

STS-39 PRESS INFORMATION

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MISSION OVERVIEW

This is the 12th flight of Discovery and the 40th for the space shuttle.

The flight crew for the STS-39 mission consists of commander Michael (Mike) L. Coats; pilot L. Blaine Hammond, Jr.; and mission specialists Guion (Guy) S. Bluford, Jr.; Gregory (Greg) J. Harbaugh; Richard (Rick) J. Hieb; Donald (Don) R. McMonagle; and Charles L. (Lacy) Veach.

STS-39 is the eighth dedicated Department of Defense (DOD) shuttle mission, and is the first such mission to be unclassified. STS-39's primary mission objective is to collect infrared, visible, ultraviolet, and X-ray data on orbiter plumes (orbital maneuvering system and reaction control system), the Earth background (aurora, earth limb, airglow), chemical and gas releases, the orbiter environment, and celestial objects (stars, nebula, galaxies, etc.). The mission is expected to provide valuable data essential to the design and development of Strategic Defense Initiative (SDI) systems.

The most complex shuttle mission to date, STS-39 showcases a wide variety of shuttle capabilities, encompassing rendezvous, multiple translational maneuvers, extended station keeping, and deployment and retrieval of a satellite. The mission involves challenging coordination tasks involving precision orbiter maneuvers/payload spacecraft commanding and observation sequences, multibody management, and a crew intensive timeline. Challenging new techniques will be employed to maximize data gathering. At times, Discovery's entire crew of seven astronauts will be required to work in careful coordination on the flight deck, synchronizing orbiter and Shuttle Pallet Satellite (SPAS)-II maneuvers and documenting key events. In all, approximately 36 hours of detached rendezvous and proximity operations are scheduled.

STS-39 consists of two primary payloads: the Infrared Background Signature Survey (IBSS), and Air Force Program

(AFP)-675. Secondary payloads include the Space Test Payload (STP)-I, Multi-Purpose Experiment Canister (MPEC), and two middeck experiments: Cloud Logic To Optimize Use of Defense Systems (CLOUDS)-IA, and Radiation Monitoring Equipment (RME)-III. IBSS and AFP-675 observations are scheduled throughout the mission. STP-I and MPEC both have a small amount of dedicated time on the last day of the mission.

IBSS is a Strategic Defense Initiative Organization (SDIO)-sponsored experiment designed to collect infrared, ultraviolet, and visible data for use in the development of ballistic missile defense sensor systems. Phenomena to be observed include orbital maneuvering system (OMS) and primary reaction control system (PRCS) engine firing exhaust plumes, the orbiter environment, the Earth and its backgrounds, chemicals and gases released into space, and celestial calibration sources.

The IBSS payload is composed of three separate hardware elements: the Shuttle Pallet Satellite (SPAS)-II, the Critical Ionization Velocity (CIV) package, and the Chemical Release Observation (CRO) package.

The deployable SPAS-II platform incorporates a cryogenically cooled infrared sensor, an ultraviolet multispectral sensor, pressure gauge, and two low light level television cameras. Following SPAS-II deployment from the orbiter, the SPAS-II IBSS sensors will observe orbiter attitude control rocket plumes, providing spatial and temporal plume phenomenology data that will be used to design SDI sensors and seekers. The orbiter will be maneuvered repeatedly for the SPAS-II experiments. SPAS-II can be commanded by the orbiter crew or by the ground.

The Critical Ionization Velocity (CIV) and the Chemical Release Observation (CRO) subexperiments are mounted in the payload bay. The CIV experiment is composed of four separate gas canisters, each containing a different gas. The canisters remain in the orbiter payload bay and release gases upon command. The

gases will be observed by SPAS-II while it is deployed and on the RMS, as well as by the CIV Monitor Package mounted in the payload bay as part of the CIV payload element. CIV is intended to provide on-orbit spectral data to examine a theory that many neutral gaseous molecules, including rocket combustion products, will be ionized when they travel through a magnetized plasma at velocities such that their kinetic energy exceeds their ionization potential. If this theory is correct, such ionization will provide additional observables on objects of interest. The three CRO subsatellites are deployed and their chemicals released later via ground commands. Two deployed and one RMS SPAS-II CRO observations will be made. Each subsatellite is loaded with a different chemical.

The nominal IBSS/SPAS-II deploy opportunity is on Orbit 31 with a backup opportunity on Orbit 32. Nominal retrieve is planned for Orbit 56 with a backup on Orbit 57.

The AFP-675 is a DOD-sponsored collection of experiments designed to measure background infrared and ultraviolet emissions, identify contamination in the orbiter environment, and demonstrate X-ray imaging proof of concept. Phenomena to be observed include the Earth's limb and airglow, auroras, celestial objects, orbiter surface glow, and contamination events. Results are critical to understanding how an SDI detection and tracking system will operate in space.

The five AFP-675 experiments [Cryogenic Infrared Radiance Instrument for Shuttle (CIRRIS)-IA; Far Ultraviolet Camera (FARUV); Uniformly Redundant Array (URA); Horizon Ultraviolet Program (HUP); and Quadrupole Ion Neutral Mass Spectrometer (QINMS)] are mounted on the nondeployable Experiment Support Structure (ESS) in the payload bay. They are completely controlled by a mission specialist through a unique aft flight deck command and monitor panel.

STP-1 is a collection of five diverse experiments designed to collect ultraviolet, infrared, zero-gravity, and data management data. The Advanced Liquid Feed Experiment (ALFE) will

evaluate the performance of advanced propellant management systems (tanks and liquid collection systems) in microgravity. The Shuttle Kinetic Infrared Test (SKIRT) will collect infrared, visible, and ultraviolet data on shuttle atomic oxygen glow effects. The Ultraviolet Limb Measurement (UVLIM) will investigate atmospheric composition. The Data System Experiment (DSE) will conduct the first space test of a 2.25-Mips super-mini-computer with an erasable optical disk data storage system. The Ascent Particle Monitor (APM) will collect particles to study contamination in the shuttle payload bay. The STP-1 experiments and their associated electronics and control systems are mounted on a Hitchhiker-M across-the-bay carrier.

