**Thesis Project Portfolio**

**Student Researched and Developed Rocket**

(Technical Report)

**The Missile Knows Where it is, But Does the Rocket Know Where it Came From? Examining the Origins and Politics of Early Military Rocketry**

(STS Research Paper)

An Undergraduate Thesis Presented to the Faculty of the School of Engineering and Applied Science University of Virginia • Charlottesville, Virginia

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## Sociotechnical synthesis

### Introduction

My technical capstone project was to create the propulsion system for a recoverable rocket with an apex of 5,000 feet. My STS capstone was to study the history and politics of the Mysorean Rocket—the first effective anti-personnel rocket in military history—and its descendants. Both projects are heavily concerned with propellants and pressure vessels, the core of rocketry. My original job within the technical capstone was to formulate, manufacture, and test the ideal propellant for our rocket. However, my role later evolved into hydrostatic testing of the motor pressure vessel to determine its ability to withstand the requisite internal pressures. Advances in both propellant and pressure vessels were among the main reasons the Mysorean rockets were so successful. The intertwined nature of politics and rocketry technology are the throughline of my technical and STS capstones.

### Technical Capstone

The goal of our team's design was originally to improve upon the design of a solid-motor rocket. Specifically, my working group, the propellant formulation sub-team of the propulsion group, was tasked with improving upon existing propellant formulations to maximize rocket performance while minimizing operational risk.

After a selection process designed to find a solid rocket propellant that was safe, efficient, and made of ingredients that the group could feasibly obtain, the sub-team decided to manufacture a compound based on variant of Ammonium Perchlorate Composite Propellant (APCP). The APCP was then supplemented with epoxy and powdered aluminum, mimicking the

famous ‘Cherry Limeade’ propellant. Cherry Limeade was developed by the MIT Rocket Team and is notable for being easy to manufacture and pour while maintaining high performance.

Our group’s aim was to further improve Cherry Limeade from what MIT and other groups had managed. However, consistent changes in engineering specifications and safety concerns applied by the capstone leaders, UVA Emergency Health Services, the Federal Aviation Administration, and Tripoli Launch Association prevented our group from manufacturing the propellant or launching the rocket. Early in the spring semester, our group pivoted to hydrostatic testing. This is a way to check the integrity of the pressure vessels being used in a rocket with known pressures by pumping the vessel full of water at a known pressure. This process involves applying fluid dynamics, material selection, and a little plumbing. A successful hydrostatic test was run, and the design of the rocket motor from other members of the propulsion team was proven solid.

**STS Research Paper**

The subject of my STS paper was the politics of Mysorean rocket. The Mysorean rocket was the first effective anti-personnel rocket in military history. It was developed in the Kingdom of Mysore—located in what is now southeast India—and used extensively against the British colonizing forces over four eighteenth-century wars. Eventually, the British prevailed and occupied Mysore. The British then bought some rockets from neutral merchants and gave them to the Royal Society’s William Congreve. He derived a rocket of his own and made the British their own mass-producible rocket—the Congreve rocket. The Congreve rocket was then used for decades as a weapon of oppression in conflicts across six continents.

Using the "Do Artifacts Have Politics?" framework developed by Winner, I examined the differences in the way the British and Mysoreans used their superior rocketry technology. The Mysoreans were much more likely to use their rocket in guerilla warfare and to defend themselves. The British used the Congreve rocket in large volleys from either ships or massed soldiers, and often to help stretch their globe-spanning empire. I argue that the Mysoreans rocket as an artifact generally had politics of liberation, while the Congreve rocket generally had politics of oppression. I also briefly touch on how Winner's framework can be applied to rocket warfare in twenty-first century warfare.

**Conclusion**

Simultaneously building a rocket and researching Mysorean and Congreve rockets made me question modern engineering practices to a degree. Mysorean artisans and British nobles were able to successfully construct effective, reproducible rockets nearly 200 years before the invention of the computer. However, with all modern science and technology behind 30 of us, we were unable to construct a rocket for our capstone. There was no lack of know-how or technology holding back the students. Instead, a lack of support and bureaucratic obstacles prevented us from constructing and launching. Professors gave us inaccurate information about what we were allowed to do, and various organizations held up our launch. Sometimes these were for seemingly trivial reasons, like certain members of the team having not launched a rocket before. Other concerns, like our sub-team potentially damaging the Mechanical Engineering building while manufacturing propellant, were a little more grounded. According to our models, our rocket would have been safe to launch and manufacture with a hefty factor of safety. But bureaucracy that Congreve and the Mysoreans rarely faced repeatedly stood in our

way. I understand that some of the guidelines were there for the safety of the students and people associated with the launches, but there comes a point where engineering can be over constrained.

That being said, I can also appreciate that the ethics around rocketry have shifted positively. Early in their development, Congreve wanted to use his rockets for whaling. That could not happen in the developed world today without severe consequences. The same bureaucracy that hindered our launch would also bring consequences against anyone who shot a Mk 66 unguided rocket at an aquatic mammal.

This is my main takeaway from a year of researching the engineering and politics of rocketry: as technological development has increased, so has the bureaucracy restraining its progress. It's a two-sided coin with pros and cons on both sides that I will need to learn to live with. This is a valuable lesson I will take with me as I go to work as an engineer for the federal government.