REBELSAT-1

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INTRODUCTION

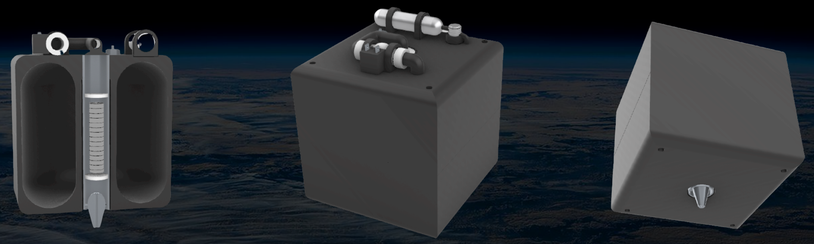
UNLV is building a CubeSat, a small satellite that can execute specific technology demonstration, educational, research, or commercial missions at relatively low cost. Nevada's first university satellite, RebelSat-1 (RS-1), is intended to test a monopropellant catalytic thruster with spike nozzle (aerospike) geometry configuration. Spike nozzles are known to have improved efficiency in vacuum environments, automatic altitude compensation, lower overall mass and volume, and introduces a novel technology for small satellite maneuvering in-orbit. These advantages are ideal for small satellites and CubeSats. However, inherent design flaws cause destructive overheating when spike nozzle engines are operated for any significant length of time. This has prevented their use on large-scale rockets, such as those used for orbital insertions. Recent research conducted by Drew D. Nemeth (University of Nevada, Las Vegas) has indicated that when paired with specialized materials, small scale spike nozzles have the potential for use in short burst operations. This is a proof of concept mission that allows the testing of major components that would be required to construct a CubeSat combustive spike nozzle thruster.

OVERVIEW

The primary goal of RebelSat-1 is to perform a hardware test of a monopropellant catalytic thruster utilizing a annual spike nozzle design. This system is design to evaluate many of the components that would eventually be required to construct a combustive spike nozzle engine of the same format. This hardware testing would set up future RebelSat missions that may utilize this configuration in burst operation. While bell nozzles provide very high efficiency when operating in the constant pressure environment they were optimized for, they begin to lose efficiency when external pressure decreases. At sea-level, a rocket engine must expand its exhaust gasses to a pressure equaling ambient (1 atm). Expanding a non-zero gas pressure to a zero gas pressure would require an infinitely large bell nozzle. While they are able to continue serving their function, bell nozzles still leave design improvement on the table for these characteristics. An aerospike design alternative has been suggested as these nozzles utilize ambient pressure as the exhaust expansion limiter. This means that spike nozzles are theoretically capable of matching bell nozzle efficiency at a specific pressure -- and outperforming it at all others. Moreover, they are also volumetrically smaller than comparable vacuum bell nozzles and are capable of having a lower mass. Despite this, spike nozzles have been plagued with overheating and manufacturing issues inherent to the design which causes them to be impractical for sustained operation and general atmospheric use. However, this does not limit the practical applications of spike nozzles. Orbital maneuvers involving satellites do not require sustained engine operation. This reduces and sometimes eliminates the overheating issues that make spike nozzles problematic. As such, burst operation spike nozzles are a research direction worthy of consideration.

METHOD

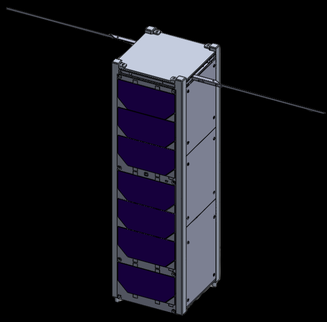
RebelSat-1 will carry a monopropellant thruster with an aerospike nozzle - potentially the first thruster of its kind to ever be flown in space. Conducted in parallel with Honors thesis research, RebelSat-1 will utilize inertial measurement units (IMU's) and GPS data to assess the performance of the aerospike thruster.



Section and external views of the propellant tank.

RESULTS

The RebelSat team has successfully designed the RS-1 satellite, including all critical subsystems and components. A proposal was submitted in conjunction with the NASA CubeSat Launch Initiative (CSLI) requirements for prospective ride-share selection. Subsystem and component testing is now proceeding apace, aiming towards full system integration by the end of 2021 as preliminary design reviews are conducted.



CAD Rendering of RS-1

CONCLUSION

Developing, integrating, and testing RebelSat-1 shall establish UNLV's first satellite research program. From this, future students will benefit from the continuation of general space technology and development research.

Furthermore, success of this mission opens up a new avenue for research and technology testing. Aerospikes have shown promise since the 1960's but were not able to find an appropriate niche that would make use of the benefits. A successful technology demonstration could catapult aerospike nozzles back into relevance in the field of small spacecraft propulsion.