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THE EMERGENCE OF CRUISE AND ANTI-SHIP BALLISTIC MISSILE THREATS AND THE IMPLICATIONS FOR THE ROYAL CANADIAN NAVY

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AIM

1. This paper aims to highlight the advancing anti-ship cruise missile (ASCM) and emerging anti-ship ballistic missile (ASBM) threats in the littoral and blue water environments and to discuss the implications for the Royal Canadian Navy (RCN) in defensive anti-air warfare (AAW) operations.[1]

INTRODUCTION

2. This paper examines the advancing ASCM and emerging ASBM threats to the RCN within the blue water and littoral environments. It also investigates the defensive AAW 'kill chain' challenges associated with these threats by analyzing the *sense*, *command*, and *act* operational functions.[2] Each section of this paper discusses the implications for the RCN. Finally, the paper provides recommendations for the RCN.

3. The future operating environment will continue to increase in complexity and will likely witness a move towards the urban, networked littoral; however, traditional blue water operations will still remain relevant.[3] The likelihood of state-on-state conflict will remain low, but it is still the most dangerous course of action for maritime operations.[4] Notably, the Canadian Minister of National Defence Mandate Letter emphasizes greater investment in strengthening the RCN while remaining committed to the North American Aerospace

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[1] This paper will only focus on defensive anti-air warfare (AAW) challenges facing the Royal Canadian Navy (RCN). It is acknowledged that there are offensive options in countering the anti-ship cruise missile (ASCM) and anti-ship ballistic missile (ASBM) threat. This approach involves deploying offensive weapon capabilities from within the joint environment to strike the ASCM and ASBM threats before they are deployed. This aspect of research is beyond the scope of this paper.

[2] The defensive AAW 'kill chain' consists of the following steps: detection, tracking, identification, decision, and interception.

[3] Department of Defence, *The Australian Army in the Urban, Networked Littoral* (Canberra: National Library of Australia, 2014), 2.

[4] Department of Defence, *Australian Defence Force Objective Force 2030 Primer* (Puckapunyal: Land Warfare Development Centre, 2011), 9–10.

Defence Command (NORAD) and the North Atlantic Treaty Organization (NATO).[5] Over the coming decades, the RCN will procure logistic supply and surface combatant ships to maintain its capability to meet its domestic and international obligations.

4. The Canadian Surface Combatant Concept of Employment states that the RCN will be required to form and lead a Maritime Task Force and if required, deploy independently or as part of a multinational group.[6] This will require the RCN to provide point AAW defence of its frigates, as well as area AAW defence over supply, merchant, and/or commercial ships operating in the littoral or blue water environments.[7] Complicating the battlespace are adversary ASCMs and ASBMs which play a significant role in supporting their anti-access/area-denial (A2/AD) operations. This will challenge the RCN's defensive AAW capabilities.[8] Consequently, the RCN will be compelled to overcome these threats in order to gain local and temporary sea control over an area to allow land operations to occur.[9]

DISCUSSION

ASCM and ASBM characteristics and development

5. **ASCM**. The ASCMs are generally multi-stage subsonic missiles that are launched from ship-, submarine-, air-, or land-based platforms with ranges up to 1,000 nautical miles. Due to technological advancements, ASCMs are now even capable of supersonic (Mach 1–5) speeds for terminal attacks. Research programs are also underway to develop hypersonic

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[5] Canada, Officer of the Prime Minister, "Minister of National Defence Mandate Letter," accessed 1, February 2016, http://pm.gc.ca/eng/minister-national-defence-mandate-letter.

[6] Department of National Defence, *Canadian Surface Combatant—Concept of Employment* (Ottawa: Directorate of Maritime Force Development, 2011), 10-11.

[7] "Point defence is posture designed for the protection of an individual ship, whereas area defence is the co-ordinated defence of a specific area (for example a Maritime Task Force) by a variety of systems"; Ministry of Defence, Joint Warfare Publication 3-63, *Joint Air Defence* (Shrivenham: Joint Doctrine & Concepts Centre, 2003), 1-11.

[8] "Anti-access (A2) capabilities are associated with denying access to major fixed-point targets, especially large forward bases, whereas area-denial (AD) capabilities threaten mobile targets over an area of operations, principally maritime forces, to include beyond the littorals"; Andrew Krepinevich, *Why Air Sea Battle?* (Washington, DC: Center for Strategic and Budgetary Assessments, 2010), 8–11.

