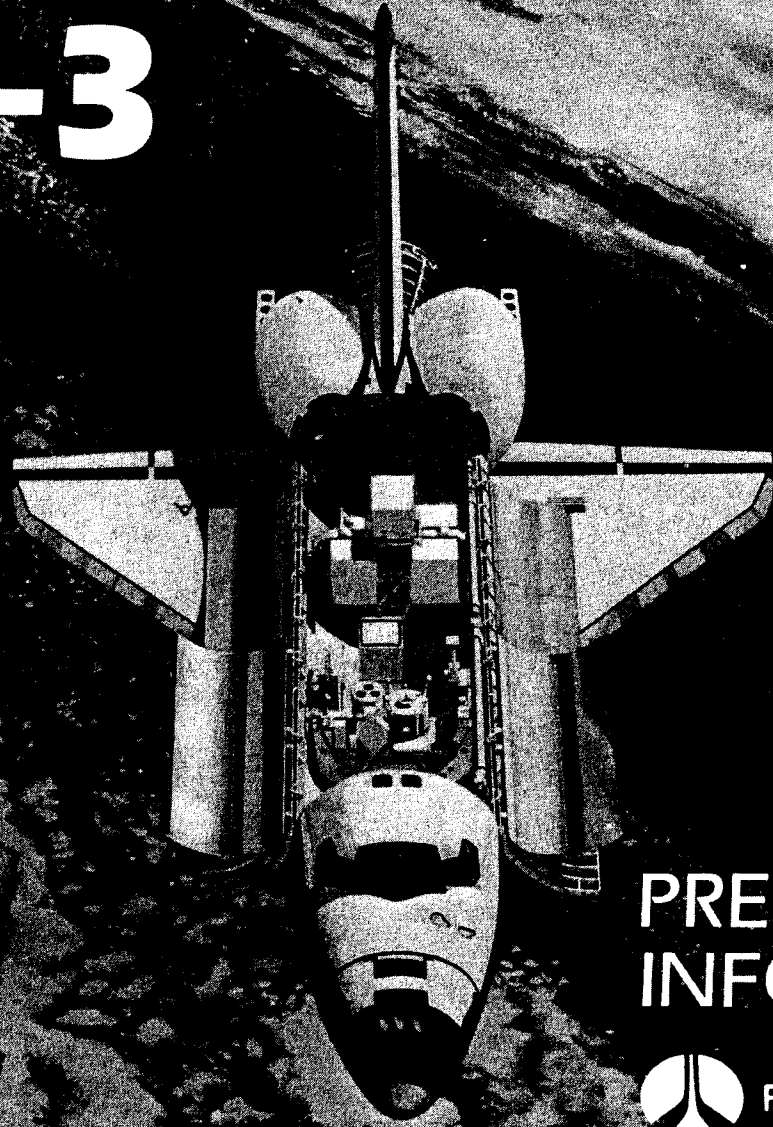March 1982

STS-3

PRESS
INFORMATION

Rockwell International

Space Transportation &
Systems Group

A PARENT(HETICAL) LOOK AT THE SHUTTLE SPACECRAFT *COLUMBIA*

There is an esoteric quality about *Columbia*, a mystique that is intriguing yet calming, and promises confidence and success.

The people who designed, developed, and are now testing *Columbia* are aware that she is something very special—and was so from the beginning.

It was apparent even in March 1979, when *Columbia*, ungainly and unglamorous, was towed from Rockwell International's Palmdale, Calif., assembly site through the city of Lancaster to NASA's Dryden Flight Research Center at Edwards AFB on the Mojave Desert. A few weeks later she was flown piggyback atop a 747 ferry aircraft to the Kennedy Space Center, Fla.

During this move *Columbia* was splotched in color: shades of black and white, the green of thermal paint, red-brown of adhesive, and, in place of the 8,500 thermal protection system tiles, off-white polyurethane blocks or cavities through which the aluminum surface showed.

But *Columbia* was beautiful to those who built her, and they had pride in her potential and future.

That's a good reason for this: the Shuttle program, the space program, represents a tremendous potential in the future, and to the hopes of all of us.
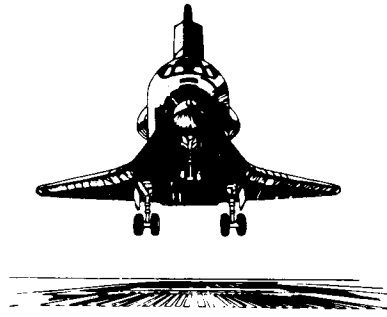
Now *Columbia* is bringing the future into today. She's proven that we have a reusable spacecraft. Her second flight last November stimulated acclaim from the scientists who had experiments aboard for her capabilities as a stable platform in space: "The Shuttle, it's the only way to fly", "a perfect stable platform", "we can build payloads at less cost and more quickly using the Shuttle as a transport."

Astronauts John Young and Bob Crippen (in April) and Joe Engle and Dick Truly (in November) all praised *Columbia* as a tremendous and magnificent flying machine. These were wonderful words from the people who flew *Columbia*, but the scientists' talk of what the Shuttle means to the scientific community is what our program is all about:

To make space flight routine and economical where its benefits will be available to the majority of people.

CONTENTS

NEWS ABOUT AMERICA'S SPACE SHUTTLE

...it comes from Rockwell International

A major test objective, vitally important to the long-range success of the Space Shuttle Transportation System program, is the capability of rapid turnaround from a landing to another launch.

In the developmental phase, the turnarounds are deliberately lengthy and incorporate extensive modifications and detailed systems checkout. In the operational phase, the time between landing and launch will be greatly reduced.

A major modification to the spacecraft *Columbia* (from STS-2 to STS-3) is the changing of experiment packages in the cargo bay. STS-2 contained the OSTA-1 pallet and five experiments. This has been removed and a new pallet, the OSS-1, has been installed with six experiments. The OSS is NASA's Office of Space Science and these experiments are primarily designed to obtain data on space environment for use in interplanetary probes. The new pallet required additional support systems, including renovations and additions in the crew compartment control and display panels. Several additional experiments will be carried out in the crew compartment mid-deck area.

In the following pages we have outlined the modifications necessary and the turnaround tasks required. The major experiments on STS-3 are described in some detail. There is also a summary of the STS-2 and STS-1 flights.

MODIFICATIONS TO *COLUMBIA* FOR STS-3

- Addition of cryogenic storage tank set No. 4 (liquid oxygen and liquid hydrogen) in the mid-fuselage to the power reactant storage and distribution system.

- Replacement of fuel cell No. 1—This fuel cell failed in the STS-2 flight and was replaced by a new unit. Fuel cells No. 1, No. 2, and No. 3 were removed and returned to United Technologies Power Systems Division for additional inspection and then reinstalled.

- Removal of the elevon cove felt reusable surface insulation (FRSI) and replacement by advanced FRSI (AFRSI).

- Replacement of auxiliary power unit (APU) No. 1—The water spray cooling system on STS-2 failed to operate for cooldown of gas generator valve module and gas generator injector. The replacement unit will be hot-fired for seven minutes after the orbiter is in place on Launch Complex 39A.

- Changed lube oil system and filter on APU No. 2 and No. 3.

- Removal and replacement of rudder/speedbrake power drive unit for O-ring material changeout.

- Removal and replacement of cathode ray tube (CRT) No. 1 and No. 4 because of an anomaly on STS-2 flight. CRT No. 1 went blank during flight and was replaced by the flight crew with CRT No. 4. CRT No. 1 then failed again after landing.

- Removal and replacement of elevon ablators.

- Removal and replacement of nose landing gear tires.

- Removal and replacement of the remote manipulator system (RMS) end effector.

- Removal and replacement of the three microwave scan beam landing decoders.

- Installation and revision of various subsystem thermal control systems due to STS-3 "cold" mission; this includes installation of main landing gear hydraulic system heaters.

- Thermal protection system:

  - Removal of approximately 449 tiles and replacement with densified tiles; this includes damaged tiles on chine area of right-side fuselage and body flap, instrumented tile modifications, and those tiles used for engineering evaluation.

  - Refurbishment of selected thermal barriers and gap fillers.

  - Re-waterproofing of tiles.

- Removal and replacement of two radar altimeters.

- Installation of experiments in crew compartment mid-deck:

  - Electrophoresis verification test (EEVT)

  - Monodisperse latex reactor (MLR)

  - Plant lignification

- Installation of "Getaway special" carrier in payload bay.

1
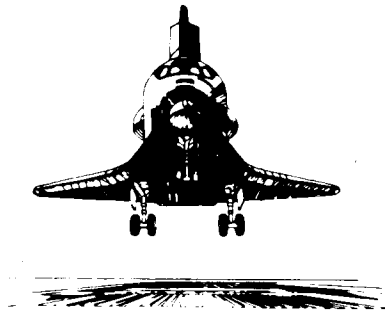
NEWS ABOUT AMERICA'S SPACE SHUTTLE

...it comes from Rockwell International

This third flight of *Columbia* is primarily a thermal test, to register the reactions of the spacecraft and its payload to the most extreme temperature differentials that could be encountered in the operational flights. Temperatures may range from 82 to 93 degrees C (180 to 200°F) on surfaces irradiated by sunlight to −82 to −93 degrees C (−180 to −200°F) on any surface out of direct sunlight or shaded by another object. With relatively small satellites, the resulting thermal strains can be checked in advance, in test chambers on earth. But such tests are not possible with the large orbiter.

STS-3 MISSION STATISTICS
PRELIMINARY

Launch—Monday, March 22, 1982, 10:00 am EST
9:00 am EST
7:00 am PST

This launch time is selected to obtain the optimum sun angle (as close to 90 degrees as possible) for the OSS-1 payload experiments at launch.

Inclination: 38 degrees
SSME Throttling: 72 to 100 percent RPL
Max q: 650/765 pounds per square foot
Altitude: 130 nautical miles (149 statute miles)
Payload Weight Up and Down: Approximately 9525 kg (21,000 lb)
Angle of Attack-Entry: 40 degrees
Crossrange: Less than 600 nautical miles (690 statute miles)
Autoland control mode to 60 meters (200 feet)
    altitude, then CSS (control stick steering)
Runway: Edwards AFB 23 lake bed; if crosswinds between 10
    and 15 knots, lake bed Runway 17.

Duration: 7 days, 3 hours, 24 minutes
Duration:
Landing: Monday, March 29, 1982, 1:24 pm EST (12:24 am
    CST, 10:24 am PST), on beginning of Orbit 116

STS-3 MISSION OBJECTIVES

- Flutter boundary tests during ascent elevon and rudder actuations

- Power reactant storage and distribution system cryogenic thermal tests (hot and cold case)

- Remote manipulator system (RMS) thermal tests (hot and cold case)

- RMS end effector grappling performance tests

**Passive Thermal Control
(Barbecue Roll)**

Sun

Earth

**Top To Sun
(+Z SI)**

Sun
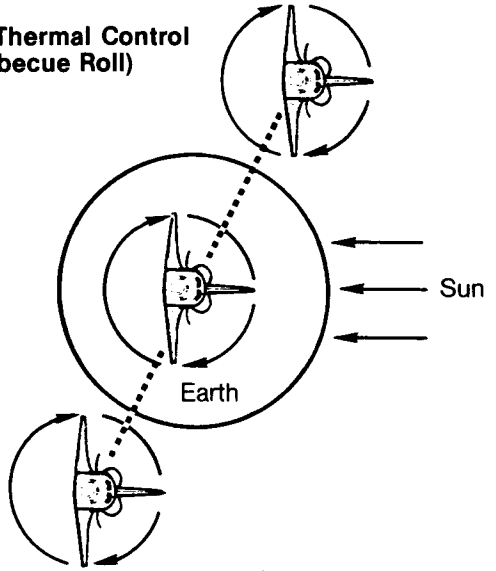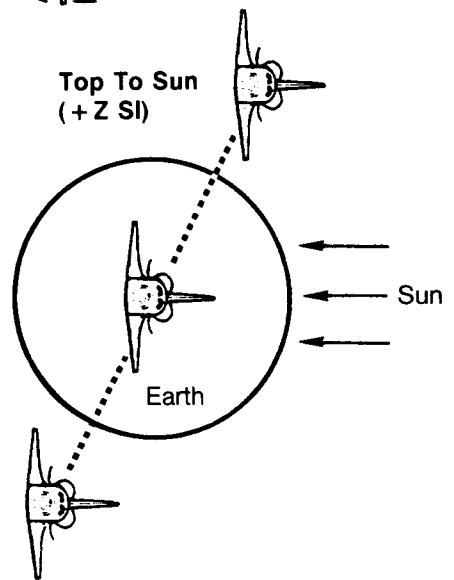
Earth

**Tail to Sun, Bottom to Earth
(Orbital Rate Roll)**

Sun

Earth

4

**Nose to Sun
(-X SI)**

Sun

Earth

Orbiter Thermal Test Attitudes

- Contamination monitoring using RMS to deploy the Induced Environment Contamination Monitor (IECM) and the Plasma Diagnostics Package (PDP)

- Payload bay door performance, thermal tests (hot and cold case)

- Inertial measurement unit (IMU) performance

- Backup flight system (BFS) with orbital maneuvering system (OMS) single-engine cold case restart and maneuvering system, in addition to reaction control system (RCS) maneuvers using the BFS

- RCS thermal tests

- Orbiter payload bay door radiator thermal tests

- Electrophoresis verification test (EEVT), mid-deck

- Monodisperse latex reactor (MLR) experiment, mid-deck

- Plant lignification experiment, mid-deck

- Insect flight motion study

- OSS-1 data takes

- Entry aero/structural tests

- Autoland demonstration to 60 meters (200 feet) attitude, then CSS (control stick steering).

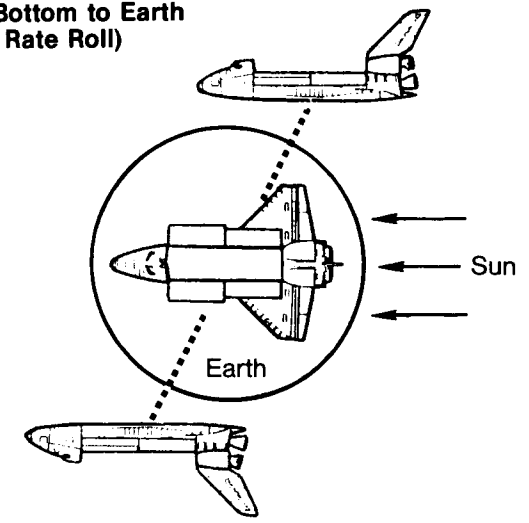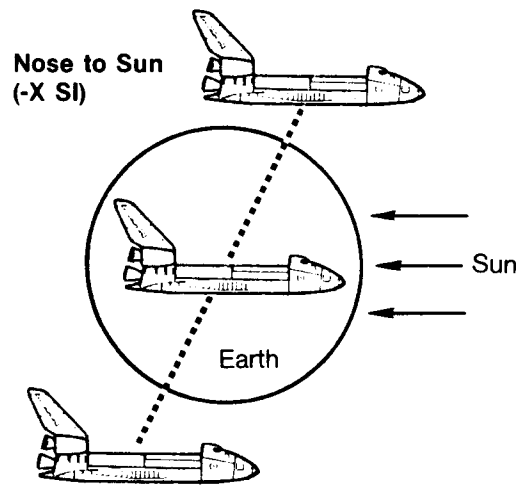- Orbiter braking test on rollout: demonstrate the minimum stopping distance of the orbiter on landing rollout using standard braking technique

ORBITAL ATTITUDES

The spacecraft can be at any attitude in orbit, nose first (which looks right, like an airplane), tail first, broadside, and the bottom or top may face the earth. The spacecraft will be positioned according to the needs of the payload.

When the spacecraft has its nose toward the sun, its attitude fixed with respect to the sun, the OSS-1 pallet and payload bay remain entirely in the shade and extreme cold. During this period, two of the OSS-1 experiments—Plasma Diagnostics Package and the Shuttle/Spacelab Induced Atmosphere experiment—can operate. The same is true with the spacecraft oriented with its tail to the sun and roll as it orbits the earth. The bottom of the spacecraft then faces the earth, again leaving the OSS-1 pallet and payload bay in the shade and extreme cold.

With the spacecraft payload bay and OSS-1 pallet facing the sun, the payload bay and pallet are exposed to its heat. During this period, the OSS-1 experiments that can operate are the Solar Ultraviolet Spectral Irradiance Monitor and the Solar Flare X-Ray Polarimeter.

The passive thermal control (PTC) mode is when the spacecraft rolls to equalize temperatures on all surfaces at any time required, especially before reentry. This is referred to as a barbecue mode.

The OSS-1 Thermal Canister and Vehicle Charging and Potential experiments can operate in any spacecraft attitude.

—	Passive thermal control (PTC) barbecue roll	: 10 hours
—	Tail to sun	: 30 hours
—	PTC	: 10 hours
—	Nose to sun (− X solar inertial)	: 80 hours
—	Top (payload bay) to sun (+ Z solar inertial)	: 26 hours
—	PTC	: 12 hours

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OSS-1 PAYLOAD

The OSS-1 payload consists of seven experiments and the power, command, data, and cooling systems required to support them.

Six of the experiments are mounted in *Columbia's* payload bay on a U-shaped 3-meter (10-foot) long pallet built by the British Aerospace Corp., under contract to ERNO (Zentral Gesellschaft-VFW Fokker mbh) and the European Space Agency (ESA). The remaining experiment is located in the crew compartment mid-deck.

The pallet occupies approximately 0.84 cubic meter (30 cubic feet) of the payload bay and weighs approximately 3855 kilograms (8500 pounds).

NASA's Goddard Space Flight Center (GSFC) is responsible for overall administration, assembly of the pallet payload, testing operations, flight operations, data handling, and liaison with the principal investigators. The experiment support system includes internal computers and special equipment required to interface with the individual experiments and with the spacecraft, a power distribution unit, multiplexer/demultiplexer, coolant pump, coldplates, utility plumbing and cabling, and structural attachments.

The six pallet-mounted experiments are: Plasma Diagnostics Package (PDP), Vehicle Charging and Potential (VCAP), Shuttle/Spacelab Induced Atmosphere, Thermal Canister, Solar Flare X-Ray Polarimeter, Solar Ultraviolet Spectral Irradiance Monitor (SUSIM), Contamination Monitor Package (CMP), and Microabrasion Foil Experiment (MFE).

The Plasma Diagnostics Package is from the University of Iowa, the Vehicle Charging and Potential Experiment from Utah State University, the Shuttle/Spacelab Induced Atmosphere from the University of Florida, the Solar Ultraviolet Spectral Irradiance Monitor from the Naval Research Laboratory, the Solar Flare X-Ray Polarimeter Experiment from Columbia University, the

Thermal Canister Experiment from NASA's GSFC, the Contamination Monitor Package is from NASA's GSFC, the Microabrasion Foil Experiment (MFE) is from the University of Kent, Kent England, and the Plant Lignification experiment from the University of Houston.

The *Columbia's* crew compartment portion of the OSS-1 payload consists of the Plant Lignification experiment mounted in the mid-deck and two 28-channel tape recorders and a control panel located at the flight deck aft station.

