Stanford students fly in zero gravity to protect satellites from tiny meteoroids (w/ Video)

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Graduate students Nicolas Lee, left, and Shandor Dektor, during one of their 37 deployment tests on the zero gravity airplane.

(PhysOrg.com) -- Stanford researchers have completed the first successful tests in zero gravity of a canopy for CubeSats – the tiny satellites that hitch rides on rockets sending larger satellites into orbit. The goal is to gather data on what happens when micrometeoroids slam into a satellite. Such impacts often knock out electronic equipment on satellites. The encounters are poorly understood, but the canopies could be a first step in eventually building "black boxes" for satellites similar to airplane flight recorders.

Orbiting the Earth is risky business for a satellite. Over a hundred billion meteoroids enter Earth's atmosphere every day, and while big, fierce, spacecraft-crushing meteoroids are rare, even the tiniest ones are a hazard.

What happens when a really tiny meteoroid (so small a stack of 500 would stand less than an inch tall) hits a satellite is not fully understood, but Stanford researchers have successfully done preliminary testing of a device that may help shed light on these collisions in space.

Some of that testing was in zero gravity, aboard a diving airplane flying over the ocean.

Nicolas Lee, a graduate student in aeronautics and astronautics, and several colleagues have designed a canopy to pop out of a tiny satellite called a CubeSat and absorb the impacts of these micrometeoroids, also known as "interplanetary flyspecks."

"The canopy might eventually be deployed to protect a spacecraft from meteoroids or shield it from the sun, but for now, we just want it to get hit," Lee said.

Even tiny meteoroids travel at tremendous speeds in orbit around the sun (more than 250,000 kilometers per hour) and pack a hefty punch when they strike a spacecraft.

"It is pretty much an explosion," Lee said.

Since the impact disrupts the satellite's electronics, no one knows exactly how the micrometeoroid causes the damage. But Lee's advisor, Sigrid Close, assistant professor of aeronautics and astronautics, has a theory.

She suspects the meteoroid instantly vaporizes into free electrons and ions that float around in a little ball. As that ball expands in the vacuum of space, it gives off energy at radio frequencies that interfere with the electronic equipment on the satellite, disrupting communications and other essential functions.

"We want to fly a dedicated mission that can study this effect and make sure that we can protect against it," Lee said. For that mission, the team would work with Andrew Kalman, a consulting professor of aeronautics and astronautics, to equip a CubeSat with plasma sensors and radio antennas to measure radio frequency emissions.

As a first step in field-testing their canopy, Lee and fellow graduate students Shandor Dektor and Joseph Johnson recently tested their canopies in zero gravity aboard a NASA airplane flying over the Gulf of Mexico.

The plane flew a flight path any rollercoaster lover would die for: up and down in a series of parabolas, from about 22,000 to 32,000 feet. At the top of each parabola, the plane's occupants experienced weightlessness for about 20 seconds, which was when the team tested how their canopies opened. Over the course of two flights and 80 parabolas, the students did 37 successful trial runs.

Operating in zero gravity took some getting used to. "You don't realize gravity is gone so you are still pushing against it," Lee said. "And so you end up feeling like you are falling upwards."

The team tested three prototypes of the canopy, each a square meter in area. One design was thin mylar, rolled up in a spiral pattern inside the little black CubeSat box. Another design had the mylar folded to expand in a radial pattern. The third design used the spiral unfolding, but with a thicker membrane for the canopy. For all the designs, the unfolding was powered by struts made of common metal tape measures rolled up with the canopies.

The thin membrane rolled in a spiral pattern was the most successful. Lee thinks with proper folding, a thicker membrane could work well, too. Although Lee had some prior experience in origami, he said getting the proper folding was initially just trial and error.

"I folded so many prototypes," he said. But after figuring out the basic geometry of the folding, he developed a mathematical algorithm to employ.

"We are also hoping to deploy some metallic sheets, which might give us a different effect than the plastic mylar we've been using," he said. "For the purpose of a meteoroid impact screen, we would need a thicker membrane so the screen doesn't break when it gets hit by a large meteoroid."

When the CubeSat is deployed in space, in addition to zero gravity, it will have to open in a vacuum, so the researchers want to take their canopies into a vacuum chamber and shoot high velocity particles at it to supplement the zero gravity tests.

As the CubeSat canopy testing progresses, Close sees long-term potential not only in protecting satellites but also in recording what spacecraft experience in orbit.

"This could lead to devices that could be attached to satellites just like a black box in an airplane," Close said.

Provided by Stanford University

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