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FUTURE SUB-SURFACE THREATS

COMMANDER DAVID DOWNIE, RN

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Commander David Downie, RN

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FUTURE SUBSURFACE THREATS

AIM

1. The aim of this paper is to explore the implications that two projected advances in subsurface capability (Submarine Launched Surface-to-Air Missiles (SubSAM) and the Autonomous Underwater Vehicle (AUV)) will bring for the Royal Canadian Navy (RCN). In addition, the paper will identify existing and nascent technologies that it will be necessary to adopt in order to counter the threat posed by both technology advances.

INTRODUCTION

2. Advances in subsurface technologies will have far reaching consequences for the future equipment requirements and coastal defence models of the RCN. This paper explores how the integration of surface to air missile technology into submarines may have implications on strategies used to employ air assets in the Anti-Submarine Warfare (ASW) role. Furthermore, it addresses the need to adopt Unmanned Air Systems (UAS) in the ASW role to reduce the RCN's exposure to potential loss of life. Separately, the introduction of the AUV and its use in weapon delivery and persistent subsurface surveillance will be discussed along with a precis of the significant challenges posed to maritime security and RCN submarine employment by such technology. A future RCN AUV capability is suggested to counter the paradigm shift that AUV technology will have on the maritime battlespace. Finally, recommendations are presented for deeper RCN investigation into the topics of SubSAM and AUV employment.

DISCUSSION

Submarine Launched Surface-to-Air Missile

3. Able to operate with relative impunity, submarines are "weapons of strategic deterrence whose presence—actual or inferred— can alter an adversary's decision-making across an entire maritime theatre of operations"[1]. Unmatched when conducting sea denial and sea control operations, submarines are nonetheless relatively fragile and are fully reliant upon stealth for survival[2]. Manned ship-based ASW helicopters and land-based Maritime Patrol Aircraft (MPA) are the primary tools used to threaten a submarine (particularly when operating in shallow or littoral waters) against which, until recently, it could not retaliate[3]. The development of the SubSAM will alter this status and provide subsurface capability to conduct limited Anti-Air Warfare (AAW), primarily in a self-defence context.

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[1] Royal Canadian Navy, *Leadmark 2050: Canada in a New Maritime World* (Ottawa: National Defence, 2016): 39.

[2] J. D. Miller, "Aggressive Defense: Force Protection From a Submarine Perspective", *Undersea Warfare*, Issue 13 (Fall 2001), accessed 21 October 2019 https://www.public.navy.mil/subfor/underseawarfaremagazine/Issues/Archives/issue_13/defense.htm

[3] Unlike other submarines or surface ships that can be offensively or defensively engaged.

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4. There are two systems currently under development that are likely to be operationally fielded within the next 5-10 years - the Interactive Defense and Attack System (IDAS)[4] and the submarine launched *missile d'interception, de combat et d'autodéfense* (MICA)[5]. Both of these weapons are designed to be launched from a standard 533mm torpedo tube at significantly below periscope depth, utilise Imaging Infra-Red (IIR)[6] seeker heads but differ in terms of approach system integration and AAW capability.

5. IDAS is designed for "easy integration into new submarine building projects as well as refits of existing submarines"[7], merely requiring an operator station linked to the firing station. A fibre optic cable attached to the missile throughout flight provides a "human-in-the-loop"[8] targeting capability. Whilst sub-sonic, this system poses a very high threat to ASW helicopters and also to slow moving, low altitude MPAs owing to the continued element of control that the submarine can exert on the weapon in flight. This allows it to be a more discriminate attack option that can be re-tasked to higher value targets once airborne. Future development is aimed at providing capability to strike surface targets for a lower value target kill option "where [the use of] a heavy weight torpedo is not appropriate"[9].

