National Defence Défense nationale

Canadian Forces College

Collège des Forces Canadiennes

THE AURORA REPLACEMENT: THE VIABILITY OF DRONES AS MARITIME PATROL AIRCRAFT

Maj R.D. Freeman

JCSP 44

Exercise *Solo Flight*

PCEMI 44

Exercice *Solo Flight*

Disclaimer

Opinions expressed remain those of the author and do not represent Department of National Defence or Canadian Forces policy. This paper may not be used without written permission.

Avertissement

Les opinons exprimées n'engagent que leurs auteurs et ne reflètent aucunement des politiques du Ministère de la Défense nationale ou des Forces canadiennes. Ce papier ne peut être reproduit sans autorisation écrite.

Canada

CANADIAN FORCES COLLEGE – COLLÈGE DES FORCES CANADIENNES
JCSP 44 – PCEMI 44
2017 – 2018

EXERCISE *SOLO FLIGHT* – EXERCICE *SOLO FLIGHT*

THE AURORA REPLACEMENT: THE VIABILITY OF DRONES AS MARITIME PATROL AIRCRAFT

Maj R.D. Freeman

Word Count: 4870

Compte de mots: 4870

THE AURORA REPLACEMENT:
THE VIABILITY OF DRONES AS MARITIME PATROL AIRCRAFT

INTRODUCTION

The CP140 Aurora aircraft, based on the Lockheed P3 Orion, has been a workhorse for the Canadian Armed Forces (CAF) for over 30 years. Originally purchased in 1982 as a Maritime Patrol Aircraft (MPA), its role has expanded significantly over the years in response to the ever-growing demand for Intelligence, Reconnaissance, and Surveillance (ISR), whether this be over water or land. The versatility of this aircraft is uncontested and the Aurora has been used in many international coalitions like Operation Active Endeavour where it provided maritime surveillance to the North Atlantic Treaty Organization (NATO) naval forces,[1] and Operation Unified Protector (OUP) where it provided maritime surveillance and overland ISR to the multi-national coalition.[2] In carrying out the Long Range Patrol (LRP) role, the CP140 is capable of ISR, Anti-Submarine Warfare (ASW), Above Surface Warfare (ASuW), Search and Rescue (SAR), Information Operations (IO), and even the Strike and Armed Reconnaissance Coordinator (SCAR-C) missions. However, this airframe is approaching the end of its life-cycle and a replacement must be identified by the 2030 timeframe.[3]

Replacement MPA like the P8 Poseidon, a derivative of the common Boeing 737 commercial aircraft is an expensive system to acquire. The United Kingdom (UK) has secured a

[1]National Defence and the Canadian Armed Forces, "Canadian Forces Operation in Mediterranean Ends," last accessed 25 April 2018, http://www.forces.gc.ca/en/news/article.page?doc=canadian-forces-operation-in-mediterranean-ends/hnocfnmf.

[2]National Defence and the Canadian Armed Forces, "Operation Mobile," last accessed 25 April 2018, http://www.forces.gc.ca/en/operations-abroad-past/op-mobile.page.

[3]Department of National Defence, Strong Secure Engaged (Ottawa: DND Canada, 2017), 65.

deal for the procurement of nine Boeing P8 at a cost of approximately 3.2 billion dollars.[4] In an interview with Frontline Defence in 2013, the Commander of the Royal Canadian Air Force (RCAF) acknowledged that a potential way forward in replacing the Aurora may include the incorporation of Unmanned Air Vehicles[5] (UAV) into the project.[6] *Strong, Secure, Engaged*, Canada's recent defence policy has also identified a new initiative for the acquisition of a Medium Altitude Long Endurance (MALE) Remotely Piloted Aircraft (RPA) capable of conducting precision strikes.[7] If RPA technology is ready to support maritime operations, then a significant cost savings and economy of scale could be achieved in acquiring one type of RPA to perform both the new MALE precision strike role and to also replace the CP140.

Although RPA technology has come a long way in the last decade, this paper will demonstrate that the CP140 must be replaced with a crewed aircraft. A capability analysis will be conducted based on the framework presented in the CAF Capability Based Planning (CPB) handbook. This Chief of Force Development publication outlines six dimensions of Measures of Capability (MoC) that are commonly used to qualitatively describe capabilities when assessing effectiveness.[8] Critical capability gaps and operating risks will be identified during this analysis that will highlight the unsuitability of RPA as a viable replacement for the CP140. This includes their inability to conduct ASW, their reliance on a vulnerable communication link that could negatively impact mission success and restrict operations, and their inherent lack of mission flexibility.

---

[4]UK Defence Journal, "First two British P-8 Poseidon Maritime Patrol Aircraft ordered," last accessed 25 April 2018, https://ukdefencejournal.org.uk/first-two-british-p-8-poseidon-maritime-patrol-aircraft-ordered/.

[5]For the purpose of this paper, the terms Unmanned Air Vehicle (UAV), Unmanned Air System (UAS), and Remotely Piloted Aircraft (RPA) all refer to an air vehicle that is remotely piloted.

[6]Chris Maclean, "Commander of the RCAF," *Frontline Defence*, no. 3 (Summer 2013): 20.

[7]Department of National Defence, *Strong Secure Engaged*…, 39, 73.

[8]There are six dimensions including scale (this includes command and control, lethality, sustain, and generic), survivability, reach, persistence, responsiveness, and interoperability. This paper will discuss all of the dimensions and sub-dimensions as they apply to maritime patrol operations with the exception of sustain and generic. Department of National Defence, *Capability Based Planning Handbook,* (Ottawa: DND Canada, 2014) 32.