The OSS-1 pallet and experiment operation will be initiated as soon as possible after opening the payload bay doors. They are
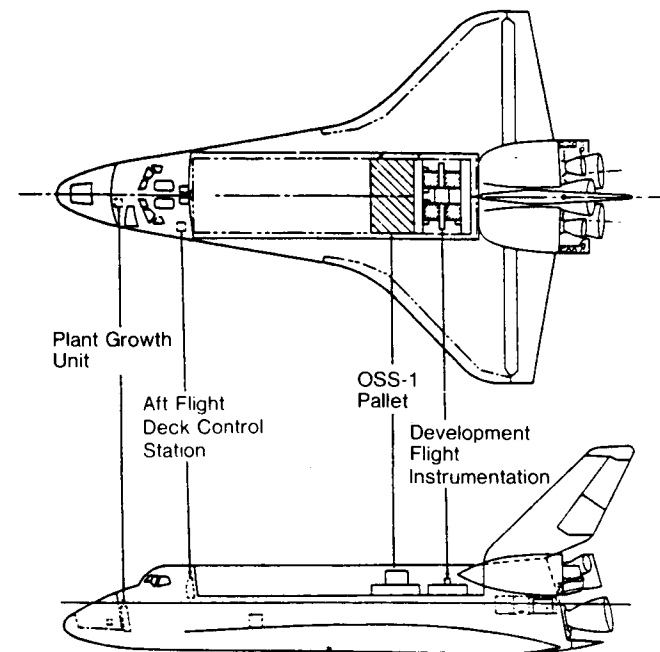
Location of Payloads on Columbia

Closed-Circuit TV Camera

Getaway Special

X_O 1307.00
Aft
Bulkhead

Extravehicular
Tether Slidewire

X_O 1057.20

•X_O 1179.13

Payload Bay
Floodlights

X_O 998.20

OSS-1 Pallet

DFI Pallet

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Remote
Manipulator
Arm

Closed-Circuit
TV Camera
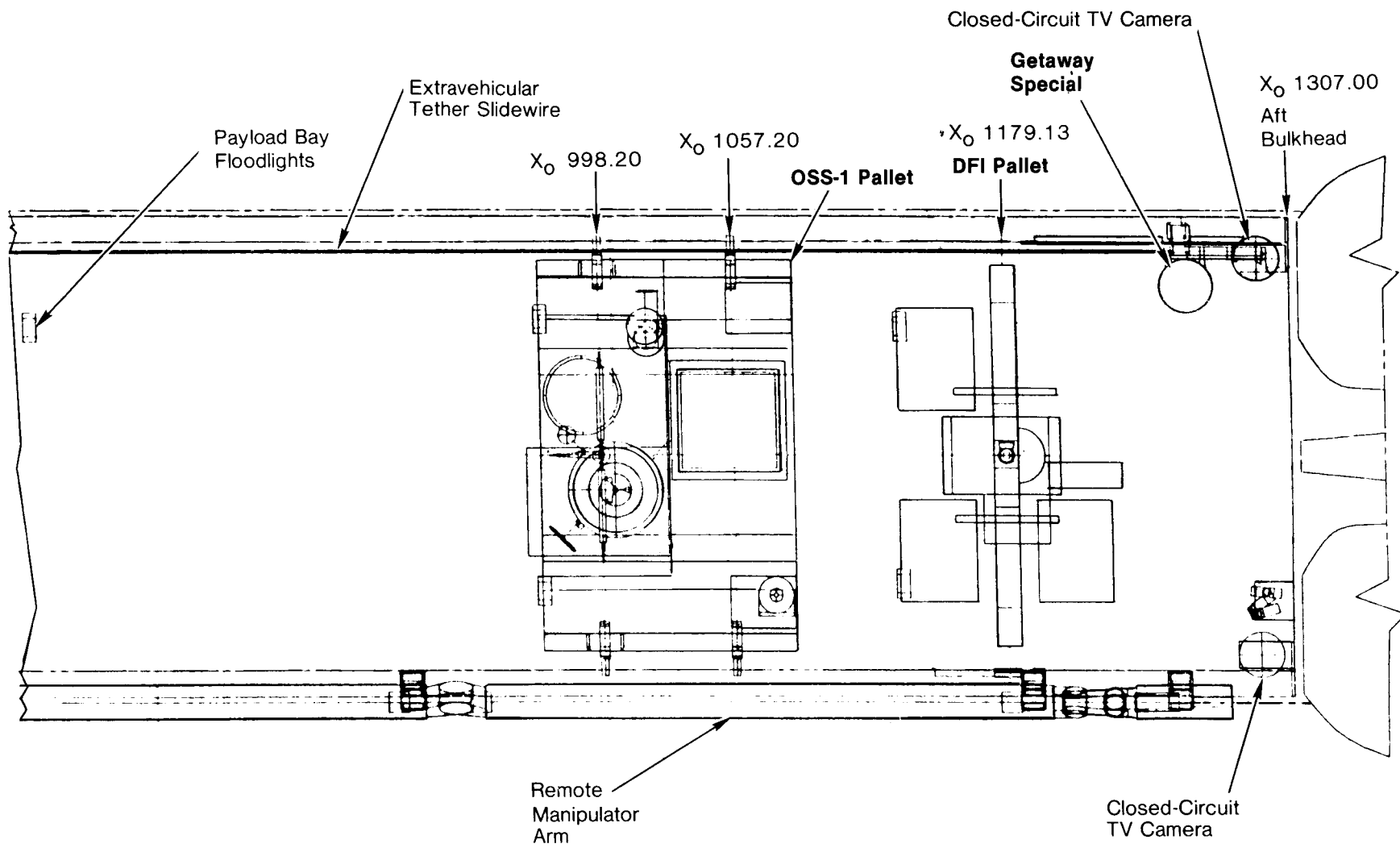
Location of OSS-1, DFI Pallet, and Getaway Special in Payload Bay

Payload Latch Controls

Payload Bay Windows

RMS Controls

Closed-Circuit Television

General-Purpose Computer Keyboard Display

Goddard Space Flight Center Tape Recorders and Control Panels

Mission Station

Payload Station
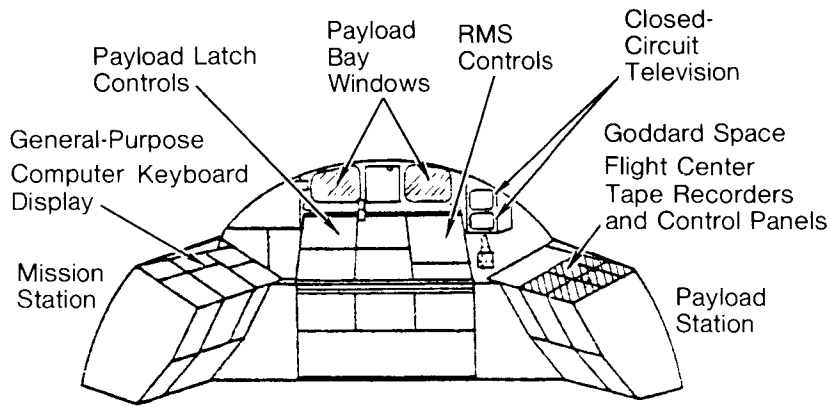
Aft Flight Deck

designed to find out more about the earth's immediate environment.

The earth is immersed in a stream of charged particles and imbedded magnetic fields that are continually emitted by the sun. Streaming ionized particles or plasma from the sun is called solar wind. The solar wind that comes toward earth causes some strange changes in the shape of earth's own magnetic field (magnetosphere). Because of earth's molten metal core, strong magnetic lines stretch out near the South Pole and curve back in near the North Pole. Under ideal conditions, the earth's magnetosphere should look like a giant doughnut, but the ram pressure of the solar wind causes the shape to be more like a comet, hemispherical on the sunside and swept out into a long tail on the nightside.

The solar wind pushes against the sunside of the magnetosphere, but cannot easily enter it. In the elongated tail, a significant quantity of solar plasma does enter and become trapped. It remains there until the plasma sheet that separates the upper and lower halves of the tail is thrown out of balance by sudden changes in the solar wind caused by a solar flare. This causes measurable increase in the speed of solar particles reaching the earth and affecting the earth's magnetosphere. When this happens, the earth's magnetic

field lines are squeezed together momentarily, allowing them to link and snap back toward earth, carrying along the trapped plasma particles. This "back door" injection causes brilliant auroral displays in massive magnetic storms that can interrupt radio or television communications and electrical power transmissions by current surges tripping circuit breakers, cause a blackout in long-distance communication, disorient satellites, or cause airplane or ship compass needles to swing erratically. Knowledge of these storms could help account for their disruptive effects.

It is also possible that changes in the solar wind influence earth's weather. If it is determined that the fluctuations among solar magnetic activity, solar wind, and magnetic field do indicate weather changes, an invaluable tool will be available to make accurate, long-term weather and climate predictions.

Thus, scientists study the boundaries between interplanetary space and the space controlled by earth and the nature of fluctuations in the boundaries. These boundaries include the magnetic envelope which surrounds earth, the magnetopause (where the magnetic field on the earth meets that of the solar wind), and the bow shock (a bow wave like that of a boat in water) created by the motion of the solar wind past the earth.

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The *Columbia*, a much larger spacecraft than those used in the past for orbital field measurements, may also affect certain measurements just by its presence. The various orientations of the spacecraft relative to its direction of motion through the earth's ionized upper atmosphere also may slightly change the existing electromagnetic field or the state of plasmas the spacecraft passes through. The spacecraft is expected to produce a "wake" in the earth's magnetosphere, making waves in the plasmas as a boat makes waves in the water. The spacecraft is also expected to create a bow shock in the direction of its motion. This shock is analogous to that formed on the sunward side of the earth from the interaction of the solar wind with the earth's magnetic field. In this case, the relative motion is that of the spacecraft flying through the ionized plasma, rather than the plasma streaming past the earth; however, the physics of the interaction is very similar. The OSS-1 experiments will define the nature and extent of these because they are impor-

Earth

Moon

Sun

Earth's
Magnetosphere

Earth Magnetosphere

Solar Flare

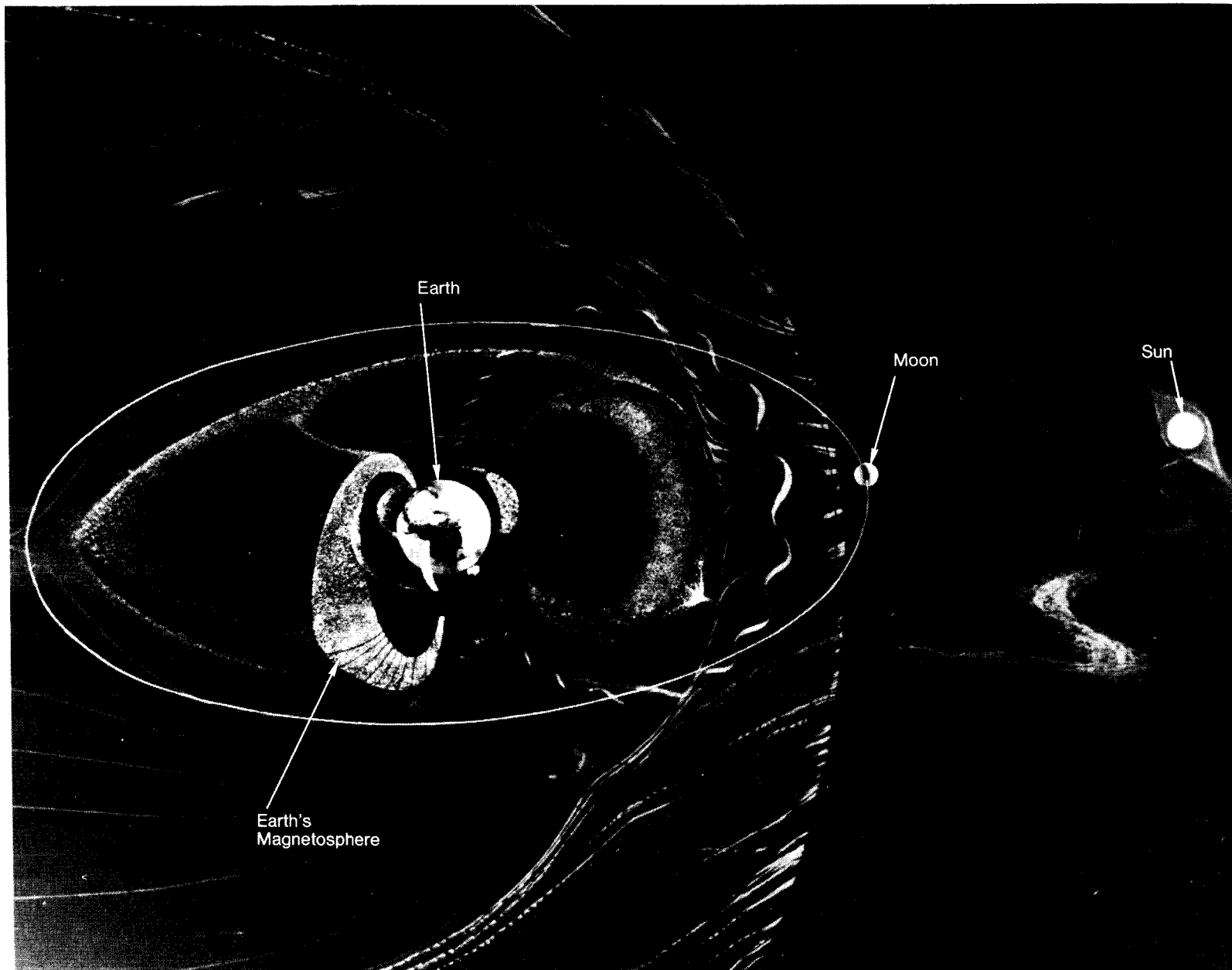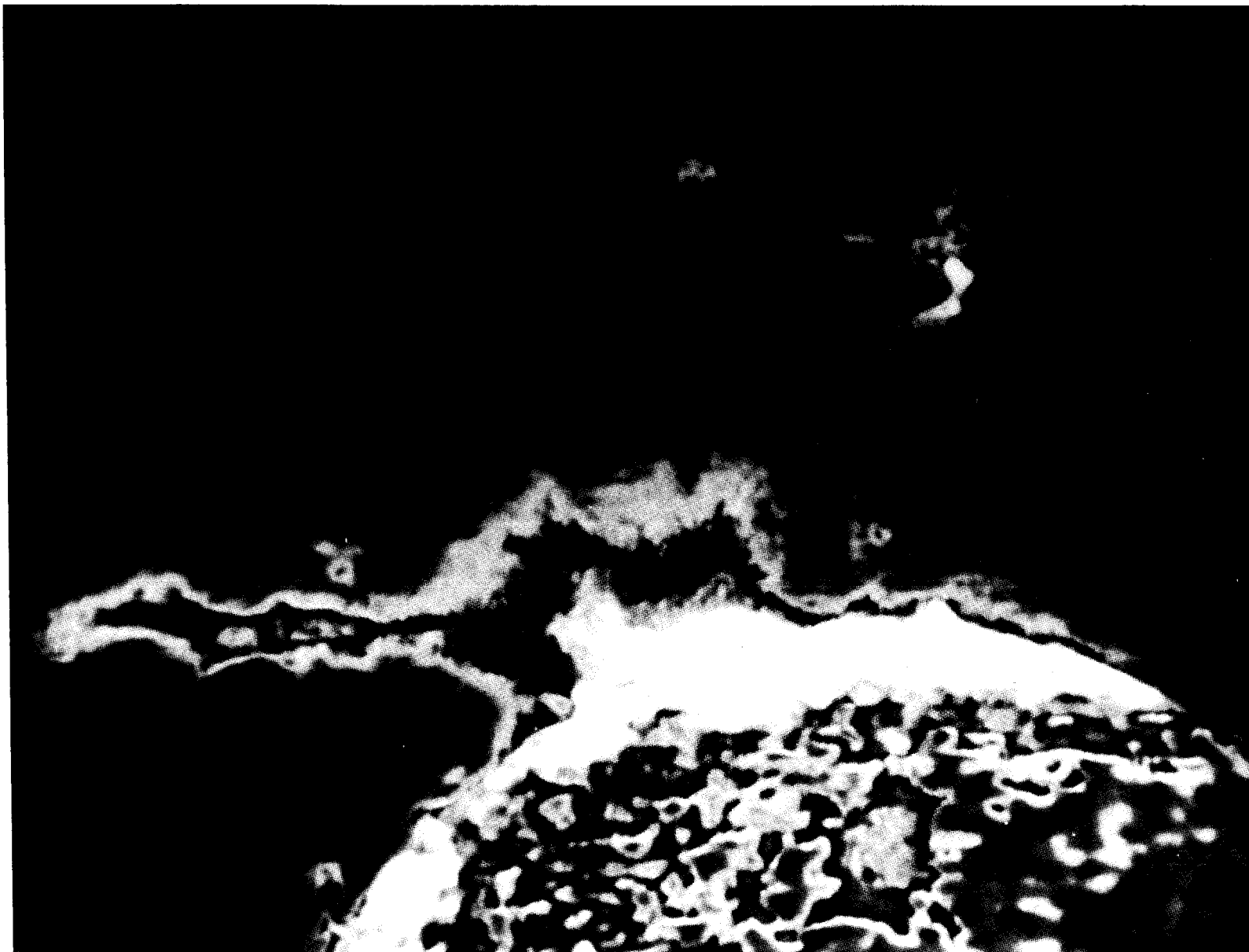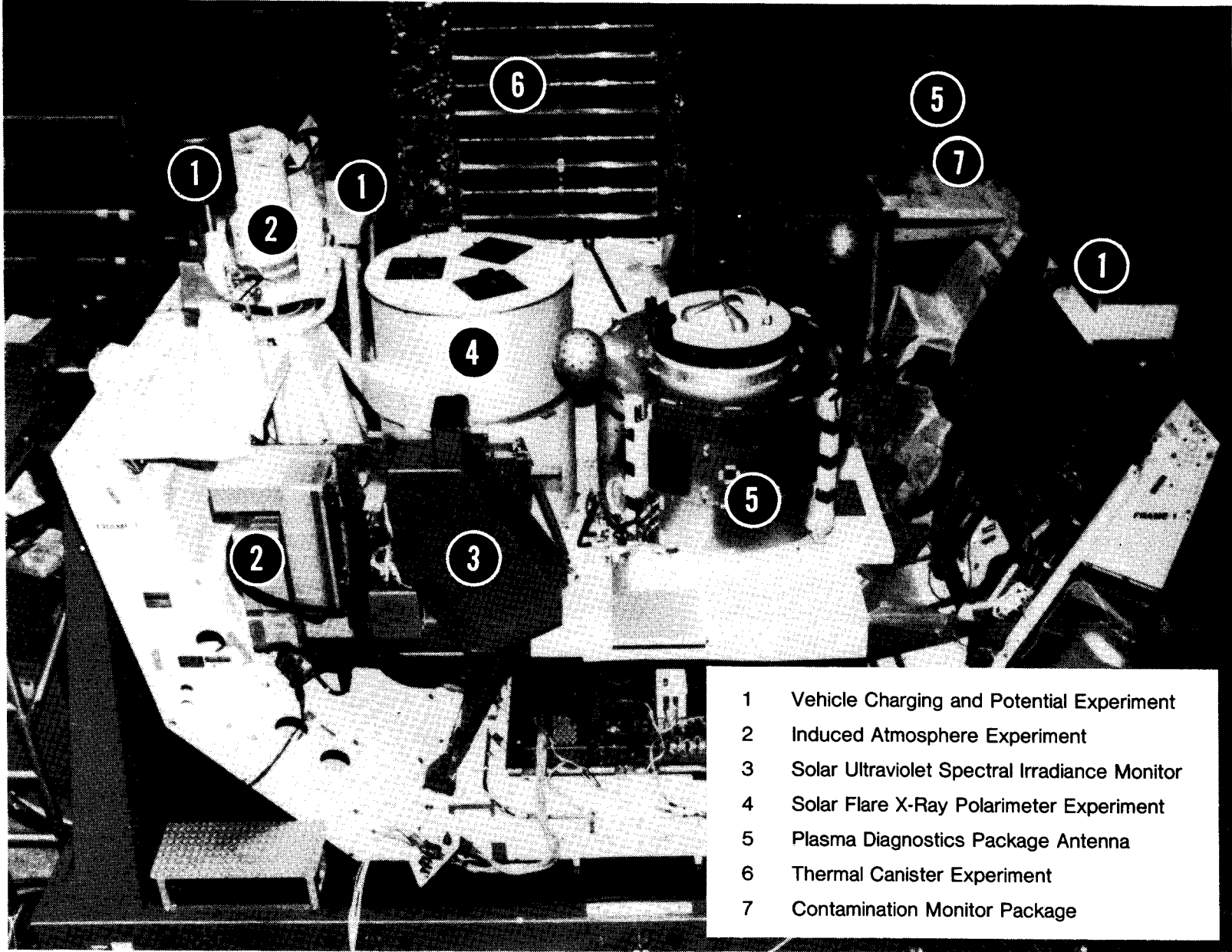|	
1	Vehicle Charging and Potential Experiment
2	Induced Atmosphere Experiment
3	Solar Ultraviolet Spectral Irradiance Monitor
4	Solar Flare X-Ray Polarimeter Experiment
5	Plasma Diagnostics Package Antenna
6	Thermal Canister Experiment
7	Contamination Monitor Package

