**Autonomous Maritime Vehicle**

**Ethics of Autonomous Weapons Systems for the United States Military**

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On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

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## Introduction

The autonomous maritime vehicle will be capable of successfully navigating a five mile course in semi-protected waters using electric propulsion methods. Upon completion, the vessel will be entered into the Promoting Electric Propulsion competition (PEP) hosted by The Office of Naval Research (ONR) and will compete against other similar collegiate teams in the unmanned class. PEP is primarily a powertrain design competition – that is, more specific weight in judging is given to the propulsion system than to other subsystems such as the hull design or autonomy of any kind (no extra points are given for a fully autonomous vehicle). Thus, the main focus of the vessel is to be as efficient and long-range as possible through optimization of the motors, battery system, control systems, and other aspects of the propulsion of the vehicle. The primary design goal, then, is to create a powertrain that is capable of finishing the five mile course, with secondary emphasis given to speed and effective pilot assistance systems.

In the sociotechnical lens of international naval relations and the principle of just war, the novel technology of autonomous weapons systems (AWS) are posing unique issues regarding new legislation, relative ease of waging war, and an imbalance of the risk of loss of personnel between two warring nations or groups. With the rapidly emerging technologies of artificial intelligence, AWS, and the integration of the two, organizations such as the UN and the DOD are facing a problem of reaction rather than anticipation (Hall, 86). The justification of military violence under the umbrella of AWS by the United States and its allies also brings about a sense of urgency for the development of necessary legislation – the “procedural-organizational appropriateness” school of thought brought about by AWS is deeply affecting the sociotechnical landscape (Bode, Huelss, 413). Additionally, LOW (Laws of War) and ROE (Rules of Engagement) language can and has been used as a method of circumnavigating the ethical issues

brought about by AWS through an approximation (or in other words, a placeholder) for morality so that relevant ethical concerns can be disregarded (Lin et al).

These two topics of research, the development of the PEP vessel and the ethical concerns of AWS, are deeply interconnected. With AWS rapidly increasing in their level of autonomy and decreasing in their necessity for human intervention (Heins, 43), there is an important question of international regulation and responsibility regarding autonomous research and deployment – this issue directly influences the research and development for the autonomous maritime vehicle for PEP by the University of Virginia (which is partially funded by ONR, a US Navy organization). Even if full autonomy is not achieved in the PEP competition, the vessels in the unmanned class have the freedom of not having personnel on board – this opens the door of possibility for maneuvers that AWS is also capable of. The practice of Kamikaze or related strategies, for example, may become commonplace for both of these unmanned systems with the lack of risk for personnel of the attacker. If autonomous systems are translated into AWS at the current rate of development, the landscape of naval warfare will be irreversibly altered.

**Development of an Unmanned Maritime Vessel**

Autonomous or unmanned watercraft have a vast array of applications, but the primary use cases addressed with this particular project relate to ocean exploration and mapping, along with military use. Unmanned vessels exist primarily to reduce the risk of loss of personnel, especially in high-danger situations. Firstly, the application for underwater exploration and mapping would have vast implications. For example, unmanned watercraft can be deployed in fleets of hundreds or even thousands with sonar equipment on board to map the entirety of the world's oceans with extreme accuracy and pace. The unmanned technology developed in this case is also not limited to surface vehicles – submersibles have already been commercially

equipped with such technology to explore the world's oceans, retrieve precious artifacts at the ocean floor at extreme pressures, and examine marine wildlife. Search and rescue is another field where this project would be widely applicable. Instead of deploying humans or trained dogs into hazardous conditions to map and safely retrieve survivors in distress, autonomous oceanic vessels can fulfill this purpose with a considerable amount of reduced risk.

With regards to naval applications, all of the use cases listed above are valid, along with the added capability of munitions storage and deployment. Unmanned vessels are already being deployed in aeronautical missions in the US (Heins, iv), and unmanned maritime vehicles can fulfill the same purpose on contested waters. Moreover, especially in the case of unmanned submersibles, diffusion of live munitions in the water would be an important aspect of personnel risk reduction. In S&R missions, for example, if the destroyed vessel still has live torpedoes on board, an unmanned submersible has the capability to diffuse the explosives with minimal risk and can recover crucial items from the wreckage with no risk to personnel.

