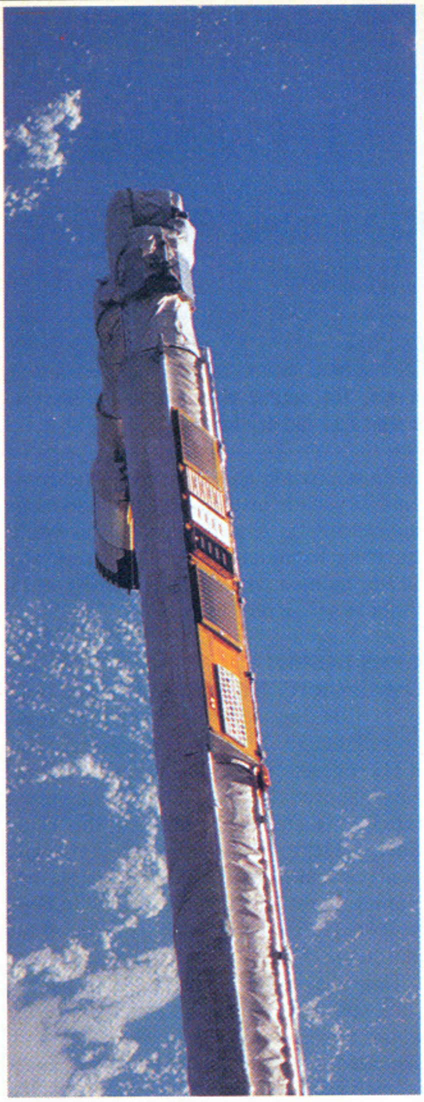


ward creating membranes with higher permeability so they can pass more material with higher selectivity, she said.

The primary objective of the shuttle experiment, which also flew earlier this year on shuttle Mission 31, is to understand the role of convective driven currents which occur in the evaporation casting of polymer membranes.

Results from the first flight were "completely amazing," McCauley said. The membranes created in zero-g were highly uniform with extremely tiny pores. "Our industrial partners are extremely interested in this," she said. The polymer tests on board the orbiter Discovery were activated by astronauts Air Force Maj. Thomas W. Akers and Coast Guard Cdr. Bruce E. Melnick. The experiment involved two sets of an apparatus consisting of three steel cylinders.

The test hardware were launched with a vacuum drawn in the largest of the cylinders, which are about the size of thermos bottles. A gel composed of a solid polymer and two solvents was then placed on a test plate in one of two smaller cylinders kept at atmospheric pressure. The third cylinder in each apparatus contained water. During the second day of Discovery's mission, Akers and Melnick opened a valve between the vacuum and sample cylinders. This evaporated the solvents creating a polymer membrane on the test plate. The water was then used to quench the membrane to halt its formation in zero-g. The test was rapidly quenched in one apparatus and left to continue for seven hours in the other apparatus.

Following the shuttle's landing at Edwards AFB, Oct. 10, the membrane samples were flown to Battelle's laboratory at Columbus, Ohio. The experiment containers were opened Oct. 15 and underwent initial microscopic examination Oct. 16, McCauley said.

A third shuttle test is set for Mission 43 next year. Battelle has also done polymer processing tests on a sounding rocket mission and NASA KC-135 zero-g aircraft flights.

The Genentech experiment is the first commercial life sciences experiment conducted on a U. S. space mission. Before launch, eight of the 16 rats carried on the flight received a natural protein developed by Genentech. The other eight rats received no protein.

Genentech investigators hope that exposing the rats to zero-g could serve as an expedient means for testing potential drugs designed to counter bone and muscle wasting and immune system disorders. Some muscle, bone and immune system changes are common effects of zero-g exposure. □

Discovery's arm was equipped with solar array samples (left) similar to the arrays on the stranded Intelsat spacecraft. They will show if the Intelsat arrays will degrade before Intelsat's rescue by the shuttle. Discovery's external tank was photographed immediately after separation (center). Note aerodynamic heating scorch marks at the forward orbiter interface point.

After Long Delay, Ulysses Mission Begins 5-Year Voyage to Expand Solar Data Base

MICHAEL MECHAM/NOORDWIJK, NETHERLANDS

The Ulysses exploration holds promise of radioing back to Earth a three-dimensional description of the inner heliosphere, a unique feat since no other spacecraft has moved above the orbital path of the planets.

