Once-marooned Spacecraft Gets an Earthly Physical

Plucked from space 4 years behind schedule, a research spacecraft begins yielding a cache of data

ON 12 JANUARY 1990 THE CREW OF THE space shuttle Columbia plucked an experiment-laden space platform from its decaying orbit just 2 months before it would have ended as a spray of falling stars.

Since its eleventh-hour rescue, the Long Duration Exposure Facility (LDEF (pronounced "el-def")) has been telling a sometimes surprising though still preliminary story about conditions in space—a story especially gripping to those aiming to build space stations and other craft fit for long tours of extraterrestrial duty. Last week, more than 400 researchers gathered near the Kennedy Space Center in Florida for the First LDEF Post-Retrieval Symposium. "This is an opportunity of a lifetime for people who are interested in the space environment's effects on materials," says Bland Stein, chairman of LDEF's Materials Special Investigation Group at NASA's Langley Research Center in Virginia.

For a while last week, the opportunity seemed a transient one for those hoping to use LDEF data to design and build the controversial Space Station Freedom. On Monday the House Appropriations Committee had axed funding for that project. But the money was at least temporarily restored on Thursday (see page 1483).

The fate of the space station notwithstanding, the LDEF project offers a treasure trove of more basic and generically useful data, said scientists at the meeting. The spacecraft carried tens of thousands of samples, ranging from spacecraft components, systems, and materials to seeds, shrimp eggs, and bacteria. They were carried mostly in 57 trays that lined the outside of the school bus-size craft. Ongoing analysis of those samples is already providing new insight into the space-worthiness of many materials, as well as into the environment of space between 180 and 270 nautical miles above Earth—a place rife with radiation, meteoroids, space-age debris, vacuum conditions, and reactive chemical species such as atomic oxygen.

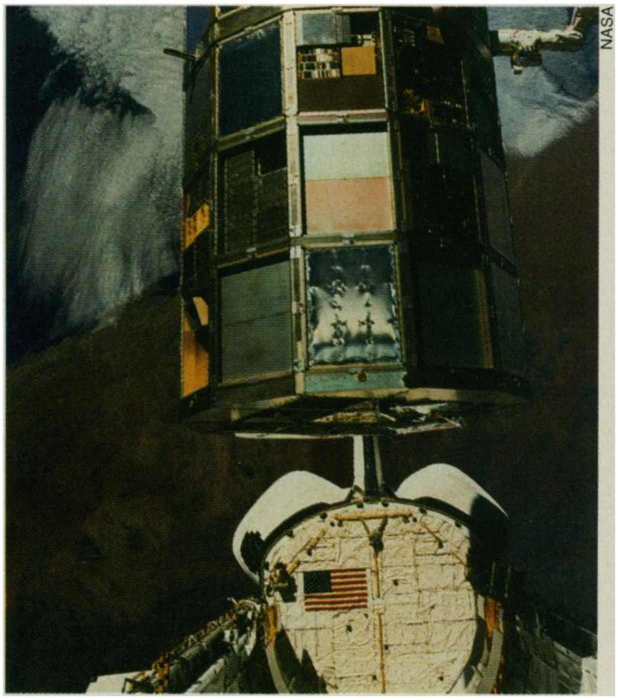
During its nearly 6-year orbital stay, which began in April 1984 and was prolonged by shuttle scheduling delays in 1985 and the explosion of the Challenger in 1986, LDEF was pitted with craters from more than 30,000 collisions with objects—some as big as poppy seeds—including space dust, paint flecks, silver solder, and micrometeoroids. J. Derral Mulholland of the Institute for Space Science and Technology in Gainesville, Florida, reported that during a 2-minute interval on 4 June 1984, LDEF passed through a debris cloud that accounted for about 1% of the year's total collisions. "It was like a shotgun blast," he said.

As expected, polymer, metal, glass, composite, and other materials mounted on the LDEF's leading edge showed far more wear and tear than matched specimens on the trailing edge or elsewhere. The erosion stems largely from high-speed contact with oxygen atoms. But many specimens, including optical fibers and metal-coated polymers, survived essentially unscathed, as did LDEF's aluminum framework.

Soon after LDEF was recovered in 1990, it was clear that atomic oxygen had taken a visible toll on its thermal control blankets—the same kind with which engineers were equipping the soon-to-be launched Hubble Space Telescope, Stein said in an interview. "The Hubble Telescope people were horrified by the possibility that the thermal control properties might have changed," he added. The blankets' teflon layers were no longer clear and the silver backing had peeled away at sites of meteorite or debris impact. Subsequent tests of the blankets eased the tension, however. "They may not look good, but they'll do their job," Stein said.

LDEF also brought a mystery back to Earth. Gary Phillips, a nuclear physicist from the Naval Research Laboratory, and his colleagues measured about 2000 times more radioactive beryllium-7, mostly on LDEF's leading edges, than the spacecraft should have collected at its orbital altitude. This isotope forms at lower atmospheric regions when cosmic rays hit nitrogen or oxygen atoms. Phillips speculates that enhanced solar flare activity in the months prior to LDEF's recovery may have generated large amounts of Be-7 in the upper polar atmosphere, which then rose to higher altitudes before migrating equator-ward into LDEF's path.

Another surprise for LDEF researchers was a brown residue, dubbed the "nicotine stain," that nearly covered the spacecraft. "We now know that it is a combination of silicones and organics," NASA's Stein says. The chemical components of the stain outgassed mostly from the thermal control paints on LDEF's external and internal surfaces. Once the substances were deposited onto LDEF surfaces, ultraviolet radiation quickly polymerized them into the brown residue. "Contamination is going to be a tremendous concern for any future spacecraft," said William Kinard, head of the LDEF science office at Langley. Optical components, thermal control devices, and sensors that rely on unobstructed surfaces are particularly vulnerable.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Catching a falling star. *Shuttle rescues LDEF.*

Results from some of the few biology experiments aboard LDEF also raised a few eyebrows. Tomato seeds that flew on LDEF and were distributed to schools last year as part of a massive nationwide educational project had a higher survival rate than matched seeds stored on the ground. Tallies from the 3.3 million students who planted the seeds indicate that space-exposed seeds germinated at a rate of 73.8%, compared to 70.3% for their Earth-stored counterparts. In another LDEF biology experiment, bacteria on a variety of seeds were found to have survived the entire trip.

For a long time to come, says Kinard, "LDEF data will be a benchmark for what the space environment is and for what happens to materials in it." ■ IVAN AMATO