



### Analysis of Designs of Space Laboratories

A report presents a review of the development of laboratories in outer space, starting from the pioneering Skylab and Salyut stations of the United States and the former Soviet Union and progressing through current and anticipated future developments. The report includes textual discussions of space-station designs, illustrated with drawings, photographs, and tables. The approach taken in the review was not to provide a comprehensive catalog of each space laboratory and every design topic that applies to it, but, rather, to illustrate architectural precedents by providing examples that illustrate major design problems and principles to be applied in solving them. Hence, the report deemphasizes information from the most recent space-station literature and concentrates on information from original design reports that show how designs originated and evolved. The most important contribution of the review was the development of a methodology, called “units of analysis,” for identifying and analyzing design issues from the perspectives of four broad domains: laboratory science, crew, modes of operations, and the system as a whole.

*This work was done by Marc M. Cohen of Ames Research Center. Further information is contained in a TSP (see page 1). ARC-14965*

### 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 arises 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 g/cm<sup>3</sup>, 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-22330.*

### Study of Dislocation-Ordered In<sub>x</sub>Ga<sub>1-x</sub>As/GaAs Quantum Dots

A report describes an experimental study of dislocation-induced spatial ordering of quantum dots (QDs) comprising nanometer-sized In<sub>x</sub>Ga<sub>1-x</sub>As islands surrounded by GaAs. Metastable heteroepitaxial structures were grown by molecular-beam epitaxy of In<sub>x</sub>Ga<sub>1-x</sub>As onto n<sup>+</sup>GaAs and semi-insulating GaAs substrates. Then the structures were relaxed during a post-growth annealing/self-organizing process leading to the formation of surface undulations that acted as preferential sites for the nucleation of QDs. Structural effects of annealing times and temperatures on the strain-relaxed In<sub>x</sub>Ga<sub>1-x</sub>As/GaAs and the subsequent spatial ordering of the QDs were analyzed by atomic-force microscopy and transmission electron microscopy. Continuous-wave spectral and time-resolved photoluminescence (PL) measurements were performed to study the effects, upon optical properties, of increased QD positional ordering, increased QD uniformity, and proximity of QDs to arrays of dislocations. PL spectral peaks of ordered QD structures formed on strain-relaxed In<sub>x</sub>Ga<sub>1-x</sub>As/GaAs layers were

found to be narrower than those of structures not so formed and ordered. Rise and decay times of time-resolved PL were found to be lower at lower temperatures — apparently as a consequence of decreased carrier-transport times within the barriers surrounding the QDs.

*This work was done by Rosa Leon of Caltech for NASA’s Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1). NPO-30691*

### Tilt-Sensitivity Analysis for Space Telescopes

A report discusses a computational-simulation study of phase-front propagation in the Laser Interferometer Space Antenna (LISA), in which space telescopes would transmit and receive metrological laser beams along 5-Gm interferometer arms. The main objective of the study was to determine the sensitivity of the average phase of a beam with respect to fluctuations in pointing of the beam. The simulations account for the effects of obscurations by a secondary mirror and its supporting struts in a telescope, and for the effects of optical imperfections (especially tilt) of a telescope. A significant innovation introduced in this study is a methodology, applicable to space telescopes in general, for predicting the effects of optical imperfections. This methodology involves a Monte Carlo simulation in which one generates many random wavefront distortions and studies their effects through computational simulations of propagation. Then one performs a statistical analysis of the results of the simulations and computes the functional relations among such important design parameters as the sizes of distortions and the mean value and the variance of the loss of performance. These functional relations provide information regarding position and orientation tolerances relevant to design and operation.

*This work was done by Miltiadis Papalexandris of Caltech and Eugene Waluschka of Goddard Space Flight Center for NASA’s Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1). NPO-30709*