NASA's SET mission to study satellite protection is ready for launch

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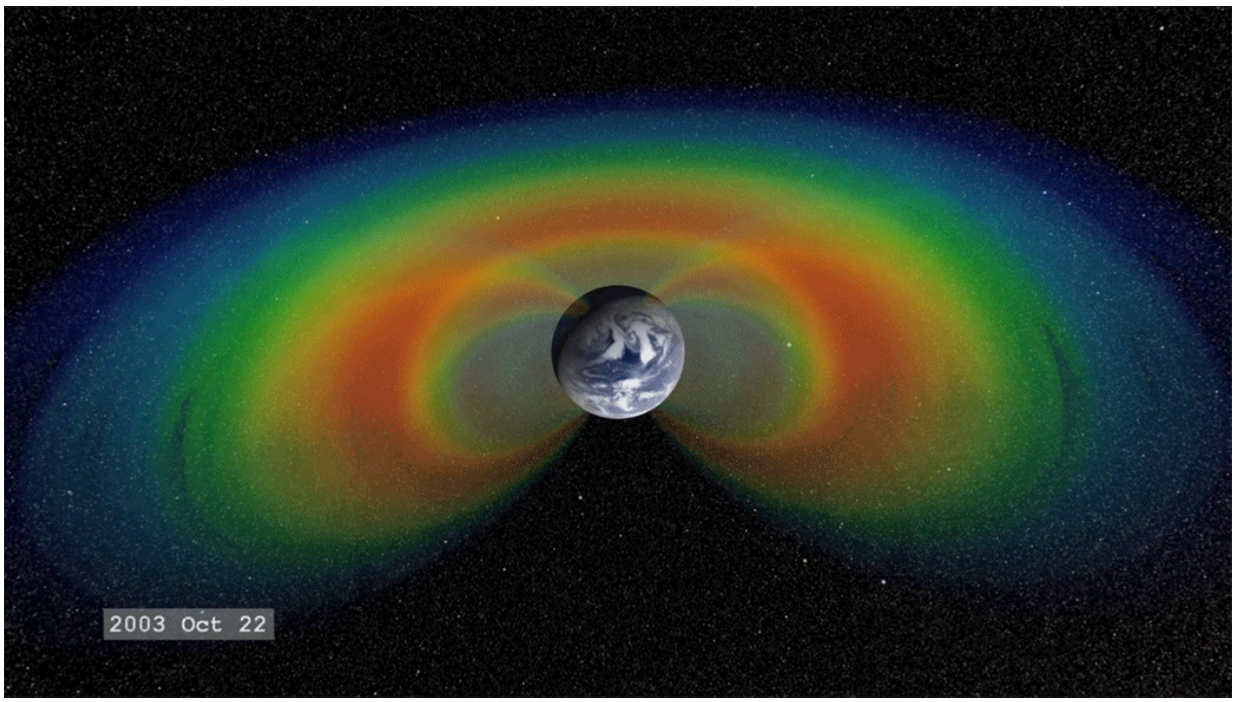

Earth's radiation belts are filled with energetic particles trapped by Earth's magnetic field that can wreak havoc with electronics we send to space. Credit: NASA's Scientific Visualization Studio/Tom Bridgman

NASA's Space Environment Testbeds, or SET, will launch in June 2019 on its mission to study how to better protect satellites in space. SET will get a ride to space on a U.S. Air Force Research Lab spacecraft aboard a SpaceX Falcon Heavy rocket from NASA's Kennedy Space Center in

Florida.

SET studies the very nature of space itself—which isn't completely empty, but brimming with radiation—and how it affects spacecraft and electronics in orbit. Energetic particles from the Sun or deep space can spark memory damage or computer upsets on spacecraft, and over time, degrade hardware. SET seeks to better understand these effects in order to improve spacecraft design, engineering, and operations, and avoid future anomalies. Spacecraft protection is a key part of NASA's mission as the agency's Artemis program seeks to explore the Moon and beyond.

"Since space radiation is one of the primary hazards space missions encounter, researching ways to improve their abilities to survive in these harsh environments will increase the survivability of near-Earth missions as well as missions to the Moon and Mars," said Reggie Eason, SET project manager at NASA Headquarters in Washington.

