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NON-STATE EMPOYMENT OF AIR POWER: ADDRESSING THE THREAT

Maj Joshua Christianson

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AIM

1. The purpose of this paper is to provide a brief survey of recent trends in Unmanned Aerial System (UAS) capabilities and proliferation; emphasizing the potential threat posed by the non-state employment of this technology, while making recommendations on how the Royal Canadian Air Force (RCAF) should address this emerging threat. Over the last two decades, the Canadian Armed Forces (CAF) and RCAF have largely divested all dedicated air defence capabilities. In light of current global trends, it is incumbent upon the RCAF to take a proactive role in developing a counter-UAS approach, both independently and as a stakeholder in a larger CAF joint air defence strategy.

INTRODUCTION

2. Recent decades have witnessed a significant change in global dynamics, factors including increasing globalization, economic inequality and the presence of multiple weak or failing states are increasing the role played by non-state actors.[1] This diverse array of actors will "add complexity to the operating environment and change the scope and nature of military operations."[2] It is within this environment that the RCAF will have to continue to operate, providing strategic reach, while enabling joint action through control of the air, surveillance and reconnaissance, air mobility, and air attack.[3] In order to continue serving as a highly responsive

[1] Department of National Defence, *Projecting Power: Canada's Air Force 2035* (Trenton: Canadian Forces Aerospace Warfare Centre, 2009), 6; Department of National Defence, *The Future Security Environment: 2013-2040* (Ottawa: Chief of Force Development, 2014), 27-29.

[2] Department of National Defence, *Strong, Secure, Engaged – Canada's Defence Policy* (Ottawa: Canada Communications Group, 2017), 51.

[3] Department of National Defence, B-GA-400/FP-001, *Canadian Armed Forces Air Doctrine* (Trenton: Canadian Forces Aerospace Warfare Centre, 2016), 4.

and flexible instrument of national power, the RCAF must be proactive and deliberate in planning and preparing for the threats posed by non-state actors and the diverse array of tactics and means they are able to employ.

3. Recent trends have demonstrated the ability of these actors to engage in various forms of warfare concurrently, while rapidly assimilating new technology to meet their ends.[4] Of particular relevance to this discussion is the recent worldwide proliferation of UASs, driven in large part by their increasing capability and a concurrent decrease in cost; resulting in their employment by a variety of non-state organizations. The approach taken in this paper will be to assess the nature of the threat posed specifically by small UAS (sUAS), and clarify the role for the RCAF with respect to Force Protection (FP) during expeditionary operations to address this threat.[5] Finally it will seek to provide potential near- and long-term courses of action, leveraging emerging allied doctrine, academic studies, and commercial options.

DISCUSSION

Understanding the Threat

> "Understanding the threat is the first step in countering it. By focusing on an enemy's capabilities and methods of operations, Air Defence (AD) commanders

[4] Department of National Defence, *The Future Security Environment: 2013-2040* (Ottawa: Chief of Force Development, 2014), 101.

[5] The Federal Aviation Administration (FAA) and Transport Canada (TC) define a small UAS (sUAS) as any unmanned aircraft weighing less than 25kg.

can best employ AD resources to protect the force and selected assets, minimize casualties, and provide freedom to manoeuvre."[6]

4. In recent years the rapid growth of UAS capability has "led to a new reality in the application of airpower."[7] The low-cost, widespread availability and ease of use have dramatically reduced previous barriers to entry; while increasing battery life, speed, and payload capacity have served as significant incentives for both hobbyists and those with potentially more malicious intent.[8] The preponderance of UAS employment affiliated with non-state actors is more closely associated with sUAS capabilities, as opposed to larger more complex systems.[9] This is of particular relevance as many of these smaller systems are commercial available, with worldwide sales exceeding 2.5 million units in 2016.[10]

5. As the commercial sector continues to drive further capability enhancements, the number of UAS users will without doubt continue to increase. Technological advancements concerning "reconnaissance and potential attack capabilities have matured to the point where UAS represent a significant threat to [military] operations," capabilities once possessed only be advanced nations are now becoming widely available.[11] As submitted to the U.S. House Committee on

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[6] Department of National Defence. B–GL–372–001/FP–001 *Air Defence Artillery Doctrine,* Directorate of Army Doctrine, (1999), 11.

