National Defence Défense nationale

Canadian Forces College

Collège des Forces Canadiennes

EVOLVING THREATS AND CANADA'S REQUIREMENT FOR GROUND-BASED AIR DEFENCE

Major Daniel Grégoire

JCSP 47

Service Paper

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.

PCEMI 47

Étude militaire

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 47 - PCEMI 47
2020 – 2021

SERVICE PAPER – ÉTUDE MILITAIRE

EVOLVING THREATS AND CANADA'S REQUIREMENT FOR GROUND-BASED AIR DEFENCE

By Major Daniel Grégoire

Word Count: 2,591

Nombre de mots : 2.591

EVOLVING THREATS AND CANADA'S REQUIREMENT FOR GROUND BASED AIR DEFENCE

AIM

1. The aim of this paper is to examine the evolving air defence threat since the divestment of the Canadian Army's (CA) ground-based air defence (GBAD) capability. With the army capability to be reintroduced in the near future, the landscape has changed significantly and will continue to do so at a rapid pace. The army must select a GBAD system that meets these new threats and has scope to continue to evolve.

INTRODUCTION

2. Canada's current defence policy, Strong Secure Engaged (SSE), has outlined the CA task to acquire a new CBAD capability to protect ground forces against air threats.[1] With respect to air defence in the CAF, the army has been responsible for low-altitude threats, while the Royal Canadian Air Force (RCAF) has retained responsibility for high altitude threats. For the purpose of this paper, the author will assume this division of air defence responsibilities will remain in place and explore short range air defence (SHORAD) threats and capabilities.

3. Over the last 50 years, technology continues to make air defence systems obsolete and necessitates constant adaptation to remain relevant. The development of IR guided missiles, anti-radiation missiles, and stealth technology severely hampered the effectiveness of AD systems when first introduced onto the battlefield. Militaries are constantly improving their ability to counter modern air defences in a constant back and forth of technological advancement to defeat air defences, and technological

[1] Canada. DND, Strong, Secure, Engaged: Canada's Defence Policy, 37.

solutions to again prevent adversaries from gaining freedom of action in the air domain and threaten ground forces.

4. Re-activation of the previous GBAD system will not address the modern threat as it has evolved, and will require new capability. This paper will address some significant new threats and trends, new technology in development by allies and adversaries, and considerations for how it can be implemented.

DISCUSSION

5. The role of air defence in the CA is to protect ground forces, primarily from the low-level air threat.[2] Prior to 2012, the CA was equipped with an integrated air defence system (IADS) with a layered system capable of detecting, tracking, and engaging a wide range of air and ground threats. The system was composed of an air defence anti-tank system (ADATS), Oerlikon-Contraves GDF 35mm cannon, and shoulder launched Javelin missiles. All three systems are no longer in service, leaving the only air defence capability that the army retains being counter-mortar battery radar systems.. Following divestment, the CA no longer had any air defence capability other than from crew served ground weapons and small arms which lack the range and accuracy to effectively engage class 1 and 2 unmanned aerial vehicles (UAV).

THE MODERN THREATS

6. To assess the CA's needs for a specific GBAD capability, it is important to first study the current threats to AD security, and future trends. There are four major threats to ground forces that are considered at the SHORAD range and below: missiles, indirect fires, aircraft, and unmanned aerial vehicles. UAVs will be a focus of this paper, as their prevalence and capability in the battlespace has grown and will

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

continue to grow in the future.[3] Missiles can be launched from further away, move at much higher speeds, and are more accurate than ever before. The most technologically advanced missiles, hypersonic missiles, can travel in excess of 5,000 km/h.[4] In addition to the great speed and precision, they are able to fly in an erratic pattern to mask their target until the last moment. There are currently no countermeasures against hypersonic missiles, and three nations in the world now possess the technology: the United States, China, and Russia. While not yet feasible to incorporate a counter-hypersonic missile layer into a GBAD system, history has shown that once a countermeasure is developed, it can effectively neutralize an adversary capability. When the Stinger missile was introduced into Afghanistan during the Soviet invasion, Soviet Air Forces were decimated, enabling Afghan rebels to maintain control of the countryside and inevitably force the withdrawal of the Soviet Union.[5] The first nation to develop and implement a hypersonic countermeasure would nullify one of the most concerning weapons in the world.

