MR-13

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

mission report

"Man Still Matters"–The Story of The First Skylab Mission

"I guess the way I could summarize this project is that it proves that man still matters. . . . You have made us all very proud with the way you handled some difficult problems in this project."

—**President Richard M. Nixon** in a radio telephone conversation with the orbiting Skylab astronauts on June 18, 1973.

The first Skylab mission, epitomized above by the President, dramatized the fact that man working in combination with automated instruments can far more fully explore and utilize space for world benefit than either can alone.

Skylab 1—which includes the Orbital Workshop (OWS) where men live and conduct experiments, the Apollo Telescope Mount (ATM) which is a solar observatory, and related docking, airlock, and electronic components—was launched at 1:31 p.m. EDT, May 14, 1973. About a minute after launch, an 800-pound meteoroid shield was torn from the OWS, ripping away one OWS solar wing and jamming the other so that it could not operate or open properly. Solar wings have arrays of silicon solar cells that convert sunlight to electricity for powering spacecraft and their experiments. Without the OWS wings, Skylab's available power supply was cut in half.

The power loss was but one of the major problems confronting Skylab. Equally serious was the loss of the shield.

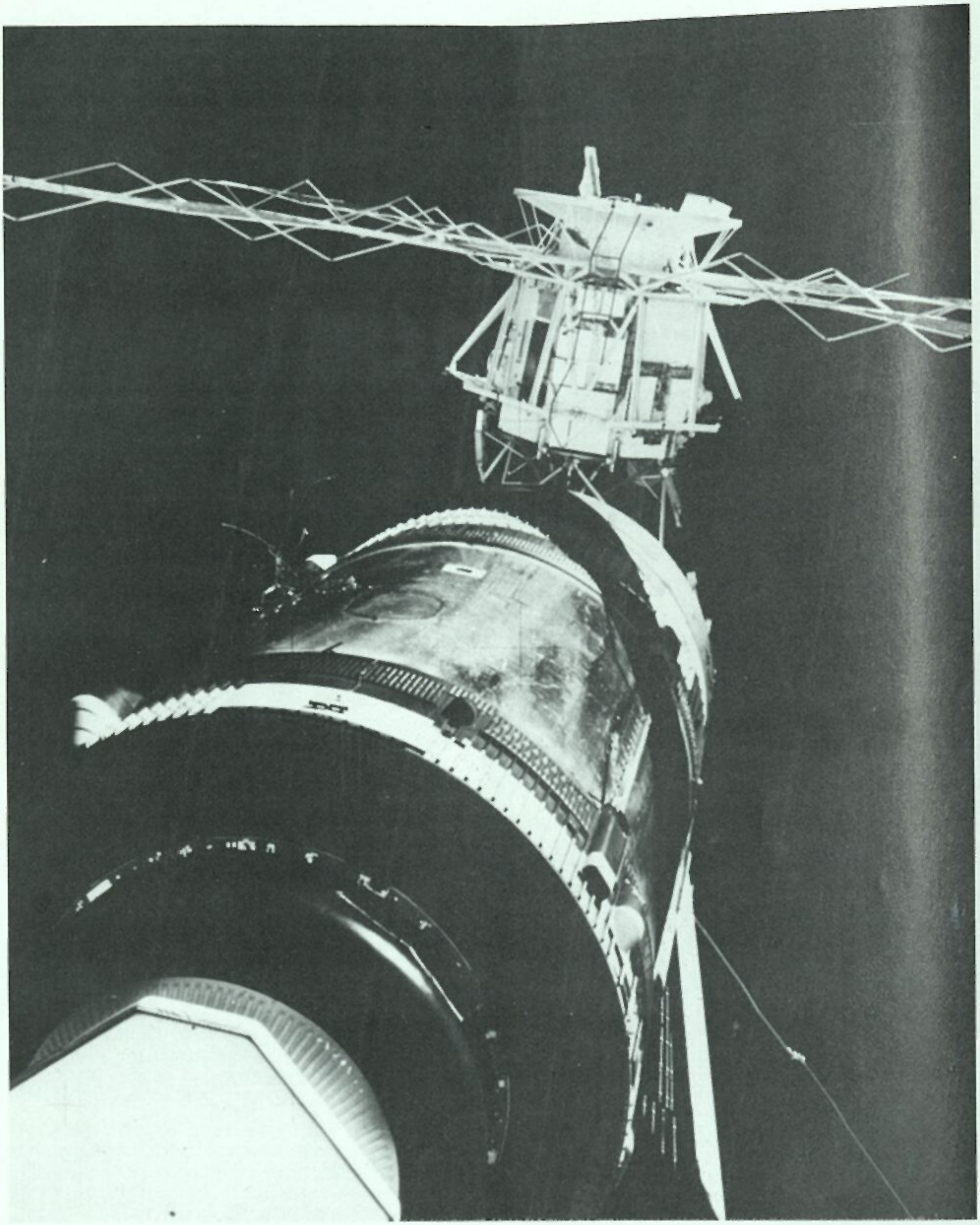
The purpose of the cylindrical shield was two-fold. Without the .025-inch thin aluminum shield, Skylab is directly exposed to microscopic dust particles that could make tiny punctures in its walls. However, engineers believe Skylab's pressurization system can readily compensate for such circumstances.