MPEC is a DOD-sponsored classified payload housed in a Get-Away Special (GAS) canister. The payload will be deployed by the crew on the last day of the mission.

CLOUDS-1A is a DOD-sponsored middeck payload consisting of a 35mm camera assembled with a motor drive, data recording system, 105mm lens, and infrared filter. The objective of CLOUDS-1A is to photograph sequences of cloud fields over various ground sites (targets of opportunity) in order to provide a more efficient assessment of relevant cloud characteristics that impact DOD systems.

The RME-III payload in Discovery's middeck measures the ionizing radiation exposure in the orbiter crew compartment. The unit contains a liquid crystal display (LCD) for real-time data display and a keyboard for controlling its functions.

Nine development test objectives (DTOs) and 13 detailed supplementary objectives (DSOs) are scheduled to be conducted.

The STS-39 flight crew is divided into a red team and blue team working 12-hour shifts followed by 12 hours off duty. This allows for continuous payload operations 24 hours a day. The commander is not assigned to a team and is free to adjust his hours real-time as necessary. The red team consists of pilot L. Blaine Hammond, Jr.; and mission specialists Charles L. (Lacy)

Veach and Richard J. Hieb. The blue team consists of mission specialists Gregory J. Harbaugh, Donald R. McMonagle, and Guion S. Bluford, Jr.

Rockwell International, under management of the Air Force Space Systems Division Space Test and Transportation Office, is integrating the entire STS-39 cargo. As contractor for the Space

Test Integration Contract (STIC), Rockwell is responsible for support of STS-39 integration, operations, training, logistics, and communication systems activities at Rockwell's Space Systems Division in Downey, Calif.; NASA's Johnson Space Center in Houston, Texas; and the Cape Canaveral Air Force Station and NASA's Kennedy Space Center in Florida.



MISSION STATISTICS

Vehicle: Discovery (OV-103), 12th flight

Launch Date/Time:

4/23/91 7:05 a.m., EDT
6:05 a.m., CDT
4:05 a.m., PDT

Launch Site: Kennedy Space Center (KSC), Fla.—
Launch Pad 39A

Launch Window: 3 hours, 26 minutes

Mission Duration: 8 days, 7 hours, 24 minutes

Landing: Nominal end of mission on Orbit 134

5/1/91 2:29 p.m., EDT
1:29 p.m., CDT
11:29 a.m., PDT

Runway: Nominal end-of-mission landing on concrete runway 22, Edwards Air Force Base (EAFB), Calif. Backup: EAFB. Weather alternates are Northrup Strip (NOR), White Sands, New Mexico; and KSC.

Transatlantic Abort Landing: Zaragoza, Spain; Alternates are Moron, Spain; and Ben Guerir, Morocco

Return to Launch Site: KSC

Abort-Once-Around: NOR

Inclination: 57 degrees

Ascent: The ascent profile for this mission is a direct insertion. Only one orbital maneuvering system thrusting maneuver, referred to as OMS-2, is used to achieve insertion into orbit. This direct-insertion profile lofts the trajectory to provide the earliest

opportunity for orbit in the event of a problem with a space shuttle main engine.

The OMS-1 thrusting maneuver after main engine cutoff plus approximately 2 minutes is eliminated in this direct-insertion ascent profile. The OMS-1 thrusting maneuver is replaced by a 5 foot-per-second reaction control system maneuver to facilitate the main propulsion system propellant dump.

Altitude: 140 nautical miles (161 statute miles) circular orbit

Space Shuttle Main Engine Thrust Level During Ascent:
104 percent

Total Lift-off Weight: Approximately 4,512,698 pounds

Orbiter Weight, Including Cargo, at Lift-off: Approximately 246,986 pounds

Payload Weight Up: Approximately 21,413 pounds

Payload Weight Down: Approximately 20,586 pounds

Orbiter Weight at Landing: Approximately 211,577 pounds

Payloads—Cargo Bay (* denotes primary payload): Infrared Background Signature Survey (IBSS)*, Air Force Program (AFP)-675*, Space Test Payload (STP)-1, Multi-Purpose Experiment Canister (MPEC)

Payloads—Middeck: Cloud Logic to Optimize Use of Defense Systems (CLOUDS)-IA, Radiation Monitoring Equipment (RME)-III

Flight Crew Members:

Commander: Michael L. Coats, third space shuttle flight
Pilot: L. Blaine Hammond, Jr., first space shuttle flight

Mission Specialist 1: Gregory J. Harbaugh, first space shuttle flight

Mission Specialist 2: Donald R. McMonagle, first space shuttle flight

Mission Specialist 3: Guion S. Bluford, Jr., second space shuttle flight

Mission Specialist 4: Charles L. (Lacy) Veach, first space shuttle flight

Mission Specialist 5: Richard J. Hieb, first space shuttle flight

Ascent Seating:

Flight deck, front left seat, commander Michael L. Coats

Flight deck, front right seat, pilot L. Blaine Hammond, Jr.

Flight deck, aft center seat, mission specialist Donald R. McMonagle

Flight deck, aft right seat, mission specialist Gregory J. Harbaugh

Middeck, mission specialist Guion S. Bluford, Jr.

Middeck, mission specialist Charles L. (Lacy) Veach

Middeck, mission specialist Richard J. Hieb

Entry Seating:

Flight deck, aft center seat, Donald R. McMonagle

Flight deck, aft right seat, Charles L. (Lacy) Veach

Middeck, mission specialist Gregory J. Harbaugh

Middeck, mission specialist Guion S. Bluford, Jr.

Middeck, mission specialist Richard J. Hieb

Extravehicular Activity Crew Members, If Required:

Extravehicular (EV) astronaut-1 is Gregory J. Harbaugh; EV-2 is Donald R. McMonagle.

