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THE USE OF UAS IN CANADA'S UNSEGREGATED AIRSPACE: FOUNDATIONS AND ROADMAP

Major J.S.F. Laplante

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L'UTILIZATION DE DRONES SANS SEGREGATION DANS L'ESPACE AERIEN CANADIEN: FONDATIONS ET PLAN D'IMPLEMENTATION

By Major J.S.F. Laplante
Par le major J.S.F. Laplante

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ABSTRACT

Recent Iraq and Afghanistan conflicts saw significant growth and success of Unmanned Aerial Systems (UAS) in roles ranging from intelligence gathering to strike missions. Accordingly, the technology associated with UAS has also benefitted from rapid investments and developments which now make UAS performance rival that of manned systems. Civilian applications of UAS technology are now explored domestically but, like for military users, face restrictions to operating in controlled airspace. Restrictions stem primarily from regulatory agencies responsible for safety of all airspace users and legal privacy considerations. As a result, UAS capability potential and demand surpass the current regulatory framework to support the full exploitation of the technology. This paper argues that, given the interest and substantial benefits to have a domestic and expeditionary UAS capability, there are requirements to pursue and present a comprehensive roadmap supporting the integration of UAS in Canadian controlled airspace. The capabilities delivered by UAS are presented and the opportunities and challenges of UAS unsegregated operation are discussed. Exploring the efforts of other countries' regulatory organizations, the final purpose of the paper will inspect the Canadian initiatives to regulate unsegregated UAS operation and discuss the roadmap for implementation. This analysis suggests that, considering technical limitations, the lack of a robust Canadian military UAS program and the limited appetite for civilian applications, the regulation of unsegregated UAS operation in Canada may not meet the established and desired timelines.

THE USE OF UAS IN CANADA'S UNSEGREGATED AIRSPACE: FOUNDATIONS AND ROADMAP

INTRODUCTION

The use of Remotely Piloted Aircraft (RPA) can be traced back to more than a hundred years ago. Initially used as targets to support naval and anti-aircraft systems, RPAs or Unmanned Aerial Vehicles (UAV) evolved to take on more complex roles in support of the military. Canada's military and industry have been involved in the development and operation of UAVs for over 60 years but the true Canadian potential of the technology emerged only recently during operations in South East Asia.[1] There, Canada successfully operated a number of Unmanned Aerial System(s) (UAS) to support ground operations and gained significant experience with the technology and its capabilities although most of the systems maintenance were leased or contracted from industry.[2]

The United States (US) military took the use of UASs to another level by developing systems that could also deliver weapons; a critical capability that acted as a force multiplier to troops deployed to Iraq and Afghanistan. The rapid proliferation of their use and the increase in the number of UASs seem to have preceded the regulatory requirements normally established for the use of airspace by manned aircraft. Indeed, the

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[1] MacDonald Detwiler Associates (MDA) Canada, "A History of Unmanned Aviation in Canada," (Canada: MDA Limited, 2008), 3. Last accessed 2 April 2013. http://www.uavs.ca/outreach/HistoryUAVs.pdf.

[2] UAS is a more appropriate acronym than UAV as it includes all components of the system instead of only the vehicle. Although Canadian regulations still uses UAV as a reference, this paper will predominantly use UAS to refer to the system.

airspace where UAS operated in both Iraq and Afghanistan was not representative of domestic or international controlled airspace elsewhere in the world and UAS operation forewent a formalized safety regulation framework. As a result, the risks of operating unmanned aircraft in a saturated combat airspace were high; risks which were accepted considering the benefits that UAS brought to the fight.

Although there exist no consistent airspace regulatory structure to match the technology, the operation of UAS in combat was successful and incidents between manned and unmanned aircraft sharing the same environment were rare. This climate of relative safety was achieved by having UAS operation emulate the safety procedures used by manned aircraft. However, UAS technology today still does not match certain safety attributes; a concern to airspace operators, managers and policy makers. The US Department of Defence (DoD) and the UAS industry have pursued greater, more fluid access to the National Airspace System (NAS) for the last decade in order to better support the training of military UAS operators and expand the potential use of the technology to civilian applications. Today, common in all countries, UAS flights are secluded to military training areas or segregated zones and all requests from industry and the military to fly in the NAS go through an elaborate review and approval process by regulatory organizations.

A more fluid access of UAS to the NAS (similar to manned aircraft's "file and fly" procedure) is met with caution in the US by the Federal Aviation Administration

(FAA) which cited gaps in the levels of safety that UAS can provide while operating next to manned aircraft and over populated areas. Consequently, little progress has been done to streamline UAS access to the airspace by the FAA. In addition, the opening of domestic airspace to commercial UAS application is also facing resistance from the public, concerned with breaches of privacy and potential criminal use of the technology.[3] Ethical considerations emerge from the proliferation of the domestic use of the technology which also affects the speed of integration of UAS in the NAS further in the US. Perhaps an indicator that the UASs' benefits are perceived to exceed their disadvantages or concerns, the US Congress, supported by the US President, recently passed a law directing the FAA to resolve the integration issue of UAS in the NAS by 2015.[4]

Notwithstanding the public's opposition and safety considerations that must be resolved, the presence of UAS sharing the airspace with manned aircraft will soon be a reality for US citizens because it is now legally supported. In Canada, the absence of a wide ranging military UAS program and the limited demand for civilian UAS services has not resulted in the same enthusiasm to chase the integration of the capability into Canadian airspace. However, there is still significant interest in Canada to open the domestic airspace to UAS in order to provide more access of the capability to emergency

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[3] Bart Elias, *Pilotless Drones: Background and Considerations for Congress Regarding Unmanned Aircraft Operations in the National Airspace System*, Washington: Congressional Research Service 7-5700 R42718, 2012, 9.

[4] 112th Congress, *Public Law 112-95* (Washington: US Government 14 Feb 2012), 73. Last accessed 25 March 2013. http://www.faa.gov/regulations_policies/reauthorization/media/PLAW-112publ95%5b1%5d.pdf.

services and other commercial applications such as surveying, crop dusting and other dangerous flying applications. In addition, it is highly possible that the Canadian Department of National Defence (DND) will be operating domestically or deploying UAS in future operations and the associated need for training UAS operators at home supports the integration of UAS in Canada's airspace.

So therein lies the problem; UAS capability potential and demand surpass the current regulatory framework to support the full exploitation of the technology. As a result, this situation impacts the potential economic gains that could be achieved by would-be UAS service providers hence the involvement of the US government, under pressure from industry lobby, to jumpstart the regulatory organizations for the resolution of the airspace integration situation. In order to maintain their respective competitive advantage; Europe, Canada and other countries are also pursuing similar resolution to UAS airspace access.

This paper will argue that, given the interest and substantial benefits to have a domestic and expeditionary UAS capability, there is a requirement to pursue and present a comprehensive roadmap supporting the integration of UAS in controlled airspace. The question will be addressed in five sections: First, the paper will present the origins of UASs by identifying critical technological advancements that contributed to operating aircraft remotely and the exclusive capabilities that UAS can deliver. Second, UAS' strengths and weaknesses will be inspected in order to decipher some of the myths surrounding UAS capabilities and identify where the technology lags that of manned aircraft. The third theme will study the opportunities and threats of UAS operating freely in unsegregated airspace which will lead to a review of international initiatives to resolve UAS integration as the fourth theme. Finally, the paper will review the Canadian airspace regulatory system and ongoing efforts to achieving unsegregated integration and report on the roadmap for implementation.

BACKGROUND

In defining UAS, one must carefully consider how the system is designed and what function it must accomplish. In some literature, the German V-1 and V-2s of the 1940s or the Fritz-X radio guided bomb are considered UAS whereas they resembled projectiles such as an arrow or javelin instead of a positively controlled aerial system.[5] For this discussion, a remote controlled missile will not be categorized as a UAS although it is acknowledged that is possesses similar flight capabilities. In order to differentiate the two, the remote controlled missiles, which are disposable, can be referred to as a weapon while UAS is referred to as a weapon system. This paper contends that a UAS has to possess a recovery element imbedded into its Concept of Operations (CONOPS).

Transport Canada (TC) defines Unmanned Aerial Vehicles (UAV) as “a power driven aircraft, other than a model aircraft, that is operated without a flight crew member

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[5] Louis C. Gerken, *UAV – Unmanned Aerial Vehicle* (Chula Vista California: American Scientific Corp., 1991), 6,

on board."[6] The FAA defines UAS as "the unmanned aircraft (UA) and all of the associated support equipment, control station, data links, telemetry, communications and navigation equipment, etc., necessary to operate the unmanned aircraft."[7] In other words, there is a distinct difference between a UAS, a remote controlled aircraft, an autonomous weapon and it is important to note that the UA is only part of the overall system.

Although humans have a very important role in the operation of unmanned systems, it is possible that future UAS operate independently in the future. Recent developments in artificial intelligence and innovations in autonomy question whether future UAS will have a requirement for a Man In The Loop (MITL) to support the decision making process.[8] The ethical questions emerging from the eventual automation of the technology are the source of many debates regarding the responsibility and the moral judgment relinquished to independently operating machines.[9] An in-depth analysis of the ethical questions on the eventual full automation of armed UAS is beyond the scope of the paper and, as a result, the paper will focus on the conventional MITL unmanned systems. The following chapter will discuss the origins of UAS, the technological innovations that made unmanned flight possible and the challenges associated with operating UAS in unsegregated airspace.

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[6] Transport Canada, Canadian Aviation Regulations (CARS) 101.01, "Definition of Unmanned Aerial Vehicle," last accessed 23 March 2013, http://www.tc.gc.ca/eng/civilaviation/standards/general-recavi-brochures-uav-2270.htm.
[7] United States. US Department of Transportation. Federal Aviation Administration (FAA). "Unmanned Aircraft (UAS) Questions and answers." Last accessed 23 March 2013. http://www.faa.gov/about/initiatives/uas/uas_faq/#Qn1.
[8] Elizabeth Quintana, "The Ethics and Legal Implications of Military Unmanned Vehicles," Occasional Paper, Royal United Services Institute for Defence and Security Studies (RUSI), 15.
[9] *Ibid*., 14.

UAS ORIGINS

Unmanned flight was the precursor to manned, heavier than air, experiments symbolized by the Wright Brothers. Indeed, in September 1903 a German scientist flew a pilotless biplane further and longer than the Wright's first flight at Kitty Hawk North Carolina on May 14, 1908.[10] Although the more recognized origins of unmanned aircraft go back to the 1920s and 30s with some development during the First World War (WWI), the most significant developments of drones and UAS' potential occurred in the 1960-70s.[11]

As with other highly technological ventures, the initial sponsors of UAS technology were military. The prime purpose of drones was, at the time, support to targeting for naval and army anti-aircraft weapon systems.[12] An actual flying target with programmable dynamic flight provided more realistic training for anti-air system operators. As the designs evolved, UAS developed in the following three main components: a vehicle which carries the payload, a ground control station to interface with the operator and the required electronic linkages to provide telemetry, sensor data and flight control commands.[13] The criticality of a reliable and robust communication links between components, capable of supporting a large amount of data is essential (and

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[10] Hugh McDaid and David Oliver, *Robot Warriors: The Top Secret History of the Pilotless Plane* (London: Orion Media, 1997), 10.
[11] Gerken, *UAV – Unmanned Aerial Vehicle…*, 6-10. Tesla had even envisioned a fleet of armed radio-controlled Pilotless Drones protecting America in 1915. http://www.vectorsite.net/twcruz_1.html
[12] *Ibid*., 6.
[13] Unmanned Aerial Systems Association, "UAS Components," last accessed 23 March 2013. http://www.uavs.org/index.php?page=uas_components.

the source of many challenges with today's technology). Radio equipment from the 1950s and 1960s used analog signals and restricted the exploitable bandwidth on the first UASs consequently limiting the operational viability of the systems.[14] Today's telecommunication systems can fully support the data exchange requirements but are still susceptible to jamming and interference; a key consideration for operation in unsegregated airspace.[15] The incident regarding the Lockheed Martin RQ-170 Sentinel which inadvertently landed in Iran in 2011 offers an example of the vulnerability of the system's communication links.[16] In addition to complex communication links, a particular invention paved the way to further advance unmanned flight. Progress in auto-pilot technology led to improvements in stabilization contributing to the resolution of the control issues experienced with the first UAS.[17] This innovation ensured that a pilot's command could be adhered to and maintained notwithstanding of the numerous variables that an aircraft must negotiate to achieve the desired flight path. Gyro-stabilization provides the benefits of inertia within the instruments and control systems which, by definition, seek to return the aircraft to a stable condition following an input from an operator.[18] For instance, as a command is given for the UA to turn right, several

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[14] Wikipedia, "Radio theory," last accessed 23 March 2013. http://en.wikipedia.org/wiki/Radio.

[15] Government Accountability Office, *Unmanned Aircraft Systems – Measuring Progress and Addressing Potential Privacy Concerns would Facilitate Integration Into The National Airspace Systems*, Report to Congressional Requesters (Washington, DC: US GAO 12-981, September 2012). 16.

[16] Politico, "Iran Drone Video Allegedly From US RQ-170 Sentinel Captured in 2011," last accessed 23 March 2013. http://www.politico.com/story/2013/02/iran-drone-video-allegedly-from-us-rq-170-sentinel-captured-in-2011-87311.html.

[17] Kenneth Munson, *World Unmanned Aircraft* (London: Jane's Publishing Company Limited, 1988), 7.

[18] National Aeronautics and Space Administration, "Brief History of Gyroscopes," last accessed 23 March 2013. http://solarsystem.nasa.gov/scitech/display.cfm?ST_ID=327.

commands must also be entered to the control surfaces, to adjust for wind, turbulence, maintenance of altitude in addition to an equal but opposite command to return to level flight once the turn has been completed. For a pilot flying with visual and physical cues, these complex commands controlling several flight surfaces become innate through training. The advent of gyro-stabilization technology simplified the pilots' work and allowed them to venture into Instrument Meteorological Conditions (IMC) where the pilot cannot determine alone the performance of the aircraft and relies on his flight instruments (now gyro-stabilized) to positively control the aircraft.[19] Thus, further development in gyro-stabilization allowed the pilots to input flight commands electronically instead of mechanically into the flight control system (this was the start of the auto-pilot) which further opened the potential for successful remote operation.[20]

For an UAS application, the complexity and amount of information that needs to be shared between the aircraft and the operator in the Ground Control Station (GCS) is staggering. Flight data must be first captured, relayed, interpreted by an operator and finally responded to by a command. Considering the limited bandwidth of the radios used in the 1960-70s, the limited technology available to capture data (all analog sensors) and the significant time delays to close a simple command loop between the vehicle and the operator, it is no surprise that the reliability of the first UAS was questionable. Although

[19] Skybrary, "Instrument Meteorological Conditions (IMC)," last accessed 23 March 2013. http://www.skybrary.aero/index.php/IMC.

[20] William Scheck, "Lawrence Sperry: Autopilot Inventor and Aviation Innovator," Historynet.com (12 June 2006). Last accessed 2 April 2013. http://www.historynet.com/lawrence-sperry-autopilot-inventor-and-aviation-innovator.htm.

similar challenges still affect the technology today, stabilization can be attributed a significant part of the success of unmanned flight.[21]

Another important and essential factor in the development of UAS is miniaturization. The ability to insert more capable sensors, computers and communication equipment in the available space and weight an UAS affords, had a significant impact on remote-controlled flight ability.[22] With more capability per weight ratio, the technology allows large platforms to support numerous sensors and provide longer endurance while smaller, more capable UAS designs are a possibility.

These developments resulted in the production of a wide array of UAS (solar powered, lighter than air, fixed wing and rotary) which are usually grouped by size and weight. In Canada, DND groups UAS in tiers: Tier One has a Maximum Take Off Weight (MTOW) of 5001Lbs or greater (such as the High Altitude Long Endurance (HALE) Global Hawk or Medium Altitude Long Endurance (MALE) Predator), Tier Two with a MTOW of 185 to 5000lbs (such as the Seeker, Heron) and Tier Three with a 0-184lbs MTOW (such as the Skylark, Scan Eagle and others).[23] It is important to note that the classification of UAS differs from one organization to the next. For instance,

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[21] Government Accountability Office, *Unmanned Aircraft Systems – Measuring Progress and Addressing Potential Privacy Concerns…,* 16.

[21] Politico, "Iran Drone Video Allegedly From US RQ-170 Sentinel Captured in 2011," last accessed 23 March 2013. http://www.politico.com/story/2013/02/iran-drone-video-allegedly-from-us-rq-170-sentinel-captured-in-2011-87311.html.p.16 could be a good source

[22] About.com, "The History of the Integrated Circuit," last accessed 23 March 2013. http://inventors.about.com/od/istartinventions/a/intergrated_circuit.htm.

