**Thesis Project Portfolio**

**Project Atlas – Hybrid Rocket Engine Development**

**(Technical Report)**

**The Rise of 3D Printed Firearms and their Disruption of Legal Frameworks through the Case of Defense Distributed**

**(STS Research Paper)**

An Undergraduate Thesis

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### Technical Project Abstract

Hybrid rocket motors offer a promising middle ground between the safety of liquid propulsion and the simplicity of solid fuels, but challenges remain in optimizing their efficiency and predictability. Project ATLAS, conducted by Aerospace Capstone Team 3 at the University of Virginia, aims to design, build, and test a laboratory-scale hybrid rocket motor to address these challenges. The motor will serve as a stable testbed for experimental oxidizer injector and fuel grain designs, with the goal of achieving a more consistent oxidizer-to-fuel (O/F) ratio and improving combustion performance. The project focuses on using 3D-printed components to lower manufacturing costs and allow rapid iteration of designs. Static fire testing, supported by a robust data acquisition system, will record thrust, pressure, temperature, and flow rate data to validate models and analyze performance. Comprehensive safety protocols and test procedures will be developed in collaboration with faculty and regulatory bodies to ensure safe motor operations and knowledge transfer to future UVA teams. The team hopes to set a precedent for future high energy projects at the University of Virginia, enhancing undergraduate education within the Mechanical and Aerospace Engineering department. The project deliverables include detailed documentation, preliminary and critical design reviews, multiple test readiness reviews, and a final thesis encompassing experimental data and design analysis. Through Project ATLAS, the team seeks to advance hybrid rocket motor technology, offering future applications for both student rocketry and the broader aerospace community.

**STS Project Abstract**

This research explores how the rise of 3D printing technologies has disrupted traditional legal frameworks through the case study of Defense Distributed. While 3D printing initially revolutionized industries like aerospace and healthcare, its democratization of manufacturing also introduced profound risks, particularly regarding the at-home production of firearms. Defense Distributed, founded by Cody Wilson, catalyzed a legal and social crisis by releasing 3D-printable gun blueprints, notably for the Liberator pistol. This event exposed major gaps in existing U.S. regulations, such as the Undetectable Firearms Act of 1988, which were ill-equipped to manage decentralized digital manufacturing. The U.S. government's initial reliance on export control laws (ITAR) failed to prevent the spread of files, igniting constitutional debates around free speech, national security, and the right to bear arms. Through the lens of technological politics, this project analyzes how 3D printing embodies political qualities by redistributing power away from centralized authorities and toward individuals. Defense Distributed's legal battle and the subsequent patchwork of state-level legislation demonstrate the mutual shaping of technology, law, and society. Using a combination of legal documents, scholarly analyses, and government reports, this research shows how disruptive technologies can outpace regulation, forcing reactive—and often fragmented—policy responses. By studying the Defense Distributed case, this project sheds light on the broader ethical, legal, and societal challenges posed by the widespread diffusion of powerful, accessible manufacturing technologies, offering a framework for understanding future technological disruptions.

**Technical and STS Relation**

The motivation and scientific foundation behind the technical project are exploratory in nature. The immature field of hybrid rocketry is under heavy exploration at the industrial level down to the educational level. The Project Atlas teams forages alongside like-minded undergraduate engineers, aiming to set a precedent for high energy projects within the School of Engineering and Applied Science at UVA. The novelty, however, is the utilization of additive manufacturing for injector designs within the rocket engine. Traditional manufacturing is severely limited on this front, leaving 3D printing capable of creating unique geometries that are otherwise unattainable. The realm of additive manufacturing found its rise in the Aerospace field before disseminating throughout the public. The combination of one-of-a-kind manufacturing capability and civilian accessibility has engendered a new forefront for society; one that it is largely unprepared for.

Project Atlas demonstrates the educational and innovative powers this technology holds, as our complex and novel injector geometries come from machines that anyone can buy and easily become accustomed too. Equally so, the potential harm that can come from the democratization of production needs to be explored. With a new frontier comes fear, which took the shape of 3D printed weaponry starting with Cody Wilson's Defense Distributed. A case that demonstrated the inability and ill-prepared nature of the United States legal system. With incapable frameworks, society risks over- or under-regulating powerful technology. In developing an outlook for AM's future, the STS paper explores the issue through the lens of technological politics to better understand the power this technology holds in the day to day lives of ordinary citizens.