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NEXT-GEN SATELLITES

through robotics and additive manufacturing

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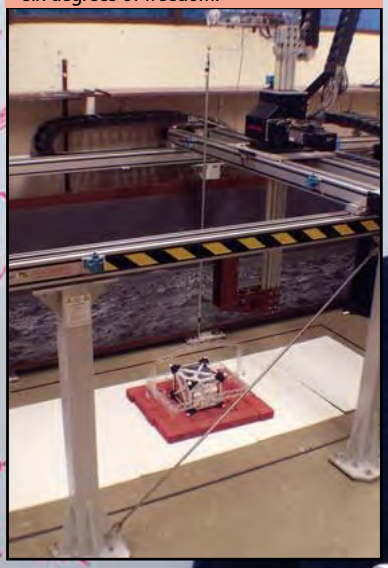
Hoppin' and tumblin' on other worlds



To replicate the operation of a hopping, box-shaped rover on the surface of a comet or asteroid, Stanford University researchers built a test stand that uses a gantry and a three-axis gimbal to simulate very low gravity and provide six degrees of freedom.

Stanford University researcher Marco Pavone holds a prototype of a microgravity hopping rover.

Stanford University

For scientists who want to explore the surfaces of asteroids or comets, traditional wheeled rovers aren't the right fit because they're designed for high-gravity bodies like Mars.

Robotics experts at Stanford University have devised an alternative concept for maneuvering across diminutive, low-gravity bodies.

The initiative is led by Marco Pavone, director of the Autonomous Systems Laboratory at Stanford. He wants to drop small, box-shaped spacecraft to the surfaces of such bodies and command them to tumble for regular maneuvering, hop when the time comes to explore a new location and shuffle to point science instruments at specific features.

"Try to play golf on a bumpy terrain," Pavone told Aerospace America. "This is an analogue to the challenge of controlling a hopping robot on an asteroid, the key goal of this project."

Pavone's spacecraft would be released cubesat-style from a main spacecraft and bound several times on the surface. Once at rest, a trio of internal flywheels would be spun up and stopped very rapidly. This produces a jolting torque that causes the device to hop or tumble depending on the speeds of the flywheels, explained Stanford graduate student Benjamin Hockman, Pavone's assistant on the project. It's all about swapping angular momentum to get to where you want to go.

The two researchers detailed their work at the NASA Innovative Advanced Concepts 2015 symposium in January. NIAC is funding their work.

Pavone said the NIAC-backed research draws on control theory, autonomous systems, coordination of multi-robot networks, formation flying and bio-inspired robotics. He also sees lessons in the Philae lander's bumpy touchdown in November on Comet 67P/Churyumov–Gerasimenko. The European Space Agency's Philae lander appears to have bounced across the comet's surface a total of four times, including the final full-stop.

"Philae illustrated the challenges of landing on low-gravity bodies," Pavone said, "and how useful a mobility option would be to get out of bad landing spots and point instruments in a desired direction."

On the surface, Pavone's spacecraft would literally spring into action. Short treks to select spots would be done through a sequence of controlled tumbles. High-altitude, point-to-point jumps are feasible too.

Pavone and Hockman are considering an approach in which the main spacecraft would observe the landers and perhaps help guide them as they move from target to target.

To mimic the movement of the hardware on a small body, they've built a six-degrees of freedom microgravity test bed at the Stanford lab. In addition, prototypes are to be flown in parabolic flights later this year.

A conceptual study is also underway for a mission to Phobos, a moon of Mars. Instrument-laden landers could probe the nature of Phobos' soil and scout for water and organics.

"The robotic exploration of small bodies will be a main NASA focus in the years to come," Pavone said. It's a quest that requires disruptive mobility concepts to obtain new science at an affordable cost.

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