COMMAND AND CONTROL AND INTEROPERABILITY

Effective Command and Control (C2) of air power assets ties into the most fundamental tenet of air power, centralized control and decentralized execution. As stated in the RCAF's air doctrine, failure to achieve this will "marginalize the effects of the other tenets of air power."[9] There is an inherent benefit with RPA in that there exists a physical separation between the crew and aircraft system, however, the link between the two is a critical control mechanism. This control link is susceptible to interference which can seriously degrade control and mission effectiveness. With the ever-growing use of Beyond Line of Sight (BLOS) communications in military operations, bandwidth availability is in high demand and coverage is not available globally. A crewed aircraft, unlike an RPA, offers more flexibility in conducting operations globally and is not critically dependent on BLOS to ensure mission success. In contrast, both RPA and crewed aircraft offer great interoperability within a joint force context, with no distinct advantage realized when comparing RPA and crewed aircraft.

Reliance on Satellite Communications

RPA are controlled via a link from the Ground Control Station[10] (GCS) to the platform through either Line of Sight (LOS) or BLOS communications. BLOS enables RPA operations at distances that far exceed the reception range of a LOS transmitter. The reliance on the continual use of Radio Frequency (RF) spectrum, LOS or BLOS, to conduct RPA operations is highlighted as a serious vulnerability in many documents. A most recent study conducted by the United States Department of Defense Science Board concluded that the risk of military satellite communications being jammed is high and they recommended that "this reality should be

---

[9]Department of National Defence, *Canadian Armed Forces Air Doctrine* …, 16.
[10]The Ground Control Station (GCS) is synonymous with Unmanned Control Station (UCS).

considered a crisis to be dealt with immediately."[11] Furthermore, other important strategic and operational planning documents such as the *Future Security Environment* (FSE)[12] handbook, and Joint Publication 3-30, *Command and Control in Joint Air Operations* (JP 3-30) also highlight the importance of protecting the integrity of control links to the various platforms. JP 3-30 states that "UAS communication links are generally more critical than those required for manned systems... therefore, communications security, specifically bandwidth protection (from both friendly interference and adversary action), is imperative."[13]

Even crewed LRP platforms such as the Block IV CP140 utilize BLOS capability to transmit mission data, and are just as vulnerable as RPA regarding jamming and interference. However, the difference is that the crewed aircraft can still continue with its mission in such a degraded environment. The only immediate effect is that the reporting of time-critical mission data will be delayed until either the satellite bandwidth is back up and running, or the aircraft has landed. Without the critical BLOS link for aircraft control and monitoring by the crew in the GCS, the RPA is unable to carry out its mission. Furthermore, the crewed aircraft has a clear advantage over RPA in that it can be launched into a known area that does not have BLOS connectivity. This offers unprecedented flexibility to the commander in tasking LRP aircraft globally regardless of the availability of satellite communications.

Standing North Atlantic Treaty Organization Agreement (STANAG) 4671 outlines the level of airworthiness that must be demonstrated by RPA for certification. "Command and control information transmitted to the UAS from the UCS (transmitted via the 'uplink') should

[11]Department of Defense and Defense Science Board*, Task Force on Military Satellite Communication and Tactical Networking: Executive Summary*, (Washington: Office of the Secretary of Defense for Acquisition, Technology, and Logistics, 2017) 2.

[12]Department of National Defence, *The Future Security Environment 2013-2040*, (Winnipeg: DND Canada, 2014) 116.

[13]Department of Defense, *Joint Publication 3-30 Command and Control of Joint Air Operations*, (Washington D.C.: Joint Chiefs of Staff, 2014) III-30.

be shown to enable positive control of the UAS during all normal operations, and transmitted at a rate consistent with safe operation."[14] This highlights that there must always be a link between the RPA and operator, regardless of the level of autonomy. Under this overarching STANAG, RPA operations will always be reliant on a control link and are vulnerable to interference.

Another complication affecting this control link is that bandwidth availability is becoming congested and is not available globally. As a Congressional Research Service paper published in 2012 reported, "the finite bandwidth that currently exists for all military aircraft, and the resulting competition for existing bandwidth, may render the expansion of UAS applications infeasible and leave many platforms grounded."[15] To complicate the matters further, the United States and other allies have relied heavily on civilian contracts for the use of the highly sought after satellite bandwidth, and contract premiums are proving to be costly.[16] Most of the current satellite infrastructure is focused on operations in the Middle East and, as a result, are unable to support bandwidth requirements globally.[17] Lack of readily available satellite bandwidth could prohibit RPA operations in certain areas of the globe.

Interoperability

Today's battlefield, whether over land or sea, involves the quick dissemination and sharing of mission data. This enables agile forces and allows commanders to take quick action in order to achieve their objectives. RCAF doctrine states that "cooperation among elements of a

---

[14]North Atlantic Treaty Organization, "NATO Standard AEP-4671 Unmanned Aircraft Systems Airworthiness Requirements," last accessed 25 April 2018, http://nso.nato.int/nso/zPublic/ap/PROM/AEP-4671%20EDA%20V1%20E.pdf. 2-H-1 Acceptable Means of Compliance 1601.

[15]Congressional Research Service, *U.S. Unmanned Aerial Systems* (Washington D.C.: Congressional Research Service, 2012), 17.

[16]Department of Defense, *Unmanned Systems Integrated Roadmap FY2013-2038,* (Washington D.C.: Department of Defense, 2014), 49.

[17]*Ibid.*

force maximizes its capabilities. It entails a unified aim, team spirit, interoperability, division of responsibility, and coordination of effort to achieve maximum effectiveness."[18] Interoperability is enabled through the use of aircraft mission equipment such as radios and data link systems. These systems can be installed on either manned or unmanned platforms as long as there are available payload and electrical capacity to power them with no distinct advantage going to either platform.

