The Future of Drones in Canada: Perspectives from a Former RCAF Fighter Pilot

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ABOUT THE AUTHOR

Fraser Holman, born in Toronto in 1943, grew up in Ottawa and graduated from the Royal Military College of Canada (RMC) at Kingston, Ontario, in 1965.

MGen Holman's military career spanned 35 years and alternated between operational and educational assignments. MGen Holman was promoted to colonel in 1986 and in 1988 was appointed Commander of BFC Bagotville, Quebec, a CF-18 Wing for a glorious two-year tour.

MGen Holman was promoted to Brigadier-General in 1990 and assigned as the (last) Deputy Chief of Staff for Operations at the 4th Allied Tactical Air Force at Heidelberg, Germany. Next, he was reassigned in 1993 to headquarters NORAD, in Colorado Springs, Colorado. He served as Vice-Director of Plans, then Deputy Commander of the Cheyenne Mountain Operations Centre, before being promoted to major-general in 1995 and becoming the J-3, Director of Operations, for NORAD.

He retired from the Canadian Forces in 1996 and returned to live in Toronto. He established himself in a consulting business and from 1997 to 2010 worked in support of the Canadian Forces College as a senior mentor and facilitator. He was appointed the Honorary Colonel of the College in 2011.

MGen Holman accumulated over 3600 hours of pilot-in-command time, primarily on the CF-18, CF-104 and the T-33, and has served as a Director and Chairman of the Board of the Canadian Institute of Strategic Studies as well as a Director of the Atlantic Council of Canada. He chairs the Board of a newly established CFC Foundation in support of the Canadian Forces College in Toronto.

In 2000 he wrote a monograph entitled NORAD in the New Millennium, published by Irwin.

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EXECUTIVE SUMMARY

What are the prospects for implementation of Unmanned Aerial Vehicles (UAVs) in the Canadian military? Holman explores many aspects of how UAVs operate, their strengths and shortcomings. Examining them in the context of the overall systems that enable their capabilities, he looks at communications vulnerabilities, degrees of automation and autonomy, categories of UAV, rotary versus fixed wing applications, legal and airspace management constraints, and the potential roles in which UAVs might offer an immediate advantage. He concludes that surveillance is a very likely application, particularly in Canada's far north. He is less sanguine about armed UAV roles, particularly when it comes to air combat. Improved reliability, a matured regulatory framework, and a more stable customer base are the critical elements for future system development.

SOMMAIRE

Quels sont les perspectives d'avenir pour la mise en œuvre de véhicules aériens sans pilotes (UAV) dans l'armée canadienne ? Holman explore plusieurs aspects de la façon dont les UAV fonctionnent, leurs points forts et les points où ils laissent à désirer. En les examinant dans le contexte des systèmes d'ensemble qui les dotent de leurs capacités, il regarde les vulnérabilités dans les communications, les degrés d'automatisation et d'autonomie, les catégories d'UAV, les applications des appareils à ailes rotatives comparées à ceux qui sont à ailes fixes, les contraintes juridiques et les contraintes de gestion de l'espace aérien, et les rôles potentiels où les UAV pourraient offrir un avantage immédiat. Il conclut que la surveillance est une application très probable, particulièrement dans le Grand-Nord canadien. Il est moins optimiste concernant les rôles des UAV armés, particulièrement en ce qui a trait au combat aérien. Les éléments critiques pour un développement futur du système sont une fiabilité accrue, un cadre réglementaire plus mûr et une base de clients plus stable.

With no shortage of enthusiasm and a degree of hyperbole in the press about the future of robotic flight, it is timely to examine the concepts and applications of Unmanned Aircraft Vehicles (UAVs) as they might apply to Canada, particularly in military usage. In the interest of full disclosure I served a full career in the Royal Canadian Air Force and Canadian Forces as a fighter pilot, so one might anticipate a certain defensive bias when it comes to UAV roles that might impact or diminish the role of piloted fighter aircraft. While I will strive to avoid any such distortions, I will argue that the most appropriate role for UAVs in the Canadian context is surveillance. While armed roles are theoretically possible I remain skeptical about their satisfying Canadian needs and about the efficacy of unmanned air-to-air platforms.