More important, the shield was painted to ward off much of the Sun's heat and keep the OWS cool. Its absence caused temperatures inside the OWS to rise ominously, threatening to spoil the food, medicines, and photographic film stowed on board at launch. Skylab's outside skin temperatures reached nearly 300 degrees Fahrenheit. Short of power and too hot for prolonged habitation, Skylab had all the hallmarks of a failure. It was saved by the dedicated and tireless efforts of the first Skylab crew—Capt. Charles Conrad, Jr.; Commander Joseph P. Kerwin, and Commander Paul J. Weitz—and NASA and industry ground personnel.

The Apollo Telescope Mount (ATM) and its solar panels had properly extended. With this power, ground controllers were able to operate Skylab. After a number of maneuvers to decrease the critical internal temperatures, Skylab was stabilized to both illuminate the ATM panels (for power) and to reduce direct sunlight on the OWS. The results:

- Internal temperatures were stabilized at 125 degrees Fahrenheit, which was still too hot for normal habitation.
- Power levels were about 2800 watts, enough for unmanned operation.
- Skylab was oriented with a 45-50 degree pitch-up (nose-up) attitude for which it was not designed. To maintain this orientation put serious strain on Skylab's supply of nitrogen gas maneuvering fuel.
- Skylab could not be oriented to point the ATM at the Sun because of temperature increases nor to aim Earth resources instruments at the ground because this would reduce sunlight on the ATM solar panels and drain the batteries.
- Beta angles—the angles between the Sun and Skylab's orbit—were moving in a way to drive OWS temperatures up again.

NASA and industry personnel pitched in offering a



View of damaged Skylab workshop, showing unshielded area where parasol was later deployed. Jammed solar wing is at lower right.

wide variety of ideas for a makeshift sun shield. These were trimmed to three that were fabricated. The three went along with Conrad, Kerwin, and Weitz when the astronauts were launched on May 25 in an attempt to save their mission and the Skylab program. The astronauts also carried other carefully selected tools, including bolt cutters, a bending tool (boat hook), tin snips and food and drugs to replace those believed already spoiled by the heat. Launched at 9 a.m. EDT, the crew rendezvoused with the space station at 4:30 p.m. EDT. They reconnoitered: maneuvering around the station, inspecting the damage, and telecasting these observations to Earth.


Skylab 2/Saturn IB takes off with Astronauts Conrad, Kerwin, and Weitz.

Then, they soft-docked—partially attached their modified Apollo Command/Service module (CSM) spacecraft, called Skylab 2, to Skylab 1—while they made preparations for standing up in Skylab 2 and attempting to free the jammed solar panel. Later, they undocked Skylab 2, maneuvered it to the jammed solar panel, and attempted unsuccessfully to free it.

