***Future of Air and Space (Aerospace) Power and the RCAF:***

**An Exploration**

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**Science Fiction imagines, Hollywood visualizes, DARPA funds, DoD acquires, the USAF employs, and the RCAF lags ten to twenty years behind**

This verbal equation nicely, but not exclusively, sums up the process of technological innovation. Arguably, air forces as the most technologically driven military service are generally at the leading edge of this process. As it unfolds in the United States (US) and the United States Air Force (USAF), not least of all because of the innovative nature of American society evident in large research and development (R&D) investments, which over recent years has become a priority for the USAF, not least of all in response to Chinese investments in modernizing its armed forces over the past decade or so. The Royal Canadian Air Force (RCAF), as well as most, if not all allied air forces will largely follow suit. This *follow-the-leader* process is the product of a long list of factors, of which several stand out.

Beyond the simple observation that the US is a global superpower, the political and strategic leader of the Western World, and has a defence budget that significantly exceeds the combined budgets of all its allies, economic cost considerations drive the RCAF, and the Department of National Defence (DND) as a whole to ensure inter-operability and await relative capability maturity. Basically, the RCAF and the Canadian Armed Forces (CAF) as a whole cannot afford to gamble on a new experimental technology/capability, despite the current government’s supposed commitment to innovation; one of the lessons, for example, of the 1950s AVRO Arrow debacle. Neither is the Canadian Defence Industrial and Technological Base (DITB) structured to engage in this process from beginning to end nor does Defence Research and Development Canada (DRDC) possess the funding and thus capability. At best, both are driven to develop new, innovative component and sub-system technologies either as a function of their engagement with, and integration into the US DITB and specific Canadian requirements, such as the current case for the Over-the-Horizon (OTH) polar and arctic radar lines.

This reality for the RCAF and the CAF also extends beyond the basic development and acquisition of new, technologically advanced capabilities into the world of doctrinal and operational development. In some ways, Hollywood’s display of futuristic military technologies, subsequent research and development (R&D) funding, through to their employment provide the foundation for operational and doctrinal development, testing and implementation. More practically, at some point in the process from the laboratory to development the scientific/engineering world meets the operational and doctrinal. In some cases, it is the operational world recognizing a capability requirement and/or deficiency which drives the scientific/engineering world. Regardless, the USAF being present at the birth is first to engage in operational and doctrinal change or transformation requirements. Their experimentation with the new technology sets the lead for RCAF absorption. The RCAF is not least of all due to its close links with the USAF, such as through the North American Aerospace Defence Command (NORAD). Combined exercises and the secondment of RCAF officers to USAF institutions, thus get exposed to new operational doctrine. This is not to suggest, that the RCAF simply absorbs these developments without question. Rather, RCAF personnel obtain the foundation of new doctrine, with opportunities to influence USAF thinking and practice, especially in the context of potentially unique Canadian requirements. Nonetheless, the second, simple verbal equation is where the USAF goes operationally and doctrinally, and the RCAF largely follows.

As a result, in order to understand the future of the RCAF, and by default the future of airpower requires an assessment of emerging US-driven technologies is essential. In so doing, it is initially useful to examine briefly the problem of prediction in the context of the concept of projection in order to recognize the limitations of future prognostications. Subsequently, future technologies, whether in the laboratory or in the R&D stage provide the stage for projecting the future role of airpower. This, in turn, provides the foundation for thinking about the future of the RCAF in form and function.

In the end, whether one thinks in terms of a revolutionary break (a la arguments surrounding the 1980s Revolution in Military Affairs (RMA) concept), or a gradual evolutionary process, the fundamental missions of airpower are unlikely to change significantly, if at all. The manner in which these missions are executed, however, are likely to be significantly different from today, not least of all as a function of two technological forces at play: artificial intelligence and energy/power generation. As a result, the USAF and subsequently the RCAF will look dramatically different in the distant future, with a range of adaption implications for the organization and its culture. Specifically, how the RCAF adapts will be a central force in its ability to absorb new technologies effectively and efficiently.

**Predicting and Projecting the Future**

To note that prediction is an inexact science is probably a gross understatement. Nonetheless, prediction is integral to the human condition. No matter the activity, behaviour or goods involved, they emerge with some element of prediction attached. Of course, the veracity of predictions varies widely. Within the scientific realm, as a product of years of empirical research and testing, behaviour in the physical, chemical and biological world scan be accurately predicted in many cases. Beyond these worlds, the veracity of prediction declines significantly. In the manufacturing world, for example, companies regularly predict for consumers the life span of their products. But, the end date predicted varies widely in reality. Moving into the human behavioural world, prediction becomes more problematic, and this is especially the case in international politics. Either predictions end up being simply wrong, or are highly contested with significant implications for policy advise.

With few exceptions, and these were largely ignored, if not ridiculed, no one predicted the end of the Cold War, the manner in which it ended, or the collapse of the Soviet Union. Even with the thawing of East-West relations occasioned by the 1987 Reagan-Gorbachev Summit in Iceland, and symbolized by the signing of the Intermediate Nuclear Forces (INF) Treaty, experts did not predict the forthcoming end of the Cold War. Instead, it was seen as the likely return to a period of peaceful co-existence or détente. In the case of contested predictions, today some experts predict a future in which China supplants the US as the dominant political, economic and military power, whereas others predict that China has peaked and will begin a period of decline. Whereas both predict, or warn of the danger of war with China, the most appropriate or useful policies to manage this danger are distinctly different, leaving decision-makers groping for answers.

