

Small Space Weather Research Mission Designed Fully by Students

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Students at the University of Colorado at Boulder are building a satellite to study the space weather generated by high-energy particles near the Earth. The Colorado Student Space Weather Experiment (CSSWE) is a CubeSat mission funded by the U.S. National Science Foundation, scheduled for launch into a low-Earth polar orbit in June 2012 as a secondary payload under NASA's Educational Launch of Nanosatellites (ELaNa) program.

CSSWE will observe energetic particles for a minimum of 3 months with two goals: to relate the location, magnitude, and frequency of solar flares to the timing, duration, and energy spectrum of solar energetic particles (SEP) reaching Earth and to determine the evolution of the energy spectrum of radiation belt electrons. To accomplish these objectives, CSSWE will measure energetic ions and electrons coming directly from the Sun while it traverses the polar regions, where Earth's magnetic field lines are directly connected to the interplanetary magnetic field. CSSWE will also measure radiation

belt particles at lower latitudes. These types of radiation can affect the operations and life spans of Earth-orbiting spacecraft. Solar particles incident over the polar caps also produce ionospheric disturbances that can affect radio frequency communications.

CSSWE (see Figure 1) consists of three stacked CubeSat units, each $10 \times 10 \times 10$ centimeters, that together will contain a single science payload, the Relativistic Electron and Proton Telescope integrated little experiment (REPTile). REPTile is a miniaturization of the Relativistic Electron and Proton Telescope (REPT) currently being built at University of Colorado's Laboratory for Atmospheric and Space Physics (LASP) for the NASA Radiation Belt Storm Probes (RBSP) mission, which consists of two identical spacecraft scheduled to launch in May 2012 that will go through the heart of the radiation belts in a low-inclination orbit. REPTile is designed to measure the directional differential flux of protons ranging between 10 and 40 megaelectron volts and electrons ranging between 0.5 and 3 megaelectron volts.

These energetic particle measurements will be used in conjunction with flare measurements from other spacecraft, such as the Extreme Ultraviolet Variability Experiment on NASA's Solar Dynamics Observatory and the Solar X-Ray Imager on NOAA's Geostationary Operational Environmental Satellite

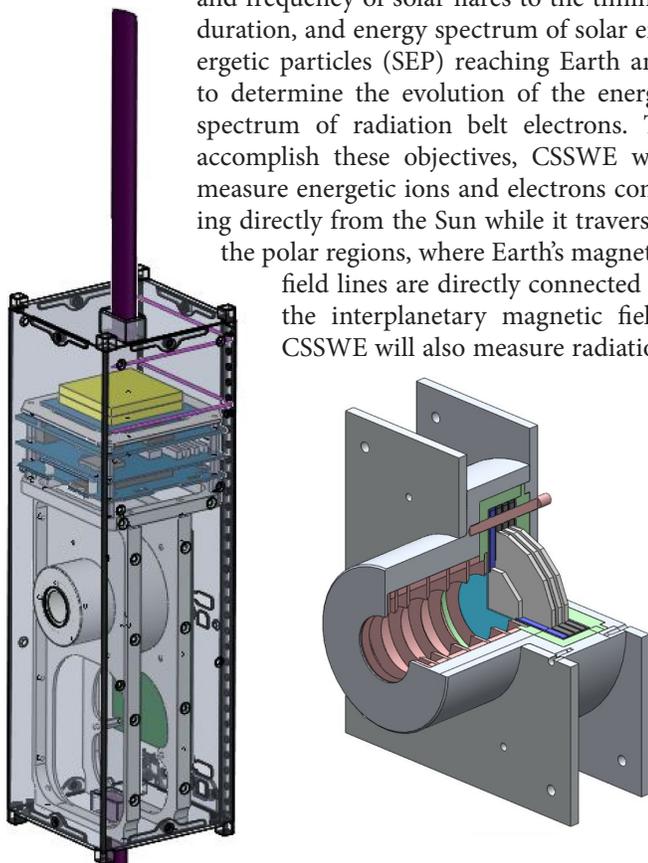


Figure 1. (left) An interior view of the Colorado Student Space Weather Experiment (CSSWE) CubeSat configuration, showing the Relativistic Electron and Proton Telescope integrated little experiment (REPTile) instrument in the center, electronic boards (in blue) and batteries (in yellow) on top of REPTile, and the deployed antenna (in purple) on the top of the CubeSat. (right) A cutaway view of the REPTile instrument, showing four disk detectors behind the collimator (pink) and the shielded housing. These detectors register incoming particles, the collimator defines the field of view, and the shielded housing prevents unwanted particles from getting into the detectors.

(GOES), to correlate flare characteristics such as strength and location with SEP characteristics such as particle flux, energy spectrum, and cutoff latitude. The coordinated observations provide a basis for giving advanced warning of SEP penetration at specific locations, which is a valuable space weather prediction. Relativistic electron measurements from REPTile will also be used in conjunction with other spacecraft, such as GOES at geosynchronous orbit and the RBSP spacecraft in the inner magnetosphere, to maximize the science return.

Education is a central part of the CSSWE program. Nearly all of the work in building the experiment is being done by graduate and undergraduate students who took or are taking a space hardware design course taught by professors Xinlin Li and Scott Palo in the University of Colorado's Department of Aerospace Engineering Sciences. More than 50 students from different majors including astronomy and planetary sciences and aerospace, mechanical, electrical, and computer engineering have helped to design the mission and build all of its subsystems. A unique feature of the class is that engineers and scientists from LASP mentor the students.

As of April 2011, the students have completed the construction of all subsystems and have begun integrated sub-

systems tests. The CubeSat system will be delivered to the California Polytechnic State University, San Luis Obispo, for integration into a standardized Poly Picosatellite Orbital Deployer (P-POD). Science data will be publicly available and analyzed by Ph.D. graduates under the supervision of Li, the mission's principal investigator.

CSSWE is an ideal class project, providing training for the next generation of engineers and scientists over the full life cycle of a satellite project. It also exemplifies the value of picosatellite missions in providing important scientific measurements complementary to other larger missions for a fraction of the time and money.

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