Left in Space

After circling Earth for nearly six years, an unmanned laboratory is coming home

By IVAN AMATO

On April 7, 1984, soaring 257 nautical miles above the Earth, astronaut Terry Hart used the space shuttle Challenger's manipulator arm to float an experiment-laden, 12-sided satellite into proper orbital orientation and then surrendered it to the invisible tethers of Earth's gravitational field.

There the laboratory – called the Long-Duration Exposure Facility (LDEF) – began its silent, vital task of just staying in space. More than 200 investigators from 70 companies, universities and research centers worldwide had loaded this orbiting techno-patchwork with 57 experiments, carried mostly on the 86 experimental trays covering the ends and the sides of the 14-foot diameter, 40-foot-long facility. And LDEF did stay in space, stranded there more than four years longer than originally planned.

For more than five years now, some of its experiments have probed, measured and monitored cosmic-ray nuclei and other space particles originating at the sun and at more distant stars. Others have studied particles trapped in Earth's magnetic field or collected micrometeoroids and other debris from the solar system's younger days. Many researchers hope to learn what happens to various materials – including reinforced epoxy composites, reflective coatings and spacecraft components such as optical fibers and solar cells – after long tours in the exotic environment of space. The health of human space travelers and the structural integrity of future spacecraft or space stations may depend on such knowledge.

NASA's original plan called for LDEF to remain aloft for 12 to 18 months, after which shuttle astronauts would retrieve it. Lacking telemetry for radioing data Earthward, the voiceless laboratory would horde its ever-growing treasury of data until researchers on *terra firma* got LDEF's experiment-laden trays into their laboratories and started to determine how space conditions had affected their samples.

As part of a tightly scheduled space program in which delays seem the norm, a postponement of LDEF's recovery until autumn of 1986 came as no surprise. But on Jan. 28, 1986, Challenger – which not only carried LDEF to its high perch but was slated to recover it – exploded over the Atlantic Ocean. Seven crew members died, and NASA postponed all future shuttle missions. Five and a half years after LDEF's launch, scientists still await its results. "The only information from LDEF so far is its orbital decay," says LDEF program manager E. Burton Lightener of NASA's Langley Research Center in Hampton, Va.

Today, as NASA gears up for a year-end retrieval mission with the shuttle Columbia, anxiety runs high. The orbit of the powerless spacecraft has dropped so much that if the planned retrieval fails, scientists will lose all their experiments and the data they carry when LDEF instead returns to Earth the hard way – by burning up as it tumbles through the atmosphere sometime in early February. Such a loss would be especially wasteful now, researchers say, because the value of LDEF data has multiplied with each extra year in orbit.

Hundreds of experiments lie in trays on the ends and sides of this orbiting lab.

In the wake of the Challenger disaster, NASA officials predicted LDEF would remain at comfortably high altitudes, far above the fiery friction of the atmosphere, until the mid-1990s. But since scientists made those calculations, unusually energetic solar activity has sent strong bursts of particles and radiation Earthward. The cosmic pelting is causing LDEF's orbit to decay much faster than anticipated. In mid-September, NASA calculated the lab was 212 nautical miles overhead and recoverable only until Feb. 1, 1990, when it would orbit too close to the upper atmosphere for the shuttle to approach safely. Lightener notes that these estimates depend on day-to-day variations in solar activity and could be off by as much as four weeks in either direction.

Major schedule delays, mechanical setbacks or a failure to maneuver LDEF into the shuttle's cargo bay are unlikely, Lightener says, but any of these glitches could derail the recovery. If plans fall through and LDEF comes tumbling down through space, NASA contends there's virtually no threat of harm to people on the ground. Nonetheless, researchers with experiments onboard liken such a reentry to the sinking of a gold-laden Spanish galleon, only without hope of recovering its priceless cargo. "It's now or never," Lightener says.

If all goes as planned, LDEF will come home in the hold of Columbia during a mission slated to begin Dec. 18, roughly six weeks before recovery becomes impossible. "You are looking at something that has to happen," Lightener says. "Things have to fall into place, and it has to keep going along on schedule."

Many of the experiments have gathered data important to planning and designing future long-duration space projects, most notably a space station. Some of these experiments involve duplicate samples of materials placed on both the leading and trailing edges of LDEF to assess the affect of chemically reactive atomic oxygen emanating from the top of the atmosphere. Other materials experiments have tested the integrity of welds, the mechanical stability and strength of polymer- or metal-based composite materials, the performance of solar-energy systems and components, and the data-storing ability of holographic crystals. Additional projects include testing the long-term condition and performance of temperature-control devices and coatings, antenna materials, optical glasses and fibers and filters used in devices that monitor atmospheric temperature and chemical composition.