OSS-1 Experiments (Top View)

1   Vehicle Charging and Potential Experiment
2   Induced Atmosphere Experiment
3   Solar Ultraviolet Spectral Irradiance Monitor
4   Solar Flare X-Ray Polarimeter Experiment
5   Plasma Diagnostics Package
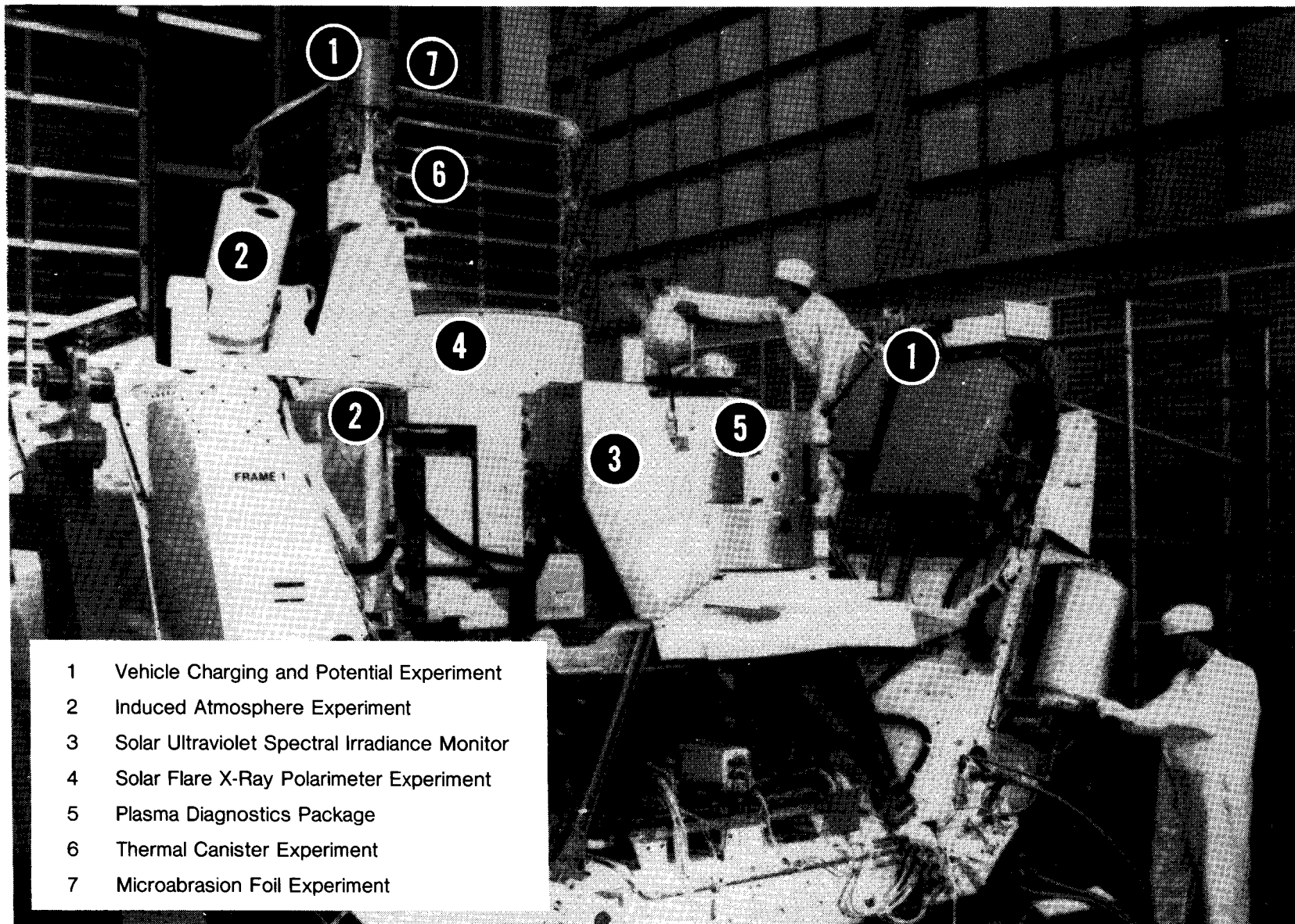6   Thermal Canister Experiment
7   Microabrasion Foil Experiment

OSS-1 Experiments (Side View)

tant boundary conditions for observations of the earth's magnetosphere from the spacecraft and so that future measurements can be accurately interpreted.

PLASMA DIAGNOSTICS PACKAGE (PDP)

The electromagnetic environment of the *Columbia* must be understood so that future measurements of the fields, waves, and plasmas naturally present around the earth can be planned and interpreted correctly. It is impossible to assess precisely the orbiter's radiated emissions through analysis and testing before flight. The PDP is designed to provide this assessment.

It is expected that the spacecraft may produce noise emissions (in radio terms) caused by its power distribution system, transmitters, and pulsed electric currents that encompass the frequency spectrum from 10 Hz (Hertz) to 1 GHz (gigahertz). To analyze this ac radiation environment, the PDP will carry four receivers that will measure the very low frequency (VLF) spectrum in 16 channels between 31 and 178 Hz, the mid-frequency spectrum in 8 channels between 311 kHz and 17.8 MHz, the very high frequency-ultra high frequency (VHF-UHF) spectrum in 4 channels between 30 MHz and 1 GHz, and the detailed spectrum between 10 Hz and 30 kHz. The radio noise diminishes with distance from the spacecraft and varies with the *Columbia's* operational mode so that the receivers operate with a wide dynamic range.

In addition to the ac fields, the *Columbia* is also expected to generate low-level dc magnetic and electric fields. The dc magnetic fields are produced by the orbiter 28 Vdc power systems and the dc fields are produced as the spacecraft moves through and is charged by the surrounding ionized plasma. These fields will be measured by a magnetometer and electrostatic sensor, respectively. The charging effects may lead to acceleration of particles, which can be detected by a low-energy proton and electron differential analyzer and by the retarding potential analyzer included in the PDP.

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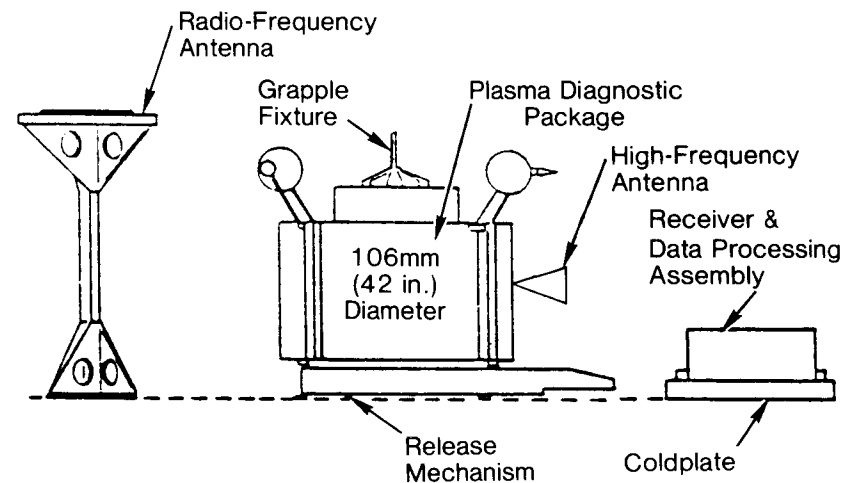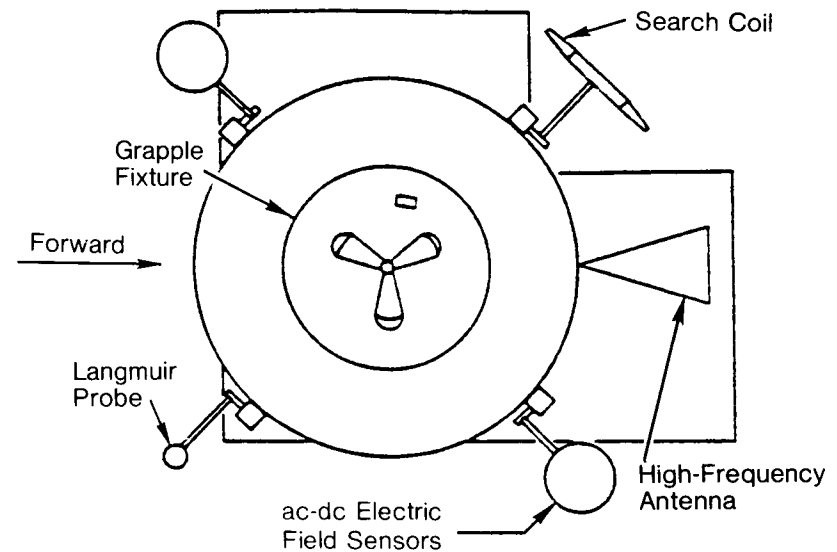
Location of Sensor Packages on Plasma Diagnostics Package

The composition and state of the ambient medium may also be affected by the presence of the *Columbia*. The composition may change if molecules are injected into the local plasma during operation of the spacecraft cooling, reaction control, and propulsion systems or if particles are intentionally injected by a fast pulse electron gun, part of the Vehicle Charging and Potential experiment. To measure the composition and state of the ambient medium and changes brought about by the orbiter, the PDP carries a Langmuir probe, an ion mass spectrometer, and a pressure gauge.

In addition to the scientific objectives to be studied using the PDP alone, the presence of the fast-pulse electron gun provides an opportunity for joint experiments in investigating the interaction of the electron beam with the ambient Shuttle environment. Magnetic measurements made by the PDP can be used to predict the direction of the electron beam and its perturbations caused by the orbiter's fields. The PDP also will be able to track the trajectory of the beam to confirm these predictions and record the spreading of the beam that may result from interactions between the electron beam and the ambient atmosphere. Charging of the spacecraft will probably occur as a result of electron gun operation, and the PDP will be able to map the resulting electric fields around the *Columbia* to a distance of 15 meters (49 feet). Electromagnetic and electrostatic wave emissions generated by the electron beam also will be detectable by the PDP.

The electromagnetic background and the plasma environment will first be measured while the PDP is on the OSS-1 pallet. The flight crew then will maneuver the remote manipulator system (RMS) end effector to grapple and latch onto the PDP grapple fixture. The PDP release mechanism will unlatch the PDP from the pallet and the RMS will move the PDP around the orbiter to map the spacecraft's fields out to 15 meters. The scan in and around the payload bay will last approximately two hours. Stationary operation with the RMS fully extended is required for at least one orbit while in the −X solar inertial (nose-to-sun) attitude hold or passive thermal control (PTC) to observe wakes and shocks. Stationary opera-

Fast-Pulse Electron Gun

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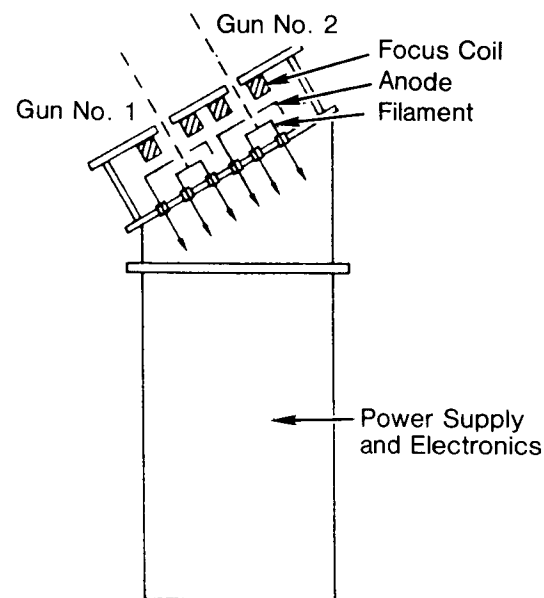
tion with the PDP located at predetermined positions outside the payload bay will be scheduled between RMS scans. Scans of the emitted beam and magnetic field around the Vehicle Charging and Potential experiment are required during operation of the electron gun. The PDP will then be returned to its position on the OSS-1 pallet and latched, after which the RMS end effector is released from the PDP grapple fixture.

The PDP experiment will be controlled by the flight crew using keyboard commands at the aft flight deck station. Science and housekeeping data will be recorded on eight dedicated tracks of the OSS-1 experiment tape recorder.

The PDP experiment weighs approximately 182 kilograms (401 pounds).
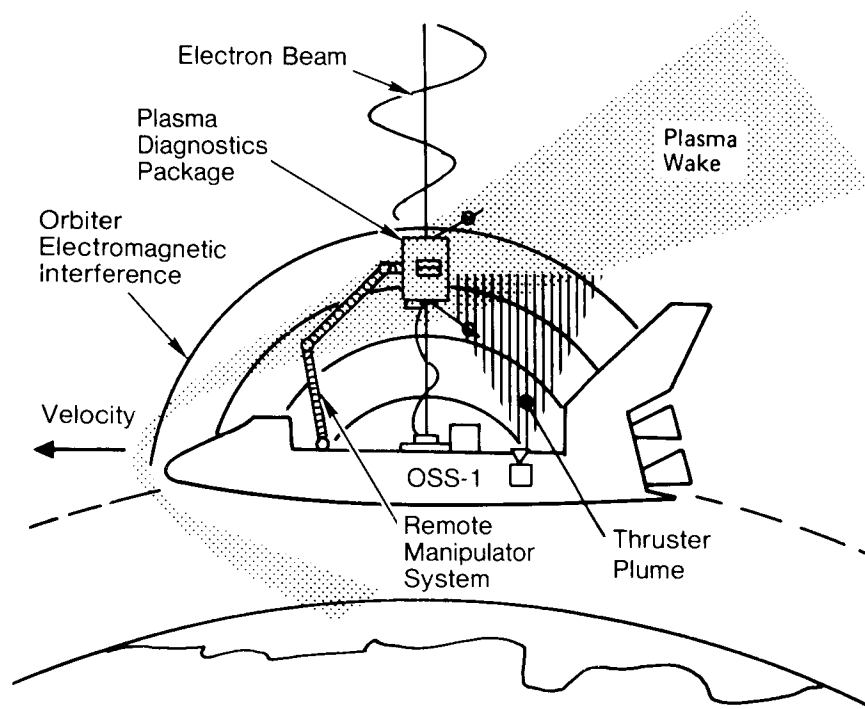
Monitoring of Plasma Effects Around Columbia

The PDP investigators and their institutions are:

- Principal Investigator:

  Dr. Stanley Shawhan
  Department of Physics and Astronomy
  University of Iowa
  Iowa City, Iowa 52242

- Co-investigators:

  Dr. Louis A. Frank, University of Iowa

Dr. Donald A. Gurnett, University of Iowa

Dr. Nicola D'Angelo, University of Iowa

Henry C. Brinton,
Goddard Space Flight Center

David Reasoner, Marshall Space Flight Center

Nobie Stone, Marshall Space Flight Center

VEHICLE CHARGING AND POTENTIAL (VCAP) EXPERIMENT

The Vehicle Charging and Potential experiment measures the charge accumulations on the orbiter and the resulting potential charges of the orbiter in flight.

The charging of space vehicles is of considerable interest because the vehicle electrical potential may deviate many hundreds of volts from its surroundings. This occurs mainly to vehicles in geostationary orbits. These charging phenomena are rarely observed for orbiting vehicles in low earth orbit (ionospheric altitudes) because the ambient thermal plasma density is normally so high that the electrical potential can rarely be driven more than a few volts from its surroundings before thermal plasma currents flow to the electrically conducting surfaces of the vehicle to maintain a net current flow of zero; that is, the electrical potential is constant.

Because the spacecraft's outer surface is covered with thermal protection, it is not clear that the vehicle will conform to this behavior. The thermal protection system tiles and felt reusable surface insulation have a very low electrical conductivity. Thus, the metallic regions to which return currents can flow are greatly limited and will be subject to strong shielding from the ion components of the ionospheric plasma as the attitude of the spacecraft changes relative to the ram direction. There is also the possibility of charge buildup on the thermal protection system, causing electric shielding of parts from return currents. The size of the spacecraft is

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such that the electromagnetic field induced by motion at orbital speeds through the geomagnetic field will result in local potential difference of a few volts from place to place on the spacecraft surfaces. This too will cause variations in the return currents to the spacecraft and will be strongly affected by its attitude relative to the geomagnetic field.

Another spacecraft characteristic considered to be important in determining its electrical potential is the relatively high ambient gas pressure expected as a result of crew compartment outgassing and water dumps. The effect of these on the plasma around the spacecraft is not clear, but either a large reduction or a large enhancement of the ambient thermal plasma will have a significant effect. Depleted plasma density will permit the potential to vary widely, whereas enhanced plasma density will have a stabilizing effect on the vehicle potential. Therefore, even in a passive orbiting mode, the orbiter could have considerable change in its electrical potential.

To attempt to restore this electric potential to near zero and to induce controlled changes in electric potential, the VCAP experiment includes a low power electron gun that can fire very short pulses of electrons. The fast-pulse electron gun can generate bursts of electrons with durations of 500 nanoseconds the several minutes at controlled rates. This gun enables assessment of effects on the spacecraft of active electron beam experiments which will be flown on a Spacelab mission.