[23] Department of National Defence, Royal Canadian Air Force, *1 Canadian Air Division Orders*. Vol. 2 – Flying Orders (Ottawa: DND Canada, 21 Dec 2012), Glossary.

even organizations from the same country have differing terms; TC classifies UAS in three classes: less than 35kg, more than 35 but less than 150kg and more than 150kg.[24] The implications and differences between UAS classifications as it applies to operating in unsegregated airspace will be explored later. Today, UAS can be as large as airliners or as small as a bird such as the Nano Air Vehicle program sponsored by the Defence Advanced Research Projects Agency (DARPA) at Figure 1.[25]

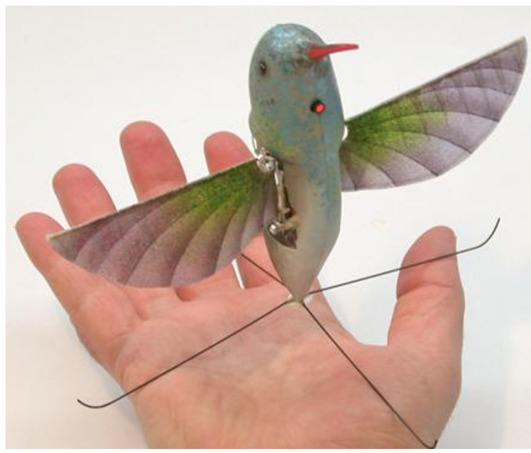

Figure 1: AeroVironnement Hummingbird Nano UAS.[26]

With the help of flight stabilization and miniaturization, from simple targeting drone beginnings, the military identified UAS as a potential surveillance and reconnaissance platform. During the Vietnam War, American Ryan 147 Remotely Piloted Vehicles (RPV) conducted thousands of Intelligence Surveillance and Reconnaissance

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[24] Transport Canada, UAV Working Group, *Transport Canada Civil Aviation Unmanned Air Vehicle Working Group Final Report* (September 2007), table 18-2. Last accessed 4 March 2013. http://www.tc.gc.ca/eng/civilaviation/standards/general-recavi-uavworkinggroup-2266.htm.
[25] DARPA, Defense Science Office, "Nano Air Vehicle," last accessed 24 March 2013. http://www.darpa.mil/Our_Work/DSO/Programs/Nano_Air_Vehicle_(NAV).aspx
[26] *Ibid.*

(ISR) sorties into enemy territory covering multiple targets per mission with a survival rate of 90%; the technology had significant potential to do more than acting as simple target training devices.[27] During the same period, in addition to the US, several other countries invested in the development of UAS technology including Canada, France, the UK, Germany, the Russian Federation, Israel, India, etc.[28] An example of Canadian innovation during the same period was the introduction of the CL227 Sentinel depicted in figure 2.[29]

Figure 2: The Canadair CL227 Sentinel.[30]

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[27] Kenneth Munson, *World Unmanned Aircraft* (London: Jane's Publishing Company Limited, 1988), 7.
[28] *Ibid*., 8.
[29] Gerken, *UAV – Unmanned Aerial Vehicle…* 15. Canada's contribution to the development of UAS materialized through numerous drones but more particularly through the CL227 sentinel (Flying Peanut) program depicted in Figure 2, the system is a Vertical Takeoff and Landing (VTOL) platform with an Electro-Optic and Infrared (EO/IR) sensor. Canadair successfully demonstrated the technology with the Canadian Military and all US armed services but did not result in significant commitment from potential customers. The subsequent upgrade to the model, the CL327 Guardian developed in the late 1990s afforded little more success. It is unfortunate that so little success was achieved considering the concept behind the development of the sentinel, which was built to military specifications (contrary to the majority of other UAS), was designed to deploy from land and maritime platforms and loiter over a target for an extended amount of time thereby providing highly stabilized quality images not subject to constant re-positioning of the platform; a marked nuisance in fixed wing designs.
[30] Unreal Aircraft, "Canadair CL227 Sentinel and CL 289," last accessed 24 March 2013. http://unrealaircraft.com/qbranch/sentinel.php.

UAS technology interest seem to be cyclic reaching its apogee in times of war and quickly disappearing from political and public interest in times of peace. Israel's Yom Kippur War of 1973 also saw a re-emergence of UAS and since the situation in Israel demands constant military action, its UAS industry thrived providing a significant amount of modern systems and influencing the industry today.[31] In fact, although the technology and use of UAS significantly increased during the Vietnam War, it was the Israeli operations in the Bekka Valley in 1982 where Israeli Air Force (IAF) UAS spotted Syrian Surface to Air Missile (SAM) batteries, which may have re-ignited the US' interest in unmanned platforms.[32]

Canada's military has had limited interest and commitment in the technology although DND does use extensive contracted services to provide targeting during exercises (MEGGIT's Vindicator) and tailored services for domestic and deployed operations (Scan Eagle, Heron,).[33] However, ongoing UAS procurement projects remain at the development phase and assets have yet to be procured and put into operation.[34] Since Canada has no current need for a deployed UAS capability, the use of available manned ISR systems such as the Aurora to support DND's needs and that of other

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[31] David Rodman, "Unmanned Aerial Vehicle in the Service of the Israel Air Force," Gloria Center (7 September 2010), last accessed 24 March 2013. http://www.gloria-center.org/2010/09/rodman-2010-09-07/.

[32] Wikipedia, "Operation Mole Cricket 19," last accessed 24 March 2013. http://en.wikipedia.org/wiki/Operation_Mole_Cricket_19.

[33] Chris Thatcher, "JUSTAS: Seeking the Right Solution," Vanguard (1 February 2013), last accessed 24 March 2013. http://vanguardcanada.com/justas-seeking-the-right-solution/.

[34] Levon Bond, "JUSTAS and Project Epsilon: Integrated Intelligence, Surveillance and Reconnaissance of the Canadian Arctic," *Canadian Military Journal* Vol 11, no. 4. Last accessed 24 March 2013. http://www.journal.forces.gc.ca/vo11/no4/24-bond-eng.asp.

government organizations presents an inexpensive and readily available option which reduces the immediate necessity to pursue a domestic UAS capability.[35] As a result, the UAS story with DND has been marked by Just In Time (JIT) delivery of the technology at the cost of losing the technical experience of trained personnel and corporate knowledge in the UAS ISR business.

Today's UAS are capable of conducting a number of missions in support of a commander. They can carry sophisticated sensors such as Electro-Optic and Infrared (EO/IR), Synthetic Aperture Radar (SAR), Electronic Warfare (EW) packages and acoustics sensors to name but a few.[36] UAS can provide communication relay capability (to include video, voice and data), that give commanders the ability to reach his/her troops within an extensive Area of Responsibility (AOR) thereby offering a more flexible yet less expensive option than access to expensive satellite communication systems.[37] As witnessed with the recent Afghan and Iraq conflicts, UAS are now able to deliver strike capability. Consequently, UAS missions can be applied to all operational functions of the Canadian Military Doctrine: Command, Sense, Act, Shield, Sustain and Generate.[38] The Command domain includes the joint effects targeting capability which UAS can assist in providing. The Sense domain is heavily based on ISR which UAS are renowned and well

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[35] *Ibid*.
[36] E.J. Schweicher, "Various Sensors Aboard UAVs," *NATO Science and Technology Organization Collaboration Support Office* (July 1999): 10-1, last accessed 24 March 2013. http://ftp.rta.nato.int/public//PubFulltext/RTO/EN/RTO-EN-009///EN-009-10.pdf. 1.
[37] *Ibid*.
[38] Department of National Defence, B-GJ-005-000/FP-001, *CFJP 01Canadian Military Doctrine*. (Ottawa: Canada, 2011-09), 2-7, last accessed 24 March 2013. http://www.cfc.forces.gc.ca/JCSPDL/Readings/B-GJ-005-000-FP-001_e.pdf.

suited for. Provided with a strike capability, UAS have proven indispensable to provide persistent armed ISR thereby supporting the Act domain. The Shield and Sustain domain have used UAS to deliver Force Protection (FP) and support the movement of troops and material convoys in dangerous areas. Finally, UAS are an indispensable force generator providing significant data to support training evolution and evaluation of tactics.[39]

With such specific and specialized capabilities developed in support of military operations, one must be careful not to omit the civilian applications where the technology can also be exploited. Ultimately, the role of UAS is to remove aircraft operators from functions where humans limit the capacity of the platform to achieve the mission either by physiological limitations or risk mitigation. UAS are best used in Dull, Dirty and Dangerous (3D) environments and have found some niche in civilian applications such as crop dusting (Japan) and border surveillance (US).[40] Several applications such as forest fire surveillance, fisheries, pollution patrols, surveying, mining and other minor tasks such as real estate aerial photography and sports coverage are examples where UAS could be used in a civilian setting.[41] Further commercial applications include: motion picture, utility and infrastructure inspection, surveying and mapping, cargo and

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[39] *Ibid*.
[40] Bart Elias, *Pilotless Drones: Background and Considerations for Congress Regarding Unmanned Aircraft Operations in the National Airspace System*, Washington: Congressional Research Service 7-5700 R42718, 2012, 2.
[41] CBC News. “Drones Fly Over Calgary Snapping Photos.” 8 Jan 2013. Last accessed 24 March 2013. http://www.cbc.ca/news/canada/calgary/story/2013/01/08/calgary-photo-drone-real-estate.html.

commercial security.[42] The net economic effect is the primary justification for the proliferation of UAS in domestic airspace. Industry estimates that government and commercial UAS market could amount to $89 billion worldwide over the next ten years.[43] As a result of the military and civilian growth into the UAS segment, there is a requirement for legislation, standardization and the potential opening of controlled airspace to UAS operators. Today, all commercial UAS in the National Airspace can only operate under a specific permit or Certificate of Waiver and Authorization (COA) and reserved airspace provided by Air Traffic Control (ATC) that is blocked to all other traffic; thereby working in a segregated environment.[44] In Canada, TC is addressing each demand on a case by case basis, issuing a Special Flight Operation Certificate (SFOC) after a formal submission by the system's operators.[45] Consequently, the process of flying UAS in controlled airspace either in the US or in Canada is arduous and does not offer a lot of flexibility for UAS operators to carry out their work domestically. Considering that large UAS have the ability to operate Beyond Line Of Sight (BLOS) and thereby can cross national, international and oceanic airspace boundaries within a single flight, the necessity of coordinating the resolution of UAS operating in unsegregated airspace

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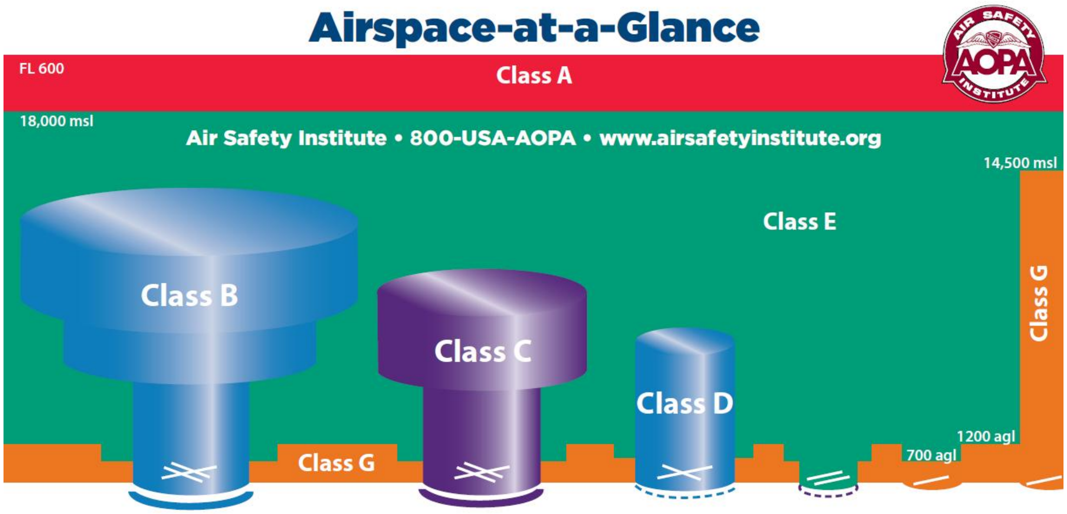
[42] Matthew T. DeGarmo, "Issues concerning Integration of Unmanned Aerial Vehicles in Civil Airspace." Centre for Advanced Aviation System Development MITRE Corporation 04W0000323 McLean Virginia, 2004, 1-16.
[43] Government Accountability Office, *Unmanned Aircraft Systems – Measuring…*, 2.
[44] Bart Elias, *Pilotless Drones: Background…*, 6.
[45] Transport Canada, "Unmanned Aerial Vehicle – UAV," last accessed 24 March 2013. http://www.tc.gc.ca/eng/civilaviation/standards/general-recavi-uav-2265.htm.

becomes an operational necessity.[46] In order to provide the reader with a broad understanding of the classes of airspace, a summary is provided at Figure 3.



Communication Requirements and Weather Minimums

Features	Class A	Class B	Class C	Class D	Class E	Class G
Minimum Pilot Qualifications	Instrument Rating	Student*	Student*	Student*	Student*	Student
Entry Requirements	IFR: ATC Clearance VFR: Operations Prohibited	ATC Clearance	IFR: ATC Clearance VFR: Two-Way Communication w/ ATC	IFR: ATC Clearance VFR: Two-Way Communication w/ ATC	IFR: ATC Clearance VFR: None	None
VFR Visibility Below 10,000 msl**	N/A	3 Statute Miles	3 Statute Miles	3 Statute Miles	3 Statute Miles	Day: 1 Statute Mile Night: 3 Statute Miles
VFR Cloud Clearance Below 10,000 msl***	N/A	Clear of Clouds	500 Below 1,000 Above 2,000 Horizontal	500 Below 1,000 Above 2,000 Horizontal	500 Below 1,000 Above 2,000 Horizontal	500 Below 1,000 Above 2,000 Horizontal
VFR Visibility 10,000 msl and Above**	N/A	3 Statute Miles	3 Statute Miles	3 Statute Miles	5 Statute Miles	5 Statute Miles
VFR Cloud Clearance 10,000 msl and Above	N/A	Clear of Clouds	500 Below 1,000 Above 2,000 Horizontal	500 Below 1,000 Above 2,000 Horizontal	1,000 Below 1,000 Above 1 Statute Mile Horizontal	1,000 Below 1,000 Above 1 Statute Mile Horizontal

* Prior to operating within Class B, C, or D airspace (or Class E airspace with an operating control tower), student, sport, and recreational pilots must meet the applicable FAR Part 61 training and endorsement requirements. Solo student, sport, and recreational pilot operations are prohibited at those airports listed in FAR Part 91, appendix D, section 4.
** Student pilot operations require at least 3 statute miles during the day and 5 statute miles visibility at night.
*** Class G VFR cloud clearance at 1,200 agl and below (day): clear of clouds. See FAR 91.155(b) through (e) for additional regulations.

Figure 3: Classes of Airspace.[47]

[46] Jerry N.Simon and Michael S. Braasch, "Deriving Sensible Requirements for UAV Sense and Avoid Systems," *IEEE Xplore* 978-1-4244-4078-8/09, 6C 4-2, last accessed 24 March 2013. http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=5347439&tag=1., 6C 4-2
[47] Aircraft Owners and Pilots Association, "Airspace at a Glance," last accessed 24 March 2013. http://www.aopa.org/asf/publications/airspace2011.pdf.

Stressing the requirement for the development of regulations for UAS operations in unsegregated airspace, the JUSTAS Statement of Requirement (SOR) specifically states that DND's UAVs "shall be able to operate in non-segregated Class A, B and C IFR airspace IAW DND policies."[48] Consequently, in order to satisfy the military objective to conduct UAS operations freely in *all* of the Canadian domestic airspace, the current regulations require amendment to satisfy the SOR requirements; this is a task that is neither simple nor that is expected to be completed rapidly.

This first chapter presented the origins of UAS and introduced gyro-stabilization and miniaturization as the two main technological innovations that allowed the development of the capable systems available today. These elaborate systems have flight characteristics similar to that of manned aircraft and now challenge the use of common airspace previously exclusive only to manned aircraft. However, are these same UAS systems ready or capable to operate next to manned aircraft or in the vicinity of populated areas? A study of the performance and challenges facing UAS technology is necessary to develop a UAS integration plan and will be the principal topics of the following sections. The next chapter will discuss the specific strengths and weaknesses associated with UAS.

