Small Tether Satellite Deployed by NRL

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(Washington, DC) -- The Naval Research Laboratory's (NRL's) Naval Center for Space Technology has designed, built and deployed a small satellite to research the gravity-gradient dynamics and survivability of a tethered system in space, known as the Tether Physics and Survivability (TiPS) experiment.

The TiPS satellite was deployed today into a circular orbit, at an altitude of 1022 km (552 nmi) and inclination of 63.4 degrees. A deployment sequence jettisoned the TiPS satellite from a host vehicle and then separated its two end masses from each other. When fully deployed, the 53.5 kg (118lb.) tethered system consisting of two small end-masses is connected by a 4 km (2.5 miles) nonconductive braided tether.

NRL, NASA, and an international network of Satellite Laser Ranging (SLR) stations are tracking the position of each end-mass to study the dynamics and survivability of tethered systems. Telemetry generated during the separation of the two end-masses was received by the United States Air Force (USAF).

The National Reconnaissance Office (NRO) is a sponsor of the TiPs program. Research and funding for this low-cost, passive experiment began in 1995. The NRO helped fund this project to increase understanding of gravity gradient tether dynamics for space operations. In addition, NRO engineers hope the research will assist the scientific community in evaluating survivability of future tethered vehicles in low-earth orbit.

Mr. Robert Towsley, TiPS Systems Engineer at NRL, explains "Tethered systems are a new and relatively untested space technology. The TiPS spacecraft is designed to characterize tether dynamics and survivability in the space environment. Specific dynamics issues of tethered systems include libration amplitudes and stability, while tether issues include internal damping and flexibility." Dr. Shannon Coffey, Mission Operations Manager of NRL's TiPS, adds "From a survivability aspect, TiPS' tether is susceptible to space debris damage. The tether, roughly 2 mm in diameter, can be severed by a particle as small as 1mm travelling at a relative velocity of 14km/s (31,318 mph)."

Mr. William Purdy, NRL's TiPS Program Manager says, "The TiPS endmasses are similar in size and weight, which dictates that both will undergo significant dynamic motion with respect to the center of mass of the system. The heaviest end mass, affectionately dubbed "Ralph," weighs 37.7 kg (83.2 lb.). Ralph contains all of the electronic components, which include the telemetry system, turncount recorder, and temperature sensors. The telemetry system, supplied by NASA, is powered by a nonrechargeable battery, which operated for the first eight hours of the satellite's life. The lighter end-mass dubbed "Norton" weighs 10.3 kg (22.8 lb.). The tether weighs 5.5 kg (12.0 lb.), and was coiled on a spool inside Ralph, much like a spinning reel."

Ralph and Norton separated at a relative velocity of approximately 5.1 m/s (16.7 ft/s). The passive deployment scheme utilized a small Marman clamp and ten spring-loaded cartridges. The initial separation energy was designed to deploy about 2 km of the tether, at which time gravity-gradient forces assisted to unwind the remainder.

The TiPS orientation is controlled by gravity gradient forces. The TiPS satellite orbits the Earth with a nominal vertical orientation, Ralph being closest to the earth. About this nominal orientation, the tethered system undergoes libration, a pendulum-like motion, about the center of mass.

A globally distributed SLR network, including NASA, DoD, and cooperating international stations, are tracking the TiPS satellite. These SLR stations provide very accurate, submeter-resolution, range data for Ralph and Norton. The SLR information is being used to determine the orbit and attitude of the tethered system. Ms. Amey Peltzer, NRL's TiPS SLR Mission Specialist reports, "This is the first time SLR data has been converted into attitude and orbit knowledge, to validate analytical models and simulations of a tethered system."

Retroreflectors are mounted on the exterior surfaces of both Ralph and Norton, for long-term passive monitoring of the tethered system. End-mass discrimination is accomplished by coating the retroreflectors of Ralph to reflect only one of the two transmitted laser wavelengths. The uncoated retroreflectors on Norton reflect both transmitted wavelengths.

And Mr. Towsley adds, "TiPS is a low-budget, quick-reaction experiment. To date, mathematical models have been developed to predict the motion and survivability of tethers in space, but little long-duration on-orbit data have been obtained. The data from TiPS will be used to verify and improve understanding of the physics of tethered systems in space as well as the mathematical models."

The Naval Research Laboratory is the Department of the Navy's corporate laboratory. NRL conducts a broad program of scientific research, technology and advanced development. The Laboratory, with a total complement of nearly 4,000 personnel, is located in southwest Washington, DC, with other major sites at the Stennis Space Center, MS; and Monterey, CA.