NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

SPACE SHUTTLE MISSION STS-41

PRESS KIT
OCTOBER 1990

ULYSSES

STS-41 INSIGNIA

STS041-S-001 -- The STS-41 insignia by the five astronaut crewmembers, depicts the space shuttle orbiting Earth after deployment of its primary payload -- the Ulysses satellite. The orbiter is shown passing over the southeastern United States, representative of its 28-degree inclination orbit. Ulysses, the Solar Exploration Satellite, will be the fastest man-made object in the universe, traveling at 30 miles per second (over 100,000 mph) and is represented by the streaking silver teardrop passing over the sun. Ulysses' path is depicted by the bright red spiral originating from the Shuttle cargo bay. The path will extend around Jupiter where Ulysses will receive a gravitational direction change that will put it in a polar trajectory around the sun. The three-legged trajectory, extending out the payload bay, is symbolic of the astronaut logo and is in honor of those who have given their lives in the conquest of space. The five stars, four gold and one silver, represent STS-41 and each of its crewmembers.

The NASA insignia design for space shuttle flights is reserved for use by the astronauts and for other official use as the NASA Administrator may authorize. Public availability has been approved only in the form of illustrations by the various news media. When and if there is any change in this policy, which we do not anticipate, it will be publicly announced.

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ULYSSES DEPLOYMENT HIGHLIGHTS STS-41 MISSION

Space Shuttle mission STS-41 will be highlighted by deployment of the Ulysses spacecraft on a 5-year journey to become the first probe to explore the polar regions of the sun.

Current scheduling indicates a likelihood of launching on Oct. 8 or 9, but a few days either side are possible, depending on actual test and preparation time needed. The actual launch date will be set at the flight readiness review, scheduled for Sept. 24-25. Landing is planned at Edwards Air Force Base, Calif. The 4-day mission will be Discovery's 11th flight.

After being deployed from Discovery under the oversight of Mission Specialist Thomas D. Akers, a two-stage Inertial Upper Stage and a single-stage Payload Assist Module will boost Ulysses on a trajectory that will take it to Jupiter in 16 months. Upon arrival, in addition to making some scientific studies of the giant planet, the spacecraft will receive a gravity assist from Jupiter into a solar orbit almost perpendicular to the plane in which the planets orbit. Ulysses is scheduled to make its first observations of the sun's southern pole between June and October 1994 and continue on to observe the northern solar pole between June and September 1995.

Also in Discovery's payload bay will be the Airborne Electrical Support Equipment, an electrical generating system mounted on the side of the bay to supply power to Ulysses. The Intelsat Solar Array Coupon, samples of solar array materials mounted on Discovery's Remote Manipulator System, is designed to study the effects of atomic oxygen wear on solar panels in preparation for a future Shuttle mission to rescue the stranded Intelsat satellite. The Shuttle Solar Backscatter Ultraviolet (SSBUV) experiment also will be in Discovery's payload bay, mounted in two Get Away Special containers. SSBUV will help fine tune the atmospheric ozone measurements made by satellites already in orbit by providing a calibration of their backscatter ultraviolet instruments.

Discovery also will carry the Chromosome and Plant Cell Division in Space experiment, a study of plant root growth patterns in microgravity; the Investigations into Polymer Membrane Processing experiment, a study of materials processing in microgravity; the Physiological Systems Experiment, an investigation of how microgravity affects bone calcium, body mass and immune cell function; the Radiation Monitoring Experiment to record radiation levels in orbit; the Solid Surface Combustion Experiment, a study of flames in microgravity; and the Voice Command System, a development experiment in voice commanding the Shuttle's onboard television cameras.

Commanding Discovery will be Richard N. Richards, Capt., USN. Robert D. Cabana, Lt. Col., USMC, is pilot. Richards will be making his second space flight, after serving as pilot of STS-28. Cabana will be making his first flight.

Mission specialists are William M. Shepherd, Capt., USN; Bruce Melnick, Cmdr., USCG; and Thomas D. Akers, Major, USAF. Shepherd is making his second flight, after being aboard STS-27. STS-41 will be Melnick's and Aker's first space flight.

Built by Dornier GmbH of West Germany, Ulysses is a joint project of the European Space Agency (ESA) and NASA.

(END OF GENERAL RELEASE; BACKGROUND INFORMATION FOLLOWS.)

GENERAL INFORMATION

NASA Select Television Transmission

NASA Select television is available on Satcom F-2R, Transponder 13, located at 72 degrees west longitude; frequency 3960.0 MHz, audio 6.8 MHz.

The schedule for television transmission from the orbiter and for the change-of-shift briefings from Johnson Space Center, Houston, will be available during the mission at Kennedy Space Center, FL; Marshall Space Flight Center, Huntsville, Ala.; Johnson Space Center; and NASA Headquarters, Washington, DC. The TV schedule will be updated daily to reflect changes dictated by mission operations.

Television schedules also may be obtained by calling COMSTOR, 713/483-5817. COMSTOR is a computer data base service requiring the use of a telephone modem. A voice update of the TV schedule may obtained by dialing 202/755-1788. This service is updated daily at noon EDT.

Status Reports

Status reports on countdown and mission progress, on-orbit activities and landing operations will be produced by the appropriate NASA news center.

Briefings

An STS-41 mission press briefing schedule will be issued prior to launch. During the mission, flight control personnel will be on 8-hour shifts. Change-of-shift briefings by the off-going flight director will occur at approximately 8-hour intervals.

STS-41 QUICK LOOK

Launch Date:	Oct. 5, 1990
Launch Site:	Kennedy Space Center, FL, Pad 39-B
Launch Window:	7:35 a.m. - 9:53 a.m. EDT
Orbiter:	Discovery (OV-103)
Orbit:	160 x 160 nautical miles
Inclination:	28.45 degrees
Landing Date:	October 9, 1990
Landing Time:	9:42 a.m. EDT
Primary Landing Site:	Edwards Air Force Base, CA
Abort Landing Sites:	Return to Launch Site - Kennedy Space Center, FL Transoceanic Abort Landing - Ben Guerir, Morocco Abort Once Around - Edwards Air Force Base, CA
Crew:	Richard N. Richards, Commander Robert D. Cabana, Pilot Bruce E. Melnick, Mission Specialist 1 William M. Shepherd, Mission Specialist 2 Thomas D. Akers, Mission Specialist 3
Cargo Bay Payloads:	Ulysses/IUS/PAM-S SSBUV Intelsat Solar Array Coupon
Middeck Payloads:	Solid Surface Combustion Experiment (SSCE) Investigations into Polymer Membrane Processing (IPMP) Chromosome and Plant Cell Division in Space (CHROMEX-2) Physiological Systems Experiment (PSE) Voice Command System (VCS) Radiation Monitoring Experiment-III (RME-III)

VEHICLE AND PAYLOAD WEIGHTS

	Pounds
Orbiter (Discovery) empty	151,265
Remote Manipulator System (payload bay)	1,180
Ulysses/IUS/PAM-S (payload bay)	44,024
Airborne Electrical Support Equipment, RTG cooling system (payload bay)	203
IUS Support Equipment (payload bay)	260
Shuttle Solar Backscatter Ultraviolet Instrument (SSBUV) (payload bay)	1,215
Chromosome and Plant Cell Division in Space (CHROMEX)	85
Investigations into Polymer Membrane Processing (IPMP)	33
Physiological Systems Experiment (PSE)	132
Radiation Monitoring Experiment-III (RME-III)	23
Solid Surface Combustion Experiment (SSCE)	140
Voice Command System (VCS)	45
Orbiter and Cargo at SRB Ignition	256,330
Total Vehicle at SRB Ignition	4,524,982
Orbiter Landing Weight	197,385