[9] This is in line with Sir Julian Corbett's naval theory; Julian S. Corbett, *Some Principles of Maritime Strategy (1911)*, reprint introduced by Eric J. Grove (Annapolis: Naval Institute Press, 1988), 16.

(>Mach 5) ASCMs.[10] The ASCM payloads can vary from high explosive warheads and sub-munitions to weapons of mass effect.[11] The sensor suite can include a combination of passive and active seekers to assist with terminal guidance, as well as global positioning and inertial navigation systems for the cruise phase. Some ASCMs, such as the Russian P-700 Granit, are also capable of salvo and cooperative engagement tactics to overwhelm the AAW 'kill chain' and increase the probability of kill.[12] Currently, the leaders in ASCM development are the U.S., Russia, India, China, and Iran.

6. **ASBM**. The ASBMs currently adopt two technologies—terminally guided ballistic missiles and boost-glide missiles.[13] Table 1 lists the major differences between the two technologies. Notwithstanding the ongoing development of ASBMs since the early 1990s, the recent Chinese tests of hypersonic ASMBs have caused concern. Between 2014 and November 2015, the Chinese conducted six tests of their DF-ZF hypersonic boost-glide vehicle that can reportedly travel at Mach 10 and perform extreme terminal-phase manoeuvres to intercept moving targets.[14] The ASBM warhead will be minimal since the kinetic energy alone will create significant damage. Academic James Acton of the Carnegie Institute assesses that the initial operating capabilities of boost-glide ASBMs will be achieved between 2018 and 2024.[15]

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[10] Countries pursuing hypersonic missiles include U.S., China, Russia, India, Japan, South Korea and Taiwan; The Diplomat, "Hypersonic Missiles and Global Security," Last modified November 13, 2015, http://thediplomat.com/2015/11/hypersonic-missiles-and-global-security/.

[11] Weapons of mass effect comprise of Chemical, Biological, Nuclear and Radiological; A. Berman *et al*, *Naval Forces' Capability for Theatre Missile Defence* (Washington, DC: National Academy Press, 2001), 26.

[12] Pacific Maritime Conference – 2010, "Evolving Naval Anti-ship Weapons Threat," accessed January 29, 2016, http://www.ausairpower.net/SP/DT-ASBM-Dec-2009.pdf; IHS Janes, "P-500 Bazal't (SS-N-12 'Sandbox')/P-700 Granit (SS-N-19 'Shipwreck')," last modified November 2, 2015, https://janes.ihs.com/Janes/Display/1499595.

[13] James M. Acton, *The Silver Bullet* (Washington, DC: Carnegie Endowment for International Peace, 2013), 37.

[14] The Diplomat, "Hypersonic Missiles and Global Security," last modified November 13, 2015, http://thediplomat.com/2015/11/hypersonic-missiles-and-global-security/; IHS Janes, "US Officials Confirm Sixth Chinese Hypersonic Manoeuvring Strike Vehicle Test," last modified November 26, 2015, https://janes.ihs.com/Janes/Display/1757405.

[15] James M. Acton, *The Silver Bullet* (Washington, DC: Carnegie Endowment for International Peace, 2013), 49.

Table 1. Key differences between ASBM technologies

	Terminally Guided Ballistic Missiles	**Boost-Glide Weapons**
Maximum range	Intercontinental	Global
Mid-course manoeuvrability	Zero	High
Terminal manoeuvrability	Limited or very limited	Medium or high
Ballistic flight path over the majority of trajectory	Yes	No
Cooperative engagement capability	No; but likely to employ salvo tactics to produce saturation of the AAW 'kill chain' process	In development

Source: Modified from Eleni Ekmektsioglou, "Hypersonic Weapons and Escalation Control in East Asia," *Strategic Studies Quarterly* 9, no. 2 (Summer 2015): 46 and Pacific Maritime Conference - 2010, "Evolving Naval Anti-ship Weapons Threat," accessed January 29, 2016, http://www.ausairpower.net/SP/DT-ASBM-Dec-2009.pdf.