Never before have scientists designed a craft specifically to study the long-term effects of the space environment on materials and components. Although researchers have had opportunities to study some objects after various periods of space exposure – such as the shuttles, Apollo return modules and components from the Solar Maximum Mission satellite – none of these was intended as an experiment for return and analysis in terrestrial laboratories.

"This is the first really long-term data that we are going to get from experiments that were set up as experiments," says materials scientist Wayne S. Slemp at NASA's Langley facility. His LDEF experiments focus on a variety of coatings, composites and polymeric materials that may one day be used for large space structures and spacecraft. "In this case, we have controlled experiments on the ground and we analyzed all materials prior to launch," Slemp says. "We'll be able to do chemical analyses and property-change studies."

Like Slemp's project, about half of LDEF's experiments are completely passive, requiring nothing more than exposure to space. Others rely on self-contained power sources – batteries or solar cells – to carry out such functions as recording data, opening valves or vaporizing liquids.

About a third of the experiments focus on basic astrophysics, biology or geoscience. By capturing atoms arriving in the solar system from distant stars as well as atoms from the sun, U.S. and Swiss physicists hope to learn about the composition of the interstellar milieu and how stars churn out different atomic nuclei. Irish researchers hope to analyze data from the ultraheavy cosmic-ray nuclei that often crash into atmospheric atoms and produce complex cascades of particles. Seven U.S. government and university researchers sent up an experiment designed to measure the energy range of fast-moving hydrogen nuclei trapped in the Earth's magnetic field. They hope to learn how such nuclei might affect people and electronic components in space, and are seeking to apply the findings to the proposed space station.

By designing experiments to capture micrometeoroids and other small particles in stacks of thin foils, British physicists hope to learn about the size, velocity, composition and distribution of such particles. Others hope to learn what proportion of orbiting debris is human-made. French, German and U.S. researchers hope to capture their own micrometeoroids for chemical analyses, which should help them understand how the solar system evolved and test a hypothesis suggesting that most micrometeoroids come from comets. Other researchers seek to study the impact craters created in a variety of metallic and glass materials by these and other space particles. Researchers from Rockwell International Corp. in Thousand Oaks, Calif., and the Technical University of Denmark in Lyngby await results from an experimental attempt to grow several types of superpure, single crystals in near-zero gravity by allowing reactant solutions to diffuse slowly toward each other through a pure solvent.

West German specialists in flight and space medicine sent along an LDEF tray designed to test the effects of cosmic radiation on proteins, plant seeds, spores and other biological materials. They expect the data will help establish radiation protection guidelines for biological experiments in space and for people on long-duration space missions.

Another life sciences experiment, coordinated by the George W. Park Seed Co. in Greenwood, S.C., tests the survivability of hundreds of types of flower and vegetable seeds in both sealed containers and ones vented to the space environment. A somewhat similar project, designed jointly by NASA and Park Seed, is intended specifically for educational purposes. To set up this experiment – called SEEDS, for Space-Exposed Experiment Developed for Students – investigators sealed 12.5 million tomato seeds (56 pounds) in five containers with transparent, domed caps to maximize exposure to mutation-causing space radiation. After recovery, NASA educational services plans to transfer the seeds into kits and distribute them to as many as 4 million students, mostly at the precollege level. The students, rather than professional scientists, will discover how the space environment affects seeds' germination rates and the plants they become. "These kids are going to get to do the first experiments," says Jim A. Alston of Park Seed.

Though finding useful mutations was not the project's intent, Alston says the company will have its eyes open for such events. "If a teacher calls and says, 'Hey, I've got this bright blue tomato,' we're going to go take a look at it," he says.

Although a few experiments may suffer from the years of delay, LDEF researchers say most experiments actually have increased in value. Compared with the information that would have come from LDEF if astronauts had retrieved the craft in 1985 as originally planned, the data windfall from the longer-duration LDEF mission will allow engineers to make far more confident extrapolations regarding the condition of materials after 20 years of service in space. The facility's extended stay in space also should sharpen the scientific picture of such phenomena as cosmic-ray nuclei and micrometeoroids.

The delay has even created new experimental possibilities. NASA has assembled four special investigation groups to uncover ways of seeking out more materials science and space engineering data by looking at the LDEF patchwork of experiments as a system. They will look closely, for example, at batteries, tape recorders and other experiment components not originally intended as samples.

But until the laboratory comes home, such plans remain no more than talk. And if further delays ground the recovery mission, LDEF's tumbling return may yield little more than a beautiful display of shooting stars. □