TRAJECTORY SEQUENCE OF EVENTS

Event	MET (d/h:m:s)	Relative Velocity (fps)	Mach	Altitude (ft)
Launch	00/00:00:00			
Begin Roll Maneuver	00/00:00:07	136	0.1	400
End Roll Maneuver	00/00:00:19	417	0.37	3,483
SSME Throttle Down to 65%	00/00:00:28	665	0.6	7,900
Max. Dyn. Pressure (Max Q)	00/00:00:51	1,146	1.11	26,448
SSME Throttle Up to 104%	00/00:00:58	1,325	1.29	33,950
SRB Staging	00/00:02:05	4,144	3.76	156,585
Main Engine Cutoff (MECO)	00/00:08:30	24,455	22.3	361,210
Zero Thrust	00/00:08:38	24,509	22.28	363,225
ET Separation	00/00:08:50			
OMS 2 Burn (160 x 160 n.m.)	00/00:39:55			
Ulysses/IUS Deploy (orbit 5)	00/06:01:00			
OMS 3 Burn (160 x 177 n.m.)	00/06:16:00			
OMS 4 Burn (160 x 156 n.m.)	00/22:56:00			
Deorbit Burn (orbit 65)	04/01:08:00			
Landing (orbit 66)	04/02:07:00			

Apogee/Perigee at MECO:	157/35 n.m.
Apogee/Perigee post-OMS 2:	160/160 n.m.
Apogee/Perigee post deploy:	160x 177 n.m.

SPACE SHUTTLE ABORT MODES

Space Shuttle launch abort philosophy is to achieve a safe and intact recovery of the flight crew, orbiter and its payload.

Abort modes include:

- Abort-To-Orbit (ATO): Partial loss of main engine thrust late enough to permit reaching a minimal 105-nautical mile orbit with orbital maneuvering system engines.

- Abort-Once-Around (AOA): Earlier main engine shutdown with the capability to allow one orbit around before landing at Edwards Air Force Base, CA; White Sands Space Harbor (Northrup Strip), NM; or the Shuttle Landing Facility (SLF) at Kennedy Space Center, FL

- Transatlantic Abort Landing (TAL): Loss of two main engines midway through powered flight would force a landing at Ben Guerir, Morocco; Moron, Spain; or Banjul, The Gambia.

- Return-To-Launch-Site (RTLS): Early shutdown of one or more engines and without enough energy to reach Ben Guerir, would result in a pitch around and thrust back toward KSC until within gliding distance of the Shuttle Landing Facility.

STS-41 contingency landing sites are Edwards AFB, White Sands, Kennedy Space Center, Ben Guerir, Moron and Banjul.

SUMMARY OF MAJOR ACTIVITIES

Flight Day 1
Ascent
Post-insertion checkout
Pre-deploy checkout
Ulysses/IUS deploy
CHROMEX-2
Detailed science objective (DSO)/detailed test objective (DTO)
Physiological systems experiment (PSE)
SSBUV outgassing

Flight Day 2
Air Force Maui Optical Site (AMOS) calibration test
Ulysses/IUS backup deploy opportunity
CHROMEX-2
DSO/DTO
RMS powerup and checkout
SSBUV Earth views
Voice command system (VCS) test #1

Flight Day 3
CHROMEX-2
DTO
SSBUV Earth views
VCS test #2

Flight Day 4
CHROMEX-2
DSO/DTO
SSBUV Earth views
VCS test #3
Flight control system (FCS) checkout
Reaction control system (RCS) hotfire
Cabin stow

Flight Day 5
CHROMEX-2 status
DSO/DTO
PSE status
SSBUV Earth views
SSBUV deactivation
Deorbit preparation
Deorbit burn
Landing at EAFB

ULYSSES MISSION

Ulysses is a joint mission conducted by the European Space Agency (ESA) and NASA to study the polar regions of the sun and the interplanetary space above the poles. The spacecraft will be the first to achieve a flight path nearly perpendicular to the ecliptic, the plane in which Earth and the other planets orbit the sun.

Throughout its 5-year mission, Ulysses will study three general areas of solar physics: the sun itself, magnetic fields and streams of particles generated by the sun and interplanetary space above the sun.

The Ulysses spacecraft, a ground control computer system and a spacecraft operations team are provided by ESA, while Space Shuttle launch, tracking and data collection during the mission are being performed by NASA and the Jet Propulsion Laboratory (JPL). Scientific instruments aboard the craft have been provided by scientific teams in both Europe and the United States.

Ulysses Mission Summary

After astronauts release Ulysses from Discovery's payload bay at an altitude of 160 nautical miles, a two-stage engine, the Inertial Upper Stage (IUS), attached to Ulysses will ignite, sending the craft on its initial trajectory.

After the IUS separates, a smaller booster engine, the Payload Assist Module (PAM-S), will fire. Before the PAM-S fires, it will spin Ulysses up to a rate of 70 revolutions per minute (rpm). After the engine burn concludes, the spin rate will slow to about 7 rpm. Boom deployment will further slow the spin rate to about 5 rpm. Ulysses will continue to spin at this rate throughout the remainder of the mission.

The booster engines will send Ulysses first to Jupiter, which the craft will encounter in February 1992. As Ulysses flies past Jupiter at about 30 degrees north Jovian latitude, the gravity of the giant planet will alter the craft's trajectory so Ulysses dives downward and away from the ecliptic plane.

In its orbit around the sun, Ulysses flight path will take it from a maximum distance from the sun of 5.4 astronomical units (AU), or about 500 million miles, to a closest approach of 1.3 AU, or about 120 million miles.

The spacecraft will reach 70 degrees south solar latitude in June 1994, beginning its transit of the sun's south polar regions. The craft will spend about 4 months south of that latitude at a distance of about 200 million miles from the sun.

In February 1995, Ulysses will cross the sun's equator, followed by its 4- month pass of the sun's northern polar region beginning in June 1995. End of mission is scheduled for Sept. 30, 1995.

The Ulysses Spacecraft

Ulysses' systems and scientific instruments are contained within a main spacecraft bus measuring 10.5 by 10.8 by 6.9 feet. Communication with Earth is maintained via a 5.4-foot-diameter, parabolic high-gain antenna.

