



### ⊕ Shields for Enhanced Protection Against High-Speed Debris

A report describes improvements over the conventional Whipple shield (two thin, spaced aluminum walls) for protecting spacecraft against high-speed impacts of orbiting debris. The debris in question arise mainly from breakup of older spacecraft. The improved shields include exterior “bumper” layers composed of hybrid fabrics woven from combinations of ceramic fibers and high-density metallic wires or, alternatively, completely metallic outer layers composed of high-strength steel or copper wires. These shields are designed to be light in weight, yet capable of protecting against orbital debris with mass densities up to about  $9 \text{ g/cm}^3$ , without generating damaging secondary debris particles. As yet another design option, improved shields can include sparsely distributed wires made of shape-memory metals that can be thermally activated from compact storage containers to form shields of predetermined shape upon arrival in orbit. The improved shields could also be used to augment shields installed previously.

*This work was done by Eric L. Christiansen and Justin H. Kerr of Johnson Space Center. Further information is contained in a TSP (see page 1).*

*This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Johnson Space Center, (281) 483-0837. Refer to MSC-23443.*

### ⊕ Scaling of Two-Phase Flows to Partial-Earth Gravity

A report presents a method of scaling, to partial-Earth gravity, of parameters that describe pressure drops and other characteristics of two-phase (liquid/vapor) flows. The development of the method was prompted by the need for a means of designing two-phase flow systems to operate on the Moon and on Mars, using fluid-properties and flow data from terrestrial two-phase-flow experiments, thus eliminating the need for partial-gravity testing. The report presents an explicit procedure for designing an Earth-based test bed that can provide hydrodynamic similarity with two-phase fluids flowing in partial-gravity systems. The procedure does not require prior knowledge of the flow regime (i.e., the spatial orientation of the phases). The method also provides for determination of pressure drops in two-phase partial-gravity flows by use of a generalization of the classical Moody chart (previously applicable to single-phase flow only). The report presents experimental data from Mars- and Moon-activity experiments that appear to demonstrate the validity of this method.

*This work was done by Kathryn M. Hurlbert of Johnson Space Center and Larry C. Witte of the University of Houston. Further information is contained in a TSP (see page 1).*

*MSC-23319*

### ⊕ Neutral-Axis Springs for Thin-Wall Integral Boom Hinges

A document proposes the use of neutral-axis springs to augment the unfolding torques of hinges that are integral parts of thin-wall composite-material booms used to deploy scientific instruments from spacecraft. A spring according to the proposal would most likely be made of metal and could be either flat or curved in the manner of a measuring tape. Under the unfolded, straight-boom condition, each spring would lie along the neutral axis of a boom. The spring would be connected to the boom by two supports at fixed locations on the boom. The spring would be fixed to one of the supports and would be free to slide through the other support. The width, thickness, and material of the spring would be chosen to tailor the spring stiffness to provide the desired torque margin to assist in deployment of the boom. The spring would also contribute to the stiffness of the boom against bending and torsion, and could contribute some damping that would help suppress unwanted vibrations caused by the deployment process or by external disturbances.

*This work was done by James M. Ryan of Goddard Space Flight Center. Further information is contained in a TSP (see page 1). GSC-14640*