First, let's be clear on what we are talking about, it is necessary to recognize the wide variety of terminology in this field, and the attendant possibilities for ambiguity and misunderstanding. Common names for the airborne element of the system include drones, robots and decoys, as well as various acronyms: Unmanned (or Uninhabited) Aerial Vehicles (UAVs), Remotely Piloted Vehicles (RPVs), Remotely Operated Aircraft (ROA) and Unmanned Combat Aerial Vehicles (UCAVs) as the most popular.[1] I will employ the term UAV in this essay.

UAVs are powered aircraft flying in the atmosphere without a human presence aboard; they can be expendable but are normally reusable. They carry a payload that may be lethal or non-lethal.[2] Ballistic missiles, cruise missiles and artillery shells are specifically excluded from the definition.

To adequately explore the issues surrounding the use of UAVs we must fully recognize that the vehicle is but one element of a complex system—generally known as an Unmanned Aircraft System (UAS).[3] Essentially the vehicles are of no value without communications and a control station with human controllers, without properly configured payload elements and without systems to launch and recover the vehicle. Other components also contribute to the effectiveness of the system—navigation support (GPS is the most common now), ground support for fuel and consumables, maintenance, payload support, and transportation as appropriate while not airborne. Many elements of the system can be located very distant from the theatre of operations, thereby permitting a reduced 'footprint' in theatre, but also underscoring their dependence on reliable communications.

In systems analysis, the overall effectiveness of the system is limited by the effectiveness of the weakest link. The vehicle itself may not be that weakest link—more likely communications constitute that weakness. When distances are great, communications are generally routed via satellite links, thereby introducing various delays and vulnerabilities. They can be encrypted for security and may employ frequency diversity in order to avoid potential jamming. But even so it appears that an RQ-170 *Sentinel* surveillance UAV was lost over Iran in late 2011 due to loss of its control links.[4] Other examples exist of lost communication links leading to loss of UAV control, loss of data, and occasionally loss of the vehicle itself, with attendant loss of sensitive hardware and technology. I am not specifically aware of UAVs that have been spoofed or seduced from their command links by hostile cyber actions, but this is a foreseeable result in contested airspace. And at the least broadband jamming can interfere with both control and data reporting.[5]

Simply having access to adequate bandwidth for fleets of UAVs will become a limiting factor. Both the control links and the data links can be voracious consumers of radio frequencies, and the finite and limited spectrum will have to be judiciously allocated. For instance the imagery datalink needs of a *Global Hawk* can be 500 Mb per second.[6] In some short range applications, an unreeling spool of fibre optic cable is a very secure and reliable solution, and one with great bandwidth, but clearly one with range limitations.

1 Lawrence Newcome gives a detailed history of some 14 different appellations over the century or so of aircraft flight, in his Unmanned Aviation: a Brief History of Unmanned Aerial Vehicles (Reston, VA: American Institute of Aeronautics and Astronautics, 2004) 3.

2 *Ibid.* 1. Newcome uses the US Joint Publication 1-02 definition as his source.

3 Reg Austin, *Unmanned Aircraft Systems: UAVs Design, Development and Deployment.* (Reston, VA: American Institute of Aeronautics and Astronautics, 2010) 9-14.

4 Micah Zenko. "10 Things you didn't know about drones." Foreign Policy Blog, March/April 2012.

5 Although when dealing with satellite communications the vehicles' antennae will be directed upwards and away from ground based jammers.

6 Reg Austin. *Unmanned Aircraft Systems.* (Reston, VA: American Institute of Aeronautics and Astronautics, 2010) 151.

A very interesting aspect of any UAV is the degree of automation available to the ground controller and onboard the vehicle. Further to that is the degree of autonomy afforded to the system or the vehicle itself. While the words are similar the differences in their meanings are vast: automation refers to programmed capabilities to simplify routine tasks, while autonomy refers to the degree of human control inherent in any operation. Transfer of automation from the control station onto the vehicle facilitates increased autonomy, but does not assure such an outcome. Various authors have offered scales to measure both characteristics. NASA has presented five levels of automation and eight levels of autonomy,[7] while Reg Austin quotes a scale of degrees of automation/autonomy from 0 to 5.[8] The latter author also portrays a US Department of Defense 10-point scale for autonomy in groups of UAVs, reaching through levels of self-organization to fully autonomous swarms.[9]