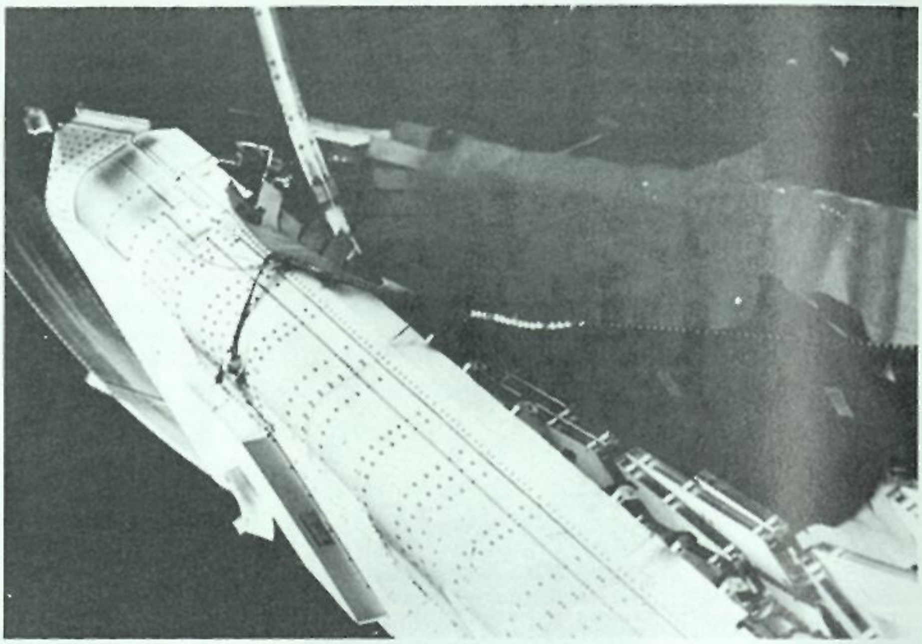
Two problems were responsible for their failure: the aluminum strip from the meteoroid shield that had twisted around the wing was held fast by a bolt that had deeply penetrated the wing; and the slope of the solar wing was such that the available tools could not adequately grip it. Ascertaining the problem, however, proved to be the first step toward its eventual solution.

When the astronauts returned to the Skylab 1 docking port, they encountered a balky mechanism which foiled four docking attempts.

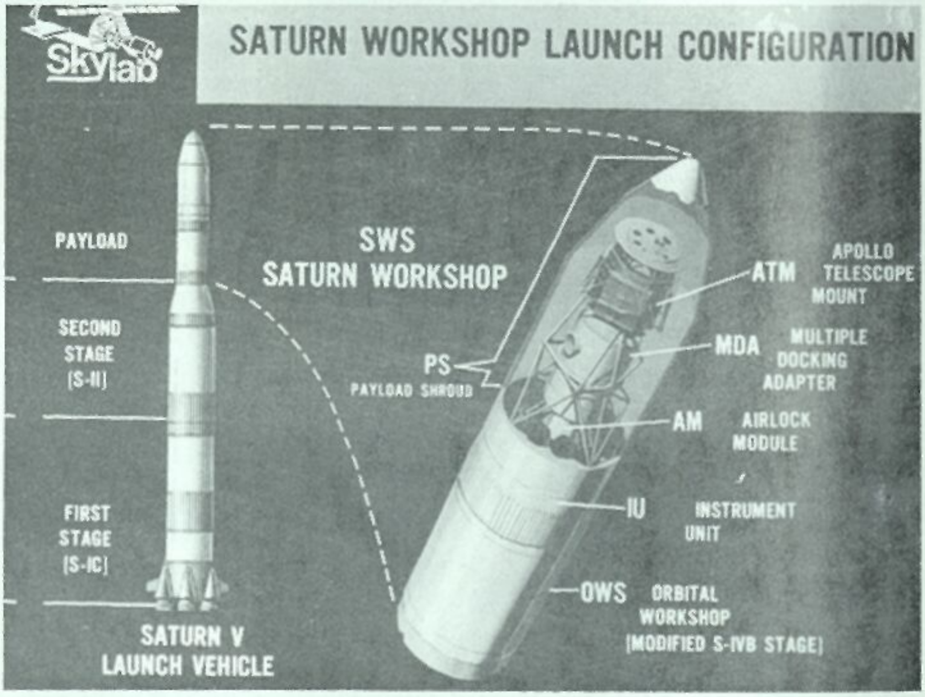
On their fifth try, using a planned back-up technique, they achieved a hard dock—full attachment—sealing their CSM to the station. The time was 11:50 p.m. The crew spent the remainder of the night in their docked CSM. (Later, they repaired the docking mechanism.)

