Taking it to (and Repairing) the Max

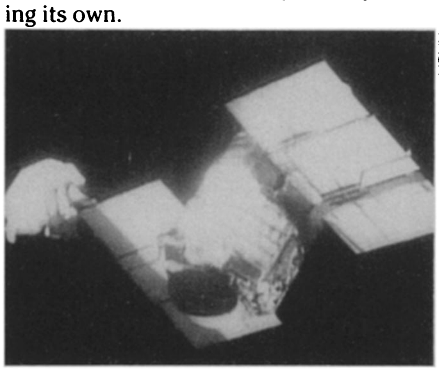
The first crew of astronauts to reach the first U.S. space station — Skylab — in 1973 had a vital task to perform before they could get down to their intended business of scientific research. The crew's job was simply to cut a metal strap, which was preventing one of the craft's solar panels from opening. But it took special tools, lengthy consultations with engineers on the ground and simultaneous space walks by two astronauts. Their success helped enable the three Skylab missions, which still stand as the longest U.S. space forays ever flown.

The crew of the space shuttle Challenger had a potentially as far-reaching objective when they took off April 5 in an attempt to rescue the crippled Solar Maximum Mission satellite, long known as "Solar Max." Launched on Feb. 14, 1980, Max had been heavily instrumented to study the sun for at least two years, but in its tenth month aloft, it blew three fuses in the attitude-control system that had been keeping it properly oriented in space. Engineers improvised a backup system using three electromagnetic "torque bars" (originally included for a different purpose), which held Max in position by controlling its orientation with respect to earth's magnetic field. But the bars provided such a weak aligning force that four of the satellite's seven scientific instruments could no longer be pointed accurately enough to do their jobs. Fortunately, Solar Max was literally designed to be fixed.

Unlike every artificial earth satellite before it, Max was built according to a modular scheme that would allow key components — such as the attitude-control system — simply to be unplugged and replaced with new ones. And the shuttle (though it had not yet made its debut when Max was launched) would make the service calls.

Before Challenger's crew could even attempt to bring Max into the shuttle's cargo bay for repairs, however, they first had to empty their craft of another payload: a 21,400-pound, 30-foot long, 12-sided cylinder called the Long-Duration Exposure Facility (LDEF). Developed at the National Aeronautics and Space Administration's Langley Research Center in Virginia, LDEF is one of the most passive satellites ever flown. No radios, no attitude-control system — LDEF is simply a storage rack, packed with dozens of individual trays and compartments containing equipment and test samples for (in this first mission) 57 separate experiments representing 194 researchers from nine countries. Its goal is simply to sit in orbit, exposing its samples to weightlessness, cosmic rays and other space conditions for 10 months, after which the shuttle will bring it back to earth for study. (Other LDEF missions now being studied would keep the rack aloft for as long as a decade, while the shuttle replaces or modifies individual experiments.)

Astronaut Terry J. Hart set LDEF out in space on Challenger's second day in orbit by using the shuttle's remote-control arm. LDEF has about two and a half times the mass of any object ever handled by the arm before but the operation went without a hitch. Because some of its experiments (such as micrometeoroid and cosmic-ray studies) must point away from the earth, while others (such as tests of components for a future earth-pointing satellite) must look "down," LDEF's mass is distributed so that the natural "gravity gradient" will keep it in the proper orientation. Early looks indicated that it was passively holding its own.



NASA

Nelson grabs a panel to try to slow Max.

The effort to service Solar Max began in the same just-as-planned fashion. With veteran astronaut Robert Crippen in the driver's seat, Challenger was maneuvered ever closer to the satellite. Finally, rookie George Nelson strapped himself into one of the sophisticated jet-equipped backpacks that had been tested for this very purpose during the previous shuttle flight two months before. Right on schedule, Nelson floated across the intervening 200 feet to link up with Max. Mounted in front of him on the protruding arms of the backpack was what amounted to a thick metal disk containing a hole sized to fit a rigid pin projecting from the satellite's side.

The plan called for Nelson to impale the disk on the pin, which was supposed to trigger a set of three teeth inside the disk, causing them automatically to snap shut on the tip and firmly link astronaut and satellite together. Nelson's approach, long practiced in NASA's simulators, was textbook perfect, and he slipped the disk onto the pin with seeming ease — only to find himself bouncing away again instead of being firmly locked to it. He tried again, approaching with a slightly greater speed, but with the same result. A third try was similarly unsuccessful. "I can't believe this," he exclaimed.

Ever since its arrival into orbit, Solar Max had been turning at a regular 1° per second, and a vital part of Nelson's docking exercise was to bring the rotation to a halt using the backpack's jets to apply the brakes. When the pin would not stay in its hole, however, the jets could not help and Nelson tried to stop Max's rotation by grabbing one of its solar panels with his space suit-gloved hands. The only result of the attempt, however, combined with the earlier bumps from the disk, was to change Max's regular rotation into a complex triaxial motion that compounded the problem of getting its movements under control.

The alternative method of capturing the satellite was to grasp it with the remote control arm, but the new "wobble," though slow, made this a formidable task, posing the problem of reaching in to a deliberately provided docking point while dodging the solar panels as they came by in their hard-to-predict pattern.

Engineers at NASA's Goddard Space Flight Center in Maryland, however, hit upon a plan. They radioed up a new program to the satellite's computer instructing it to use the magnetic torque bars to bring all this motion to a halt. Tense moments were spent, however, waiting for the "damping" to take effect, since Max's batteries, now being charged by solar panels only seldom pointed at the sun, were draining rapidly.

With less than an hour of power remaining, the solar panels happened to fall into sunlight for about 10 minutes at a stretch. This provided eight priceless hours of power (almost everything else aboard Max but its receiver was turned off), and when Max finally came to a near-stop, the Goddard team set up another computer program that both gave Max a simple, stabilizing rotation and left it pointing at the sun. This time, with Hart at the controls of the arm, the capture was almost easy.

The next day, Nelson and fellow rookie James van Hoften space walked through Max's repairs in well under their allotted time. Besides plugging in the new attitude-control module, they replaced the main electronic box on one of the satellite's scientific instruments — a coronagraph/polarimeter, not designed in easy-fix modules — and added a protective cover to another, an x-ray polychromator. By SN's deadline, the renewed Solar Max was being checked out in preparation for return to its orbit the following day.

— *J. Eberhart*