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[48] Department of National Defence. *Joint UAS Surveillance and Target Acquisition System (JUSTAS) Statement of Requirements (SOR) V2.0.* (Ottawa: 2012), 9/40.

UAS STRENGTHS AND WEAKNESSES

Proponents of UAS assert that in certain domains, the technology exceeds the capabilities of manned aircraft.[49] Admittedly, removing the human element from danger while operating a very capable aircraft from the safety of a ground station is appealing but do UAS strengths outweigh their weaknesses? This chapter will explore the main attributes of UAS and consider their weaknesses compared to existing manned platform assigned the same tasks. Through the use of examples and statistics related to their performance within a given task and environment, this section will present the Canadian Military perspective to UAS and rationalize the current situation for the reader. Considering the ever increasing capacity and capabilities of UAS, the last section of the chapter will discuss the ethical dilemma(s) linked to fully autonomous systems.

A MATURE TECHNOLOGY

A significant strength of UAS technology is persistence. Depending on the type of UAS, some designs such as the Zephyr developed by QinetiQ of the UK, can loiter for weeks and even months over a given area.[50] More common UAS such as the Heron from IAI, Predator or the Reaper from General Atomics, have endurance exceeding 20 hours and the advent of lighter than air UAS promise even longer flights.[51] The ability to launch

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[49] Department of Defence, USAF, "Air Force Unmanned Aerial System (UAS) Flight Plan 2009-2047," Presentation by LtGen Deptula DCOS ISR, 2009, 9.
[50] Air Force Technology, "Zephyr Solar-Powered HALE UAV, United Kingdom," last accessed 24 March 2013. http://www.airforce-technology.com/projects/zephyr/.
[51] Hugh McDaid and David Oliver, *Robot Warriors: The Top Secret History of the Pilotless Plane* (London: Orion Media, 1997), 107.

a platform and its sensors for a flight much longer than it is possible with a manned aircraft has significant technical advantages (i.e. less maintenance per flight and no need to support a human pod) but also presents remarkable operational benefits. Uninterrupted surveillance provided by UAS not only translates into a better support to the customers of UAS products, it also means that fewer assets are required to support the same mission. Consequently, this reduction in the number of platforms required to support a given mission results in a considerable increased efficiency in manning to fly and maintain the system thereby generating significant savings for the UAS owners and customers.[52]

With over a hundred years of innovation and development, UAS seem to have attained a level of maturity rivaling that of manned flight. UAS are using the latest fly by wire and composite technologies and utilize the latest processors and software available.[53] Navigation equipment supported by the Global Positioning System (GPS) combined with inertial navigation instruments now provide a three dimensional position that is accurate to less than 10 meters. Precision equipment such as Differential GPS (DGPS) and laser systems used to support approaches and landing are accurate to one meter or less (the Heron system uses this technology for instance) making safe automated takeoff and landings a reality.[54] UA's improving flying reliability and accurate navigation systems should logically result in a more dependable system. However, the complexity of

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[52] Department of the Air Force, *The U.S. Air Force Remotely Piloted Aircraft and Unmanned Aerial Vehicle Strategic Vision* (Washington DC: USAF, 2005), 6-7, last accessed 4 March 2013. http://www.af.mil/shared/media/document/AFD-060322-009.pdf.
[53] *Ibid.*, 5.
[54] Morag Chivers, "Differential GPS Explained," *ESRI*, last accessed 24 March 2013. http://www.esri.com/news/arcuser/0103/differential1of2.html.

the information received by the sensors which detect an UA's behaviour, the significant computing power required to assess, transmit and interface with the operator significantly increases the amount of computations required over that of a manned aircraft and require secure communication links to complete the control loop.[55] As a result, although UAS demonstrate signs of technical maturity, the significant computing functions required and the vulnerability of the communication links increase the potential for failure somewhere in the system and contributes to ongoing reliability challenges.

UAS Operator training presents both a strength and a weakness for the system. Taking for example the Reaper program in the US which is one of the most comprehensive in the world, operator training has matured where operators, picked from qualified IFR-rated Pilots, go through a rigorous training program before being employed operationally.[56] However, the certification process and standards have yet to be regulated at the civilian level and for the regulators such as the FAA, this situation presents a significant risk to other manned aircraft operating in the same environment. Because the military system is self-normalized with regards to the certification of its pilots (including UAS operators) and while it adheres to or surpasses the national requirements, there is a need to resolve the UAS operator certification gap with clear direction from national and civil airspace authorities.[57] In order to support all potential UAS operators (civilian or

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[55] Government Accountability Office, *Unmanned Aircraft Systems – Measuring…* 17.
[56] Department of the Air Force, "Air Force UAS Flight Plan 2009-2047,"…, 32,
[57] Department of National Defence, Directorate of Flight Safety, A-GA-135-003/AG-001, *Flight Safety Manuals* (Ottawa: DND Canada, 2013), last accessed March 2013. http://www.rcaf-arc.forces.gc.ca/dfs-dsv/page-eng.asp?id=1719.

military) and alleviate the risks associated with a lack of certification, the FAA and TC have explored the requirement for UAS pilots and maintainers certification.[58] In essence, the intent is to create a separate category for UA operators because of the potential for personnel other than pilots to fly these aircraft. The strength of the approach potentially reaches a wider pool of UAS operators. Efforts are being made to provide guidance on technical instruction, testing and physical certification for UAS operators.[59] A shared objective from the various international organizations addressing this issue is to make the certification of UAS and overall operation akin to that of manned aircraft. Logically, this path should result in a more manageable implementation and easier acceptance by the aviation community for UAS operations in unsegregated airspace. Although operator training is in place in military circles, UAS operator and maintainer certification and standards processes comparable to manned aircraft for both civilian and military applications, must be resolved in order to operate within unsegregated airspace.

An objective evaluation of UAS capabilities identifies several weaknesses that are at the origin of the delays in making the technology more prominent in today's airspace. Although the technology has matured, the complexity of the system contributes to ongoing and significant technical issues that have thankfully resulted, until now, in limited material damage and no direct human casualties. For example, one of the largest UAS operating in the US; the Global Hawk, had a major mishap in June of 2012resulting

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[58] Transport Canada, UAV Working Group, *Transport Canada Civil Aviation Unmanned Air Vehicle Working Group Final Report*, (September 2007), Sections 16 and 17. Last accessed 4 March 2013. http://www.tc.gc.ca/eng/civilaviation/standards/general-recavi-uavworkinggroup-2266.htm.
[59] *Ibid.*, 27/61.

in the uncontrolled crash in the Maryland swamps. A loss of authority on the flight surfaces and a mismanaged emergency from the crew were identified as the contributing factors to the incident.[60] In Canada, there are several flight safety incidents related to the operation of UAS and one of the most prominent and related directly to DND was the 2010 crash of a Heron MALE UAS during an Australian training mission in Suffield Alberta. The crash, attributed to an erroneous altimeter setting from the pilot, resulted in the complete loss of the aircraft, cut power lines and a brush fire.[61] These two examples are evidence that the systems retain serious flaws and reflect accurately the flight safety data collected: human *operators* account for a fifth of the cause for UAS accidents.[62] From an outside observer, it appears that although the material-related accident rate has diminished for UAS over the years, the human factor remains and represents an important training and proficiency issue.[63]

The assumption that UAS are inherently less expensive to operate than manned aircraft may be another weakness of the design and needs to be explored further. While it may be true that smaller and less complex systems are inexpensive to purchase and operate, the MALE and HALE technology implementation and support costs are

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[60] Aram Roston, "How a Large US Navy UAV Crashed in Maryland, from 18000 feet," *Defense News* (7 January 2013), last accessed 24 March 2013. http://www.defensenews.com/article/20130107/C4ISR02/301070006/How-Large-U-S-Navy-UAV-Plummeted-From-18-000-Feet?odyssey=mod%7Cnewswell%7Ctext%7CFRONTPAGE%7Cp.

[61] Department of National Defence, Directorate of Flight Safety, "Aircraft Occurrence Summary," *Investigation Report Heron 255 16 July 2010*, last accessed 24 March 2013. http://www.rcaf-arc.forces.gc.ca/vital/dfs-dsv/nr-sp/docs/I/epi/heron255-16jul10.pdf.

[62] Sharon D. Manning, *et al.*, *The Role of Human Causal Factors in US Army Unmanned Aerial Vehicle Incidents,* (USAARL Report No. 2004-11, March 2004), 5. Last accessed 24 March 2013. http://www.dtic.mil/cgi-bin/GetTRDoc?Location=U2&doc=GetTRDoc.pdf&AD=ADA421592

[63] *Ibid*.

comparable to and sometimes higher than that of manned platforms. While the operation of UAS may result in operational savings through variables such as the initial acquisition costs, domestic and deployed infrastructure required, the support systems and the location limitations where the UAS can be operated, recovered and launched present restraints that need to be considered when compared against manned systems.

The argument for UAS operational costs savings, for a similar manned platform, is that the fuel and personnel required to power the UAS are significantly lower to that of manned aircraft.[64] For instance, let's consider for comparison a deployed large UAS (MALE/HALE) on an armed ISR task; the comparative acquisition costs of a single seat fighter aircraft is nearly twice that of a MQ-9 Reaper.[65] In the same context, the support systems required to achieve the mission are more complex for the UAS than that of the manned system. The large bandwidth and satellite communications and navigation systems required to support the UAS are an integral part of its ability to carry out the mission and therefore the cumulative support costs are substantial.[66] Although some

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[64] Department of the Air Force, *...Unmanned Aerial Vehicle Strategic Vision...*, 6.
[65] Ashley Boyle, "The US and its UAVs: A Cost-Benefit Analysis," *American Security Project (ASP),* (24 July 2012), last accessed 24 March 2013. http://americansecurityproject.org/blog/2012/the-us-and-its-uavs-a-cost-benefit-analysis/.
[66] Tim Bonds, et al., "Employing Commercial Satellite Communications: Wideband Investment Options for the Department of Defense," *Rand Project Air Force*. (Arlington VA: Rand Corporation, 2000), 113. Last accessed 24 March 2013. http://www.dtic.mil/cgi-bin/GetTRDoc?Location=U2&doc=GetTRDoc.pdf&AD=ADA379491. For example, a research in 1998 situated the Satellite communications needs for the USAF at US 1.2B.

capabilities such as satellite communication are also leveraged by manned aircraft, the complexity and demand is significantly less than that of the UAS fleet.[67]

The infrastructure required presents some similarities between manned and unmanned aircraft. Both require a paved and supported airfield to deploy, both need a maintenance organization, administrative and operational support. The differences in infrastructure are more tangible at the technical level as the UAS will require specific ground navigation and communication facilities and additional real estate for the Ground Control Stations (GCS), short range communication and launch/recovery equipment.[68] In contrast, a single-seat fighter aircraft can deploy as a self-contained system and support missions with only limited infrastructure, communication and ground maintenance. The requirement to have complex ground support equipment to support UAS operation introduces another variable to the efficiency of the platform. Because today's UAS can only deploy to an established location and, as a result, offer less flexibility than that of a fighter aircraft, the deployment of additional support infrastructure is a significant additional cost to UAS operation.

[67] Henry Kenyon, "As UAV Grows, Bandwidth Limits Become a Concern," *GCN*, (19 Oct 2010), 2. Last accessed 24 March 2013. http://gcn.com/Articles/2010/10/19/Air-Force-Ponders-UAV-Technologies.aspx?Page=2. and http://medillonthehill.net/2012/02/attack-of-the-drones-the-hidden-dangers-of-more-unmanned-aircraft/

[68] Department of Defence, "Selected Acquisition Report: MQ-9 UAS Reaper," *Defense Acquisition Management Information Retrieval*, RCS: DD-A&T(Q&A)823-424 (Washington: 31 December 2011), 37. Last accessed 24 March 2013. http://www.dod.mil/pubs/foi/logistics_material_readiness/acq_bud_fin/SARs/DEC%202011%20SAR/MQ-9%20UAS%20REAPER%20-%20SAR%20-%2031%20DEC%202011.pdf.

Table 1 summarizes the comparative cost analysis of the above discussion for manned and unmanned platform types. The conclusion to be drawn from the cost analysis between UAS and manned aircraft is, depending on the type of UAS and the manner it is operated, costs are similar. Costs are highly dependent on the type of UAS used and mission assigned. For a HALE and MALE UAS, the research indicates that costs are comparable to that of manned aircraft. For smaller UAS, acquisition and operation costs may be significantly less than that of manned platforms.

Cost Factor	UAS	Manned aircraft
Acquisition	Less Expensive	More expensive (up to 10 times more for similar capabilities)
Operation **(Fuel and Operators)**	Less expensive (Better endurance, less iterations to support the same mission)	More expensive
Support Communications	Very expensive (satellite access and infrastructure measured in Billions)	Relatively inexpensive
Support **Infrastructure**	Expensive and Complex	Inexpensive

Table 1: Comparative cost of UAS with Manned aircraft

There exist advantages to using UAS and options that are not readily available to manned aircraft. Some of the cost constraints of using UAS can be alleviated by foregoing the acquisition and relying on contractors to provide the service. Considering the financial situation and urgency of the requirement to support a UAS deployment to East Asia, DND relied heavily on Alternate Service Delivery (ASD) during the Afghan conflict. For instance, the ASD approach allowed MacDonald Detwiler Associates (MDA) to become a worldwide provider of tailored ISR support services.[69] ASD delivered the capability faster and cheaper than the formal governmental acquisition process could have. Further supporting this approach is the relatively shorter training requirement of the crews to operate UAS systems (although future certification requirements may level the training bill to that of manned aircraft).

Military ASD initiatives, where civilian entities deliver a portion of the capability (maintenance, training for instance), have a positive effect on industry growth and allow the military to advance other related technology segments.[70] The military UAS delivery through ASD approach represents a strength in contrast to manned aircraft where the complexity of the systems cannot be easily delivered by industry in a timely manner to address an urgent need. In civilian applications, UAS introduce the possibility for significant cost savings. For instance, very capable small UAS are now available at a

[69] MacDonald Detwiler Associates (MDA) Canada, "Persist-INT On Demand Surveillance Services," last accessed 25 March 2013. http://www.uavs.ca/defence/overview/.
[70] *Ibid*.

purchase price of less than $1000.[71] Their affordability, ability to take high quality pictures and fly in confined spaces, make them a great option for law enforcement, emergency services and other commercial applications such as pipeline surveying and aerial filming.[72] For instance, the sole acquisition costs of a Predator used to patrol the US-Mexico border is approximately $4.5 Million while a P-3 manned aircraft used for the same purpose is around $36 Million.[73] Combined with increased endurance and cheaper operating costs, UASs present a net strength over a manned option.[74]

In addition, small UAS used in civilian applications provide significant flexibility. Many small civilian UAS can be carried in a backpack-type container and be prepared and launched in a matter of minutes.[75] The operation of the systems supported by inexpensive auto pilot and stabilization software, often available free online, adds to the strength of UAS in civilian applications.

In contrast, airspace restrictions and exploitation permits are established for the commercial use of small UAS in Canada to control the technology and reduce the risks for potential air-to-air conflicts and can only be approved by TC.[76] Consequently, although small UAS can easily be deployed and operated in Canadian airspace, they

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[71] Chris Anderson, "Here Comes the Drones," *Wired* (July, 2012), 102.
[72] *Ibid*., 105.
[73] Jason Blazakis, "Border Security and Unmanned Aerial Vehicles," *Congressional Research Service, Report for Congress* RS21698, 2004, CRS-4.
[74] *Ibid*.
[75] Canadian American Strategic Review, "Draganflyer X8 UAV," November 2010, last accessed 25 March 2013. http://www.casr.ca/doc-acan-draganflyer-uav.htm.
[76] CBC News. "Drones Fly Over Calgary Snapping Photos" 8 Jan 2013. Last accessed 24 March 2013. http://www.cbc.ca/news/canada/calgary/story/2013/01/08/calgary-photo-drone-real-estate.html.

suffer the same restrictions imposed on military systems where their inherent flexibility is limited by airspace segregation requirements. An organized and well legislated opening of airspace to unsegregated UAS operations will likely have tremendous impact on availability, services and proliferation of UAS technology in both military and commercial sectors.

The analysis of UAS strength and weaknesses in this paper has purposely omitted the clear attribute of removing humans from the dangerous battle space. In essence, this technology has the distinctive strength of allowing UAS operators to project power without projecting human vulnerability.[77] This attribute is easily noticeable in a military context but can also be a benefit in civilian applications. For instance, following the March 11th 2011 Japanese earthquake and Tsunami, American Global Hawks flew over the irradiated area in dangerous circumstances to collect data and imagery of the area.[78]

By further giving UAS a strike capability, the lethality of the system combined with the complete safety of its operators are the source of ethical discussions. The argument is that there is a disconnect between the capabilities of UAS, the proportionality of military effort and the leveling of forces in the battlefield.[79] In other words, the advantages gained by the users of strike-capable UAS far exceed the ability of the

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[77] Department of the Air Force, "Air Force UAS Flight Plan 2009-2047,"…, 4.