The inclusion of plasma measurements in the OSS-1 considerably expands the scientific return. This expansion is achieved if the fast-pulse electron gun is operated while the Plasma Diagnostics Package is mapping the distribution of particles and fields around the spacecraft. The result will be a better knowledge of the direction and spread of the electron beam, which can be correlated with the earth's ambient field direction and the observed charging effects on the surface of the spacecraft.

The electrical properties of *Columbia* will be measured during both passive orbital operations and periods when the potential of the spacecraft is intentionally altered using the electron gun.
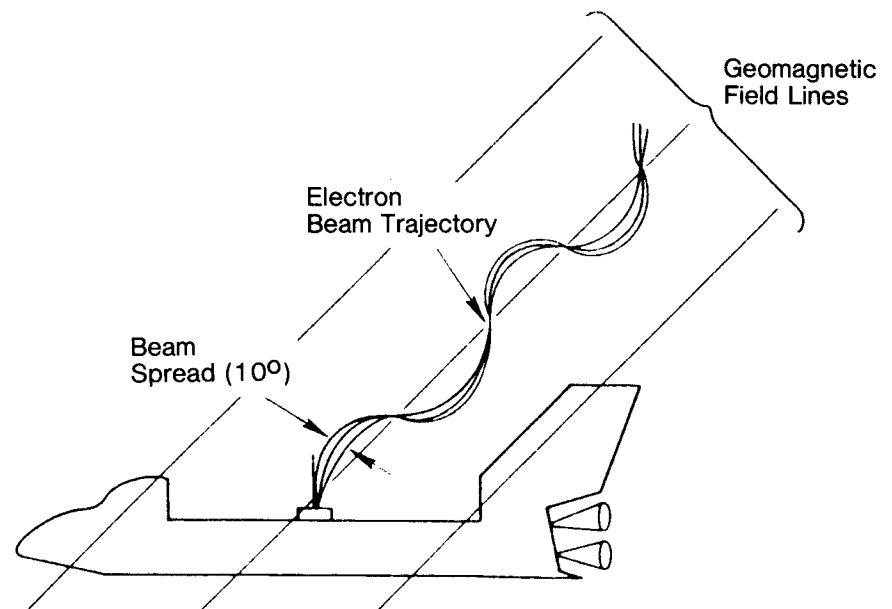
Typical Trajectories of Electrons Fired From Fast-Pulse Electron Gun

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The instruments, designed and supplied by Utah State University, consist of three types: two charge and current measuring probes, a spherical retarding potential analyzer-Langmuir probe combination, and the fast-pulse electron gun.

The charge and current probe consists of two adjacent sensors, one metallic and one dielectric. The current flowing to the metallic sensor is used as an indication of the return current to exposed metal surfaces on the spacecraft. The dielectric sensor provides a measurement of the charge accumulating on dielectric surfaces on *Columbia*. The material used in the dielectric charge current probe sensor is the same as the spacecraft's felt reusable surface insulation material. Both charge and current probes respond rapidly to changes. They can monitor variations limited only by the telemetry sampling rate of 60 per second. Using peak detecting currents, they can give an indication of rapid short-lived changes lasting longer than 100 nanoseconds.
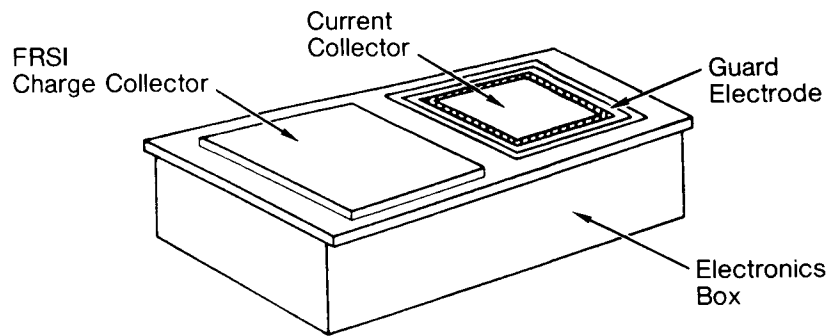
Charge and Current Probe
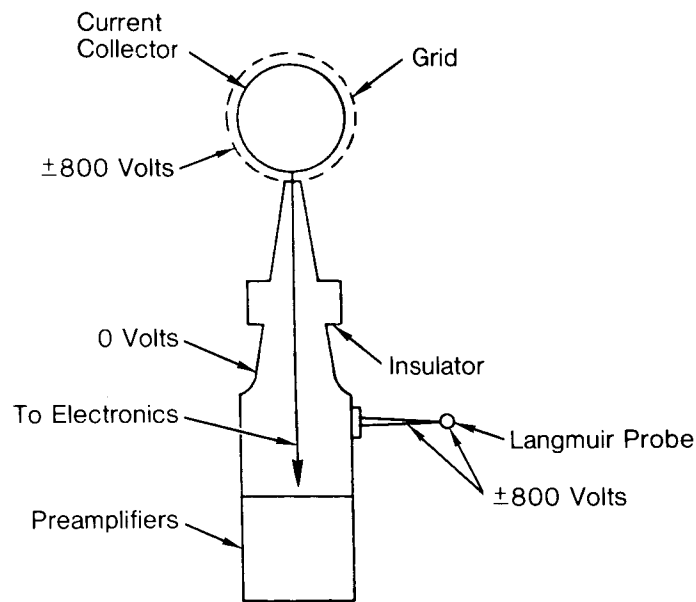
Analyzer Schematic

Vehicle Charging and Potential Analyzer

Two sets of the charge and current probe instruments will be mounted on diagonally opposite corners of the OSS-1 pallet. This will give the best opportunity to measure the variation in return current and charge distribution at different locations on the spacecraft. Both sensors have a passive mode when their electrodes are held at ground potential and have an active mode when potentials are applied by command to the sensors. The active mode permits measurements to be made of the charging time constraints and the neutralization current magnitudes in the absence of electron gun operation.

The spherical retarding potential analyzer-Langmuir probe measures vehicle potential relative to plasma, electron density, and plasma temperatures. The sequence of operation in the different modes is controlled by the OSS-1 computer and will be preprogrammed. The capability also exists to change mode by both ground and flight crew commands.

The VCAP experiment weighs approximately 116 kilograms (255 pounds).

The VCAP investigators and their institutions are:

*   Principal Investigator:

    Dr. Peter Banks
    Physics Department, UMC 41
    Utah State University
    Logan, Utah 84321

*   Co-investigators:

    Dr. W. J. Raitt, Utah State University

    Dr. P. R. Williamson, Utah State University

    Dr. R. Goldstein, Jet Propulsion Laboratory

Dr. T. Obayashi, University of Tokyo, Japan

Dr. U. Samir, University of Michigan

Dr. H. Liemohn, Battelle Memorial Institute, Pacific Northwest Laboratories

Dr. L. Linson, Science Applications Inc.

Dr. C. R. Chappel, Marshall Space Flight Center

Dr. J. L. Burch, Marshall Space Flight Center

MEASUREMENT OF SHUTTLE/SPACELAB INDUCED ATMOSPHERE

This experiment is to study the gas/dust environment of the spacecraft and to observe the astronomical diffuse skylight.

The Shuttle spacecraft has been designed to minimize particulate and radiative emissions that may contribute to the ambient atmosphere in orbit through which the spacecraft is moving. This was accomplished through the selection of materials used in the spacecraft. It is hoped that the spacecraft will provide the same benign environment as that of Skylab (1973 and 1974).

This experiment will provide data on the extent to which dust particles and various volatile materials evaporating from the spacecraft produce a local "cloud" in the "sky" through which astronomical observations must be made. This spacecraft-induced contamination manifests itself in several ways that affect remote sensing instrumentation: by material deposition that can decrease transmission or degrade optical surfaces, by sunlight scattered from gaseous and particulate material which is seen as a spacecraft corona that can degrade observations during spacecraft day, and by particulates that individually and collectively affect imaging and infrared systems. Measurements of these effects, in turn, can be used to detect, probe, and monitor the contamination cloud.

The contamination cloud around a spacecraft and the interplanetary or zodiacal dust cloud are similar in a number of ways. Both phenomena are seen by virtue of the scattering of solar radiation. The contaminant cloud is confined to regions near the spacecraft so that only one scattering angle is involved for each direction of view. The zodiacal dust is distributed throughout the solar system, and a range of scattering angles is encountered along any one line of sight. It is necessary to record the optical properties of each cloud: brightness and polarization in different colors of spectrum (using appropriate filters) and for different positions on the sky and at different times.

Generally, the contamination cloud will be most conspicuous when it is illuminated by sunlight; the interplanetary cloud will be best observable when the spacecraft is on the dark side of the earth or when the contaminant cloud is shadowed by the vehicle. That is, nighttime observations contain data on starlight and zodiacal light; daytime observations contain data on the spacecraft's cloud, starlight, and zodiacal light.

Comparison of day/night or night/day data gives the characteristics of the spacecraft cloud directly. With this current instrument, it is hoped that new insight can be obtained on the size, shape, composition, and overall properties of the interplanetary dust.

In the absence of contamination, the diffuse sky radiation as seen from the earth's atmosphere consists primarily of zodiacal light, light from bright stars "resolved" by the instrument, integrated light from faint unresolved stars, and diffuse galactic light. It is extremely difficult to analyze these phenomena separately in ground observations that also include atmospheric emissions so, in recent years, an increasing number of observations has been made from space.

Unfortunately, large regions of sky remain unobserved, especially for polarization, and there are relatively few observations in the important, but difficult to observe, ultraviolet and infrared spectral regions.

Detector Package
Field Lens
Shutter
Polarization Analyzer
Lens
Primary Objective
Field-of-View Wheel
Lens
Interference Filters
Cap and Calibration Source
Sun Shield
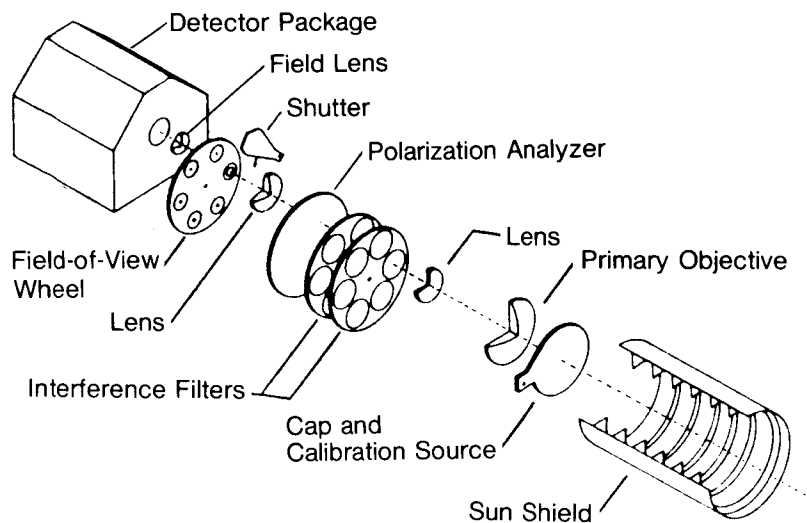
Shuttle/Spacelab Induced Atmosphere Photometer Optical Train

These encompass studies of the zodiacal light and the properties of dust particles in interplanetary space and in the Milky Way. Zodiacal light is the only source of information on the large-scale properties of the interplanetary dust. The very faint zodiacal light is, in part, sunlight scattered by dust located in the solar system. Although the light can be seen under ideal circumstances (low latitude, high altitude) from the ground, the interference from the earth's natural airflow as well as man-produced light makes its scientific study extremely difficult. The result is that the fundamental characteristics of the zodiacal light are presently very poorly known and interpretations of existing optical data range from particles that are dominant in the submicron sizes to particles that are primarily a millimeter or so in size.

If it is possible to account for all the other components of scattered light, this instrument may provide a new and useful tool for studying the tiny bits of matter that populate the vast distances of interstellar space.

The instrument is called a photometric contamination analyzer. It is basically a photometer or sophisticated light-level meter that measures the amount of light and its polarization coming at any one time from one direction in the sky, in each of ten different bands of color.

The instrument has automatic, start, stop, and mode change capability which will be programmed before flight. The capability exists to change modes by both the ground and flight crew commands. The data is recorded on the OSS-1 recorder.

The weight of the Shuttle/Spacelab Induced Atmosphere experiment is approximately 75 kilograms (165 pounds).

The experiment investigators and their institutions are:

- Principal Investigator:

    Dr. J. L. Weinberg
    Space Astronomy Laboratory
    University of Florida
    Gainesville, Florida 32611

- Co-investigators:
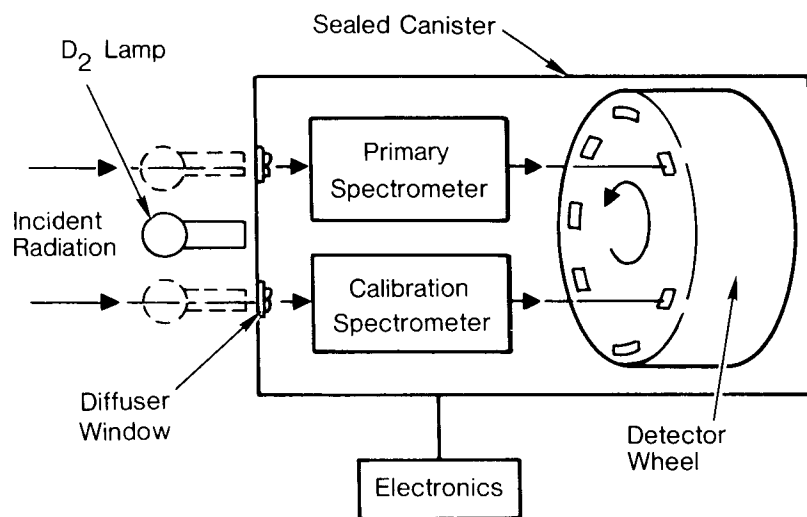
    Dr. D. W. Schuerman, University of Florida

    Dr. F. Giovane, University of Florida

    Dr. J. A. M. McDonnell,
    University of Kent at Canterbury, U.K.

SOLAR ULTRAVIOLET SPECTRAL IRRADIANCE MONITOR (SUSIM)

The Solar Ultraviolet Spectral Irradiance Monitor experiment will monitor solar radiation in the ultraviolet range.

Solar Ultraviolet Spectral Irradiance Monitor

Interest in accurate measurements of the sun's ultraviolet radiation and its range of variability has recently been heightened by our increasing concern over long-range changes in the earth's atmosphere and climate.

This short-wavelength radiation, absorbed in the outer reaches of the earth's atmosphere, plays an important role in determining the physical properties of the upper atmosphere and, by implication, in influencing the condition of the lower levels that affect our lives.

The solar ultraviolet flux between 120 and 300 nanometers is absorbed in the terrestrial atmosphere over a wide range of altitude. The absorption in this wavelength region is dominated by the oxygen molecule, O_2, and ozone, O_3. The absorption coefficients for these molecules vary considerably with wavelength (by a thousand or more).

The data collected will be used in conjunction with data from future flights to investigate the long-term variability in solar ultraviolet radiation.

This dictates a high degree of accuracy in pointing and in instrument calibration. For this reason a sun sensor has been included to provide a two-axis pointing error signal for the flight crew, so that ±0.5 degree pointing accuracy can be obtained by the flight crew of the orbiter attitude.

The experiment operation is initiated and stopped by ground command.

The weight of the Solar Ultraviolet Spectral Irradiance Monitor experiment is approximately 50 kilograms (110 pounds).

The experiment investigators and their institutions are:

- Principal Investigator:

  Dr. Guenter E. Brueckner
  Code 7142
  Naval Research Laboratory
  Washington, D.C. 20373

- Co-investigators:
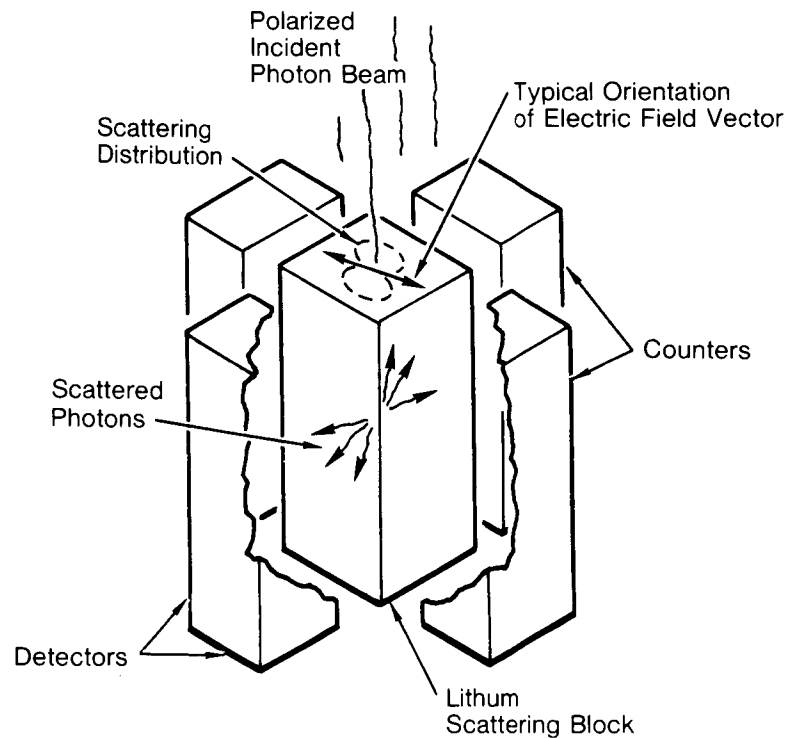
  Dr. John-David F. Bartoe,
  Naval Research Laboratory

  Dr. Dianne K. Prinz,
  Naval Research Laboratory

  Michael E. Van Hoosier,
  Naval Research Laboratory

SOLAR FLARE X-RAY POLARIMETER EXPERIMENT

This experiment will observe the sun and, in the event a solar flare occurs, will measure the degree of polarization of the X-ray radiation.

Solar X-Ray Polarimeter

A precise determination of the polarization would provide a major advance in our understanding of the physical processes that drive solar flares.

It is already known, through observations of gamma rays, radio emission, and other manifestations of energetic particles, that particles are accelerated, sometimes in two or more stages, in such an event.

At least two fundamental questions remain, however: what is the nature of the mechanism by which these particles are energized, and how do they produce the observed emissions?

The most compelling evidence for the presence of high-energy electrons during flare events is given by the observation of hard X-ray bursts. Although such emission might be produced by a very hot thermal gas (having a temperature of 100 million degrees), most models of the emission propose that beams of high-energy electrons, which are trapped by magnetic field lines, simultaneously emit microwaves by synchrotron radiation and X-rays by linear bremsstrahlung ("braking radiation" in German). The bremsstrahlung are the result of collisions with the ambient gas of the solar atmosphere.

Further support for this fundamental role of high-energy electrons in flares is given by comparisons of X-ray and optical flare emission, which indicate that the onset of hard X-ray emission generally precedes the maximum in the chromospheric emission recorded in the hydrogen emission at visible wavelengths.