Three comments may be offered with respect to these aspects. First, that automation by itself implies a degree of predictability in behaviour and the consequent vulnerability in combat situations. The second and opposing observation is that programmed responses when situated in unforeseen circumstances sometimes create unintended consequences—'automation surprises' as they are sometimes known. Thirdly, and critical for the application of military force, is the notion of control: the military, and the Canadian Forces in particular, exists to exercise the application or threat of *controlled* violence. There is a clear and continuous chain of command from the Chief of Defence Staff (CDS) to the lowest level trigger-puller. This concept applies with UAVs as well, which means that there should always be a human in ultimate control of any UAV that is delivering weapons. Artificial intelligence may eventually offer effective algorithms of control but these are not available in the short term. David Mets accurately summarizes the point: "Notwithstanding great technological advances … we shall insist on keeping a human "in the loop" to limit the chances for collateral damage or fratricide."[10]

UAVs are classified by range and altitude into rough groupings: High Altitude Long Endurance (HALE) vehicles operate above 50,000 feet and fly missions lasting as long as 36 hours. The *Global Hawk* jet-powered UAV is a prime example of this type, with the size of a modest airliner. Medium Altitude Long Endurance (MALE) UAVs operate up to about 25,000 feet and have mission lengths of 24 hours. They can provide continuous surveillance at tactical ranges and have the flexibility to be armed for strikes. The well-known propeller-driven *Predator* is the prime example of these. For shorter range requirements there is a very wide range of UAVs stretching right down to hand launched vehicles such as *Desert Hawk;* typically these vehicles allow a ground commander to see over the next hill and to patrol his close-in area of interest.

Fixed wing vehicles such as the above major categories need runways to launch and recover. For the smaller versions a catapult or hand launch will suffice and recovery can be by parachute or similar mechanisms. However, there is a decided simplicity in having a vertical take-off and landing (VTOL) system, and there are many types of helicopter variant UAVs that do just that. Probably the most successful Canadian UAV design is the 1980s vintage Canadair CL-227 *Peanut* that operates with contra-rotating helicopter blades. While limited to shorter ranges and lower altitudes by their aerodynamics and speeds, VTOL devices can readily be brought to the most forward areas of the battlefield or based onboard ships. They will naturally be of shorter range and shorter endurance, as well as having some limitations on their payload capacity, but their accessibility and responsiveness make them invaluable in the tactical realm. While there will clearly be a need for this type of UAV as a tactical platform in support of smaller units, I will focus on the longer range, longer endurance vehicles used in support of wider and often more strategic missions.[11]

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7 Quoted in Richard Barnhart et al. *Introduction to Unmanned Aircraft Systems.* (Boca Raton, FL: CRC Press, 2012) 112-113.

8 Reg Austin. *Unmanned Aircraft Systems.* (Reston, VA: American Institute of Aeronautics and Astronautics, 2010) 300.

9 *Ibid.* 316.

10 David R Mets. *Airpower and Technology: Smart and Unmanned Weapons.* (Westport, CT: Praeger, 2009) 190.

11 We also exclude the mini- and nano-UAVs which can approach insect sizes, and in theory can act in swarms.

Debates have taken place on the needs for international law to address UAVs as a category, but no such law exists. In the case of recognized armed combat they are constrained by the principles of the long-standing laws of armed conflict, which in particular require weapon systems to discriminate between combatant and non-combatant, and to employ minimum force to accomplish legitimate military requirements. In situations short of armed conflict, they are subject to the domestic legal regimes of the countries where they may operate; these regimes are of course unique to each country and often inconsistent between each other. Individual sovereignty considerations are dominant, but various approaches are developing with respect to surveillance and to privacy concerns.