Prediction is also central to the military world. Senior military decision-makers grapple with predicting the future nature, occasion, and location of war, or threats to national security as the foundation for planning, capability acquisitions and exercises. All militaries undertake on a fairly regular basis future studies, usually out to twenty years or so, although it appears little attention is ever paid to the veracity of future studies from the distant past. Nonetheless, prediction is essential as a means to make a case to their political masters for decisions about employment and investment. In some ways, predicting the future is an attempt to escape the old adage that militaries always prepare to fight the last war. Simply, as another barrier to the prediction problem resides the tendency to take the lessons of the past and transfer them linearly to the present in the future, only to be surprised as a result.

Even so, the veracity of military predictions varies widely, as they do across the breadth of human activity. Illustrative are predictions of the life cycle of major platforms. For example, Canada’s acquisition of the CF-18 in the 1980s came with a rough prediction of its life cycle. Even so, the CF-18, partially a function of mid-life upgrades, rigorous and advanced maintenance technologies, and life extensions will have been in service long past predicted dates before its planned retirement in 2035.

This is not unique to the Canada and the RCAF, but is a longstanding trend for all air forces not least of all given the costs of a new generation of aircraft that continue to rise relative to the costs of life extensions and the politics of defence spending. At the same time, enhanced production and engineering materials and techniques, alongside the capacity to modernize on-board computer and avionics sub-systems further facilitate life extensions. In simple terms, the basic structure of aircraft can be readily extended, while its operational guts can be modernized with new advanced technologies. Eventually, however, the platform and its operational functionality reach an end point, and this end point is as much driven by age itself as the emergence of new technologies, driven by predicted military requirements. When that point is reached cannot be predicted and remains a product of the unpredictable interplay of contesting endogenous and exogenous factors.

While prediction is clearly problematic, but necessary, projecting the future based upon recent past and current behaviour is a useful alternative. In this sense, prediction implies something will happen, whereas projection in implies that something may happen. Whether it does or not is an open, and of course debatable question. A useful illustration in the military world is found in the process leading to the development and employment of ballistic missile defences (BMD).

Turning back to the simple first verbal equation, the development of rocketry or missiles can be traced back to science fiction of the late 19th Century, subsequently and crudely portrayed in early films. It moved into the scientific realm roughly in the early to mid-20th century, and then recognized by the military as a potential means to develop long range artillery, exhibited for the first time in World War II. Once identified and funded by the military for military purposes, the process also became driven by a need to research and develop possible counters to the new technology. Hence, the development of rockets or missiles for offensive or strike purposes spawns the search for the development of a defence against them.

This military R&D process generates a dynamic of inevitability, although its manifestation in time and form is unpredictable. In the BMD case, endogenous technological limitations combined with exogenous Cold War political considerations related to strategic instability made the future of BMD unpredictable, and its evolution was not a simple linear process. On the investment side of the equation alone, funding for BMD evolved in starts and stops and its specific form and function varied significantly over time. Nonetheless, BMD emerged as an inevitable trend long before endogenous and exogenous forces came into alignment following the end of the Cold War, although the final outcome in terms of form, function and utility remained unpredictable, and still today possesses an element of unpredictability.[[1]](#footnote-1)

A list of all the endogenous and exogenous forces or factors at play are beyond the scope of this exploration, nor are they easily separated into exclusive elements for they are in constant interaction. This is especially true for the technological innovation variable, which is a significant trend setter for projecting the future, especially in the case of the US and USAF: a technologically problem solving society and a technologically driven organization. Endogenous technological innovation is driven by perceived military requirements as they evolve in response to real, or perceived threats and manifested in the provision of investment. These, in turn, are affected by their perceived impact on existing organizational and cultural beliefs and values.

Exogenous innovation is driven by basic civilian and/or corporate research, which comes to be identified as having military potential, leading to military investment as well. Identifying which comes first, and predicting which innovation will militarily succeed is problematic, to say the least. They are interactive in essence. At the same time, a host of political, economic and bureaucratic forces engage sometimes to enhance the process and other times to retard it.

Central to this interactive process is the US Department of Defense’s (DoD) Defence Advanced Research Product Agency (DARPA). It acts in some ways as the interlocutor between these civilian and military worlds, providing funding for pure laboratory research with possible, but unpredictable future military applications, and military directed research. Of course, other investment actors are engaged in this complicated interactive process, including the USAF itself. Nonetheless, ongoing DARPA projects, albeit veiled in secrecy, along with other actors, provide the foundation to project both the future of airpower and thus the potential future of the RCAF.

Finally, projecting, rather than predicting the future is also a product of the time differential between technological development and operational employment. The pace of technological development, evident for example in Moore’s law, has increased significantly over the past several decades. In contrast, manufacturing, acquisition and employment have not kept pace for obvious political, economic and bureaucratic reasons, despite repeated calls and attempts for reform. Thus, the operational side largely lags significantly behind the development side. How far behind varies widely depending on the product/technology. Nonetheless, this reality is another factor that works against prediction *per se* and supports projection.

**The Future of Airpower**

Despite dramatic technological changes in airpower capabilities since its emergence in rudimentary form in World War I, the core missions of airpower have not changed. In basic form, these include surveillance and reconnaissance (S&R), air supremacy or control, interdiction, strategic strike, and the transportation of personnel and material and search and rescue to support the military as a whole, and civil authorities. Since the development of outer space capabilities, these missions have also been conceptualized as extending into this domain, although with the exception of S&R, and related navigation aids via the Global Positioning System (GPS) and advanced communications, none of the other core air force missions have become operational as of yet. Nonetheless, as air forces and the USAF in particular dominate the space domain, their core missions deeply embedded in their culture can be projected into space in the future, and this is one of the reasons, as detailed below, why the concept of aerospace power can be projected to become reality sometime.

