Thesis Project Portfolio

Student Researched and Developed High Power Rocket

(Technical Report)

Responsible Innovation of Deep Sea Vehicles

(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

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Table of Contents

Executive Summary

The ocean is the next frontier for humankind, while many think its outer space, our ocean may hold the answers to centuries old questions. Fish school for a plethora of benefits, including hydrodynamic efficiency and pack protection from predators. By studying why and how fish school, it can provide key insights in the future of deep-sea robotics. While the exploration of our ocean has been going on for centuries, the safety of these brave scientists and explorers has been questioned with the recent Titan submarine accident. Learning about the current rules and regulations as well as their enforcers will provide a path forward to a safe and innovative space. With underwater exploration becoming more popular, there must be a way to get access to places that are not yet accessible for deep space vehicles, this will be done by underwater robotics. These robots will provide safety measure for explorers as well reaching never before thought possible places due to their bio-inspired nature.

Underwater robotics will provide easier and more efficient access to deep and more unreachable places in our ocean. The first step towards this is understanding how ocean animals are able to navigate in these spaces so well. Experimenting with fish schooling patterns can help us understand how we can bridge the gap between 3D printed fish in the water channel and real-life fish in the ocean. Modeling fish at different vertical distances will provide insights into the ideal schooling pattern.

Vertically spaced fins with in phase oscillation show that thrust decreases as separation increases. Similarly, for lift and power production, they decrease as separation increases. The ideal separation case was found to be 0.1 of the chord lengths of the fin. This case was further studied at different Reynolds numbers and was found to match with computational fluid dynamics (CFD) studies. This was further confirmed by 3D particle image velocimetry, which also found consistency with the CFD studies.

Underwater exploration, more specifically tourism, is the up and coming industry adjacent to the space tourism industry. However, there is an alarming lack of rules and regulations which led to the Titan submarine accident. Who creates and enforces these rules and regulations, is crucial to understand so that further accidents can be prevented. By reviewing a case study of the Titan submarine accident, we can understand all the many minor mistakes that led to the needless loss of five lives.

After reviewing numerous organizations that seemingly should be in charge of underwater exploration, no one has any laws specifically targeting them. Some organizations do not even have a definition of underwater vehicles let alone rules and regulations. The Titan submarine accident provided evidence as well that the Ocean Gate CEO, Stockton Rush was not safety focused. He fired one of his employees for raising safety concerns about the Titan just months before the incident. There is a severe lack of accountability, rules, and regulations in this industry and there needs to be drastic action taken soon to prevent another accident from happening.

Underwater exploration and robotics are crucial as we go into the future, potentially even more so that that of space. Solutions to problems that our world is facing may be just under the surface in places that only robots have the hope of reaching.