The next day, they entered and prepared to erect a sun shield over the OWS. They had three approaches, of which the prime (preferred) one was a parasol erected from inside the station through an airlock originally intended for solar-oriented scientific expermients. The parasol was the least difficult means to deploy. Using procedures conceived just two days earlier, the crew made a boom composed of five rods screwed end to end at the top of which was a folded shade. They poked this boom through the airlock. When the boom was out far enough, the sunshade was opened. The shade was designed to cover an area 22 x 24 feet, but it had a few wrinkles. Still it covered about 90 percent of the meteoroid shield area and brought inside temperatures gradually down. In about 11 days, the inside temperature was a comfortable 75 degrees.

The other techniques were to be used if debris blocked the scientific airlock through which the parasol was poked. In one, the astronauts would stand in the open hatch of their command module and unroll a trapezoidal awning from the bottom, or far end, of Skylab to the handrail of the ATM. The narrow end of the awning would be toward the ATM.



Close-up of jammed solar wing, showing aluminum strapping that held it.



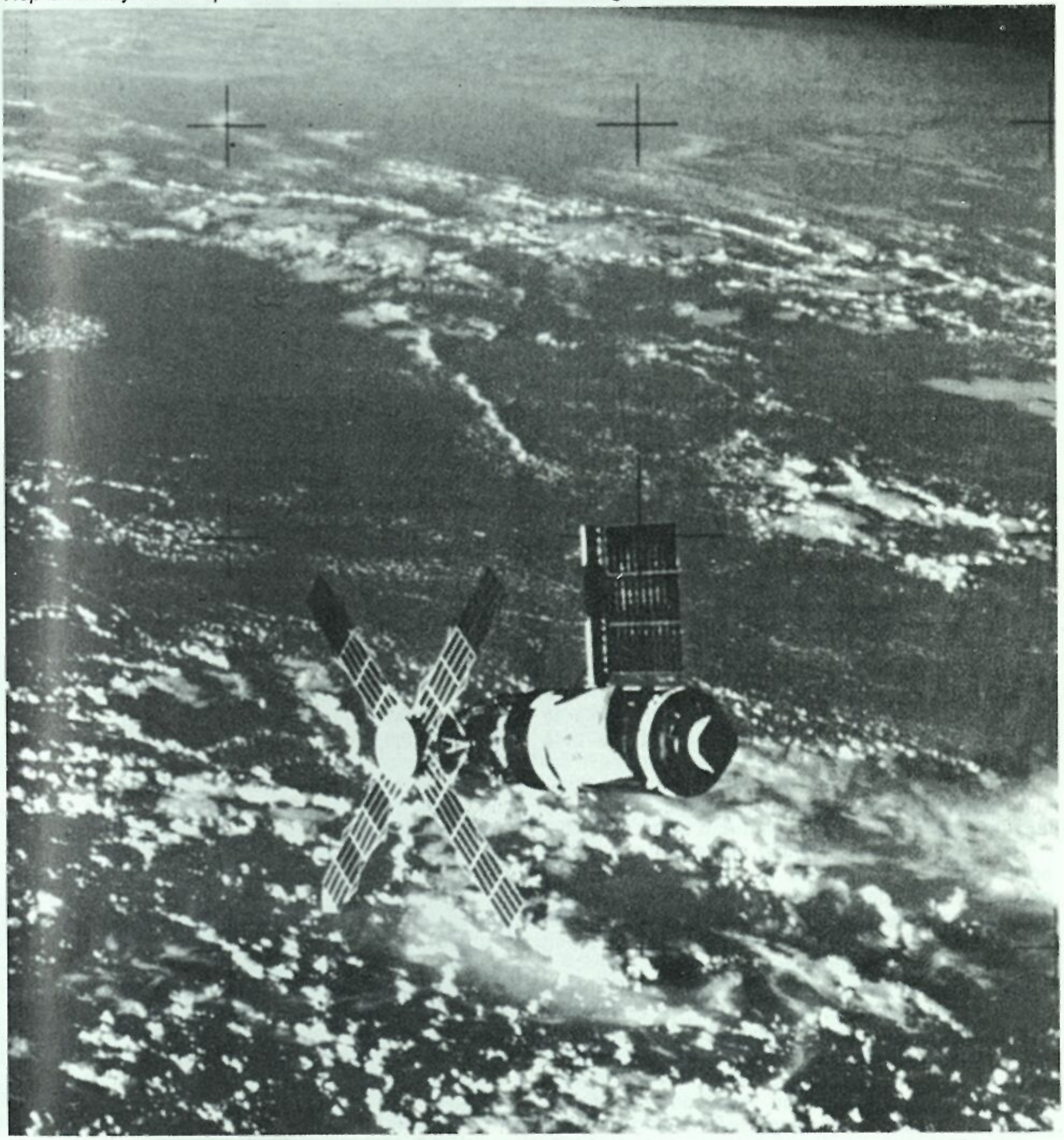
Skylab workshop showing principal components.

