SPACE '93

From biomedical experiments to Hubble's long-awaited repair

By RON COWEN

It's a year in space that will encompass the routine and the riveting. Missions range from monitoring the vital signs of shuttle crews to improving the scientific health of the ailing Hubble Space Telescope. While mechanical and operational delays will likely alter the flight calendar, NASA hopes to stick reasonably close to the following schedule:

January: The space agency plans to kick off its 1993 flight schedule Jan. 13 with the launch of an instrument that will probe the origin of the diffuse, low-energy X-ray background that bathes the nearby interstellar medium of our galaxy. Carried aloft in the payload bay of the space shuttle Endeavor, the Diffuse X-ray Spectrometer (DXS) has twin detectors that together will test the theory that these low-energy X-rays are emitted by a bubble of ionized gas that envelops our solar system and extends for hundreds of light-years beyond. Astronomers suspect that the bubble was created when one or more stars exploded as supernovas more than 100,000 years ago (SN: 1/2/93, p.4).

To verify this theory, DXS will examine several regions of the sky, measuring the direction of origin of X-rays that range in wavelength from 42 angstroms to 84 angstroms. From these data, astronomers can determine the intensity of the X-ray emissions in this wavelength band. If particular ionized atoms emit the X-rays, they will produce a telltale set of peaks and valleys in the spectrum recorded by DXS. In this way, researchers can identify the temperature, ionization state, and elements that make up the ionized gas scientists believe emits the X-rays.

February: NASA and a group of U.S. researchers will collaborate with German scientists for the second German Spacelab mission, a 10-day exploration known as Spacelab D-2. The flight will include experiments in human physiology, basic biology, and materials science in the microgravity environment of space.

Several of the studies will follow up on experiments conducted during the first German Spacelab mission, launched in 1985, as well as the first U.S. life sciences Spacelab mission, flown two years ago. Crew members will participate in studies of the heart, blood flow, and blood pressure.

Scientists will also continue to analyze a puzzling aspect of how the lungs function. On the ground, gravity and the location of the lungs in the upper chest conspire to concentrate air at the top of the lungs and blood at the bottom. Researchers had expected that in weightlessness, the air-blood distribution in the lungs would become uniform. Contrary to predictions, however, scientists have found that the same non-uniform concentration of blood and air persists in space. By monitoring lung function in new experiments, researchers hope to understand how and perhaps why the lung maintains its ground-based mix of blood and air in space.

March: NASA plans to launch the second in a series of four flights devoted to studying the interaction between the sun and Earth's atmosphere. Known as ATLAS-2 (for Atmospheric Laboratory for Applications and Science), this shuttle-borne instrument package, flown for seven to nine days, will help measure how the chemical composition of Earth's atmosphere changes as a function of latitude and season. The experiment will also record chemical differences in the atmosphere between night and day.

Collectively, the ATLAS missions will provide a global record of long-term changes in total energy radiated by the sun, variations in the intensity of solar radiation at specific wavelengths, and measurements of the distribution of key chemicals — including those that erode our planet's protective ozone layer — in Earth's middle atmosphere. ATLAS-2's high-resolution, meter-long interferometer will detect trace gases in Earth's atmosphere, while an infrared spectrometer will track the sun's radiation output. Because the shuttle's orbit will sometimes take the experiment directly beneath the Upper Atmosphere Research Satellite (UARS), instruments on ATLAS will help calibrate those on the long-term UARS craft.