7. Indirect fires such as rockets, artillery and mortars have not had significant technological improvements over the last 20 years, but their range and effectiveness has been dramatically improved through the pairing with UAV for target acquisition. As demonstrated in the Russian-Ukraine conflict, the use of UAV in detecting and identifying targets has devastating effects. In Zelenopillya, Ukraine, two Ukrainian battalions were reportedly being observed by small UAVs, and moments later

---

[3] Emergen Research. "Unmanned Aerial Vehicle Market Size To Be Worth USD 56.18 Billion by 2027". 22 Dec. 2020, Accessed 3 Feb 2021. www.globenewswire.com/news-release/2020/12/22/2149086/0/en/Unmanned-Aerial-Vehicle-UAV-Market-Size-To-Be-Worth-USD-56-18-Billion-by-2027-Emergen-Research.html

[4] Speier, R. et al. Hypersonic Missile Nonproliferation: Hindering the Spread of a New Class of Weapons. (Santa Monica, CA: RAND Corporation, 2017). https://www.rand.org/pubs/research_reports/RR2137.html

[5] Werrell, Kenneth P. *ARCHIE, FLAK, AAA, and SAM: A Short Operational History of Ground-Based Air Defense*. (n.d.: Tannenberg Publishing, 2015). 289

received an MLRS barrage that left 30 soldiers dead and the combat vehicles of both battalions destroyed.[6] The pairing of UAV with indirect fires enabled destruction of ground forces from the extreme reach of MLRS and artillery batteries. This outlines the need to have GBAD capability that targets mini and micro UAV in order to protect ground forces.

8. The UAV threat is no longer novel or new, but as the technology is more available around the world, different tactics and employment are challenging AD technology is matching the capability of these platforms. UAVs classified as "Loitering Munitions" are a type of drone that carry a significant payload and are capable of loitering in an area for over an hour before striking a target. For example, the Polish Warmate UAV can operate at low altitudes, and strike vehicles or targets as directed by its controller.[7] On its own, there are many types of AD systems capable of targeting and defeating it, such as electronic attacks, kinetic systems, or energy weapons. This type of weapon becomes increasing threatening were it to be employed as a drone swarm. A swarm of drones is capable of overwhelming GBAD simply by creating more targets than its effectors can track or engage effectively. China has been developing swarm technology, notably with its CH-109 drone. Tests reported in 2020 established a swarm of over 100 drones, each capable of being armed as a kamikaze style weapon.[8] To defend against drone swarms would need a system capable of rapidly targeting and destroying successive targets. According to a recent study

[6] Fox, Amos. "Understanding Modern Russian War: Ubiquitous Rocket, Artillery to Enable Battlefield Swarming, Siege Warfare." *Fires* (Sep, 2017). 23

[7] Wb Group. "WARMATE Loitering Munitions." *WB GROUP*, 8 July 2020, Accessed 3 Feb 2021. www.wbgroup.pl/en/produkt/warmate-loitering-munnitions/

[8] Janes. "China Likely to Deploy New Multiple UAV Launcher in near Future.". *Janes.com.* 21 Oct 2020, Accessed 3 Feb 2021. www.janes.com/defence-news/news-detail/china-likely-to-deploy-new-multiple-uav-launcher-in-near-future

comparing different UAV countermeasures, a counter-drone swarm may be a future defence against a drone swarm.[9]

9. Artificial intelligence applications for UAV may make them even harder to defeat with current AD options. Having an onboard database of detailed military targets, and sensors to positively identify them on the ground, drones could be fully autonomous and perform search and destroy type missions without needing communications with a controller. This will make electronic attacks more challenging if there are no communications systems by a UAV, and if used in conjunction with alternatives to GPS guidance.

10. The explosive growth of UAV in the commercial and civilian sectors have brought UAV technology to non-state actors as well. In 2018, ISIS forces in Mosul began drone attacks against Iraqi security forces using simple $650 drones carrying grenades.[10] Such tactics are easily incorporated by non-state actors, and could even pose a threat within Canada. Providing security for G-8 summits, or protecting critical infrastructure with electronic countermeasures would be effective against the intrusion of aggressive drones or overzealous hobbyists. Having an electronic attack effector in a GBAD system could easily neutralize a commercial UAV. Small UAV designed with military grade electronic systems can be more resistant to electronic attack, but the defence industry has already realized the potential market of these counter UAV systems.

11. The growth of the use of UAV in conflict has prompted the defence industry to rapidly develop new technological solutions. A diverse array of systems have been

[9]Guitton, Matthieu J. "Fighting the Locusts: Implementing Military Countermeasures Against Drones and Drone Swarms." *Scandinavian Journal of Military Studies* 4, no. 1 (2021): 26.