In the other, two astronauts would step from an airlock in the airlock module, affix a special bracket to the outside wall, and attach two long poles to the bracket, pointing them toward the bottom of he Skylab. At the ends of the poles are pulleys with rope threaded through them. A V-shaped sheet of reflecting material would be hoisted like an inverted sail toward the bottom of Skylab.

Immediately after parasol deployment, the crew activated the OWS and began their planned scientific experiments. They succeeded in making up time lost more or less but were plagued by a worsening shortage of electric power. Four batteries in the ATM that were overheated in the pitch-up attitude when ground controllers tried to balance OWS temperatures and ATM solar panel illumination (see above) tripped out prematurely (at 50 percent rather than 20 percent of full charge). Another battery dropped off the line completely. Because of the power shortage, the astronauts had to cut back substantially on such important experiments as Earth survey and solar studies.

NASA officials were well aware of the difficulties and dangers (particularly where sharp edges might

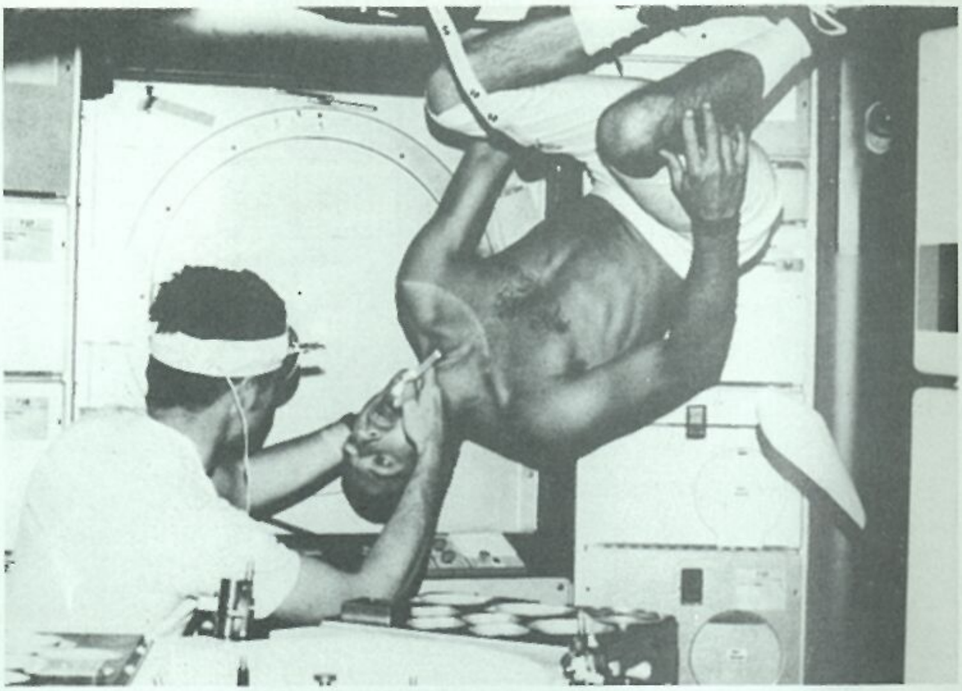
Repaired Skylab with parasol sunshade and extended solar wing.



exist) of a spacewalk (extravehicular activity, or EVA). Moreover, the section of Skylab where the jammed solar panel was located was never designed for spacewalking. It had neither handrails nor footholds to serve as anchors to offset forces imposed by an astronaut's work. But officials were confident that a well planned and carefully executed EVA could be successfully carried out despite these hindrances.