[7] Major Dillon R. Patterson, "Defeating the Threat of Small Unmanned Aerial Systems," *Air & Space Power Journal* 31, no. 1 (Spring 2017): 19.

[8] Rutrell Yasin, "A tactical approach to unmanned aircraft system threat response," *C4ISRNet*, September 2016. https://www.srcinc.com/pdf/Whitepaper-Countering-the-CUAS-shortcomings.pdf; Lieutenant-Colonel Thomas S. Palmer and Colonel (Retired) John Geis II, "Defeating Small Civilian Unmanned Aerial Systems to Maintain Air Superiority," *Air & Space Power Journal* 31, no. 2 (Summer 2017): 102.

[9] Defence Threat Reduction Agency. *Unmanned Aircraft System (UAS) Technical Exploitation Lexicon*. (7 December 2017), 3.

[10] Fortune, "Drone Sales Have Tripled in the Last Year," last accessed 29 January 2018, http://fortune.com/2016/05/25/drones-ndp-revenue/.

[11] Department of the Army, *Counter – Unmanned Aircraft (C-UAS) Strategy Extract* (Washington, DC: Department of the Army, 5 October, 2016), 5.

Homeland Security, "never before have highly-capable UAVs been so inexpensive and widely available…one can buy over the internet today a UAV that rivals the…surveillance and guidance capability of military UAVs."[12]

6. The capabilities and potential applications for commercial off-the-shelf, modified or homemade sUAS are diverse and continually evolving. Initially used primarily for basic intelligence, surveillance and reconnaissance (ISR) tasks, non-state organizations such as the Islamic State in Iraq and Syria (ISIS) and Hezbollah have fully integrated UASs into targeting operations. Recent examples include leveraging this capability to provide real-time vectoring of vehicle-borne IED attacks, battle damage assessments for mortar or rocket attacks, or even weaponizing the drones themselves for direct 'kamikaze style' employment or deployment of grenades or bomblets.[13] Additionally sUAS could be used in an airspace interference capacity, denying the use of airspace and serving in a limited offensive or defensive counter air or air mine role.[14] This combination of kinetic and non-kinetic ISR role serves to directly threaten both the physical and informational domains of RCAF operations.

7. The sUAS programs of multiple non-state organizations have now matured to the point that formal UAS units have been established, in effect creating small tactical-level air forces.[15]

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[12] Humphreys, Todd. "Statement on the Security Threat Posed by Unmanned Aerial Systems and Possible Countermeasures," *House Committee on Homeland Security*, (2015): 2.

[13] Major Dan Walters, "Countering the Small-Unmanned-Aircraft-System Threat to the Canadian Armed Forces," *Royal Canadian Air Force Journal* 5, no. 4 (Fall 2016): 30; Susannah George and Lori Hinnant, "ISIS using drones, other innovating tactics with deadly effect," *CTV News Online,* 1 February 2017, https://www.ctvnews.ca/world/is-using-drones-other-innovating-tactics-with-deadly-effect-1.3266034.

[14] Lieutenant-Colonel Leslie F. Hauck III and Colonel (Retired) John Geis II, "Air Mines," *Air & Space Power Journal* 31, no. 1 (Spring 2017): 26.

[15] Joby Warrick, "Use of weaponized drones by ISIS spurs terrorism fears," *The Washington Post*, 21 February 2017; The Jamestown Foundation – Global Research & Analysis, "Hezbollah's Drone Program Sets Precedents for Non-State Actors," last modified 10 November 2017, https://jamestown.org/program/hezbollahs-drone-program-sets-precedents-non-state-actors/

ISIS was reported to have flown an average 300 UAS missions per month during the peak of the battle for Mosul, while Hezbollah has published multiple high profile videos from UAS footage over Syria and Israel.[16] Most recently, non-state UAS employment culminated in a swarming UAS attack on Russian air and naval bases located in Khmeimim and Tartus in Syria, involving 13 drones.[17]

8. From an air force perspective, the potential damage from sUAS attacks was assessed as part of a recent National Research Council (NRC) study.[18] Both kinetic and weaponized damage on aircraft, personnel and infrastructure was assessed using a sUAS. Unarmed, kinetic damage alone was still sufficient to cause fatal injuries to exposed personnel, while collisions with aircraft exceeded all FAA thresholds for airframe and turbine damage. Using a weaponized UAS with a 5kg payload, significant damage/death was causes to aircraft, infrastructure and personnel.

