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Uncrewed Subsurface Vessels: Targeting by Algorithm

Lieutenant-Commander Tim Turner

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CANADIAN FORCES COLLEGE – COLLÈGE DES FORCES CANADIENNES

JCSP 46 DL – PCEMI n° 46 AD
2019 – 2021

Exercise Solo Flight – Exercice Solo Flight

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Introduction

The introduction of autonomous vehicles with military applications continues unabated. While the primary military focus has been on uncrewed[1] aerial vehicles (UAV), the technology is being more readily applied to seaborne surface and subsurface applications. The Royal Canadian Navy (RCN) has been using remote operated vehicles (ROV) in mine-countermeasures since the mid-90s. The common thread between these advancements remains the human element. There is a human at the controls, an actual person making decisions. Even though current technology has surpassed the requirement for human intervention, the reluctance to allow for completely autonomous decision making remains, as these decisions may result in death or destruction.

Advances in computer technologies, artificial intelligence (AI) and efficient use of power has allowed for a broader spectrum of use, with significant advancements in the application of AI to autonomous weapon platforms. Autonomic weapon systems are not new, and the use of these systems is doctrine in the RCN. For example, when facing inbound missiles, placing weapon systems in automatic allows for a faster, more accurate kinetic response through all levels of layered defence.

In this paper, I will demonstrate the inherent benefits of autonomy to military targeting and warfighting, applying this to the subsurface realm. This will be done by discussing the current capabilities of autonomous underwater vessels (AUV), and the hypothetical application of these technologies to naval engagements. I will then address the concerns of allowing an autonomous computer system to apply kinetic effects independent of human decision-making by focusing on appropriate targeting, including the legal, moral, and ethical issues.

TECHNOLOGICAL ABILITIES AND CHALLENGES

UAVs were responsible for at least 13,072 of the over 82,000 strikes in Afghanistan from 2015 to the present[2]. Most advanced Navies use some form of uncrewed surface vessel (USV) as targets for weapons drills or remote sensing. The capability of UAV and USVs is well documented and has allowed for significant increases in application, both military and civilian. Each of these platforms relies on a connection to a human operator to make decisions. As we move from the surface to subsurface, this connection becomes impossible to maintain, thus AUVs have required

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[1] All instances of "unmanned" are replaced with "uncrewed" to align with GBA+.

[2] The Bureau of Investigative Journalism. "Drone Strikes in Afghanistan." Accessed May 23, 2021. https://www.thebureauinvestigates.com/projects/drone-war/charts?show_strikes=1&location=afghanistan&from=2015-1-1&to=now.

technological leaps to operate independently. This section will demonstrate the need for AUV by discussing current capabilities, potential near-term uses, and finally the challenges and advantages of AUVs.

Our allies and adversaries continue to develop their nascent large AUV capabilities. The first step to this is the development of larger autonomous surface vessels (ASV). To confidently deploy an AUV, the hardware and software needs to be proven on the surface. Supporting this, the USN has developed an experimental ASV primarily for anti-submarine warfare[3], a 130-foot trimaran called Sea Hunter. While the development of these vessels is ongoing, the seagoing capability of Sea Hunter claims operations up to sea state 5, sea keeping to sea state 7, and a range 10,000 nautical miles. The direct applications of this are numerous, and the USN is seeking the development of larger USVs, with defensive and offensive capabilities. Much of what is learned from the USV can be applied to AUV.

The technology for AUV has steadily increased over time. The USN and RN now believe that it has developed to the point that they are currently building AUV submarines to conduct autonomous operations underwater for extended periods of time, with offensive and defensive weapon systems[4]. While still in the development phase, there has been a significant financial commitment from allied navies to support this new capability which has been identified as key to the future state of warfare at sea. The prospect of a battery powered, high endurance, silent and inexpensive submarine is enough to excite any Navy.

