When the robot lands, the springs in the legs are compressed as they absorb much of the impact. As the legs retract, a constant-force spring motor attached to the spool winds in the leg cables to keep them taught. A unidirectional clutch in line with the spool and the spool motor drive allows the spool to quickly overrun the motor drive when winding up the cable, but locks when the springs in the legs try to pull the cable back out. This action prevents bouncing after landing and provides for storage of energy for reuse on the next hop. A motor-driven gyroscope mounted on the lower hexagonal frame helps to prevent tumbling of the robot during hopping and was tested through computer simulation.

This work was done by Paulo Younse and Hrand Aghazarian of Caltech for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1). NPO-45062

Launchable and Retrievable Tetherobot

The reach of an exploratory robot on rough terrain would be extended.

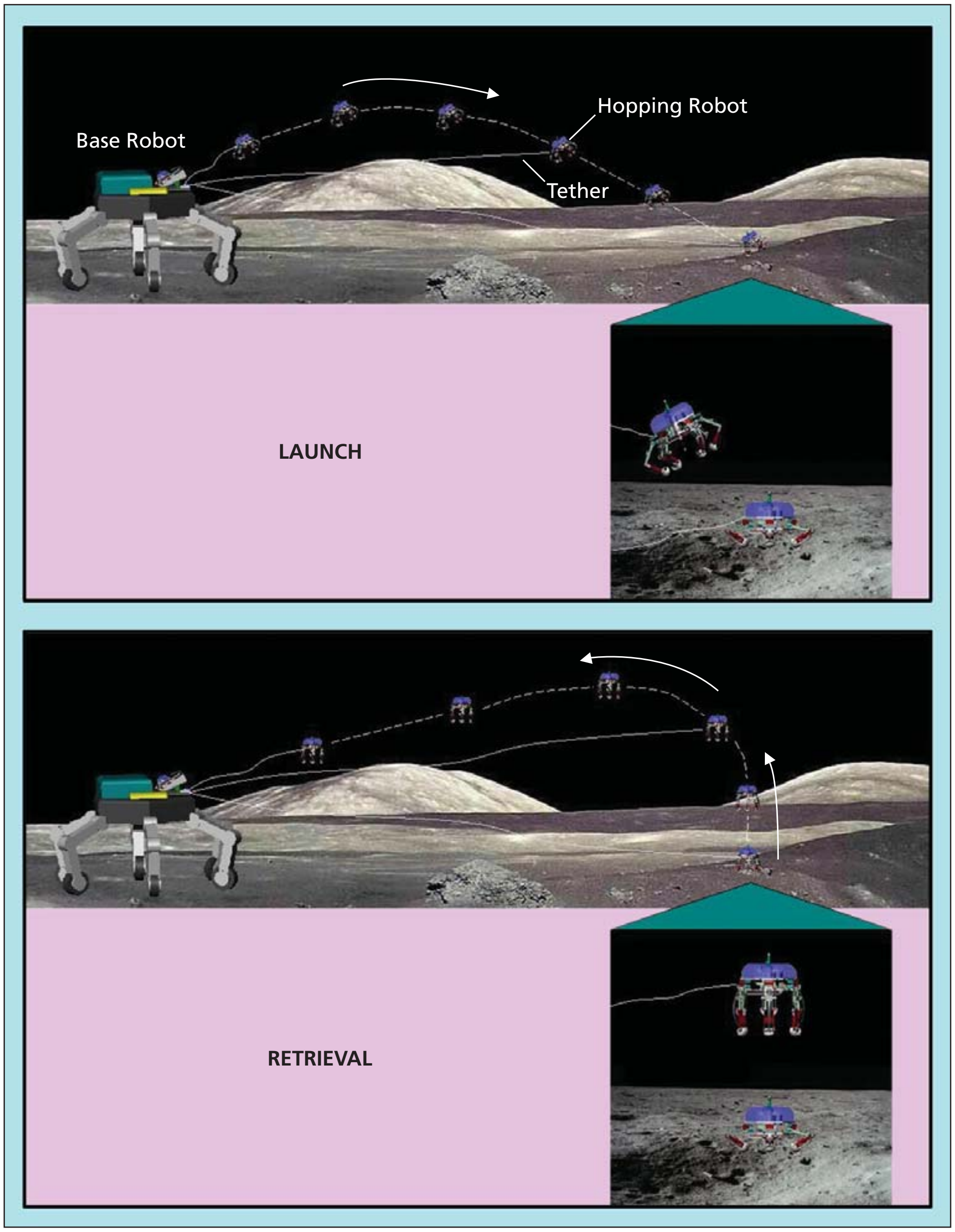
NASA's Jet Propulsion Laboratory, Pasadena, California

A proposed robotic system for scientific exploration of rough terrain would include a stationary or infrequently moving larger base robot, to which would be tethered a smaller hopping robot of the type described in the immediately preceding article. The two-robot design would extend the reach of the base robot, making it possible to explore nearby locations that might otherwise be inaccessible or too hazardous for the base robot.