Force Protection, Air Defence, and a role for the RCAF

9. Maintenance of operational effectiveness and freedom of action within a threat environment is accomplished through robust FP measures. FP is comprised of all measures taken to "manage risk and minimize vulnerabilities to personnel, information, material, facilities and activities from all threats."[19] From an RCAF perspective, this emphasizes a tailored and scaled

[16] Mark Pomerleau, "How $650 drones are creating problems in Iraq and Syria." *C4ISRNet*, Last modified 5 January 2018. https://www.c4isrnet.com/unmanned/uas/2018/01/05/how-650-drones-are-creating-problems-in-iraq-and-syria/

[17] Tom Embury-Dennis, "Russia says mysterious armed drones are attacking its military bases in Syria," *The Independent*, 10 January 2018, http://redstar.ru/index.php/component/k2/item/35573-ataka-dronov-na-khmejmim-i-tartus-otrazhena.

[18] National Research Council, LTR-FRL-2016-0037, *Investigation of Generic Concepts of the Counter Unmanned Aircraft System (UAS) Incursion Detection Problem* (Ottawa: NRC Flight Research Laboratory, 31 May 2016), 131-132.

[19] Department of National Defence, B-GJ-005-314/FP-000, *CF Joint Force Protection* (Ottawa: Joint Doctrine Branch, 2006), 1-1.

response to provide protection both in depth and redundancy for vital resources including personnel, aircraft and air bases.[20] Considering the potential sUAS threat, FP measures to protect these assets are critical to addressing the vulnerabilities to both the physical and informational domains.[21]

10. Air and missile defence represents a key element of any comprehensive FP plan. Air defence (AD) includes "all measures designed to nullify or reduce the effectiveness of hostile air action."[22] Effective AD requires a mix of capabilities, both active and passive, including counter-air operations and ground based air defence (GBAD).[23] Passive measures include those such as detection, warning, hardening, dispersal and camouflage; whereas active AD measures aim to engage, destroy, nullify or reduce the effectiveness of an adversary's air power.[24] With respect to active air defence, the development of a fully integrated air defence system (IADS), leveraging both airborne and ground-based AD, is based on four principles: mix, mass, mobility and integration.[25] In short, these principles emphasize the adequate combination and concentration of air and ground-based resources, in order to achieve fully synchronized and integrated AD in depth. In this regard, it is important to note that the CF-18 currently represents the CAFs sole active AD capability, one which is not ideally suited to meet the challenges posed by the sUAS threat.

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[20] Department of National Defence, B-GA-400/FP-001, *Canadian Armed Forces Air Doctrine* (Trenton: Canadian Forces Aerospace Warfare Centre, 2016), 25; Department of National Defence, B-GA-405-001/FP-001, *Aerospace Force Protection Doctrine* (Trenton: Canadian Forces Aerospace Warfare Centre, 08 August, 2008), ix, 3-5.

[21] Department of National Defence, B-GA-405-000/FP-001, *Canadian Forces Aerospace Shield Doctrine* (Trenton: Canadian Forces Aerospace Warfare Centre, 2012), 19.

[22] Department of National Defence, B-GJ-005-314/FP-000, *CF Joint Force Protection* (Ottawa: Joint Doctrine Branch, 2006), 4-3.

[23] Department of National Defence, B-GA-403-000/FP-001, *Canadian Forces Aerospace Shape Doctrine* (Trenton: Canadian Forces Aerospace Warfare Centre, 2014), 35.

[24] *Ibid*, 34

[25] Department of National Defence, B-GL-332-005/FP-001 *Insert: Air Defence Artillery (V2.4)*, (Ottawa: DND Canada, 1999), 8-2.

11. The RCAF has a vested interest in ensuring its personnel, assets, facilities and information are protected when deployed. Regarding operations, commanders at all levels are accountable and responsible for all aspects of FP of assigned forces.[26] Within the RCAF, "1 Canadian Air Division (1CAD) is the lead for FP…all Air Force FP policy is developed and maintained by 1CAD…who is responsible for FP across the spectrum of Air Force activity."[27] During operations, the RCAF will present forces as an Air Task Force (ATF). ATF Commanders are charged with the responsibility to plan for and ensure the FP of assigned units, to include air and missile defence; dependent upon the nature of the threat this may include a dedicated ATF force protection element (FPE).[28] Thus as evidenced here, the RCAF has a responsibility to address the sUAS threat and corresponding FP aspects across multiple levels of command.

