Mechanics/Machinery

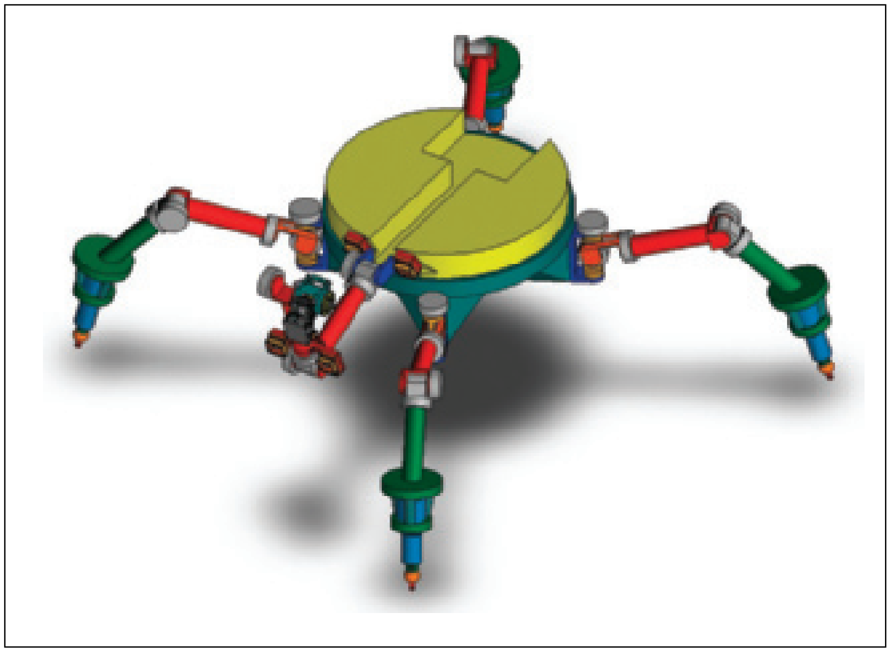
Robot Would Climb Steep Terrain

This walking robot could even climb under overhangs.

NASA's Jet Propulsion Laboratory, Pasadena, California

The figure depicts the steep terrain access robot (STAR) — a walking robot that has been proposed for exploring steep terrain on remote planets. Robots based on the STAR concept could also be used on steep terrain on Earth for diverse purposes that could include not only scientific exploration but also military reconnaissance and search-and-rescue operations.

The STAR would be able to climb up or down on slopes as steep as vertical, and even beyond vertical to overhangs. Its system of walking mechanisms and controls would be to react forces and maintain stability. The STAR would be capable of performing such tasks as acquisition of samples and placement of instruments. To enable the STAR to anchor itself in the terrain on steep slopes to maintain stability and react forces, it would be necessary to equip the tips of the walking legs with new ultrasonic/sonic drill corers (USDCs) and to develop sensors and control algorithms to enable robust utilization of the USDCs.



The **Steep Terrain Access Robot** would walk by use of legs tipped with ultrasonic/sonic devices that would anchor themselves in the terrain.

The plan for the initial stage of development calls for construction of a prototype STAR as a combination of a walking robot, denoted the LEMUR IIb, that was described in "Modification of a Legged Robot to Favor Climbing" (NPO-40354), *NASA Tech Briefs*, Vol. 30, No. 4 (April 2006), page 80. The prototype would enable testing of the STAR concept on planar slopes. Eventually, a robot more like the one shown in the figure would be constructed. This robot would be capable of moving over slopes having three-dimensional features.

This work was done by Brett Kennedy, Anthony Ganino, Hrand Aghazarian, Robert Hogg, Michael McHenry, and Michael Garrett of Caltech for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1).

The software used in this innovation is available for commercial licensing. Please contact Karina Edmonds of the California Institute of Technology at (626) 395-2322. Refer to NPO-41158.

Measuring Dynamic Transfer Functions of Cavitating Pumps

Flow and pressure perturbations are imposed; transfer functions are computed from responses.

Marshall Space Flight Center, Alabama

A water-flow test facility has been built to enable measurement of dynamic transfer functions (DTFs) of cavitating pumps and of inducers in such pumps. Originally, the facility was intended for use in an investigation of the effects of cavitation in a rocket-engine low-pressure oxygen turbopump. The facility can also be used to measure DTFs of cavitating pumps in general.

It is necessary to measure DTFs in order to understand the dynamic couplings between a cavitating pump and the rest of the flow system of which the pump is a part. In the case of a turbopump, inducer cavitation dynamics can cause flow and pressure pulsations arriving at the turbopump inlet to become amplified by the turbopump, thereby giving rise to very large flow and pressure fluctuations in the feed system served by the turbopump. If the feed system in question is a rocket-engine fuel or oxidizer feed system, these flow and pressure fluctuations can, in turn, cause large variations in engine thrust, even to the point of pogo instability. Within the turbopump, the cavitation-induced dynamic couplings generate intense dynamic loads on the inducer blades and the rotor. These loads cause blade failures, seal rubs, and rotordynamic instabilities.

The DTF-measurement facility was constructed by integrating DTF-measuring equipment into a prior pump-testing facility. The major pieces of the DTF-measuring equipment, in order of position along the flow starting at the upstream end, are an inlet flow pulser, inlet flow conditioner, inlet bandwidth-enhanced electromagnetic flowmeter, inlet pressure-measurement station, test inducer, discharge collector, exit flow conditioner, exit enhanced-bandwidth electromagnetic flowmeter, exit flow pulser, flow conditioner, loop flowmeter, and throttle valve. A magnetic-bearing-supported test rotor that was part of the original pump-testing facility is used to support and drive the test inducer. A closed reservoir from the original pump-testing facility is retained for supplying fluid to the inlet and receiving fluid from the outlet of the pump or inducer under test. The facility also includes instrumentation and data-acquisition and data-processing systems designed specifically for quantifying dynamic transfer functions of cavitating inducers.

The flow pulsers can be used to superimpose discrete-frequency pressure and flow fluctuations on the mean loop flow. The enhanced-bandwidth electromagnetic flowmeters enable accurate measurement of the time-dependent components of flow. Special-purpose software calculates parameters of a four-terminal transfer function model of the cavitating pump or inducer system from the amplitudes and relative phases of inlet and exit flow and pressure pulsations over a range of perturbation frequencies and cavitation numbers.

This work was done by Daniel Baun of Concepts NREC for Marshall Space Flight Center. For further information, contact Sammy Nabors, MSFC Commercialization Assistance Lead, at sammy.a.nabors@nasa.gov. Refer to MFS-32519-1.