Thus, this would suggest that acceleration of particles to high energies is the initial result of the conversion of energy from some stored form (as in distorted magnetic fields) into the kinetic energy of particle motion. Brightening of the chromosphere and the development of a 10 to 20-million degree thermal plasma that emits soft X rays would then be subsequent effects of the dissipation of energy carried by these accelerated particles.

The experiment operation will be started and stopped by ground command.

The weight of the Solar Flare X-ray Polarimeter experiment is approximately 189 kilograms (416 pounds).

Experiment investigators and their institutions are:

- Principal Investigator:

     Dr. Robert Novick
     Columbia University
     Columbia Astrophysics Laboratory
     538 West 120th Street
     New York, New York 10027

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- Co-investigator:

    Dr. Gary A. Chanan, Columbia University

THERMAL CANISTER EXPERIMENT

The Shuttle spacecraft can orbit at a wide variety of inclinations and orientations. Although this versatility enables an experimenter to use the flight opportunity most effectively, the thermal environments of instruments, particularly those placed deep within the pallet in the payload bay, will fluctuate widely as the spacecraft changes its orientation.

Although it is possible to design individual instruments to cope with the wide range of thermal conditions, an alternative and perhaps more economical approach would be to provide a benign environment so that many different instruments could be used without special adaptation.

One system that appears to be feasible is using heat pipe technology already developed. Although this technology has had wide
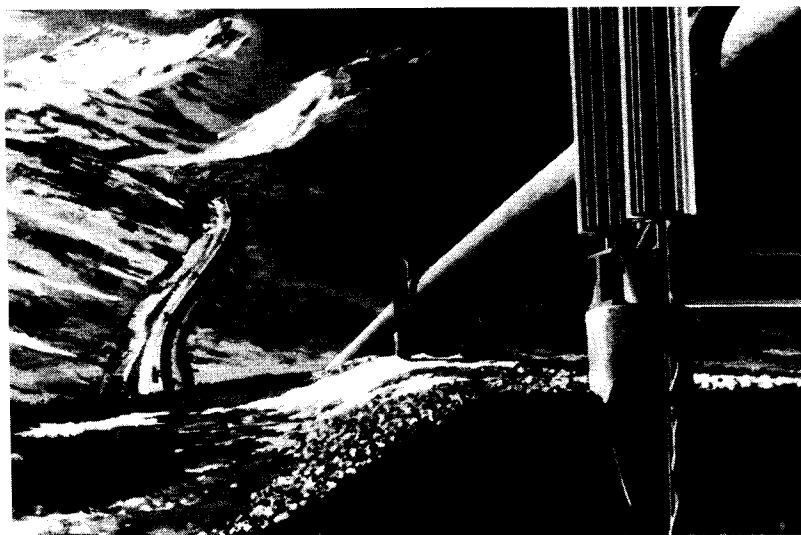
Use of Heat Pipe Technology on Alaskan Pipeline

ground-based applications, its use in space has been limited and requires further evaluation, particularly under the wide range of conditions that will be encountered in the orbiter environment.

Heat pipes were used to solve the Alaskan oil pipeline environmental problem; 110,000 heat pipes using ammonia fluid sealed in the heat pipes supported the pipeline above the Arctic tundra. The heat pipes protected the tundra environment by keeping the permafrost frozen in the winter and absorbing the heat from the crude oil in the pipeline, moving the heat upward into the atmosphere. In addition, during the winter, the heat pipes maintained a solid mass of permafrost around each supporting pipe, thus reducing the shifting of soil and pipeline settling, and preventing stress of the oil line to the point of rupture.

The thermal canister will test the capability of heat pipes by controlling the flow of a liquid, and thus heat from the interior of the canister, to an external radiator that radiates the heat to space. This is accomplished by using simulated heat loads (heaters) within the canister. This temperature control system will maintain temperatures within narrow limits under all thermal environments encountered and with different levels of internal power dissipation.

The internal power dissipation and operating modes are controlled by an internal sequencer which is programmed before flight. The flight crew can override the planned sequence if needed to compensate for changes in the planned spacecraft attitude. The thermal canister has its own dedicated tape recorder.

The weight of the Thermal Canister experiment is approximately 150 kilograms (330 pounds).

The experiment investigator and his institution is:

- Principal Investigator:

    Stanford Ollendorf
    Code 732
    NASA/Goddard Space Flight Center
    Greenbelt, Maryland 20771

CONTAMINATION MONITOR PACKAGE (CMP)

The Contamination Monitor Package is designed to measure the buildup of molecular and gas contaminants within the spacecraft environment. The measurements, when correlated with other instruments in the payload bay on this flight, are expected to provide valuable insights as to how molecular contamination affects instrument performance.

The CMP measurements will provide information impossible to obtain in a laboratory and outline a profile of the molecular contaminants generated by the spacecraft and its payload in flight. Some molecular sources that might affect sensitive instrumentation are; spacecraft systems and payloads outgassing: operation of the reaction control and orbital maneuvering systems; venting of relief valves from the various fluid systems, and dumping of excess water in the extremely cold emvironment of space. The experiment will measure buildup of materials on surfaces of the spacecraft during all phases of launch, ascent, orbit and during descent which would be useful to scientists developing experiments such as highly sensitive optical components in future Space Shuttle flights.

The information is relayed to scientists in the Payload Operations Control Center (POCC) at the Johnson Space Center, Houston in near real time.

The CMP is located on the aft/port (left) corner of the OSS-1 pallet. The CMP is 304 millimeters (12 inches) long, 177 millimeters (7 inches) wide, and 177 millimeters (7 inches) tall. Its weight is 7 kilograms (17 pounds).

The CMP contains temperature controlled quartz crystal microbalance (tqcm) sensors which view both inside and outside the payload bay and the IECM experiment. Two passive witness mirrors supplied by the Naval Research Laboratory are mounted on the experiment. The mirrors are coated with magnesium fluoride over aluminum, a material commonly used for optics in instruments designed to make ultraviolet measurements. The ultraviolet reflectivity of these mirrors will be tested from to and after the flight to monitor those contaminants which specifically affect ultraviolet reflectivity.

The CMP experiment is developed by NASA's Goddard Space Flight Center in Greenbelt, Maryland and funded by the U.S. Air Force Space Division.

The principle investigator on the CMP is Jean Triolo, Goddard Space Flight Center, Greenbelt, Maryland. The co-investigators include Captain Paul Porzio, USAF Space Division, Los Angeles, California, Carl Maag, Jet Propulsion Laboratory, Pasadena, California and Roy McIntosh and Ray Kruger, both of Goddard.

MICROABRASION FOIL EXPERIMENT (MFE)

The Microabrasion Foil Experiment will measure the quantative amount, chemical content, and density of micrometeorites encountered by the spacecraft in near-Earth orbit.

When comets and asteroids are formed, in different regions of the solar system, particle and material content should differ. Comets apparently were formed at large distances from the Sun by the aggregation of ice and small dust grains. Asteroids, on the other hand, are believed to have been formed by the aggregation of stone and metallic dust grains which condensed 4.6 billion years ago from the Mars/Jupiter region of the solar nebula. Data from these tiny particles are expected to yeild new basic information about the history of our solar system.

The MFE is a one-square meter sheet of aluminum foil pieces of varying density bonded to a plastic (Kapton) substrate or foundation and is mounted on top of the Thermal Canister Experiment (TCE). As the micrometeorites hit the foil's thin surface, they puncture the foil and form craters. Very light particles cannot penetrate the foil, but will form an impact crater on the foil surface. Somewhat heavier particles will penetrate the foil to a depth which depends upon the particle's velocity. Heavier particles will not be fragmented and will survive almost intact. Icy particles will fragment and form a number of small craters. An analysis of the fragmentation profiles on the plastic sheet under the aluminum foil will yield information on the particles' density. those micrometeorites which at least partially survive the impact will undergo analysis.

The data return is dependent entirely upon post-flight analysis.

This is the first experiment developed outside of the United States to fly on the Space Shuttle.

The MFE weight is 1 kilogram (2.2 pounds).

The MFE experiment scientist is Dr. J. A. M. McDonnell, Space Sciences Laboratory, University of Kent, Canterbury, Kent, England.

Participating scientists are Dr. William C. Carey and Dr. David Dixon, both from the University of Kent also.

INFLUENCE OF WEIGHTLESSNESS ON PLANT LIGNIFICATION EXPERIMENT

This experiment is in a container located in a single locker in the forward area of the mid-deck of the flight crew compartment.

Lignin is the second-most abundant carbon compound (after cellulose) in plants, comprising up to about 30 percent of woody plant tissues and significant portions of other plant materials. Thus, a major portion of photosynthetically fixed carbon is diverted from chemically and nutritionally valuable proteins, fats, and carbohydrates into relatively valueless lignin. The ability to control, increase, or reduce lignin synthesis at will—more lignin where it is needed, less lignin where it is not needed and to replace it with other carbon compounds that are more valuable—would be a highly useful tool for agriculturists.

Lignin provides the strength and form in plants that make them useful as ornamental objects, as sources of structural materials, and as upright bearers of harvestable food and chemicals. On the other hand, lignin interferes with efforts to extract wood fibers for paper and chemical cellulose and affects the digestibility and nutritional value of foods while itself having relatively little commercial value except as fuel.
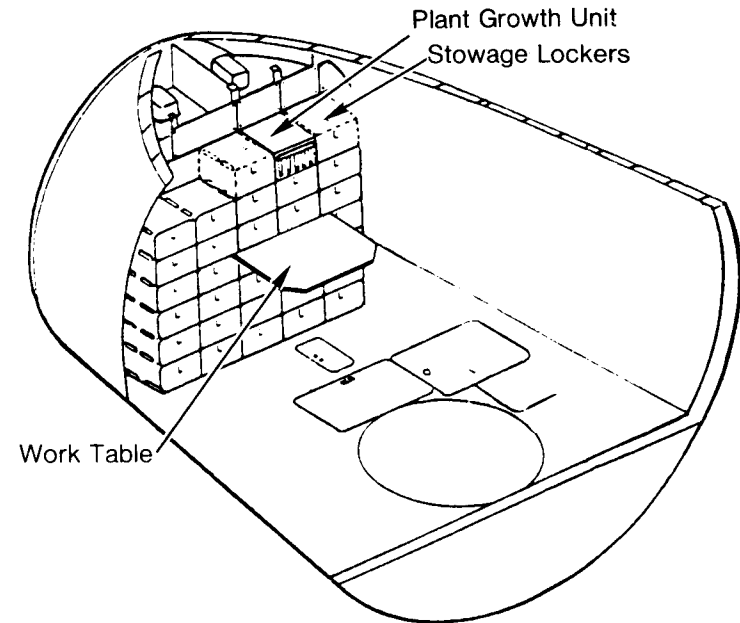
Location of Plant Lignification Experiment

Lignin cross links and binds the spirally wound linear cellulose chains of the plant cell wall to provide strength and rigidity for maintaining aerial growth against the pull of gravity, but also profoundly affects plant form to provide varying degrees of strength and bulk.

This experiment tests the hypothesis that plants grown in the absence of gravity will synthesize less lignin than plants grown at earth gravity (one g). The selection of experimental plants is a lignification response that can be experimentally manipulated and measured. Activity of lignin pathway enzymes and lignin deposition are known to progress from the base of the seedling upward. Thus, the standard scheme for sampling involves longitudinal sectioning of plant stems with analysis and comparison of tissues according to the equivalent vertical position.

Pine seedlings will be selected at a known stage of development and will be planted in two of the experiment container plant

chambers, ungerminated oat seeds will be planted in two chambers, and mung bean seeds will be planted in the two remaining chambers.

The flight package container, termed the Plant Growth unit, consists of lights, cooling fans, heaters, and associated electronics for controlling and monitoring temperature and light cycles.

The growing plants are contained in a set of small, sealed, plastic and metal chambers, each having a cast aluminum base and a clear (Lexan) top held together by screws or clamps and sealed by a rubber gasket. The growth substrate is contained in the metal base and consists of a water reservoir of agar gel over which is inserted a
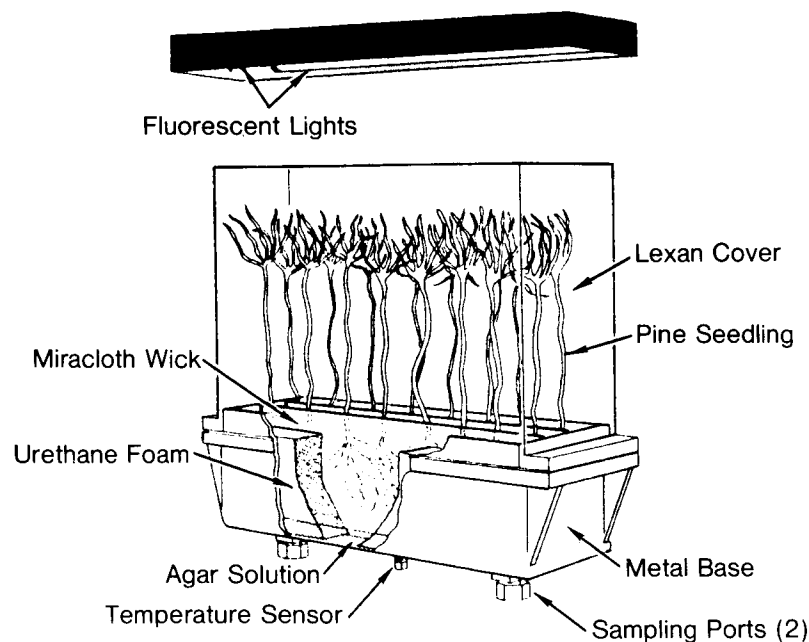
urethane foam and miracloth sandwich. The hydrophobic foam provides form support to seeds and plant roots and prevents water creep that would result in drowning of the plants or poor aeration of the roots. The miracloth wick provides for conduction of water upward from the agar reservoir. The metal base is equipped with fittings to permit installation of a thermister probe for sensing chamber temperature and rubber septum sampling parts for flushing the interior of the chamber and for sampling metabolic gases.

The plant growth unit provides limited control of temperature through regulation of fan speed and a strip heater and a timer to provide for a defined period of the light cycle. It also provides for measurement and continual (15-minute interval) recording of the temperatures within each of the sealed chambers.

A set of controlled experiments, with the plants growing in a one-g environment, will be conducted after the flight using the flight hardware and flight temperature data. Lignin data from the flight and control plants will be compared for temporal and spatial patterns of lignin deposition to assess the validity of the hypothesis that lignin will be reduced in plants grown in zero gravity.

The weight of the lignin experiment is approximately 25 kilograms (55 pounds).

The lignification experiment investigators and their institutions are.

- Principal Investigator:

    Dr. Joe Cowles
    Department of Biology
    University of Houston
    Cullen Boulevard
    Houston, Texas 77004

- Co-investigator:

    Dr. H. William Scheld, University of Houston

Fluorescent Lights

Lexan Cover

Pine Seedling

Miracloth Wick

Urethane Foam

Agar Solution

Temperature Sensor

Metal Base

Sampling Ports (2)

One of Six Plant Growth Units

ELECTROPHORESIS EQUIPMENT VERIFICATION TEST (EEVT)

This equipment was first used on the Apollo-Soyuz Test Project (ASTP) flight in July of 1975. The equipment is designed for separating individual biological cells and large molecules in a zero-g environment. In the ASTP flight, malfunctions occurred that resulted in unsatisfactory cell separations on several experimental runs, and less than optimum results in otherwise successful runs due to system operating techniques. The problems have been identified and corrected. The hardware is tested in this flight to verify its function and performance before committing the electrophoresis system for operational use.

The U.S. materials processing in space (MPS) program is designed to accommodate applied research payloads on economically viable materials, technology, and industrial processes in space and is part of a space processing applications program. It is hoped that this technology will develop products that cannot be produced on earth, or that can be improved greatly by being processed in space. NASA is confident that these payloads will advance new product technology and make significant contributions to American industry for many years.

On earth, people accept the pull of gravity and the atmosphere as essential elements in their existence. Weight is the balance between the earth's gravitational attraction and the centrifugal force caused by the earth's constant high-speed rotation. It is commonly thought of as a force pulling the body or object downward; we refer to it as a force of one-g at sea level. In space (earth orbit), the gravitational attraction of earth to an object is reduced as the object moves away from earth, while centrifugal force increases as it moves faster. In a stable orbit, the two forces equal and cancel each other. This is referred to as zero-g or weightlessness.

Until orbital space flights became possible, a zero-gravity environment could be produced only for very short periods in free fall. Drop towers, aircraft nose-overs, and sounding rocket coast periods could provide periods of zero or reduced gravity lasting from a few seconds to six minutes.

Gravity and the atmosphere often pose serious problems in the manufacturing of certain very important products. The space environment, with its zero gravity and almost perfect vacuum, offers interesting possibilities for large-scale manufacturing of products.

Space processing can provide advantages by lowering costs through the more efficient processing available in space. More frequently, it provides the capability for producing substances or devices that cannot be produced in the presence of gravity and an atmosphere.

Examples of the difference between earth and space environments are the effects of gravity on the processes of sedimentation and convection. An example of sedimentation is fruit gelatin dessert; the gelatin must be allowed to thicken to a certain extent before adding fruit or the fruit will settle to the bottom. Sedimentation is caused by the effect of gravity on mixtures of solid particles in liquids.

Convection is either the upward movement of part of a gas or liquid that is heated, or the downward movement of a gas or liquid that is cooled. It is caused by the difference in gravity force-weight or buoyancy—which occurs at different temperatures. Wind is an example of natural convection of the air; the currents observed in a heated glass pot of water is another example.

In space, sedimentation and convection are virtually absent. A liquid mixture containing materials of greatly differing densities can be solidified without the materials separating. Without convection, some parts of the liquid mixture will get much hotter or colder than on earth. This enables control of the way liquids solidify and thereby control of the product produced. The lack of gravitational forces in space also allows liquids to levitate, or float freely, so that processes can be conducted in space that are impossible on earth because the liquids to be processed would react with their containers.

In earth's one-g environment, it is almost impossible to process useful quantities of some pure biologicals (such as vaccines). Pharmaceutical companies are presently spending millions of dollars a

year on research to improve biological processing. A method called electrophoresis may be used in zero-g to obtain quantities of highly superior, purer biological substances than those that can be produced on earth.

The electrophoresis method separates biological materials, such as human cells, by means of an electrical field (electrical voltage force). In zero-g, the cells will separate because each cell reacts in a different degree to the electrical field. Electrophoresis is not a new process. It has been widely used in blood and urine analysis. However, sedimentation becomes a serious problem in electrophoresis on earth if the particles to be separated are large and heavy, since the gravitational forces on the particles become large relative to the electrophoresis forces. Convection also causes currents that tend to remix the separate factions.

In the Apollo-Soyuz test, kidney cells and lymphocytes were separated in zero-g. The kidney cells were processed to isolate pure urokinase. Urokinase is the only natural substance known to be effective in dissolving blood clots. The kidney cells separated in space produced six to seven times more urokinase than could have been produced on earth.

Production of large quantities of urokinase outside the human body for use in treating heart attacks, strokes, phlebitis (inflammation of a vein or veins) is difficult because of the large amounts of urine required to obtain urokinase on earth. These Apollo-Soyuz results produced starter quantities that are cultured in laboratories here on earth.