The five-year mission to the Sun, jointly undertaken by the European Space Agency and NASA, will serve scientists from 12 nations and 49 institutions.

Launched aboard shuttle Discovery Oct. 6, the spacecraft was propelled beyond Earth's orbit by a two-stage Boeing Inertial Upper Stage booster and a McDonnell-Douglas Payload Assist Module (AW&ST Oct. 15, p. 22). Ulysses is to reach the Sun with a gravity assist from Jupiter.

Although its biggest payoff will not begin until June, 1994, when it passes beneath the Sun's south polar region, Ulysses should begin providing scientific dividends in about 40 days. Then Ulysses' full complement of nine solar physics instruments is expected to be operational.

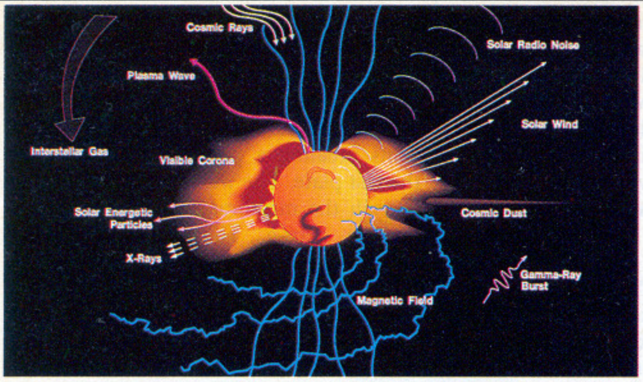
The instruments will begin collecting data on the heliosphere, the vast region of space that extends beyond the planets from the Sun's corona, its outer atmosphere. An early bonus may come in the detection of gravitational waves, so far unrecorded, but predicted by Einstein, ESA Science Director Roger Bonnet said during a briefing here at the European Space Research and Technology Center (ESTEC). Ulysses' radio instrument package may detect them.

But scientists are interested primarily in the final 15 months of the 808-lb. (367-kg.) spacecraft's voyage. That is when it begins a south polar pass, journeys up the Sun's face to sample the solar wind at every latitude and traverses the north pole in September, 1995.

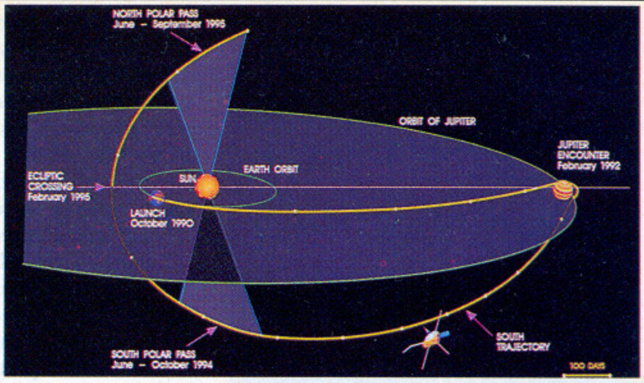
Whether funding will be available to extend the mission will depend on whether the institutions sponsoring its science hardware are willing to pay $5-10 million for annual operations costs, Bonnet said. The Ulysses spacecraft (minus launch and development costs) is valued at some $117 million.

Previous solar expeditions, such as the 1960-70s era ISEE and HEOS spacecraft, were constrained by their trajectories, which stayed within the Sun's ecliptic—the orbital path that the planets follow. The Sun's 7-deg. swing on its spin axis has afforded measurements slightly off center of the solar equator, which increased knowledge of the solar corona and the solar wind—the vast outflowing of magnetized and ionized gas, or plasma, that flows radially away from the Sun. Ulysses' goal is to expand this data to the full Sun.

Solar eclipse photos have revealed a



Solar, interplanetary and galactic science will be investigated by the Ulysses mission. The ESA spacecraft will be the first to investigate the



solar corona from pole-to-pole. The second view shows the Ulysses trajectory. The white dots represent 100-day intervals.

striking asymmetry in the corona in the Sun's extreme latitudes. Coronal spikes are more pronounced in the equatorial region, and there appear to be strong differences in the outflowing of the solar wind itself between the equator and the poles, Ulysses project scientist Peter Wenzel said. The solar wind flows much faster—360 to 620 mi./sec. (700-1,000 km./sec.)—in the polar regions than in lower latitudes, where it moves at 250 mi./sec. (400 km./sec).