As early as 2004, the United States had noted interoperability issues amongst their own RPA. Dyke Weatherington, head of DOD's UAS planning taskforce, noted: "There have been cases where a service's UAV, if it could have gotten data to another service, another component, it may have provided better situational awareness on a specific threat in a specific area."[19] Some of these issues have been addressed and examples from modern joint warfare campaigns have seen the seamless incorporation of RPA on the battlefield. In OUP, RPA worked alongside other air assets in prosecuting the same target. Will Laidlaw, a British Apache pilot who flew in this international joint air campaign recalls firing a Hellfire missile from his helicopter at a Libyan target that was being laser-pointed by a Reaper RPA, who had a much better vantage point.[20]

Newer RPA designs can accommodate more payload, generate more electrical power, and incorporate smaller mission and avionics sub-components. In 2012, General Atomics released a press statement describing the new features available with the Block 5 Reaper that included increased power capacity and a backup generator, dual ARC-210 multi-purpose radios, secure data link, and increased data transmission capacity.[21] As far as interoperability is

---

[18]Department of National Defence, *Canadian Armed Forces Air Doctrine* …, 14.
[19]Congressional Research Service, *U.S. Unmanned Aerial Systems*…, 16.
[20]Will Laidlaw, *Apache Over Libya* (London: Pen and Sword Aviation, 2016), 118.
[21]General Atomics and Affiliated Companies, "GA-ASI Introduces System-wide Enhancements for Predator B/MQ-9," last Accessed 27 April 2018, http://www.ga.com/ga-asi-introduces-system-wide-enhancements-for-predator-bmq-9.

concerned, the predecessor of the MQ4C Triton is equipped with Link-16 whereas the current Block III CP140 is not.[22] Viasat now offers a Small Tactical Terminal developed for smaller platforms to enable Link-16 interoperability that weighs only 16.5 pounds.[23] The US Department of Defense (DoD) has made it a priority to address interoperability issues stating that future RPA shall be based on "open architectures, non-proprietary interfaces, and government owned data rights…to further enable a broader net-centric environment that is truly interoperable, open, and scalable."[24]

Future Canadian RPA acquisition requirements should fall in-line with DoD interoperability initiatives as stated above. In the end, the driving factor is the ability to install and operate the various mission systems and this is not a platform-specific problem as long as sufficient payload capacity and power is available for their operation. Regardless of the platform that replaces the CP140, it must be capable of fulfilling SSE's mandate to ensure "the seamless integration with partners and sharing of information. The Royal Canadian Air Force must be capable of contributing to and exploiting a system-of-systems approach that now defines most modern military forces."[25] With the advent of newer technologies, there is no distinct advantage as far as interoperability is concerned when comparing RPA to traditional crewed MPA.

Although good interoperability is achievable with crewed aircraft and RPA, the lack of satellite availability and ever-rising costs will be factors that could constrain maritime RPA operations globally. As identified in the Royal Canadian Navy's *Leadmark 2050* document, MPA "expand the breadth of a maritime theatre of operations and conduct an assigned task over

---

[22]Naval Technology, "MQ-4C Triton Broad Area Maritime Surveillance (BAMS) UAS," last Accessed 27 April 2018, https://www.naval-technology.com/projects/mq-4c-triton-bams-uas-us/.

[23]Viasat, "Small Tactical Terminal (STT) KOR-24," last Accessed 27 April 2018, https://www.viasat.com/files/assets/web/datasheets/STT_datasheet_039_web.pdf.

[24]Department of Defense, *Unmanned Systems Integrated Roadmap FY2013*-2038…, 31.

[25]Department of National Defence, *Strong, Secure,* Engaged…, 39.

a tactically meaningful period of time."[26] Seeing that the earth's surface is covered with over 70 percent water,[27] this represents a significant potential operational area, and connectivity issues could deny RPA accessibility and agility to maritime forces.

PERSISTENCE, REACH, AND RESPONSIVENESS

Persistence, reach, and responsiveness are characteristics that define where a force element can operate, for how long, and how flexible it is in responding to the situation. The RPA offers a distinct advantage over crewed aircraft with its extremely long endurance times. However, in the maritime ASW context, this is negated by the fact that an RPA could run out of critical sonobuoys long before the end of its on-station period. RPA and crewed aircraft both have very long ranges, and with the advent of newer technology can both safely operate globally over the high seas under the rules of Due Regard. Crewed aircraft have a greater advantage regarding responsiveness as they are typically easier to deploy and they also offer more flexibility to maritime operations by fulfilling multiple mission sub-sets in the same sortie.

Endurance

As presented in the RCAF's air doctrine manual, impermanence is a unique characteristic of air power that must be considered by planners. Aircraft cannot stay airborne indefinitely and more than one platform may need to be rotated to achieve the desired air effect.[28] RPA are designed to have long endurance times and offer tremendous persistence in this regard. In May 2017, General Atomics reported that their Certifiable Predator B (CPB) broke an endurance

---

[26] Department of National Defence, *Canada in a New Maritime World LEADMARK 2050*, (Ottawa: DND Canada, 2016), 41.

[27] United States Geological Survey, "How much water is there on, in, and above the Earth?" last Accessed 25 April 2018, https://water.usgs.gov/edu/earthhowmuch.html.

[28] Department of National Defence, *Canadian Armed Forces Air Doctrine* …, 13.

record of over 48 hours.[29] The MQ4C Triton is also capable of endurance times that exceed 24 hours[30] which is still far greater than that of crewed aircraft. The CP140 has an endurance of approximately 12 hours[31] and the P8 has an endurance of over 10 hours.[32] In the maritime domain, an on-station time of 24 hours or greater would significantly increase the efficiency of support to naval operations and would also benefit the RCAF. Arguably, less Yearly Flying Hours (YFR) would be lost on transit time by the relieving platforms and a reduced tempo for ground support personnel would also occur. To support a 24-hour mission far fewer airframes would be needed with less air and ground crew which would reduce overall operating and maintenance costs.

RPA have a distinct advantage regards persistence, however, in the context of conducting ASW, an on-station time of 24 hours would be unfeasible for just one airframe tracking a submarine. With a finite number of sonobuoys available for use, an RPA would run out of them and lose contact with the submarine long before the end of the on-station period. Submarine detection ranges are classified but the US Los Angeles class submarine can cover a distance of approximately 600 nm in a 24 hour period.[33] During ASW exercises, it is not uncommon for crewed MPA to run out of sonobuoys with on-station times as short as four hours.[34] To fulfill

---

[29] General Atomics and Affiliated Companies, "MQ-9B SkyGuardian Remains Airborne for Over 48 Hours Non-Stop," last Accessed 24 April 2018, http://www.ga-asi.com/mq-9b-skyguardian-remains-airborne-for-over-48-hours-non-stop.