Of course, not all air forces possess the capability to undertake all these missions, whether in terms of airpower or space. The costs alone of acquiring, maintaining and employing the full range of capabilities are simply beyond the capacity and in some cases the political will of most states. This also extends into the R&D realm. Only the great powers possess such capabilities and R&D, and this is especially pronounced in the case of the US and USAF. As noted above, the US sets the lead and its allies respond and adapt.

In the case of emerging technologies, two in particular stand out – artificial intelligence (AI) and energy/power generation. The former has already emerged in operational terms at least in its relative infancy.[[2]](#footnote-2) The latter remains in various stages from laboratory to experimental. Projecting both into the future, like BMD, has a degree of general inevitability.

AI is both conceptually, definitionally, and practically complicated.[[3]](#footnote-3) In current military applications, attention is focused on its utility to command and control decision-making. Basically, as evident in NORAD’s Pathfinder Project, AI or more practically its subset machine learning, enables advanced computer algorithms to analyze large amounts of data from multiple sensors, and rapidly identify relevant patterns to enhance human decision-making. In Air Force terms, this can be conceptualized by John Boyd’s Observe, Orient, Decide, Act (OODA) loop in which AI speeds up the process providing a significant advantage, relative to less advanced adversaries[[4]](#footnote-4). This, for example, is embedded in the fifth-generation Joint Strike Fighter (F-35). Whether this includes the capability of the onboard AI-enabled computer to make independent decisions on the weapon’s release or simply prioritizes targets for the pilot is difficult to know given its highly classified nature. The former is generally known as a human-on-the-loop, whereas the latter is a human-in-the-loop. Beyond these two categories are future projections of full -machine-independent decision-making with no human engagement.

A further operational example is unmanned aerial vehicles (UAVs) or remotely piloted aerial systems (RPAS), which undertake S&R and ground attack missions. Until recently, these capabilities were not truly AI enabled. They either undertake pre-programmed flight paths and/or are piloted by humans on the ground, who make decisions on weapons release.[[5]](#footnote-5) As the next step into the AI/Machine Learning world is the capacity of the platform itself to independently alter its flight in response to sensor data, such as to track an object or target of interest, and ultimately to release its weapon with no human input (autonomous) or at best with a human-on-loop (semi-autonomous) as a failsafe check. The most pronounced existing capability is the employment of facial recognition technology for target identification.

There are numerous debates today on war, ethical, moral, and legal implications relative to the application of AI/Machine Learning technology.[[6]](#footnote-6) Even so, the trajectory of AI/Machine learning-enabled airpower is towards a pilotless air force in which semi-autonomous or fully autonomous platforms are capable of undertaking the entire range of airpower missions. This would also extend into the transportation/logistical support realm through the employment of advanced robotics.

The likelihood of fully autonomous pilotless air platforms in the foreseeable future is low not least of all as a function of the human condition informed by apocalyptic visions of a future where machines become sentient. Indicative is the current conceptualization of future AI-enabled air doctrine, whether in terms of humans in or on the loop, in which a manned mother ship controls or monitors swarms of pilotless air platforms undertaking the warfighting missions of airpower. Of note here is this projection is simply a linear extrapolation of existing capabilities found in the Airborne Warning and Control (AWACS) and the Joint Surveillance Target Acquisition Radar System (JSTARS) platforms.

Projecting from the past and the present into a future pilotless air or aerospace force is a product of several interrelated factors. First, as partially informed by Western liberal humanist values regarding war, the pattern over the past century or so has been to remove the human further and further away from the forward edge of battle. AI-enabled platforms are simply the next step along this trajectory.

Second, the air environment has become increasingly hostile due to advanced technological developments in ground and naval-based integrated air and missile defences.[[7]](#footnote-7) This, in turn, has driven forward the requirement for greater and greater long-distance standoff precision strike capabilities, which have existed for some time. Although such capabilities have existed since the development of long-range ballistic missiles, enhanced accuracy in the context of this hostile air environment has brought these capabilities potentially into play for conventional war, whereas in the past these missiles were synonymous with nuclear weapons.

This reality, however, is a double-edged sword in relation to projecting airpower into the future. Simply, war is fully entering into the missile age, where aircraft, manned or not, are being driven further and further away from the battlefield, reinforced by longer and longer-range surveillance, reconnaissance and precision targeting (SRT) capabilities, especially from space and air-based capabilities, which will be AI-enabled. In so doing, ground and naval-based strike capabilities can be projected to be able to take on the warfighting missions of airpower, with significant potential implications for the future of air forces, if not the entire service structure of national armed forces.

Third, in returning to the pilotless air force projection, humans/pilots relative to speed and manoeuvrability have reached a physical limit due to gravity forces. The demand for greater manoeuvrability at greater speeds in the atmosphere is also driven by the hostile air environment. AI-enabled pilotless aircraft easily overcome this limit. This is evident to some degree with the development of hypersonic vehicles and research on nuclear-powered cruise missiles, which will eventually be married to AI. However, this limitation may also be overcome as a function of ongoing research into advanced g-suits and internal cockpit environments. In addition, DARPA through its Neural Engineering System Design (NESD) program is seeking to develop a brain-implanted system to link the brain and computer systems.[[8]](#footnote-8)

Finally, there are cost considerations pushing AI-enabled pilotless platforms forward. The costs of modern manned aircraft continue to increase at significant rates, even when defence inflation is taken into account,[[9]](#footnote-9) AI enabled pilotless platforms are generally seen as less costly and more affordable, allowing states potentially to acquire more platforms. This is reinforced by developments in miniaturization, as currently evident in the small to nanosatellite world. Projecting these developments into the world of airpower is also a response to the increasingly hostile air environment which underpins the aforementioned concept of swarms of pilotless platforms. Simply, mass is projected as the means to overwhelm these defences. But, in this case, as a function of AI-enabled technology, it will be mass-married to quality or precision. As a result, pilotless small, precision-capable and AI-enabled platforms may provide a comparatively cheap alternative to current manned aircraft, which, in turn, given the diffusion of technology will open a new world of airpower to smaller states, with implications for the US difficult to project.