6. MICA provides different defensive options for the submarine. Directly integrated into the submarine's existing sensor suite, the weapon will be provided targeting data that allows "designation and engagement of helicopters even whilst deeply submerged"[10]. The missile itself is supersonic[11] and consequently poses a higher threat to higher altitude, faster moving MPAs than an equivalent sub-sonic system[12]. A 'fire-and-forget'[13] weapon, MICA allows the launching submarine to immediately vacate the area upon weapon release thus potentially evading immediate detection by other ASW assets.

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[4] Thyssen Krupp Marine Systems, "IDAS - Interactive Defense and Attack System for Submarines", accessed 18 October 2019 https://www.thyssenkrupp-marinesystems.com/en/missile-system-idas.html.

[5] Naval Group, "Sub-launched MICA system against helicopters and aircraft", accessed 18 October 2019 https://www.naval-group.com/wp-content/uploads/2017/01/submarine-air-warfare-sub-launched-mica-system-against-helicopters-and-aircraft.pdf

[6] IIR seeker heads "use imaging technology and processing algorithms to determine the target position by the shape of the aircraft, and these seekers are not susceptible to jamming by current systems." William Caplan, "IR imaging seekers may be very resistant to laser jamming", accessed 20 October 2019 https://www.spie.org/news/5614-ir-imaging-seekers-may-be-very-resistant-to-laser-jamming?SSO=1

[7] Ibid.

[8] Thyssen Krupp Marine Systems, "IDAS . . ."

[9] Ibid.

[10] Naval Group, "Sub-launched MICA . . . "

[11] Ibid.

[12] The higher speed of the weapon minimises the reaction time advantage of faster moving, higher altitude aircraft.

[13] Ibid. 'Fire-and-forget' is a term denoting a weapon that has an autonomous guidance capability that requires no further input from the launch vessel post release.

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SubSAM Implications

7. The SubSAM capability can be described as providing a zone of aerial protection around the submarine equivalent in radius to the range of the missile (<20km[14]) within which the threat to airborne assets becomes extremely high. This zone is unlikely to be precisely located unless the target is being tracked by a subsurface asset. Consequently, launching any manned aerial assets to conduct ASW operations against a SubSAM equipped adversary becomes potentially very expensive in terms of both lives and airframes. With the IDAS system providing 4 missiles per torpedo tube[15], it can be surmised that a single submarine has the potential to neutralize all of the organic, ship-based airborne ASW assets within a task group without necessarily being targeted itself. As a result, this would confine the prosecution of effective ASW in the RCN) to surface ships and submarines, vastly reducing the overall ASW coverage area and detection ranges.

8. However, adoption of the SubSAM capability by the RCN could provide the submarine fleet with a significant tactical advantage in the future. In particular, the surface strike capability of future SubSAM systems[16] would introduce an intermediate offensive choice for the submarine to take, adding to the current limited 'sink' or 'do not sink' options that the Heavy Weight Torpedo provides.

SubSAM Counter Capability

9. An effective counter to the aerial protection effect of the SubSAM capability is to utilise Unmanned Air Systems (UAS)[17] within the threat zone. The main advantage of such systems is that they generally cost significantly less that their manned counterparts (e.g. a MQ-8C Fire Scout costs approx. 20% of a CH-148[18]) and do not put Canadian lives directly in harm's way of the SubSAM threat. These UAS could be controlled remotely from a ship- or land-based ground station or via a manned ASW airborne asset operating behind the line of ASW advance. Currently there are several categories of UAS in development that would be able to either fulfil the role of the MPA for coastal defence or the role of the ASW helicopter for blue water fleet defence.

10. The MQ-9 Predator B is an example of a high endurance, land-based UAS that could be used in the MPA role. The aircraft successfully conducted ASW trials in 2017 where it was used to "demonstrate the remote detection and tracking of submerged

[14] This is the declared range of the MICA as per Naval Group, "Sub-launched MICA . . . "

[15] Thyssen Krupp Marine Systems, "IDAS . . ."

[16] Thyssen Krupp Marine Systems, "IDAS . . ."

[17] For this paper, the term UAS is used to cover all variants of unmanned systems including Remotely Piloted Aircraft.