As UAVs have been developed over the past several decades, their flights have mostly taken place in either reserved military airspace or in combat zones. In both environments they have not had to worry much about potential airspace conflicts with other aircraft or other users of the airspace. Now that much wider use is being planned, including civilian users of UAVs, the airspace control authorities, Transport Canada, the US Federal Aviation Administration (FAA) and others, have had to contemplate the required standards for safety of flight by UAVs. They focus on not creating a danger to existing users of the airspace nor to property on the surface.

Piloted aircraft are always operated on a 'see and be seen' basis: even when under Air Traffic Control direction pilots are responsible to take action to avoid any other aircraft they see in their area. The analogy in unmanned flight is a concept called Detect, Sense and Avoid (DSA).[12] Arguments can be made that a UAV can carry much better sensors than the pilot's eyeballs, and that fail-safe algorithms can be devised to conduct evasive actions. But all of that is overhead, which reduces the capacity of the payload in weight, power and frequency usage. In any event, such systems are still in rather early development; the noted analyst Reg Austin estimates it will take several decades before a light and affordable system could be available.[13]

Beyond the DSA system, a certification process for the operator and airworthiness standards for the vehicle and the system will be required, analogous to the measures for control of piloted aircraft. Setting such standards are urgent challenges for agencies such as the FAA, who have been given by Congress a 2015 target date to have a complete set of regulations for UAVs to operate in civilian airspace.[14] Up to now safety has been governed by individual flight authorizations (Special Flight Operation Certificates issued by Transport Canada for example), and separation is controlled either by piloted chase aircraft, or by segregation of designated airspace.

Turning now to the variety of potential roles for which UAVS are suited, the list is virtually limitless. However, to assess which roles are the most likely to be transferred to them is a bit easier. It is commonly asserted that UAVs are employed where the tasks are "dull, dirty, or dangerous".[15] In addition many believe that UAVs will be cheaper, smaller and more stealthy, higher performing, and less intrusive.[16] Not all of these expectations can be met simultaneously and some may be overly ambitious. Unmanned aircraft can indeed be smaller and lighter, but there will always be a human pilot/operator required somewhere in the system with attendant costs in communications and the like.

Related to the question of cost is the loss rate for UAVs. To date they are much more accident-prone than general aviation. It was observed by Richard Barnhart last year that UAV reliability will have to improve by two orders of magnitude (or 100 times) to compare to manned flight.[17] While some may think that an advantage of UAVs is that they can be lost with impunity, there are certainly costs associated with that philosophy—in system credibility as well as in money wasted.

12 Richard Barnhart et al. *Introduction to Unmanned Aircraft Systems.* (Boca Raton, FL: CRC Press, 2012) 138.
13 Reg Austin. *Unmanned Aircraft Systems.* (Reston, VA:American Institute of Aeronautics and Astronautics, 2010) 89.
14 Nick Paumgarten. "Here's Looking at You." *New Yorker.* (88:13, 14 May 2012).
15 Peter Singer. *Wired for War.* (New York: Penguin Press, 2009) 63. See also Austin, p5.
16 Reg Austin. *Unmanned Aircraft Systems.* (Reston, VA:American Institute of Aeronautics and Astronautics, 2010) 7.
17 Richard Barnhart et al. *Introduction to Unmanned Aircraft Systems.* (Boca Raton, FL: CRC Press, 2012) 176.

The list of realistic military roles is extensive—collection of intelligence, surveillance and reconnaissance (ISR), decoy, communication relay, electronic warfare, strike, suppression of air defences, target designation, air quality monitoring, logistic resupply and possibly interception. For completeness one might add a number of civilian roles such as crop survey and spraying, power line and pipeline inspection, mapping, weather, traffic services, police and fire services support.

However, the main plausible categories of roles for military applications for Canada will be surveillance, ground attack and air combat. Communication relay, decoying, electronic warfare and target designation can be considered to be variations on the performance of surveillance UAVs. Likewise we can include suppression of enemy air defences and strike in the category of ground attack.

There is no doubt that surveillance in its many guises can be readily and effectively accomplished by UAVs. Their persistence and reduced signature makes them very attractive in this role in its widest sense. Radio, optical, electro-optical, radar, infrared, and laser sensors are available and can establish patterns of behaviour in a thorough and consistent manner. This role is equally valuable at both the local tactical level (by *Predators* for instance), or at the wider, strategic level (by *Global Hawks*). This is a role that clearly fits into the 'dull' category of repetitive work. But it may also be 'dangerous' in hostile airspace.