Alongside projecting into the new world of AI-enabled airpower capabilities is research and development related to energy/propulsion generation. In 1958, the USAF adopted the concept of aerospace as a single domain in part to make a claim on the development of rocketry/missiles. In 2002, the USAF dropped aerospace in favour of air and space as separate domains as a function of their distinct physical environments. This has been cemented with the recent establishment of a separate US Space Force, although it remains under the jurisdiction of the US Secretary of the Air Force.

During the *aerospace* era, the transference of airpower theory to outer space emerged, even though the physical characteristics of space are distinct from the air domain. Of particular note was the US Space Command’s (USSPACECOM) Long Range Vision in 1998.[[10]](#footnote-10) Central to this vision was obtaining control of space and integrating space into terrestrial military operations, which reflected the warfighting missions of airpower. Even with the adoption of air and space power, USAF doctrine for some time still contained an aerospace definition: “the ability to project military power or influence through the control and exploitation of air, space, and cyberspace to achieve strategic, operational, or tactical objectives.”[[11]](#footnote-11) Only in 2022 did USAF doctrine return to a strict atmospheric definition: “the ability to project military power through control and exploitation in, from and through the air. [[12]](#footnote-12) In 2020, the US Space Force released its first Space Power Capstone Doctrine, although it does not contain an explicit definition of space doctrine.[[13]](#footnote-13)

For now, air and space remain separate and distinct domains as a function of current energy/propulsion technology. Access to space requires a distinctly different propulsion system such that airbreathing planes cannot transit into space, and space platforms, satellites and the now cancelled US Space Shuttle needed to be boosted into space. Nor could these space platforms return to the atmosphere and conduct any missions. Indeed, satellites are designed to *burn up* upon reentry, the Space Shuttle to glide back to Earth Earth, and the recent Space X Falcon 9 rocket booster to return intact to Earth for reuse. In addition, the costs as a function of fuel weight still limit the capacity of satellites to maneuver while in orbit. In other words, the maneuverability of platforms central to the execution of airpower missions is not obtained in space. Satellites largely remain trapped in fixed orbits.[[14]](#footnote-14)

The physical barrier between air and space has been partially overcome with the development of hypersonic vehicles in two types; glide vehicles and cruise missiles.[[15]](#footnote-15) Both are boosted into the lowest reaches of outer space by missiles or rockets at an altitude between 20 and 60 kilometres (km).[[16]](#footnote-16) While their maneuverability at the speeds generated at these altitudes is limited due to stresses on the airframe, upon reentry into the atmosphere their maneuverability is enhanced. Related and initiated by NASA, DARPA undertook the XS-1 experimental sub-orbital space plane project, which is designed to transit to and from space under its own power.[[17]](#footnote-17) However, it is unable to transit into orbital space.[[18]](#footnote-18) Nonetheless, hypersonics and the XS-1 represent an initial first step on the path to domain merger.

R&D into new energy generation/propulsion technologies has been underway for some time. Most of these technologies are directly related to space travel and the future manned mission to Mars. They include nuclear fission propulsion, nuclear electric, iodine-fueled electric, solar, plasma, magnetic levitation and beamed energy. Nuclear-powered solutions remain problematic for launch due to fears of a launch failure and the dispersal of radioactive material back to earth. Plasma, magnetic levitation and beamed energy employing ground-based lasers are directly related to launch. The specific characteristics of these technologies are unknown in the public domain, but it is likely that they will solve the air-space barrier and provide the ability to move seamlessly from air to space and back again, and fully maneuver in outer space.[[19]](#footnote-19) Once achieved, the transference of airpower missions to space will become a reality and aerospace will merge as a true single domain.

Indicative of developments is the USAF’s two robotic X37B Space Planes.[[20]](#footnote-20) Modelled on the Space Shuttle, the planes have undertaken six secret missions, with the last operating for 780 days in orbit. Information regarding its capabilities is classified. It still requires a booster rocket to reach space but is a harbinger of a future of direct access to space. Reflecting this projection is the idea of developing space cruisers for satellite defence missions in space. Regardless, future new propulsion technologies will eventually break down the barrier between air and space to create a truly integrated aerospace domain, in which airpower missions can be fully undertaken in space.

Related to energy generation is also the development of directed energy weapons for non-lethal and kinetic employment for aircraft.[[21]](#footnote-21) Its roots can be traced back to the Ballistic Missile Defense Organization’s (BMDO) USAF Airborne Laser. These await the development of more efficient and small power sources that could be placed upon aircraft.

There are, of course, other new technologies under research with applications for airpower. These, for example, include enhanced stealth capabilities with the ultimate goal of providing an aircraft with a ‘cloaking’ capability, and even further potentially in the far distant future ‘shapeshifting’ technology. Regardless, it is clear that air forces, led by the US and USAF will face significant challenges as new technologies emerge over the next twenty years or so, and this is especially the case for the RCAF.

**The Future of the RCAF**

As a function of the global fraternity of the air, RCAF missions do not deviate significantly from USAF or any other air force in theory. Although terminology varies from country to country, practically, for political and cost reasons the ability of the RCAF to execute all the missions is constrained. For example, the strategic strike mission does not in any meaningful sense exist for the RCAF, not least of all because Canadian governments largely perceive the role of the CAF, and thus the RCAF as primarily defensive in nature. Indicative, the RCAF’s strategic bombing capability was the first to go after World War II. Although the costs of such a capability were and are problematic given defence spending, Canadian defence policy continues to eschew a strategic strike mission.