[18] MQ-8C estimated to cost USD $10.8 million or CAD $14.14 million each. US Department of Defense, "Contracts" accessed 20 October 2019 https://www.defense.gov/Newsroom/Contracts/Contract/Article/939786/. CH-148 buy CAD $2.04 billion for 28 assets or CAD $72.85 million per aircraft. Government of Canada, "CH-148 Cyclone procurement project", accessed 20 October 2019 https://www.canada.ca/en/department-national-defence/services/procurement/ch-148-cyclone.html

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contacts, such as submarines, during a US Naval exercise"[19]. The demonstration utilised multiple sensors on the aircraft (including Synthetic Aperture RADAR) in conjunction with a sonobuoy receiver and data processing mission system to successfully track subsurface threats[20]. With an endurance of 27 hours, the ability to carry a 1361 kg payload and equipped with a satellite communications (SATCOM) datalink[21], the MQ-9 Predator B would be well suited to conduct an advanced warning MPA role over any of Canada's maritime threat zones without the risk of loss of Canadian life.

11. UAS that are capable of blue water ASW operations require to be organically deployable and recoverable from RCN vessels that are out of range of land bases[22]. In addition, they should be able to replicate some capability of existing air assets (to deploy sonobuoys, use RADAR or have active dipping sonar) to make them truly useful in an ASW capacity. Collating both requirements means that the main practical option is to use a form of rotorcraft for the task[23]. The MQ-8C Fire Scout[24] has an endurance of 12 hours, a payload of up to 227 kg and is currently being developed by the manufacturer to undertake ASW operations, including sonobuoy and Unmanned Underwater Vehicle (UUV) launching[25]. The aircraft is designed to operate in conjunction with a manned aircraft and will be fitted with Link 16 for high bandwidth secure communications[26]. Whilst based on a full-size civilian helicopter model, the MQ-8C is relatively compact, fully marinized (including a folding rotor head[27]) and would be able to operate alongside the CH-148 Cyclone on the large flight deck and hangar of the future Canadian Surface

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[19] Mike Ball, "Predator B UAS Demonstrates Anti-Submarine Warfare", accessed 20 October 2019 https://www.unmannedsystemstechnology.com/2017/11/predator-b-uas-demonstrates-anti-submarine-warfare/

[20] Ibid.

[21] General Atomics Aeronautical, "Predator B data sheet", accessed 20 October 2019 http://www.ga-asi.com/predator-b

[22] Royal Canadian Navy, *Leadmark 2050: Canada in a New Maritime World* (Ottawa: National Defence, 2016): 68.

[23] Conventional aircraft with the payload capacity to deploy sonobuoys are unable to be recovered without a runway. Parachute recovery systems are not accurate enough to ensure landing on the flight deck and so will have to land in the sea. At higher sea states this will result in extremely difficult recovery options for the RCN platform and likely cause damage or loss of the UAS in the process. Lighter than air UAS (airships) are not fast enough to cover the distances required for effective ASW operations.

[24] Northrop Grumman Aerospace Systems, "MQ-8C_Fire_Scout_Data_Sheet", accessed 20 October 2019 https://www.northropgrumman.com/Capabilities/FireScout/Documents/pageDocuments/MQ-8C_Fire_Scout_Data_Sheet.pdf

[25] Northrop Grumman Aerospace Systems, "Northrop Grumman Showcases Autonomous Maritime Capabilities at U.S. Navy's Advanced Naval Technology Exercise" dated 19 September 2018, accessed 20 October 2019. https://news.northropgrumman.com/news/releases/northrop-grumman-showcases-autonomous-maritime-capabilities-at-u-s-navys-advanced-naval-technology-exercise

[26] Beth Stevenson, "USN expands MQ-8C Fire Scout Capability", *Jane's 360*; 14 April 2019, accessed 20 October 2019. https://www.janes.com/article/87877/usn-expands-mq-8c-fire-scout-capability

[27] Northrop Grumman Aerospace Systems, "MQ-8C_Fire_Scout_Data_Sheet" . . .