[78] Tony Capaccio, "Northrup Drone Flies Over Japan Reactor to Collect Data," *Bloomberg*, 17 March 2011, last accessed 25 March 2013. http://www.bloomberg.com/news/2011-03-16/northrop-grumman-drone-to-fly-over-japan-reactor-to-gather-data.html.

[79] Patrick Lin, "Ethical Blowback from Emerging Technologies," *Journal of Military Ethics*, 9, no. 4 (2010): 313. Last accessed 25 March 2013. http://www.tandfonline.com/doi/pdf/10.1080/15027570.2010.536401.

opponents to retaliate on an equal field. From a military perspective, the argument is not rational since the objective of military action according to Clausewitz "will always be the art of defeating our opponent in combat" and "at every instant be on the defensive and thus should place our forces as much under cover as possible."[80] As a result, to disregard the capability available in a soldier's arsenal from a military standpoint is irresponsible. UAS are merely the evolution of the military tools such as the first club used by our Stone Age ancestors was an extension of their fists in combat. Similarly, the ethical questioning of the use of UAS is a reminder of the banning of crossbows by the church in medieval times where the use of the weapon was cited as a contradiction to chivalry.[81]

The weakness associated with the proliferation of UAS is that the availability and lethality of smaller systems make the technology available to all and, in time, will naturally level the battle space. Another ethical question arises from the development and use of fully automated systems capable of flight, targeting and engagement without MITL safeguards. Although the technical issues may be resolved to achieve the capability, allowing an autonomous drone to carry out a strike mission unassisted raises the question of who, if not the UAS, can afford responsibility for the actions carried out by the UAS? While there is work being done on generating "ethical governor" routines in UAS software which would prevent inadvertent strikes against the wrong targets, the

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[80] Carl von Clausewitz, *Principles of War*, ed. and Trans. Hans W. Gatzke (The Military Service Publishing Company, 1942), last accessed 25 March 2013. http://www.clausewitz.com/readings/Principles/#I.
[81] Lin, "Ethical Blowback from Emerging Technologies,"…, 320-321

philosophical dilemma remain.[82] The Ronald Arkin's team ethical governor research, in essence, attempts to program a fail-safe virtual decision-making system with specific guidance to address a plethora of potential ethical, safety and moral situations.[83] The prospect of a robot taking the decision of launching a weapon or not is an extreme ethical example that complements Isaac Asimov's three laws of robotics originally developed in the 1940s:

> 1. A robot may not injure a human being or, through inaction, allow a human being to come to harm.
> 2. A robot must obey orders given it by human beings except where such orders would conflict with the First Law.
> 3. A robot must protect its own existence as long as such protection does not conflict with the First or Second Law.[84]

The real possibility of a drone conducting an autonomous flight in controlled airspace raises similar ethical questions and an equal need for sturdy decision–making software. Although a fully automated system able to process information faster, devoid of emotions and governed by strict rules is likely be more efficient and safe than the current MITL system, it represents a weakness because it cannot ethically attribute the responsibility of UAS actions to a person.[85] This last conundrum raises the concern that if this technology is controlled by terrorists, ethical questions may not limit the use of such

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[82] Ronald C. Arkin, Patrick Ulam, and Brittany Duncan, "An Ethical Governor for Constraining Lethal Action in an Autonomous System," Georgia Tech Online Publications, Technical Report GIT-GVU-09-02, last accessed 28 March 2013. http://www.cc.gatech.edu/ai/robot-lab/online-publications/GIT-GVU-09-02.pdf.
[83] *Ibid*.
[84] Auburn University, "Isaac Asimov's Three Laws of Robotics," last accessed 2 April 2013. http://www.auburn.edu/~vestmon/robotics.html.
[85] Elizabeth Quintana, "The Ethics and Legal Implications of Military Unmanned Vehicles," Occasional Paper, Royal United Services Institute for Defence and Security Studies (RUSI), 2008, 16.

weapons because the cost-benefit of fully automated UAS would be advantageous. Finally, the prospect of fully autonomous systems waging wars against other autonomous systems resulting in limited human casualties raises the concern that war would now be too easy to engage in. A quote by General Lee summarizes the latter concept: “It is well that war is so terrible, or we would grow too fond of it.”[86] By de-humanizing war through autonomous systems, the resultant may be increased instability and nations more inclined to use military action to resolve petty differences. Consequently, autonomous future UAS-led wars may exacerbate the human condition rather than serving to resolve political differences.

The maturity of UAS technology makes it a credible candidate to take some of the duties away or contribute to manned aircraft missions. The short discussion of UAS’ strengths and weaknesses above reveals that several attributes are countered by weaknesses that require careful evaluation by potential operators. For instance, the inexpensive UAS acquisition costs compared to that of manned aircraft is countered by significant costs in infrastructure and support systems requirements. UAS technology which affords more capability and autonomy is also at the center of ethical discussions which restricts the full development and use of autonomous systems. It is recognized that UAS equipment is expected to expand and the legislation of unsegregated airspace used by military and civilian operators will likely expedite the development of standards that will allow a more fluid integration of unmanned aircraft in controlled airspace.

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[86] Lin, “Ethical Blowback from Emerging Technologies,”…, 325.

Considering UAS strengths and weaknesses presented, the next chapter will further explore the opportunities and threats associated with UAS and their integration in the airspace.

UAS OPPORTUNITIES AND THREATS

The ability to operate UAS in non-segregated airspace presents a number of opportunities to both military and civilian enterprises. Consider for instance a simple joint training mission located in Alberta requiring ISR support whereas the UAS base could be located on Vancouver Island, British Columbia a province away. While acknowledging that there exists the possibility to airlift the entire system to the area of operation as it is stated in the requirements of the JUSTAS system: “The UAS, including support vehicles, shall be transportable by CF CC130 aircraft,” it is important to note the additional costs and complexity associated with the limited Canadian airlift capacity to support domestic operations and other costs incurred by deploying the UAS team and material.[87] In contrast, the capability to task the UAS to support the domestic exercise or operation without the need to deploy the assets and personnel would result in significant savings, a reduction in the complexity of the support required and a smaller footprint at the deployed location. In order for the UAS to support the mission from its home base, it must takeoff, travel and proceed to the area while sharing the airspace with other manned traffic and receive clearances by ATC after the mission to coordinate the flight back to

[87] Department of National Defence, *Joint UAS Surveillance and Target Acquisition System (JUSTAS) Statement of Requirements (SOR) V2.0.* (Ottawa: 2012), 10/40.

BC. Currently, the only way for the military to support such a mission is to reserve and segregate all airspace to be used by the UAS and afford sufficient buffer with adjacent traffic for added safety.[88] These restrictions can only be organized through an onerous approval process that requires significant lead time and, realistically, the segregation of a large amount of airspace spanning two provinces in a busy corridor is unlikely. Having the ability to proceed with an unsegregated ATC clearance would allow added flexibility and support UAS operations to the same extent as manned aircraft operating in IFR conditions. Building on this example, this chapter will explore the military and civilian opportunities and contrast them with the associated threats to allowing unsegregated UAS operations.

OPPORTUNITIES

The opportunities for UAS in unsegregated airspace can be derived by their inherent capability and by identifying the gaps in ISR coverage that UAS are designed to fill. Therefore, a brief examination of the current Canadian ISR platforms is necessary. Canada possesses several manned ISR platforms in its inventory of which the fixed wing assets are the CP140 Aurora and the CF188 Hornet.[89] Other platforms fill the ISR role with some limitations such as the Sea King and Griffon helicopters and the leased Scan

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[88] Transport Canada. Staff Instruction 623-001. *The review and Processing of an Application for a Special Flight Operations Certificate (SFOC) for the Operation of an Unmanned Air Vehicle (UAV) System,* Ottawa: General Aviation Office SI 623-001 Issue 01, 27 Nov 2008, last accessed 4 March 2013. http://www.tc.gc.ca/media/documents/ca-opssvs/623-001_1.pdf, 3.
[89] Department of National Defense, "Royal Canadian Air Force Aircraft," last accessed 25 March 2013. http://www.rcaf-arc.forces.gc.ca/v2/equip/index-eng.asp.

Eagle tactical UAS assists the Canadian Army (CA) and Royal Canadian Navy (RCN) on exercises and deployments.[90] While also noting that the upcoming replacement to the Sea King: the CH148 Cyclone, will have significant ISR capabilities, this analysis will focus on the two fixed wing platforms as they compare closest to the capabilities the Joint UAS Surveillance and Target Acquisition System (JUSTAS) program is destined to deliver.[91] Though the Auroras and Hornets can support ISR missions, the Aurora (although capable) currently lacks air-to-ground strike capability and the Hornet lacks the persistence sought by customers of armed ISR. An UAS provides both persistence and some designs, including the intended capabilities of the JUSTAS program, can also provide air-to-ground strike capability to a level matching that of manned platforms.[92]

As part of a Joint Task Force, both Auroras and Hornets deployed successfully in support of Op MOBILE under TF LIBBECCIO in 2011. While Hornets were tasked to conduct air strikes, Auroras were used to acquire intelligence for mission support. Libyan airspace presented surface-to-air threats and risk mitigation measures were necessary to ensure the safety of manned platforms thereby limiting their ability to freely operate in the area.[93]

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[90] Combined Maritime Forces, "HMCS Regina Disrupts Probable Drug Exchange," 15 Janurary 2013, last accessed 25 March 2013. http://combinedmaritimeforces.com/2013/01/15/hmcs-regina-disrupts-probable-drug-exchange/.
[91] Department of National Defence, *Joint UAS Surveillance and Target Acquisition System (JUSTAS) Statement of Requirements (SOR) V2.0...*, 13/40 (chapter 5).
[92] *Ibid*., 29/40.
[93] Department of National Defense, Canadian Joint Operations Command (CJOC), *Op Mobile*, last accessed 25 March 2013. http://www.cjoc.forces.gc.ca/exp/mobile/index-eng.asp. It is important to note that initially Auroras were not allowed to fly over land and only and high altitude keeping a significant

In high threat environments, there exist clear opportunities to facilitate UAS operation than manned aircraft through the entire elimination of risk to personnel. In addition, UAS platforms can provide more surveillance missions in regions where there are unknown threats.[94] The proliferation of UAS usage in recent conflicts by Canada's allies serves as a testimony to the capability.[95] In Afghanistan, Canada's organic ISR support was provided by UAS instead of manned aircraft. Limited real estate available at the deployed location for crews, planes, maintenance facilities and the presence of a surface-to-air threat did not support the deployment of Canadian manned ISR platforms.[96] Consequently, while recognizing the dangers in planning for future wars by resolving issues from previous conflicts (i.e. prepare for the last war); the potential for future deployment of UAS to a conflict with similar threats is high.

UAS present an appealing and low risk option to provide vital ISR services to Canadian commanders. In a climate of military budget constraints where alliances and other foreign commitments must be supported, UASs are an interesting investment opportunity for Canada. In other words, UAS technology and the associated high demand for ISR services would, if adopted by DND, represent a relatively inexpensive niche of expertise and contribution to a coalition effort such as a mission supported by NATO or

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distance from shore due to SA threats. Eventually, Auroras were allowed to conduct overland operations towards the end of the mission.

[94] Jacqueline D. Van Ovost, "Global Mobility: Anywhere, Anytime, Any Threat? Countering the Manpads Challenge," occasional paper no. 38 Air University Maxwell AFB, Alabama, 2005, 22. Last accessed 25 March 2013. http://www.dtic.mil/cgi-bin/GetTRDoc?Location=U2&doc=GetTRDoc.pdf&AD=ADA463420.

[95] Department of the Air Force, "Air Force UAS Flight Plan 2009-2047,"…, 5

[96] Jacqueline D. Van Ovost, "Global Mobility: Anywhere, Anytime, Any Threat?..., 10.

the UN.[97] It is realistic to affirm that Canada is likely to use UAS in the future on deployed and domestic operations that could include humanitarian and law enforcement assistance components.[98] Resolving the unsegregated airspace operation question will present significant opportunities domestically.

Recalling the scenario of the training mission in Alberta and considering the requirement for a deployed capability for future Canadian UAS systems, the ability of operating freely in Canadian controlled airspace would represent a positive Force Generation (FG) factor.[99] In other words, by supporting training exercises at home simulating the capability expected to be used abroad or domestically, the UAS crews would be able to train and maintain their readiness for Force Employment (FE).[100]

Secondly, the appetite for and noticeably increased use of UAS data by intelligence agencies from all elements support the inclusion of these specific ISR platforms in joint operations and training exercise. The ability to put into effect, through training, all aspects of ISR data collection from tasking to distribution is consolidated through national doctrine where "the central tenet of the CF is to have adaptable, combat-ready, deployable forces *trained* [emphasis added] and willing to fight and win in support

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[97] Pierre Claude Nolin, "Unmanned Aerial Vehicles: Opportunities and Challenges for the Alliance," Special report for the NATO Parliamentary Assembly (November 2012), 5.
[98] Department of National Defence, B-GJ-005-300/FP-001, CFJP 3.0 - *Operations* (Ottawa: Chief of the Defence Staff, 2011-09), 6-9, 6-10. Last accessed 28 March 2013. http://www.cfc.forces.gc.ca/JCSPDL/Readings/B-GJ-005-300-FP-001_e.pdf.
[99] Department of National Defence, B-GJ-00500-000/FP-001, CFJP 01 *Canadian Military Doctrine,* (Ottawa: Chief of the Defense Staff, 2011), GL-3
[100] *Ibid*.

of Canadian government interests."[101] A facilitated access to the domestic airspace for the Canadian Military UAS assets, will contribute to both FG and domestic FE of the capability.

The mandatory requirements outlined in the JUSTAS SOR cite specifically that the intent for UAS fleet is to support up to three lines of tasking daily of which one is domestic and up to two Force Employment missions are either deployed or domestic.[102] An ability to support domestic training and operations from home base would alleviate technical and manpower pressure, which would translate into increased availability of the assets to commanders. In other words, fully integrating UAS operations and its products into a joint exercise while being able to support the task without deploying ground support, personnel and equipment from home base would result in significant savings in logistic and administrative costs. As a result, the capability of UAS to operate in unsegregated airspace not only presents practical but also potential financial benefits to Canadian commanders.

Looking outwardly from a military UAS perspective, the flexibility of operating in unsegregated airspace to support FG requirements for all elements of the Canadian Forces also presents an opportunity for UAS to carry out FE missions in domestic airspace and, consequently, in international controlled airspace. As a result, DND would be better positioned to deploy its UAS capability worldwide in support of military

[101] *Ibid*., 6-1.
[102] Department of National Defence, *JUSTAS SOR...*, 8/40.

activities. However, because support to Other Government Department (OGD) missions such as security, fisheries, drug interdiction, pollution patrols, forest fire surveillance, etc., is not DND's primary interest, OGDs may revert to their own UAS resources.[103] For instance, the RCMP are investing heavily into small tactical UAS to support accident scene surveying, provide a bird's eye view for tactical teams and assistance in locating missing persons.[104] In the US, the Customs and Border Protection (CBP) uses UAS extensively to patrol the Mexican border; apprehending more than 1000 illegal migrants a year and have used them also in disaster response.[105] Realistically in Canada, OGD support may better be delivered by civilian UAS service providers who could be contracting their skills to the government, similar to services delivered by industry to DND in Kandahar for the Heron by MDA and the continuing provision of the Scan Eagle capability by ING Robotic Aviation.[106] This opportunity is likely to generate an increase in civilian UAS investment which, through the competitive process, may reduce OGD expenses even further. Although the proliferation of UAS through the opening of the airspace to unsegregated flight presents several opportunities, there is a need to consider the negative impact of such an initiative. The following section will explore threats introduced due to UAS use in domestic and international airspace.

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[103] Glennon J. Harrison, *Unmanned Aircraft Systems (UAS): Manufacturing Trends*. (Washington, DC: Congressional Research Service R42938, 30 January 2013), 5. Last accessed 4 March 2013. http://www.fas.org/sgp/crs/natsec/R42938.pdf.

[104] Douglas Quan, "Not Just for Modern Warfare: RCMP to Expand Use of Drone Mini-Helicopters," *The National Post* (27 Jan 2013): 2, last accessed 25 March 2013. http://news.nationalpost.com/2013/01/27/not-just-for-modern-warfare-rcmp-to-expand-use-of-drone-mini-helicopters/.

