

Thesis Project Portfolio

Designing a Solid Propellant Rocket

(Technical Report)

**Leaning On Collaboration: The Impact of NASA's Newfound Private and International
Dependence on Modern Spaceflight**

(STS Research Paper)

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Sociotechnical Synthesis

As we approach the 52nd anniversary of the last time a human set foot on the moon, engineers and administrators at NASA have decided that this streak must end in the coming years. The Artemis program, a bold set of initiatives marrying technological advances with preparatory goals, aims to return humanity to the lunar surface, establishing a permanent lunar base in the process. Much like the Apollo program from the 1960s and 1970s, Artemis requires careful mission planning, vehicle design, and manufacturing to ensure the completion of the mission and the safe return of the crew.

However, NASA adopted a specific operational philosophy for Artemis that differs heavily from the way Apollo operated. Where Apollo parts were largely designed and manufactured in-house with help from solely American contractors, Artemis has leaned on several private and international partners, with some even competing for contracts. Ultimately, Artemis represents a new way of transporting humans to the moon, differing significantly from Apollo and hinting at far-reaching implications for how NASA conducts space travel going forward.

The STS deliverable attempts to demystify these implications by analyzing the organizational structure of both the Artemis program and the former Apollo program. Particularly, viewing the organizational structure of these programs through the lens of Actor-Network Theory uncovers the relationships that differentiate them. Combining this with the outside political environment of each program allows us to extrapolate how space travel may operate in the future.

My technical project lies on a much smaller scale, wherein my team of undergraduate aerospace engineering students attempted to design, fabricate, and launch a medium-sized solid propulsion rocket. I worked within the propulsion team, responsible for manufacturing the rocket motor. The project encountered several setbacks but ultimately finished with a full design and fabrication of a working model.

The solid-propulsion aspect of the rocket stems from the nature of the propellant. Instead of a liquid propellant, which requires a fuel tank and valve release mechanisms, a solid propellant manifests as a firm paste that is packed into a tube to prepare for firing. While other types of rocket motors exist, such as hybrid engines that contain both solid and liquid propellant, we quickly determined that a solely solid propellant motor would work best for our design goals, experience, and timeframe.

Our team first encountered a significant obstacle when determining how to manufacture our propellant. Formulating rocket fuel is an extremely arduous and dangerous task performed with highly toxic chemicals; without proper protection, ventilation, and help from experts, one can expect to make critical mistakes with dire consequences. As a result, in accordance with the advice of the University's Environmental Health and Safety division, we decided to forego formulating our own propellant and instead purchase a commercial reload kit – essentially a pre-made propellant package that we fit inside the rocket.

Manufacturing the rocket motor required developing CAD models of the interior motor and drilling a cylindrical aluminum stock to match those specifications. I used a lathe to drill symmetric grooves into the aluminum so that rubber O-rings could be inserted. These O-rings allow the rocket motor to effectively seal in hot gases and prevent material from exiting out of anywhere but the nozzle of the rocket.

The project culminated in a final presentation to our supervisors detailing the progress we had made throughout the year, as well as how we tackled unanticipated challenges. As an extracurricular bonus, I helped design a plan for a hydrostatic test, in which water is pumped into the rocket at high pressures to simulate the firing of the motor. Through this test, we can evaluate all seals in the rocket casing.