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Combatant (CSC)[28]. This capability could naturally be deployed with the CSC's Low Frequency Towed Array SONAR system[29] in the future for dedicated ASW operations.

Autonomous Underwater Vehicles

12. Autonomous Underwater Vehicles (AUV) have been fielded in increasing numbers over the last decade by many of the major sea powers in the world[30]. The UK[31], USA[32], China[33] and Russia[34] are amongst the many nations actively developing AUV to prosecute a broad spectrum of maritime warfare effects including ASW, Anti-Surface Warfare and Intelligence, Surveillance and Reconnaissance[35]. There are two key categories of AUV that pose a capability challenge to current subsurface detection and disruption methods; AUV torpedoes and AUV oceanic gliders.

13. AUV torpedoes provide high speed weapon delivery over a very long range such that the point of origin (be it ship, aircraft or submarine) will remain potentially undetected[36]. An extreme example of this is the Russian Poseidon, which is purported to be capable of travelling the distance from Russia to the eastern coast of Canada at 100 kts to deliver a 100-megaton nuclear payload[37]. A less extreme example is the SeaHake Mod

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[28] Comparison based on data provided by the Rt Hon Michael Fallon MP on the UK Type 26 Frigate. Rt Hon Michael Fallon MP, untitled letter to Rory Stewart MP dated 9 October 2014, Annex A; 1. accessed 20 October 2019 https://www.parliament.uk/documents/commons-committees/defence/141009_SoS_re_Type_26_Global_Combat_Ship.pdf

[29] Ultra Electronics Maritime Systems, "Canada's Combat Ship Team: Ultra Electronics to Provide High Tech Sonar Capability", dated July 2018 accessed 21 October 2019 https://www.ultra-ms.com/media/press-releases/CSCHomeTeam-Ultra-UEMS.aspx

[30] Globalnewswire.com, "Global $2.65 Billion Unmanned Underwater Vehicles Market 2017-2021", dated 10 March 2017 accessed 21 October 2019 https://www.globenewswire.com/news-release/2017/03/10/934263/0/en/Global-2-65-Billion-Unmanned-Underwater-Vehicles-Market-2017-2021.html

[31] United Kingdom Ministry of Defence, "Notice Competition document: developing the Royal Navy's autonomous underwater capability", dated 6 June 2019 accessed 20 October 2019. https://www.gov.uk/government/publications/competition-developing-the-royal-navys-autonomous-underwater-capability/competition-document-developing-the-royal-navys-autonomous-underwater-capability

[32] Ben Werner. "Navy Awards Boeing $43 Million to Build Four Orca XLUUVs", *USNI*, last accessed 21 October 2019. https://news.usni.org/2019/02/13/41119

[33] H I Sutton. "China Navy Reveals New Large Underwater Robot Which Could Be A Game Changer", *Forbes.com*, last accessed 21 October 2019, https://www.forbes.com/sites/hisutton/2019/10/01/china-reveals-new-robot-underwater-vehicle-hsu-001/#4f6da3911991

[34] Franz-Stefan Gady. "US Intelligence: Russia's Nuclear-Capable 'Poseidon' Underwater Drone Ready for Service by 2027", *The Diplomat*, 26 March 2019:1 https://thediplomat.com/2019/03/us-intelligence-russias-nuclear-capable-poseidon-underwater-drone-ready-for-service-by-2027/

[35] F Ruadulescu and I Chiorcea. "Considerations Regarding the Need for the Use of Unmanned Systems in the Naval Forces Operations." *International Scientific Conference "Strategies XXI."* (2017): 362.

[36] Tyson Bergmann. "ASW Tactics and Doctrine Obsolescence: How Advances in Technology are Reshaping the Future ASW Battlespace", (Joint Command and Staff Course Service Paper, Canadian Forces College, 2018), 5.

[37] Ibid.

