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CAPSTONE: A PHOTON-ENABLED SMALL SPACECRAFT MISSION IN SUPPORT OF LUNAR
EXPLORATION

Abstract

Rocket Lab is moving up the value chain with the Photon small spacecraft and down the value chain with spacecraft components, built around the acquisition of Sinclair Interplanetary. As low-cost access to space and advancements in small satellite technology continues to progress, small spacecraft are increasingly being utilized in support of larger, long-term programs for human exploration beyond low Earth orbit.

One such mission is Rocket Lab's 2021 mission to the Moon for NASA in support of the agency's Artemis Program to send the first woman and next man to the lunar south pole by 2024. Combining a dedicated launch onboard the Electron small launch vehicle and the Photon spacecraft, Rocket Lab was selected by NASA to deliver the Cislunar Autonomous Positioning System Technology Operations and Navigation Experiment (CAPSTONE) to cislunar space, where the small satellite is expected to be the first spacecraft to operate in a near rectilinear halo orbit (NRHO) around the Moon after following a ballistic lunar transfer. Once placed in this unique orbit, CAPSTONE will validate the power, propulsion, and navigation requirements to remain stabilized in NRHO, communication capabilities with Earth and with other assets in lunar orbit, and the reliability of innovative and customizable small satellite platforms like Photon to retire risk and demonstrate technologies that reduce logistical uncertainties for long-term space exploration programs like Artemis. While NASA performs the primary mission, Rocket Lab plans to execute a lunar flyby with Photon that will increase the mission's value by demonstrating the deep-space capabilities of small spacecraft for future Decadal-class science missions.

This paper will detail the technological capabilities of Rocket Lab's Photon platform, including Photon's utilization of the flight-proven Curie propulsion system incorporated with high power generation, high-accuracy attitude determination and control, radio communication, custom solar panels, sensors, actuators, and unique software solutions. This paper will also explore the guidance, navigation, and control architecture developed for this mission, including the phasing orbit approach to deploy CAPSTONE on a ballistic lunar transfer; and Rocket Lab's secondary mission objective to demonstrate high-energy Photon deep space operations capabilities with a lunar flyby once CAPSTONE has been successfully deployed.