[30] Northrop Grumman, "Triton Data Sheet," Last Accessed 24 April 2018, http://www.northropgrumman.com/Capabilities/Triton/Documents/pageDocuments/Triton_data_sheet.pdf.

[31] Royal Canadian Air Force, "CP-140 Aurora," last Accessed 24 April 2018, http://www.rcaf-arc.forces.gc.ca/en/aircraft-current/cp-140.page.

[32] The US Navy website quotes 4 hours on station at 1200 nm. Assuming a speed of 400 knots, this would equate to three hours of transit time each way yielding a ten hour flight. Fuel flow is greater at maximum range airspeed as opposed to maximum endurance airspeed for turbo-fan powered aircraft. Naval Systems Command, "P-8A Poseidon," last Accessed 24 April 2018, http://www.navair.navy.mil/index.cfm?fuseaction=home.display&key=cfd01141-cd4e-4db8-a6b2-7e8fbfb31b86.

[33] This figure is based on a transit speed of 25 knots. United States Navy, "U.S. Navy Fact Sheet," last accessed 24 April 2018, http://www.navy.mil/navydata/fact_print.asp?cid=4100&tid=100&ct=4&page=1.

[34] Based on personal experience as a crew commander on the CP140 from 2009 to 2011.

the ASW role, multiple RPA would be required to ensure adequate handovers at intervals well below their maximum endurance times to ensure continual contact with sonobuoys, negating their advantage of long persistence. As will be discussed later, RPA technology has also not evolved to the point where they can deploy sonobuoys. The RPA persistence advantage is much better suited for surface surveillance like that of the MQ4C Triton. It was developed to provide surveillance over an area of greater than 2,000 nm in one sortie.[35] At this point in time, the US Navy has no concept of operations for employing RPA solely for ASW operations.

Range and Accessibility to Airspace

One of the key components of reach is the range of a particular platform. When comparing the ranges between RPA and crewed aircraft, they all offer an incredible amount of flexibility to commanders. The P8 range is approximately 4500 nm[36] and the CP140 range is approximately 4000 nm.[37] The ranges of bigger RPA match or exceed that of current crewed aircraft with the MQ4C having a maximum range of 8200 nm.[38] A factor that is more important than range is the accessibility of platforms to operate in certain classes of airspace. In 2013, the German government canceled the Eurohawk programme because its certification was at high risk of not meeting airworthiness standards required to fly in European airspace. The program cost German

[35]United States Navy, "MQ-4C Triton," last accessed 24 April 2018, http://www.navy.mil/navydata/fact_display.asp?cid=4350&tid=500&ct=4.

[36]Boeing, "An Intelligence, Surveillance and Reconnaissance Solution," last accessed 24 April 2018, https://www.boeing.com/defense/maritime-surveillance/p-8-poseidon/index.page.

[37]Royal Canadian Air Force, "CP-140 Aurora," last Accessed 24 April 2018, http://www.rcaf-arc.forces.gc.ca/en/aircraft-current/cp-140.page.

[38]United States Navy, "MQ-4C Triton," last accessed 24 April 2018, http://www.navy.mil/navydata/fact_display.asp?cid=4350&tid=500&ct=4.

taxpayers almost half of a billion euros.[39] The Eurohawk was a derivative of the US Global Hawk which has unprecedented range.

RPA companies have now incorporated new systems that will open up access to civilian controlled airspace. Military aircraft conducting operations over the high seas operate under the Due Regard principle as detailed in Article Three of the Chicago Convention. It specifies that aircraft operating in controlled airspace, not under positive control of the air traffic services, must either operate under Visual Meteorological Conditions (VMC), under positive radar control of another station, or be equipped with a radar that can provide air traffic separation.[40] These rules are to ensure that military operations do not pose a hazard to civilian air traffic. Due Regard operations offer an enormous amount of agility for LRP platforms to operate as required within an assigned area without being constrained by civilian air traffic services. The challenge with RPA is that without human crew onboard, they cannot operate under the 'See and be Seen' principle of Visual Flight Rules (VFR) to ensure traffic separation. The CPB, a derivative of the Predator incorporates new technological advances that will enable it to fly in controlled airspace and operate under Due Regard. This includes a Due Regard Radar that is integrated with an Aircraft Collision Avoidance System to satisfy the Due Regard requirements as stated previously.[41] Furthermore, the CPB is being designed around the stringent airworthiness requirements as defined by NATO STANAGS, the Federal Aviation Administration, and the European Aviation Safety Agency to demonstrate compliance enabling operations in controlled

[39]Deutsche Welle, "Sky-high costs for Germany's grounded Euro Hawk," last accessed 23 April 2018, http://www.dw.com/en/sky-high-costs-for-germanys-grounded-euro-hawk/a-18596366.

[40]International Civil Aviation Organization, "ICAO Civil/Military Cooperation Symposium Operation of State Aircraft," last accessed 22 April 2018, https://www.icao.int/EURNAT/Other%20Meetings%20Seminars%20and%20Workshops/ICAO%20Civil-Military%20Cooperation%20Meetings/ICAO%20Civil-military%20Cooperation%20Symposium%202015/ICMCS%20IP01.pdf.