Ways and tools to loosen the panel were tested in the Neutral Buoyancy Simulator, the underwater replica of Skylab, at the Marshall Space Flight Center, Huntsville, Ala. The buoyancy of the water simulates to some extent the weightlessness of space. Later Conrad, Kerwin, and Weitz practiced the procedures inside the OWS.

Then, on June 7, 1973, Conrad and Kerwin spent nearly four hours in the most difficult and daring of all orbital repair jobs. First, they assembled a 25-foot pole with a bolt cutter at one end. A tether, or lanyard, was fashioned to work the blades of the bolt cutter. While Conrad held the pole out from the side of the airlock module, Kerwin climbed onto the struts of the ATM. He took the pole from Conrad



Conrad takes advantage of zero gravity to facilitate mouth and throat examination by Kerwin, who is an M.D.

and fastened one end with a tether to the struts.

This job was done while on Earth's night side under Skylab floodlights. At orbital sunrise, Conrad maneuvered the pole to clamp the bolt cutters on the aluminum strip holding the solar panel. Then Conrad moved hand over hand along the pole to the solar wing. Tethers were run along the pole between the ATM struts and the solar wing.

While Conrad held the bolt cutters on the aluminum strip, Kerwin pulled on the other end of the lanyard to snap the blades shut and sever the strip.

They then attached a tether about half-way down on the solar panel, tied the rope to the ATM struts, and stood up under the rope. The tension thus applied to the solar wing broke loose a stuck bracket that still held the wing, permitting the wing to swing out and finally lock into place.

The panels of the wing were not yet fully deployed because the hydraulic fluid needed to drive them into position was frozen. When Conrad and Kerwin were safely back inside of the space station, Mission Control in Houston pitched Skylab upward again to direct sunlight on the fluid mechanism. Shortly, the panels fully deployed, adding approximately 3000 watts of desperately needed electricity to Skylab's power. The surge of power also began to charge eight batteries that had been useless.

In addition, the Skylab "We fix anything crew," as they jokingly called themselves, repaired a number of other malfunctioning instruments. Among them: a jammed gear mechanism for driving an ultraviolet telescope, a balky tape recorder, a battery not producing power because of a stuck contact in its regulator (Conrad hit it with a hammer), and a non-operating valves in the cooling system.

Thus, human intelligence, and ability to meet unanticipated situations enabled the first Skylab mission to carry out nearly all of its planned scientific and technical experiments.

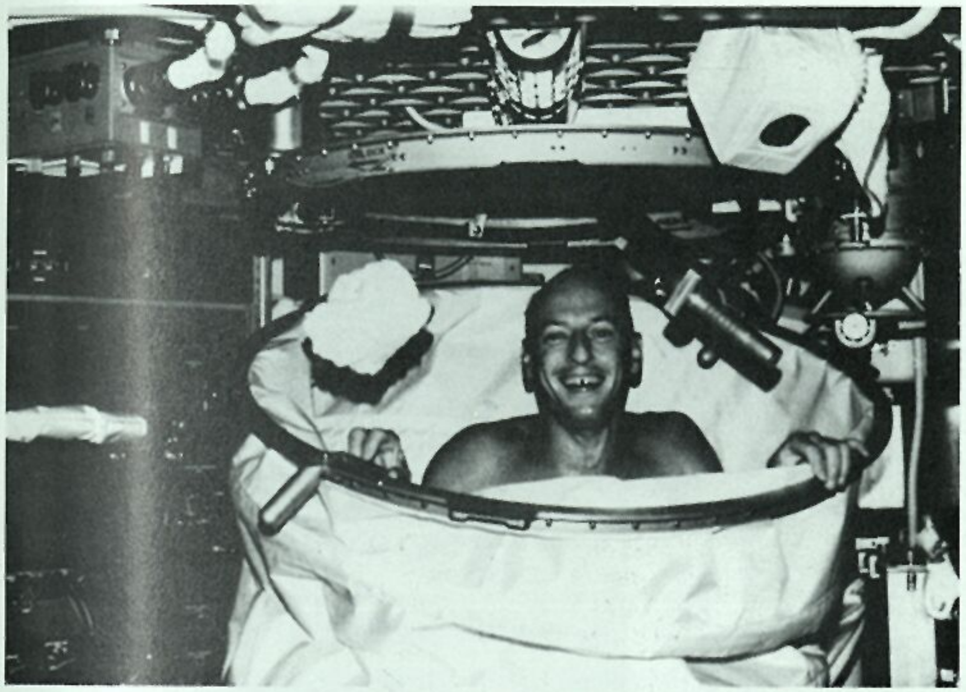
Although NASA has for years studied the Sun with automated Orbiting Solar Observatories, its more than 30,000 solar pictures from the four-week Skylab mission have been described by physicists as exceeding their wildest expectations.