[105] Rusty L. Weiger, "Military Unmanned Aircraft Systems in Support of Homeland Security," Master's thesis, U.S. Army War College, Pennsylvania, 2007, 5.

[106] Defense Industry Daily, "Canada, Australia Contract for Heron UAVs," 17 July 2011. last accessed 25 March 2013. http://www.defenseindustrydaily.com/Canada-Contracts-for-Heron-UAVs-05024/.

THREATS

UAS still suffer from the effects of early experimentation and operational failures that contribute to the difficulty of gaining the public's acceptance and confidence in the technology. The Heron crash in Suffield, AB in 2010 and its associated damage to public property serves as a recent example of the failures that affected the public's acceptance of the technology.[107] Truthfully, there are significant risks in operating unmanned systems in the same vicinity as manned aircraft or over populated areas. These risks or threats are present in various realms such as financial, technical, legal, ethical, political and regulatory standards. This section will explore the many detractors to making unsegregated flying for UAS a possibility. Referring to Maslow's psychological analysis of human's hierarchy of needs, the detractors from UAS technology can be organized similarly as depicted in figure 4.[108]

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[107] Department of National Defence, Directorate of Flight Safety, "Aircraft Occurrence Summary,...
[108] Saul McLeod, "Maslow's Hierarchy of Needs," last accessed 25 March 2013. http://www.simplypsychology.org/maslow.html#.

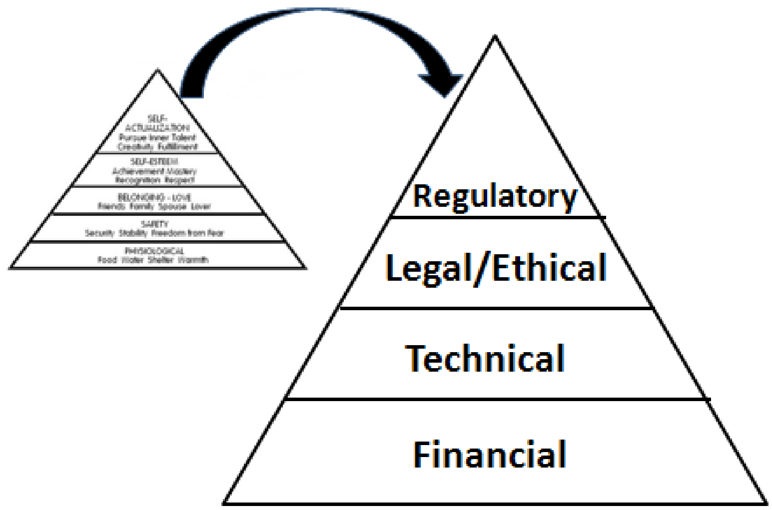

Figure 4: Pyramid of Detractors based on Maslow's pyramid of needs.[109]

In order to achieve the aim of flying UAS in unsegregated airspace, the detractors cannot be addressed and resolved or addressed in isolation. This paper suggests that all of the detractors need to be resolved or at least sufficiently mitigated for the objective to be attained.

At the very base of *the pyramid of detractors* resides the financial factor. Without financial support and resource commitment from governments and organizations involved, the process cannot proceed further up to the next level. Although the affordability of UAS has been approached in Chapter Two as a strength of the system, when compared to manned aircraft, there still remains a measure of financial and

[109] *Ibid*.

resource constraints related to the purchase, support and manning of the capability.[110] Furthermore, most UAS currently in service do not have the equipment suite which would allow them to fly in unsegregated airspace and require additional funds for re-fit. In Canada, the Canadian Forces Defence Strategy (CFDS) does not specifically identify JUSTAS as a major procurement program.[111] Delays in the procurement of the main Canadian military UAS acquisition will likely translate in further delays in the implementation of the unsegregated plan in Canada. Furthermore, a recent interview with the newly appointed Commander of the Air Force, Lt General Blondin, indicates that the Canadian Air Force may not be ready to pursue this capability immediately because other technologies are emerging and the JUSTAS program competes with other pressing government procurement.[112] In the US, the UAS programs are also under significant review and deal with potential consolidation of their various projects which have been widely expanded throughout the four services.[113] As a result, unless financial resources are committed to the capability, the possibility of operating UAS in unsegregated airspace is threatened.

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[110] Ashley Boyle, "The US and its UAVs: A Cost-Benefit Analysis," *American Security Project (ASP),* (24 July 2012), last accessed 24 March 2013. http://americansecurityproject.org/blog/2012/the-us-and-its-uavs-a-cost-benefit-analysis/.

[111] Department of National Defence, *Canada First Defence Strategy,* (Ottawa: DND Canada, June 2010), 12.

[112] Chris Thatcher, "Seeking Alternatives: New RCAF Commander Turns to Technology," *Vanguard* (7 January 2013), last accessed 24 March 2013. http://vanguardcanada.com/seeking-alternatives-new-rcaf-commander-turns-to-technology/.

[113] CRS Report for Congress, "Intelligence, Surveillance, and Reconnaissance (ISR) Programs: Issues for Congress," 22 Feb 2005, CRS-1. Last accessed 28 March 2013. http://www.dtic.mil/cgi-bin/GetTRDoc?Location=U2&doc=GetTRDoc.pdf&AD=ADA447906.

The second level in the pyramid of detractors reflects the reality that without adequate technology to address all of the requirements set by airspace governing agencies and securing the financial backing to support the efforts, the opening of the airspace to unmanned systems cannot be achieved. The problematic sense and avoidance problem can be addressed through a number of electronic sensors which are already being used on manned aircraft. For instance, the Automatic Dependent Surveillance-Broadcast (ADS-B), a system that sends own flight information and can receive the broadcasts from other aircraft in the same vicinity can contribute to traffic de-confliction.[114] For a UAS, being able to receive this information would help in resolving the situational awareness and collision avoidance challenges. However, the system is optional at the moment and a malfunction would result in other aircraft not broadcasting or not receiving the UAS flight information.

An active traffic avoidance system is currently in use with large manned aircraft; the Traffic Alert and Collision Avoidance System (TCAS). TCAS uses the aircraft's transponder and an interrogator to broadcast and sense the proximity and conflicting flight paths from other aircraft.[115] The system processes the information and displays an avoidance path for any conflicting traffic. TCAS does not inject commands into the flight control system but for a UAS, it could potentially be linked directly to flight controls and

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[114] United Nations, International Civil Aviation Organization (ICAO), *Operational Use of ADS-B in Non-Radar Airspace Generic Design Safety Case,* ICAO Separation and Safety Panel, 1.0. Last accessed 4 March 2013. http://adsb.tc.faa.gov/RFG/ADS-B%20in%20NRA%20Saftey%20Case.pdf.
[115] James K. Kuchar, and Ann C. Drumm, "The Traffic Alert and Collision Avoidance System," *Lincoln Laboratory Journal* 10, No. 2 (2007): 280. Last accessed 4 March 2013. http://www.ll.mit.edu/publications/journal/pdf/vol16_no2/16_2_04Kuchar.pdf.

eliminate the delay in the operator's response to the TCAS cues.[116] ADS-B and TCAS were developed in an effort to improve the performance of the see and avoid responsibility of manned aircraft while operating in IFR conditions. Because of the nature of UAS operation and control, systems will predominantly operate under IFR rules. Consequently, it would appear that through such collision avoidance systems, the sense and avoid requirements of Advisory Circular 90-48C (AC90-48C); which outlines the responsibilities and techniques to be used by pilots in collision avoidance and one of the principal documents restricting the NAS access to UAS, would be partially met.[117] But these systems are only optional on smaller personal aircraft, especially those that typically operate under Visual Flight Rules (VFR).[118] As a result, unless ADS-B and TCAS is made mandatory to all users of the airspace (which is highly unlikely for the foreseeable future), the requirement to "see and avoid" still applies for UAS in unsegregated airspace. In order to operate UAS in unsegregated airspace with sufficient sense and avoid capability to satisfy FAA's AC90-48C, the UAS may require a self-sustained, all around, active traffic detection system such as air-to-air Radar. UAS operations may be constrained by the amount of technology they can support (weight,

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[116] *Ibid*.

[117] US Department of Transportation, Federal Aviation Administration (FAA), *Advisory Circular 90-48C – Pilot's Role in Collision Avoidance*. AC 90-48C, 18 March 1983. Last accessed 5 March 2013. http://rgl.faa.gov/Regulatory_and_Guidance_Library/rgAdvisoryCircular.nsf/list/AC%2090-48C/$FILE/AC90-48c.pdf.

[118] Transport Canada, Canadian Aviation Regulations (CARS) Part VI, "General Operating and Flight Rules," last accessed 23 March 2013. http://www.tc.gc.ca/eng/civilaviation/regserv/cars/part6-subpart2-3281.htm.

power, antenna, etc.) to achieve this pre-requisite to fly in unsegregated airspace.[119] Accordingly, small UAS may not be able to operate in controlled airspace given the challenges raised by the sense and avoid system.

Taking into consideration the growth of the industry and the financial implication of the technology, the UAS' eventual presence in unsegregated airspace is highly likely. The multiple operational and commercial opportunities that UAS offer civilian and governmental organizations need the implementation of a more fluid access to airspace in order to avoid the onerous approval process currently in place in Canada and the US. However, over 10 years of pressure on regulating agencies such as the FAA and TC from industry seeking market opportunities have yet to result in the satisfactory guidance and legislation required to address the associated threats.

The third level of the pyramid of detractors is legal and, more specifically, ethical issues of operating UAS in domestic airspace. There are two main ethical questions arising from the use of UAS in unsegregated airspace. First the responsibility for the system's actions when it operates autonomously and second, the respect of individuals' privacy while operating UAS surveillance systems. Because fully autonomous UAS in unsegregated airspace is likely to be a long term goal, the common understanding is that, although remotely located from the actual aircraft, a human operator will be in control of

[119] Government Accountability Office, *Unmanned Aircraft Systems – Use in the National Airspace System and the Role of the Department of Homeland Security*. Report to Congressional Requesters, (Washington, DC: US GAO 12-889T, July 2012), 6.

the system as a whole for the foreseeable future.[120] Consequently, this paper contends that the responsibility for the operation and safety of the aircraft remains fully with the UAS operator and is a condition to operating in non-segregated airspace. The ethical question of robots operating independently has been the subject of numerous articles and debate in the *Journal of Military Ethics*.[121] The question of fully autonomous UAS diverges from the scope of this paper and, as a result, although the ethical dilemma is acknowledged, the fully autonomous question will not be pursued further.

Nevertheless, aside from autonomous conduct, UAS operations raise other ethical issues. Since the UAS' main purpose is to collect data through sensors, questions concerning privacy are critical. The possibility of having Canadians snooping on Canadians is possible and presents a problem that has not been addressed specifically for unmanned vehicles. In Canada, Section 8 of the Charter of Rights state that "[e]veryone has the right to be secure against unreasonable search or seizure."[122] This right regulates the actions of police and government entities towards its citizens. However, there are some nuances with expectations of privacy which have been at the forefront of significant debate because the legal system has yet to catch up with the technology.

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[120] Mark Edward Peterson, "The UAV and the Current and Future Regulatory Construct for Integration into the National Airspace System," *Journal of Air Law and Commerce* 71 (2006): 531.
[121] P.W. Singer, "The Ethics of Killer Applications: Why is it so Hard to Talk About Morality When it Comes to New Military Technology?" *Journal of Military Ethics* Vol. 9 No. 4 (2010): 303.
[122] Canada Heritage, "Human Rights Program – Legal Rights Section 8," last accessed 25 March 2013. http://www.pch.gc.ca/pgm/pdp-hrp/canada/guide/lgl-eng.cfm#sec8.

For instance, the expectation of privacy from a citizen in his fenced backyard could be breached by a UAS (or manned platform) flying overhead.[123] Because DND and police forces already possess airborne surveillance equipment on manned aircraft, it is important to note that the guidelines currently imposed on existing surveillance systems would still apply to UAS. For example, the privacy act specifically states that "no personal information shall be collected by a government institution unless it relates directly to an operating program or activity of the institution."[124] In other words, unless the surveillance is supported by a warrant, the collection of information on specific individuals is prohibited. The legal system is adjusting its policing access to information such as cellphone technology. In some cases, an unprotected cellphone (a cellphone without a password protection) in Canada can now be the subject of a police search without a warrant and is not considered an invasion of privacy.[125] This legal dilution of the individual's privacy protection, if unchecked, could potentially affect a similar dilution to the controls governing UAS' gathered information. However, a distinction must be made in the case of public gatherings; if an individual partakes in a public gathering, that individual relinquishes some of his/her expectations of privacy. For instance, images collected by individual citizens using their own cameras (i.e. surveillance systems) during the 2011 Vancouver Stanley Cup riots combined with the

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[123] Paul McBride, "Beyond Orwell: The Application of Unmanned Aircraft Systems in Domestic Surveillance Operations." *Journal of Air Law and Commerce* 74 (2009): 642-643.
[124] Minister of Justice. *Privacy Act.* Ottawa: Minister of Justice, 1985, 4.
[125] Peter Small, "Privacy rights: Police can search unprotected cellphone without warrant, appeal court rules," *The Star*. 20 Feb 2013, last accessed 25 March 2013. http://www.thestar.com/news/crime/2013/02/20/privacy_rights_police_can_search_unprotected_cellphone_without_warrant_appeal_court_rules.html.

city's security cameras have been used by the legal system to prosecute offenders. There was no expectation of privacy during that public event and the surveillance equipment was not focused on one person in particular.[126] As a result, one can infer that the same conditions and expectations might apply to an UAS.

In an attempt to regulate surveillance systems further, the Office of the Privacy Commissioner (OPC) has developed a list of guidelines to govern the manner by which surveillance can be carried out and what information can be used to prosecute any offense witnessed by the systems.[127] Although the guidelines call for policy to be implemented, they are not legally binding and only appeal to the good will of the operators of surveillance systems and be conscious of individuals' rights to privacy.[128]

In the US, the situation is similar with the fourth amendment as the overarching document governing the privacy of its citizens. The Constitution's Fourth Amendment guarantees:

> The right of the people to be secure in their person, papers and effects shall not be violated by unreasonable searches and seizures and no warrants shall issue, but upon probable cause supported by Oath or affirmation and particularly describing the place to be searched, and the persons or things to be seized.[129]

[126] Vancouver Police Department, "Vancouver Police Department 2011 Stanley Cup Playoff Riot Review," 6 September 2011, last accessed 25 March 2013. http://vancouver.ca/police/assets/pdf/reports-policies/vpd-riot-review.pdf.
[127] Minister of Justice. *Privacy Act.* (Ottawa: Minister of Justice, 1985), 4.
[128] Office of the Privacy Commissioner, "OPC Guidelines for the Use of Video Surveillance of Public places by Police and Law Enforcement Authorities," March 2006, last accessed 25 March 2013. https://www.priv.gc.ca/information/guide/vs_060301_e.asp.
[129] Peter Connelly, "The Fourth Amendment and Section 8 of the Canadian Charter of Rights and Freedom: What has Been Done? What is to be Done?" *Criminal Law Quarterly* no. 27 (1984-1985): 183, last

In other words, like Canada's privacy laws, in the majority of criminal cases only specific and legally sanctioned surveillance on individuals is allowed. Regarding the privacy's ethical question of government's use of UAS' gathered information in domestic airspace, the intent of the laws and guidelines in place in Canada and in the US is to protect the rights of its citizens. The concern is that the governments may not have the resources required to police and invigilate government, civilian and commercial misuse of UAS surveillance sensors. In Canada, the policy recommended by the OPC is a step in the right direction with the recommendation that one person be designated responsible (and prosecutable) for the use of a given surveillance system.[130] Until policy and associated laws are implemented, there exists the issue that an UAS in the hands of an unethical, irresponsible operator could engage in illegal surveillance and potentially cause significant damage to individual privacy if not checked. There is considerable work to be done in the legal area to satisfy the ethical issues arising with the operation of UAS in domestic airspace.

The final level of the pyramid of detractors is the airspace regulatory and standards requirements driven by controlling agencies. In the US, the FAA has been under significant pressure from both government and civilian organizations to establish the conditions by which UAS flight in unsegregated airspace could be possible. The FAA is criticized for its slow handling of the file because after more than 10 years of analysis,

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accessed 25 March 2013. http://heinonline.org/HOL/Page?handle=hein.journals/clwqrty27&div=28&g_sent=1&collection=journals.

