Thesis Project Portfolio

Autonomous Maritime Vehicle

(Technical Report)

Autonomous Weapons Systems and the Ethics of Unmanned Warfare

(STS Research Paper)

An Undergraduate Thesis

Presented to the Faculty of the School of Engineering and Applied Science

University of Virginia • Charlottesville, Virginia

In Fulfillment of the Requirements for the Degree

Bachelor of Science, School of Engineering

William Orser Renken

Spring, 2024

Department of Mechanical and Aerospace Engineering

Table of Contents

Executive Summary

Autonomous systems are a novel, rapidly developing technology that has the potential to change the world socio-technical theater dramatically for the better or for the worse. The technical research outlined in this portfolio centers around the development of an unmanned electric racing vessel for the Promoting Electric Propulsion (PEP) competition hosted by the American Society of Naval Engineers (ASNE) and the Office of Naval Research (ONR). The project, the Autonomous Maritime Vehicle (AMV) aims to prove the feasibility of electric propulsion in military and recreational vessels by completing a five mile endurance race. The STS portion of this portfolio will examine the ethics and responsibility associated with the development of Autonomous Weapons Systems (AWS) as it pertains to loss of life, just warfare, and system malfunction. As the militaries and armed organizations of the world adopt this new technology at a pace faster than appropriate legislation can be penned, the accountability for AWS should be clearly defined in the interim. Both of these topics are deeply intertwined with the idea of new weapons development and implementation for both the United States Navy and the world at large. While the AMV is certainly not a military-grade piece of technology, others akin to it are already in development or even deployed.

The AMV addresses the issue of internal combustion engines (ICEs) being phased out of military development. As the U.S Navy investigates other propulsion methods such as nuclear and electric (powered by battery cells or even hydrogen fuel cells), electric propulsion systems that can be powerful, efficient, and long range become high in demand. Methods of this research include evaluation of customer needs and design restrictions, exploration of current systems, design and manufacturing of a unique system, testing, and finally competition.

After the PEP competition, design flaws were identified in the AMV. The electronic speed controller (ESC) drew too much current after a gearbox seized and friction-welded itself. This is remedied by the implementation of direct drive, eliminating the need for a gearbox and improving system reliability. A rudder was also added in addition to the existing thrust vectoring system that was designed to improve agility and handling.

The STS research centers around the following question: with the rapid, largely unregulated development of autonomous weapons systems on the forefront of military technology, who is to blame for the loss of life due to malfunction or even successful implementation? The technical ability of AWS presents an unprecedented concern for governmental stability and lowers the price of entry of highly destructive, targeted warfare. The methodologies by which this question is examined will be Actor-Network Theory (ANT) and Responsible Research and Innovation (RRI). (Law, 1992) (Stilgoe, Owen, Macnaghten, 2013, 1570)

Evidence for the STS research included reports from the DoD, the Marine Corps, lawyers involved in international law, and researchers from Cambridge University, among others of similar associations. The consensus of these parties was that legislation is far behind the development and implementation of AWS, and the algorithms are to blame for the behavior of the technology. The conclusion drawn is that the developers of the algorithms are to be held accountable for the behavior (and misbehavior) of AWS.

Autonomous technology, particularly as it pertains to the military, is rapidly developing. The fact that a system capable of both speed and autonomy can be designed and manufactured in less than a year holds testament to the real problem of the technology being difficult to keep up with in terms of regulation.