

Satellite's Plight Teaches Students Highs and Lows of Space Research

Students and researchers at Boston University, with the help of experts from around the country, have been working furiously to revive their tiny research satellite, TERRIERS, which lost power shortly after launch on 18 May. Designed to do ionospheric studies and built largely by BU students, the Tomographic Experiment using Radiative Recombinative Ionospheric EUV and Radio Sources (whose acronym is a nod to the school's canine mascot) had failed to orient itself with its solar panels pointing toward the Sun. As *PHYSICS TODAY* went to press, the hope was that the satellite's orbit would soon precess to a better angle.

"We're hopeful that we can do something, but it's really dependent on the orbit dynamics and all the torques acting on the spacecraft," says Brent Robertson, of NASA's Goddard Space Flight Center, who's been working on the rescue effort. "We're going to be very lucky if we recover TERRIERS."

A trivial problem

With the satellite's science mission on hold, the mood at the mission control center, housed on the fourth floor of BU's astronomy and physics building, is somewhat subdued. But in the first few hours of 18 May, the team couldn't have been happier. Given the string of recent rocket failures, there was understandable relief when the launch from Vandenberg Air Force Base went off without a hitch, and again when radio contact was established about six hours later. But operators soon noticed that the battery, designed to run eight hours between charges, was draining unexpectedly. By the end of that first day, the satellite had fallen silent.

A recovery team was promptly assembled, and, starting with about 30 possible problems, they painstakingly narrowed the list to a sign error in the attitude control algorithm, which left the solar array pointed 160° away from the Sun.

The team is now keeping tabs on the vessel through the North American Air Defense Command, which tracks satellites and space debris for the Air Force. The chances of recovery are considered slim. However, Robertson says, should the spacecraft precess to where its spin axis is pointing, say, 70° from the Sun, a few hours would be sufficient to recharge the battery and wake up the satellite, at which point the commands to reorient the vessel could be uploaded. To improve the odds of making contact, a second ground sta-

tion has been set up at the NASA facility in Poker Flat, Alaska, 30 miles north of Fairbanks.

"That satellite is frustratingly healthy," says Robert Goeke, chief engineer at the MIT Center for Space Research and a consultant on TERRIERS. "There's nothing broken as far as we can tell. It's a trivial problem in the sense that if we could get the commands to the satellite just once, we could fix it, and everything would be cool."

Lessons learned

Tiny by today's standards, the \$4 million, 123 kg craft is designed to do global ionospheric tomography, in which extreme ultraviolet, radio, and visible light measurements will be combined to create high-resolution



STILL HOPEFUL of contacting the TERRIERS satellite, students continue to send up commands from the mission control center at Boston University; shown from left to right are Kevin Wilton, Jeremy Coombs, and Janine Lyn. In early June, a second ground station was set up in Poker Flat, Alaska.

three-dimensional images of Earth's upper atmosphere. TERRIERS is equipped with five EUV slit spectrographs, as well as a novel optics-free solar EUV spectrometer for monitoring solar flux in the 7 to 40 nm range. "Combining the EUV emissions with ground-based optical and radar gives you a much more robust reconstruction of the ionosphere. You really get a whole feel for what's going on," explains Andrew Stephan, an astronomy graduate student who worked on the spacecraft's primary instruments.

The BU effort is the second of three low-cost, university-based missions developed under the NASA-funded Student Explorer Demonstration Initiative. The first STEDI mission, launched in February 1998, is the University of Colorado at Boulder's Student Nitric Oxide Explorer, which has been studying the effects of energy from the Sun and the magnetosphere on nitric oxide densities in the lower thermosphere. The third, which should be ready in about a year, is the Uni-

versity of New Hampshire's Cooperative Astrophysics and Technology Satellite, designed to measure the distance and polarization of gamma-ray bursts.

As its name implies, STEDI was designed to give students more hands-on experience in space research, says Paul Coleman, president of the Universities Space Research Association, which first pitched the STEDI concept to NASA and has been overseeing the missions. "Old guys like me remember how it was in the early days of the space program, when students were involved in every aspect, from the tip of the rocket nozzle to the top of the nose cone," Coleman says. As missions grew bigger, costlier, and longer, students were largely relegated to data collection and analysis. "I kept thinking there must be a way to bring back the student involvement and still do mainstream research," says Coleman. "From my discussions with students, I think it's worked better than I ever

dreamed." Last year, citing STEDI as a model, NASA created a standing program of small University-Class Explorer missions.

According to Supriya Chakrabarti, director of BU's Center for Space Physics, about fifty students have played key roles in designing, building, and testing the various instruments. (The satellite bus itself was supplied by AeroAstro of Herndon, Virginia.) "The students deserve a lot of credit. They are disappointed, but I think they understand that this is a risky business."

Indeed, notes MIT's Goeke, the students are inadvertently learning a hard lesson about research: "In this sort of experimental space business, you can hardly advance professionally unless the hardware gets up into space and it works."

"I'm being optimistic, but it kind of goes in waves," says Stephan. "We realize there are some things that are beyond our control. But if nature gives us the opportunity, we know what to do."

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