Looking out to the future, the first observation is that the RCAF of today will most likely look roughly the same over the next twenty years, if not longer., as a function of ongoing modernization and acquisition projects. Given past history, RCAF capabilities/platforms are acquired and remain in service for forty or more years (a la the CF-180). Of current capabilities in the RCAF inventory, two will stand out for replacement over the next twenty years. First, the Griffin tactical helicopter in the support of the army and acquired in the early 1990s will approach the end of its life, and it is highly unlikely that the Army will eschew this capability for future operations at home and abroad. Second, the tactical and strategic lift capabilities embodied in the Chinook, Hercules-J and Globemaster acquired in the early 2000s will shortly reach the twenty-year point where mid-life upgrades and technological modernization will be required. These lift capabilities, which also include the Griffin are vital especially for domestic operations in aid and assistance to the civil power, if recent evidence of domestic demand on the RCAF and the CAF *writ large* and projections of a significant increase in natural disasters caused by climate change prove correct.

Roughly since the release of the 2017 Defence White Paper, *Strong, Secure and Engaged*, the RCAF has entered into a major modernization and capability regeneration phase. Indeed, with the exception of the aforementioned lift capabilities, the entire fleet is in the process of being replaced, along with the acquisition of new capabilities. After over a decade of delay, the CF-18 will be replaced by the advanced fifth-generation CF-35 Joint Strike Fighter. Its SAR capabilities are being replaced by the Airbus C-295 Kingfisher. The Multi-Mission project to replace the aged Aurora patrol aircraft is underway, with initial indications that the RCAF will acquire the Boeing P-8 surveillance aircraft.[[22]](#footnote-22) The RCAF is also acquiring a replacement for the Polaris VIP aircraft and air-to-air refuelling capability with nine Airbus 330 Multi-Role Tanker Transport Aircraft (designated the C-330 Husky).[[23]](#footnote-23) Finally, the RCAF will acquire a new capability with the acquisition of Remotely Piloted Aerial Systems (Unmanned Aerial Vehicle-UAV) to provide airborne intelligence, surveillance, reconnaissance and precision strike capability.[[24]](#footnote-24) Finally, central to NORAD modernization is the acquisition of two new radar systems to replace the obsolete North Warning System – an Over-the-Horizon (OTH) Arctic system to be located in Southern Ontario and an OTH Polar System in the High Arctic.

Alongside these air-breathing projects and new ground-based surveillance systems, the RCAF is also committed to acquiring a new suite of space-based capabilities. As a follow-up to the Polar Epsilon 1 and 2 Projects, the Deep Enhanced Surveillance from Space Project (DESSP) is in process with an estimated deployment date sometime after 2035.[[25]](#footnote-25) The Protected Military Satellite Communications Project will ensure guaranteed access to the secure US Advanced Extremely High Frequency (AEHF) military satellite communications system, with access to all three military services, and will resolve the communications problems in the high Arctic.[[26]](#footnote-26) The Surveillance of Space 2 project is a follow -up capability to the Sapphire deep space surveillance capability, set for initial delivery in 2024-25.[[27]](#footnote-27) Enhanced SAR capabilities will follow from the Medium Earth Orbit Search and Rescue Project.[[28]](#footnote-28) The net result of these projects is the RCAF, responsible for space, will expand from a single military satellite, Sapphire, to multiple space-based capabilities integrated into and supporting the RCAF, the other two services, civil authorities, and allies as warranted. Reflecting this commitment to enhanced space-based capabilities, in 2022 the RCAF established 3 Canadian Space Divisions.

Alongside these modernization and new capability projects, identified in the 2017 *Strong, Secure and Engaged*, the 2018 Defence Capabilities Investment Plan and the 2022 NORAD Modernization announcement are a host of additional projects essential to exploit these capabilities. Among these, *inter alia,* are major infrastructure investments for the two major fighter bases, 3 Wing Bagotville and 4 Wing Cold Lake, the three Arctic Forward Operating Locations (FOLs) at Yellowknife, Iqaluit and Inuvik,[[29]](#footnote-29) modernized command and control capabilities, especially the Combined Air Operations Centre (CAOC) at 17 Wing CFB, a possible ground-based fibre-optics communication system from the Arctic to the south, the adoption of cloud-based command and control (CBC2), and the full digitization of the RCAF.

Putting all these projects together will create an RCAF in a form somewhat similar to the past, but also one that is dramatically different in structure and capability. They create a series of interesting challenges for the RCAF. The projects represent probably the largest investment made by the government into the RCAF since World War II. However, the RCAF, as the CAF as a whole, faces major resource challenges in meeting the deadlines for implementation and delivery. These stem from a lack of internal personnel and the problematic nature of the Canadian capital procurement process. In addition, the current economic situation led the government to mandate $ 1 billion in budget cuts. The allocation of this budget cut is left in the hands of DND, which raises issues concerning project priorities not only for the RCAF but also for the CAF. DND is also likely to face further budget cuts if the economy does not recover. Finally, it is difficult to project the nature of the international security environment and the potential impact of a future government on current modernization commitments.

Whether these projects are completed as temporally projected is an open question. Even so, this timeframe provides the RCAF with significant lead time to assess new technological developments and with them the doctrinal and operational implications as they emerge from the USAF. Tracking these developments and their implications also represents a challenge for the RCAF in terms of constrained resources. The demands of modernization implementation are likely to capture the full attention of the RCAF, with little resources left to prepare for the distant future.