April: Space shuttle Endeavor will fly a suite of experiments, designed by private industry, in a carrier known as Spacehab. The mission will also carry at least one NASA experiment, which will measure the small amount of jitter, or acceleration,

Month	Event
January	Diffuse X-ray Spectrometer
February	Spacelab D-2
March	ATLAS-2
April	Spacehab
May	NOAA-I (weather satellite)
July	Advanced Communications Technology Satellite; ORFEUS (ultraviolet spectrometer)
August	Sea-Viewing Wide Field Sensor; Spacelab Life Sciences-2
December	NOAA-J (weather satellite); Wind; Hubble Space Telescope repair

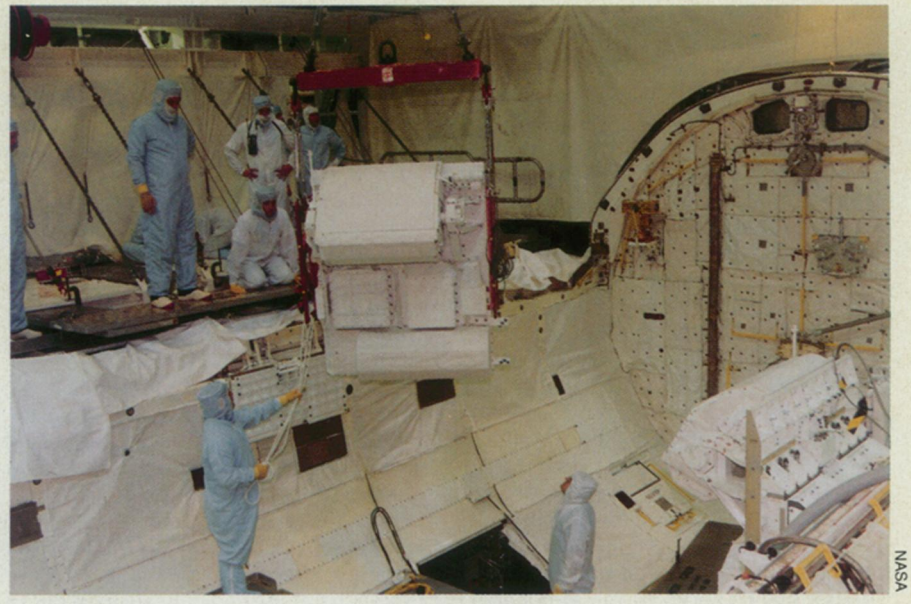
in the shuttle bay's microgravity environment.

May: NASA will launch the first of two new Polar Orbiting Environmental Satellites for the National Oceanic and Atmospheric Administration. Known as NOAA-I, this satellite will circle Earth in a polar orbit and has a design lifetime of two years. Because NOAA-I flies at much lower altitudes than geostationary satellites, which track a single spot on the Earth, this craft's precision temperature sounder can record more accurate temperatures at a variety of depths in the atmosphere.

July: Deployed from the space shuttle Discovery and propelled into a geostationary orbit, NASA's Advanced Communications Technology Satellite (ACTS) will combine the communications capabilities of satellites and those of fiber optics. While fiber-optic systems on Earth now include some 60,000 miles of optical cables, including transoceanic links, these ground-based systems can't quickly change the way they send information in order to route data to different users in rapid succession. The ACTS system, however, does allow such rapid reconfiguration. After conducting a series of communications experiments with the satellite over the next two years, NASA plans to turn ACTS over to private industry.

On the same shuttle flight, NASA will collaborate with DARA, the German space agency, to launch the first in a series of U.S.-German missions that will employ a reusable science satellite called Astro-SPAS. For its debut, Astro-SPAS will carry an instrument that measures ultraviolet radiation. Known as the Orbiting and Retrievable Far and Extreme Ultraviolet Spectrometer (ORFEUS), the instrument consists of a main telescope and three spectrometers.

In practice, the shuttle carries Astro-SPAS to low-Earth orbit, where it is deployed from the cargo bay. Using batteries to power cold-gas thrusters and a star tracker, the free-flying satellite will execute a series of programmed operations at a distance of more than 20 miles from the space shuttle during the next four to six days. These include pointing at 80 to 250 celestial targets with an accuracy of 5 to 10 arc seconds. The satellite will then be retrieved and returned to the shuttle cargo bay for use on later missions.