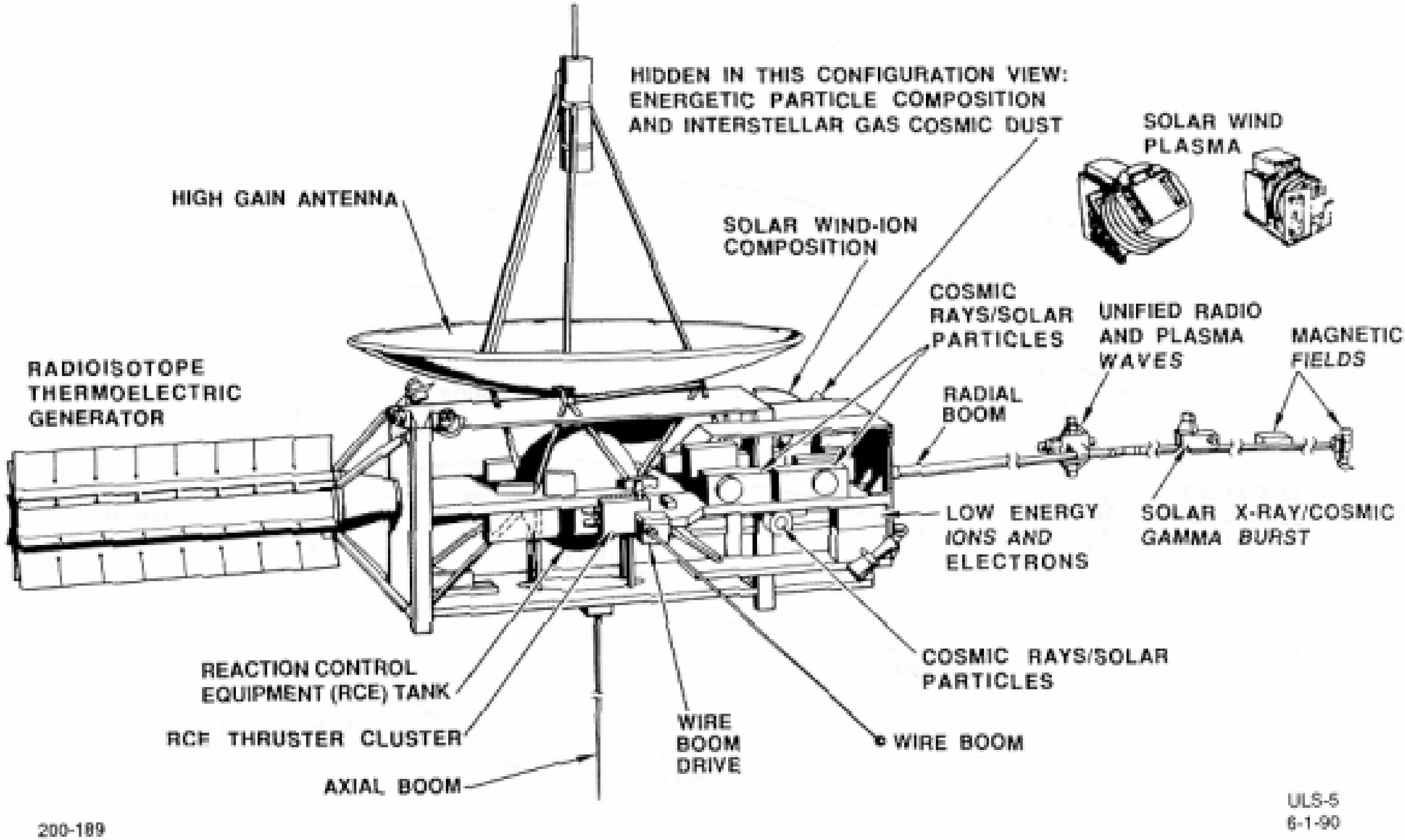
After release from Discovery's cargo bay, the 807-pound spacecraft will deploy an 18.2-foot radial boom carrying several experiment sensors, as well as a 238-foot dipole wire boom and a 26.2-foot axial boom, which serve as antennas for a radio wave-plasma wave experiment.

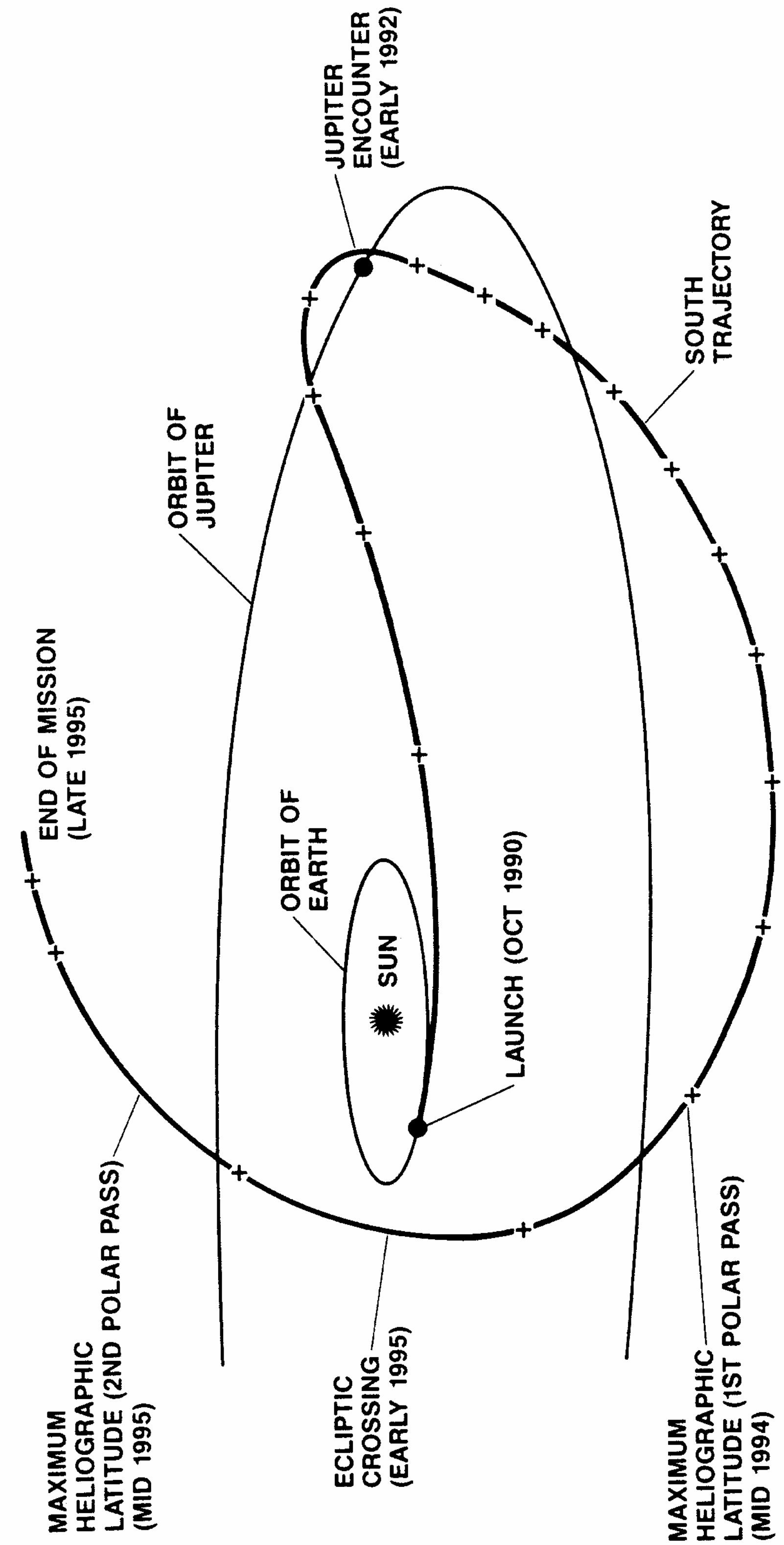
The Ulysses spacecraft's main computer is its onboard data handling system, responsible for processing commands received from the ground as well as managing and passing on all data from each of Ulysses' science instruments. This system includes: a decoder unit, which processes incoming signals from the spacecraft radio and passes on commands to other systems; a central terminal unit, which distributes commands, monitors and collects data on spacecraft systems, and stores and passes on data from Ulysses' science instruments; remote units, which handle input-output to and from spacecraft systems; and the data storage unit, two tape recorders. Each of the tape recorders can store 45.8 million bits of data -- representing 16 to 64 hours of data-taking, depending on how often data are sampled.