[41]General Atomics Aeronautical, "The Sky's Not the Limit. General Atomics Aeronautical Continues to Push RPAS Boundaries," last accessed 24 April 2018, http://www.ga-asi.com/Websites/gaasi/images/products/aircraft_systems/pdf/capability_profile.pdf.

civilian airspace. The United Kingdom is planning on purchasing 26 of these platforms to enhance their ISR capability.[42]

Deployability and Mission Flexibility

When comparing the airspeed envelopes between RPA and crewed aircraft, not one particular design offers a distinct advantage over the other. Newer RPA are now just as fast as current crewed aircraft. The MQ4C Triton has a maximum speed of 331 knots True Airspeed (TAS) and the Predator C Avenger has a maximum speed of 400 knots TAS. This is comparable to the CP140 and P3C platforms. Other factors in responsiveness highlight bigger capability differences over airspeed envelopes.

Launch and recovery operations are distinctively different when comparing RPA to crewed aircraft. Normally, the launch and recovery of RPA are conducted with specialized aircrew and equipment that needs to be set-up at the forward operating airfield and at emergency airfields for diversions.[43] Having to plan the logistics of deploying launch and recovery crews to the forward operating base and to diversionary airfields could negatively impact responsiveness. Traditional crewed aircraft offer better responsiveness with their abilities to deploy globally in as little as 12 hours, and subsequently launch on operations. General Atomics is addressing this dependence on a heavy launch and recovery footprint by incorporating a BLOS launch and recovery capability that would eliminate the need to forward deploy these crews.[44] This would

---

[42]Air Force Technology, "Certifiable Predator B: a new generation sharpens its claws," last accessed 24 April 2018, https://www.airforce-technology.com/features/featurecertifiable-predator-b-a-new-generation-sharpens-its-claws-5760856/.

[43]Joint Chiefs of Staff, *Joint Publication 3-30 Command and Control of Joint Air Operations…,* III-32.

[44]General Atomics and Affiliated Companies, "GA-ASI Demonstrates SATCOM Launch and Recovery Capability for MQ-9B," last accessed 24 April 2018, http://www.ga.com/ga-asi-demonstrates-satcom-launch-and-recovery-capability-for-mq-9b.

offer unprecedented flexibility in RPA deployment responsiveness provided that the appropriate agreements to operate at the forward base are in-place, however, this technology has just been demonstrated and may not be fielded for some time.

RCAF air doctrine describes the importance of flexibility and versatility in the application of air power in that it can be "quickly and decisively shifted from one objective to another."[45] Flexibility offers increased responsiveness to a changing situation where one platform can fill many roles and quickly react to maximize effectiveness. Current crewed MPA can switch between many mission sub-sets once airborne having been designed to fulfill the multi-mission role. In OUP, the CP140 would concurrently collect maritime surveillance, overland surveillance, and hold airborne SAR standby.[46] Current RPA are not designed to be able to conduct so many mission sub-sets at once due to their limitations with space for sensors and payload. Although future systems may address this shortfall, crewed LRP platforms will continue to offer much more versatility and responsiveness to commanders over RPA.

Recent technological advances have solved many of the initial issues of accessibility to airspace. This tied with ever enduring persistence and the ability for RPA to operate in icing conditions, paves the way for full Instrument Flight Rules (IFR) certification of these platforms. This is a big step forward in addressing agility to operate globally in all weather conditions. However, as was discussed earlier, crewed platforms do not have to rely on launch and recovery crews and can currently switch between multiple mission sub-sets airborne. RPA are limited to what missions they can accomplish.

---

[45]Department of National Defence, *Canadian Armed Forces Air Doctrine* …, 17.

[46]Typical CP140 search stores capacity includes over 80 sonobuoys, LUU-2B para-rescue flares, marine smoke markers, SKAD. Daniel Arsenault and Joshua Christianson, "The CP140 Aurora Experience within Task Force Libeccio and Operation MOBILE," in *The Royal Canadian Air Force Journal*, Vol. 1 no. 2 (Summer 2012), 30.

LETHALITY AND SURVIVABILITY

Lethality is the capability of a force element to detect, target, engage, and destroy threats. This is a fundamental capability that is required within the maritime environment and crewed MPA platforms such as the CP140, P3C, and P8 are able to execute the entire kill-chain, from detect to destroy for ASW missions. This brings a tremendous amount of flexibility to maritime force commanders in that a submarine may be tracked and prosecuted well outside of the range of organic maritime helicopter coverage and at zero threat to a friendly maritime task group. Furthermore, ballistic missile submarines can also be tracked anywhere around the globe in all-weather conditions. As discussed throughout the paper, crewed platforms typically carry more payload due to their size. Modern western RPA technology has not been developed to the point where one RPA or even multiple RPA have demonstrated the ability to conduct ASW on a submerged contact. Crewed aircraft have the distinct advantage in this regard. Survivability is the ability to conduct operations while considering the opponent's threat capability and environmental factors threatening the force element. Recent technological advancements have closed the gap between crewed aircraft and RPA as far as operating in adverse weather, with no particular advantage attributable to either RPA or crewed aircraft when considering all possible threats.

Payload

At present, there are no western built fixed-wing RPA that can simultaneously carry and launch sonobuoys and torpedoes. ADCOM systems, based in the United Arab Emirates (UAE), unveiled an ASW variant of their United 40 MALE RPA that is supposed to be capable of laying a passive field of sonobuoys and even dropping a light-weight torpedo,[47] however, the results of this proof of concept testing are not known. Furthermore, the intended purchaser, Russia has not publically released a statement that this RPA will be used to conduct ASW, but rather will be used for "strategic missions such as near real time combat assessment, battle damage assessment and intelligence preparation of the battlefield."[48] The capabilities of this RPA match those of the MQ4C Triton, not those of a crewed MPA.