Intravehicular Astronaut: Guion S. Bluford

Entry: Automatic mode until subsonic, then control-stick steering

Notes:

- The flight crew is divided into a red team and blue team working 12-hour shifts followed by 12 hours off duty. This

allows for continuous payload operations 24 hours a day. The commander is not assigned to a team and is free to adjust his hours real-time as necessary.

- The red team consists of pilot L. Blaine Hammond, Jr.; and mission specialists Charles L. (Lacy) Veach and Richard J. Hieb. The blue team consists of mission specialists Gregory J. Harbaugh, Donald R. McMonagle, and Guion S. Bluford, Jr.
- The remote manipulator system is installed in Discovery's payload bay for this mission. The galley and the four-tier-bunk sleep stations are installed in Discovery's middeck.
- STS-39 marks the Discovery debut of new, upgraded general-purpose computers (IBM AP-101S) that are replacing the existing GPCs aboard the space shuttle orbiter fleet. The upgraded computers allow NASA to incorporate more capabilities into the orbiters and apply advanced computer technologies that were not available when the orbiter was first designed. The new computer design began in January 1984, whereas the older design began in January 1972. The set of five upgraded GPCs, plus a spare, provides 2.5 times the existing memory capacity and up to three times the existing processor speed with minimum impact on flight software. They are half the size, weigh approximately half as much, and require less power to operate. The central processor unit and the input/output processor, previously installed as two separate boxes, are now a single unit.

The new GPCs use the existing shuttle software with only subtle changes. However, the increases in memory and processing speed allow for future innovations in the shuttle's data processing system.

Although there is no real difference in the way the crew will operate with the new computers, the upgrade increases the reliability and efficiency in commanding the shuttle systems. The predicted "mean time between failures" (MTBF) for the advanced GPCs is 6,000 hours, and it is hoped to reach 10,000 hours. The MTBF for the original GPCs is 5,200 hours.

Specifications

Dimensions: 19.55 in. by 7.62 in. by 10.2 in.

Weight: 64 lb

Memory capacity: 262,000 words (32-bits each)

Processing rate: 1 million instructions per second

Power requirements: 550 watts

MISSION OBJECTIVES

- Primary Payloads
 - Infrared Background Signature Survey (IBSS)
 - Air Force Program (AFP)-675
- Secondary Payloads
 - Space Test Payload (STP)-1
- Multi-Purpose Experiment Canister (MPEC) deploy
- Cloud Logic To Optimize Use of Defense Systems (CLOUDS)-1A
- Radiation Monitoring Equipment (RME)-III
- Development Test Objectives (DTOs)/Detailed Supplementary Objectives (DSOs)

FLIGHT ACTIVITIES OVERVIEW

Flight Day 1

Red Team:

- Ku-band antenna deploy
- Priority Group B powerdown
- RMS powerup and checkout
- Aft controller checkout
- STP-I activation
- AFP-675 initialization and checkout
- RME-III activation
- IBSS checkout

Blue Team:

- AFP-675 operations

Flight Day 2

Red Team:

- AFP-675 operations

Blue Team:

- AFP-675 operations
- SPAS-II/IBSS predeploy checkout
- SPAS-II/IBSS grapple, unberth

Flight Day 3

Red Team:

- SPAS-II/IBSS release, attitude control checkout
- Separation to far field (10 km)
- OMS plume sequence 1
- Far-field station keeping
- IBSS operations: Earth scan, Earth limb, CO₂ Earth sweep

Blue Team:

- Far-field OMS plume sequences 2, 3

- Far-field primary RCS plume sequence
- IBSS experiment operations
- CRO C deploy
- Transition to near field (2 km)
- Near-field OMS plume sequences 4, 5

Flight Day 4

Red Team:

- Orbiter systems redundant component checkout
- IBSS experiment operations
- CIV operations
- Phase out to rendezvous initiation range
- CRO C observation
- CRO B deploy
- SPAS-II/IBSS rendezvous operations
- CRO B observation
- SPAS-II/IBSS capture

Blue Team:

- SPAS-II/IBSS berth
- Orbit adjust - CRO C avoidance
- STP-I operations
- AFP-675 operations

Flight Day 5

Red Team:

- AFP-675

Blue Team:

- AFP-675
- CRO A deploy

Flight Day 6

Red Team:

AFP-675
SPAS-II/IBSS predeploy checkout
SPAS-II/IBSS attached operations
CRO A observation
STP-1 operations

Blue Team:

SPAS-II/IBSS attached operations
CIV operations
Orbiter environment
SPAS-II/IBSS berth

Flight Day 7

Red Team:

SPAS-II/IBSS in-bay operations
AFP-675

Blue Team:

AFP-675

Flight Day 8

Red Team:

Flight control system checkout
AFP-675 operations
STP-1 dedicated operations

Blue Team:

STP-1 dedicated operations
AFP-675 deactivation
MPEC deploy
Cabin stow

Flight Day 9

Payload deactivation

Deorbit prep

Landing

Notes:

- Each flight day includes a number of scheduled housekeeping activities. These include inertial measurement unit alignment, supply water dump (as required), waste water dump (as required), fuel cell purge, Ku-band antenna cable repositioning, and a daily private medical conference.
- Due to power requirements and the length of the mission, an equipment powerdown (referred to as a Group B powerdown), is executed by the Red Team on Flight Day 1 to conserve cryogenics for a full mission duration plus two extension days (if required). Powerdown activities include powering off three of Discovery's four CRTs, placing three of Discovery's five general purpose computers on standby mode, placing one of Discovery's three inertial measurement units on standby mode, and powering off three of Discovery's eight flight-critical multiplexers (two forward, one aft).