Another system, attitude and orbit control, is responsible for determining the Ulysses craft's attitude in space, as well as firing thrusters to control the attitude and spin rate. This system includes a redundant computer, sun sensors and the reaction control system, including eight thrusters and the hydrazine fuel system. Ulysses' load of 73 pounds of monopropellant hydrazine fuel is stored in a single diaphragm tank mounted on the spacecraft's spin axis.

The spacecraft's telecommunications system includes two S-band receivers, two 5-watt S-band transmitters, two 20-watt X-band transmitters, the high-gain antenna and two smaller low-gain antennas. The high-gain antenna is used to transmit in either S band or X band as well as to receive in S band. The low-gain antennas are used both to transmit and receive in the S band. The spacecraft receives commands from Earth on a frequency of 2111.607 MHz in the S band. The craft can transmit to Earth on 2293.148 MHz in the S band or on 8408.209 MHz in the X band.

Ulysses' power source is a radioisotope thermo-electric generator (RTG), similar to RTGs flown on previous solar system exploration missions. RTGs are required for these deep-space missions because solar arrays large enough to generate sufficient power so far from the sun would be too large and too heavy to be launched by available means. In the RTG, heat produced by the natural decay of plutonium-238 is converted into electricity by thermocouples.


HIDDEN IN THIS CONFIGURATION VIEW:
ENERGETIC PARTICLE COMPOSITION
AND INTERSTELLAR GAS COSMIC DUST
SOLAR WIND PLASMA
HIGH GAIN ANTENNA
SOLAR WIND-ION COMPOSITION
COSMIC RAYS/SOLAR PARTICLES
UNIFIED RADIO AND PLASMA WAVES
MAGNETIC FIELDS
RADIOISOTOPE THERMOELECTRIC GENERATOR
RADIAL BOOM
LOW ENERGY IONS AND ELECTRONS
SOLAR X-RAY/COSMIC GAMMA BURST
REACTION CONTROL EQUIPMENT (RCE) TANK
COSMIC RAYS/SOLAR PARTICLES
RCE THRUSTER CLUSTER
WIRE BOOM DRIVE
WIRE BOOM
AXIAL BOOM
200-189
ULS-5
6-1-90



JUPITER ENCOUNTER (EARLY 1992)
SOUTH TRAJECTORY
ORBIT OF JUPITER
END OF MISSION (LATE 1995)
ORBIT OF EARTH
SUN
LAUNCH (OCT 1990)
MAXIMUM HELIOGRAPHIC LATITUDE (2ND POLAR PASS) (MID 1995)
ECLIPTIC CROSSING (EARLY 1995)
MAXIMUM HELIOGRAPHIC LATITUDE (1ST POLAR PASS) (MID 1994)

ULYSSES CIENTIFIC EXPERIMENTS

Ulysses' scientific payload is composed of nine instruments. In addition, the spacecraft radio will be used to conduct a pair of experiments over and above its function of communicating with Earth, bringing the total number of experiments to 11. Finally, two other investigation teams will conduct interdisciplinary studies.

The experiments are:

-- Magnetic fields. This investigation will measure the strength and direction of the sun's polar magnetic fields, which are poorly known because they are difficult to observe from Earth. These measurements will help identify specific regions of the corona, the outer portion of the sun's atmosphere, from which the solar wind originates. They also will be important in understanding the propagation of energetic particles of both solar and galactic origin, which are guided by the magnetic field. Principal investigator of the experiment is Dr. Andre Balogh of Imperial College, London.

-- Solar-wind plasma. The solar wind is a fully ionized gas, or "plasma," consisting of electrons and the positively charged atoms (ions) from which the electrons have been removed. This experiment will measure the basic properties of these ions and electrons such as speed, density and temperature. The outflowing solar wind is expected to be different, and possibly simpler, in the sun's polar regions than near the equator. If this is true, it should be easier to relate the observed solar-wind particles to conditions in the region of the sun where they originated. Dr. Samuel J. Bame of Los Alamos National Laboratory is principal investigator.

-- Solar-wind ion-composition spectrometer (SWICS). This investigation will detect heavy ions (elements up to and including iron) which exist in the corona and which constitute a minor but important constituent of the solar wind. By measuring the composition, temperature and degree of ionization of

this component, it should be possible to infer the temperature of the corona in the source region. This investigation will also detect solar-wind ions that have been accelerated or energized in interplanetary space, possibly including the sun's polar regions. Dr. George Gloeckler of the University of Maryland and Dr. Johannes Geiss of Universitt Bern, Switzerland, are co-principal investigators.

-- Heliospheric instrument for spectra, composition and anisotropy at low energies. This energetic particle detector will measure the composition and properties of low-energy solar-wind ions that have been accelerated to higher energies than those observed by the SWICS. Such particles can be energized at the sun as part of the process that produces solar flares or in interplanetary space. The investigation will determine whether such particles exist in the sun's polar regions. If so, the measurements can be used to further study their origin, storage in the corona and subsequent propagation into space. Dr. Louis J. Lanzerotti of Bell Laboratories, New Jersey, is principal investigator.

-- Energetic-particle composition and neutral gas. An array of charged- particle telescopes on Ulysses will detect medium-energy charged particles and determine their composition, relative abundances, energies and direction of travel. Charged particles in this energy range mark a transition between solar particles and cosmic-ray particles which are accelerated elsewhere in the galaxy and travel vast distances to reach the solar system. A separate instrument will detect neutral helium atoms entering the solar system from interstellar space and will determine their speed, direction of arrival, temperature and density. Dr. Erhardt Keppler of the Max-Planck-Institut fuer Aeronomie in Lindau, Germany, is principal investigator.

-- Cosmic and solar particle investigation. This experiment covers even higher-energy cosmic rays as well as detecting energetic solar and interplanetary particles. Cosmic rays, which have been studied for many years near the solar equator, are likely to have preferred access to the equatorial zone of the solar system by way of the sun's polar regions. This experiment may measure the properties of the cosmic rays before they are strongly modified by their interaction with the solar-interplanetary magnetic field. At present, the properties of cosmic rays at these energies are not known as they exist in interstellar space. Dr. John A. Simpson of the University of Chicago is principal investigator.

-- Solar X-rays and cosmic gamma rays. This experiment will detect X-rays which are emitted sporadically from the vicinity of solar active regions. Although these X-rays have been observed for many years by spacecraft above the Earth's atmosphere, the altitude in the solar atmosphere at which the radiation is emitted and its directivity, which would help identify the source mechanism, are unknown. As Ulysses travels pole-ward, the sun will cut off or "occult" radiation at low altitudes and affect how the intensity varies with direction to the source. Cosmic gamma-ray bursts were detected about 20 years ago but their origin has remained obscure. By accurately timing their arrival at Ulysses and at Earth, their source location can be pinpointed precisely to see what astrophysical objects or bodies give rise to them. Dr. Kevin Hurley of the University of California, Berkeley, and Dr. Michael Sommer of the Max-Planck-Institut fuer Extraterrestrische Physik in Garching, Germany, are co-principal investigators.