As RPA payload capacity continues to grow, it is feasible that they could carry enough payload to conduct ASW. When comparing the load-out of the CP140 that typically carries four torpedoes and approximately 80 sonobuoys, this amounts to around 4,000 pounds of payload.[49] The CPB can carry upwards of 4,000 pounds of external payload.[50] As well, Airbus has demonstrated that torpedoes can be launched from hard points mounted under the wing of a fixed-wing aircraft,[51] proving that this technology is available and could be incorporated into RPA. The main issue lies with storage and launch capabilities of sonobuoys. The dimensions of A-sized sonobuoys, the most widely used variety among NATO countries, are three feet long by approximately 5 inches in diameter and require specialized launchers in order to effectively drop them.[52] This represents a significant volume challenge for RPA to carry an operationally relevant amount of sonobuoys to effectively track submerged submarines. This would restrict the number of sonobuoys that one RPA could employ during ASW requiring the need to

[47]Jane's 360, "United-40 gains ASW capability," last accessed 21 April 2018, http://www.janes.com/article/49331/united-40-gains-asw-capability-idx15d2.

[48]UAS Vision, "Russia Begins Flight Tests of Adcom United 40," last accessed 22 April 2018, https://www.uasvision.com/2016/05/03/russia-begins-flight-tests-of-adcom-united-40/.

[49]Four MK-46 torpedoes at 2,000 pounds, 60 SSQ53 DIFAR sonobuoys at 1,300 pounds, and 20 SSQ52 DICAS sonobuoys at 700 pounds for a total of 4,000 pounds.

[50]General Atomics Aeronautical, "Multi-Role - Single Solution," last accessed 21 April 2018, http://www.ga-asi.com/Websites/gaasi/images/products/aircraft_systems/pdf/MQ-9B-Capability-Profile-II.pdf.

[51]Flight Global, "Airbus demonstrates torpedo launch with C-295," last accessed 20 April 2018, https://www.flightglobal.com/news/articles/airbus-demonstrates-torpedo-launch-with-c-295-341721/.

[52]Federation of American Scientists, "Approved Navy Training System Plan for the Navy Consolidated Sonobuoys," last accessed 20 April 2018, https://fas.org/man/dod-101/sys/ship/weaps/docs/ntsp-Sonobuoy.pdf.

continuously relieve the on-station RPA with another. This concept completely negates the fundamental advantage of RPA over crewed platforms, that of extremely long endurance times.

Risk to Aircrew

One of the biggest advantages of the RPA is that there exists no threat to human life when conducting operations. However, with the cost of High Altitude Long Endurance (HALE) and MALE UAVs mounting, and any LRP RPA would inevitably be a costly airframe with all of its sensors[53], the appetite to lose aircraft to factors like extreme weather or enemy fire is not palatable. The high cost of these systems may negate the risk of losing them in certain circumstances. Although the benefit of operating in remote areas goes to the RPA, the reliability of crewed aircraft is still very good. The LRP fleet has operated the CP140 for 36 years in remote areas of the world like the high arctic and halfway across the Atlantic Ocean without having an accident resulting in the loss of life or an airframe.

Weather

In past years, critics have pointed out that RPA were incapable of operating in adverse weather conditions like turbulence and icing.[54] However, recent technological advances have solved many of these issues. The MQ4C Triton, a derivative of the Northrop Grumman Global Hawk, is capable of operations in challenging weather conditions. It incorporates a new reinforced airframe design that meets gust load requirements and has de-icing capabilities for the

[53]Congressional Research Service, *U.S. Unmanned Aerial Systems*…, 10.
[54]J.C. Kenny, "Unmanned Aircraft Systems: Are Expectations Realistic?" (Joint Command and Staff Program Solo Flight Paper, Canadian Forces College, 2012) 35.

V-shaped tail, wings, and engine inlet.[55] The General Atomics CPB builds on the legacy Predator airframe and incorporates anti-icing features that enable flight in adverse weather.[56] When comparing de-icing and anti-icing capabilities, recent HALE and MALE RPA have airframe systems that are comparable to those found on crewed aircraft enabling operations in all-weather conditions.

Detectability and Self Defence

Airborne platforms can be detected in the visual, aural, and Radio Frequency (RF) spectrum, whether by radar or by detecting its RF emissions. The RAND Corporation published a report for the US Navy in 2010 entitled *Applications for United States Navy Unmanned Aircraft Systems*, and it stated that RPA are more susceptible to counter detection, tracking, and attack by enemy air defences. This is due to their dependence on the control link that requires more frequent and active transmissions than that of crewed aircraft.[57] While they may be more vulnerable to being tracked with sophisticated equipment in the RF spectrum, RPA offer better counter detection capabilities in other domains. Radar Cross Section (RCS) information is not available within the unclassified realm, however, it is logical to assume that the bigger the air vehicle, the bigger the RCS for non-stealth platforms like the P8. Having smaller and fewer engines, RPA could very well offer an advantage regarding acoustic counter detection and the Infra-Red signature could arguably be smaller than that of much heavier crewed aircraft that

[55] Northrop Grumman, "MQ-4C Triton. Making the World's Oceans Smaller," last accessed 20 April 2018, http://www.northropgrumman.com/Capabilities/Triton/Pages/default.aspx.

[56] General Atomics Aeronautical, "The Sky's Not the Limit. General Atomics Aeronautical Continues to Push RPAS Boundaries," last accessed 24 April 2018, http://www.ga-asi.com/Websites/gaasi/images/products/aircraft_systems/pdf/capability_profile.pdf.

[57] Brien Alkire, James G. Kallimani, Louis R. Moore, and Peter A. Wilson, *Applications for Navy Unmanned Aircraft Systems.* (Santa Monica: RAND Corporation, 2010) 38.

need more powerful engines. In the visual spectrum, RPA are normally smaller and therefore harder to detect with the naked eye. Not one platform offers a distinct advantage when considering all scenarios. Where the RPA may be harder to detect, crewed aircraft also have self-protection measures including Directed Infra-Red Counter Measures (DIRCM), chaff, and flares that are currently not available for use on RPA.[58]

The delta in payload carriage and use currently favours crewed aircraft over RPA in providing flexible multi-mission capabilities to maritime joint force commanders. This is evident when looking at the force construct of the United States Navy that has decided to augment crewed aircraft with RPA, not replace them in the maritime domain. As Kreuzer points out in his book entitled *Drones, the Future of Air Warfare*, the greatest potential for RPA in the future lies with maritime operations during peacetime.[59] Even though RPA operations remove the risk to human life, these systems are becoming so complex and expensive that this may negate the will to lose one. It is feasible that in the future, sonobuoy carriage and launch from fixed-wing RPA could become a reality. Until this technology has been demonstrated, Canada can ill afford to invest in a developmental and experimental acquisition project for fear of unpredictable delays much like the Maritime Helicopter (MH) replacement.