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4 ER torpedo which is conventionally armed, has a range of 140 km, is capable of self-navigation and is able to loiter whilst waiting for its target (or additional weapons) to arrive into the combat area[38]. This weapon system is intended to operate both from ashore as a coastal defence system and also as an offensive capability for shipboard use[39]. Designed as a modular system[40], SeaHake has the ability to deliver alternate payloads and therefore it is feasible that future AUV "missions could include deploying payloads such as … inactive mines"[41] for a long-ranged sea area denial capability.

14. AUV oceanic gliders are able to operate for prolonged periods of time (in excess of twelve months) without requiring refuelling or manned intervention[42]. The Wave Glider system is such an AUV and is "wave-propelled with continuous diurnal solar panel support of electrical systems"[43] that power a sensor payload and communications equipment. AUV gliders can be deployed in networked fleets to cover significant ocean volume and use SATCOM to relay detailed sensor information back to surface ships or shore[44]. AUV gliders are relatively inexpensive[45] and military applications for such systems are being developed that will provide a subsurface threat detection capability and a communications gateway to a SATCOM network for subsurface assets[46].

AUV Implications

15. With a submarine able to deploy multiple AUV torpedoes in quick succession at long range, a single aggressor could threaten high value assets in a naval base by deploying waves of munitions that could loiter whilst selectively hunting for their individual targets[47]. This would be a devastating first strike weapon that, if timed correctly, could cripple an entire coast's naval defences in a single offensive or at least deny the use of the port by sinking vessels in the channel entrance. Similarly, AUV delivered smart mines could be pre-seeded within a sea area that an adversary deems

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[38] Sayan Majumdar. "SeaHake: The German Torpedo." *Vayu Aerospace and Defence Review* (May 2017): 95. https://search.proquest.com/docview/1916148797?accountid=9867

[39] Jeremy Binnie. "Analysis: UAE may have acquired long-range mod4 ER torpedo vessels", *Jane's Defence Weekly*, 12 October 2015: 1, https://janes.ihs.com/DefenceWeekly/DisplayFile/jdw59955?edition=2015

[40] Ibid.

[41] U.S. Congress, House of Representatives, Committee on Armed Services. *Game changers: undersea warfare: hearing before the Subcommittee on Seapower and Projection Forces of the Committee on Armed Services*, *114th Cong., 1st sess* (Washington: U.S. Government Publishing Office, 2015): 49.

[42] Tracy A. Villareal and Cara Wilson. "A comparison of the pac-X trans-pacific wave glider data and satellite data (MODIS, aquarius, TRMM and VIIRS)." *PloS one* 9, no. 3 (2014): 1. https://doi.org/10.1371/journal.pone.0092280

[43] Ibid; 2.

[44] Liquid Robotics. "Defence Security": 1, https://www.liquid-robotics.com/markets/defense-security/ accessed 21 October 2019.

[45] David Hambling. "The Inescapable Net: Unmanned Systems in Anti-Submarine Warfare", *BASIC Parliamentary Briefings on Trident Renewal* Briefing No.1 (March 2016): 7.

[46] Ibid.

[47] Jeremy Binnie. "Analysis: UAE …"

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tactically or strategically pertinent but remain dormant indefinitely until activated by the owner at an appropriate political or strategic juncture.

16. The use of AUV oceanic gliders as persistent sensor platforms by other nations will pose a significant constraint on the covert deployment of RCN submarines. This will be especially true in relatively narrow channel areas such as the St Lawrence Seaway and the Straits of Hormuz. If seeded with passively monitoring AUV gliders, submarine passage through such confined waterways will face an extremely high probability of detection. Future submarine deployments by all nations will risk exposure to non-allied hostile actors in this manner and thus negate the submarine's primary strategic attribute of stealth.