Other scientific inquiries concern magnetic field lines, which appear open at the poles but closed in vast loops in the mid-latitudes, Wenzel said. The Sun also will reverse its polarity during Ulysses' visit, another phenomenon that has scientists stumped.

The current model of the heliospheric magnetic field appears nearly radial as it flows from the poles, but in situ measurements have not confirmed this view. Nor can scientists know if it is easier for cosmic rays to enter the solar atmosphere through the polar regions—as many suspect.

The Ulysses pole-to-pole voyage should expand current knowledge of solar physics greatly by creating the first three-dimensional assessment of the solar environment based on in situ measurements.

As the Sun is the only star within Earth's reach, scientists expect these measurements will provide clues to the behavior of distant stars and their relationship to the cosmos.

ULYSSES PAYLOAD

The polar studies will be conducted from about 2 AU (1 astronomical unit equals 93 million mi.), while the spacecraft will dip to about 1.3 AU when it conducts measurements at the equator.

Ulysses' scientific payload weighs 55 kg. and consists of nine instruments to measure the solar wind, structure of the interface between the Sun and solar wind, solar magnetic field, solar and interplanetary energetic particles, galactic cosmic rays, solar radio bursts and plasma waves, interstellar and interplanetary neutral gas and dust, and solar X-rays.

Although not its primary objective, the mission will investigate Jupiter's south polar magnetosphere, territory not explored by the Pioneer or Voyager missions, and which will not be reached by the Galileo probes launched last year.

Jupiter, the largest planet, provides the tremendous gravitational kick that Ulysses needs to twist away from the ecliptic plane and reach a polar trajectory to the Sun (AW&ST Oct. 1, p. 96). The spacecraft's trajectory is bent away from its equatorial approach in a path that slips

> *Ulysses should expand knowledge by creating first three-dimensional assessment of the solar environment*

along the Jovian backside and out from beneath the planet's south pole and then back to the Sun. Because of its speed, Ulysses will arrive and leave Jupiter before Galileo arrives.

An out-of-ecliptic space mission first was discussed just two years after the launch of Sputnik in 1957. NASA and ESA jointly conceived of a mission in 1974. Approval was granted in 1977, with the U. S. to provide one of two spacecraft, the launch and the spacecraft's Radio-isotope Thermo-electric Generator (RTG). ESA contributed the second spacecraft.

Launch originally was scheduled for 1983, but NASA's shuttle delays, the Challenger explosion and funding lapses conspired to push it back. One way to measure the time lost is that early communications between European and U. S. scientists was by mail. Now they are by mini-fax.

West Germany's Dornier GmbH. was selected to lead a 20-member industrial consortium to build the ESA spacecraft. The bus must withstand the strains of an out-of-ecliptic trajectory and exposure to Jovian radiation belts and magnetic fields. It must provide an electromagnetic compatibility with instruments of wide-ranging sensitivity. And it must do this while traveling as much as 5.3 AU from the Earth, an area where solar intensity is 25 times less than on Earth.

GPHS DESIGN

Only an RTG has sufficient power over such distances, according to senior engineer Santiago Ximenez de Ferran. The RTG chosen is of a General Purpose Heat Source (GPHS) design manufactured by General Electric for the U. S. Energy Dept. Ulysses' GPHS/RTG will produce approximately 285 w. at the beginning of the mission and 250 w. in September, 1995, when it ends. It is fueled by plutonium-238.