-- Unified radio and plasma-wave experiment. Two sets of long, deployable antennas are used to measure high-frequency radio waves emitted from solar active regions as well as lower-frequency "plasma" waves generated in the solar wind near the spacecraft. The radio-wave observations will be used to diagnose the space medium between the sun's polar regions and Ulysses. Observations of the locally generated waves will provide information about the internal workings of the polar wind, particularly the instabilities that transfer energy between the waves and their constituent particles. Dr. Robert G. Stone of the NASA Goddard Space Flight Center, Greenbelt, Md., is principal investigator.

-- Cosmic dust. From the speed and direction of the small particles detected by this experiment, their interplanetary trajectories can be deduced. Mass and charge of the dust particles also will be measured so that competing effects on their motion of solar radiation, gravitation and solar-wind particles can be studied. The distribution of dust and its changing properties from the solar equator to the sun's poles will help distinguish the contributions of three major sources: comets, asteroids and interstellar dust. Dr. Eberhard Gruen of the Max-Planck-Institut fuer Kernphysik in Heidelberg, Germany, is principal investigator.

-- Coronal sounding. This experiment uses signals transmitted simultaneously by Ulysses' radio at two frequencies to infer properties of the sun's corona along the path from the spacecraft to the radio receivers on Earth. From subtle shifts in phase of these two signals, the density and directed velocity of coronal electrons can be inferred at the location where the radio waves pass closest to the sun. Of particular scientific interest are these properties of the corona in the sun's polar regions as Ulysses ascends in latitude. Dr. Hans Volland of Universitaet Bonn, Germany, is principal investigator.

-- Gravitational waves. This investigation also makes use of the spacecraft radio transmitter for scientific purposes. According to Einstein's theory of relativity, the motion of large masses in the universe -- such as those associated with the formation of black holes -- should cause the radiation of gravitational waves. Although such waves have yet to be detected, they could be observed through their effect on the spacecraft, which is expected to undergo a slight perturbation that might be detectable as a shift in frequency of Ulysses' radio signal. Dr. Bruno Bertotti of Universita di Pavia, Italy, is principal investigator.

In addition to the 11 experiment teams, two investigation teams will study interdisciplinary topics:

-- Directional discontinuities. The solar-wind plasma is not homogenous but consists of adjacent regions in which the plasma and magnetic field are different. These regions are separated by thin surfaces, called discontinuities, across which the properties change abruptly. Ulysses measurements will be compared with theoretical models developed by a team led by Dr. Joseph Lemaire of the Institut d'Aeronomie Spatiale de Belgique, Belgium.

-- Mass loss and ion composition. This team will combine measurements of the solar wind and magnetic field to study the mass and angular momentum lost by the sun in the equatorial and polar regions. A second problem which will be studied is the dependence of the solar wind composition on solar latitude. This team is led by Dr. Giancarlo Noci of the Istituto di Astronomia, Italy.

TRACKING AND DATA ACQUISITION

Throughout the Ulysses mission, tracking and data acquisition will be performed through NASA's Deep Space Network (DSN).

The DSN includes antenna complexes at Goldstone, in California's Mojave Desert; near Madrid, Spain; and at Tidbinbilla, near Canberra, Australia. The complexes are spaced approximately 120 degrees apart in longitude around the globe so that, as the Earth turns, a given spacecraft will nearly always be in view of one of the DSN complexes.

Each complex is equipped with a 230-foot-diameter antenna; two 112-foot antennas; and an 85-foot antenna. Each antenna transmits and receives. The receiving systems include low-noise amplifiers. Transmitters on the 230-foot antennas are rated at 100 kilowatts of power, while the 112-and 85-foot antennas have 20-kilowatt transmitters. Each antenna station also is equipped with data handling and interstation communication equipment.

During most of the mission, the DSN will be in contact with Ulysses 8 hours per day. The spacecraft will record all its science and engineering data during the 16 hours it is out of touch with Earth; during the 8 hours of DSN contact, the spacecraft will transmit stored data from the craft's tape recorder.

Mission plans call for a 112-foot antenna to be used both to transmit to and receive from Ulysses. To conserve antenna coverage during periods of high demand on the DSN, ground teams can switch to the 230-foot antennas for communication with Ulysses; the larger antennas permit a higher data rate, so 4 hours of antenna coverage each 48 hours is sufficient.

Data streams received from Ulysses at the DSN station are processed and transmitted to the Mission Control and Computing Center at JPL in Pasadena, Calif. Data are transmitted to Pasadena from the various DSN stations by a combination of land lines, ground microwave links and Earth-orbiting communication satellites.

ULYSSES MANAGEMENT

The Ulysses spacecraft was built for ESA by Dornier GmbH (Inc.) of Germany. Subcontractors included firms in Austria, Belgium, Denmark, France, Italy, The Netherlands, Spain, Sweden, Switzerland, the United Kingdom and the United States. In addition to providing the spacecraft, ESA is responsible for spacecraft operations.

Launch on Space Shuttle Discovery is provided by NASA. In addition, NASA is responsible for the IUS and PAM-S upper-stage engines, built for the U.S. Air Force by Boeing Aerospace & Electronics Co. (IUS) and McDonnell Douglas Space

Systems Co. (PAM-S). NASA also provides the radioisotope thermo-electric generator (RTG), built for the U.S. Department of Energy by the General Electric Co.

Tracking through the Deep Space Network and ground operations facilities in Pasadena, Calif., are managed for NASA by JPL. The U.S. portion of the Ulysses mission is managed by JPL for NASA's Office of Space Science and Applications.

CHROMEX-2

The Chromosome and Plant Cell Division (CHROMEX-2) experiment is designed to study some of the most important phenomena associated with plant growth. The CHROMEX-2 experiment aims to determine how the genetic material in the root cells responsible for root growth in flowering plants responds to microgravity.

All plants, in the presence of light, have the unique ability to convert carbon dioxide and water into food and oxygen. Any long expedition or isolated settlement beyond Earth orbit will almost certainly necessitate the use of plants to manufacture food for crew members. In addition, information from space based life sciences research promotes fundamental understanding of the mechanisms responsible for plant growth and development. An improved understanding of plant responses to spaceflight is required for the long-term goal of a controlled ecological life support system for space use.

One of the practical benefits of studying and designing plant growth systems (and eventually agricultural systems) for use in space is the contribution this work may make to developing new intensive farming practices for extreme environments on Earth. Over the last few decades, basic research in the plant sciences has enabled the great increase in crop productivity (the "green revolution") that has transformed modern agriculture. Plant research in space may help provide the necessary fundamental knowledge for the next generation of agricultural biotechnology.

Dr. Abraham D. Krikorian of the State University of New York at Stony Brook is the principal investigator. This experiment has been developed at the Kennedy Space Center and uses the Plant Growth Unit developed by the NASA Ames Research Center.

Results From The First Flight Of CHROMEX

The first flight of CHROMEX in March 1989 showed that spaceflight seems to have a distinct, measurable and negative effect on the structural integrity of chromosomes in root tip cells. The plantlets grew well, but at the cellular level, in the chromosomes in rapidly dividing root tip cells, damage was clearly visible through light microscopy. Damage or aberrations were seen in 3-30% of dividing cell chromosomes. Ground controls were damage-free. The

exact cause for the chromosomal aberrations seen on CHROMEX-1 is not known, but data from the radiation measuring devices flown with the plantlets suggest that radiation alone was insufficient to cause the observed damage. The principal investigator has suggested that an interaction of microgravity and radiation may be responsible. This hypothesis cannot be fully tested until an artificial gravity centrifuge is developed to enable additional space biology experiments.

