32nd IAA SYMPOSIUM ON SMALL SATELLITE MISSIONS (B4)
Access to Space for Small Satellite Missions (5)

Author: Ms. Maria Chytka
University of Alabama in Huntsville, United States

Ms. Cailin Bain
University of Alabama in Huntsville, United States
Mr. Anthony Shipp
University of Alabama in Huntsville, United States
Mr. Samuel Arnold
University of Alabama in Huntsville, United States
Mr. Michael Angeles
University of Alabama in Huntsville, United States
Mr. Tanner Land
University of Alabama in Huntsville, United States
Ms. Miranda Van Rensselaer
Univeristy of Alabama in Huntsville, United States
Ms. Amy LeBleu-DeBartola
University of Alabama in Huntsville, United States
Mr. Andrew Jordan
University of Alabama in Huntsville, United States
Mr. Triston Tindell
University of Alabama in Huntsville, United States
Mr. Jackson Lee
University of Alabama in Huntsville, United States
Mr. Gregory Calhoun
University of Alabama in Huntsville, United States
Mr. Harrison Slusser
University of Alabama in Huntsville, United States
Mr. Keller Powell
University of Alabama in Huntsville, United States
Mr. Joshua Franklin
University of Alabama in Huntsville, United States
Mr. Lucas Thelen
University of Alabama in Huntsville, United States
Mr. Ben Campbell
University of Alabama in Huntsville, United States
Mr. James Roberson
University of Alabama in Huntsville, United States

IN-SPACE AND ATMOSPHERIC REENTRY ENERGY GENERATION WITH AMALTHEA – A CUBESAT-BASED TECHNOLOGY DEMONSTRATION

Abstract

Size, weight, and power are challenging aspects of designing electrical power systems for long-term space missions. However, harvesting energy in situ provides a solution. AMALTHEA (Autonomous Maneuverable Atmospheric Laboratory for Thermal and Hypersonic Energy Analysis) is a suborbital sounding rocket payload to research power generation in space and via atmospheric re-entry heating. The payload consists of three main subsystems: a previously flown spacecraft bus, an attitude control and energy generation demonstration (ICARUS, Induced Charging from Atmospheric Re-entry by a University Spacecraft), and a gene radiation experiment (GUARD, Genes Under Acute Radiation Dosage). AMALTHEA flew on a Terrier-Improved Malemute sounding rocket on August 12, 2025 from NASA Wallops Flight Facility. ICARUS is an ejected 1.5U CubeSat-based deployable that investigates the viability and effectiveness of using thermoelectric materials on spacecraft undergoing atmospheric re-entry as an alternative method of power generation. The device has four flap heat shields deployed in flight to provide passive re-entry stability. These aluminum flaps contain embedded solar panels and Peltier thermoelectric generator modules with custom heatsinks. Ground testing of the integrated Peltier modules was done with a convective heat source, temperature sensors, and a fan; testing showed a current of 156.25 mA at 2.5 mV, which proves the concept's viability. During flight, the deployable exploits the thermal gradient across the flaps from re-entry heating with the Seebeck effect, i.e., thermoelectric coupling, to generate electricity. Data was meant to relay back to the main payload for logging via a radio, however, anomalies in radio communications during flight prevented this. The flap design, development, and ground testing show the potential of embedded thermoelectric materials in re-entry heatshields. This technology can be applied in electrical power systems for exoplanetary missions to Venus, Titan, or for reusable spacecraft on Earth. GUARD is a biology experiment focused on measuring exo-ionospheric x-ray and gamma radiation of a suborbital flight and characterizing the effects of this exposure on the population genetics of live bacteria. The strains flown, E. coli and P. aeruginosa, were double sealed in both Polypropylene and PFA tubes and mounted in a 3D printed ABS enclosure. The strains are being analyzed via hybrid genome assembly to compare the genomic makeup of survivors to the ground control. This comparison highlights genes that may have contributed to sample survival following exposure to pre-launch ambient temperature fluctuations, space-based ionizing radiation, as well as harsh launch and re-entry environments.