The electrophoresis equipment, consisting of an electrophoresis unit and an equipment stowage locker containing a camera, film, and a cryogenic freezer, are stowed in the crew compartment mid-deck aft bulkhead for launch and entry and operated in place.

One of the flight crew will be required to activate the equipment and perform timed tests designed to demonstrate and measure system performance.

MONODISPERSE LATEX REACTOR (MLR) EXPERIMENT

The monodisperse latex reactor is designed to conduct experiments associated with the production of monodisperse latex particles in the near weightlessness of space.

Potential latex particle applications include medical research in pore size standards, diagnostic testing, cell research, and as drug carriers in cancer research.

The particles also may be used as calibration standards for cell counters, electron microscopes, and air pollution.

The monodisperse latex reactor is located in the crew compartment mid-deck. It occupies the space of three mid-deck stowage lockers. It requires electrical power from the spacecraft to maintain timing and provide intermittent stirring operations in orbit.

This experiment is scheduled for operation during the flight crew sleep period to provide low-g conditions.

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INSECT FLIGHT MOTION STUDY (Student Experiment)

The Insect in Flight Motion study is an experiment to observe and film the adaptation of insect flight in zero gravity.

The experiment is in a container stowed in a drawer in the mid-deck of the spacecraft. In flight, the astronaut will remove the container holding the insects from the drawer, attach it to the wall of the mid-deck and observe and film the insects as they fly in the zero gravity environment. After filming, the astronaut removes the insect container from the wall and returns it to the locker.

Insects chosen for the experiment are the velvetbean caterpillar moth and the honeybee. The choice of these insects were due to; hardy life span; the moth varies from the bee in the wing

area to body size ratio, the moth having a large wing area and small body and the bee a smaller wing to body ratio; readily available source.

The insects and film will be returned to Earth for post-flight analysis and preparation of a final report.

The experimenter is Todd E. Nelson, age 18, Rose Creek, Minnesota and attends Southland High School at Adams, Minnesota.

The program is a Shuttle Student Involvement Program joint venture of NASA and the National Science Teachers Association.

GETAWAY SPECIAL

The getaway special concept is to supply a carrier for the Space Transportation System operational flights which will provide opportunities for low-cost Space Shuttle flights for scientific and research and development experiments. In this flight, the getaway special to be flown is for verififcation purposes and will provide data on the flight environment of its carrier. It consists of one 0.14 cubic meter (5 cubic feet) container.

The getaway special carrier is located on the starboard (right) side of the payload bay between orbiter station $X_0 = 1191$ and $X_0 = 1249$. The overall weight of the getaway special in STS-3 is 308 kilograms (680 pounds).

The instrumentation located in its containers includes very sensitive acceleration, temperature, vibration, and acoustic sensors. The data is recorded on two-self-contained tape recorders. The con-

tainer also contains a power supply and a command decoder which will be operated by the flight crew command to start, stop, and change the operational mode.

The crew compartment portion of the getaway special system consists of a hand-held digital encoder keyboard which is connected by cable to the payload switch panel at the aft flight decks.

The basic idea of the getaway special is to permit companies and universities, large and small—and even private citizens—to develop and send into space their own small self-contained space payloads.

These small units would have their own power supply and data recording systems, if required. They would remain in the payload bay of the Space Shuttle orbiter for the duration of the flight, which will be variable for a given flight.

The cost of this unique service will depend on the size and weight of the experiment: getaway specials of 90 kilograms (200 pounds) and 0.14 cubic meter (5 cubic feet) may be flown at a cost of $10,000; 45 kilograms (100 pounds) and 0.07 cubic meter (2.5 cubic feet) for $5,000, and 27 kilograms (60 pounds), and 0.07 cubic meter at $3,000. If additional services of the spacecraft or its flight crew are required (flipping switches, connecting to a NASA-provided battery pack, etc.), the price will be negotiated for each package.

The getaway special program offers private individuals and companies the opportunity to conduct space research in a manner previously available only to the government and very large corporations. Such small packages can be used as test beds for larger, follow-on experiments which would be flown on the Spacelab. In addition, the getaway special offers an opportunity to help enhance
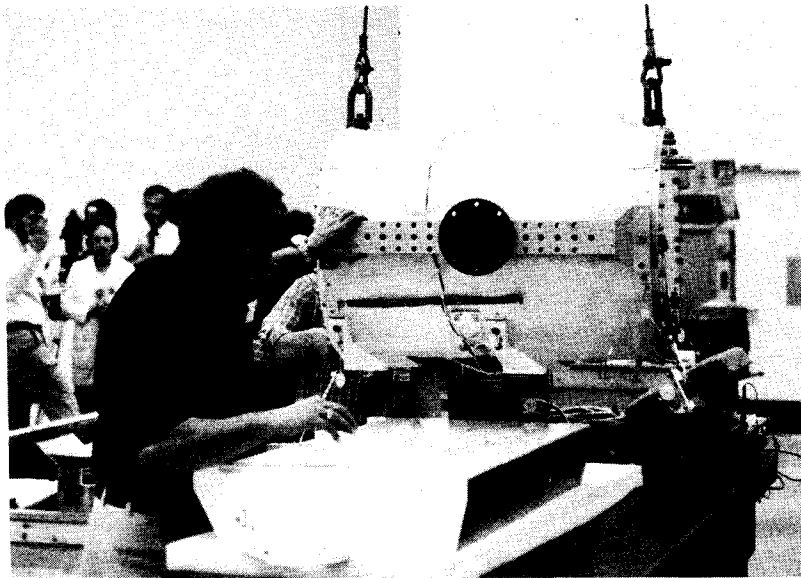
Getaway Special Container

science and engineering education and to help set the course for the beneficial uses of space for years to come.

For detailed information on this unusual program, write the Public Affairs Office, NASA Marshall Space Flight Center, Alabama, 35812, or Director, Space Transportation System Operations, Code MO, NASA Headquarters, Washington, D.C., 20546.

CARGO BAY STORAGE ASSEMBLY (CBSA)

The Cargo Bay Storage Assembly contains miscellaneous tools for use in the payload bay. It is located on the starboard (right) side of the payload bay forward of the OSS-1 pallet between Orbiter station $X_0 = 636$ and $X_0 = 693$.

The CBSA is approximately 1066 millimeters (42 inches) wide, 609 millimeters (24 inches) in depth and 914 millimeters (36 inches) in height. The CBSA weight is 259 kilograms (573 pounds).

ORBITER EXPERIMENT (OEX) SUPPORT SYSTEMS

The support system for the orbiter experiments was developed to record the data obtained by such experiments and to provide time correlation for the recorded data. The information obtained through the sensors of the OEX instruments must be recorded during the orbiter mission because there will be no real-time or delayed downlink of OEX data. In addition, the analog data produced by certain instruments must be digitized for recording.

The support system for the OEX consists of five packages: the OEX recorder, the interface control module (ICM), and the pulse code modulation (PCM) master, PCM slave, and data hand handling electronics (DHE) package. The ICM is the primary interface between the OEX recorder and the experiment instruments and between the recorder and the orbiter subsystems. The ICM transmits operating commands from the orbiter MDM to the instruments and controls the operation of the recorder to correspond to the instrument operation. Time signals will be received by the ICM from the orbiter timing buffer, converted to a frequency-modulated signal, and transmitted to the recorder to provide the time information needed. The recorder will carry 2804 meters (9200 feet) of magnetic tape that will permit up to two hours of recording time at the rate of 38 millimeters (15 inches) per second. After the return of the spacecraft, the data tape will be played back for recording on a ground system. The tape will not usually be removed from the spacecraft.

AERODYNAMIC COEFFICIENT IDENTIFICATION PACKAGE (ACIP)

The ACIP is a sensor package installed below the payload bay area in the aft area of the mid-fuselage at station Xo1069. It contains a rate gyro package, a linear accelerometer package, an angular accelerometer package, and associated electronics.

The ACIP will collect aerodynamic data in the hypersonic, supersonic, and transonic flight regimes, regions in which there has been little opportunity for gathering and accumulating practical data, to establish an extensive aerodynamic data base for verification of and correlation with ground-based test data including assessments of the uncertainties in such data. In addition, it will provide flight dynamics state and variable data in support of other technology areas, such as aerothermal and structural dynamics.

The implementation of the ACIP will benefit the Space Shuttle because the more precise data obtainable through the ACIP will enable earlier attainment of the full operational capability of the Space Shuttle. Currently installed instrumentation provides data that is sufficiently precise for spacecraft operations but not for research. The result is that constraint removal would either be based on less substantive data or would require a long-term program of gathering less accurate data.
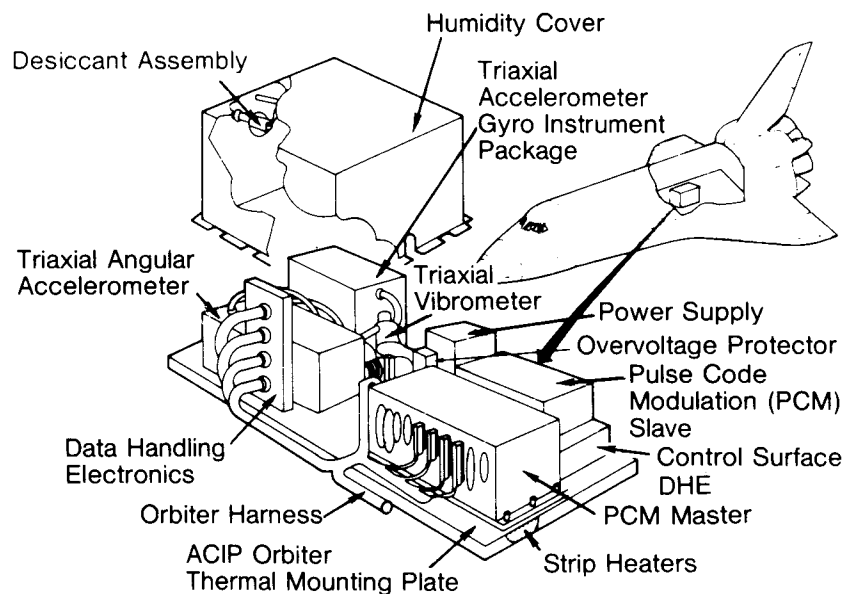
Aerodynamic Coefficient Identification Package (ACIP) Experiment

Forward

Mid-Deck

Interface Control
Module

OEX Recorder
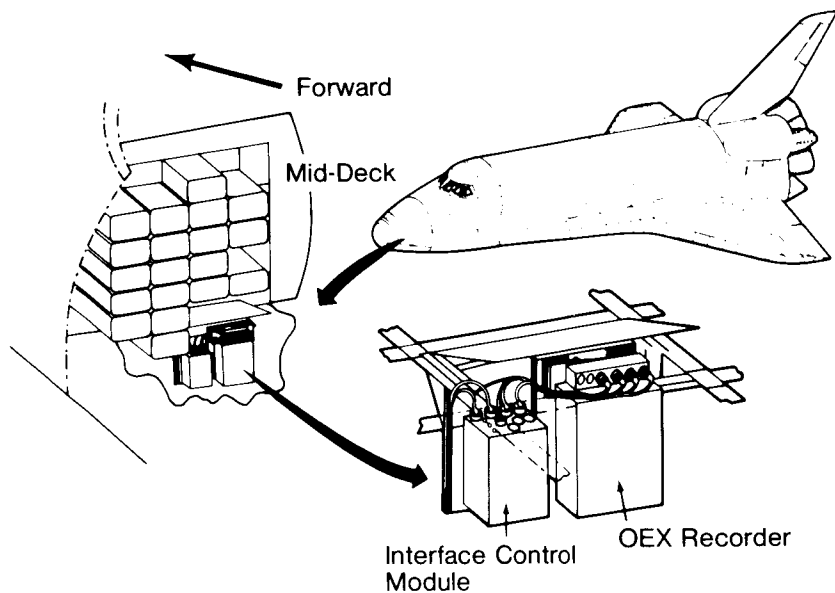
ACIP Experiment

Although all of the generic types of data required for aerodynamic parameter identification are available from the baseline spacecraft systems, the data is not suitable for experimentation due to such factors as sample rate deficiencies, sensor ranges too large for bit resolutions, or computer cycle time/core size interactions. In addition, the baseline data compromises operational measurements and is not subject to the desired changes required for experiments. The ACIP places a sensor package on the spacecraft to obtain experiment measurements that are not available through the baseline system.

The ACIP incorporates three triaxial instruments: one of dual-range linear accelerometers, one of angular accelerometers, and one of rate gyros. Also included are the power conditioner for the gyros, the power control system, and the housekeeping components for the instruments. The ACIP is aligned to the orbiter axes to a very high order of accuracy. Mounted on the ACIP base is a triaxial vibrometer which will provide the structural vibration characteristics of the orbiter affecting the ACIP experiment necessary for baseline

filtration of accelerometer data. The output signals of the instruments are recorded on the OEX tape recorder. The ACIP operates through launch and through the entry and descent phases. The internal instruments continuously sense the dynamic and performance characteristics of the orbiter through these critical flight phases. In addition, the ACIP receives indications of position of the control surfaces and converts them into higher orders of precision before recording them with the attitude data. Power is supplied from the mid-power control assembly 3 main bus C. Heaters are employed on the package and controlled by a switch on panel R11.

Weight of the ACIP is 119 kilograms (262 pounds). The principal technologist for the experiment is David Howes of NASA's Johnson Space Center.

DYNAMICS, ACOUSTIC, AND THERMAL ENVIRONMENT (DATE)

The DATE exeriment is to acquire environmental response and input data for prediction of environments for future payloads. The environments are neither constant nor consistent throughout the payload bay and are influenced by interactions among cargo elements.

The DATE experiment consists of accelerometers and force gauges (for dynamic influences), microphones (for vibra-acoustic effects), and thermal sensors. These devices will be installed on both payload components and carrying structure (pallet, shelf, etc.). DATE has no commands or telemetry interfaces. This data is recorded on the OEX recorder whenever the recorder is on.

INDUCED ENVIRONMENT CONTAMINATION MONITOR (IECM)

Measurements of the Space Shuttle environment are needed to verify that contamination associated with the Space Shuttle will not interfere with the gathering of data during flight. Definition of the Space Shuttle contamination environment will help in finding solu-

Dynamic and Acoustic Measurements,
DFI Pallet Locations:
    Trunnion, Orbiter Side
    Trunnion, DFI Pallet Side
    Keel, Orbiter Side
    Keel, DFI Pallet Side

Dynamic and Acoustic Measurements,
OSS-1 Pallet Locations:
    Trunnion, Orbiter Side
    Trunnion, OSS Pallet Side
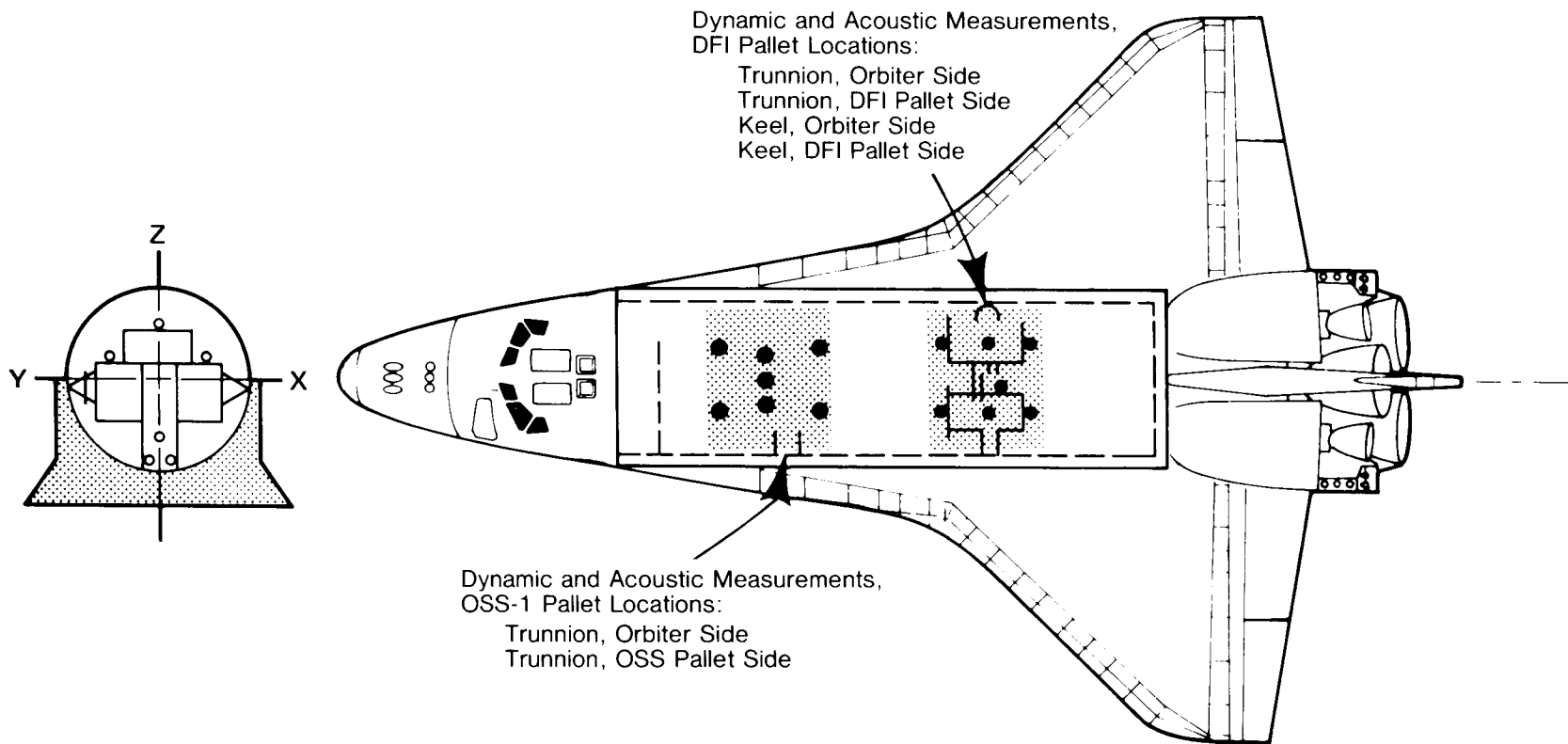
Dynamics, Acoustic, and Thermal Environment (DATE) Experiment

tions to contaminant problems that may possibly arise during the Space Shuttle operational phase.

Measurements of the contamination environment will be made using the integrated set of instruments designated as the IECM.

The IECM will measure and record concentration levels of gases and particulate contamination emitted by the Space Shuttle during all phases of the mission.

The IECM is self-contained aluminum unit and contains ten instruments and supporting systems mounted on the Development Flight Instrument (DFI) unit. The IECM weighs 360 kilograms (793.9 pounds). The instruments are: humidity monitor, dew point hygrometers, air sampler, cascade impactor, passive sample array, optical effects module, temperature controlled quartz crystal microbalance, cryogenic quartz crystal microbalance, camera/photometer, and mass spectrometer and gas.

The IECM has an internal battery for launch/deorbit and utilizes orbiter 28-Vdc power in orbit. The IECM is passively cooled via structural baffles and warmed by 28-Vdc electrical heaters. The IECM self-contained tape recorder is automatically controlled by the data acquisition control system.