Roots grown in space also were seen to have a higher percentage of cells undergoing division than ground controls. As expected, roots grew in all directions in space, while roots grew normally and downward on the ground controls. More root tissue grew on the space flown plants, but this was probably due to the increased moisture held in the foam used as artificial soil in the Plant Growth Unit. The plants were grown as planned without microbial contamination throughout the flight and ground control experiments.

SOLID SURFACE COMBUSTION EXPERIMENT

The Solid Surface Combustion Experiment (SSCE) will study the basic behavior of fire by examining the spreading of flame over solid fuels without the influence of gravity. This research may lead to improvements in fire prevention or control both on Earth and in spacecraft.

On Earth, spreading flames are strongly affected by gravity. Hot gases, which are less dense than cold gases, ascend from flames in the same way that oil floats on water. This phenomena -- "buoyant convection" -- removes hot gases from the flame and draws in fresh air to take their place. The resulting air motion tends to cool the flame. However, it also provides fresh oxygen, which makes the flame hotter. The heating and cooling effects compete, with the outcome depending upon the speed of the airflow (A campfire, for example, is strengthened by blowing, while a match can be blown out). Scientists quantify the airflow effects on Earth by augmenting buoyant convection with controlled amounts of forced convection. On Earth, gravity prevents observation of airflows slower than buoyant convection speeds, limiting the ability to develop complete models of solid surface combustion.

SSCE will provide observations of flames spreading without buoyant convection. Air motion is eliminated except to the extent that the flame spreads into fresh air and away from the hot gases. Convective cooling and the heating effect of fresh oxygen are simultaneously minimized. The competition between heating and cooling effects will be quantified by performing tests in artificial atmospheres that have different fractional amounts of oxygen (the air we breathe is 21% oxygen).

The SSCE hardware consists of a chamber to house the burning sample, two cameras to record the experiment on film and a computer to control experiment operations. Fuel and air temperatures are recorded during the experiment for comparison with theory. The SSCE test plan calls for eight Shuttle flights over the next 3 years. Five flights will use samples made of a special ashless filter paper and three will use samples of polymethylmethacrylate (PMMA), commonly known as Plexiglas. Each test will be conducted in an artificial atmosphere containing oxygen at levels ranging from 35% to 50%.

The SSCE was conceived by the principle investigator, Dr. Robert A. Altenkirch, Dean of Engineering at Mississippi State University; the flight hardware was developed by the NASA Lewis Research Center, Cleveland.

SHUTTLE SOLAR BACKSCATTER ULTRAVIOLET (SSBUV) INSTRUMENT

The Shuttle Solar Backscatter Ultraviolet (SSBUV) instrument was developed by NASA to compare the observations of several ozone measuring instruments aboard the National Oceanic and Atmospheric Administration's TIROS satellites (NOAA-9 and NOAA-11) and NASA's NIMBUS-7 satellite. The SSBUV data is used to calibrate these instruments to insure the most accurate readings possible for the detection of ozone trends.

The SSBUV will help scientists solve the problem of data reliability caused by the calibration drift of the Solar Backscatter Ultraviolet (SBUV) instruments on these satellites. The SSBUV uses the Space Shuttle's orbital flight path to assess instrument performance by directly comparing data from identical instruments aboard the TIROS spacecraft and NIMBUS-7 as the Shuttle and satellite pass over the same Earth location within an hour. These orbital coincidences can occur 17 times a day.

The satellite-based SBUV instruments estimate the amount and height distribution of ozone in the upper atmosphere by measuring the incident solar ultraviolet radiation and ultraviolet radiation backscattered from the Earth's atmosphere. The SBUV measures these parameters in 12 discrete wavelength

channels in the ultraviolet. Because ozone absorbs in the ultraviolet, an ozone measurement can be derived from the ratio of backscattered radiation at different wavelengths, providing an index of the vertical distribution of ozone in the atmosphere.

The SSBUV has been flown once, on STS-34 in October 1989. Its mission successfully completed, the SSBUV was refurbished, recalibrated and reprocessed for flight. NASA plans to fly the SSBUV approximately once a year for the duration of the ozone monitoring program, which is expected to last until the year 2000. As the project continues, the older satellites with which SSBUV works are expected to be replaced to insure continuity of calibration and results.

The SSBUV instrument and its dedicated electronics, power, data and command systems are mounted in the Shuttle's payload bay in two Get Away Special canisters that together weigh 1,200 pounds. The instrument canister holds the

SSBUV, its aspect sensors and in-flight calibration system. A motorized door assembly opens the canister to allow the SSBUV to view the sun and Earth and closes during in-flight calibration. The support canister contains the power system, data storage and command decoders. The dedicated power system can operate the SSBUV for approximately 40 hours.

The SSBUV is managed by NASA's Goddard Space Flight Center, Greenbelt, Md., for the Office of Space Science and Applications. Ernest Hilsenrath is the principal investigator. Donald Williams is the experiment manager.

INTELSAT SOLAR ARRAY COUPON

The Intelsat Solar Array Coupon (ISAC) experiment on STS-41 is being flown by NASA for the International Telecommunications Satellite Organization (INTELSAT). The experiment will measure the effects of atomic oxygen in low Earth orbit on the Intelsat satellite's solar arrays, to judge if the stranded satellite's arrays will be seriously damaged by those effects.

Intelsat, launched aboard a commercial expendable launch vehicle earlier this year, is stranded in a low orbit and is, at the request of the company, being evaluated for a possible Space Shuttle rescue mission in 1992.

ISAC consists of two solar array material samples mounted on Discovery's remote manipulator system (RMS) arm. The arm will be extended to hold the samples perpendicular to the Shuttle payload bay, facing the direction of travel, for at least 23 consecutive hours.

PHYSIOLOGICAL SYSTEMS EXPERIMENT

The Physiological Systems Experiment (PSE) is a middeck payload sponsored by the Pennsylvania State University's Center for Cell Research, a NASA Office of Commercial Programs Center for the Commercial Development of Space. The corporate affiliate leading the PSE investigation is Genentech, Inc., South San Francisco, Calif., with NASA's Ames Research Center, Mountain View, Calif., providing payload and mission integration support.

The goal of the PSE is to investigate whether biological changes caused by near weightlessness mimic Earth-based medical conditions closely enough to facilitate pharmacological evaluation of potential new therapies.

Research previously conducted by investigators at NASA, Penn State and other institutions has revealed that in the process of adapting to near weightlessness, or microgravity, animals and humans experience a variety of physiological changes including loss of bone and lean body tissue, some decreased immune cell function, change in hormone secretion and cardiac deconditioning, among others. These changes occur in space-bound animals and people soon after leaving Earth's gravitational field. Therefore, exposure to conditions of microgravity during the course of space flight might serve as a useful and expedient means of testing potential therapies for bone and muscle wasting, organ tissue regeneration and immune system disorders.

Genentech is a biotechnology company engaged in the research, development, manufacture and marketing of recombinant DNA-based pharmaceuticals. The company replicates natural proteins and evaluates their pharmacological potential to treat a range of medical disorders.