STS-39 CREW ASSIGNMENTS

Commander (Michael L. Coats): Overall mission decisions; deploy, separation, and rendezvous; orbiter systems; detailed test objectives

Pilot (L. Blaine Hammond, Jr.): Orbiter systems, piloting tasks

Mission Specialist 1 (Gregory J. Harbaugh): IBSS, RMS

Mission Specialist 2 (Donald R. McMonagle): Orbiter systems, piloting tasks, RME-III

Mission Specialist 3 (Guion S. Bluford, Jr.): AFP-675, STP-I, MPEC

Mission Specialist 4 [Charles L. (Lacy) Veach]: AFP-675, CLOUDS-IA

Mission Specialist 5 (Richard J. Hieb): IBSS, RMS



STS-39 crewmembers (left to right): Charles L. (Lacy) Veach, Donald R. McMonagle, Gregory J. Harbaugh, Michael L. Coats, L. Blaine Hammond Jr., Richard J. Hieb and Guion S. Bluford Jr. Coats is mission commander; Hammond, pilot, and the others are mission specialists

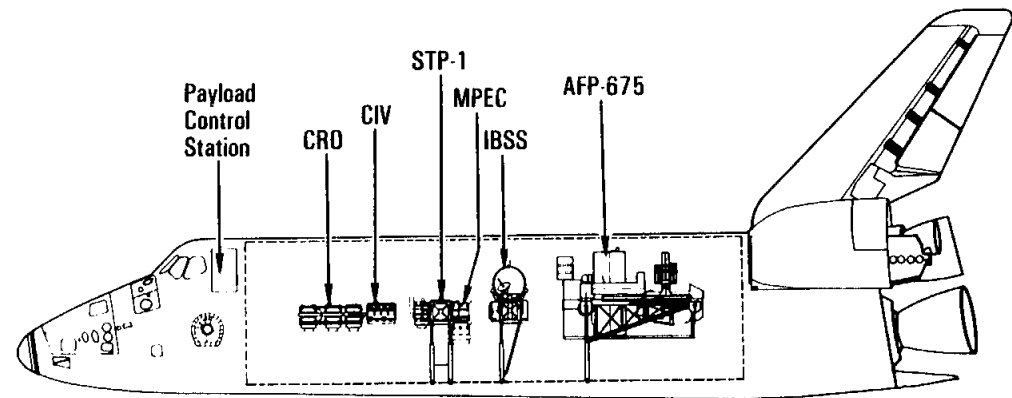
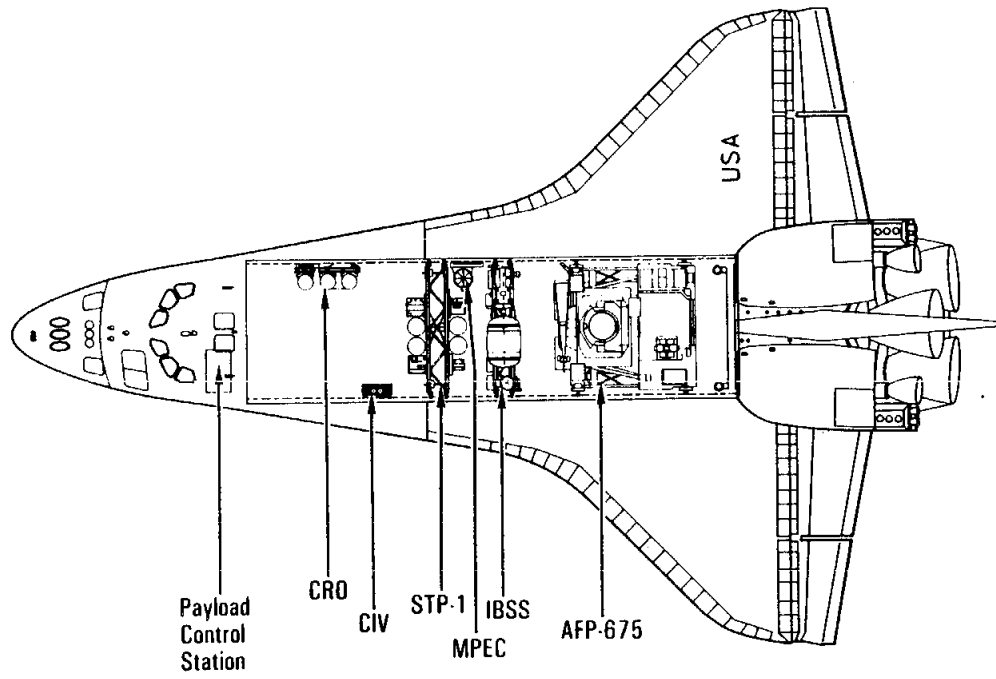
DEVELOPMENT TEST OBJECTIVES

- Entry aerodynamic control surfaces test, part 7 (performed only if reaction control system propellant is available)
- Ascent structural capability evaluation
- Ascent compartment venting evaluation
- Descent compartment venting evaluation
- Entry structural capability
- Vibration and acoustic evaluation
- Hot nosewheel steering runway evaluation
- Carbon brake systems test, condition 3
- Crosswind landing performance

DETAILED SUPPLEMENTARY OBJECTIVES

- Variations in supin and standing heart rate, blood pressure, and cardiac size as a function of space flight duration and time postflight
- In-flight aerobic exercise
- Changes in baroreceptor reflex function
- Blood pressure variability during space flight
- Orthostatic function during entry, landing, and egress
- Visual-vestibular integration as a function of adaptation
- Postural equilibrium control during entry, landing, and egress
- Lower body negative pressure following space flight
- Effects of space flight on aerobic and anaerobic metabolism during rest and exercise: the role of body composition
- Changes in the endocrine regulation of orthostatic tolerance following space flight
- Documentary television
- Documentary motion picture photography
- Documentary still photography

PAYLOAD CONFIGURATION



INFRARED BACKGROUND SIGNATURE SURVEY

The Infrared Background Signature Survey is a Strategic Defense Initiative Organization sponsored program whose objective is to obtain infrared, ultraviolet, and visible scientific data on natural and induced geophysical phenomena for use in the development of ballistic missile defense sensor systems. The payload is composed of three separate hardware elements: the Shuttle Pallet Satellite (SPAS)-II, the Critical Ionization Velocity (CIV) package, and the Chemical Release Observation (CRO) experiment.