[10]Martin, Guy. "The Rise of UAVs and Counter-UAV Technology." *Military Technology* 41, no. 6 (2017). 7

developed but each system has a weakness that can be exploited by an adversary, or does not make economic sense.[11] The key to an effective GBAD is having layers and multiple effectors and sensors. For example, having solely a missile based system will not be effective against a swarm of mini UAV. Energy weapons such as lasers have demonstrated their effectiveness at tracking and destroying UAV and are being produced by the leading defence companies in the United States.[12] However, energy weapons are not the ultimate solution. Lasers can be affected by rain, fog, or smoke, which could reduce their effectiveness. [13] Further, if GBAD targets utilized an ablative coating or mirrors as part of their exterior, they could have resistance to energy weapons.[14] Electronic attacks have been proven useful in defending against UAV, and have the potential to stop swarms of unsophisticated systems. In the Ukrainian conflict in the Donbass region, Russian forces were able to effectively take control of US supplied Raven UAVS once they were launched.[15] Electronic attacks can jam communications, spoof GPS systems, and cause remote piloted UAV to lose control and crash. Despite the strength and weakness of EW and energy weapons, kinetic weapons still maintain a general purpose standard. The main drawbacks of kinetic systems is the requirement for ammunition, and accuracy of fire.

ALLIED GBAD CAPABILITIES

---

[11]Guitton, Matthieu J. "Fighting the Locusts: Implementing Military Countermeasures Against Drones and Drone Swarms." *Scandinavian Journal of Military Studies* 4, no. 1 (2021): 31

[12]Janes. "GBAD Moon Rising: Examining Future Radar and Anti-Air Technologies". *Janes.com*, Accessed 2 Feb 2021. https://customer-janes-com.cfc.idm.oclc.org/Janes/Display/FG_3722995-IDR

[13]Zohuri, Bahman. *Directed Energy Weapons: Physics of High Energy Lasers (HEL)*. :Cham: Springer International Publishing AG, 2016). 161

[14]Hambling, D. (2016, November 4). Drones Fight Back Against Laser Weapons. *Popular Science*. Accessed 1 Feb 2021. https://www.popsci.com/laser-guns-are-targeting-uavs-but-drones-are-fighting-back

[15]Stewart, Phil. "Exclusive: U.S.-Supplied Drones Disappoint Ukraine at the Front Lines." *Reuters*, Thomson Reuters, 21 Dec. 2016, Accessed 2 Feb 2021. www.reuters.com/article/us-usa-ukraine-drones-exclusive-idUSKBN14A26D.

12. Considering acquiring the same equipment and capabilities of allied GBAD systems can have many benefits including interoperability, reduced costs, and ability to provide direct support. Both the UK and US are actively seeking to upgrade their systems to meet developing threats such as UAVs after post-Cold War neglect.

13. Currently the US employs a robust system, primarily with the employment of Patriot missile systems for high and medium altitude air defence (HIMAR), and at the SHORAD level weapons platforms are based on the FIM-92 Stinger missile. The UK system is based on Rapier and Starstreak missiles.[16] Both have vehicle mounted and shoulder fire capability, providing dispersed defences. These systems are effective at detecting and engaging missiles, rockets, and aircraft, however not effective or overly costly against mini and micro-UAV. This shortcoming prompted the US military to rapidly procure a new system named IM-SHORAD in 2020.[17] This new prototype system, a relatively small investment for the US Army at 1.3 billion dollars, is based off a Stryker chassis and carries 4 FIM-92 stingers, a 40mm cannon, 2 Hellfire missiles, and a variety of active and passive sensors to detect and track threats. It is expected to have an energy weapon applied in the future. While the new system is still under development, the fact it will utilize a similar chassis to the CA LAV 6 is notable in terms of compatibility.

14. Israel is surrounded by nations hostile to it, and over the decades has been on the receiving end of a large number of attacks by missiles, rockets, and artillery. It is not surprising that it employs a very robust GBAD capability. According to the Israeli Defence Force, the system successfully intercepted 83% of incoming rockets from

---

[16]United Kingdom. "Artillery and Air Defence." *The British Army*, Accessed 1 Feb 2021. https://www.army.mod.uk/equipment/artillery-and-air-defence

[17]Hambling, David. "How the U.S. Army's Billion-Dollar Gamble On Drone Defense Could Go Wrong." *Forbes*, Forbes Magazine, 14 Oct. 2020, https://www.forbes.com/sites/davidhambling/2020/10/14/how-us-armys-billion-dollar-gamble-on-drone-defense-could-go-wrong/?sh=16fe11a05898

Gaza over an eight day period.[18] The Iron Dome system it currently uses for SHORAD is capable of detecting and intercepting missiles, rockets artillery, and precision guided munitions if the system assesses the impact zone to be of significance. With multi emission radars, and each system with 20 Tamir missiles as interceptors, the system trades off mobility, and has yet to be updated with a counter UAV capability. What the system does provide is a superior counter rocket, artillery, and mortar capability (C-RAM), a focus of the CA GBAD project according to the Defence Capability Blueprint.[19] As Israel works to develop its energy weapon equivalent to the Iron Dome, it will be a system of interest.