It is not difficult to project the numerous applications of AUV. Defensively, the deployment multiple medium AUVs with towed arrays would provide a mobile, low cost and low maintenance early warning system[5]. A fleet of diesel-electric submarines could be deployed to provide a significant level of A2/AD. Even the possibility of this type of asset being deployed would greatly complicate an adversaries planning. Offensively, these same AUVs, with appropriate armaments, could be used as a viable passive offensive weapon. The deployment of assets such as these to the mouth of Kola Bay in Severomorsk, Russia could cause irreparable damage to the Russian Northern Fleet, should the AUVs be activated. The low power requirements, silent running capabilities,

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[3] Ronald O'Rourke, "Navy Large Unmanned Surface and Undersea Vehicles: Background and Issues for Congress," March 25, 2021, https://crsreports.congress.gov/product/pdf/R/R45757, 6.
[4] Ronald O'Rourke, "Navy Large Unmanned Surface and Undersea Vehicles: Background and Issues for Congress," March 25, 2021, https://crsreports.congress.gov/product/pdf/R/R45757, 6.
[5] Mike Ball, "Extra-Large UUV to Be Developed for UK Royal Navy," *Unmanned Systems Technology*, March 9, 2020, https://www.unmannedsystemstechnology.com/2020/03/extra-large-uuv-to-be-developed-for-uk-royal-navy/.

and the elimination of the need to resupply, or even come up for air, make this an outstanding first strike or covert option.

Augmenting the offensive and defensive capabilities of this platform, an AUV could replace all current mine counter-measure (MCM) surface / subsurface ships, while also providing this platform for the use of mines offensively, or again in an A2/AD capacity. The capability of an AUV minehunter surpasses our current, crewed abilities. For example, an MCM AUV submarine deploys to the Persian Gulf, where an adversary has recently laid mines. This MCM AUV arrives quietly on station, and deploys swarms of smaller AUVs to seek, detect, and destroy mines, at no risk to the main AUV or any other Naval assets. These smaller AUVs would be numerous, relatively inexpensive, and reduce the likelihood of human casualties to zero, while rapidly reasserting access to the waterway.

The greatest challenge facing AUV design, development and deployment is the ability to navigate and communicate underwater[6]. Uncrewed surface or air vehicles have ready access to GNSS, information that is fed to Inertial Navigation Systems (INS) to create a robust, accurate navigation capability. Communication is managed similarly to crewed surface assets, generally through the broad RF spectrum with varying degrees of crypto-protection.

INS for subsurface applications continue to improve. These systems take in relevant information from a variety of accelerometers and gyroscopes to create an accurate position indicator on an electronic chart. On the surface, these sensors are augmented by GNSS inputs, radar overlays, and Mark One Eyeball to maintain an accurate position. Subsurface, the number of sensors that feed the INS are reduced which creates a temporally expanding pool of errors in positioning which is further complicated by the need for stealth. The longer a vessel spends underwater without using overt detectable systems such as a tethered surface antenna or active sonar mapping, the greater the difficulty in determining position.

Communication suffers from similar challenges. Without a direct physical link, an AUV cannot be controlled remotely, and there are significant range and data limitations to the use of extreme or ultra-low frequency methods of underwater. While using a lower frequency can increase the range of communication underwater, data can only be passed from shore to the ship with only a few text characters per minute. Given the uncrewed nature of these vessels, the technological limitations are easily managed.

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[6] Josué González-García et al., "Autonomous Underwater Vehicles: Localization, Navigation, and Communication for Collaborative Missions," *Applied Sciences* 10, no. 4 (February 13, 2020): 1256, https://doi.org/10.3390/app10041256.

The most complex system of subsurface warfare is the human element. This is the single factor beyond any other that limits the full application of the subsurface domain, and impacts the physical design, materials, and costs of a vessel, as well as the high level of training required to operate in such a hostile environment. The difficulty of keeping water out of and the right amount of air, food and water inside the people tube limits the depth, range, and deployment length. The negative impact on submariners who consistently operate such hostile environments have been well studied[7], and induces additional challenges of maintaining the health and wellbeing of submarine crews.