7. **Challenges for the Royal Canadian Navy**. The advances in ASCMs and the emergence of ASBMs pose significant challenges for the RCN, especially when deployed as part of a Maritime Task Force, with strategic assets attached. The high capital cost and strategic implications of losing an aircraft carrier, an amphibian, logistics support, or a commercial ship to an ASCM or an ASBM justify the continued development of these weapons.[16] The proliferation of these weapons among state and non-state actors will also create issues for the RCN.[17] *Jane's Defence* reported, in as early as 1996, that 75 countries already possessed 130 cruise missile types.[18] Hezbollah's successful deployment of a land-based ASCM against an Israeli frigate in 2006 demonstrated the missile's accessibility to a non-state actor, as well as its effectiveness. The evolution of hypersonic missiles will make point and area AAW defence extremely challenging in the foreseeable future. At a

[16] In 2014 the estimated cost for long-range ASCM and ASBM were $1 million-$3 million and $6 million-$10 million respectively. In the same year estimated cost of a U.S. destroyer and carrier were $1 billion-$2 billion and $11 billion respectively; Brian Clark, *Commanding the Seas* (Washington, DC: Center for Strategic and Budgetary Assessments), 18.

[17] Department of National Defence, *The Future Security Environment 2008-2030 - Part 1: Current and Emerging Trends.* Winnipeg: 17 Wing Winnipeg Publishing Office, 2010, 95.

[18] IHS Defence, "Cruise Missiles," Last accessed 2 February 2016, https://janes.ihs.com/Janes/Display/1658410.

Congressional hearing in January 2014, the Technical Director of the U.S. National Air and Space Intelligence Center stated that, "Hypersonic missiles of any kind, whether they're glide vehicles or cruise missiles, are extremely difficult to defend against because the time is so compressed between initial detection, being able to get a fire solution, and then just being able to have a weapon that can intercept them."[19] Consequently, it is imperative for the RCN to take a holistic approach to effectively counter these threats through a critical analysis of the *sense*, *command*, and *act* operational functions.[20]

Sense operational function

8. The *sense* operational function provides a commander with the necessary information by integrating the data from detection systems.[21] This information can then be used to plan and execute actions. This function provides the commander with decision superiority and the ability to proceed with the AAW 'kill chain.' The *sense* function primarily involves detection, tracking, and identification of targets; consequently, several challenges posed by ASCMs and ASBMs should be overcome.

9. **ASCM sense challenges**. The main challenges with cruise missile detection, tracking, and identification include the following:

a. **Terrain masking**. Low-altitude ASCMs use terrain-hugging techniques to limit their exposure to ground-, air- or sea-based radar systems. This is a particular concern for naval platforms operating in the littoral environment where the

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[19] Congressional Hearing, *Hearing before the U.S.-China Economic and Security Review Commission* (Washington, DC: U.S. Government Printing Office, 2014), 37–38.

[20] The Canadian Surface Combatant Concept of Employment document states that the RCN must be able execute the following tasks: multi-threat warfare, support to forces ashore, embargo operations, maritime interdiction, non-combatant evacuation operations, counter piracy, contribute to NORAD, Maritime Domain Awareness, Sovereignty Patrol, Public Service and Assistance to Law Enforcement Agencies, Search and Rescue (SAR), Humanitarian Assistance and Disaster Relief (HA/DR), Overseas Regional Engagement, Domestic Community Engagement; Department of National Defence, Canadian Surface Combatant—Concept of Employment (Ottawa: Directorate of Maritime Force Development, 2011), 15–16.

[21] Department of National Defence, B-GL-300-001/FP-001, *Land Operations* (Ottawa: DND Canada, 2008), 4–19.

unmasking range may be extremely close. Additionally, sea-skimming ASCMs hide below sensor elevations and amongst the sea clutter.

b. **Low observability**. Improvements in stealth technology through the reduction of radar cross-section and multispectral emissions will enable ASCMs to stay below the detection threshold.

c. **Mission planning**. Adversaries will plan flight paths that circumvent sensors and AAW weapon coverage.

d. **Suppression of enemy air defence (SEAD).** Adversaries will employ electronic warfare techniques from a combination of platforms, including the attacking ASCM, to confuse or interrupt the *sense, command*, and *act* operational functions.

e. **Multiple speed profiles.** The ASCMs that vary their speed (from subsonic to supersonic or hypersonic) are able to reduce radar range gating and Doppler effectiveness and hence make sensor tracking extremely difficult.

10. **ASBM sense challenges**. The main challenge with detecting an ASBM is the significant distance between the launch location and the Maritime Task Force. The issue becomes more complicated when the reentry vehicle (RV) is in its exo-atmospheric trajectory.[22] During this trajectory, it can be difficult to distinguish the RV from space debris and decoy vehicles.[23]

11. **Implications for the Royal Canadian Navy**. As ASCMs and ASBMs become more sophisticated, sensing them will become significantly more challenging. This situation is

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[22] Exo-atmospheric trajectory refers to a trajectory outside the atmosphere. ASBM leave the atmosphere during the cruise phase.