[130] Office of the Privacy Commissioner, "OPC Guidelines for the Use of Video Surveillance …

it has yet to issue an overarching set of regulations for UAS operation and, as a result, continues to process requests on a case by case basis.[131] The relatively good safety record associated with the FAA's approach to authorize UAS flights may have contributed to the delay in developing a more streamlined process. The FAA's recommended (and prudent) approach is a gradual opening of the airspace which is planned to take effect in 2015.[132] For the industry looking to cash in on the technology and take the competitive advantage of the domestic UAS services' market, the delay in the development of regulations has financial ramifications. Indeed, financial forecasts indicate that the industry in the US could grow "from 6.6 billion in 2013 to 11.4 billion in 2022," consequently, a delay in legislation could translate in big losses to civilian UAS service providers [133] The details of the FAA's implementation plan will be covered in Chapter 4 while the next section will cover the central issue to opening the airspace to UAS.

Though the potential for material and human losses exists in the event of a UAS incident, the same considerations and precautions are shared with manned aircraft. The FAA's concern to opening the airspace to UAS is summarized simply by the confirmation of the capacity for UAS to provide the same levels of safety that a manned aircraft can provide.[134] The key difference and source of concerns for the FAA is the

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[131] Bart Elias, *Pilotless Drones: Background and Considerations for Congress Regarding Unmanned Aircraft Operations in the National Airspace System,* Washington: Congressional Research Service 7-5700 R42718, 2012, 5.
[132] *Ibid*.
[133] Government Accountability Office, *Unmanned Aircraft Systems – Measuring…*, 2.
[134] Matthew T. DeGarmo, "Issues concerning Integration of Unmanned Aerial Vehicles in Civil Airspace," Centre for Advanced Aviation System Development MITRE Corporation 04W0000323 McLean Virginia, 2004, 2-1.

UAS' ability to "see and avoid" which is inherent to manned aircraft, a responsibility of the pilot and a significant contributor to flight safety in the National Air Space.[135] FAA AC90-48C as previously presented, outlines the responsibilities and techniques to be used by pilots in collision avoidance and one of the principal documents restricting the NAS access to UAS.[136] Consequently UAS rely heavily on technology to bridge the "see and avoid" gap transforming it into a "*sense* [emphasis added] and avoid" requirement. Combined with the development of certification standards for UAS and operators, this aspect presents a serious threat to opening the airspace to unmanned systems.

Analysis of the interconnected financial, technical, ethical, political/regulatory threats identifies the sense and avoid issue as the leading problem to be resolved to allow unsegregated UAS operation. Ultimately, there will always be an element of risk associated with operating UAS in unsegregated airspace; the question is how much risk is acceptable to the public? In order to achieve the desired conditions where a UAS flight is managed identically to that of a manned flight (through ATC clearances, traffic separation procedures, sensors and communications), several agencies have developed the road map that is expected to achieve the objective. The next chapter will explore the various initiatives in the US, Europe and Australia to allow unsegregated UAS flight drawing comparisons and guiding the discussion towards the final section of the paper: the unsegregated UAS operation regulatory efforts in Canada.

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[135] Federal Aviation Administration (FAA), *Advisory Circular 90-48C…,* 1.
[136] *Ibid*., 2.

ALLIED COUNTRIES' INITIATIVES

UNITED STATES

As the prominent user of UAS technology worldwide, the US is also a trailblazer in pursuing the opening of the National Air Space (NAS) to its newest users. A 2004 Defense Science Board (DSB) report identified the requirement to shorten the FAA approval process to allow a more reactive timeframe than the current two month long COA process.[137] Supporting this request is the fact that there were 342 COAs issued by the FAA between January and July 2012 representing an increase of 230% from all UAS COAs issued in 2009.[138] Along with the opening of the domestic airspace, the DSB report also recognized the need for standardization of UAS operations internationally in order to "transit to/from combat areas and perform time-sensitive training."[139] Considering the expanding use of UAS internationally, the ability to ferry a UAS to an operations area without the need for elaborate logistical requirements would improve efficiency.

Though the need to operate UAS in the same manner as a manned aircraft was identified in the early 2000s, there has been little concrete progress made to open the NAS. As a result, while the US is heavily involved in international UAS operations and

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[137] International Civil Aviation Organization (ICAO), *Operational Use of ADS-B in Non-Radar Airspace Generic Design Safety Case,* ICAO Separation and Safety Panel, 37. Last accessed 4 March 2013. http://adsb.tc.faa.gov/RFG/ADS-B%20in%20NRA%20Saftey%20Case.pdf.

[138] Government Accountability Office. *Unmanned Aircraft Systems – Measuring Progress and Addressing Potential Privacy Concerns would Facilitate Integration Into The National Airspace Systems,*Washington, DC: US GAO 12-981, September 2012., 7. and Bart Elias, *Pilotless Drones: Background and Considerations for Congress…*,, 6.

[139] International Civil Aviation Organization (ICAO), *Operational Use of ADS-B…*, 37.

in great need of facilitating the training of its crews, the timeframe involved to secure a drone flight outside of restricted military airspace remains stalled in the same prolonged process. As UAS operations have expanded to other government departments and agencies, a need arose for a revised approval process to consider UAS contingency applications in the event of natural disasters and crisis.[140] On the heels of Hurricane Katrina and more recently Hurricane Sandy, the use of drones to detect and study the formation of hurricanes, provide surveillance of the recovery efforts or "Wi-Fi in the sky" were identified as requirements by affected communities.[141] The problem in these recent events is that the drones, although available, could not secure access to the NAS to provide timely support because the regulations were simply not in place yet.[142] Ironically, some of first the aerial pictures provided of hurricane Sandy originated from personal and real estate (i.e. commercial) drone operators.[143]

The increase in the demand for UAS products and the rise in the number of military and civilian UAS flights over the past decade forced the government to join industry and the military to make the opening of the skies a priority. After a decade of limited guidance and direction, US congress created law P.L. 112-95 in 2012 which states

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[140] Jason Blazakis, "Border Security and Unmanned Aerial Vehicles…, CRS-6.
[141] Julie Johnsson, Mark Chediak, "Sandy Legacy has Utilities Opening Wallets for Drones," *Bloomberg* 24 Dec 2012, last accessed 25 March 2013. http://www.bloomberg.com/news/2012-12-24/sandy-legacy-has-utilities-opening-wallets-for-drones.html.
[142] Gerry Smith, "Drones, Balloons May Help In Next Hurricane, Beaming WI-FI from the Sky," *Huffington Post* 15 November 2012, last accessed 25 March 2013. http://www.huffingtonpost.com/2012/11/13/drones-balloons-hurricane-wi-fi_n_2124709.html.
[143] Kashmir Hill, "Sandy Through the Eyes of Youtube and a Drone: Falling Trees, Fires and Flooding," *Forbes* 02 November 2012. Last accessed 25 March 2013. http://www.forbes.com/sites/kashmirhill/2012/11/02/sandy-through-the-eyes-of-youtube-and-a-drone-falling-trees-fires-and-flooding/.

"the FAA is [also] required to develop a comprehensive plan to safely accelerate integration of civilian unmanned aircraft into the national airspace system as soon as practicable but no later than September 2015."[144] It is important to note that the law does not limit itself to governmental UAS applications but specifically identifies civilian unmanned aircraft as the priority. This positive development will allow industry and government users of the technology to operate under the same framework.

P.L. 112-95 identifies safety concerns linked to UAS sharing the skies with manned aircraft such as requirements for certification of both systems and operators, a need to identify the measures and technologies necessary to make UAS activities as safe and routine as possible, the requirement for a scheduled and phased integration and the administrative duties to make the integration work.[145] The law also recognizes the condition that has proven one of the biggest challenges and threats to the success of UAS matching the performance of manned aircraft: the inclusion of a sense and avoid capability.[146] In order to meet the intent of the law, the technology required to provide this capability will need to be integrated in UAS within three years to meet the FAA deadline of 2015.

Should the sense and avoid technology be unable to meet the requirements stated by the FAA, the integration of UAS in the NAS could suffer additional delays. With

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[144] Bart Elias, *Pilotless Drones: Background…*, 7.
[145] 112th Congress, *Public Law 112-95* (Washington: US Government 14 Feb 2012), 73. Last accessed 25 March 2013. http://www.faa.gov/regulations_policies/reauthorization/media/PLAW-112publ95%5b1%5d.pdf.
[146] *Ibid*.

proper technical guidance from the FAA and the legal support from Congress, the onus will be on industry and government agencies operating UAS to develop the systems that will meet the conditions necessary to fly unsegregated in the NAS.

However, technology alone may not be enough to satisfy the exigencies of *Air Laws*. Mark A. Petersen from the McGill University Faculty of Law pointed out other changes to UAS operations in shared airspace required to emulate the performance and standards of manned aircraft through anti-collision systems, radio interface with ATC and operator certification.[147] In his 2006 paper, Peterson also singled out the specific responsibilities of a governing country to provide the necessary safety measures ensuring that the International Civil Aviation Organization (ICAO) rules for collision avoidance and Security Against Acts of Unlawful Interference are respected.[148] ICAO rules drafted shortly after World War Two (WWII) were originally meant for manned aircraft and if UAS become equal users of the airspace, the US government will need to retain and adhere to ICAO rules. This adherence will serve two purposes to the UAS operators: First, it will set the conditions to operate domestically along with other ICAO users (foreign operators within domestic airspace) and second, by respecting the ICAO restrictions and providing the same margins of safety, it will contribute to other countries adopting the globally influential US' directions (operate UAS internationally).[149]

[147] Mark Edward Peterson, "The UAV and the Current and Future Regulatory Construct…, 562.
[148] *Ibid*., 563
[149] *Ibid*., 562, 563.

Although considerable technological challenges may be addressed for larger UAS such as sense and avoid capability, radio relay and collision avoidance systems, smaller UAS on the other hand may not be able to provide the same level of collision avoidance and will need to be addressed separately. To this end, P.L. 112-95 incorporated exceptions and exemptions to small public safety agencies where UAS of 4.4 pounds or less operating within visual range and at less than 400 feet.[150] In essence, apart from a few restrictions, this approach would give emergency crews the clearance to deploy small UAS without the need for additional authorization from the FAA. Considering the low risk associated with the operation of such a small aircraft and the fact that some allowances already exist for the operation of small UAS in low altitude uncontrolled airspace, such an exemption represents a straightforward example of policy that, if also adopted in Canada, would provide high operational returns for emergency crews for a low risk and cost to the public.[151]

With such an exemption, the benefits reaped by emergency crews and the public appear significant, however, it is important to consider the implications and potential dangers associated with these same exemptions. Although the law demands that the operator flies the small emergency UAS within visual range, the ocular perspective of the ground operator compared to that of a pilot in an aircraft is quite limited. In addition, the likelihood of the UAS operator observing the video feed of the UAS instead of the actual performance of the aircraft is high and affects the objective and expectations of the

[150] 112th Congress, *Public Law 112-95…*, 77.
[151] Douglas Quan, “Not Just for Modern Warfare: RCMP to Expand Use of Drone Mini-Helicopters…, 2.

exemption. Since there are no stated requirements for small UAS operating in these regimes to have anti-collision lights or air-to-air separation electronic systems, they still present a risk to other aircraft.[152] However, since model aircraft already operate within acceptable margins of safety under similar rules, it is reasonable to assume that small UAS operation in the same environment would be equally safe.[153] The future proliferation of small UAS may demand a review of the policy should safety concerns emerge from a flooded low level airspace.

Other organizations are contributing in establishing minimum standards for UAS. In addition to the FAA, the Radio Technical Commission for Aeronautics (RTCA) a private, non-profit organization is also working on establishing the standards for UAS operations in the NAS.[154] RTCA Sub Committee 203 (SC203), dedicated to UAS, has already delivered several papers contributing on the development of regulations and requirements to make the access of UAS in the NAS a possibility. In particular, it plans on delivering a set of papers on Minimum Aviation Performance Standards (MASPS) which will define the Sense and Avoid and Command and Control requirements by

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[152] Sam Biddle, "Plane Passenger Spots Mystery Drone Over Brooklyn," *Gizmodo* 5 March 2013, last accessed 25 March 2013. http://gizmodo.com/5988643/plane-passenger-spots-mystery-drone-over-brooklyn.

[153] US Department of Transportation, Federal Aviation Administration (FAA), *Advisory Circular 91-57 – Model Aircraft Operating Standards*, AC 91-57, 09 June 1981. Last accessed 25 March 2013. http://rgl.faa.gov/Regulatory_and_Guidance_Library/rgAdvisoryCircular.nsf/0/1acfc3f689769a56862569e70077c9cc/$FILE/ATTBJMAC/ac91-57.pdf.

[154] Radio Technical Commission for Aeronautics, "RTCA Mission," last accessed 25 March 2013. http://www.rtca.org/aboutrtca.asp.

December 2013, in time to support Congress' guidance.[155] The participation of national organizations in resolving the requirements to integrate UAS and the legal guidance of the US government through P.L. 112-95 indicate a marked interest to resolving the UAS integration question.

The US is leading UAS integration in unsegregated airspace with policy and regulations and has set the course to develop a plan to give its UAS industry the requirements for the necessary technology to meet the demands for NAS operations. It is difficult to assess at this point whether the technology will be able to catch up in time to exploit the set delivery of the FAA plan by 2015. The FAA has already developed a working set of conditions that satisfies most small UAS operations at low level but has still to address the requirements for larger UAS operating in more complex conditions. Until then, the US will continue to rely on a proven COA authorization process to fly UAS which will support deliberate and planned operations but will still lack the flexibility that a "file and fly" capability would provide UAS users.[156] Nevertheless, the US is taking an aggressive approach to remain a leader in the UAS field and the direction of its legislation will likely influence international policies. The next section will discuss the European approach to supporting UAS flight in their domestic airspace.

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[155] Radio Technical Commission for Aeronautics, "SC-203 Unmanned Aircraft Systems," last accessed 25 March 2013. http://www.rtca.org/comm/Committee.cfm?id=45

[156] GCN, "DoD Aiming to Lift Restrictions on Unmanned Flight in US Airspace," *GCN* 08 March 2012, 2. Last accessed 25 March 2013. http://gcn.com/Articles/2012/03/08/DOD-FAA-domestic-unmanned-aircraft-flights.aspx?Page=2.

EUROPEAN INITIATIVES

The aviation regulatory framework in Europe is more complex than in North America and requires some study to understand the mechanisms involved to change aviation regulations. As the European industry and governments are also working towards a set of regulations to support the integration of UAS in unsegregated airspace, the existing European airspace management system is working towards the building of a "Single Sky" initiative that will put all of European Union's air traffic management under one umbrella; the EUROCONTROL.[157] Other organizations such as the European Aviation Safety Agency (EASA), an EU organization dedicated to *advising* policy makers on aviation safety matters, contribute to the overall safety of European airspace and is a major player in developing UAS regulations.[158] EASA also alleviates some of the duties formerly performed by national aviation regulators such as the certification of aircraft types and pilot certification which will now be applicable to all of Europe instead of nationally.[159]

However, even with an overarching traffic management organization, there exists a residual need to maintain nationally controlled entities because the adherence and enforcement of ICAO regulations over a given territory is the responsibility of the

[157] EUROCONTROL, "Single European Sky: for a Performant Air Traffic System in Europe," *EUROCONTROL*, last accessed 25 March 2013. http://www.eurocontrol.int/dossiers/single-european-sky.
[158] European Aviation Safety Agency, "What we do," EASA, last accessed 25 March 2013. https://www.easa.europa.eu/what-we-do.php.
[159] *Ibid*.

signatory to ICAO which are all sovereign states.[160] In other words, since neither EUROCONTROL nor EASA is a signatory to ICAO, they are subordinate to the national aviation safety entities. As a result, EUROCONTROL and EASA may advise member nations on UAS issues and coordinate the adherence to the rules but the implementation is a national responsibility that cannot be devolved easily to a larger organization. The European example used in further discussion of UAS integration is the United Kingdom (UK) model as it is representative of the challenges faced by numerous countries.

In the UK the Civil Aviation Authority (CAA) is the equivalent to the FAA in the US.[161] The CAA developed its own UAS guidance through its CAP 722 document entitled *Unmanned Aircraft System Operation in U.K. Airspace – Guidance*.[162] The ultimate aim of CAP 722 is to "develop a regulatory framework which will enable the full integration of UAS activities with manned aircraft operations throughout the U.K. airspace."[163] The UK policy towards UAS operations can best be summarized as:

> UAS operating in the UK must meet at least the same safety and operational standards as manned aircraft. Thus, UAS operations must be as safe as manned aircraft insofar as they must not present or create a greater hazard to persons, property, vehicles or vessels, whilst in the air or on the ground, than that attributable to the operations of manned aircraft of equivalent class or category.[164]

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[160] International Civil Aviation Organization (ICAO). *Vision and Mission*. Last accessed 25 March 2013. http://www.icao.int/Pages/vision-and-mission.aspx.
[161] *Ibid*.
[162] Civil Aviation Authority, *CAP 722 Unmanned Aircraft System Operations in UK Airspace – Guidance* (Norwich U.K.: CAA, 10 Aug 2012). Last accessed 25 March 2013. http://www.caa.co.uk/docs/33/CAP722.pdf.
[163] *Ibid*., foreword, 1.
[164] *Ibid*., Section 1 Chap 1, 1.