Canada's North, with its wide expanses of sparsely populated territory, is an ideal fit for the HALE surveillance role, and indeed the government has been exploring this type of application.[18] A fleet of *Global Hawk* operating at high altitudes could cover these wider areas with little impact on other aviation, and could provide multi-spectral coverage of sovereign lands and waters that is otherwise not available. One might note that satellite sensors have lower resolution, lower revisit frequency and really cannot be directed as responsively as UAV coverage can. However, such a UAV solution is not inexpensive, with recent estimates ranging in the neighbourhood of $1billion for a *Global Hawk*-like program. It is nonetheless a needed, passive, defensive role, not requiring weapons - possibly a comfort to the Canadian population.

Moving on to armed UAVs, the *Predator* is the best example of a system that although designed for surveillance has some armed variants and can deliver precision weapons on surface targets once they are identified. Inasmuch as the CF deploys to hostile theatres of operations, this is an attractive capability, however it would appear to have very limited application at home. As the MALE system loiters at lower altitudes its sensors have increased resolution and quicker response to a developing situation. And the flexibility to launch weapons provides a very desirable agility of response—with a man-in-the-loop we should recall. So far Canada has been able to rely on coalition partner nations to provide this capability when deployed, and it may be reasonable to continue this posture.

What about Canada getting involved in targeted killings of terrorist leaders such as the US has recently been doing with drones in Pakistan and Yemen? Canada has no such aspirations to my mind. We have no covert intelligence system to operate abroad; we have no pattern of acquiring deep strike weapons systems[19]; and we have no interest in intervening in foreign lands unless it is with partners in a coalition of some sort. Canada has long had the technical capacity to acquire cruise missiles and an armed UAV would be the current analog of that capability. But Canadian policy has eschewed such involvement—the legal regime is often dubious and such actions would often seem inconsistent with Canadian values. Accordingly I would find it unlikely that we might wish to employ such weapons of precision intervention even if they might be available. The primary role for the Canadian Forces is to defend Canada at home and I do not foresee the utility of armed UAVs in that role.

18 Murray Brewster. "Ottawa considers high-altitude drones for Arctic surveillance: Ottawa looks at drones for North." *The Canadian Press.* 30 May 2012.

19 Operating CF-104s in a nuclear strike role in Europe in the 60s and early 70s might seem to contravene this idea, but it was a tactical usage and was cancelled after less than a decade.

The final role we will explore is that of air combat. Here I remain a skeptic. Although the US Air Force is investigating potential unmanned combat aerial vehicles (UCAVs) such as the *Boeing X-45* and the *Northrup-Grumman X-47,*[20] the concepts remain very sophisticated and complex. Theoretically higher performance can be achieved without having to cater to a human pilot's physical limits. However, ultimately success in this field will require artificial intelligence to a level as yet unseen. Aerial combat is a personal, creative activity where predictability is a sure route to defeat. Assuming a remote operator in the loop also suggests delays in decisions and in execution compared to a pilot in the cockpit. This is an expensive and elusive goal that, in my judgement, will not be achieved for some decades.

To close, we can see that UAVs have come a long way in recent years, largely due to dramatic improvements in miniaturization and communication technology. Their wide application to surveillance is almost assured; when it comes to delivering weapons or particularly to air combat the case is not as persuasive for Canada at present.

Looking ahead we turn to the judgement of another aviator, Lawrence 'Nuke' Newcome: "to develop further, unmanned aviation … needs improved reliability, a regulatory framework, and a stable customer base, in that order."[21] While his assessment dates almost a decade ago, its wisdom still stands today. We will watch the future with great interest.

20 Bill Yenne. *Attack of the Drones: a History of Unmanned Aerial Combat.* (St Paul, MN: Zenith Press, 2004) 105-119.

21 Laurence Newcome. *Unmanned Aviation: a Brief History of Unmanned Aerial Vehicles.* (Reston, VA: American Institute of Aeronautics and Astronautics, 2004) 136.

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