[23] A. Berman *et al*, *Naval Forces' Capability for Theatre Missile Defence* (Washington, DC: National Academy Press, 2001), 46.

especially applicable in the littoral environment where complex physical terrain is common. This will require the RCN to adopt an integrated approach to the sense function as opposed to exclusively relying on its organic ship-based sensors. The sensors will need to be both active and passive, and access to strategic assets will be essential, especially for ASBM detection during the launch and cruise phases. These systems should include manned or unmanned airborne early warning, advanced ship-based radar, over-the-horizon-radar, electronic support, and space-based multispectral sensors to ensure confidence in sensing.[24] The fusion of sensor information will be critical in the establishment of a recognized air picture, which will provide early detection and improved tracking and identification. In the situation where the Canadian Armed Forces (CAF) have no access to national strategic assets, they should ensure that they can access near-real-time feeds from their allies and partners.[25] Additionally, Canada must emphasize the effective employment of *sense* assets to ensure that vulnerabilities are mitigated and sensor capabilities are maximized. The *sense* function must remain a priority in the complex battlespace because adversaries are continually developing technologies and techniques that will result in missiles staying below the detection threshold until it is possibly too late to effectively respond.

Command operational function

12. The *command* operational function takes the outputs of the *sense* function to determine the current situation and compares it with the desired state.[26] Once this assessment is completed, the *command* function will plan and direct actions to counter the ASCM and

[24] As at 2006 the only two countries that had deployed and dedicated space-based missile sensing were the U.S. and Russian Federation. These sensors use electo-optical and infrared satellites; Geoffrey Forden, "A Consolidation of Satellites for Shared Missile Launch Surveillance," MIT's Program on Science, Technology and Society (September 2006): 8.

[25] Near-Real-Time is information that is seen in a platform which is relayed from external sources over tactical data links. Real-time information is that seen in a platforms tactical data system from its own sensors; Ministry of Defence, Joint Warfare Publication 6-00, *Communications and Information Systems Support to Joint Operations* (Shrivenham: Joint Doctrine & Concepts Centre, 2003), Annex 4J—Tactical Data Links.

[26] Department of National Defence, B-GA-401-000/FP-001, *Aerospace Command Doctrine* (Ottawa: DND Canada, 2008), 1–2.

ASBM threats. Within the AAW 'kill chain,' the command function resides within the decision task. This process is vital for effective point and area AAW defence, with a high reliance on computing, communications and procedures. As ASCM and ASBM capabilities increase and the battlespace becomes more complex, the requirement for effective command of the AAW battle will be even more critical. Consequently, the RCN should be focusing its efforts on three main areas:

a. **Integration**. The command function in the AAW battle must be capable of seamlessly integrating sea, land, air, and space capabilities into its environment. This will require significant cooperation and planning with joint, inter-agency, and coalition partners in an effort to resolve command and control issues. Additionally, it will require superior 'blue force tracking' to ensure maximum situational awareness to minimize fratricide.

b. **Decision superiority**. This is associated with synthesizing sensor information, determining fire-control options—using a combination of computer processing and cognitive thinking—and proceeding with kinetic and/or non-kinetic responses. This will be extremely challenging against high speed and manoeuvrable ASCMs and ASBMs that may utilize their cooperative engagement capability in salvo tactics. The time from the detection of an ASCM in blue water to the impact could be less than 10 seconds.[27] Restrictive rules of engagement (ROE), difficulties in positive identification, integration of joint assets, and multiple friendly and/or neutral airborne and seaborne assets in the battlespace may further complicate the command environment. This will

[27] Ten seconds is based on a hypersonic missile travelling at Mach 8 being detected at a radar horizon of 30 kilometers.

obviously create a situation where the *command* function will be placed under significant pressure.

c. **Communications**. Currently, the naval communications architecture is based around Link 16 tactical data exchange network, which is well suited to the current operating environment. However, as the battlespace complexity increases, Link 16 will need to advance accordingly. This will require near-real-time transfer of information across the *sense*, *command* and *act* functions to effectively strike targets over an extended area. Furthermore, time constraints associated with joining the Link 16 network should be reduced to allow for seamless integration, as well as robust jamming countermeasures.[28]

13. **Implications for the Royal Canadian Navy.** To be effective in the future AAW defence operating environment, the RCN must ensure that it leads the development of a joint concept of operations (CONOPS) in an effort to understand these complex challenges. This must be complemented with an AAW defence combat system that is capable of determining area and point defence fire-control options for a commander in real time. This AAW defence combat system must also be interoperable with allied weapons systems and capable of ‘block upgrades’ to ensure effectiveness against emerging threats. Importantly, fully automatic fire-control solutions must be examined because traditional commander-in-loop processes will be vulnerable and potentially unable to effectively process the sensor and fire-control information in extremely compressed timelines.