CONCLUSION

This capability-based analysis has shown that RPA technology has progressed significantly in the last decade or so, and companies have addressed many drone specific deficiencies. This has elevated the playing field where it is now feasible for RPA to operate at

---

[58]Department of Defense, *Unmanned Systems Integrated Roadmap FY2013*-2038…, 63.
[59]Michael P. Kreuzer, *Drones and the Future of Air Warfare*. (New York: Routledge, 2016) 164.

speeds equivalent to current crewed aircraft, in all weather conditions, and even within controlled airspace. However, the crucial link between the ground station and RPA can be seen as a significant vulnerability restricting operating flexibility in certain areas of the globe. In addressing this vital communication link, and the possibility of designing a fully autonomous RPA, there is the ethical issue of the reliance on artificial intelligence to conduct a weapon drop that must be acknowledged.

If technological advances enable torpedo and sonobuoy carriage and launching from RPA, then it may be viable to replace the CP140 fleet with such systems. In this case, a risk analysis must be conducted to understand the communication vulnerabilities that exist between the platform and the operator. However, this technology has not been demonstrated on RPA and if a Request for Proposal was written for the replacement of the CP140 fleet today, the option of incorporating a crewed platform to fulfill the ASW role would be a critical component of maintaining the status-quo of maritime air capabilities. With the time expiration of the CP140 airframe sometime within the 2030s, Canada cannot afford to partner up under an experimental and developmental project to develop something new.

Perhaps a system of systems approach would be better served for the CP140 replacement project where the greater capability is leveraged for a particular mission sub-set. The US Navy and Royal Australian Air Force (RAAF)[60] have modeled their MPA replacement strategies around this very concept. This includes leveraging the persistence of the RPA to conduct ever enduring ISR coupled with a crewed aircraft to primarily conduct ASW and be the final link of the kill chain. Crewed platforms also provide agile forces that can adapt to changing mission

[60] Air Force, "MQ-4C Triton Unmanned Aircraft System," Last accessed 3 May 2018, https://www.airforce.gov.au/technology/aircraft/intelligence-surveillance-and-reconnaissance/mq-4c-triton-unmanned-aircraft.

scenarios giving more flexibility to commanders as was demonstrated by the employment of the CP140 in OUP. If a suitable RPA system could fulfill both SSE's new unmanned overland precision strike capability and conduct persistent maritime ISR, then Canada should consider expanding the mission sub-set of the newly acquired drone to leverage cost and operating efficiencies. This could, in fact, reduce the overall acquisition cost of the CP140 replacement in that fewer crewed aircraft would need to be purchased if maritime ISR could be augmented by RPA. It is recommended that the Director of Air Requirements (DAR) keep apprised of technological RPA advancements and monitor the disposition of allied MPA fleets worldwide to learn valuable information that could be brought forward to enhance Canada's future LRP capabilities.

BIBLIOGRAPHY

Air Force. "MQ-4C Triton Unmanned Aircraft System." Last accessed 3 May 2018. https://www.airforce.gov.au/technology/aircraft/intelligence-surveillance-and-reconnaissance/mq-4c-triton-unmanned-aircraft.

Air Force Technology. "Certifiable Predator B: a new generation sharpens its claws." Last accessed 24 April 2018. https://www.airforce-technology.com/features/featurecertifiable-predator-b-a-new-generation-sharpens-its-claws-5760856/.

Alkire, Brien, Kallimani, James G., Moore, Louis R., and Wilson, Peter A. *Applications for Navy Unmanned Aircraft Systems.* Santa Monica: RAND Corporation, 2010.

Arsenault, Daniel, and Christianson, Joshua. "The CP140 Aurora Experience within Task Force Libeccio and Operation MOBILE." In *The Royal Canadian Air Force Journal*, Vol. 1 no. 2 (Summer 2012): 27-37.

Boeing. "An Intelligence, Surveillance and Reconnaissance Solution." Last accessed 24 April 2018. https://www.boeing.com/defense/maritime-surveillance/p-8-poseidon/index.page.

Canada. Department of National Defence. B-GA-400-000/FP-001, *Canadian Armed Forces Air Doctrine*. Trenton: DND Canada, 2016.

Canada. Department of National Defence. *Canada in a New Maritime World LEADMARK 2050*. Ottawa: DND Canada, 2016.

Canada. Department of National Defence. *Capability Based Planning Handbook.* Ottawa: DND Canada, 2014.

Canada. Department of National Defence. *Strong, Secure, Engaged, Canada's Defence Policy*. Ottawa: DND Canada, 2017.

Canada. Department of National Defence. *The Future Security Environment 2013-2040.* Winnipeg: DND Canada, 2014.

Deutsche Welle. "Sky-high costs for Germany's grounded Euro Hawk." Last accessed 23 April 2018. http://www.dw.com/en/sky-high-costs-for-germanys-grounded-euro-hawk/a-18596366.

Federation of American Scientists. "Approved Navy Training System Plan for the Navy Consolidated Sonobuoys." Last accessed 20 April 2018. https://fas.org/man/dod-101/sys/ship/weaps/docs/ntsp-Sonobuoy.pdf.

Flight Global. "Airbus demonstrates torpedo launch with C-295." Last accessed 20 April 2018. https://www.flightglobal.com/news/articles/airbus-demonstrates-torpedo-launch-with-c-295-341721/.

General Atomics Aeronautical. "Multi-Role - Single Solution." Last accessed 21 April 2018. http://www.ga-asi.com/Websites/gaasi/images/products/aircraft_systems/pdf/MQ-9B-Capability-Profile-II.pdf.