12. AD operations are inherently "joint and the integration of all service components is required to fight the counter air battle."[29] The air component of a joint force will often rely on land and maritime components to provide elements of FP for its assets, while it concurrently provides protection to other components where possible.[30] For example, the Canadian Army (CA) has traditionally been primarily responsible for provision of GBAD against low level

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[26] Department of National Defence, B-GJ-005-314/FP-000, *CF Joint Force Protection* (Ottawa: Joint Doctrine Branch, 2006), 1-2.

[27] Department of National Defence, B-GA-405-001/FP-001, *Aerospace Force Protection Doctrine* (Trenton: Canadian Forces Aerospace Warfare Centre, 08 August, 2008), 3-2.

[28] Department of National Defence, B-GA-402-005/FP-001, *Expeditionary Air Operations Doctrine (Final Endorsement Draft)* (Trenton: Canadian Forces Aerospace Warfare Centre, 2015), 5-1; Department of National Defence, B-GA-400/FP-001, *Canadian Armed Forces Air Doctrine* (Trenton: Canadian Forces Aerospace Warfare Centre, 2016), 46/

[29] Department of National Defence. B–GL–372–001/FP–001 *Air Defence Artillery Doctrine,* Directorate of Army Doctrine, (1999), 34.

[30] Department of National Defence, B-GJ-005-314/FP-000, *CF Joint Force Protection* (Ottawa: Joint Doctrine Branch, 2006), 1-2.

threats.[31] Although much of this capability has been divested, reinvestment and development of future capabilities would likely require close integration between the CA and RCAF in addressing the sUAS threat. From an expeditionary joint perspective, it is also important to note that the deployed CAF Joint Task Force commander is ultimately responsible for FP of the deployed force in theatre. In this regard, the ATF must meet the force employment objectives of the JTF commander, to include relevant FP requirements.[32] As the UAS threat continues to evolve and proliferate, the RCAF and its deployed ATFs will be required to address this threat with regards to FP, both in relation to air force specific considerations and as a key component of the larger joint force.

Countering the UAS Threat

13. Traditional airfield security measures are insufficient to detect and defeat the modern sUAS threat; moreover, due to a number of unique characteristics, sUAS are also exceptionally challenging targets for traditional IADS. Although passive AD is a critical aspect of the overall FP approach, options such as camouflage, concealment or use of hardened shelters are not always sufficient, particularly in more austere locations and for large aircraft. Thus the focus for this paper will be on active sUAS AD options. Both the US Army and Air Force have identified three distinct steps in the Counter-UAS approach: detection, identification, and defeat.[33]

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[31] Department of National Defence, B–GL–372–001/FP–001 *Air Defence Artillery Doctrine*, (Ottawa: DND Canada, 1999), 7.

[32] Department of National Defence, B-GA-400/FP-001, *Canadian Armed Forces Air Doctrine* (Trenton: Canadian Forces Aerospace Warfare Centre, 2016), 47.

[33] Rutrell Yasin, "A tactical approach to unmanned aircraft system threat response," *C4ISRNet*, September 2016. https://www.srcinc.com/pdf/Whitepaper-Countering-the-CUAS-shortcomings.pdf; Department of the Army, *Counter – Unmanned Aircraft (C-UAS) Strategy Extract* (Washington, DC: Department of the Army, 5 October, 2016), 9.

14. Due to the small size, low altitude and relative speeds of sUAS, these aircraft are very difficult to detect, track and identify using traditional means. Their negligible radar cross section, minimal Doppler and small size and heat signature render them almost invisible, or difficult to distinguish from background clutter and birds by most conventional radars and electro-optic/infra-red (EO/IR) systems.[34] In a recent NRC study, using combined radar and EO/IR, sUAS systems were able to close within 3km of sensors before detection. It was assessed that in these instances this would not allow for a response or 'defeat' of the sUAS before it was within kinetic or intelligence gathering range.[35] To enable timely detection and identification, US doctrine and lessons learned from the recent Counter-UAS exercise BLACK DART illustrated a requirement for an integrated combination of radar, EO/IR, acoustic and electronic sensors.[36] Such an approach should leverage emerging technology designed for small air contact detection, such as the LSTAR radar and software package for example, while incorporating simple measures such as improving airfield/security zone lighting.[37]