SET aims its sights on a part of near-Earth space called the slot region: the gap between two of Earth's vast radiation belts, also known as the Van Allen belts. The doughnut-shaped Van Allen belts seethe with radiation trapped by Earth's magnetic field. Where SET orbits is thought to be calmer, but known to vary during extreme space weather storms driven by the Sun. How much it changes exactly, and how quickly, remains uncertain.

"There haven't been too many measurements to tell us how bad things get in the slot region," said Michael Xapsos. Xapsos is one of two members on the SET Project Scientist Team alongside astrophysicist Yihua Zheng at NASA's Goddard Space Flight Center in Greenbelt, Maryland. "That's why we're going there. Before we put satellites there, you have to be aware of how variable the environment is," Xapsos said.

The slot region is an attractive one for satellites—especially navigation and communications satellites—because from about 12,000 miles up, it offers not only a relatively friendly radiation environment, but also a wide view of Earth. During intense magnetic storms, however, energetic particles from the outer belt can surge into the slot region.

SET will survey the slot region, providing some of the first day-to-day weather measurements of this particular neighborhood in near-Earth space. The mission also studies the fine details of how radiation damages instruments and tests different methods to protect them, helping engineers build parts better suited for spaceflight.

"Electronic devices these days are so small, complicated and fast," Xapsos said. The smaller a device is, the more vulnerable it is to radiation damage, and the more challenging it is to predict its performance in space. "SET will allow us to better understand what happens when an ion hits a device, and to improve models for how often these upsets occur."

There are two kinds of radiation damage that SET studies. The first are known as single event effects—that is, what happens when a high-energy ion accelerated by a solar eruption or from a galactic cosmic ray pierces electronics. These strikes happen at random, one particle at a time, and load a circuit with extra electric charge. The result can be a data flip—in binary code, for example, flipping a 0 to a 1—that affects stored memory or the programs that run spacecraft. Many spacecraft are equipped to recover from these snags, but at worst, they can cause system crashes and catastrophic damage.

But these dramatic blows aren't the only concern—milder radiation over time degrades circuits too. Charged particles trapped in the radiation belts weather electronics, gradually reducing their performance the longer they're in orbit.

SET is equipped with a space weather monitor and three circuit board experiments—each no larger than a postcard—to study both types of damage.

CREDANCE—short for the Cosmic Radiation Environment Dosimetry and Charging Experiment—is SET's space weather monitor, built to survey cosmic rays and particles in the radiation belts. These are the high-energy fragments of atoms that can pierce the walls of spacecraft, damaging electronics.

Credit: NASA's Goddard Space Flight Center

Two circuit board experiments also study single event effects. COTS-2—standing for Commercial Off the Shelf—collects information on the frequency of single event effects and how to mitigate them, especially in specialized computer chips. DIME—short for the Dosimetry Intercomparison and Miniaturization Experiment—consists of two separate boards that together demonstrate six different ways to measure space radiation using affordable, commercially available parts. The experiment can help future missions decide the best way to monitor radiation for their spacecraft.

Another circuit board experiment focuses on total radiation dose. ELDRS—short for Enhanced Low Dose Rate Sensitivity—is named for the mystery it studies: the ELDRS effect. This is what engineers call the intensified damage that certain types of electronics face when exposed to mild radiation over time—as opposed to the lesser damage experienced if exposed to the same total dose all at once. Information from this experiment will help improve test methods on Earth to make electronics space-ready.

Together, the SET experiments will expand our understanding of the near-Earth space environment and how its radiation impacts instruments. "SET data will directly go into improving our models so we can better evaluate the radiation environment future missions will encounter," said Goddard aerospace engineer Megan Casey. Models are a key component in selecting and testing any electronics destined for spaceflight.

SET is part of the Space Environment Effects (SFx) experiment, one of three experiments on board the Demonstration and Science Experiments, or DSX, spacecraft being launched by the U.S. Air Force.

DSX is launching as part of the Space Test Program-2 (STP-2) mission, managed by the U.S. Air Force Space and Missile Systems Center (SMC). SET is one of four NASA missions on this STP-2 launch—all of which are dedicated to improving technology in space. DSX separates from the launch vehicle approximately 3.5 hours after launch.

SET is the latest addition to NASA's fleet of heliophysics observatories. NASA heliophysics missions study a vast interconnected system from the Sun to the space surrounding Earth and other planets, and to the farthest limits of the Sun's constantly flowing stream of solar wind. SET's observations provide key information on the Sun's effects on our spacecraft, enabling further exploration of space.

Provided by NASA's Goddard Space Flight Center

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