The IBSS instruments will perform the following observations:

- Shuttle orbital maneuvering system (OMS) and primary reaction control system (PRCS) engine firing exhaust plumes (signatures are crucial to the validation of plume models)
- The Earth and its backgrounds, including Earth limb, Earth scan, and auroras (backgrounds produced by atmospheric chemical processes must be characterized)
- Contaminant environment surrounding the orbiter (backgrounds produced by spacecraft contaminants affect sensor performance, and spacecraft contaminants deposited on sensor components reduce sensitivity)
- Chemicals and gasses released from subsatellites and systems mounted in the shuttle payload bay (vehicle identification may be enhanced by chemical release observations, while plume signature enhancement may result from gaseous molecules that are ionized as they travel through magnetic plasmas)

- Celestial calibration sources (measure signature of resident space objects)

Data collected from these observations will be used to confirm existing models.

The nominal IBSS/SPAS-II deploy opportunity is on Orbit 31 with a backup opportunity on Orbit 32. Nominal retrieve is planned for Orbit 56 with a backup on Orbit 57.

IBSS is sponsored by the SDIO, which also manages the overall program. Supporting SDIO in program management are several systems engineering and technical analysis firms, including Stears, Kiya, and Wright, Arlington, Va.; Orbital Systems Limited, Lanham, Md.; Nichols Research Corp., Vienna, Va.; and Hernandez Engineering, Inc., Houston, Texas. Integration of the payload and operations with the shuttle are the responsibility of the U.S. Air Force Headquarters Space Systems Division, Los Angeles Air Force Base, Calif.; The Aerospace Corporation, Los Angeles, Calif.; Federal Electric Corporation, Vandenberg Air Force Base, Calif.; Rockwell International Space Systems Division, Downey, Calif.; and the 6595th Test and Evaluation Group/DTR and Western Test Range, Vandenberg Air Force Base, Calif. The CIV package is managed by Phillips Laboratory's Geophysics Directorate, Space Physics Division, Hanscom Air Force Base, Mass. The CRO experiment is managed by the Phillips Laboratory's West Coast office, Los Angeles Air Force Base, Calif.

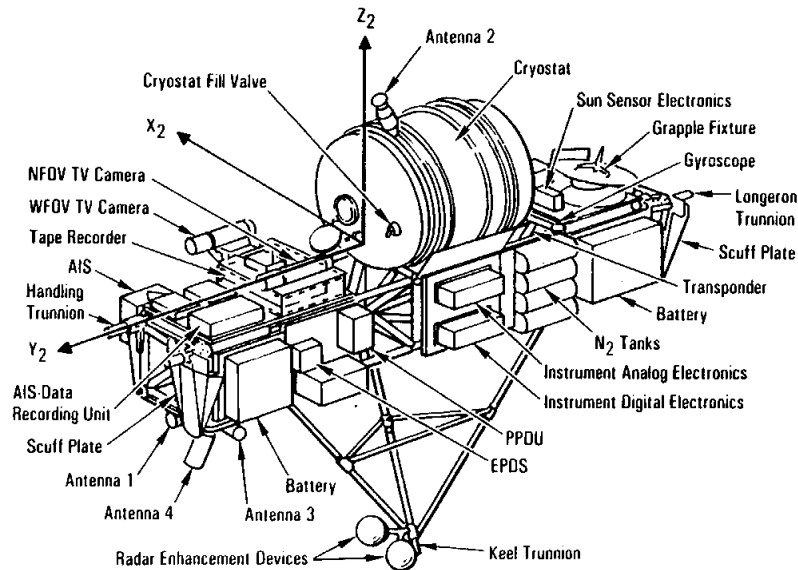
Other IBSS participants include the following:

| Component | Company | Country |
|---|---|----------------|
| Prime contractor/integrator, SPAS-II | Messerschmitt-Bolkow-Blohm | Germany |
| Cryostat | Linde | Germany |
| Infrared sensor | Kayser-Threde | Germany |
| Drive motors | University of Berlin | Germany |
| Radiometer detectors—prime | AEG Telefunken | Germany |
| Radiometer filters | Optical Coatings Lab, Inc. | U.K. |
| Spectrometer detectors—prime | Aerojet | U.S. |
| Spectrometer and radiometer detectors | Santa Barbara Research Center | U.S. |
| Spectrometer grating | Bausch & Lomb | U.S. |
| Mirrors | Sensor System Group | U.S. |
| Internal source | Infrared Laboratory, Inc. | U.S. |
| Tuning fork chopper | Frequency Control Products | U.S. |
| Arizona Imager/Spectrograph | University of Arizona | U.S. |
| Portable calibration source | Utah State University | U.S. |
| CRO satellites | Defense Systems, Inc. | U.S. |
| CRO launcher cylinders/support beams | NASA Goddard Space Flight Center | U.S. |
| CRO aircraft sensor platform operations (HALO aircraft) | Phillips Laboratory | U.S. |
| | Weapons Directorate and 4950th Test Group | |
| CRO aircraft sensor platform operations support | BDM Corp. | U.S. |
| | Aeromet Inc. | U.S. |
| | Automated Sciences Group, Inc. | U.S. |
| CIV gas release system/system integration | Physical Sciences, Inc. | U.S. |
| CIV payload support system manufacturer | Northeastern University | U.S. |
| CIV general mechanical manufacturing | Wentworth Institute of Technology | U.S. |
| CIV pressure gauge subsystem | John Hopkins University | U.S. |
| CIV radiometer subsystem | Research Science, Inc. | U.S. |
| CIV Langmuir probe | University of Iowa | U.S. |