One of the discoveries from these pictures is that the Sun's corona is much more dynamic, or changeable, than many scientists believed. The corona is the Sun's outer atmosphere which extends millions of kilometers into space. Its dynamic behavior is believed due to interactions of its ionized (electrified) gases with the solar magnetic field.

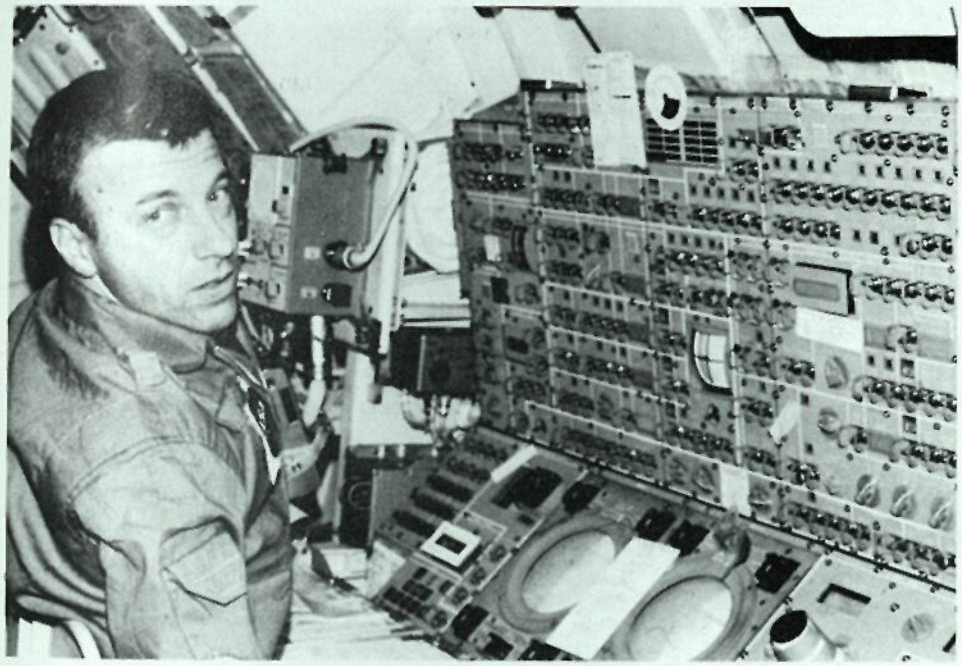
On June 15, automatic instruments on Skylab reported a moderately strong solar flare—a sudden outburst of matter from the Sun. Immediately the astronauts directed the ATM instruments toward and zeroed them in on the flare, making the best sequential observations yet of this kind of phenomenon. The flare released as much energy as mankind uses in decades. Science still does not understand how energy is accumulated and released in a flare. Skylab's solar studies will contribute to unravelling this mystery and perhaps to the solution of potential energy shortages on Earth.