NASA

In preparation for a flight scheduled for next week, technicians install the Diffuse X-ray Spectrometer in the cargo bay of the space shuttle Endeavor.

August: The two missions this month range from measuring ocean color to monitoring heart and lung function.

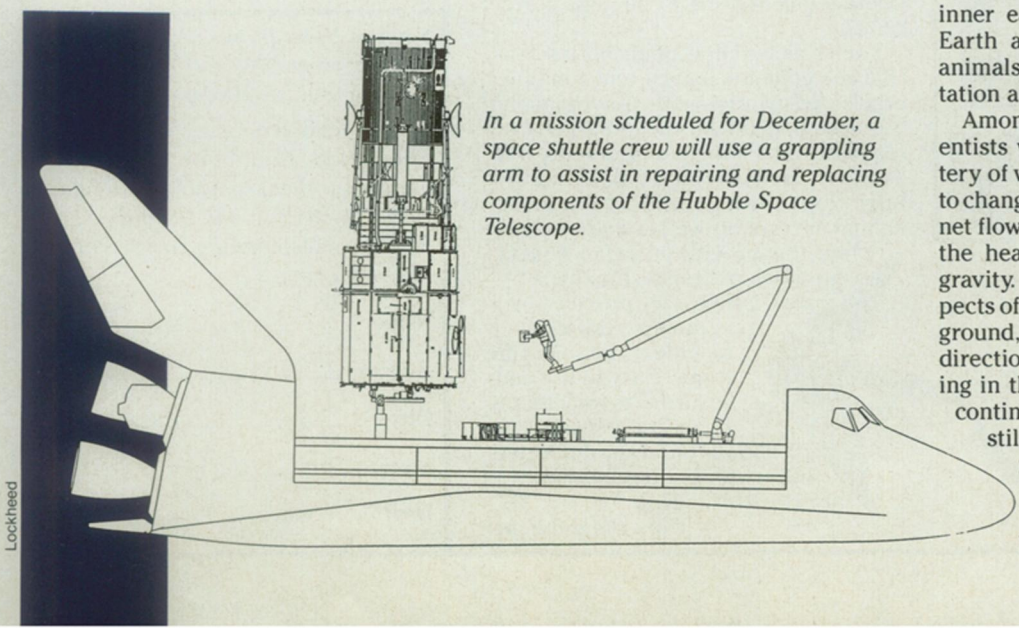
The Sea-Viewing Wide Field Sensor (SeaWiFS) satellite, launched by a Pegasus rocket, will record changes in ocean color that indicate concentrations of phytoplankton and chlorophyll on the ocean surface. Mapping concentrations of phytoplankton, a storehouse for carbon, aids researchers in understanding the role of the oceans in the global carbon cycle. The presence of chlorophyll and phytoplankton also indicates those regions of the oceans where nutrients congregate.

In August, NASA will also launch Spacelab Life Sciences-2, the second of four U.S. Spacelabs devoted to the life sciences. Many of the 14 experiments in this shuttle-borne laboratory's 14-day flight will follow up on studies conducted during the first life sciences mission, launched in 1991. From that mission, researchers discovered that reduced amounts of the hormone erythropoietin decrease production of red blood cells in the bone marrow, suggesting a new way to control red blood cell concentrations.

This time around, the Spacelab team will monitor the effects of injecting erythropoietin into laboratory rats. In other laboratory rats, scientists will study how weightlessness affects the structure and function of an organ in the inner ear called the otolith, which on Earth acts as a gravity sensor, giving animals and humans their sense of orientation and balance.

Among the human crew, Spacelab scientists will further investigate the mystery of why blood pressure doesn't seem to change in space—even though there's a net flow of blood from the extremities to the head and chest in the absence of gravity. Researchers will also study aspects of head and eye movements. On the ground, when our head moves in one direction, our eyes compensate by rotating in the opposite direction so that we continue to view the world standing still. In space, however, such coupled reflexes may be disturbed.