Regardless, it is evident that one of the major challenges the RCAF will face concerns the impact of AI as it unfolds. As noted above, AI currently is centred upon command and control, in which this advanced technology provides the ability to exploit large amounts of data quickly to enhance the decision-making process. In NORAD parlance, AI is critical to all domain awareness, information dominance and decision superiority.[[30]](#footnote-30) This, in turn, is also critical for the modernization of RCAF command and control, especially at the CAOC in Winnipeg employed by Canada NORAD Regional (CANR) and the Joint Forces Air Component Command (JFACC). Underlying this is the critical importance of CBC2, and digitizing the RCAF and the CAF within the context of joint forces; a requirement in which both lag significantly behind the US and many of the allies.

As far as future projections of AI-based pilotless platforms/capabilities, the RCAF will remain a piloted air force at least for the life span of the new capabilities being acquired. It is safe to assume that most of the new capabilities can be upgraded with advanced AI. How far the RCAF will go down this path remains to be seen, but will be significantly determined by the core requirement to maintain interoperability with US forces and the USAF in the context of NORAD, NATO and other potential overseas missions. This is especially the case for the acquisition of RPAS, such that they can evolve into a semi-autonomous or autonomous capability pending USAF developments. Nonetheless, the decision point for upgrades is well off into the future.

Even so, at the core of the ongoing AI revolution or evolution are significant implications for the nature and culture of the RCAF in many ways. Whether in terms of digitization, CBC2, or platforms, AI should serve to reduce personnel requirements as technology replaces labour. Imagining a distant future of pilotless platforms, for example, would at least partially resolve the longstanding problems of pilot recruitment and retention. Across the RCAF, AI technology will not only reduce labour demands but also portend a potential transformation of RCAF culture.

From the onset of airpower, the RCAF like all air forces has been dominated by the pilot. Senior command, in turn, is dominated by pilots. Given the human condition, it is likely that AI-enabled capabilities will be employed with a human-on-loop well into the future. It is just that pilots will no longer be in the cockpit on most platforms. As a failsafe measure, the human-on-loop will still need the skills of a pilot, but not the physical capabilities. The RCAF officer or non-commissioned member (NCM) will likely look much different than today, albeit possessing similar skills, but with more technological abilities.[[31]](#footnote-31) Overall, science and technological expertise within the RCAF at all levels will be a priority, which in turn will alter the skills essential for senior leadership.[[32]](#footnote-32) This, then, creates the likely requirement to re-structure the RCAF, especially in terms of the trade categories. At the same time, the RCAF on the recruitment front will have to compete increasingly with the civil computing/engineering sector for labour. The entire training and education components embedded in 2 Canadian Air Division are also likely to require major overall and new investments.

Finally, above all else, senior leadership must recognize that the new and future generations of RCAF personnel are going to look different and possess different skills and values than personnel today in many ways. Partially a function of changes within society at large, the RCAF will have to adapt in order to ensure that the force reflects society. In so doing, new career paths will need to be identified and implemented under senior leadership.

Although not entirely a product of AI and related advanced communications, surveillance, reconnaissance, targeting and strike systems, the RCAF also faces challenges related to combined and joint operations. Although both combined and joint operational requirements have existed for some time, inter and intra-service-based silos or stovepipes remain to be fully overcome. For the RCAF, combined has largely meant cooperation and integration with the USAF. Jointness remains limited and somewhat rhetorical. However, existing and future technologies are a major driver of fully linked combined and joint forces eliminating inter-service silos. In part, this is also a function of the US Regional Command Structure as embodied in its Unified Command Plan. Following the US lead, it is now currently embodied in the US Joint All Domain Command and Control (JADCC) construct (in Canada pan-domain is employed without command and control). Interoperability with the US and as a result the other allies is a critical priority for the RCAF, and as the US breaks down barriers, the RCAF will follow. At the operational level, for example, is the strategic concept of Integrated Air and Missile Defence (IAMD), in which air, naval and land-based capabilities need to be fully connected to ensure the efficient use of all air defence assets.

Whereas, for example, in the past air assets remained under the command and control of Air Force personnel, the future is likely to enable direct command and control by the other services as well. As noted in the previous section, army personnel will be able to direct air assets to targets without intermediary air force engagement, enhancing decision superiority in the field. In the case of NORAD, what remains a largely exclusive Air Force organization is likely to evolve into a truly joint one.[[33]](#footnote-33) In other words, senior officers across the services are increasingly required to have a deep understanding of all the services’ thinking and operating procedures. As a future distant projection, jointness drives toward a future of a single unified (purple) force structure. This, in turn, raises significant implications for RCAF, as well as the other services culture, which remain a significant barrier to be overcome.

Finally, as a function of the centrality of all domain awareness breaking down silos is future development with regard to access to space. At some time in the future, the physical barriers separating air and space will be overcome, which will have major force structure, doctrinal and capability implications for the RCAF. Today, space is labelled as a competitive, congested and contested domain. The congested component relates to existing and ongoing new satellite constellations, especially in Low Earth Orbit (LEO), and growing space debris is likely to be resolved through new technology in terms of small and nano-satellites, and the development of new technology that will support the removal of space debris. This will include new and more efficient lightweight energy generation technology to ensure defunct satellites can be readily and effectively removed from vital earth orbits, which should include the planned new RCAF military satellites.

It is the contested component relative to breaking the air-space barrier that poses a major challenge. Already as a function of BMD capabilities, the major powers possess operational kinetic abilities to strike at satellites in space. In addition, the new generation of long-range air-to-air missiles, which are to be acquired by the RCAF for the F-35, are likely to have a nascent anti-satellite capability.[[34]](#footnote-34) Although not yet a truly integrated warfighting domain, it is evident that its evolution into such a domain, and the merger into a single aerospace domain is just a matter of time. This raises significant implications for the RCAF relative to longstanding Canadian non-weaponization of space policy, its focus on non-kinetic space defensive measures, RCAF force structure, interoperability with the US and its allies, and combined and joint command and control.