IECM

Grapple Fixture

Support Structure

Forward

DFI Pallet

Forward

IECM

DFI Pallet

Development Flight Instrumentation

Induced Environment Contamination Monitor (IECM)

X = 124 millimeters
(4.8686 inches)

Y = 90 millimeters
(3.566 inches)

Z = 79 millimeters
(3.166 inches)

Air Sampler Bottles

Cryogenic Quartz Crystal Microbalance

Access Door to Arm & Safe Plug

Cascade Injector

Cameras

Plume Pressure Gauge

Forward

Passive Array

Temperature-Controlled Quartz Microbalance (4 places)

Mass Spectrometer

Optical Effects Module

Mounting Flange

J1 Power Connector

J2 Signal Connector

IECM Location

34

The humidity monitor is in operation during prelaunch through launch, and during entry and landing. An oscillator varies the frequency as a function of the amount of water present.

Dew point hygrometers are in operation during prelaunch through launch, and entry and landing. A mirror is cooled until condensation begins and a thermister on a mirror provides the data.

Air samplers consist of five bottles. Two are open for one minute at launch. One opens for a short period after solid rocket booster staging. The remaining two are opened for a period during entry.

Cascade impactor operates before and throughout the mission. A quartz crystal microbalance system measures the concentration and particle size distribution of contaminants. The data rate varies by mission phase, such as one per minute during orbit.

Passive sample array consists of 48 optical samples which are exposed to the Space Shuttle environment throughout the mission.

The optical effects module measures light transmission and scattering sequentially on six optical samples mounted on a carousel exposed to the payload bay. Data is taken on each sample approximately every nine and one-half minutes.

Temperature controlled quartz crystal microbalances measure the amount of molecular contamination deposited on a crystal sensor periodically at various temperatures. There are five sensors, one on each of the exposed sides of the IECM. Between each data take, sensor temperature is raised to clean off deposited material. It takes 10 hours to run through a complete sequence in orbit.

The cryogenic quartz crystal microbalance measures the amount of molecular contamination deposited on the crystal sensor, plus Z only. This is similar to the temperature-controlled microbalance but uses passive radiative detector cooling.

The camera/photometer makes optical measurements of induced particulate environment and background brightness. It uses two 16 millimeter Bolex movie cameras, 24 frames per hour.

The mass spectrometer and gas identify the off-gassing and out-gassing modecules in the payload bay and define the gas cloud through which optical experiments must look. It is activated by the flight crew via the IECM switch on the flight deck display and control panel, R11. It analyzes a series of mass groups of data taken every scan, then idles for five minutes between scans. It is calibrated by gas release.

The IECM operations prelaunch uplink ascent mode multiplexer/demultiplexer resets commands and configures the IECM for

IECM Contamination Data Points Using RMS
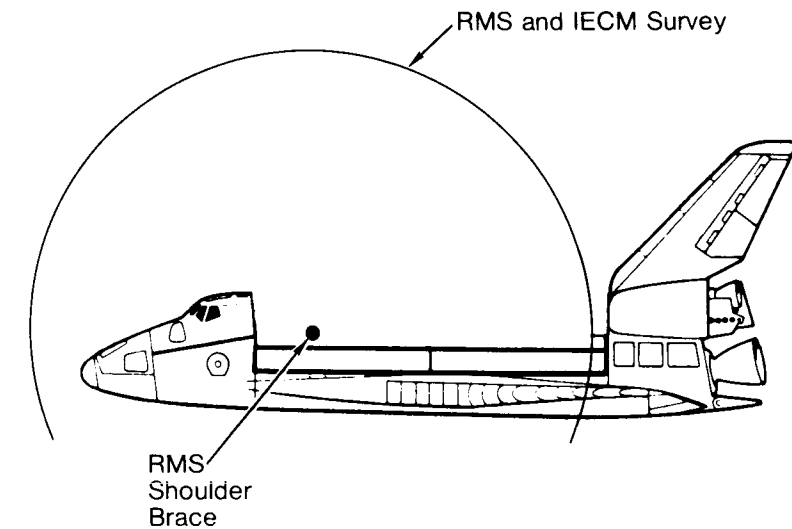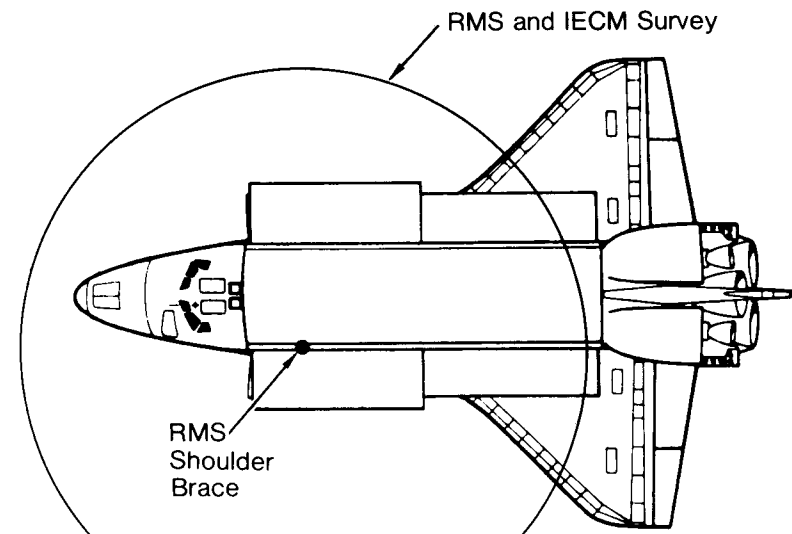
ascent mode processing. The T-O disconnect initiates mode processing and at T-O plus 150 seconds completes ascent mode processing.

In this flight, the IECM will monitor for contamination in place on the DFI in the payload bay and will be deployed using the RMS to allow a contamination/plume survey of the payload capture area. The RMS end effector will engage and latch onto the IECM grapple fixture and the IECM will then be released from the DFI. The RMS will position the IECM to various locations and the IECM measures the contamination flow field. This will be accomplished with reaction control system engine thrusting periods for a minimum of 80 milliseconds and without RCS engine thrusting periods in addition to operating and not operating the flash evaporator system.

In orbit the IECM uplink orbit mode multiplexer/demultiplexer reset command initiates orbit mode processing. One to two hours after payload bay door opening on orbit 1 or 2, the IECM switch on panel R11 is moved to position 1, and the mass spectrometer is on low bit rate. At a convenient time the IECM switch on panel R11 is moved to position 2, and starts gas release and the mass spectrometer is on high bit rate. After 45 minutes, the IECM switch panel R11 is positioned to 1, and the mass spectrometer is on low bit rate. Fifteen to 45 minutes prior to final payload bay door closure, the IECM switch on panel R11 is positioned to 2, and the mass spectrometer is off. The uplink deorbit mode multiplexer/demultiplexer reset command configures the IECM for the deorbit mode.

THERMAL PROTECTION SYSTEM (TPS)

The TPS experiment is subdivided into two groups: tile gap heating effects and the catalytic surface effects. These experiments will provide a better understanding of TPS heating phenomena which could lead to a lower design surface temperature that would result in lighter TPS with greater reusability.

Tile Gap Heating Effects. This experiment will evaluate the effects of tile gap and edge radii geometry on the spacecraft TPS convective heating. the panel will continue the study of tile edge

radii effects on gap heating during entry. Gap and edge radii geometry will be evaluated with different panels on each subsequent flight for a maximum of six flights.

The experiment consists of a removable carrier panel with 11 TPS tiles of baseline material located on the underside of the space-

The Gap Heating Effects Experiment
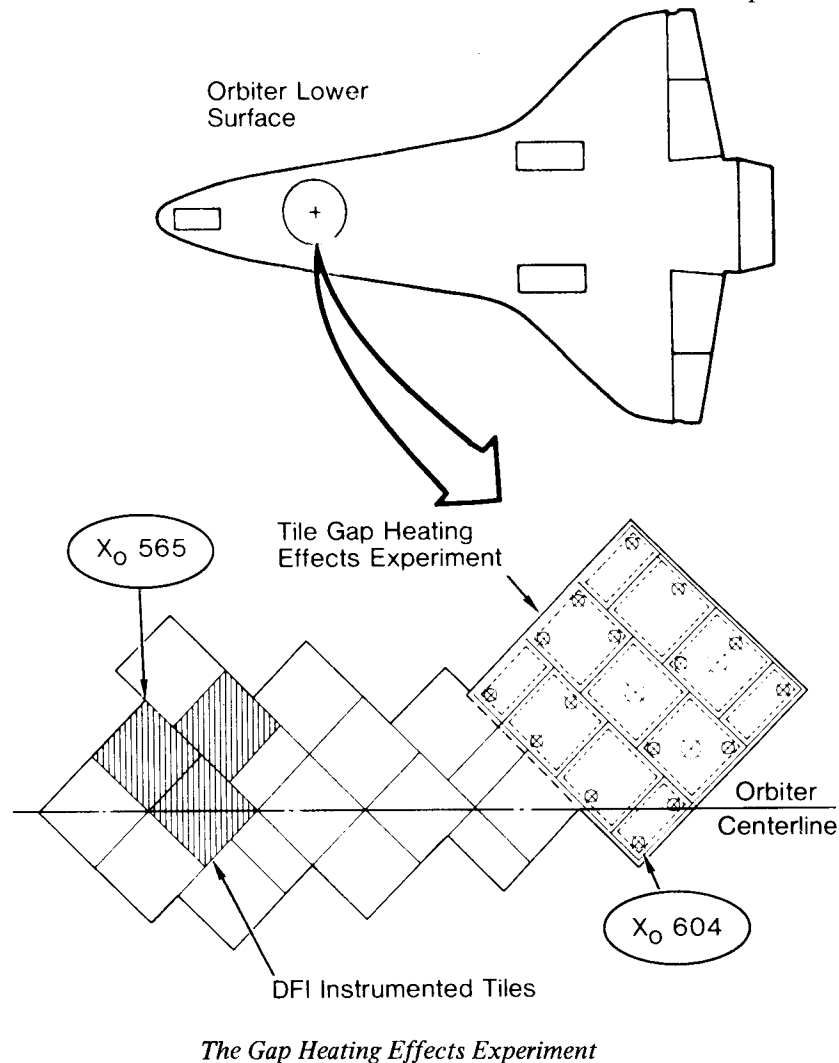
craft fuselage. Measurements through the tiles and in the gaps will provide temperature data during entry. This experiment will provide flight data on the effects of gap and edge radii variances on entry heating.

The tile gap heating effects experiment will be conducted by principal investigator technologist William Pitts of NASA Ames Research Center.

Catalytic Surface Effects. This experiment will verify predictions of the effects of surface catalytic efficiency on convective heating rates. Indications from analyses and ground test are that the design criteria for the spacecraft TPS may be overly conservative because surface catalytic efficiency was not included. To obtain flight data for comparison, this experiment was proposed.

The experiment will use ten baseline tiles, having DFI thermocouples, located along the lower mid fuselage of the spacecraft.

Two of these tiles will be sprayed with an overcoat consisting of iron-cobalt-chromia spinel (a highly efficient catalytic material) in a polyvinyl acetate binder. The overcoat is compatible with the existing baseline tile coating. During ascent the polyvinyl acetate will burn out of the overcoat, leaving the high emittance iron cobalt chromia spinel exposed.

During entry, beginning at 121,920 meters (400,000 feet) and continuing through landing, the thermocouple measurements will be recorded by the PCM recorder. As an aid in evaluating this data, comparisons will be made using DFI measurements recorded on baseline tiles adjacent to the tiles with the overcoat.

On later flights, up to six tiles will be coated to provide catalytic efficiency data. This experiment is conducted by principal investigator David Stewart of NASA Ames Research Center.

2300°F

2575°F

2000°F

1800°F

2000°F

2300°F

2625°F

38

2000°F

T = Thermocouple

Locations:
(X_O = 364 in)

(X_O = 416 in.)

(X_O = 435 in.)

(X_O = 575 in.)

(X_O = 620 in.)

STS-2
(X_O 754 in.)
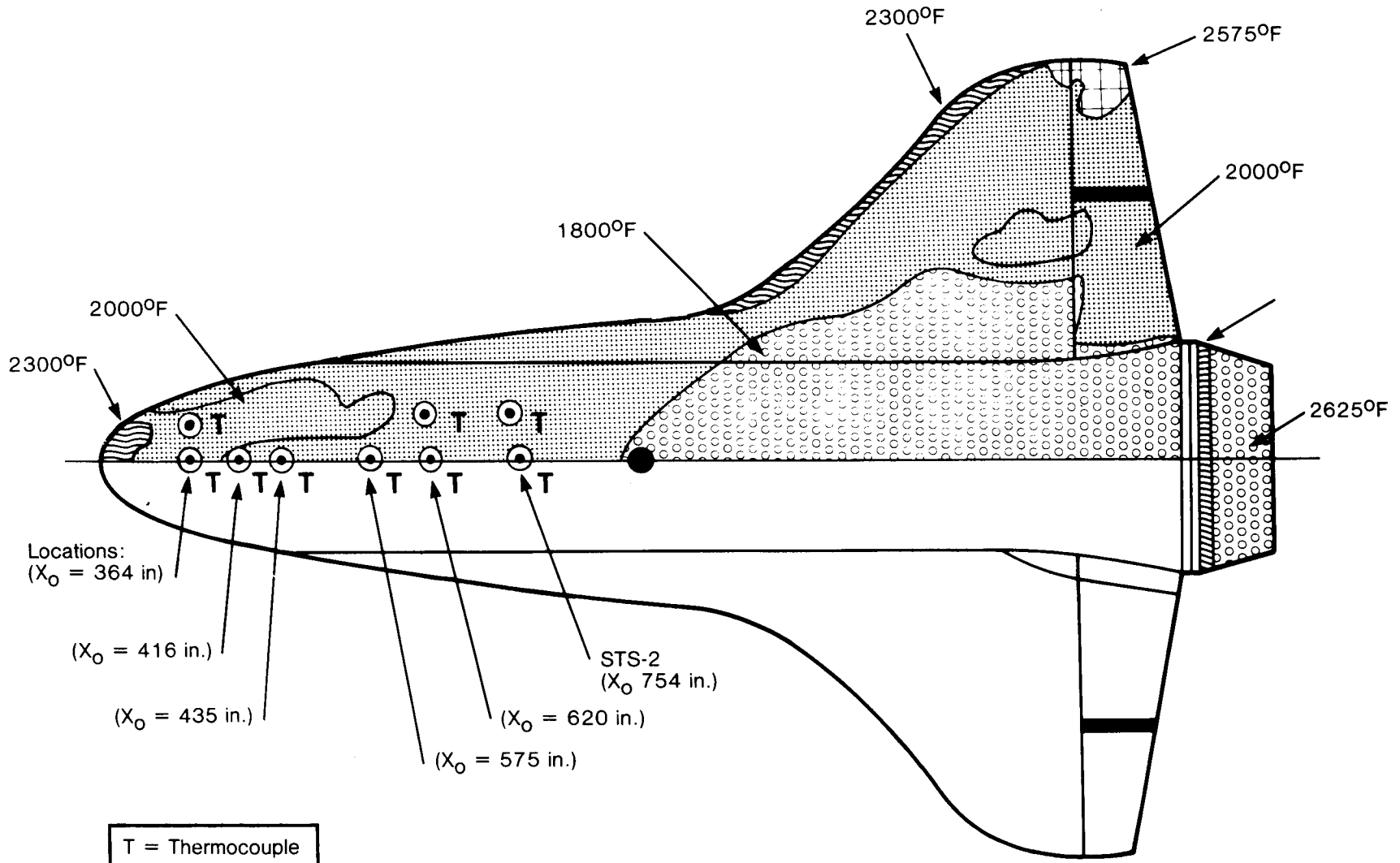
Lower Surface View

Catalytic Surface Effects Experiment
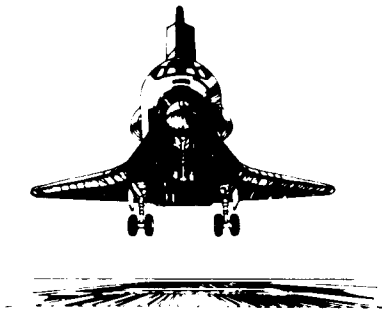
NEWS ABOUT AMERICA'S SPACE SHUTTLE

...it comes from Rockwell International

STS-1 SUMMARY

"The Space Shuttle did more than prove our technological abilities, it raised our expectations once more; it started us dreaming again..."

— President Ronald Reagan,
Address to Joint Session of
Congress, April 28, 1981.

The success of the first Space Shuttle flight (STS-1) was marked by superb systems performance of the Rockwell-built orbiter *Columbia.*

The 54-hour mission (April 12-14, 1981) began with a flawless and spectacular launch from Pad 39A at NASA's Kennedy Space Center in Florida. After two days of orbital activities, the STS-1 crew of Commander John W. Young and Pilot Robert Crippen brought the 99-ton *Columbia* to a textbook-perfect landing on a dry lake-bed runway at Edwards Air Force Base, California, before a crowd of more than 100,000.

Assessment of flight test results shows all major objectives were accomplished. A problem with the on-board data recorder which developed early in the flight caused loss of some data.

The STS-1 crew described *Columbia's* maiden flight as nominal and said the spacecraft performed superbly.

Astronaut Young, at the crew's post-flight press conference (April 23), said, "The first Space Shuttle flight can truly be called nominal, although I think we can do away with the word nominal. You can call it phenomenal."

According to the crew, the five major test areas and performance in each were:

- Propulsion systems..."went super."

- Mechanical systems..."worked great."

- Man/machine interface..."was superb."

- Thermal tests checked out..."very well."

- Avionics systems test..."were just terrific."

Of the 135 test objectives, Young said that, except for the loss of some data through recorder malfunctions, "we got them all."

MISSION SUMMARY

Liftoff Through OMS-2 Maneuver. Liftoff of STS-1 occurred at 1:12:00:03.8 GMT on April 12, 1981. The trajectory was as planned with all events up through payload bay door opening and

radiator deployment occurring normally. The orbital parameters after the OMS (orbital maneuvering system)-2 firing were an apogee of 133.7 nautical miles (153 statute miles) and a perigee of 132.7 n.mi. (152 statute miles), as expected.

The main propulsion system performed normally.

The APU's (auxiliary power units) operated as expected with no apparent problems. The hydraulics systems also operated normally, although all three water boiler and vent temperatures were higher than expected. These conditions are thought to have been caused by freezing of boiler water.

The fuel cells, cryogenics, and electrical power distribution systems all performed satisfactorily with no anomalies. The liftoff electrical loads were about 23 kW, some 5 to 7 kW lower than predicted.

4 Hours Through 24 Hours—April 13, 1981. The OMS-3 and OMS-4 maneuvers were completed as planned, raising the orbit to a 145-n.mi. (166 statute miles) apogee by a 144-n.mi. (165 statute miles) perigee. The propellant remaining after the maneuvers was at the predicted levels, indicating satisfactory system performance.

Orbiter temperatures remained within acceptable limits. The flight control systems checks, using one auxiliary power unit, went as planned.

During the first television pass at approximately 13:53 GMT, the flight crew directed the onboard TV camera at the OMS pods, showing some TPS damage on both pods.