AUV Counter Capability

17. In order to counter AUV delivered weapons there is a requirement first to detect them or their parent delivery vehicle. The USA has deployed a wide area, long-range detection system composed of networked AUV sensors (Persistent Littoral Undersea Surveillance, Networked (PLUSNet)[48]) that is designed to detect the latest generation of ultra-quiet, Air Independent Propulsion submarines[49]. Such a system could be established at key positions along the Canadian coasts, located beyond the maximum range of AUV torpedoes/smart mines in order to provide prior warning to the RCN and Canadian authorities. This type of system will provide early warning of a threat but will not neutralise it, which would be a task for RCN submarines or a dedicated high-speed anti-torpedo weapon system.

18. Countering AUV gliders will be challenging owing to the ease with which they can be deployed in vast numbers. Disabling enough of an established network to slip a submarine through will likely provide enough data for the operating nation to discern the likely cause. There are two main options as counter strategies. Firstly, AUV gliders are extremely slow (average 1.5 kts[50]) and therefore, during peacetime or pre-conflict shaping operations, a submarine should be able to pierce an AUV glider detection screen. This would ensure that the location of the submarine would be initially identified but, unless further unfriendly ASW assets were in situ, should allow a submarine to escape into open ocean. The second option should be effective in actively opposed situations, where a screen of specialised air-dropped AUV hunter killers is deployed ahead of the submarine. This tactic could be used routinely to sweep the area and will leave the enemy uncertain whether or not a submarine actually transited through during the sensor deprived period.

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[48] James Luby *et al*. "An At-Sea, Autonomous, Closed-Loop Concept Study for Detecting and Tracking Submerged Objects." *U.S. Navy Journal of Underwater Acoustics*; Vol 59, No 4 October 2009.

[49] Marc S. Stewart, and John Pavlos. "A means to networked persistent undersea surveillance." *In Technology Symposium*. 2006.

[50] Brian Bingham *et al*. "Passive and active acoustics using an autonomous wave glider." *Journal of Field Robotics* 29, no. 6 (2012): 920.

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CONCLUSION

19. The threat posed by SubSAM and AUV technologies will change the maritime battlespace over the next decades. Existing strategies used to employ air assets in the ASW role will no longer be acceptable from a risk to life perspective. Incorporation of unmanned systems into the RCN's inventory will be required to restore the primary means of ASW defence available organically to surface ships. In addition, the offensive capability that can be gained by the RCN's submarine fleet by integrating SubSAM would provide a significant boost to their combat utility in a limited war scenario. In contrast, evolution of the extra-long range AUV torpedo/smart mine will pose significant coastal defence challenges. This will require investment in long range persistent subsurface surveillance to provide warning within sufficient time to meaningfully react. Such a system will warn of a threat but will not neutralise it and further investment into a counter weapon (employed either from RCN submarines or as a dedicated capability) will be required. Persistent subsurface surveillance by non-allied nation AUVs will also shift the balance of the future maritime battlespace away from the submarine. Detection will be highly likely in coastal waters or narrow straits/channels and so urgent consideration of counter strategies or capabilities is required by the RCN submarine community. Finally, whilst it is clear that nascent SubSAM and AUV technologies will drastically alter the strategies and tactics of naval warfare over the next 10 years, they are potentially not the only ones. The RCN must stay connected to future advances in subsurface research and development in order to ensure that it can continue to provide Canada with the maritime defence it expects.

RECOMMENDATIONS

20. It is recommended that the Director of Naval Requirements:

a. Instigates an exploratory committee to further determine what tactical options integrating SubSAM capability into the Victoria Class will bring to the RCN.

b. Instigates an exploratory committee to further determine the need for an ASW UAS to be included in the RCN order of battle;

c. Funds an AUV program to have a capability to detect an AUV torpedo or its delivery vehicle at range and to provide persistent subsurface surveillance of Canadian coastal and near-coastal waters;

d. Instigates an exploratory committee to investigate options to provide an anti-torpedo defence system for Canadian near coastal waters; and

e. Instigates an exploratory committee to investigate strategies to defeat persistent subsurface surveillance of submarines.

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