



## Mechanics/Machinery

### Microgravity, Mesh-Crawling Legged Robots

**These relatively inexpensive robots may be used in search and rescue operations.**

*NASA's Jet Propulsion Laboratory, Pasadena, California*

The design, fabrication, and microgravity flight-testing are part of a continuing development of palm-sized mobile robots that resemble spiders (except that they have six legs apiece, whereas a spider has eight legs). Denoted SpiderBots (see figure), they are prototypes of proposed product line of relatively inexpensive walking robots that could be deployed in large numbers to function cooperatively in construction, repair, exploration, search, and rescue activities in connection with exploration of outer space and remote planets.

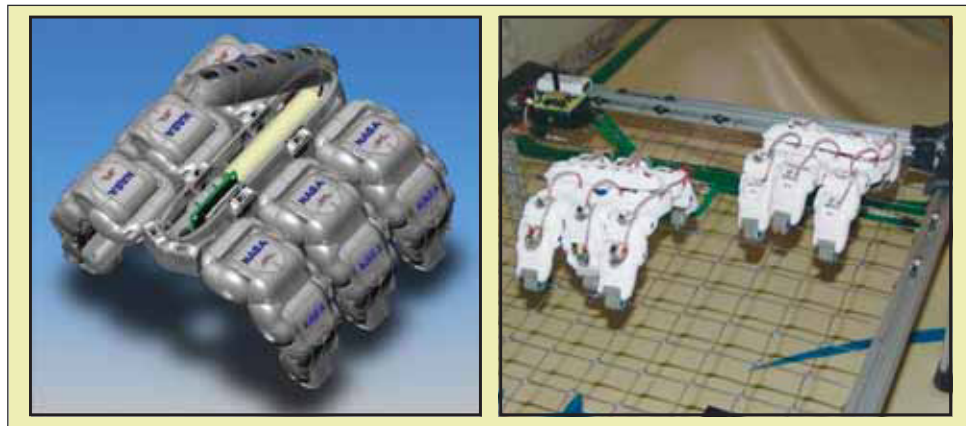
Relative to other legged robots, including ones reported in previous *NASA Tech Briefs* articles, SpiderBots are smaller, less power-hungry, and more specialized. A SpiderBot at the present stage of development is designed primarily to demonstrate that it can crawl on a flexible rectangular mesh (in micro-gravity) and secondarily that it can walk on flat surfaces and assemble simple structures. Each leg includes two spring-compliant joints and a

gripping actuator. The SpiderBot moves in a hard-coded set of tripod gaits involving alternating motions of legs variously anchored or not anchored to a mesh.

The robots were recently tested on a reduced gravity aircraft and were able to demonstrate crawling along the mesh during the microgravity portion of the parabolic flight. In one contemplated improvement, feedback from sensors on the feet would provide indications of success or the lack

thereof in gripping a mesh, thereby contributing to robust, fault-tolerant operation.

*This work was done by Alberto Behar, Neville Marzwell, Jaret Matthews, and Krandalyn Richardson of Caltech; Jonathan Wall and Michael Poole of Blue Sky Robotics; David Foor of Texas A&M University; and Damian Rodgers of ISU (International Space University) for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1). NPO-42672*



Photos of SpiderBots show a prototype and one crawling on a mesh.

### Advanced Active-Magnetic-Bearing Thrust-Measurement System

**Automatic multipoint calibration and a fringing model are used to increase accuracy.**

*Stennis Space Center, Mississippi*

An advanced thrust-measurement system utilizes active magnetic bearings to both (1) levitate a floating frame in all six degrees of freedom and (2) measure the levitation forces between the floating frame and a grounded frame. This system was developed for original use in measuring the thrust exerted by a rocket engine mounted on the floating frame, but can just as well be used in other force-measurement applications.

This system offers several advantages over prior thrust-measurement systems

based on mechanical support by flexures and/or load cells:

- The system includes multiple active magnetic bearings for each degree of freedom, so that by selective use of one, some, or all of these bearings, it is possible to test a given article over a wide force range in the same fixture, eliminating the need to transfer the article to different test fixtures to obtain the benefit of full-scale accuracy of different force-measurement devices for different force ranges.

- Like other active magnetic bearings, the active magnetic bearings of this system include closed-loop control subsystems, through which the stiffness and damping characteristics of the magnetic bearings can be modified electronically.
- The design of the system minimizes or eliminates cross-axis force-measurement errors. The active magnetic bearings are configured to provide support against movement along all three orthogonal Cartesian axes, and such that the support along a given axis does not