Act operational function

[28] A. Berman *et al*, *Naval Forces’ Capability for Theatre Missile Defence* (Washington, DC: National Academy Press, 2001), 22.

14. The *act* operational function involves a kinetic or non-kinetic response to achieve the desired effect of countering ASCM and ASBM threats.[29] The key to doing so is synchronizing kinetic and non-kinetic effects in a multilayered approach. Such an approach in the defensive AAW battle entails the employment of area and close-in weapon systems, platform manoeuvres, and electronic countermeasures (ECMs). However, several challenges are associated with emerging ASCM and ASBM threats, including the following:

a. **Cooperative engagement capability and salvo tactics**. The emergence of cooperative engagement capability and salvo tactics with terminal stage manoeuvres will challenge current kinetic and non-kinetic AAW weapon systems. This may result in multiple ASCMs and/or ASBMs attacking a strategic platform by using multi-axis tactics in the terminal phase to overwhelm area and point AAW weapons systems.

b. **ASCM and ASBM speeds**. The supersonic and hypersonic speeds of emerging ASCMs and ASBMs will make an effective kinetic response challenging. Conventional defence systems will have insufficient time to launch, then arm, and intercept these threats. Additionally, close-in weapon systems will be ineffective due to the kinetic energy of the missiles. This will create significant problems in countering this threat.

15. **Implications for the Royal Canadian Navy**. The RCN's current suite of kinetic defence weapons will be challenged against the emerging threats. However, non-kinetic weapons and tactics in the form of ECMs or manoeuvres may be capable of providing one layer of defence. What will also be required are advances in kinetic weapon systems, including electromagnetic railguns and directed energy lasers. Consequently, it is

[29] Department of National Defence, B-GL-300-001/FP-001, *Land Operations* (Ottawa: DND Canada, 2008), 4–19.

recommended that the RCN work with allies and partners in the development of both kinetic and non-kinetic capabilities. If kinetic options are prohibitive in terms of cost and technology, then an aggressive ECM program should be conducted.[30] Additionally, the RCN should invest significant thinking to developing tactics that will minimize the threats.

CONCLUSION

16. The emergence of ASCMs and ASBMs technologies will pose significant challenges for the RCN in providing point and area AAW defence within the littoral and blue water environments. This paper has highlighted the characteristics and development of ASCMs and ASBMs and their proliferation amongst state and non-state actors. The *sense*, *command*, and *act* operational functions have then been used to demonstrate the RCN's impending difficulties in attempting to counter the threats. Each section of this paper has discussed the implications for the RCN to provide the context for future force development and procurement. As the RCN moves forward and leads or contributes to a Maritime Task Force, it must be ready to counter the ASCM and ASBM threats. This initiative will require the RCN to maintain a cognitive and technological edge so that it can seamlessly integrate with its allies and partners.

RECOMMENDATIONS

17. The CAF Defence Intelligence Command should actively assess and monitor ASCM and ASBM technologies, as well as seek inputs into the force development planning process and the Canadian Forces Maritime Warfare Centre.

18. The RCN should lead the development of a joint area AAW defence CONOPS for the littoral and blue water environments.

[30] The challenge with effective ECM is that it generally requires an understanding of an adversary's sensor and guidance systems.

19. The integration of joint, inter-agency, and allied tactical, operational, and strategic sensors must be examined to ensure that a robust, recognized air picture is established to provide sufficient time to proceed through the AAW 'kill chain.'

20. The RCN AAW defence combat system must remain fully interoperable with allied systems.

21. Defence and Research Development Canada should work with allies and partners in the development of advanced kinetic and non-kinetic weapon systems that are capable of countering ASCM and ASBM threats.

22. The Canadian Forces Maritime Warfare Centre should pursue the development of tactics to minimize the ASCM and ASBM threat.

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