In other words, similar to that of the North American objective, the level of safety associated with UAS operation must be comparable to that of manned aircraft. UAS weight and purpose define the governing policy for operation into UK's airspace. Under CAP 722, all UAS under 150kg of weight and all military, government and experimental UAS will operate under the national policy (CAA) while civilian UAS of more than 150kg in weight will operate under the EASA rules.[165] This approach allows for future management of large civilian UAS to operate over the entire EUROCONTROL airspace without being subject to individual national legislation. For military UAS flying over another nations' airspace, the same conditions as that of manned military aircraft apply and are depicted in ICAO guidance where prior permission to overfly a foreign country with a military aircraft must be previously secured.[166] As a result, EASA is responsible for certification of some of the aircraft and the UK, in this situation, is responsible for the certification of other UAS.

A confusing situation emerges due to the interpretation of airworthiness differing from one agency to the other. For instance, EASA's airworthiness certification does not consider the sense and avoid capability of UAS as a requirement stating that this particular requirement is relinquished to "the authorities responsible for the safety

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[165] *Ibid*., Sect 1 Chap 1, 2.
[166] Guy Gratton, "Aircraft Technical – International Flight policy," *Global Aviator* 01 July 2012, last accessed 25 March 2013. http://www.globalaviator.co.za/July%202012/aircrafttechnical.htm.

regulation of air navigation services" which in this case would be CAA.[167] In other words, EASA does not certify the requirements for UAS that would encompass all classes of airspace and the national entity that is a signatory to ICAO needs to manage the regulation, equipment and performance of aircraft within its area of responsibility.[168] The separation of responsibility for the development of the requirements may make sense in this case since EASA certifies the systems and does not regulate the airspace where the system will be used. However, this approach increases the complexity of the implementation of the regulations by adding another organizational layer to participate and implement the UAS integration into unsegregated airspace. Consequently, work in support of UAS integration is being done in parallel as EASA formed its own working group; EUROCAE WG73 while the CAA in the UK has developed its own guidance manual; CAP722.[169]

Contrary to the US legislative efforts, there is no specific and aggressive government timeline for the full integration of UAS in unsegregated airspace. Therefore, EASA and the rest of Europe will likely follow the US' lead upon their planned implementation in 2015.

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[167] European Aviation Safety Agency. *Policy Statement Airworthiness Certification of Unmanned Aircraft Systems (UAS) – E.Y013-01*. EASA, 2009, 11. Last accessed 25 March 2013. http://www.easa.europa.eu/certification/docs/policy-statements/E.Y013-01_%20UAS_%20Policy.pdf.
[168] *Ibid*.
[169] EUROCAE, "Working Group 73 – UAV Systems," last accessed 25 March 2013. http://www.eurocae.net/working-groups/wg-list/42-wg-73.html.

Until their own integration regulations are finalized, the UK relies on the Certificate of Airworthiness process to control UAS flights.[170] In an effort to make the effort as fluid as possible, the UK has adopted two different mechanisms; one for light UAS of 150kg or less and one for general UAS certification.[171] The light UAS approach allows the UK to manage the larger number of UAS which operate in uncontrolled airspace through methods similar to those for model aircraft.[172] At the moment, the CAA does not allow any flight in controlled airspace unless the system possesses a sense and avoid capability that has satisfied the two basic elements defined by the CAA: separation insurance or adherence to ATC clearance, and collision avoidance which allows the system to detect conflicting traffic and carry out manoeuvers to avoid collisions.[173] The CAA only specifies the technical requirements to be met (i.e. system must be as good as or better than the manned platforms) and leaves the resolution and demonstration of the capability to industry. As a result, most UAS flights approved by the CAA are either conducted in uncontrolled airspace, within segregated airspace or under a special airspace reservation previously arranged with ATC.[174] Although the UK and the European Union have the regulatory instruments in place to support an eventual UAS integration, there remains a significant gap to bridge between the expectations of the regulatory entities (which are purposely vague to allow the regulatory safety mechanisms to be adjusted to

[170] Civil Aviation Authority, *CAP 722 Unmanned Aircraft System Operations in UK Airspace…,* Sect 3 Chap 2, 2.
[171] *Ibid*., 3.
[172] Mark Edward Peterson, “The UAV and the Current and Future Regulatory Construct…, 590.
[173] Civil Aviation Authority, *CAP 722 Unmanned Aircraft System Operations in UK Airspace…,* Sect 2, Chap 2, 1.
[174] *Ibid*., Section 2 Chap 1, 2.

the evolving UAS situation) and the technical performance the industry can deliver to satisfy the requirements.

AUSTRALIA

Although other countries such as Israel, France, Russia and China have significant UAS programs, Australia's size and resources resembles that of Canada making it a useful model for the development of Canadian regulations.

The Civil Aviation Safety Authority (CASA) is Australia's agency responsible for the safety regulation of air operations and in charge of developing guidelines for UAS operation within their airspace.[175] The main document governing the management of aviation in Australia is the Civil Aviation Safety Regulations (CASR) of 1998.[176] In particular, CASR part 101 pertains to the operation of UAS in Australian airspace.[177] A basic study of CASR Part 101 reveals that Australia's approach to operating UAS in integrated airspace appears slightly more open to have UAS operating in the vicinity of manned aircraft than either the US or European regulations would allow. For instance, the Advisory Circular AC101-1(0) providing additional guidance to UAS operations specifies in the collision avoidance section that:

[175] Civil Aviation Safety Authority, "CASA Organization," last accessed 1 April 2013. http://www.casa.gov.au/scripts/nc.dll?WCMS:STANDARD::pc=PC_91621.
[176] Civil Aviation Safety Authority. "Civil Aviation Safety Regulations 1998 (CASR 1998)," Last accessed 1 April 2013. http://casa.gov.au/scripts/nc.dll?WCMS:STANDARD::pc=PC_90991.
[177] *Ibid.*, Part 101.

> UAV flights in controlled airspace will be treated as IFR flights subject to ATC control […] CASA *may require* [emphasis added] a large UAV to be equipped with an SSR transponder, a collision avoidance system *or* [emphasis added] forward looking television as appropriate for the type of operation.[178]

The guidance suggests that UAS flights should be treated as IFR. The Australian approach is logical given that other manned aircraft operating in an environment with unreliable visual cues are also subject to IFR rules. Important to note is the responsibility for collision avoidance resides solely on the aircraft operator and not ATC. One must be careful to not interpret the "subject to ATC control" statement above as an acceptance of liability of ATC controllers for the operation of a given UAS in IFR. ATC has the complex duty and responsibility to manage the skies safely and efficiently; although the capability exists for ATC to provide positive control for collision avoidance to UAS operators, the liability resides with the aircraft and not the controllers.[179]

Other considerations in regards to air-to-air collision avoidance resemble closely the concerns raised by other countries' organizations such as the FAA and the CAA. However, the terms used by the Australian agency appear more accommodating to UAS

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[178] Civil Aviation Safety Authority (CASA), *Advisory Circular 101-1(0) – Unmanned Aircraft and Rockets – Unmanned Aerial Vehicle (UAV) Operations, Design Specification, Maintenance and Training of Human Resources* (CASA AC 101-1(0), July 2002), 3, last accessed 5 March 2013. http://www.casa.gov.au/scripts/nc.dll?WCMS:OLDASSET::svPath=/rules/1998casr/101/,svFileName=101c01.pdf.

[179] Transport Canada, Transport Canada Aeronautical Information Manual (TC AIM). "RAC – Rules of the Air and Air Traffic Services." (Canada, 18 October 2012), 163. Last accessed 1 April 2012. http://www.tc.gc.ca/media/documents/ca-publications/tp14371e-6.pdf. (Although this reference is from Transport Canada, CASA shares the same policy for collision avoidance remaining the pilot's responsibility even under positive ATC control).

operations.[180] The operating word in the citation above is that CASA *may* require the operator to equip the aircraft with sense and avoid capability; it is not a requirement.[181] One should be cautious in concluding that Australia permits unchecked UAS operations. CASA still carries out a detailed review of each of the requests before granting its authorization. All commercial applications of UAS flights must receive an Operator Certificate (OC) from CASA which acknowledges the person's (or organization's) ability to operate the system as safely as a manned platform and, where shortcomings are found in the ability of the UAS to satisfy the safety metrics, provides the flexibility to add specific restrictions/conditions to the OC.[182] In addition to the OC and similar to the US and the UK, all small UAS flying above 400feet and large UAS must also receive a COA which will authorize operation into a specified airspace.[183] An interesting aspect of the Australian policy is its acceptance of potential autonomous operations. Contrary to other countries where autonomous operation is simply not addressed or accepted in unsegregated airspace, CASA recognizes the potential for future autonomous operations or programmed flight but requires the operators to be able to take positive control upon request.[184] Recognizing the potential risk of a lost link to the aircraft and the capability of

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[180] Civil Aviation Safety Authority (CASA), *Advisory Circular 101-1(0) – UAV Operations…* Section 5.7, 3.
[181] Mark Edward Peterson, "The UAV and the Current and Future Regulatory Construct…, 584.
[182] Civil Aviation Safety Authority (CASA), *Advisory Circular 101-1(0) – UAV Operations…* Section 12.2.21, 7.
[183] *Ibid*., Section 12.2.3, 17. The CASA classification of UAVs is similar to that of other countries where small UAVs have a weight of less than 150Kg and large UAVs are larger than 150Kg http://www.southampton.ac.uk/~jps7/D8%20website/Australian%20UAV%20safety%20rules.pdf
[184] *Ibid*., Section 5.2.2, 2.

UAS to carry out an emergency automated flight to a set recovery location, the operator must simply brief this information to CASA during the COA authorization process.[185]

In a way, CASA's approach may be more constrictive than any other country's because it demands of the operators several layers of approval to operate within unsegregated airspace such as the OC and the COA. For instance, in accordance with the CASR, the pilot (or operator) of a UAS must have several qualifications such as a radio operator certificate, training and qualification on the system and an IFR license.[186] CASA's process encompasses the operating area approval for temporary, semi-permanent and permanent UAS operation areas and the operating approval which defines the parameters of the area, UAS communication, limitations and safety.[187] As a result, the current process and the timelines required to secure a UAS flight in Australia are comparable to that of the US and take approximately 90 days.[188] The integration of UAS in unsegregated airspace is far from being a "file and fly" process in Australia and there is no significant pressure to change the regulations in the near future as the current status satisfies the demands of both military and industry in the region.

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[185] *Ibid*., Section 5.15.3, 7.
[186] Mark Edward Peterson, "The UAV and the Current and Future Regulatory Construct…, 586.
[187] Civil Aviation Safety Authority (CASA), *Advisory Circular 101-1(0) – UAV Operations…* Section 12.2.3, 17.
[188] Mark Edward Peterson, "The UAV and the Current and Future Regulatory Construct…, 586.

CANADA'S ROADMAP FOR UAS INTEGRATION

The discussion has thus far explored the capabilities of UAS, investigated the opportunities and threats of the technology and has presented other country's initiatives to facilitate the integration of UAS in unsegregated airspace. Taking in consideration the challenges facing the integration of UAS in Canadian airspace, this chapter will present the initiatives being pursued by Canadian regulation and policy organizations, the industry and government agencies and will report on a roadmap to achieve the objective in Canada. TC's involvement in resolving the integration issue first materialized in 2007 with the leading of a UAV Working Group (WG) encompassing numerous players from industry, the military and government agencies.[189] The 2007 working group generated an ambitious work plan which scheduled UASs' safe airspace integration by 2012 which made the Canadian plan the fastest implementation strategy in the world.[190] The reality is that the work plan was not implemented within the set timeframe and TC continues to process UAS flights within Canadian controlled airspace through the use of SFOCs a process re-enforced through a TC Staff Instruction 623-001 (SI623-001) in 2008.[191] The SI provided the necessary information for TC's Staff to make a decision regarding the safe approval of a SFOC covering the system, operator liability, risks and advisory

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[189] Transport Canada, UAV Working Group, *Transport Canada Civil Aviation UAV Working Group Final Report…,* Appendix A, Members.
[190] *Ibid*., Figure 12-2, (20/61).
[191] Transport Canada, Staff Instruction 623-001, *The review and Processing of an Application for a Special Flight Operations Certificate (SFOC) for the Operation of an Unmanned Air Vehicle (UAV) System,* (Ottawa: General Aviation Office SI 623-001 Issue 01, 27 Nov 2008), 3. Last accessed 4 March 2013. http://www.tc.gc.ca/media/documents/ca-opssvs/623-001_1.pdf.

requirements.[192] A more recent report of the *Unmanned Air Vehicle Systems Program Design Working Group* stated in 2010 that the likely completion of the phased approach to UAS integration in Canada would be 2016.[193] Phase 1 of the program design working group, completed in 2012, addressed documentation review and recommended regulations changes applicable to small UAS of less than 25kgs.[194] Note here that the working group recommended a change in weight for small UAV classification from 35kgs (currently in CAR SI 623-001) to 25kgs to account for the potential lethality of the vehicle.[195] A 2012 MITRE corporation paper studied the idea that if UAS were small enough, less regulations would be required considering the limited damage they could inflict to a manned aircraft.[196] In essence, the collision avoidance strategy would not be required and hence no additional regulation would be required. Although the 25kg figure far exceeds the lethality threshold identified by the MITRE Paper (2.5 lbs.), the lower weight recommended by the working group is an indicator of the effort to limit the potential damage that could be caused by a small UAS on property and persons.[197]

Addressing the small UAS accessibility is in line with the expectations of the TC's UAV Working Group, supported by a US study that small UAS will form the

[192] Transport Canada, UAV Working Group, *UAV Systems Program Design Working Group – Phase 1 Final Report* (Ottawa: General Aviation Office, March 2012), 25-26. Last accessed 4 March 2013. http://www.h-a-c.ca/UAV_REPORT.pdf.
[193] *Ibid*., 7.
[194] *Ibid*., 5.
[195] *Ibid*. The 35Kg is an artifact of model aircraft regulations that initially was applied to UAV operation.
[196] Andrew Lacher and David Maroney, "A New Paradigm for Small UAS," Centre for Advanced Aviation System Development MITRE Corporation, (McLean: Virginia, 2012), 2.
[197] *Ibid*., 12.

majority of unmanned assets used in Canadian airspace in the future.[198] Subsequent phases of the working group are intended to address small UAS related issues but the difficult question of beyond visual range operation and the complicated sense and avoid technology for larger UAS is not expected to be available before the completion of Phase Four (4) integration in 2016.[199] Consider that the working group's reports are *informational* only and aimed at supporting the Canadian Air Regulations Advisory Council (CARAC) composed of members of the government, industry and TC.[200] Consider also that CARAC proposes regulation changes to the Canadian Air Regulation Council (CARC) which ultimately recommends new or amended Canadian Aviation Regulations (CARs) to TC for implementation.[201] Consequently, due to the elaborate processes necessary after the submission of the working groups' final recommendations, the situation challenges the veracity of the planned timeline. Figure 5 is a representation of the CAR amendment process for UAV operation in Canada.

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198 Transport Canada, UAV Working Group, *Transport Canada Civil Aviation UAV Working Group Final Report…* Section 12.1.4.

199 Transport Canada, UAV Program Design Working Group. *Terms of Reference - UAV Systems Program Design Working Group*. March 2010, 7. Last accessed 4 March 2013. http://www.h-a-c.ca/UAV_Terms_of_Reference_2010.pdf.

200 Transport Canada. "Canadian Aviation Regulation Advisory Council (CARAC)." Last accessed 1 April 2013. http://www.tc.gc.ca/eng/civilaviation/regserv/affairs-carac-more-100.htm.

201 *Ibid*.