The system would include a launching mechanism and a motor-driven reel on the larger robot. The outer end of the tether would be attached to the smaller robot; the inner end of the tether would be attached to the reel.

The figure depicts the launching and retrieval process. The launching mechanism would aim and throw the smaller robot toward a target location, and the tether would be paid out from the reel as the hopping robot flew toward the target. Upon completion of exploratory activity at the target location, the smaller robot would be made to hop and, in a coordinated motion, the tether would be wound onto the reel to pull the smaller robot back to the larger one.

At the time of reporting the information for this article, the launching and retrieval processes had been studied by computational simulations for various



The **Smaller Tethered Hopping Robot** would be thrown toward a target by a launching mechanism on the larger robot. Later, the hopping robot would be retrieved by reeling in the tether during a hop.

launching angles, target distances, hopping heights and angles, and tether-reel-in rates. A prototype hopping robot and a reel had been built. Work on the launching mechanism and on control subsystems for the hopping robot and the reel remained to be done.

*This work was done by Paulo Younse and Hrand Aghazarian of Caltech for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1).***NPO-45063**

Hybrid Heat Exchangers

John H. Glenn Research Center, Cleveland, Ohio

A hybrid light-weight heat exchanger concept has been developed that uses high-conductivity carbon-carbon (C–C) composites as the heat-transfer fins and uses conventional high-temperature metals, such as Inconel, nickel, and titanium as the parting sheets to meet leakage and structural requirements.

In order to maximize thermal conductivity, the majority of carbon fiber is aligned in the fin direction resulting in 300 W/m·K or higher conductivity in the fin directions. As a result of this fiber orientation, the coefficient of thermal expansion (CTE) of the C–C composite in both non-fiber directions matches well with the CTE of various high-temperature metal alloys. This allows the joining of fins and parting sheets by using high-temperature braze alloys.

This work was done by Jianping Gene Tu and Wei Shih of Allcomp Inc. for Glenn Research Center. Further information is contained in a TSP (see page 1).

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Glenn Research Center, Innovative Partnerships Office, Attn: Steve Fedor, Mail Stop 4–8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-18454-1.

Orbital Winch for High-Strength, Space-Survivable Tethers

Marshall Space Flight Center, Alabama

An Orbital Winch mechanism enables high-load, multi-line tethers to be deployed and retracted without rotating the spool on which the tether is wound. To minimize damage to the tether and the wound package during retraction or deployment under load, it can incorporate a Tension Management Module that reduces the infeed tension by a factor of 15 through the use of a powered capstan with guide rollers. This design eliminates the need for rotating high-voltage electrical connections in tether systems that use propellantless electro-dynamic propulsion. It can also eliminate the need for rotating optical connections in applications where the tether contains optical fibers.

This winch design was developed to deploy a 15-km-long, 15-kg high-strength Hoytether structure incorporating conductive wires as part of the MXER-1 demonstration mission concept. Two slewing rings that orbit around the tether spool, combined with translation of one of the slewing rings back and forth along the spool axis to traverse the wind point, enables the winch to wind the tether. Variations of the traverse motion of the slewing ring can accomplish level winds and conical pirn winds. By removing the non-traversing slewing ring, and adding an actuated guide arm, the winch can manage rapid, low-drag deployment of a tether off the end of a pirn-wound spool, followed by controlled retraction and rewinding, in a manner very similar to a spin-casting reel. The winch requires at least two motor driver controller units to coordinate the action of two stepper motors to accomplish tether deployment or retraction.

This work was done by Robert Hoyt, Ian Barnes, Jeffrey Slostad, and Scott Frank of Tethers Unlimited, Inc. for Marshall Space Flight Center. For further information, contact Sammy Nabors, MSFC Commercialization Assistance Lead, at sammy.a.nabors@nasa.gov. Refer to MFS-32589-1.