24 Hours Through 48 Hours—April 14, 1981. An assessment of the thermal and structural loads for the area of the TPS damage on the OMS pods was completed. The over-all assessment for the tile damage was that the orbiter was safe for reentry.

Three planned RCS firings were performed with the expected results.

The APU gas generator injector bed temperatures dropped to 236°F (normal range—350°F to 410°F) at 1:23:30 GMT, indicating the loss of the APU 2 gas generator heater B. The heater was switched from the B to the A system and the temperatures began increasing. Approximately 4-1/2 hours later, the gas generator injector bed temperatures were again decreasing. The heater was switched to the B system, but no increase was noted; it was then returned to system A, again with no increase in temperature. It was determined through a real-time ground test that APU 2 would start satisfactorily at bed temperatures as low as +70°F.

During the flight control system checkout, the horizontal situation indicator (HSI) compass card did not respond properly. The indicator was off 5 degrees during the "low" test and did not drive at all during the repeated "high" test. A test procedure was performed by the crew and the indicator again failed to respond, with the card appearing stuck. Later, during the Ops 8 checkout, the crew reported normal HSI function.

The -Y star tracker experienced an anomaly at 1:16:53 GMT. Bright object protection was being provided by an interim backup circuit which senses light in the field of view and was latching the shutter closed. The crew opened the shutter via an override command for subsequent alignments.

The on-orbit electrical loads were about 15 to 25-1/2 kW, some 2 kW lower than predicted.

48 Hours Through Landing—April 14, 1981. Entry preparation was accomplished according to the crew activity plan and without problems. A nominal reentry was flown, and touchdown occurred at 104:18:20:56 GMT. Post-rollout operations were accomplished without incident, and ground cooling was connected about 16 minutes after landing. The flight crew left the orbiter 1 hour and 8 minutes later. This occurred after a delay for the ground crew to clear hazardous vapors indicated in the vicinity of the orbiter side hatch.

Entry Loads and Consumables. Structural, power, and heat rejection entry loads were generally lower than predicted, as were the APU, RCS, and active thermal control subsystem (ATCS) consumables usage. Orbiter structure backface temperatures also were lower than expected.

Solid Rocket Booster Recovery. SRB recovery was accomplished after some difficulty with the nozzle plugging operations. Divers were able to plug the nozzles using backup procedures and hardware and the solid rocket motor cases, frustums, and re-maining hardware was returned to KSC for inspection and processing.

External Tank Reentry. The external tank reentry and disposal process began and proceeded as planned, until the external tank rupture occurred at a higher altitude than expected. Verbal reports from the ET tracking ship indicate that the debris footprint was also larger than expected. Tracking data was returned on an expedited basis for in-depth evaluation.

STS-1 MISSION FACTS

Commander: John W. Young
Pilot: Robert L. Crippen
Mission Duration—54 hours, 21 minutes, 57 seconds
Miles Traveled—approximately 1,074,567 nautical miles
   (933,757 statute miles)
Orbits of Earth—36
Orbital Altitude—145 nautical miles (166 statute miles)
Landing Touchdown—853 meters (2800 feet) beyond
   planned touchdown point

Landing Rollout—2741 meters (8993 feet) from main
   gear touchdown
Orbiter Weight at Landing—Approximately 89,014
   kilograms (196,500 pounds)
Landing Speed at Main Gear Touchdown—180 to 185 knots
   (207 to 212 mph)

All of the 135 flight test objectives assigned to STS-1 were
accomplished based on data available as of this date.

STS-1 TIMELINE

Day of Year	GMT* Hr-Min-Sec	Event	Day of Year	GMT* Hr-Min-Sec	Event
102	12:00:03	Liftoff		16:47:00	Payload bay doors open
	12:00:47	Initiate throttle down of the main engines to 65%	104	14:29:55	Payload bay doors closed
	12:00:56	Max q (maximum dynamic pressure)		17:17:23	Orbiter APU No. 2 and No. 3 activation
	12:01:05	Initiate throttle up of the main engines to 100%		17:21:35	Deorbit-OMS ignition
				17:43:16	Orbiter APU No. 1 activation
	12:02:14	Solid Rocket Booster separation		17:49:05	Entry interface 121,920 meters (400,000 feet)
	12:07:36	3 "g" acceleration limit		18:08:30	Exit blackout
	12:08:38	MECO (main engine cutoff)		18:14:34	Terminal area energy management
	12:09:02	External Tank separation		18:20:00	Landing gear deployment
	12:10:38	OMS-1 (Orbital Maneuvering System-1) ignition		18:20:51	Main landing gear contact
				18:21:11	Nose landing gear contact
	12:14:57	Orbiter APU deactivation		18:21:57	Wheel stop
	12:44:06	OMS-2 ignition		18:22:39	Orbiter APU deactivation
	13:43:07	Payload bay door open close/open tests		19:28:00	Crew egress
	18:20:50	OMS-3 ignition			
	19:05:36	OMS-4 ignition			
		RCS-1 test			
		RCS-2 test	*GMT—Subtract 5 hours for EST		
103	14:48:00	Payload bay doors closed, deorbit rehearsal RCS-3 test		6 hours for CST	
				7 hours for MST	
				8 hours for PST	
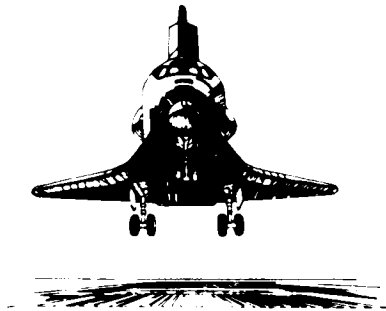
NEWS ABOUT AMERICA'S SPACE SHUTTLE

...it comes from Rockwell International

STS-2 SUMMARY

The planned 124-hour mission began with a flawless and spectacular launch from pad 39A at NASA's Kennedy Space Center in Florida on November 12, 1981. At approximately 2 hours and 35 minutes into the mission, a ph high indication was observed on Fuel Cell 1. Two hours later, a drop of 0.8 volt on Fuel Cell 1 occurred over a very short interval. This voltage drop after two hours of a high ph reading confirmed the loss of one or more cells in Fuel Cell 1. The decision was made to shut down and secure Fuel Cell 1. Because of the loss of Fuel Cell 1, mission plans were reviewed and refined for a 54-hour minimum mission and power levels reduced to compensate for the loss of the fuel cell. After two days in orbit, the STS-2 crew of Commander Joe Engle and Pilot Richard Truly brought the *Columbia* to a landing on the dry lakebed runway at Edwards Air Force Base, California, 54 hours, 13 minutes, and 11 seconds after liftoff, on November 14, 1981.

With the shortened flight, approximately 90 percent of the major mission objectives was successful (233 of 258) and 60 percent (38 of 63) of the tests requiring in-orbit crew involvement was completed.

Sixty-four of 94 desired OSTA-1 science data takes were completed and about 73 hours of data were acquired on the various sensors. The scientists evaluating the initial OSTA-1 science data takes are ecstatic with the results of the data and stated that the Space Shuttle is a magnificent flying platform for the experiment package.

The STS-2 crew described *Columbia's* second flight as a magnificent flying machine.

MISSION SUMMARY

Prelaunch, Nov. 4, 1981. The terminal countdown for the initial attempt to launch STS-2 was conducted on November 4, 1981. The countdown proceeded normally until T-9 minutes when the ground launch sequencer stopped the count for a launch commit criteria violation of the liquid oxygen (LOX) mass quantity redline. The automatic sequencer resumed the countdown approximately two minutes later, when the LOX mass quantity redline was cleared.

The three orbiter auxiliary power units (APU's) were started on time and in sequence and a "Go" was given on all three units even though the lube oil outlet pressures on No. 1 and No. 3 APU were higher than anticipated. The countdown continued normally until T-31 seconds, when the sequencer halted the count due to a violation of the spacecraft's power reactant storage distribution (PRSD) oxygen (O_2) tank pressure limits (800 psia). A real-time decision had been made to lower the O_2 tank pressure limits to 775 psia and continue the count, but the sequencer operator was unable to clear the limits.

The spacecraft APU's were turned off at approximately 12:48:12 GMT, and planning was begun for a recycle at T-9 minutes.

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After further analysis and discussion by Rockwell and NASA of the higher than expected lube oil outlet pressures on APU's 1 and 3 , it was determined to scrub the launch, as there was no APU test data available for mission duty cycles with a possible clogged filter and contaminated oil. The spacecraft's APU gearbox was flushed, reserviced, and the filters were changed on APU's No. 1 and No. 3

Prelaunch, Nov. 12, 1981. The second launch countdown for STS-2 was conducted on November 12, 1981.

The planned launch time was delayed on November 11, 1981, approximately three hours, due to a malfunction in one of the MDM's (multiplexer/demultiplexer) that provided critical telemetry information. The malfunction was corrected with a replacement unit from Orbiter Vehicle 099, the *Challenger.*

The countdown for the second launch attempt of STS-2 proceeded as planned until T-9 minutes. At that point, the solid rocket booster hydraulic power unit (HPU) gas generator bed temperature fell below the minimum redline value of 190°F. The countdown resumed after it was determined that the violation had resulted from procedural difficulty with the HPU heater.

Liftoff Through OMS-2 Maneuver. Liftoff of STS-2 occurred at 15:10:00 GMT on November 12, 1981.

The trajectory was as planned with all events up through payload bay door opening and radiator deployment occurring normally. The orbital parameters after the OMS-2 maneuver indicated an apogee of 125.0 nautical miles (143 statute miles) and a perigee of 120.1 n.mi. (138 statute miles).

The avionics system operated well and very little data were lost during the solid rocket booster operations because of plume interference.

The main propulsion system performed normally, and the propellant dump and vacuum inerting were completed successfully.

The flash evaporater system started normally but shut down after main engine cutoff before temperature control could be regained. This type of shutdown was suspected to be due to a logic problem in the flash evaporator system controller. The system was cycled off/on by the flight crew and temperature control reestablished on primary system A.

The *Columbia's* APU's operated well, but APU No. 3 was shut down manually one minute early due to a higher than expected lube oil temperature. The high lube oil temperature was due to freezing in water spray boiler No. 3. Water spray boiler No. 3 later thawed without further problems. After shutdown of APU No. 1, System A cooling apparently failed and did not cool the pump and valve properly.

The fuel cells, cryogenics, and electrical power distribution systems all performed satisfactorily with no anomalies. The liftoff electrical loads were about 23 kW, very similar to STS-1.

The reaction control, structural, and mechanical systems all performed well.

A preliminary review of pad and vehicle-mounted sensors to monitor for spacecraft overpressure indicates that overpressures and vehicle responses to vehicle overpressure were both approximately 20 to 30 percent of those experienced on STS-1. Approximately 2 hours and 35 minutes into the mission, a ph high indication was observed on Fuel Cell 1. Two hours later, a drop of 0.8 volt on Fuel Cell 1 occurred over a very short interval. This voltage drop after two hours of a high ph reading confirmed the loss of one or more cells in Fuel Cell 1. The decision was made to shut down the fuel cell. A procedure was developed and implemented to secure Fuel Cell 1.

4 Hours Through 24 Hours, Nov. 12, 1981. The OMS-3A, OMS-3B, and OMS-4 maneuvers were completed, raising the orbit to a 144-n.mi. apogee and a 139-n.mi. (159 statute mile) perigee. During the OMS-3B burn, the left OMS oxidizer quantity read

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approximately 6 percent higher than predicted. Two thermal measurements (OMS high point bleed lines) violated the 50°F lower limit, causing an onboard fault message. The onboard limits were changed to 40°F. Data review indicated nominal OMS performance for the three burns.

The APU data were thoroughly reviewed to eliminate the concern for bubbles forming in the fuel due to the high soakback temperatures following launch. APU No. 2 was selected for the flight control system (FCS) checkout run and the entry restart sequence established: APU 3, APU 2, and APU 1.

Because of the loss of Fuel Cell 1, mission plans were reviewed and refined for a 54-hour minimum mission and power levels reduced to compensate for the loss of the fuel cell.

OSTA-1 pallet system activation was completed and coolant loop and pallet structure temperatures were slightly higher than expected. The remote manipulator system (RMS) was activated, and RMS temperatures were as expected.

24 Hours Through 48 Hours, Nov. 13, 1981. With the decision to perform a minimum mission of approximately 54 hours, the major activities of the second day consisted of RMS checkout, data-gathering with the OSTA experiments, and other primary test objectives.

The majority of the RMS minimum mission objectives were accomplished except for berthing in the backup mode. Several TV camera failures were experienced during RMS operations but caused no difficulty. Near the end of Day 2, a problem was noted by the crew in the RMS shoulder joint drive (yaw) in the backup mode. The crew returned to primary and secured the RMS for entry. This problem was determined to be a broken wire connection.

OSTA-1 activities continued with some minor constraints due to loss of the fuel cell. Pallet data continued to confirm flow restrictions in the pump package. The DFI coolant loop remained stable

with low delta pressure from the pump across the system coldplate. Troubleshooting plans were developed but deferred until after landing.

Cathode Ray Tube 1 failed at approximately 22:30:00 GMT. The flight crew replaced it using CRT 4.

The Fuel Cell 3 oxygen flow meter was erratic, with the reading switching from off-scale high to off-scale low. O_2 cryo tank quantity did not confirm excessive usage, and a sensor malfunction was suspected.

Entry procedures for two fuel cells and the possibility of another fuel cell failure were assessed and refined. Current loads for Fuel Cells 2 and 3 ranged from 200 to 275 amperes, with Fuel Cell 2 carrying a slightly higher load.

The flash evaporator system continued to stay in standby after nightside operations. The port (left side) radiators were stowed to maintain a higher heatload on the evaporator during nightside operations so that the evaporator would operate normally. A flash evaporator test was planned for entry day.

All hydraulic parameters remained within expected and acceptable ranges. A modified test was performed to obtain empirical data for hydraulic orbital thermal certification. Temperature responses require more detailed analysis to assess thermal adequacy for the STS-3 cold mission.

48 Hours Through Landing, Nov. 14, 1981. Flash evaporator system diagnostic tests were performed to verify satisfactory full-up operation on primary A and primary B controllers. Following the test, flash evaporator system operation was initiated on primary A, and operation was normal.

The theodolite measurements for payload bay door deflections could not be accomplished because of bracket movements. The crew

reported each time the unit was touched, readings were disturbed and further tests were deleted.

Flight control system checkout was performed using APU No. 2 for 4 minutes. All operating parameters were normal.

The main propulsion system helium system was configured for entry with the left and pneumatic helium isolation valves in the open position instead of being controlled by the general-purpose computer. Helium pressurized the propellant line manifolds early, causing the loss of approximately 45 pounds of helium through the engine high pressure oxidizer turbopump seals before the oxygen prevalves were closed. As a result, the Space Shuttle Main Engine (SSME) oxygen lines were not purged during entry. Oxygen prevalves were operated as soon as practical after rollout until helium depletion to purge any moisture from the system.

The forward RCS dump was successfully completed at entry interface minus 18 minutes, using RCS engines FIL, F3L, F2R, and F4R.

All *Columbia's* APU's were started and run successfully through entry. There were no indications of gearbox, filter, or lubrication jet plugging. The APU's were run for 15 minutes after rollout and the hydraulic load test and SSME repositioning completed satisfactorily.

Just before entry, the OEX recorder would not respond to ground uplink commands. Ground commands were sent several times to initiate Aerodynamic Coefficient Package data recording.

All planned preprogrammed test inputs and aerodynamic stock inputs were completed.

The air data system functioned well and air data was introduced into the navigation as planned at Mach 2.5. Lift-to-drag ratios, as well as vehicle trim positions after blackout, were as predicted.

Performance of Fuel Cells 2 and 3 was as predicted throughout the entry phase. Entry loads ranged from 8.6 kW to a peak of 10.6 kW of Fuel Cell 2, for an average power level of approximately 9.1 kW. Fuel Cell 3 entry loads ranged from 7.8 to 8.8 kW for an average power level of approximately 8.3 kW.

STS-2 landed at 21:23:11 GMT at the Dryden Flight Research facility. All spacecraft systems operated satisfactorily during entry. The landing was switched to runway 23 instead of runway 15 because of high crosswinds.

Solid Rocket Booster Recovery. SRB recovery was accomplished after considerable difficulty because of severe weather in the recovery zone. Solid rocket motor cases, frustums, and remaining hardware were returned to KSC for inspection and processing.

External Tank Reentry. The external tank reentry and disposal process began and proceeded as planned, and the external tank rupture occurred very close to nominal based on the initial estimate of engine cutoff conditions. Tracking data is being evaluated.

STS-2 MISSION FACTS

Commander: Joe Engle

Pilot: Richard Truly

Mission Duration—54 hours, 13 minutes, 11 seconds

Miles Traveled—Approximately 1,074,567 nautical miles (933,757 statute miles)

Orbits of Earth—36

Orbital Altitude—137 nautical miles (157 statute miles)

Landing Touchdown—Approximately 304 meters (1,000 feet) earlier than planned touchdown point

Landing Rollout—Approximately 2133 meters (7000 feet) from main gear touchdown

Orbiter Weight at Landing—Approximately 92,534 kilograms (204,000 pounds)

Landing Speed at Main Gear Touchdown—Approximately 195 knots (224 miles per hour)

STS-2 TIMELINE

Day of Year	GMT* Hr:Min:Sec	Event
316	15:09:59	Liftoff
	15:10:44	Initiate throttle-down of main engine to 68%
	15:10:52	Max. q (maximum dynamic pressure)
	15:11:04	Initiate throttle up of main engines to 100%
	15:12:13	Solid rocket booster separation
	15:17:36	Throttle main engines down for 3-g acceleration limit
	15:18:33	MECO (main engine cutoff)
	15:18:57	External tank separation
	15:20:33	OMS (orbital maneuvering system)-1 ignition
	15:23:27	Orbiter auxiliary power unit deactivation
	15:51:50	OMS-2 ignition
	17:42:39	Payload bay doors close/open tests—complete
316	19:10:00	OSTA (Office of Space and Terrestrial Applications)-1 experiment activation
	22:54:59	OMS-3A ignition
	22:59:14	OMS-3B ignition
	23:43:19	OMS-4 ignition
317	14:25:00	Remote manipulator system (RMS) group 1 tests
318	14:26:00	OSTA-1 experiment deactivation

Day of Year	GMT* Hr:Min:Sec	Event
	14:58:51	APU No. 2 start, flight control system checkout
	16:35:00	OSTA-1 pallet deactivation
	16:47:33	Payload bay doors closed—port
	17:05:19	Payload bay doors closed—starboard
	20:18:15	APU No. 3 activation
	20:23:15	Deorbit—OMS ignition
	20:37:36	APU No. 2 and No. 1 activation
	20:50:36	Entry interface 121,920 meters (400,000 feet)
	21:09:40	Exit blackout
	21:16:30	Terminal area energy management (TAEM)
	21:23:11	Main landing gear contact
	21:23:27	Nose landing gear contact
	21:24:04	Wheel stop
	21:38:14	Orbiter auxiliary power unit deactivation

*GMT—Subtract 5 hours for EST
6 hours for CST
7 hours for MST
8 hours for PST