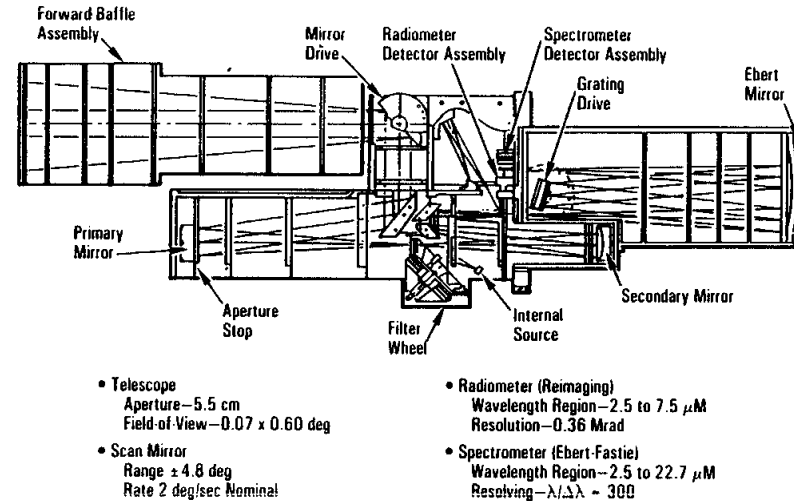
SPAS-II

The Shuttle Pallet Satellite-II element incorporates a cryogenically cooled (liquid helium) infrared radiometer and spectrometer, the Arizona Imager/Spectrograph (AIS) multispectral (ultraviolet to infrared) sensor, two low light level television cameras, and various support subsystems on a modular graphite-epoxy pallet. Observations are planned to be conducted with the SPAS-II deployed, on the remote manipulator system (RMS), and in the payload bay. SPAS-II will be deployed and later retrieved from the orbiter using the RMS and will maneuver at ranges of up to 20 km from the orbiter to gather data. SPAS-II has an active control system for pointing and attitude control during deployed operations and can be commanded by the on-board crew or by the ground. Precision control of the SPAS-II by the crew—involving over 250 separate commands—is required for successful experiment observations.

The SPAS-II pallet is an improved version of the SPAS-I pallet that previously flew aboard Challenger on STS-7 in 1983 and on STS-41B in 1984.



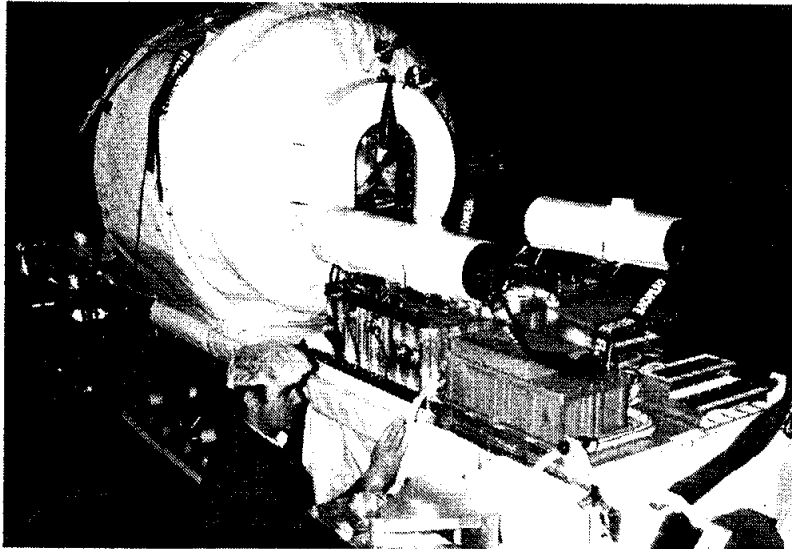
SPAS-II/IBSS Spacecraft



IBSS Sensor

SPAS-II sensors will gather spectral, spatial and temporal radiometric data on the optical signature of orbiter OMS and PRCS exhaust plume firings in the appropriate regions of the infrared, ultraviolet, and visible spectrums. These plumes resemble those produced by systems of interest. Interaction of the outer plume regions with the atmosphere will be characterized, as well as the region of the orbiter near the exit nozzle.

SPAS-II will also be used to characterize the Earth background from the Earth limb to the hard Earth, and in areas around the solar specular point. Measurements will consist of Earth limb and Earth scan observations with SPAS-II deployed, auroral observations with SPAS-II on the RMS, and AIS Earth limb observations from the payload bay. Radiometric spatial, spectral, and temporal data from these observations will be used to establish the background against which approaching ICBMs would be viewed by a sensor system as they came over the horizon. Measurements will be taken of the Earth's surface under various conditions of light and darkness, hard Earth and water, and clouds and cloudlessness. The Earth scan observations include observations of spatial clutter in carbon dioxide bands, observations of areas around the solar specular point, the terminator, and limb-to-Earth scans. The Earth limb observations

