Books & Reports

Flexible Shields for Protecting Spacecraft Against Debris

A report presents the concept of Flexshield — a class of versatile, lightweight, flexible shields for protecting spacecraft against impacts by small meteors and orbiting debris. The Flexshield concept incorporates elements of, but goes beyond, prior spacecraft-shielding concepts, including those of Whipple shields and, more recently, multi-shock shields and multi-shock blankets. A shield of the Flexshield type includes multiple outer layers (called "bumpers" in the art) made, variously, of advanced ceramic and/or polymeric fibers spaced apart from each other by a lightweight foam. As in prior such shields, the bumpers serve to shock an impinging hypervelocity particle, causing it to disintegrate, vaporize, and spread out over a larger area so that it can be stopped by an innermost layer (back sheet). The flexibility of the fabric layers and compressibility of the foam make it possible to compress and fold the shield for transport, then deploy the shield for use. The shield can be attached to a spacecraft by use of snaps, hook-and-pile patches, or other devices. The shield can also contain multilayer insulation material, so that it provides some thermal protection in addition to mechanical protection.

This work was done by Eric L. Christiansen and Jeanne Lee Crews of **Johnson Space Center**.

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-23314.

Part 2 of a Computational Study of a Drop-Laden Mixing Layer

This second of three reports on a computational study of a mixing layer laden with evaporating liquid drops presents the evaluation of Large Eddy Simulation (LES) models. The LES models were evaluated on an existing database that had been generated using Direct Numerical Simulation (DNS). The DNS method and the database are described in the first report of this series, "Part 1 of a Computational Study of a Drop-Laden Mixing Layer" (NPO-30719), *NASA Tech Briefs*, Vol. 28, No.7 (July 2004), page 59. The LES equations, which are derived by applying a spatial filter to the DNS set, govern the evolution of the larger scales of the flow and can therefore be solved on a coarser grid. Consistent with the reduction in grid points, the DNS drops would be represented by fewer drops, called "computational drops" in the LES context. The LES equations contain terms that cannot be directly computed on the coarser grid and that must instead be modeled. Two types of models are necessary: (1) those for the filtered source terms representing the effects of drops on the filtered flow field and (2) those for the sub-grid scale (SGS) fluxes arising from filtering the convective terms in the DNS equations. All of the filtered-source-term models that were developed were found to overestimate the filtered source terms. For modeling the SGS fluxes, constant-coefficient Smagorinsky, gradient, and scale-similarity models were assessed and calibrated on the DNS database. The Smagorinsky model correlated poorly with the SGS fluxes, whereas the gradient and scale-similarity models were well correlated with the SGS quantities that they represented.

This work was done by Nora Okong'o and Josette Bellan of Caltech for **NASA's Jet Propulsion Laboratory**. *Further information is contained in a TSP (see page 1).*
NPO-30732

Controllable Curved Mirrors Made From Single-Layer EAP Films

A document proposes that lightweight, deployable, large-aperture, controllable curved mirrors made of reflectively coated thin electroactive-polymer (EAP) films be developed for use in spaceborne microwave and optical systems. In these mirrors, the EAP films would serve as both structures and actuators. EAPs that are potentially suitable for such use include piezoelectric, electrostrictive, ferroelectric, and dielectric polymers. These materials exhibit strains proportional to the squares of applied electric fields. Utilizing this phenomenon, a curved mirror according to the proposal could be made from a flat film, upon which a nonuniform electrostatic potential (decreasing from the center toward the edge) would be imposed to obtain a required curvature. The effect would be analogous to that of an old-fashioned metalworking practice in which a flat metal sheet is made into a bowl by hammering it repeatedly, the frequency of hammer blows decreasing with distance from the center. In operation, the nonuniform electrostatic potential could be imposed by use of an electron gun. Calculations have shown that by use of a single-layer film made of a currently available EAP, it would be possible to control the focal length of a 2-m-diameter mirror from infinity to 1.25 m.

This work was done by Xiaoqi Bao, Yoseph Bar-Cohen, and Stewart Sherrit of Caltech for **NASA's Jet Propulsion Laboratory**. *Further information is contained in a TSP (see page 1).*
NPO-40275

Demonstration of a Pyrotechnic Bolt-Retractor System

A paper describes a demonstration of the X-38 bolt-retractor system (BRS) on a spacecraft-simulating apparatus, called the Large Mobility Base, in NASA's Flight Robotics Laboratory (FRL). The BRS design was proven safe by testing in NASA's Pyrotechnic Shock Facility (PSF) before being demonstrated in the FRL. The paper describes the BRS, FRL, PSF, and interface hardware. Information on the bolt-retraction time and spacecraft-simulator acceleration, and an analysis of forces, are presented. The purpose of the demonstration was to show the capability of the FRL for testing of the use of pyrotechnics to separate stages of a spacecraft. Although a formal test was not performed because of schedule and budget constraints, the data in the report show that the BRS is a successful design concept and the FRL is suitable for future separation tests.

This work was done by Nick Johnston, Rafiq Ahmed, Craig Garrison, Joseph Gaines, and Jason Waggoner of **Marshall Space Flight Center.** *To obtain a copy of the paper,"X-38 Bolt Retractor Subsystem Separation Demonstration," NASA/TM-2002-212047, September 2002, access http://trs.nis.nasa.gov/archive/00000604.*
MFS-31874