December: NASA launches satellites this month that will both explore the impact of the



Lockheed

In a mission scheduled for December, a space shuttle crew will use a grappling arm to assist in repairing and replacing components of the Hubble Space Telescope.

solar wind on our planet and monitor Earth's weather. The latter mission, another Polar Orbiting Environmental Satellite, known as NOAA-J, will track hurricanes and other meteorological phenomena from a polar orbit.

A craft called Wind, the second of an international group of instruments designed to study solar-terrestrial physics, will examine the transport of energy from the sun to Earth. In part, Wind will act as an early-warning system for detecting geomagnetic storms, auroras, and other disturbances triggered by the sun's stream of charged particles, the solar wind.

Orbiting the sun in such a way that it always remains directly between the sun and Earth, the satellite will record the impact of the solar wind one to two hours before the ion stream strikes our planet's magnetosphere. This may enable Wind to predict disturbances in the atmosphere and on the ground that stem from solar activity. And in combination with instruments that examine Earth's magnetosphere directly, the craft will aid in understanding exactly how Earth responds to a particular intensity of solar ions.

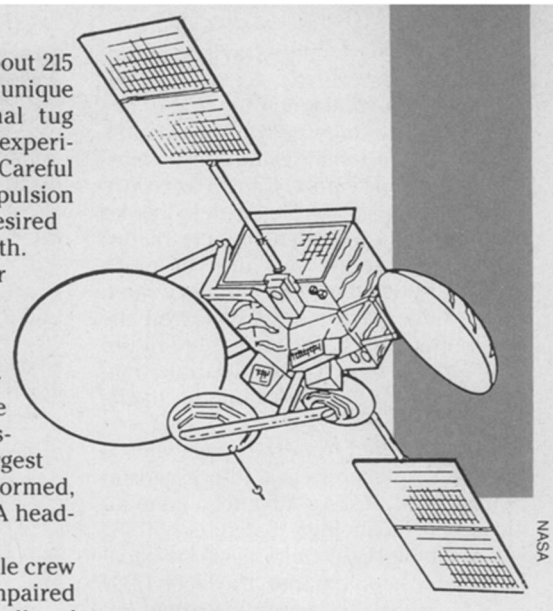
In order to examine the solar wind, the craft—launched by a Delta 2 rocket—will first swing by the moon, getting a gravitational kick that will send it into an orbit around the sun, at a distance of some 1.4 million kilometers from Earth, about 215 times the planet's radius. At that unique location, the sun's gravitational tug equals that of Earth, and the craft experiences no net gravitational force. Careful navigation and an on-board propulsion system will keep the craft in its desired orbit about the sun, in front of Earth.

Talk about saving the best for last: NASA plans to cap 1993 with an unprecedented—and complicated—manned mission. Indeed, the long-awaited mission to repair the flawed, $2 billion Hubble Space Telescope is the most complex mission to date, involving the largest number of spacewalks ever performed, says Joseph K. Alexander at NASA headquarters in Washington, D.C.

In just eight days, a space shuttle crew will attempt to link up with the impaired Hubble and accomplish a laundry list of time-consuming and delicate fix-it operations. The crew won't try to replace Hubble's flawed primary mirror. Instead, they will insert a set of corrective "eyeglasses" between the troublesome mirror and three of the telescope's instruments in order to compensate for the optical flaws.

To make room for the corrective optics, the crew will have to sacrifice the telescope's photometer. They will also attempt to replace the fourth instrument, the still-functioning Wide-Field/Planetary Camera, with a new model that has corrective optics built into it. In addition, the crew intends to replace the Hubble's wobbly solar panels and replace faulty gyroscopes.

Even if the shuttle team doesn't manage to accomplish all these tasks, notes Alexander, "in many ways the Hubble repair mission is going to be a grand climax of 1993 in space science." □



NASA

The Advanced Communications Technology Satellite, scheduled to orbit Earth in July.