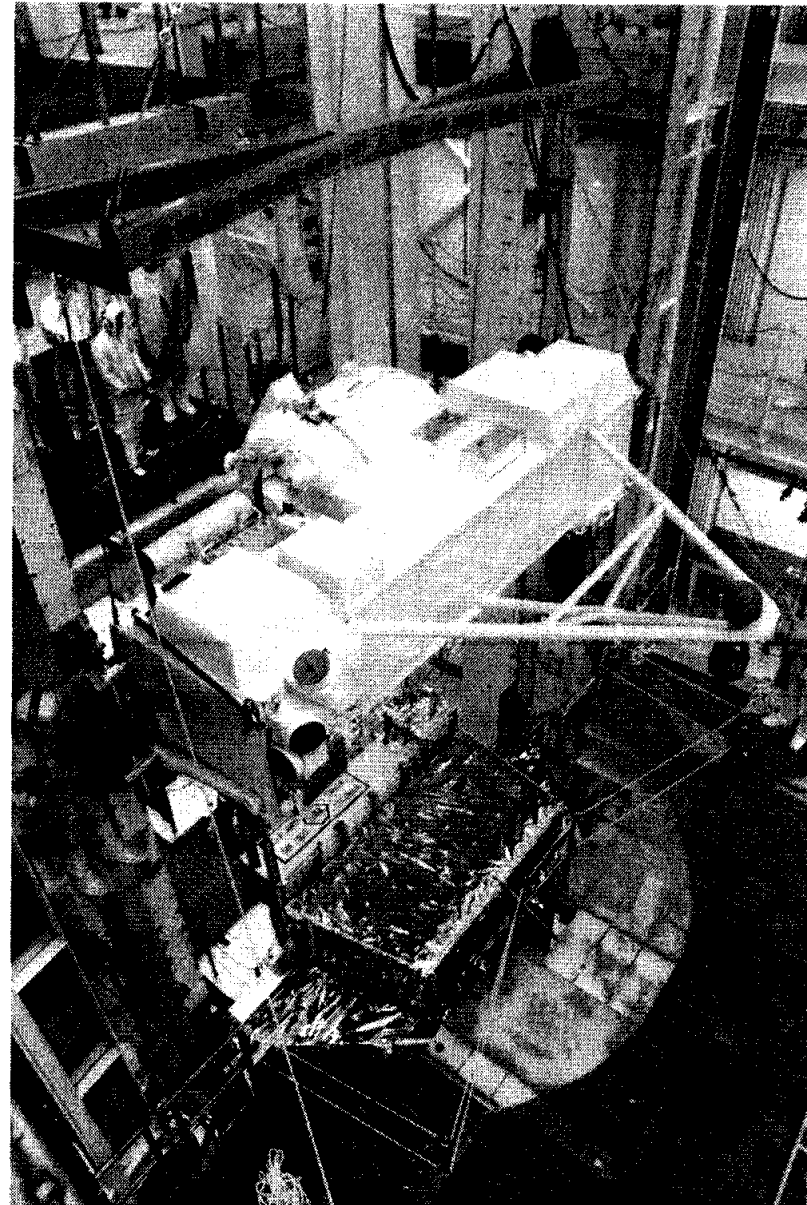


Shuttle Pallet Satellite (SPAS)-II

will include day, night, and terminator views. Auroral emissions (Northern and Southern Lights) will also be measured, as available.

Finally, to characterize the effects of contaminating materials coming from a sensor platform itself, the environment around the orbiter payload bay will be measured by the SPAS-II/IBSS infrared sensor and AIS sensors, "parked" nearby. These measurements will be taken with the orbiter in a "quiet" state, as well as during fuel cell purges, water dumps, thruster firings, and other contaminating events. Observations will be in the infrared, visible, and ultraviolet regions of the electromagnetic spectrum.

The "orbiter glow" phenomenon will also be studied. This phenomenon occurs where the rarified atmosphere strikes orbiter surfaces, especially the tail, causing visible and infrared radiance. The glow is thought to be caused by some type of interaction between the ambient atmosphere and the spacecraft surface, although sufficient data does not exist to fully understand the process. A number of possible mechanisms have been proposed,



Infrared Background Signature Survey (IBSS) Shuttle Pallet Satellite (SPAS)-II

including gas phase collisions, surface-aided chemiluminescence reactions with adsorbates on orbiter surfaces, and surface reactions with the atomic oxygen environment leading to material loss or compositional changes. The spectrum of the glow is relatively diffuse and based primarily in the red-infrared region. The glow intensity is dependent upon the surface orientation to the velocity vector. The glow intensity seems to vary as a function of the atomic oxygen density and the type of material.

Multispectral signatures will be characterized in order to understand this contaminant environment and the atmospheres expected to surround future SDI orbiting space-based sensor system platforms or target vehicles.

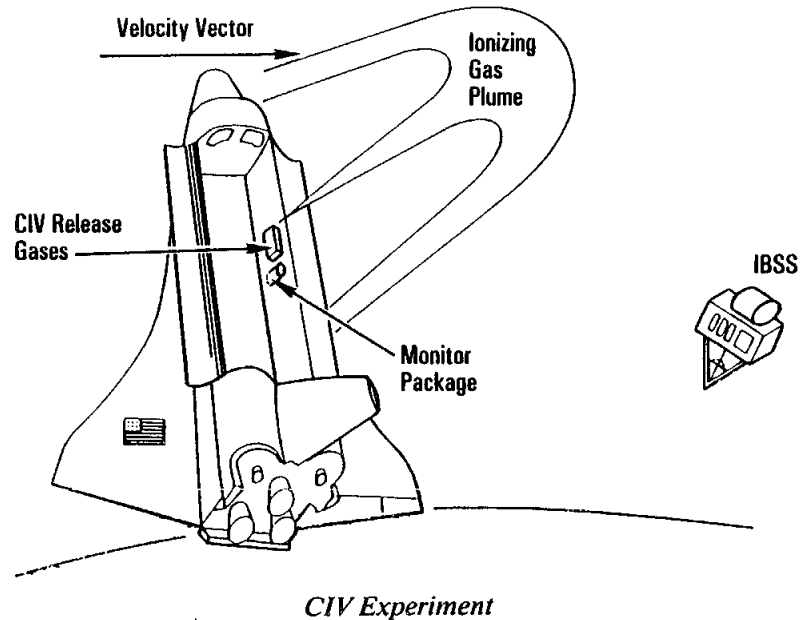
CIV

The Critical Ionization Velocity experiment will investigate the interaction of neutral gas molecules, such as those present in rocket combustion products, with the ambient weakly-magnetized plasma. The experiment is intended to provide on-orbit spectral data to examine a theory that holds that many neutral gaseous molecules will be ionized when they travel through a magnetized plasma at velocities such that their kinetic energy exceeds their ionization potential. Ions so created would then flow along the local magnetic lines of force and generate emissions that can be detected by spaceborne sensors, thereby permitting tracking of the vehicle releasing the gases. If this theory is correct, such ionization could provide additional observables on objects of interest.