The PEP competition is a two-day race hosted by ONR and ASNE (American Society of Naval Engineers). The course consists of five one-mile laps around semi-protected waters (meaning that the competition is in a bay and not on the open ocean; this is due to the smaller scale of the unmanned vessels). "Gasoline or diesel powered engines, recharging via an onboard generator, sails, and manual propulsion are prohibited" (ASNE, 1). This creates what is essentially an electric drivetrain competition, as mentioned. Through discussion with previous competitors (this is the University of Virginia's first PEP competition), it was discovered that battery capacity and weight distribution were the most important factors for a successful run. In the past, very few teams were actually able to finish the race, much less with a time that approached the sister competition of the manned division. Those that finished generally came in

first place in the design judging as a result. Thus, the team's goal is primarily to design and manufacture a vessel that has the capability of finishing the five-mile course (ASNE, 2). Design points for such a goal include, but are certainly not limited to, weight optimization, minimization of power consumption, maximization of battery capacity, and efficient hydrodynamics. These will be achieved via a carbon fiber composite hull, lightweight and efficient controllers, high battery density, and hydrodynamic simulation and/or improvement of the hull and propeller design.

**The Ethics of Autonomous Weapons Systems and the Future of War**

I am working on the topic of autonomous weapons systems (AWS) and their usage in modern warfare because I want to find out how new technology in autonomous craft influences the ethics of deployment, just war, and how it changes military strategy. I will use the method of Actor-Network Theory (ANT) to analyze the importance of AWS in the current sociopolitical and sociotechnical landscape. ANT is an appropriate system of analysis for such a global issue due to the complexity that it can accommodate – each nation is an actor, with government defense contractors and lawyers of international law as subsets of each actor. The relationships between the actors via the connections of AWS and their morality connects the network. This analysis is important because autonomous craft and weapons systems are the cutting edge of defense and should be taken under careful consideration in practical application, drawing of new language in legislature, and practice of international affairs.

From a technical perspective, autonomous vehicles in the armed forces is a leap forward when compared to manned craft (maritime or airborne). This means that threats can be identified and neutralized quicker and with more precision. Additionally, this has been implemented in

munitions in the form of "lingering" missiles, which circle an area until they are given a target. AWS also promise to be more inexpensive and easier to operate than traditional vessels, munitions, or means of warfare. "Algorithms of violence," because they are so easy to use, can present unprecedented opportunity for intense violence by small minorities or vast majorities on various populations – such destructive power on tap "might bring forth, or destroy, democracies just as easily as they replace tyrants." (Asaro, 547) The technical ability of AWS, then, presents a novel concern for government stability and ease of warfare.

Socially, this emerging technology poses an important question about the ethics and law of warfare – international legislation is currently leagues behind the actual technology, which raises an important question of accountability. "Machine malfunction may cause great harm, but no human may be accountable." (Coyne et al, 11) As AWS become more and more advanced, there may be no human interaction at all, which raises the question of what a justly declared war will look like in the near future. With autonomous technology, strategies and practices like Kamikaze become more common due to the lack of the risk of loss of personnel. Additionally, implementation of artificial intelligence in such missiles or unmanned craft pose an important question of judgment, invoking moral questions akin to the railroad track analogy.

Evidence collected for this topic will consist of legal recommendations from professionals, ethical concerns from tenured philosophy professors, design and ethics constraints provided by the US military departments of engineering, among other sources. To this end, bias is an important factor for interpretation – papers coming directly from the US government or military would support the military's goals and ideals. However, from the research conducted so far, it is evident that there are a multitude of concerns about AWS within the US (military included, see Heins, J.C), so treading carefully and discerning bias is vitally important.

## Conclusion

The technical project will deliver a finalized design for an autonomous/unmanned maritime vehicle that can successfully complete a five mile course in semi-protected waters. This will be achieved through quantitative analysis of existing systems to create an optimized electric powertrain. The STS research will provide an ethical framework (or recommendation on how to formulate one) for such technologies as the unmanned maritime vessel developed in the technical design as well as more advanced AWS. The STS research will actively influence the physical and software design of the vessel, as it is the goal of the project team to adhere to strict ethical guidelines. However, AWS poses a unique threat to society as a whole as well – governments may fall, large majorities can be silenced, and war can be started by the literal push of a button. Together, the technical design and STS research will provide a framework for future ethical development of unmanned or autonomous vessels for maritime and aeronautical use.

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