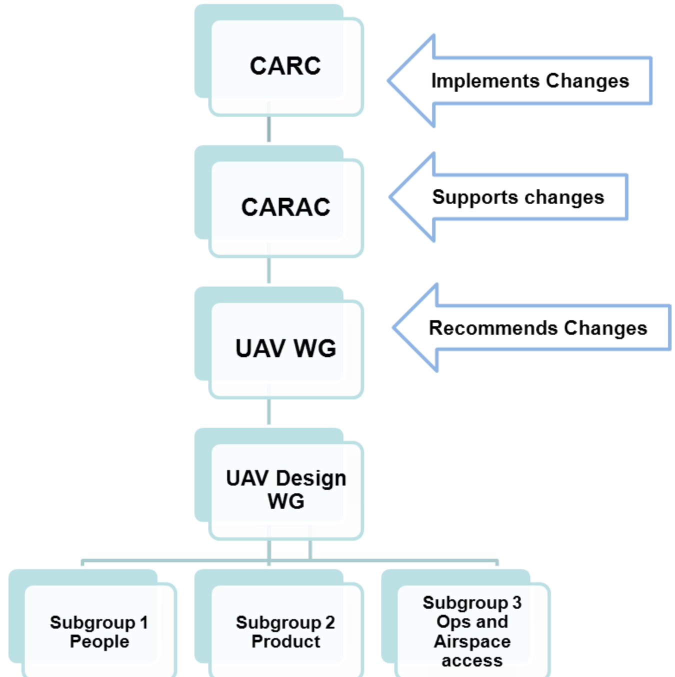

Figure 5: Canada's CARs Amendment Process for UAS[202]

The situation outlined by SI 623-001 where a specific authorization must be processed for every request to operate UAS in controlled airspace, is extremely similar to that of the US COA process. The US and Canada are engaged in a Regulatory Cooperation Council (RCC) between TC and the FAA. A December 2012 report highlighted that the mechanisms were in place between the countries to align and share the regulatory details of civilian use of non-segregated airspace.[203] Consequently, notwithstanding TC's UAV working group activities, the US' 2015 objective for the

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[202] Transport Canada, Canadian Aviation Regulations (CARS), "About The Canadian Aviation Regulations (CARs)," last accessed 23 March 2013. http://www.tc.gc.ca/eng/civilaviation/regserv/cars/about-1170.htm.

[203] Canada-United States, "Progress Report to Leaders," Regulatory Cooperation Council (RCC), (December 2012), 10. Last accessed 1 April 2013. http://www.whitehouse.gov/sites/default/files/docs/pco_bnet-30471-v38-rcc-progress_report_-_dec_2012_final.pdf.

FAA to resolve the issue will likely influence Canada's solution for UAS in its own territory by aligning its regulations to that of the FAA. The historically close regulatory relationship between the FAA and TC, materialized previously to contend with aircraft and pilot certification, supports an equally close relationship into resolving UAS in controlled airspace.[204]

UAS Certification

Reflected in the working group's subgroup - 1 responsibilities, the major issues to be addressed, in order to provide Canada with a permanent and more efficient means to allowing unsegregated UAS operation, are the qualification of the operators, the certification of the systems and the regulation of airspace access.[205] The JUSTAS program, probably the most ambitious and complex UAS program in Canada, will be used to conduct a brief case study of the performance required to meet the planned regulations and compare them to the project's stipulated requirements. Stated in SI 623-001 and common to all other countries' efforts to provide this integration; an unmanned vehicle needs to provide the same level of safety as of manned aircraft.[206] One of the methods by which manned aircraft strive for the safety and the commonality of standards

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[204] Bilateral Aviation Safety Agreement (BASA), *FAA/TCCA Implementation Procedures Covering Design Approval, Production Activities, Export Airworthiness Approval, Post Design Approval Activities, and Technical Assistance Between Authorities* (Canada: Revision 1, 5 June 2008), 1. Last accessed 5 March 2013. http://www.faa.gov/aircraft/air_cert/international/bilateral_agreements/baa_basa_listing/media/CanadaIPA.pdf.

[205] Transport Canada, UAV Program Design Working Group. *Terms of Reference…,* 3.

[206] Transport Canada, Staff Instruction 623-001, *The review and Processing of an Application for a Special Flight Operations Certificate (SFOC)…*, 9.

in the industry is through certification. Since UAS match the Canadian Aeronautics Act's definition of an aircraft: "any machine capable of deriving support in the atmosphere from reactions of the air," the expectation from TC and its WGs is that the vehicle *and* [emphasis added] the rest of the system contributing to the operation of the vehicle must also be certified for operation in Canadian airspace.[207] This extended certification to more than the vehicle (a departure from normal procedures in Canada) is reflected in the TC's WG report and through the JUSTAS SOR where the emphasis is on Canadian military airworthiness standards.[208]

The military airworthiness standards are outlined in the Technical Airworthiness Manual (TAM) and the Airworthiness Design Standards Manual (ADSM) which are managed by the Technical Airworthiness Authority (TAA). [209] In Canada, the Minister of National Defence holds the TAA responsibility for DND but these duties have been delegated through the Chief of Defense Staff (CDS) to the Director General Aerospace Equipment Program Management (DGAEPM).[210] The issue now becomes DND's overall certification of UASs in Canada. Although DND's airworthiness program is self-certified in the eyes of TC, there is no specific civilian guidance at this point to conduct the

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[207] Department of Justice, *Aeronautics Act*, (Canada: R.S.C., 1985 c. A-2), 1. Last accessed 2 April 2013. http://laws-lois.justice.gc.ca/eng/acts/A-2/page-1.html?texthighlight=definitions+definition+aircraft#s-3.

[208] Department of National Defence, *JUSTAS SOR...*, Section 3.1 and 4.9.1b, 7 and 12.

[209] Department of National Defence, *Technical Airworthiness Manual- Definitions*, last accessed 2 April 2013. http://www.materiel.forces.gc.ca/en/taa-tam.page.

[210] Department of National Defence, *Overview of the Technical Airworthiness Program*, last accessed 2 April 2013. http://www.materiel.forces.gc.ca/en/taa-au.page.

certification of the overall UAS system, whether military or civilian.[211] As a result, DND's airworthiness program needs to line up with that of the civilian organizations in order to provide the appropriate levels of safety in order to operate in Canadian airspace. Consequently, although the JUSTAS SOR identifies the airworthiness requirements, the certification standards of the system need to originate from TC. Compartmentalizing the problem, most of the UA component of the UAS can be certified using the existing certification standards for manned aircraft. However, the ground control stations, the communications links, software and flight control systems must also be certified to achieve the level of technical certification equal to that of manned aircraft.[212] Although certification of all aspects of UAS is identified and the requirement for revised CARs Part Six for General Operating and Flight Rules recommended, these suggestions are not valid until the completion of the *Design Working Group* final stage four report due to be delivered in 2016.[213] In the absence of existing civilian national airworthiness certification guidance and regulations, the requirement to adhere to the military airworthiness program leaves the problem open to interpretation by would-be contractors.[214] The Canadian UAS roadmap will require that CARs reflect the certification prerequisites for all system components.

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[211] Matthew T. DeGarmo, "Issues concerning Integration of Unmanned Aerial Vehicles in Civil Airspace," Centre for Advanced Aviation System Development MITRE Corporation 04W0000323 (McLean Virginia, 2004), 2-47.
[212] *Ibid*.
[213] Transport Canada, UAV Working Group, *Transport Canada Civil Aviation UAV Working Group Final Report…,* Section 20.
[214] Department of National Defence, *JUSTAS SOR...*, 9/40

Frequency Spectrum and communication robustness

A problematic item for the certification of a UAS is the communication links with the UA. In the case of JUSTAS, not only the robustness of the communication links must provide an acceptable level of safety to avoid signal interference or interruptions, it must also provide some security protection due to the classified nature of the information transmitted from the sensors to the ground station.[215] Jamming and intentional hacking of UAS signals pose real threats to safe operation. Low cost GPS jammers are readily available and can result in loss of the UA and, more importantly, cause damage to the public.[216] Consequently, although civilian agencies such as TC will likely develop requirements and standards to suit civilian safety standards, military drones will have to not only implement the civilian standards but also consider hostile survivability requirements.

Although there is no global dedicated frequency spectrum for UAS operation currently, the International Transmissions Union (ITU), a United Nations (UN) organization explored the question and the requirements linked to UAS operation.[217] ITU's objective through this exercise was only to determine the spectrum requirements for both ground based and satellite systems and did not result in regulations, leaving this duty to national agencies such as Canadian Radio Telecommunication Commission (CRTC in Canada) or the Federal Communications Commission (FCC in the US) to

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[215] *Ibid*., 7/40.
[216] Bart Elias, *Pilotless Drones: Background…*, 12.
[217] *Ibid*., 13.

legislate.[218] So far, the CRTC and FCC have addressed UAS licencing on a case by case basis (similar to TC and the FAA) and do not have a formal spectrum identified for UAS operation.[219] There remains a significant gap in the permanent or more streamlined frequency spectrum management of UAS operation before its integration in unsegregated airspace. The Canadian UAS integration roadmap requires regulation regarding frequency spectrum development and that systems display sufficient robustness to jamming and hacking.

Human factors

The JUSTAS SOR does not specify mandatory operator qualifications nor certifications therefore one must deduce that DND operators are subject to similar qualifications as that of manned aircraft as per 1 CAD Orders.[220] The Orders stipulate that the Air Vehicle Operator(s) (AVO) should hold an aircrew qualification and all the physical and currency performance requirements along with an IFR ticket.[221] However, it is important to note that other occupations have operated military UAVs in the past and will likely continue to operate them in the future. For instance, the AVOs for the Scan Eagle unit in Afghanistan were artillery Non-Commissioned Members (NCMs) and the

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[218] International Telecommunication Union (ITU), *Characteristics of Unmanned Aircraft Systems and Spectrum Requirements to Support Their Safe Operation in Non-Segregated Airspace* (Geneva: ITU-R M.2171, 2010), 1. Last accessed March 4 2013. http://www.itu.int/dms_pub/itu-r/opb/rep/R-REP-M.2171-2009-PDF-E.pdf.

[219] Bart Elias, *Pilotless Drones: Background…*, 13.

[220] Department of National Defence, Royal Canadian Air Force, *1 Canadian Air Division Orders* Vol. 5 – Standards and Currency, article 5-501 (Ottawa: DND Canada, 21 Dec 2009), 4.

[221] *Ibid*.

same applies for the Scan Eagle detachments operating aboard ships.[222] Consequently, the certification of UAV operators in DND cannot be secluded to one element; it will likely involve personnel from all three services who will operate various types of UAS in different environment in support of their respective elements. Organizations must consider the physiological requirements for UAV operators as it is likely to differ from current aircrew standards.[223]

TC, through its WG previously identified UAV operator situation by defining the qualification required for each type of UAS and highlighted restrictions depending on the complexity of the flight environment. For example, a UAV weighing less than 35 kg operating within visual range under VFR conditions only requires a "Pilot permit – UAS" restricted to type rating while a UAV weighing more than 150kg operating in an IFR environment (such as JUSTAS) would require a private or commercial pilot licence (same as manned aircraft) with an IFR rating.[224] Similar certification is then necessary for UA maintainers and technicians responsible for communication links. Problem now arise in that the occupations who maintain the communication links for DND were not involved in the airworthiness process in the past. The Canadian UAS integration roadmap

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[222] Department of National Defence, Canadian Joint Operations Command (CJOC), "Scan Eagle goes to sea," last accessed 2 April 2013. http://www.cjoc-coic.forces.gc.ca/fs-ev/2012/02/03-eng.asp.
[223] Government Accountability Office. *Unmanned Aircraft Systems – Measuring Progress and Addressing Potential Privacy Concerns would Facilitate Integration into the National Airspace Systems* (Washington, DC: US GAO 12-981, September 2012), 18.
[224] Transport Canada, UAV Working Group, *Transport Canada Civil Aviation UAV Working Group Final Report…,* Section 19, p. 36-39.

requires human factors and the associated regulations from the CARs to reflect the new operating environment.

Public acceptance

The biggest challenge to UAS integration in Canada may be the acceptance of domestic surveillance. The paper discussed briefly the regulations and privacy considerations that prevent government agencies to conduct unsanctioned surveillance on Canadian citizens but these guidelines may not be sufficient to prevent corporate espionage or breach of privacy from commercial applications.[225] While industry plans for the exponential UAS technological expansion, there is a risk of the illegal and criminal use of these same UAS.[226] As long as the public weighs the positive security (provided by DND), safety (provided by emergency services) and efficiency (from commercial use) attributes of UAS more heavily than the privacy threat issues, UAS integration in Canadian airspace will be possible. Consequently, the roadmap requires a public sensitization campaign by government and industry in order to benefit from eventual access to shared airspace.

[225] Office of the Privacy Commissioner, "OPC Guidelines for the Use of Video Surveillance of Public places by Police and Law Enforcement Authorities," March 2006, last accessed 25 March 2013. https://www.priv.gc.ca/information/guide/vs_060301_e.asp.
[226] Naomi Wolf, "The coming Drone Attack on America." *The Guardian* (21 December 2012). Last accessed 4 March 2013. http://www.guardian.co.uk/commentisfree/2012/dec/21/coming-drone-attack-america.

Canadian UAS roadmap summary

Although the Canadian UAS stakeholders have already begun the work on the roadmap to operating UAS in unsegregated airspace, the desired or planned timelines are not met. The limited appetite for a robust military UAS acquisition program and small scale industry lobbying may have contributed to the delays in establishing the regulatory framework necessary to operating UAS along manned aircraft in controlled airspace. However, work accomplished through the 2007 TC WG and ongoing efforts of sub committees maintain the Canadian interest in resolving the problem. Canadian unsegregated UAS operation roadmap will achieve its objective only once operator certification, the reliability of communication links and the public's acceptance are achieved. The task is complex and the attribution of clear timelines, from past experience, is likely to be met with disappointment. Nevertheless, the value of UAS operation in unsegregated airspace for both military and commercial application justifies the interest and persistence in the resolution of the subject.

CONCLUSION

The eventual integration of UAS in Canadian domestic airspace is supported by the advantages that the technology has over manned aircraft and the economic benefits that industry can exploit. Recent exponential growth of the military segment of the technology indicates that future wars will likely see the participation of UAS which demands some domestic airspace access capabilities but, more importantly, the availability of international airspace to support the projection of military power elsewhere. Canada, along with other UAS-savvy countries have plans to ensure a safe transition to the presence of UAS in the same environment of manned aircraft. The UAS problem facing the regulatory organizations is wide ranging considering that the solution must cater to the various types of aircraft from bird-like miniature machines to airliner-size, complex weapon systems.

Although a review of historical progression of UAS technology supports the resolution of technical issues such as sense and avoid and collision avoidance capability, there remains public resistance in the acceptance to share airspace with drones. This resistance is partly due to safety and to the legal questions related to privacy and potential criminal use of UAS. Because sociological issues are complex and require significant effort, lobbying and time to resolve, the current timelines presented by government and industry may be optimistic and may not represent a credible timeframe for integration.

Contrary to the US, pressure on Canada's regulators does not originate from the military segment but from industry. Because DND does not possess UASs in its inventory and previous Just in Time delivery of the capability was successful in the past, it is likely that Canada will pursue a similar approach for the delivery of UAS capability in the future. Consequently, the urgency to find a UAS airspace integration resolution may not be perceived until Canada takes part in another conflict or when a specific domestic requirement for military UAS is identified. Factoring in Canada's smaller scale UAS industry and that, supported by further miniaturization, small commercial UAS operating in uncontrolled airspace are likely to form the majority of UAS operation over Canada's territory, the airspace integration solution eventually delivered by TC may not address the specific military requirements. In addition, limited TC resources available to carry out the necessary regulation changes may not be sufficient to meet the US' timeframe of 2015. As a result, some of Canada's robotic and UAS industry could suffer economically from missed opportunities. It would appear that for Canada, a wait and see approach combined with the integration of the US' regulations to the Canadian' CARs once available would seem the most likely roadmap.

The paper argued that given the interest and substantial benefits to have a domestic and expeditionary UAS capability, there is a requirement to pursue and present a comprehensive roadmap supporting the integration of UAS in controlled airspace. The research indicated that although the above thesis applies directly to the US, the requirement to find a solution to UAS integration in Canada is not under the same pressure or urgency. Nonetheless, significant efforts are being deployed by TC and all associated national regulatory organizations to facilitate operation of UAS in domestic airspace. Similarly, other countries have adopted a series of objectives to support a phased integration of UAS in their respective airspace. Considering technical and sociological challenges of drones operating in the vicinity of manned aircraft, the integration roadmap will likely not be a straight “point to point” path but resemble more a series of heading corrections in order to adjust to the technology, the risks and the relevance of UAS in a given environment.

The US Congress support through law for the integration of the technology domestically gives confidence that a solution can be reached by 2015. The political, sociological and legal factors of UAS integration have only been briefly presented to the reader in this paper. In order to fully satisfy the intent of the government and the industry, the resolution of the problem will require the technical satisfaction of the regulations and the development of a strategy addressing public resistance to the UAS-related privacy and ethical questions.

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