CISLUNAR EXPLORERS: A STUDENT CUBESAT DEMONSTRATING LOW-COST TECHNOLOGIES FOR LUNAR EXPLORATION. Curran D. Muhlberger[1], [1]Cornell Ann S. Bowers College of Computing and Information Science, 107 Hoy Road, Ithaca, NY 14850, curran@cs.cornell.edu.

Introduction: Developed since 2014 by students in Cornell University's Space Systems Design Studio, the Cislunar Explorers mission proposes to send a pair of 3U CubeSats to lunar orbit and demonstrate new technologies for water electrolysis propulsion and optical navigation in cislunar space. The vehicles showcase the results of a synergistic design process that reduces size and cost, paving the way for smaller missions to participate in lunar exploration. With water as the propellant, the architecture is suitable for missions leveraging *in situ* resource utilization, while water's safety and simple storage requirements lend themselves to the constraints of nanosatellite platforms.

A symbiosis between subsystems makes water electrolysis propulsion viable on such small vehicles. Launching as a pair provides redundancy as well as a natural way to impart a spin during deployment. The spacecraft's spin separates the electrolysis products (hydrogen and oxygen gas) from the liquid propellant while also reducing the hardware required for attitude determination and control—the moment of a single cold gas thruster and the fields of view of three cameras vary with rotation to cover all directions. Propellant slosh dampens out nutation, passively stabilizing the rotation axis. The water tank also acts as a natural heat sink for the avionics (keeping the propellant from freezing) and is an integral structural component.

Costs are also kept low by using off-the-shelf avionics, including a Raspberry Pi flight computer, Raspberry Pi camera modules, and hobbyist breakout boards for sensors. The flight software is written in Python, leveraging existing libraries to interface with sensors, which lowers the barrier of entry for new developers. The optical navigation system performs efficient rolling shutter correction and stereographic reprojection to maximize the accuracy of measurements made of the Earth and Moon, even when largely in shadow, with modest computational resources. Using the SurRender [1] image simulator, this system can be tuned and verified for other trajectories and camera sensors; preliminary results suggest translational accuracy within 100 km, sufficient for guidance into lunar orbit.

Competing successfully in NASA's Cube Quest Challenge, Cislunar Explorers was originally manifested on Artemis 1. However, student-led missions present unique challenges, and difficulties during integration have forced a delay. The spacecraft are on track for completion within the next year, and the lessons learned [2] should help future small-scale lunar missions reduce cost and integration time. Through demonstration of water electrolysis propulsion and autonomous navigation on a small, low-cost platform, Cislunar Explorers hopes to broaden participation in orbital lunar science and encourage smaller lander concepts utilizing *in situ* resources for sample return.

Acknowledgments: The mission team would like to thank NASA's Centennial Challenges program for supporting Cislunar Explorers through the Cube Quest Challenge, our payload partners at Los Alamos National Laboratory, our advisors from the National Space Society, and Airbus for use of their SurRender software. We are also grateful for the numerous students who have contributed to this project over the past 7 years.

References: [1] Brochard R. et al. (2018) arXiv:1810.01423 [astro-ph.IM]. [2] Zucherman A. et al. (2020) SSC 20, WP2-23.