**Conclusion**

Even from the perspective of projecting the future, uncertainty remains. Not only is it difficult to project when new technologies affect the nature of war and conflict, but the airpower mission suite, operational doctrine, capital investments and priorities, and organizational structures, beliefs and values will come to fruition. It is also difficult to project, never mind predict, which technologies will actually transition from the laboratory to the R&D stage, and finally to operational deployment. This is compounded by the increasing impact of developments in the civil/commercial world and recognition of their utility and adaptability to the airpower world. Regardless, it is clear that a significant transformation of the means, but not the ends of airpower, will take place. At best, militaries must keep a close eye on these technological developments and will face difficult choices in the future, with wide-scale implications for the political, strategic, theatre and tactical levels in decisions regarding the employment of airpower as determined by national command authorities.

For the RCAF, this will be no easy task with a natural concentration on the multi-faceted and multi-domain modernization and capability regeneration projects underway that will lead to a *new* RCAF over the next twenty years or more. The danger, however, is being able to adapt the planned capabilities to technological developments at an unpredictable point in time, the potential emergence of an unexpected, disruptive technology that might generate rapid obsolescence, and/or the employment of new technologies by adversaries in an unexpected manner. Even so, as a function of the close, embedded relationship with the USAF, the RCAF has a window to prepare and adapt as necessary. Whether it will be able to is the key question given the complicated exogenous and endogenous factors play. Nonetheless, at the core of the type of air force Canada requires remains interoperability, whether one thinks in deterrence, defence or aid and assistance to civil authorities.

1. For example, the US strategic BMD remains a limited capability against lesser long range ballistic missile threats, and it remains to be seen whether it will be expanded into a much larger capability. Over time, BMD under its various labels, has shifted from strategic defence of the US as a whole, a limited strategic defence against lesser ballistic missile threats, to the operational theatre and tactical level and back and forth. For an analysis in the case of Canada, see James Fergusson. *Canada and Ballistic Missile Defence 1954-2010: déjà vu all over again.* Vancouver: University of British Columbia Press. 2010. [↑](#footnote-ref-1)
2. Michele A. Flournoy. “AI is Already at War: How Artificial Intelligence Will Transform the Military” *Foreign Affairs*. 102:6, 2023, pp, 56-69. [↑](#footnote-ref-2)
3. *Artificial Intelligence vs. Machine Learning.* Columbia University Engineering. <https://ai.engineering.columbia.edu/ai-vs-machine-learning/> [↑](#footnote-ref-3)
4. The best and most recent study on Boyd is Daniel Ford. *A Noble Vision: John Boyd, OODA Loop and America’s War on Terror.* New York. Createspace/Warbird Books. 2010. [↑](#footnote-ref-4)
5. Hollywood’s version is the 2016 film *Eye in the Sky.* [↑](#footnote-ref-5)
6. For example, see Emery, John R. “Algorithms, AI, and Ethics of War.” *Peace Review*, vol. 33, no. 2, 3 June 2021, pp. pp. 205–212, <https://doi.org/10.1080/10402659.2021.1998749>; Paul Scharre. *Army of None: Autonomous Weapons and the Future of War*. New York: W.W. Norton & Company*,* 2019. [↑](#footnote-ref-6)
7. This observation has been reinforced by the apparent lessons of the ongoing Russo-Ukranian War. However, caution must be exercised in extrapolating from these lessons in the context of a future conflict involving US led airpower. [↑](#footnote-ref-7)
8. #  DARPA. *Towards a High-Resolution, Implantable Neural Interface.* July 10, 2017. <https://www.darpa.mil/news-events/2017-07-10>