15. The development of any counter-UAS strategy must also incorporate a means of defeating the threat. Further lessons from BLACK DART have illustrated that the principles of IADS and defensive counter air doctrine are both relevant in that any proposed long-term

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[34] Department of Defense, Joint Publication 3-0, *Joint Operations* (Washington, DC: US Joint Chiefs of Staff, 17 January 2017), 1-8; Department of the Army, ATP 3-01.8, *Techniques for Combined Arms for Air Defense* (Washington, DC: Department of the Army, 29 July 2016), 1-6.

[35] National Research Council, LTR-FRL-2016-0037, *Investigation of Generic Concepts of the Counter Unmanned Aircraft System (UAS) Incursion Detection Problem* (Ottawa: NRC Flight Research Laboratory, 31 May 2016), 133-136.

[36] Major Dillon R. Patterson, "Defeating the Threat of Small Unmanned Aerial Systems," *Air & Space Power Journal* 31, no. 1 (Spring 2017): 21; Department of the Army, *Counter – Unmanned Aircraft (C-UAS) Strategy Extract* (Washington, DC: Department of the Army, 5 October, 2016), 10.

[37] Rutrell Yasin, "A tactical approach to unmanned aircraft system threat response," *C4ISRNet*, September 2016. https://www.srcinc.com/pdf/Whitepaper-Countering-the-CUAS-shortcomings.pdf; Lieutenant-Colonel Thomas S. Palmer and Colonel (Retired) John Geis II, "Defeating Small Civilian Unmanned Aerial Systems to Maintain Air Superiority," *Air & Space Power Journal* 31, no. 2 (Summer 2017): 111.

solution should include a mixed and layered approach, providing defence in depth.[38] While any permanent joint integrated solution should incorporate both kinetic and non-kinetic options, the acquisition and employment of current kinetic options such as the US Army Enhanced Area Protection and Survivability (EAPS) system or Northrup Grumman counter-rocket and mortar (C-RAM) system are likely beyond the scope of a strictly RCAF solution.[39] Moreover, many of these systems have the potential to do more collateral damage than the sUAS itself. A further consideration is cost, with C-RAM rounds costing $16,000 each, proliferation or swarms of sUASs could quickly impose significant costs.[40] Many of the most popular approaches to counter-UAS are now employing electronic warfare (EW) methods, jamming or interfering with the UAS command link and/or GPS signal.[41] This option is particularly attractive as the risk of collateral damage is low, as is the cost of operation. Much of this technology has also been commercially driven, resulting in numerous commercial off-the-shelf, self-contained portable systems already being available, including DroneSentry, SkyTracker, Silent-Archer, and AUDS among others.[42]

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[38] Major Dillon R. Patterson, "Defeating the Threat of Small Unmanned Aerial Systems," *Air & Space Power Journal* 31, no. 1 (Spring 2017): 21.

[39] Lieutenant-Colonel Thomas S. Palmer and Colonel (Retired) John Geis II, "Defeating Small Civilian Unmanned Aerial Systems to Maintain Air Superiority," *Air & Space Power Journal* 31, no. 2 (Summer 2017): 106.

[40] Major Dan Walters, "Countering the Small-Unmanned-Aircraft-System Threat to the Canadian Armed Forces," *Royal Canadian Air Force Journal* 5, no. 4 (Fall 2016): 32.

[41] Major Dan Walters, "Countering the Small-Unmanned-Aircraft-System Threat to the Canadian Armed Forces," *Royal Canadian Air Force Journal* 5, no. 4 (Fall 2016): 32.

[42] Blighter Surveillance Systems, "AUDS Anti-UAV Defence System," last accessed 1 February 2018, http://www.blighter.com/products/auds-anti-uav-defence-system.html; CACI International Inc., "Skytracker," last accessed 1 February 2018, http://www.caci.com/skytracker/; Droneshield, "DroneSentry," last accessed 1 February 2018, https://www.droneshield.com/sentry/; SRC Inc., "Silent-Archer Counter-UAS Technology," last accessed 1 February 2018, https://www.srcinc.com/what-we-do/counter-uas/.