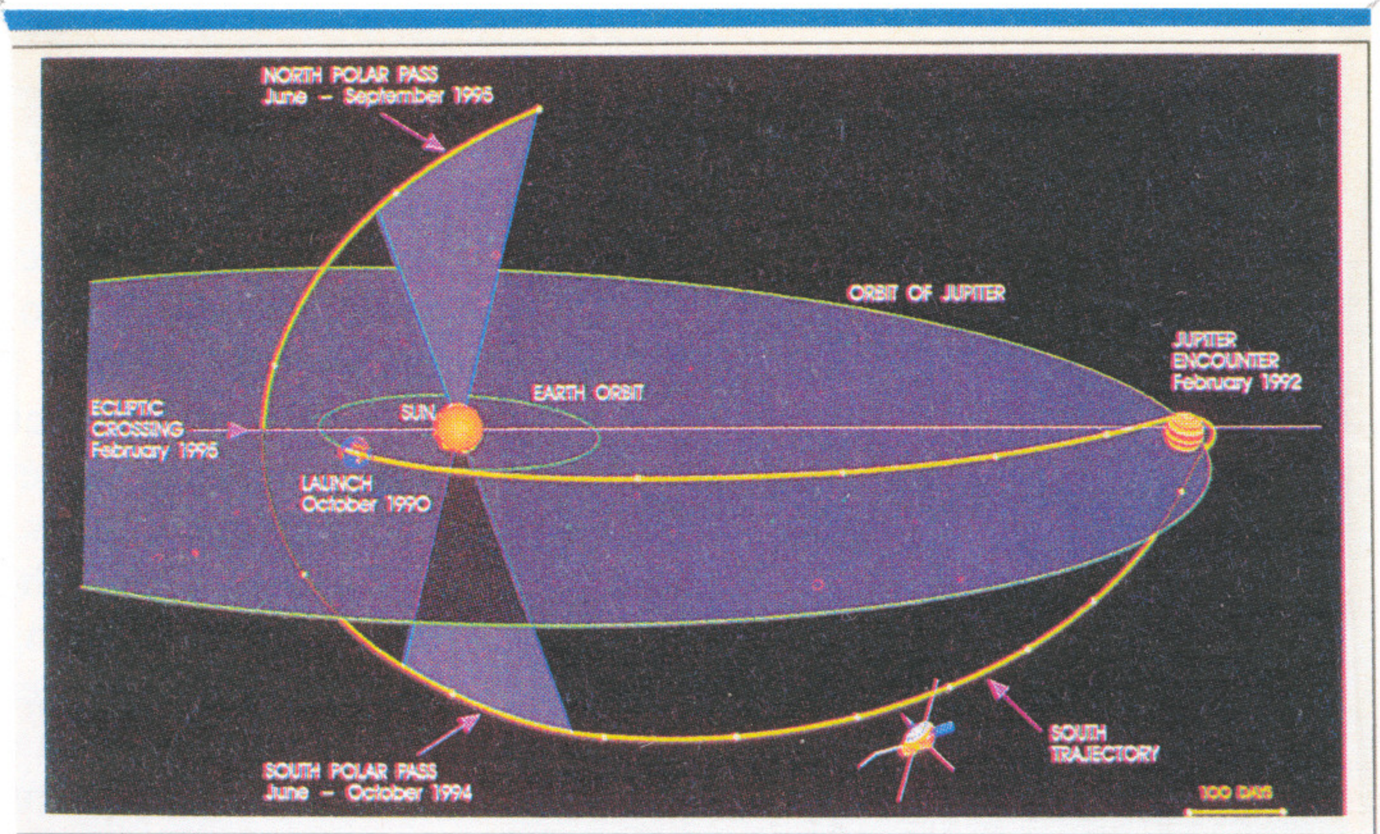
Had they been available, solar panels with sufficient power at such distances would have been prohibitively heavy and degraded in the Jovian atmosphere, ESA officials said.

Ulysses' power demands will be significant. Its instruments are to function throughout the 4.7-year mission rather than be dormant during transfer phases. The instruments require cooling to laboratory-like conditions of -20 C.

Because Ulysses cannot maintain constant line-of-site communications with NASA's Deep Space Network, large amounts of data will have to be stored for later playback. The spacecraft has redundant 45-microbit tape recorders.

The spacecraft will require almost daily attitude adjustment maneuvers to maintain its precise trajectory.

As conceived, the mission would have two spacecraft to build a stereoscopic view of the Sun through simultaneous observations of the solar hemispheres. NASA's spacecraft was to carry cameras to provide a bird's eye image of the Sun and its corona. But NASA's spacecraft fell victim to shuttle development budget demands. It was a bitter disappointment—and lesson about joint commitments—to ESA. Despite the loss and delay, Wenzel said the Ulysses expedition remains full of promise that none other can fulfill. □


NORTH POLAR PASS
June – September 1995
ORBIT OF JUPITER
JUPITER
ENCOUNTER
February 1992
ECLIPTIC
CROSSING
February 1995
SUN
EARTH ORBIT
LAUNCH
October 1990
SOUTH
TRAJECTORY
SOUTH POLAR PASS
June – October 1994
100 DAYS