 [↑](#footnote-ref-8)
9. Defence inflation is generally estimated to run six or more percentage points above general inflation due to the unique technologically driven characteristics of the defence production world, especially in the case of the US which is culturally driven by quality over quantity. [↑](#footnote-ref-9)
10. US Space Command. *Long Range Plan: Implementing USSPACECOM’s Vision for 2020.* Colorado Springs;USSPACE COM. 1998. [↑](#footnote-ref-10)
11. Cited in Maj Kenneth Grosselin, USAF. “A Culture of Military Spacepower”. *Air and Space Power Journal.* Spring, 2020. p. 80. <https://www.airuniversity.af.edu/Portals/10/ASPJ/journals/Volume-34_Issue-1/SEA-Grsselin.pdf> [↑](#footnote-ref-11)
12. United States Air Force. *Air Force Doctrine Publication #1.* April 2022. <https://www.airandspaceforces.com/app/uploads/2021/04/AFDP-1-1-1.pdf> [↑](#footnote-ref-12)
13. United States Space Force. *Spacepower: Doctrine for Space Forces.* June 2020. <https://www.spaceforce.mil/Portals/1/Space%20Capstone%20Publication_10%20Aug%202020.pdf> [↑](#footnote-ref-13)
14. The development of solar energy generation provides some capacity for maneuver, such as enabling the International Space Station to maintain its orbit. By in large, solar energy and residual fuel are designed to boost a failed satellite into a high earth orbit parking slot, and/or ensure it re-enters the atmosphere at the proper angle to burn up. [↑](#footnote-ref-14)
15. Hypersonic glide vehicles are unpowered and use the atmosphere to maneuver. Hypersonic cruise missiles are powered by scramjet engines which employ the limited amount of air molecules for engine use. The former are employed by Russia, whereas the latter are a US development program. With an engine, the cruise variant is more maneuverable, hence the label cruise missile. Their capabilities are likely to be enhanced by AI integration. [↑](#footnote-ref-15)
16. For details related to hypersonics and defence against them, see Abraham Mahshie. *Hypersonics Defense: How hypersonic weapons maneuver and what to do about it.* Air & Space Forces Magazine. Jan. 19, 2022. <https://www.airandspaceforces.com/article/hypersonics-defense/> [↑](#footnote-ref-16)
17. Jeff Foust. *Boeing drops out of DARPA Experimental Spaceplane program.* Space News. January 2020. [https://spacenews.com/boeing-drops-out-of-darpa-experimental-spaceplane-program/#:~:text=WASHINGTON%20—%20Boeing%20has%20decided%20to,running%20efforts%20in%20space%20access](https://spacenews.com/boeing-drops-out-of-darpa-experimental-spaceplane-program/%22%20%5Cl%20%22%3A~%3Atext%3DWASHINGTON%20%E2%80%94%20Boeing%20has%20decided%20to%2Crunning%20efforts%20in%20space%20access). [↑](#footnote-ref-17)
18. The traditional definition of space is the Karman line set at 100 km. above sea level. Sub-orbital space us traditionally the area between 100 km. and 150 km, the minimum altitude for obtaining an orbit. The SR-71 Blackbird can reach an altitude of 21 km. For now, there is no agreed label for the area between 21 km and 100 km where hypersonics operate. [↑](#footnote-ref-18)
19. In some of the literature a distinction is made between inner space and outer space. The former relates to orbits around earth, and latter space outside of these of these orbits. [↑](#footnote-ref-19)
20. Michael Wall. *The US Space Force’s Secretive X-37B Space Plane: Ten Surprising Facts.* Space.com September 1, 2021. [https://www.space.com/x-37b-military-space-plane-surprising-facts#](https://www.space.com/x-37b-military-space-plane-surprising-facts) [↑](#footnote-ref-20)
21. Alfred Cannin.*Directed-Energy Weapons: An Option for Strategic De-escalation.* Air & Space Power Journal -Technology. Fall, 2021. <https://www.airuniversity.af.edu/Portals/10/ASPJ/journals/Volume-35_Issue-3/T-Cannin.pdf> [↑](#footnote-ref-21)
22. Bombardier has recently proposed to offer the RCAF a variant of the Global 6500 series aircraft to compete for the Multi-mission aircraft contract and with its partner, General Dynamics Mission Systems Canada, have a called for an open competition. David Pugliese. *Bombardier Teams with Ottawa Firm to offer RCAF New Surveillance Aircraft.* Ottawa Citizen. 18 May 2023. <https://ottawacitizen.com/news/national/defence-watch/bombardier-teams-with-ottawa-firm-to-offer-rcaf-new-surveillance-aircraft> [↑](#footnote-ref-22)
23. Department of National Defence. *The Strategic Tanker Transport Project and NORAD Modernization. 25* July 3023. <https://www.canada.ca/en/department-national-defence/news/2023/07/the-strategic-tanker-transport-capability-project-and-norad-modernization0.html> [↑](#footnote-ref-23)
24. Department of National Defence. *Remote ly Piloted Aircraft (RPAS) System. 12* December 2022. <http://dgpaapp.forces.gc.ca/en/defence-capabilities-blueprint/project-details.asp?id=977> [↑](#footnote-ref-24)
25. Polar Epsilon 1 and 2 were designed to exploit the Canadian Space Agency’s RADARSAT Constellation. On DESSP, see Department of National Defence. *Defence Enhanced Surveillance from Space Project (DESSP) (NORAD Modernization.* December 1, 2022. http://dgpaapp.forces.gc.ca/en/defence-capabilities-blueprint/project-details.asp?id=1791 [↑](#footnote-ref-25)
26. Department of National Defence. *Protected Military Satellite Communications.q1* December 2022. http://dgpaapp.forces.gc.ca/en/defence-capabilities-blueprint/project-details.asp?id=1760 [↑](#footnote-ref-26)
27. Department of National Defence. *Surveillance of Space 2. 1* December 2022. <http://dgpaapp.forces.gc.ca/en/defence-capabilities-blueprint/project-details.asp?id=1920> [↑](#footnote-ref-27)
28. Department of National Defence. *Medium Earth Orbit Search and Rescue.1* December 2022. <http://dgpaapp.forces.gc.ca/en/defence-capabilities-blueprint/project-details.asp?id=996> p. 20 [↑](#footnote-ref-28)
29. There is an internal debate within the RCAF about whether 5 Wing Goose Bay is an FOL or a Deployed Operating Base (DOB). [↑](#footnote-ref-29)
30. NORAD and USNORTHCOM. “Executive Summary” *Strategy*. March, 2021. [https://www.northcom.mil/Portals/28/(U)%20NORAD-USNORTHCOM%20Strategy%20EXSUM%20-%20Signed.pdf](https://www.northcom.mil/Portals/28/%28U%29%20NORAD-USNORTHCOM%20Strategy%20EXSUM%20-%20Signed.pdf) [↑](#footnote-ref-30)
31. This harkens back to the internal debate within the USAF of decades ago whether RPAS should be piloted by officers or NCMs. [↑](#footnote-ref-31)
32. For a detailed discussion, see Maj. General William T. Cooley and Col. George M. Dougherty. *Every Airman and Guardian a Technologist: Reinvigorating a Disruptive Technology Culture.* Air & Space Power Journal. Summer, 2021. <https://www.airuniversity.af.edu/Portals/10/ASPJ/journals/Volume-35_Issue-2/V-Cooley_Dougherty.pdf> [↑](#footnote-ref-32)
33. In 2006, NORAD acquired a maritime warning mission, which brought naval personnel into the organization. Since then, NORAD commanders have included two senior US naval officers, and one US Army General, although since 2016 it has reverted back to USAF commanders. [↑](#footnote-ref-33)
34. In the 1980s, USAF deployed such a capability from a F-15. The programme was canceled with the end of the Cold War. [↑](#footnote-ref-34)