The Alabama Experiment on Galactic-Ray In-Situ Shielding (AEGIS) Project

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ABSTRACT:

Alabama Experiment on Galactic-ray In-situ Shielding (AEGIS) is a 6U CubeSat to characterize the effect of deep space radiation environments on lunar regolith-based shielding while providing a workforce development platform under a statewide coalition of universities. In 2018, the Alabama Space Grant Consortium (ASGC) initiated the workforce development program to teach students from multiple engineering disciplines the rigors and requirements of spacecraft design. AEGIS is the flagship mission of this program, conducted 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. The unique approach of AEGIS as a university-based collaboration offers both research and education opportunities, opening the door for future partnerships and missions with increasingly ambitious goals and science deliverables. AEGIS has applied to be manifested aboard the Artemis 2 launch vehicle under the CubeSat Launch Initiative. This presentation provides an overview of the science mission and its objectives, the project organization and management approach, and the spacecraft design.

Mission Overview

AEGIS is a 6U CubeSat proposed to fly on Artemis 2 as a collaborative mission with both scientific and educational objectives based on NASA Strategic Knowledge Gaps (SKGs) for human exploration:

Scientific Objectives

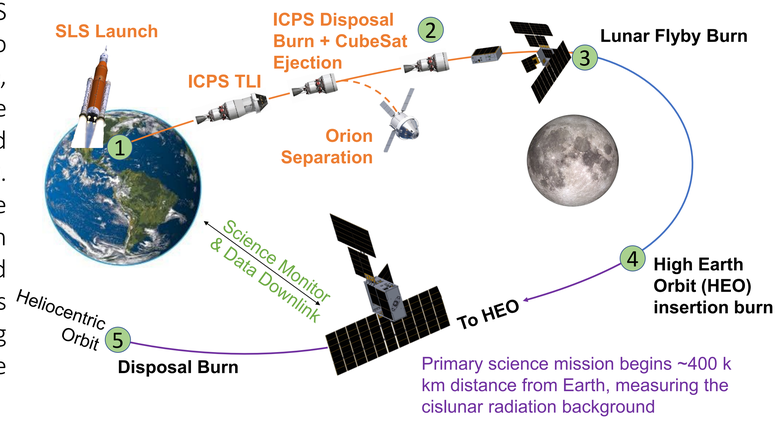
Address NASA SKGs for lunar exploration by measuring the shielding capabilities of lunar regolith-based shielding material in a cislunar environment

Educational Objectives

Provide students with hands-on experience in spacecraft development including management, design, test, and assembly

- Engage both undergraduate and gradate students
- Provide faculty opportunity for class and research projects

The science objectives of AEGIS require the spacecraft to operate in cislunar space, allowing measurements of the cosmic ray background beyond the shielding present at LEO. The materials being tested are based on lunar regolith products potentially to be used for habitat construction or as spacecraft shielding, retiring risk for their application in the future.

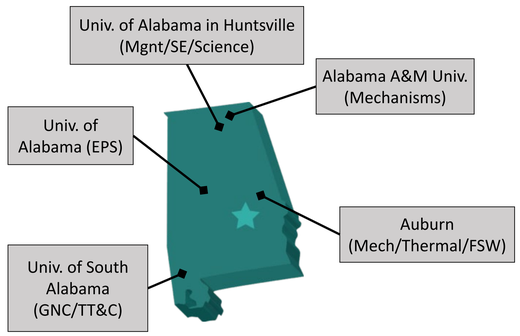


Primary science mission begins ~400 k km distance from Earth, measuring the cislunar radiation background

Statewide Program

ASGC initiated development of AEGIS under a new SmallSat program designed to further satellite and educational development across the state; AEGIS is the first of many future missions. The program is sponsored by industry partners and led by faculty at space grant universities in the state.

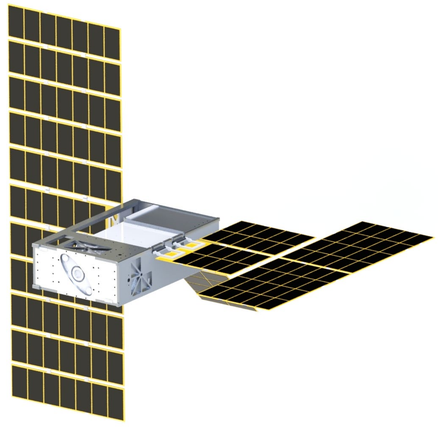
At each institution, students work under faculty members in conjunction with class and research work tailored to AEGIS development objectives. Management of the project is organized via graduate students in key project leadership roles.

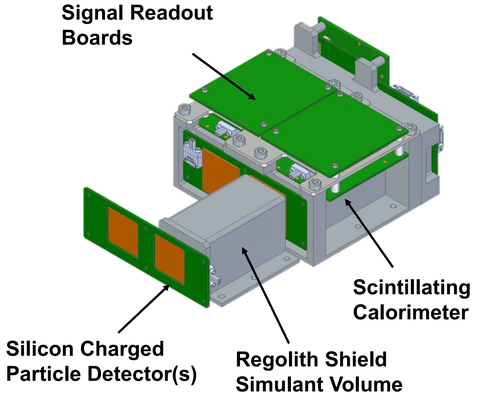


AEGIS is a partnership between five universities across Alabama, each responsible for different subsystems of the spacecraft and/or elements of the mission.

Spacecraft and Payload Design

- Pointing requirements from science and TT&C subsystems are realized by four RWP050 reaction wheels from Blue Canyon Technology.
- Thrust Vector Control(TVC) on the Enpulsion IFM Nano SE allows for desaturation of the pitch and yaw wheels. The roll wheel will be desaturated by a two-phase feedback linearization scheme which utilizes non-zero cross-products of inertia and constant pitch torque from the TVC.
- The novel desaturation method inures to the benefit of the spacecraft's 2x3 U shape by using the pitch and yaw wheels to non-linearly drive the roll wheel's angular momentum to zero.
- Once the roll wheel is desaturated, the pitch and yaw wheels are individually desaturated.
- Propellant mass for the desaturation maneuver is less than 60 g over 6 months of mission duration.
- Thruster power generation during the 20-day HEO insertion burn is ensured by aligning the primary solar arrays to one side of the spacecraft and rolling about the thrust vector when the sun crosses the thrust vector along the ecliptic plane.
- Alternating between clockwise and counter-clockwise rotations allows for conservation of roll wheel angular momentum in the event of unanticipated angular momentum drift.
- Two Shape Memory Alloy(SMA) technology demonstrations are onboard: a deployable radiator and secondary array hinge. Thermomechanical SMA models have been created for design validation.





The science payload is a charged particle detector that uses silicon detector pairs with a scintillating crystal calorimeter to record background particles as they pass through a control and shielded volume. These measurements provide insight on particle interactions of the shield and calculation of dose reduction from the shield material.

The instrument will have the ability to distinguish ion charge and energy spectrum in the detector using a combination of energy measurements and coincidence triggering between the silicon detectors and calorimeter. Each side of the instrument operates independently to measure the shield and control volumes.

ACKNOWLEDGMENTS:

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