16. With respect to the sUAS threat, "there is not one solution that fits all."[43] In the near-term the aim for the RCAF should be to address key vulnerabilities, while deliberately accepting any residual risk from a properly assessed sUAS threat. In order to maintain key attributes such as reach and responsiveness, any acquired system should be readily transportable, as well as easy to both deploy and employ. Similar attributes are currently being sought by the US Air Force in a recent request for proposals; however, a wide-variety of commercial operations as discussed above are already available that would adequately address key elements of the sUAS threat.[44] Many of these systems utilize the full-spectrum of integrated sensors, linked to a means of electronic defeat with the concurrent ability to geo-locate the ground control node. Such a system could also be combined with a limited kinetic means such as ATF force protection element armed with shotguns and improved airfield lighting, a combination which has proven very effective for close sUAS engagements.[45] Lastly, technology alone will not address this issue, any successful RCAF sUAS strategy will have to also incorporate appropriate doctrine, Tactics, Techniques and Procedures (TTPs), and clearly delineate applicable rules of engagement (ROE).

17. Regarding a long-term solution, the sUAS threat ultimately represents a joint integrated defence problem. As identified in the recent US Counter-UAS strategy, no single army or air force capability "can from a proficiency or sufficiency standpoint defeat the UAS threat," a joint approach will be required.[46] Integrated air and missile defence should continue to play a key role, in this respect, the CA has traditionally been the CAF lead for GBAD. The CA and Directorate

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[43] Rutrell Yasin, "A tactical approach to unmanned aircraft system threat response," *C4ISRNet*, September 2016. https://www.srcinc.com/pdf/Whitepaper-Countering-the-CUAS-shortcomings.pdf.

[44] *Ibid*.

[45] Lieutenant-Colonel Thomas S. Palmer and Colonel (Retired) John Geis II, "Defeating Small Civilian Unmanned Aerial Systems to Maintain Air Superiority," *Air & Space Power Journal* 31, no. 2 (Summer 2017): 111.

[46] Department of the Army, *Counter – Unmanned Aircraft (C-UAS) Strategy Extract* (Washington, DC: Department of the Army, 5 October, 2016), 7.

of Land Requirements are currently pursuing the 'ground-based air and munitions defence project' which aims to address the full spectrum of air threats by delivering an integrated sensor, command and control, and munitions and launcher system within the 2026-2036 timeframe.[47] From an RCAF standpoint, our aim as air power experts should be to influence this joint solution space, while also ensuring that any near-term RCAF solutions are interoperable and/or complementary to the final joint outcome.

CONCLUSION

18. Recent decades have witnessed a shift in global dynamics, one outcome of which has been an increasingly significant role played by non-state actors. The influence of these organizations has manifested itself in a variety of way including altering both the scope and nature of modern conflict. These actors have often proven highly innovative, likely as a means of addressing their inherent technological asymmetry as compared to state adversaries. sUASs have become a significant means by which they aim to balance this asymmetry. Recent conflicts have witnessed mass employment of UASs by both state and non-state actors. Unfortunately, decades of operations in the absence of a credible air threat to the CAF and RCAF has led to the divestment and atrophy of much of our AD capability. The emergence of sUAS employment by non-state actors is fundamentally challenging the state monopoly on airpower and now poses a significant credible threat to RCAF personnel, aircraft, facilities, information, and activities. These trends are anticipated to continue, resulting in a tangible impact on our freedom of action and mission success. Thus it behooves the RCAF to immediately adopt a proactive and

[47] Department of National Defence, "Ground Based Air and Munition Defence," last accessed 30 January 2018, http://www.forces.gc.ca/en/business-defence-acquisition-guide-2016/land-systems-22.page; Department of National Defence. *Strong, Secure, Engaged – Canada's Defence Policy* (Ottawa: Canada Communications Group, 2017), 102.

deliberate FP strategy to address this emerging threat, both in terms of those elements unique to the air environment and as part of a larger CAF joint force.

RECOMMENDATIONS

19. In the near-term the RCAF should investigate the feasibility of acquiring a commercial counter-UAS system in order to address the current sUAS threat. This will have to be accompanied by a proactive approach to development of applicable counter-UAS and expeditionary air doctrine, TTPs and ROE and participation in relevant readiness exercises.

20. The RCAF should work closely with other CAF joint stakeholders towards the development of a long-term comprehensive IADS to address the full-spectrum of air threats including sUAS.

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