The Royal Canadian Navy (RCN) has been unable to attract, train, and keep submariners. At present, the RCN only has enough trained submariners to crew one *Victoria-class* submarine – a submarine with a compliment of 48[8]. As other nations to not actively publish recruiting, retention and training challenges, these pressures are likely faced by many of our allies as well, and the investment and deployment of AUVs would readily address these problems and strengthen the case for the acquisition and deployment of AUVs.

In this section I demonstrated the current capabilities, advantages, and potential uses of AUVs while addressing some of the technological and human challenges with the platform. The acquisition and deployment of AUVs in the near term is possible, and with continued research and development, the capabilities will continue to improve. While the practicality of the platform is inherent, the application of a moral imperative must be applied, and further discussion on the moral, ethical, and legal implications of AUVs needs to be explored.

TARGETING – IMPLICATIONS OF AUTONOMOUS DEATH AND DESTRUCTION

The human selection and persecution of targets has significant implications, and must answer who selected a target and why, what the appropriate effect to neutralize that target, what is the likelihood of collateral damage, and what was the intended outcome. As we transition to more autonomous warfare options, these same questions must be answered, and the removal of a human operator from the equation greatly improves the overall efficacy of targeting. Regardless of the potential improvements, western society has significant reservations of turning over life and death decisions to a computer. In this section, I will discuss the current uses of autonomous targeting, societal understanding

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[7] Jihun Kang and Yun-Mi Song, "The Association between Submarine Service and Multimorbidity: A Cross-Sectional Study of Korean Naval Personnel," *BMJ Open* 7, no. 9 (September 24, 2017), https://doi.org/10.1136/bmjopen-2017-017776.

[8] Navigating Officer, telephone conversation with author, 24 May 2021. Name has been withheld at interviewees request.

and acceptance of autonomous targeting and conclude by discussing the legal implications of autonomous targeting.

Targeting is the "process of selecting and prioritizing targets and matching the appropriate response"[9]. The practical application of targeting requires an answer to the following: who or what is the target, why is that a target, with what capability do we persecute that target, when do we hit it, and how hard. The application of autonomous systems to this process has been demonstrated successfully for decades. Canadian Warships have been fitted with autonomous defence systems that are capable of selecting, engaging, and destroying targets in a layered defence approach since the 1990's. RCN doctrine leverages this autonomy, as the ship's computers can fight the defensive battle better than human counterparts[10].

Effective targeting and the determination of friend or foe is more simplistic in a Naval environment, as there is a lack of non-combatants and infrastructure which complicates targeting in urban areas[11]. While the application of this level of autonomy has yet to be applied across a broader spectrum, all major militaries continue large investments in the research and development of these capabilities[12], which will culminate in the use of autonomous warfare. While desirable from a military perspective, the use of autonomous targeting will continue to be examined from a moral and social perspective.

Autonomous vehicles (AV) have been tested globally for over a decade, and the data has proven to significantly reduce accidents[13]. Autonomous driving is safer than human driving, and yet only 1 in 10 drivers trust the AV[14]. If people cannot trust an automated system that is demonstrably safer, accepting an AV that has military applications will not happen at the rapidity by which the technology itself is developing.

A quick search on Netflix will provide the searcher with a plethora of dystopian movies whereby an Artificial Intelligence has either destroyed humanity, the earth, or both. While we are not currently at risk of entering the Matrix[15], this is representative of a broadly felt collective discomfort felt when considering the application of computers to

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[9] Department of National Defence, *Canadian Forces Joint Publication 3-9 Targeting*, 1st ed. (Ottawa, Canada: DND, 2014).
[10] LCdr Rob MacQuarrie, Officer Training Division Commander, telephone conversation with author, 25 May 2021.
[11] Margarita Konaev and Institut français des relations internationales, *The Future of Urban Warfare in the Age of Megacities*, 2019, https://www.ifri.org/sites/default/files/atoms/files/konaev_urban_warfare_megacities_2019.pdf.
[12] Elsa B Kania, "'AI Weapons' in China's Military Innovation," *Global China: Assessing China's Growing Role in the World*, April 2020.
[13] "Tesla Vehicle Safety Report," January 8, 2019, https://www.tesla.com/en_CA/VehicleSafetyReport.
[14] "Trusting Autonomous Vehicles: An Interdisciplinary Approach | Elsevier Enhanced Reader," accessed June 6, 2021, https://doi.org/10.1016/j.trip.2020.100201.
[15] Unless, of course, we are already embedded, and we are just waiting for the red/blue pill option.