In this experiment, eight healthy rats will receive one of the natural proteins Genentech has developed. An identical group will accompany them during the flight, but will not receive the protein, thereby providing a standard of comparison for the treated group. Both groups will be housed in self-contained animal enclosure modules which provide sophisticated environmental controls and plenty of food and water throughout the flights duration. The experiment's design and intent has received the review and approval of the Animal Care and Use Committees from both NASA and Genentech. Laboratory animal veterinarians will oversee selection, care and handling of the animals.

Following the flight, the rat tissues will be thoroughly evaluated by teams of scientists from Genentech and the Center for Cell Research in a series of studies which will require several months.

Dr. Wesley Hymer is Director of the Center for Cell Research at Penn State and co-investigator for PSE. Dr. Michael Cronin, Genentech, is principal investigator.

INVESTIGATIONS INTO POLYMER MEMBRANE PROCESSING

The Investigations into Polymer Membrane Processing (IPMP), a middeck payload, will make its second Space Shuttle flight for the Office of Commercial Programs-sponsored Battelle Advanced Materials Center for the Commercial Development of Space (CCDS) in Columbus, Ohio.

The objective of the IPMP research program is to gain a fundamental understanding of the role of convection driven currents in the transport processes which occur during the evaporation casting of polymer membranes and, in particular, to investigate how these transport processes influence membrane morphology.

Polymer membranes have been used in the separations industry for many years for such applications as desalination of water, atmospheric purification, purification of medicines and dialysis of kidneys and blood.

The IPMP payload uses the evaporation casting method to produce polymer membranes. In this process, a polymer membrane is prepared by forming a mixed solution of polymer and solvent into a thin layer; the solution is then evaporated to dryness. The polymer membrane is left with a certain degree of porosity and then can be used for the applications listed above.

The IPMP investigations on STS-41 will seek to determine the importance of the evaporation step in the formation of thin-film membranes by controlling the convective flows. Convective flows are a natural result of the effects of gravity on liquids or gasses that are non-uniform in specific density. The microgravity of space will permit research to study polymer membrane casting in a convection-free environment.

The IPMP program will increase the existing knowledge base regarding the effects of convection in the evaporation process. In turn, industry will use this understanding to improve commercial processing techniques on Earth with the ultimate goal of optimizing membrane properties.

The IPMP payload on STS-41 consists of two experimental units that occupy a single small storage tray (one-half of a middeck locker) which weighs less than 20 pounds.

Early in Flight Day 1, a crew member will turn the valve to the first stop to activate the evaporation process. Turning the valve opens the pathway between the large and sample cylinders causing the solvents in the sample to evaporate into the evacuated larger cylinders. Both flight units are activated at the same time.

The STS-41 experiment will investigate the effects of evaporation time on the resulting membranes by deactivating the two units at different times. The evaporation process will be terminated in the first unit after a period of 5 minutes, by turning the valve to its final position. This causes the process to terminate by flushing the sample with water vapor, and thus setting the membrane structure. After the process is terminated, the resulting membrane then will not be affected by gravitational forces experienced during reentry, landing and post-flight operations. The second unit will be deactivated after a period of 7 hours.

In IPMP's initial flight on STS-31, mixed solvent systems were evaporated in the absence of convection to control the porosity of the polymer membrane. Ground-based control experiments also were performed. Results from STS-31 strongly correlated with previous KC-135 aircraft testing and with a similar experiment flown on the Consort 3 sounding rocket flight in May 1990. The morphology of polymer membranes processed in reduced gravity showed noticeable differences from that of membranes processed on Earth.

However, following post-flight analysis of the STS-31 experiment, it was decided to incorporate a minor modification to the hardware to significantly improve confidence in the analysis by providing additional insight into the problem. In addition, the modification would further remove remaining variables in the experiment.

The two most significant variables remaining in the experiment as originally configured are the time factor and the gravitational forces affecting the samples prior to retrieval of the payload. With the addition of a 75-cc cylinder containing a small quantity of distilled water pressurized with compressed air to greater than 14 psig, Space Shuttle crew members will be able to abruptly terminate (or "quench") the vacuum evaporation process by flushing the sample with water vapor. After the process is terminated, the resulting membrane will not be further affected by gravity variations. The planned modifications will not alter the experimental objectives and, in fact, will further contribute to a better understanding of the transport mechanisms involved in the evaporation casting process.

Subsequent flights of the IPMP payload will use different polymers, solvents and polymer-to-solvent ratios. However, because of the modification to the hardware, the polymer/solvent combination used on this flight will be the same as that used on the first slight. The polymer, polysulfone, is swollen with a mixture of dimethylacetamide and acetone in the IPMP units. Combinations of polymers and solvents for later experiments will be selected and/or adjusted based on the results of these first flights.

Principal investigators for the IPMP is Dr. Vince McGinness of Battelle. Lisa A. McCauley, Associate Director of the Battelle CCDS, is Program Manager.

VOICE COMMAND SYSTEM

The Voice Command System (VCS) is a flight experiment using technology developed at the Johnson Space Center, Houston, to control the onboard Space Shuttle television cameras using verbal commands.

On STS-41, the VCS will be used by mission specialists William Shepherd and Bruce Melnick. The system allows the astronauts to control the cameras hands-free using simple verbal commands, such as "stop, up, down, zoom in, zoom out, left, right." The VCS unit is installed in Discovery's aft flight deck, in an instrument panel directly below the standard closed circuit television displays and controls.

Shepherd and Melnick will operate the VCS at least three times each during the mission. The original television displays and controls on board Discovery will be used for standard operations during the flight. When the VCS is powered on, the manual controls will remain operational, and the cameras can be controlled using either method.

The VCS displays and controls are a 2- by 10-inch fluorescent display and three switches, a power switch, mode switch and reset switch. Voice commands from Shepherd and Melnick have been recorded prior to the flight and voice templates inside the VCS were made to allow the computer to recognize them. When using the VCS, the mission specialist will wear a special headset with a microphone that feeds the verbal commands into the system.

If successful, the VCS could be incorporated as standard equipment aboard the Shuttle, allowing much simpler television operations. Such simplification could greatly reduce the amount of hands-on work needed for television operations during such times as maneuvers with the Shuttle's remote manipulator system robotic arm. Normally, an astronaut controlling the arm uses two hands for the task and must remove one hand to adjust television coverage. Information from this flight can determine if microgravity affects the user's voice patterns in a way that can inhibit the VCS's ability to recognize them.

RADIATION MONITORING EQUIPMENT-III

The Radiation Monitoring Equipment-III measures ionizing radiation exposure to the crew within the orbiter cabin. RME-III measures gamma ray, electron, neutron and proton radiation and calculates -- in real time -- exposure in RADS-tissue equivalent. The information is stored in memory modules for post-flight analysis.

The hand-held instrument will be stored in a middeck locker during flight except for activation and memory module replacement periods. RME-III will be activated as soon as possible after achieving orbit and will operate throughout the mission. A crew member will enter the correct mission elapsed time upon activation and change memory modules every two days.

RME-III is the current configuration, replacing the earlier RME-I and RME-II units. RME-III last flew on STS-31. The experiment has four zinc-air batteries and five AA batteries in each replaceable memory module.

RME-III is sponsored by the Department of Defense in cooperation with NASA.

STS-41 CREWMEMBERS

STS041-S-002 -- Pictured near the flight line at Ellington Field in front of T-38A NASA 915, STS-41 crewmembers pose for their official portrait prior to an early morning T-38A flight. Kneeling, from the left are pilot Robert D. Cabana and mission commander Richard N. Richards. Standing, from left are mission specialists Bruce E. Melnick, Thomas D. Akers, and William M. Shepherd. Portrait taken by JSC photographer Mark Sowa.

