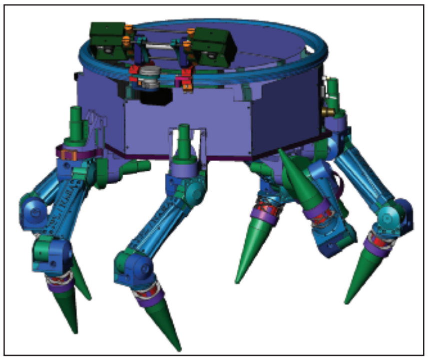

The **LEMUR** II can move its stereoscopic cameras along a circular track to view objects at any azimuth. Its symmetrical arrangement of six limbs enables motion along any azimuth heading.

simple mechanical operations with one or both of its front limbs. It could also transmit images to a host computer.

Each of the six limbs of the LEMUR I was operated independently. Each of the four rear limbs had three degrees of freedom (DOFs), while each of the front two limbs had four DOFs. The front two limbs were designed to hold, operate, and/or be integrated with tools. The LEMUR I included an onboard computer equipped with an assortment of digital control circuits, digital input/output circuits, analog-to-digital converters for input, and digital-to-analog (D/A) converters for output. Feedback from optical encoders in the limb actuators was utilized for closed-loop microcomputer control of the positions and velocities of the actuators.

The LEMUR II incorporates the following improvements over the LEMUR I:

- The drive trains for the joints of the LEMUR II are more sophisticated, providing greater torque and accuracy.
- The six limbs are arranged symmetrically about a hexagonal body platform instead of in straight lines along the sides. This symmetrical arrangement is more conducive to omnidirectional movement in a plane.
- The number of degrees of freedom of each of the rear four limbs has been increased by one. Now, every limb has four degrees of freedom: three at the hip (or shoulder, depending on one's perspective) and one at the knee (or elbow, depending on one's perspective).
- Now every limb (instead of only the two front limbs) can perform operations. For this purpose, each limb is tipped with an improved quick-release mechanism for swapping of end-effector tools.
- New end-effector tools have been developed. These include an instrumented rotary driver that accepts all tool bits that have 0.125-in. (3.175-mm)-diameter shanks, a charge-coupled-device video camera, a super bright light-emitting diode for illuminating the work area of the robot, and a generic collet tool that can be quickly and inexpensively modified to accept any cylindrical object up to 0.5 in. (12.7 mm) in diameter.
- The stereoscopic cameras are mounted on a carriage that moves along a circular track, thereby providing for omnidirectional machine vision.
- The control software has been augmented with software that implements innovations reported in two prior *NASA Tech Briefs* articles: the HIPS algorithm ["Hybrid Image-Plane/Stereo Manipulation" (NPO-30492), Vol. 28, No. 7 (July 2004), page 55] and the CAMPOUT architecture ["An Architecture for Controlling Multiple Robots" (NPO-30345), Vol. 28, No. 10 (October 2004), page 65].

This work was done by Brett Kennedy, Avi Okon, Hrand Aghazarian, Matthew Robinson, Michael Garrett, and Lee Magnone of Caltech for **NASA's Jet Propulsion Laboratory**. *Further information is contained in a TSP (see page 1).*
NPO-35140

Miniature Linear Actuator for Small Spacecraft

Goddard Space Flight Center, Greenbelt, Maryland

A report discusses the development of a kit of mechanisms intended for use aboard future spacecraft having masses between 10 and 100 kg. The report focuses mostly on two prototypes of one of the mechanisms: a miniature linear actuator based on a shape-memory-alloy (SMA) wire. In this actuator, as in SMA-wire actuators described previously in *NASA Tech Briefs*, a spring biases a moving part toward one limit of its stroke and is restrained or pulled toward the other limit of the stroke by an SMA wire, which assumes a slightly lesser or greater "remembered" length, depending on whether or not an electric current is applied to the wire to heat it above a transition temperature. Topics addressed in the report include the need to develop mechanisms like these, the general approach to be taken in designing SMA actuators, tests of the two prototypes of the miniature linear actuators, and improvements in the second prototype over the first prototype resulting in reduced mass and increased stroke. The report also presents recommendations for future development, briefly discusses problems of tolerances and working with small parts, states a need for better understanding of behaviors of SMAs, and presents conclusions.

This work was done by Cliff E. Willey and Stuart W. Hill of Johns Hopkins University Applied Physics Laboratory for **Goddard Space Flight Center**. *Further information is contained in a TSP (see page 1).*
GSC-14706-1