INTEGRATION INTO THE CA

15. With almost ten years elapsed since GBAD was divested from the CA, the RCA likely has few members experienced with the previous surface to air systems. They do still retain the doctrine, and experience coordinating with the RCAF on operations. It makes sense for the RCA Corps to continue with possession of the capability. The key assessments to make before selecting a specific system to acquire comes to some fundamental concepts to counter the current threats.

16. First, Canada's employment of GBAD is most likely to be in support of expeditionary operations. Employing GBAD domestically would be limited to specific events such as G-8 Summits or Olympics, although an important consideration.

17. The key considerations this paper proposes as a focus for system selection are mobility, survivability, layers of multiple effectors, both active and passive sensors, and the ability to track and engage multiple targets. Linking all systems will require a

[18]Janes. "Land Warfare Platforms: Artillery & Air Defence - Iron Dome". *Janes.com*, Accessed 2 Feb 2021. https://customer-janes-com.cfc.idm.oclc.org/Janes/Display/JLADA041-JAAD

[19]Government of Canada, National Defence. "Government of Canada." *Defence Capabilities Blueprint*, Accessed 30 Jan 2021. https://dgpaapp.forces.gc.ca/en/defence-capabilities-blueprint/project-details.asp?id=940

command system connecting multiple platforms and enabling rapid and secure information sharing with joint partners. AI and automation for some systems can rapidly differentiate friend or foe in a contested environment.

18. Mobility provides the system protection and evasion ability. The Iron Dome system cannot rapidly mobilize, or keep pace with a mechanized force. The second aspect of mobility is that it allows AD units to continuously reposition, relocate to higher threat zones, and ensure balanced coverage in an area of operations.[20] Air defence systems are a high priority target in modern conflict, and stationary elements can easily be targeted or avoided.

19. The importance of multiple layers of defence against different threats necessitates a wide range of effectors and sensors. One platform could potentially possess a kinetic effector such as a remote weapon system minigun, energy weapon, and an EW system to address all SHORAD threat types. Also key to providing dispersed GBAD capability would be dismounted or UAV effectors and sensors to compliment the system, much like the Javelin missile provided the previous CA GBAD system.

20. In a contested environment, active sensors generate an EM signature that weapons such as anti-radiation missiles can target. Active radar systems used by Iraq in the Gulf War were prone to destruction by air attack once their targeting radars were activated.[21] A system that is composed of both passive and active sensors will be adaptable to an environment with a technological advanced adversary, or a more permissible environment such as stability operations.

---

[20]Groborsch, Thomas. "Drone Defense from Combined Arms for Air Defense to Organic Ground Based Air Defense." *Fires* (2018b). 40

[21]Olsen, John Andreas. *A History of Air Warfare*, edited by Olsen, John Andreas. 1st ed. (Washington, D.C: Potomac Books. 2006). 184

CONCLUSION

21. With military and commercial spending on drones increasing annually, it is important to have countermeasures against them to ensure the security of ground forces. These and other emerging threats demonstrate the need for GBAD technologies to adapt new countermeasure systems. The GBAD capabilities currently offered and in development by defence industries far exceeds the scope of this paper to fully assess, however the principles discussed should be incorporated to ensure an enduring, relevant, and robust capability is integrated into the CA.

22. C-UAV technologies are still relatively new in development, and at this time no single sensor and effector system can cover the wide range of UAV and missile capability. The incorporation of energy weapons, small interceptor missiles, kinetic weapons, and EW should be encompassed in one solution to address the ever widening range of SHORAD threats. Small man portable dismounted effectors can assist ground forces in protection from these threats, but the sensor capabilities of a vehicle platform will ultimately provide more meaningful protection. A system that focuses on only one threat risks being quickly obsolete, so an adaptable and upgradeable platform will ensure a longer lifespan and greater security for ground forces.

23. As the CA is poised to re-invest in GBAD it is imperative to ensure emerging and future threats to ground forces are encompassed in the solution. The threat to ground forces by UAV and indirect fires should be a priority, however the threat from aircraft and missiles remains extant in modern conflicts.