PHOTO CREDIT: NASA or National Aeronautics and Space Administration.

BIOGRAPHICAL DATA

RICHARD N. RICHARDS, 44, Capt., USN, will serve as commander. Selected as an astronaut in 1980, he considers St. Louis, MO, his hometown. Richards will be making his second space flight. Richards served as pilot of STS-28, a dedicated Department of Defense mission launched Aug. 8, 1989.

He graduated from Riverview Gardens High School, St. Louis, in 1964. Richards received a bachelor of science degree in chemical engineering from the University of Missouri in 1969 and received a master of science degree in aeronautical systems from the University of West Florida in 1970. Commissioned as a Navy Ensign upon graduation from the University of Missouri, Richards was designated a Naval aviator in August 1970. His flight experience has included more than 4,000 hours in 16 different types of aircraft, including more than 400 aircraft carrier landings.

ROBERT D. CABANA, 41, Lt. Col., USMC, will serve as pilot. Selected as an astronaut in 1985, Cabana considers Minneapolis, his hometown. He will be making his first space flight.

Cabana graduated from Washburn High School, Minneapolis, in 1967 and received a bachelor of science degree in mathematics from the Naval Academy in 1971. He has logged more than 3,700 flying hours in 32 different types of aircraft, including the AD-1 oblique wing research aircraft.

At NASA, Cabana has worked as the Astronaut Office Space Shuttle flight software coordinator, deputy chief of aircraft operations and lead astronaut in the Shuttle avionics integration laboratory, where the orbiter's flight software is tested.

BRUCE E. MELNICK, 40, Cdr, USCG, will serve as Mission Specialist 1. Selected as an astronaut in 1987, he was born in New York, but considers Clearwater, FL, his hometown. He will be making his first space flight.

Melnick graduated from Clearwater High School in 1967 and attended Georgia Tech in 1967-68. He received a bachelor of science degree in engineering from the Coast Guard Academy in 1972 and received a master of science in aeronautical systems from the University of West Florida in 1975.

At NASA, Melnick has served on the astronaut support personnel team and currently represents the Astronaut Office in the assembly and checkout of the new Space Shuttle orbiter Endeavour at the contractor facilities in Downey and Palmdale, CA.

WILLIAM M. SHEPHERD, 41, Capt., USN, will serve as Mission Specialist 2. Selected by NASA as an astronaut in 1984, he was born in Oak Ridge, TN. Shepherd will be making his second space flight.

Shepherd served as Mission Specialist on STS-27, a dedicated Department of Defense flight, launched Dec. 2, 1988.

Shepherd graduated from Arcadia High School, Scottsdale, AZ, in 1967. He received a bachelor of science degree in aerospace engineering from the Naval Academy in 1971 and received degrees of ocean engineer and master of science in mechanical engineering from the Massachusetts Institute of Technology in 1978.

BIOGRAPHICAL DATA

THOMAS D. AKERS, 39, Major, USAF, will serve as Mission Specialist 3. Selected as an astronaut in 1987, he considers Eminence, Mo., his hometown. This will be Akers first space flight.

Akers currently serves as the Astronaut Office focal point for Space Shuttle software development and the integration of new computer hardware for future Shuttle missions.

Akers graduated from Eminence High School, valedictorian of his class. After graduating from the University of Missouri-Rolla in 1975, he spent 4 years as high school principal in Eminence. He joined the Air Force in 1979 and was serving as executive officer to the Armament Division's deputy commander for research, development and acquisition at Eglin AFB, FL when selected for the astronaut program.

MISSION MANAGEMENT TEAM

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J.R. Thompson	Deputy Administrator
Dr. William B. Lenoir	Associate Administrator, Office of Space Flight
Robert L. Crippen	Director, Space Shuttle
Leonard S. Nicholson	Deputy Director, Space Shuttle (Program)
Brewster Shaw	Deputy Director, Space Shuttle (Operations)
Lennard A. Fisk	Associate Administrator, Space Science and Applications
Alphonso V. Diaz	Deputy Associate Administrator, Space Science and Applications
Dr. Wesley Huntress	Director, Solar System Exploration Division
Frank A. Carr	Deputy Director, Solar System Exploration Division
Robert F. Murray	Program Manager
Dr. J. David Bohlin	Program Scientist

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Dr. Roger Bonnet	Director of Scientific Programmes
David Dale	Head of Scientific Projects
Derek Eaton	Project Manager

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Derek Eaton	Manager, Ulysses Project
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Koos Leertouwer	Ground/Launch Operations Manager Ulysses Project
Alan Hawkyard	Integration Manager, Ulysses Project
Peter Caseley	Science Instruments Manager Ulysses Project

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G. Porter Bridwell	Acting Manager, Solid Rocket Motor Project
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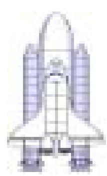
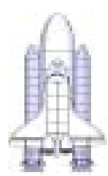
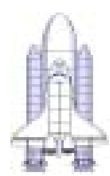
Joanne H. Morgan	Director, Payload Project Management

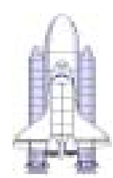
SHUTTLE FLIGHTS AS OF OCTOBER 1990

35 TOTAL FLIGHTS OF THE SHUTTLE SYSTEM -- 10 SINCE RETURN TO FLIGHT









	STS-51L 01/28/86	STS-31 04/24/90 - 04/29/90	
STS-32 01/09/90 - 01/20/90	STS-61A 10/30/85 - 11/06/85	STS-33 11/22/89 - 11/27/89	
STS-28 08/08/89 - 08/13/89	STS-51F 07/29/85 - 08/06/85	STS-29 03/13/89 - 03/18/89	
STS-61C 01/12/86 - 01/18/86	STS-51B 04/29/85 - 05/06/85	STS-26 09/29/88 - 10/03/88	
STS-9 11/28/83 - 12/08/83	STS-41G 10/05/84 - 10/13/84	STS-51-I 08/27/85 - 09/03/85	STS-36 02/28/90 - 03/04/90
STS-5 11/11/82 - 11/16/82	STS-41C 04/06/84 - 04/13/84	STS-51G 06/17/85 - 06/24/85	STS-34 10/18/89 - 10/23/89
STS-4 06/27/82 - 07/04/82	STS-41B 02/03/84 - 02/11/84	STS-51D 04/12/85 - 04/19/85	STS-30 05/04/89 - 05/08/89
STS-3 03/22/82 - 03/30/82	STS-8 08/30/83 - 09/05/83	STS-51C 01/24/85 - 01/27/85	STS-27 12/02/88 - 12/06/88
STS-2 11/12/81 - 11/14/81	STS-7 06/18/83 - 06/24/83	STS-51A 11/08/84 - 11/16/84	STS-61B 11/26/85 - 12/03/85
STS-1 04/12/81 - 04/14/81	STS-6 04/04/83 - 04/09/83	STS-41D 08/30/84 - 09/05/84	STS-51J 10/03/85 - 10/07/85
OV-102 **Columbia** **(9 flights)**	**OV-099** **Challenger** **(10 flights)**	**OV-103** **Discovery** **(10 flights)**	**OV-104** **Atlantis** **(6 flights)**