Conrad, Kerwin, and Weitz also brought back more than 7000 scientific pictures of Earth. The pictures are in demand by industry, agriculture, weather services, city planners, ecologists, fishing companies, prospectors, mapmakers, dam-builders, and many others concerned with Earths' resources and environment. They cover 31 states and six other countries.

Among the most crucial of Skylab experiments are those about man himself: how he responds and adapts to weightlessness in prolonged space flight. The outcome will not only bear significantly on planning for future flights but also add to knowledge



Conrad smiles after washing in Skylab shower facility. Before washing, the astronaut pulls the curtain from the floor and attaches it to the ceiling. Water is drawn off by a vacuum cleaner. (If water escaped, it would float around.)



Weitz at control and display panel of ATM.

about bodily functions. Such additional knowledge may aid future doctors in fighting human illness.

During the first Skylab mission, as well as the earlier Mercury and Gemini manned Earth orbital flights and the Apollo lunar explorations expeditions, many changes in astronaut bodily systems occurred. Among these were losses in muscular tissue, bone calcium, red blood cell mass, and other fluids and weakening of the cardiovascular (heart and circulatory) system—generally those bodily elements and systems that on Earth must cope with the pull of gravity. Scientists want to know whether these effects level off in prolonged space flight or, if not, plan to develop measures to counteract them.

They also want more information on how man adapts to work in space. The first Skylab mission indicated man can adjust rapidly to zero gravity, or weightlessness. Conrad, Kerwin, and Weitz became so proficient that ground personnel had to increase their planned workload to keep them fully occupied.

None of the three experienced space sickness (as did some astronauts on previous shorter space missions and the crew of Skylab 3 early in its 59-day mission that began July 28, 1973). Even when they were spun at 30 revolutions per minute in a rotating chair on Skylab, they did not get motion sickness.

Part of New England from Skylab. Note Cape Cod peninsula at right; Long Island, lower left.

Conrad and Weitz receive cheers after stepping from their Apollo command module onto the recovery vessel, Ticonderoga. Kerwin, in background, is emerging from module.

They could tolerate only half that speed on the ground.

Another significant finding of Skylab is that adequate well designed body restraints are necessary for men to perform efficiently in space. In another area, the men advised that tomatoes should be small enough to be eaten whole and that salt sprinkled on food bounces off.

Because the body does not have to work as hard in the zero gravity of space as on Earth, scientists were concerned about the deconditioning of the astronauts as a result of their long mission. Because of this, they wanted to examine them and their inflight specimens of frozen urine, freeze-dried blood, and other materials as soon as possible after recovery. They also wished to avoid possible contamination of the specimens by the warm, moist sea air.

As a result, plans were made to pick up the retuning spacemen and Skylab 2 together rather than their leaving their spacecraft in the water and climbing aboard a helicopter as in previous space missions, such as Apollo.

Conrad, Kerwin, and Weitz splashed down in the Pacific about 1344 kilometers (840 miles) southwest of San Diego, Calif., at 9:50 a.m. EDT, June 22, 1973, aftre 28 days and 50 minutes of space flight. At 10:34 a.m., they emerged from their spacecraft, which had been hoisted to the deck of the recovery ship, U.S.S. Ticonderoga.

All three astronauts stepped unsurely onto the carrier deck. The effects they experienced are comparable to standing up after a long period in bed.

They wore pressure pants to counteract, if necessary, orthostatic hypertension, a precipitous drop in blood pressure that could cause them to faint. As a further precaution, they also lay back on their couches after splashdown. Orthostatic hypertension would result from the inability of the cardiovascular system to fight gravity and push blood up from the lower extremities. Pooling of blood in the legs has been a common reaction in returning spacemen. Kerwin was the only astronaut who felt sufficiently faint to inflate his pressure pants.

As most of their predecessors, all three astronauts lost weight during their 4-week flight: Conrad, nearly 4 pounds; Kerwin, 6½; and Weitz, about 8. In other ways too, the first Skylab crew, like all people, showed individual variations in their responses to the 28-day space flight.

The first Skylab mission, in addition to providing a wealth of scientific, medical and technical data, set a new record for the longest manned space flight. Just as and perhaps more important, it made possible and laid a foundation for the two longer Skylab missions scheduled to follow it.

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