RECOMMENDATION

24. It is recommended the CA partner with defence industry and allies to fully assess C-UAV and C-RAM options before committing to a system that is unproven, or has an effectiveness lifespan that will not endure or adapt. It is critical that the GBAD system is able to address the threat from Class 1 and 2 UAV, including swarms, in addition to incorporating technological advancements in C-RAM.

BIBLIOGRAPHY

Canada. DND. BGL-372-001/FP-001 Air Defence Artillery Doctrine. Ottawa: Canada, 1999.

Canada. DND. Strong, Secure, Engaged: Canada's Defence Policy. Ottawa, Ont.: 2017.

Daugirdas, Kristina and Julian Davis Mortenson. "China Announces New Air Defense Identification Zone Over East China Sea, Prompting U.S. Response." *The American Journal of International Law* 108, no. 1 (2014).

Fox, Amos. "Understanding Modern Russian War: Ubiquitous Rocket, Artillery to Enable Battlefield Swarming, Siege Warfare." *Fires* (2017a): 25.

Groborsch, Thomas. "Drone Defense from Combined Arms for Air Defense to Organic Ground Based Air Defense." *Fires* (2018b): 38-45.

Guitton, Matthieu J. "Fighting the Locusts: Implementing Military Countermeasures Against Drones and Drone Swarms." *Scandinavian Journal of Military Studies* 4, no. 1 (2021).

Hambling, D. (2016, November 4). Drones Fight Back Against Laser Weapons. *Popular Science*. Retrieved from https://www.popsci.com/laser-guns-are-targeting-uavs-but-drones-are-fighting-back

Janes. “China Likely to Deploy New Multiple UAV Launcher in near Future.”. *Janes.com*. 21 Oct 2020, Accessed 3 Feb 2021. www.janes.com/defence-news/news-detail/china-likely-to-deploy-new-multiple-uav-launcher-in-near-future

Judson, Jen. "Army must have Future C-RAM, C-UAS Capability: AMD Portfolio Changes Reflect 'Growing Understanding' of Threat." *Inside the Pentagon's Inside Missile Defense* 18, no. 22 (2012).

Karako, Thomas and Wes Rumbaugh. *Distributed Defense: New Operational Concepts for Integrated Air and Missile Defense*. Blue Ridge Summit: Center for Strategic & International Studies, 2017.

Kerns, A.J, et al. 2014. Unmanned Aircraft Capture and Control Via GPS Spoofing. *Journal of Field Robotics*. 30(4). 617-636. https://doi.org/10.1002/rob.21513.

Martin, Guy. "The Rise of UAVs and Counter-UAV Technology." *Military Technology* 41, no. 6 (2017).

Olsen, John Andreas. *A History of Air Warfare*, edited by Olsen, John Andreas. 1st ed. Washington, D.C: Potomac Books, 2006.

Sehrawat, Vivek. *Drones and the Law: International Responses to Rapid Drone Proliferation*. Bingley: Emerald Publishing Limited, 2020.

Singh, Mandeep. *Air Defence Artillery in Combat, 1972 to the Present: The Age of Surface-to-Air Missiles*. Havertown: Pen & Sword Books Limited, 2020.

Speier, R. et al, *Hypersonic Missile Nonproliferation: Hindering the Speed of a New Class of Weapons*. Santa Monica, CA. Rand Corporation. 2017. https://www.rand.org/pubs/research_reports/RR2137.html

Spillman, Christopher. "Air Defense Artillery 2016, Beyond." *Fires* (2016).

Stewart, Phil. “Exclusive: U.S.-Supplied Drones Disappoint Ukraine at the Front Lines.” *Reuters*, Thomson Reuters, 21 Dec. 2016, www.reuters.com/article/us-usa-ukraine-drones-exclusive-idUSKBN14A26D.

United States. Department of Defence. *Counter-Small Unmanned Aircraft Systems Strategy.* US. Washington: D.C. 2021.

Vilímek, Jakub. "Small Unmanned Aerial Vehicles – Threats and Defence Against Them." *Science & Military Journal* 14, no. 2 (2019): 32-39.

Werrell, Kenneth P. *ARCHIE, FLAK, AAA, and SAM: A Short Operational History of Ground-Based Air Defense*: Tannenberg Publishing, 2015.

Wb Group. “WARMATE Loitering Munitions.” *WB GROUP*, 8 July 2020, Accessed 3 Feb 2021. www.wbgroup.pl/en/produkt/warmate-loitering-munnitions/

Zohuri, Bahman. *Directed Energy Weapons: Physics of High Energy Lasers (HEL)*. Cham: Springer International Publishing AG, 2016.