in sustaining COIN campaigns. Airlift offers flexibility, reach, and speed, in additional to being largely immune to guerrilla tactics.

However, airlift operations are not fundamentally different in COIN than they are in conventional warfare. Similarly, airborne ISR can meaningfully contribute to COIN; however, airborne ISR does have its limitations, which can be amplified in a theatre where an enemy employs guerrilla tactics. This stresses the need for multiple sources of intelligence to produce a fused intelligence picture.

The kinetic employment of air power is the most debated aspect of air operations in COIN. Air power is a highly discriminative form of lethal power when compared with ground alternatives, in addition to carrying a low risk to blue forces, both of which make air power a politically sensitive option for decision makers. Despite the kinetic effectiveness of air power, the impact of air power in COIN should be measured not in terms of "kills," but in its contributions in winning hearts and minds. The kinetic employment of air power can play a major role in COIN, but it must be used with extreme care and if used incorrectly, can be damaging to the strategic goal of the campaign. Moreover, it is important to note that air power should not do it alone; it should be part of a joint military campaign, which in turn should be part of a larger strategy that includes social, political and economic efforts.

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ABBREVIATIONS

COIN	counterinsurgency
IED	improvised explosive device
ISR	intelligence, surveillance and reconnaissance
MINUSMA	United Nations Multidimensional Integrated Stabilization Mission in Mali
UAV	unmanned aerial vehicle

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ASPOC 1703 FROM THE OTHER SIDE

BY CAPTAIN R. J. MILLEN, CD

The most valuable element of instruction is relatability. Why do I need to know this? As a student of the Air and Space Power Operations Course (ASPOC), I had already had the benefit of serving as deployed J-Staff during Operation MOBILE, which was a sometimes-rough pioneering of the Royal Canadian Air Force (RCAF) doctrine we know today. As well, I'd seen the maritime perspective in a very small air task force (ATF). Now, as a member of the air staff at Task Force Mali (TF Mali), I can confidently consolidate both experience *and* academics to support the commander as a staff officer.

The greatest benefit of ASPOC is that students are challenged beyond their silo or stove-pipe and asked to think like an engineer, a logistician, an intelligence officer, and so forth. Ultimately, it doesn't matter what your service background is, you must perform as an officer, and nothing purges credibility faster than saying, "but I'm a <trade>! Doing <other trade> stuff isn't my thing." *Everything* is your thing. Those who have taken ASPOC have a keen sense for this, and I consider it both a compliment and a testament to versatility when TF Mali members ask me what it is I actually do back home.

Another benefit of the course is creating a thinking atmosphere at a certain career confluence, with the great differentiator of rank removed from the occasion. While military courtesies are obliged, ASPOC teaches that having a process is important, good ideas matter, communicating them effectively is critical, and the work ethic to see them through is vital. As militaries adapt to the prevailing generation and the rank gap narrows, it is necessary to answer the "why" behind decisions. Sitting in the room while a senior says something wrong is no longer the done thing. Here in the ATF, I challenge my superiors constantly—often to their amusement—but I've never been present for a decision where I've felt like I didn't have my chance to offer valid input.

Never forget the primacy of operations. An ASPOC graduate knows this and that makes you a Swiss Army knife to your commander. Conducting a unit disciplinary investigation may seem far from the fight, but your willingness and flexibility to embrace any role—because *you* see the entire task force (TF) construct and know the link between that job and the ones that save lives—builds trust with your commander and earns the respect of your peers and subordinates. In the first weeks, I was tasked with something I'd never done before: coordinating rifle zeroing for staff/supporters, which required air travel to a nearby range due to road threats. This involved 60 shooters, Canadian Army force protection, and a CH147F with ground crew and aircrew. I literally referred to the "Anderson Waterfall" for a mini-operational planning process. Were the results ideal? No, but was I effective, safe and repeatable? Yes, and I'll be better the next time. ASPOC set me up for that.

As a recommended addition to the course, I suggest including Sentinel training. Our very diligent Padre presented the initiative to our commander. Now, over 80 members of TF Mali have this important credential: one that helps members recognize those who are struggling, creates a willingness to see things through their lens, and uses compassionate communications to assist on a peer basis. This training is a real treasure—one that I wish existed years ago—and is an essential injection of humanity into a system too often devoid of it. At the very least, it has certainly harmonized roommate relations!

I very much enjoy my role in this TF. I feel that the ASPOC curriculum has set me up well both to use the tools myself and to share the perspective appropriately with (and learn from) members of different rank and experience. TF Mali Roto 1 further benefitted by attending ASOC (air support operations centre, formerly OCCC) together, which was pivotal in building the team that tackles problems together daily. Please don't hesitate to contact myself or fellow graduate, Captain (Capt) Bianca Einsfeld, if you are interested in a window into life as a deployed staff officer.

Capt Rob Millen is currently deployed as A7 in TF Mali HQ (Headquarters): his sixth international operation. He has served with United Nations and NATO forces in both Royal Canadian Navy and RCAF service, as both a line and staff officer. Most recently a CH124 Sea King pilot, Capt Millen awaits transition to the CH148 Cyclone helicopter.

ABBREVIATIONS

ASPOC	Air & Space Power Operations Course
ATF	air task force
Capt	captain
RCAF	Royal Canadian Air Force
TF	task force
TF Mali	Task Force Mali