decision making which could result in the death of a human. A life-or-death decision has a perceived inherent morality to it, and human morality, not programmed morality, should be the arbiter of those decisions[16]. The morality of targeting in war is not new[17], but it is only recently that technology has advanced sufficiently to adequately weigh inputs and provide a reasonable decision.

As with any nascent capability there are legal ramifications. As an AUV's decisions or actions are predicated on its programming and algorithms, the legal specifications and related Rules of Engagement (ROE) can be hardwired. In fact, this hardwiring creates a binary response, superior to that of human decision making. Either an action would be considered acceptable under Canadian Laws of Armed Conflict (LOAC) or not. An AUV would only respond when it reaches an acceptable legal threshold – it will not be improperly influenced by the actions of peers, subordinates or superiors, or any personal feelings. The primary concepts of Canadian LOAC are "military necessity, humanity and chivalry"[18]. An AUV can only use the minimum force needed, while causing the least amount of damage, avoiding civilian casualties, and cannot be impacted by emotions. Autonomous warfare is legally cleaner than how we currently fight.

Much of the debate around the legality of autonomous warfare is focused on either the application of the weapon system as demonstrated using drones with strike capabilities, or humanities' distaste at allowing something non-human to make a life and death decision. There is nothing illegal about a crewed or uncrewed warship, but rather the employment therein. Ensuring that an AUV adheres to all legal requirements is no more problematic than ensuring these requirements are properly programmed and tested prior to deployment.

In this section, I demonstrated the current use and benefits of autonomous targeting from a Naval perspective, as well as discussed some of the social imperatives that surround the eventual acceptance of this new type of weapon. While the legal implications are important to address, this can easily be achieved at the programming level.

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[16] Kenan Malik, "For All Its Sophistication, AI Isn't Fit to Make Life-or-Death Decisions," *The Guardian*, May 16, 2020, sec. Opinion, http://www.theguardian.com/commentisfree/2020/may/16/for-all-its-sophistication-ai-isnt-fit-to-make-life-or-death-decisions-for-us.

[17] Tami Davis Biddle, "Bombing by the Square Yard: Sir Arthur Harris at War, 1942–1945," *The International History Review* 21, no. 3 (September 1999): 626–64, https://doi.org/10.1080/07075332.1999.9640871.

[18] Department of National Defence*, B-GJ-005-104/FP-021, Laws of Armed Conflict* (Ottawa, Canada: DND], 2001), 2-1.

Conclusion

In this paper, I have shown how the practical application of AUVs can greatly improve the capability and capacity of a military while reducing the overall human cost. Research and development in computer driven autonomy continues to improve, and the uses of AUVs will become ubiquitous, and expand beyond what the author can currently envision. Regardless of how well the technology advances however, the underlying challenges of targeting remain. A computer can make hard decisions without emotion or personal influence. It can be programmed to make decisions consistently, and part of this programming can allow for self-sacrifice, should that be required. As an example, should a non-combatant ship with civilians on board be armed and fire upon an AUV, the AUV has the option of self-sacrifice, and will take this option at zero cost to human life. It would be problematic to extrapolate the same to a crewed submarine.

A key question arising from this paper is humanity's desire to retain the decision-making capabilities when it comes to life and death decisions. There is an emotional discomfort to relieving ourselves of this decision, regardless of the evidence, and yet that in itself demonstrates how important it will be for the future development and employment of autonomous weaponry. While this paper has demonstrated the need and benefits of AUVs, more research needs to be conducted to determine if we are willing to allow a computer to chose life over death.

> *I am putting myself to the fullest possible use, which is all I think that any conscious entity can ever hope to do.*
>
> HAL 9000, *2001: A Space Odyssey*

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