The Alabama Experiment on Galactic-Ray In-Situ Shielding (AEGIS) Project: A Multi-University 6U CubeSat for Radiation Shielding Analysis and Workforce Development. J. Fuchs[1] and M. Halvorson[2], [1]University of Alabama in Huntsville, [2]Auburn University.

Introduction: AEGIS is a 6U CubeSat for researching radiation shielding of lunar regolith based materials while providing a platform for workforce development under a statewide coalition of universities. In 2018 the Alabama Space Grant Consortium (ASGC) initiated a workforce development program to teach students across multiple engineering disciplines the rigors and requirements of spacecraft design. The flagship mission of this program is AEGIS, being led by five universities across the state. As an educational program the project is led and developed entirely by students with the support of faculty, industry, and NASA mentors. AEGIS uses a unique approach to university based missions that offers both research and education in a collaborative environment, opening the door for future opportunities in ambitious university-led projects. AEGIS is a proposed mission for Artemis 2 as a secondary payload under the CubeSat Launch Initiative.

Background and Motivations: Long term human exploration of both the surface of the moon and deep space must overcome significant challenges, chief among these is mitigation of the radiation background. Recent exploration plans highlight the development of in-situ resource utilization (ISRU) for fuel, surface structural materials, and as radiation shielding. NASA outlined in their Strategic Knowledge Gaps (SKGs) the need to understanding radiation shielding strategies to live and work in the lunar environment. Understanding how well potential lunar regolith based construction and shielding materials preform in the deep space radiation environment is a crucial step in paving the way for human exploration.

Science Mission Objectives: The AEGIS mission addresses SKG III-G (additionally supporting SKG II-B) by measuring the effectiveness of lunar regolith-based radiation shielding for lunar or interplanetary exploration by leveraging lunar ISRU. AEGIS will fly a sample of regolith-based ISRU products, currently being researched, and measure its interactions with the two primary radiation sources: solar energetic particles and galactic cosmic rays.

Instrumentation. ISRU test material is placed within a linear energy transfer detector using silicon thin/thick pairs on either side of the material to measure the LET spectrum, paired with a cesium iodide scintillator calorimeter of for enhanced charge identification. For low energy particles, such as solar protons, the instrument can fully absorb particles with the calorimeter for complete energy and charge identification. For high energy galactic rays, the instrument will operate in an LET detection mode, with the calorimeter enabling better energy resolution, to identify charge and provide insight into the high energy interaction of the galactic rays in a high-Z shield.

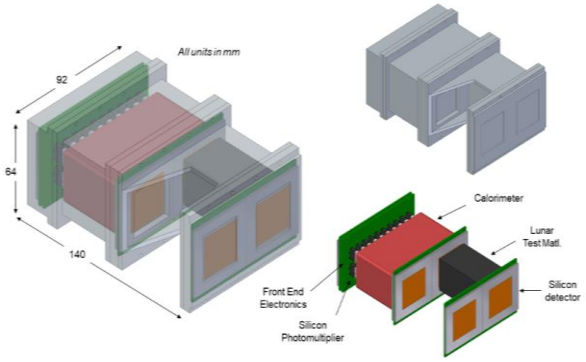

Fig. 1 Instrument overview with major elements and dimensions labeled. Two sides of the instrument readout separately for control and shielded background comparison.

Spacecraft and Mission Design: To measure the radiation environment the CubeSat will fly in a high earth orbit (HEO), around 400 k km altitude, to measure the background radiation environment that is present in deep space beyond the major influence of the magnetosphere. As a secondary payload the mission is designed for an ejection on a heliocentric trajectory (from the SLS on a Artemis mission) and will use a propulsion system with a lunar flyby to achieve an HEO orbit. The entire spacecraft fits in a 6U volume (roughly 10x20x30 cm^3).

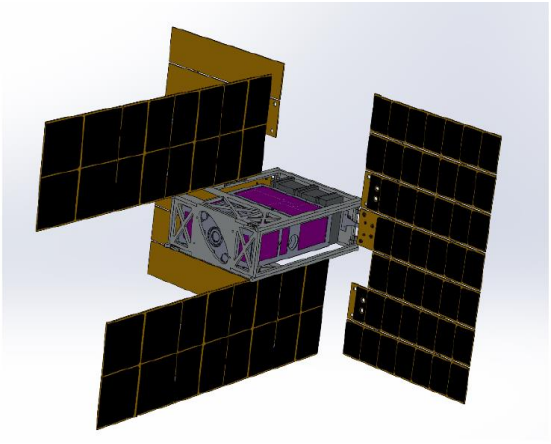

Fig. 2 CAD rendering of spacecraft conceptual design. Pre-PDR.

Educational Mission Objectives: AEGIS is part of a statewide satellite program led by the ASGC to spur development and educational opportunities for students in universities across the state of Alabama. As part of this program, AEGIS is currently developed by five partnering universities in the state. The project is student-led in all aspects, from management to the engineer systems. Student involvement ranges from undergraduate senior design projects to graduate thesis work. At each of the partnering universities, faculty members sponsor and lead development of individual subsystems with the students teams. Mentoring the project is a group of industry and NASA personnel that aid development. By bringing together multiple universities in a large scale project, students have the opportunity to experience the challenges of distributed development and better prepare themselves for the larger projects they will experience after graduation in the modern workforce. Industry partnership is also a large part of the program in both funding, resources, and mentorship, generating a synergy with the university system in building the next generation of engineers and scientists.

Workforce Development Focus: Students in the AEGIS project apply technical backgrounds developed in their individual studies to advance subsystem design across a multitude of engineering disciplines. Electrical engineering students in the Command and Data Handling design team evaluated processing, memory, and thermal requirements for OBC selection, but they are currently developing a radiation-tolerant OBC for the next ASGC mission with spatial, informational, and temporal redundancy strategies to mitigate single event effects. Software engineering students have worked with members of JPL to program F Prime, the software framework to be used on the Mars 2020 rover, on the Real Time Operating System governing the AEGIS Flight Software. Mechanical students have assessed structural considerations, integrated electric propulsion units, calculated thermal aspects such as internal heat generation and thermal soakback from the ion plume, devised shape memory alloy hinges for the solar arrays, and constructed shape memory alloy thermal deployable radiators with variable emissivity surface coatings. The AEGIS Project is taking a student-first perspective on establishing the paradigm by which all other Space Grant Consortiums may enable students to enact satellite missions across geographically disperse universities.

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