General Atomics Aeronautical. "The Sky's Not the Limit. General Atomics Aeronautical Continues to Push RPAS Boundaries." Last accessed 24 April 2018. http://www.ga-asi.com/Websites/gaasi/images/products/aircraft_systems/pdf/capability_profile.pdf.

General Atomics and Affiliated Companies. "GA-ASI Demonstrates SATCOM Launch and Recovery Capability for MQ-9B." Last accessed 24 April 2018. http://www.ga.com/ga-asi-demonstrates-satcom-launch-and-recovery-capability-for-mq-9b.

General Atomics and Affiliated Companies. "GA-ASI Introduces System-wide Enhancements for Predator B/MQ-9." Last Accessed 27 April 2018. http://www.ga.com/ga-asi-introduces-system-wide-enhancements-for-predator-bmq-9.

General Atomics and Affiliated Companies. "MQ-9B SkyGuardian Remains Airborne for Over 48 Hours Non-Stop." Last Accessed 24 April 2018. http://www.ga-asi.com/mq-9b-skyguardian-remains-airborne-for-over-48-hours-non-stop.

International Civil Aviation Organization. "ICAO Civil/Military Cooperation Symposium Operation of State Aircraft." Last accessed 22 April 2018. https://www.icao.int/EURNAT/Other%20Meetings%20Seminars%20and%20Workshops/ICAO%20Civil-Military%20Cooperation%20Meetings/ICAO%20Civil-military%20Cooperation%20Symposium%202015/ICMCS%20IP01.pdf.

Jane's 360. "United-40 gains ASW capability." Last accessed 21 April 2018. http://www.janes.com/article/49331/united-40-gains-asw-capability-idx15d2.

Kenny, J.C. "Unmanned Aircraft Systems: Are Expectations Realistic?" Joint Command and Staff Program Solo Flight Paper, Canadian Forces College, 2012.

Kreuzer, Michael P. *Drones and the Future of Air Warfare*. New York: Routledge, 2016.

Laidlaw, Will. *Apache Over Libya*. London: Pen and Sword Aviation, 2016.

Maclean, Chris. "Commander of the RCAF." *Frontline Defence*, no. 3 (Summer 2013): 8-21.

National Defence and the Canadian Armed Forces. "Canadian Forces Operation in Mediterranean Ends." Last accessed 25 April 2018. http://www.forces.gc.ca/en/news/article.page?doc=canadian-forces-operation-in-mediterranean-ends/hnocfnmf.

National Defence and the Canadian Armed Forces. "Operation Mobile." Last accessed 25 April 2018. http://www.forces.gc.ca/en/operations-abroad-past/op-mobile.page.

Naval Systems Command. "P-8A Poseidon." Last Accessed 24 April 2018. http://www.navair.navy.mil/index.cfm?fuseaction=home.display&key=cfd01141-cd4e-4db8-a6b2-7e8fbfb31b86.

Naval Technology. "MQ-4C Triton Broad Area Maritime Surveillance (BAMS) UAS." Last Accessed 27 April 2018. https://www.naval-technology.com/projects/mq-4c-triton-bams-uas-us/.

North Atlantic Treaty Organization. "NATO Standard AEP-4671 Unmanned Aircraft Systems Airworthiness Requirements." Last accessed 25 April 2018. http://nso.nato.int/nso/zPublic/ap/PROM/AEP-4671%20EDA%20V1%20E.pdf.

Northrop Grumman. "MQ-4C Triton. Making the World's Oceans Smaller." Last accessed 20 April 2018. http://www.northropgrumman.com/Capabilities/Triton/Pages/default.aspx.

Northrop Grumman. "Triton Data Sheet." Last Accessed 24 April 2018. http://www.northropgrumman.com/Capabilities/Triton/Documents/pageDocuments/Triton_data_sheet.pdf.

Royal Canadian Air Force. "CP-140 Aurora." Last Accessed 24 April 2018. http://www.rcaf-arc.forces.gc.ca/en/aircraft-current/cp-140.page.

UAS Vision. "Russia Begins Flight Tests of Adcom United 40." Last accessed 22 April 2018. https://www.uasvision.com/2016/05/03/russia-begins-flight-tests-of-adcom-united-40/.

UK Defence Journal. "First two British P-8 Poseidon Maritime Patrol Aircraft ordered." Last accessed 25 April 2018. https://ukdefencejournal.org.uk/first-two-british-p-8-poseidon-maritime-patrol-aircraft-ordered/.

United States. CRS Report for Congress. *U.S. Unmanned Aerial Systems*. Washington D.C.: Congressional Research Service, 2012.

United States. Department of Defense. *Unmanned Systems Integrated Roadmap FY2013-2038.* Washington D.C.: Department of Defense, 2014.

United States. Department of Defense and Defense Science Board. *Task Force on Military Satellite Communication and Tactical Networking*: *Executive Summary*. Washington D.C.: Office of the Secretary of Defense for Acquisition, Technology, and Logistics, 2017.

United States. Joint Chiefs of Staff. *Joint Publication 3-30 Command and Control of Joint Air Operations.* Washington D.C.: Joint Chiefs of Staff, 2014.

United States Geological Survey. "How much water is there on, in, and above the Earth?" Last accessed 25 April 2018. https://water.usgs.gov/edu/earthhowmuch.html.

United States Navy. "MQ-4C Triton." Last accessed 24 April 2018. http://www.navy.mil/navydata/fact_display.asp?cid=4350&tid=500&ct=4.

United States Navy. “U.S. Navy Fact Sheet.” Last accessed 24 April 2018. http://www.navy.mil/navydata/fact_print.asp?cid=4100&tid=100&ct=4&page=1.

Viasat. “Small Tactical Terminal (STT) KOR-24.” Last Accessed 27 April 2018. https://www.viasat.com/files/assets/web/datasheets/STT_datasheet_039_web.pdf.