Two mechanisms are responsible for ionization:

- Kinetic energy of a gas exceeds its ionization potential due to its relative velocity with the ambient plasma. The resulting plasma instability is expected to enhance ionization.
- Charge exchange between the gases released and ambient ions (mainly oxygen)

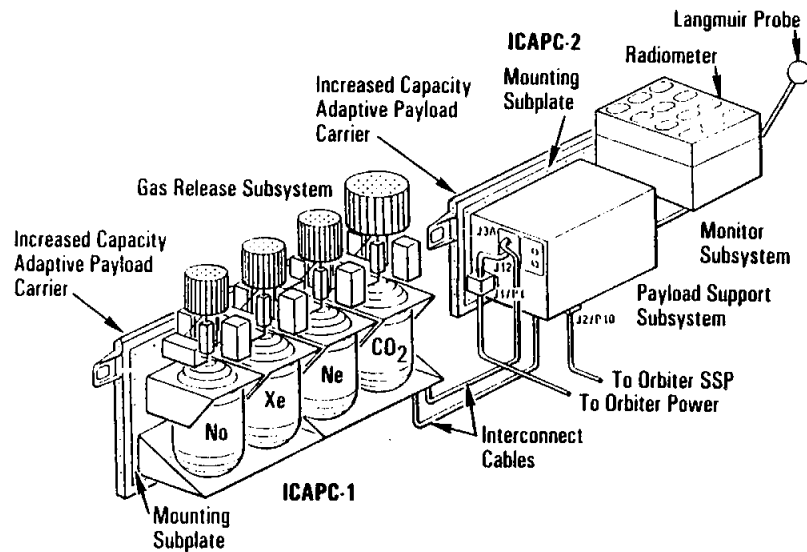
The CIV experiment includes four compressed gas canisters loaded with different gases (xenon, neon, carbon dioxide, and



nitrous oxide). The canisters are located in the forward port side of Discovery's payload bay and remain attached to the orbiter.

Upon crew command, plumes of gas will be released out of the orbiter payload bay. The SPAS-II, "parked" about 2 km away, will take infrared, visible, and ultraviolet radiometric spatial, spectral, and temporal measurements of the gas plumes. A CIV data acquisition package mounted in the payload bay as part of the CIV payload element will also record visible and ultraviolet data. A Langmuir probe will measure the ambient electron density and temperature. The CIV hardware weighs approximately 500 pounds.

Gases under pressure will be ejected at different angles to the orbital velocity (such that collisions with the thin orbital atmosphere will enhance ionization) and to the local magnetic field lines. The gases have been selected and the release mechanism designed so that the critical ionization velocity should be reached for three of the four gases when they are released into the RAM direction. Because the orientation and strength of the local magnetic field is expected to affect the intensity of the



CIV Experiment

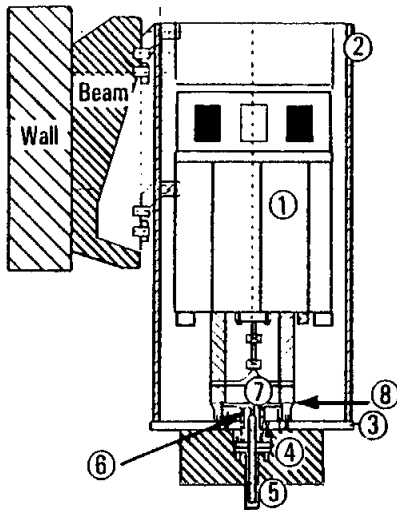
ionization phenomenon, the gas releases will be observed with the local magnetic field approximately parallel to RAM and perpendicular to RAM. The effect of ambient electron density on the phenomenon will be observed by repeating the observations in both the daylight and darkness.

CRO

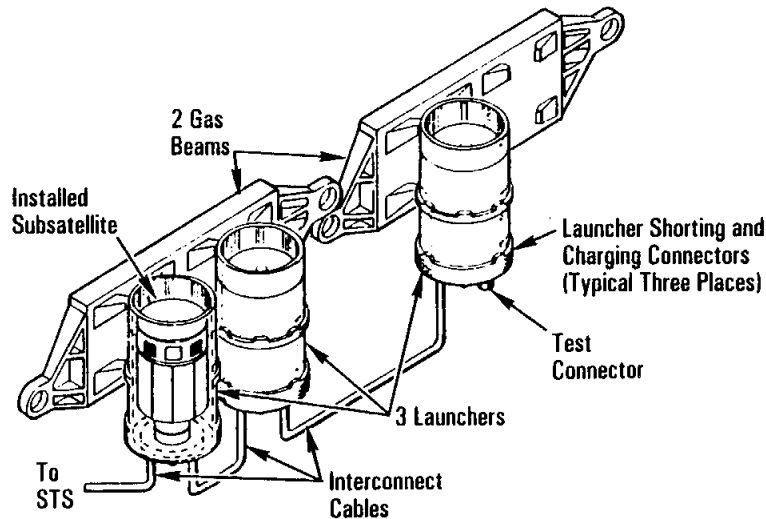
The Chemical Release Observation portion of the IBSS mission is an experiment designed to collect infrared, visible, and ultraviolet time-resolved radiometric data associated with chemicals that may be released by vehicles of interest in near-Earth orbit as obscurants. Such data may help to identify these vehicles. The experiment is located in the forward starboard side of Discovery's payload bay and consists of three separate subsatellites and their launchers. The CRO hardware weighs approximately 900 pounds. The subsatellites will be deployed and will release chemicals upon ground command for two deployed and one RMS SPAS-II observations. Simultaneous observations will be made from the SPAS-II sensors, ground sensors at VAFB,



Chemical Release Observation (CRO) Experiment



1. Satellite
2. Launcher Canister
3. Base Plate
4. Electronics
5. Guide Rod
6. Spring
7. Pusher Plate
8. V Band and Retention Springs



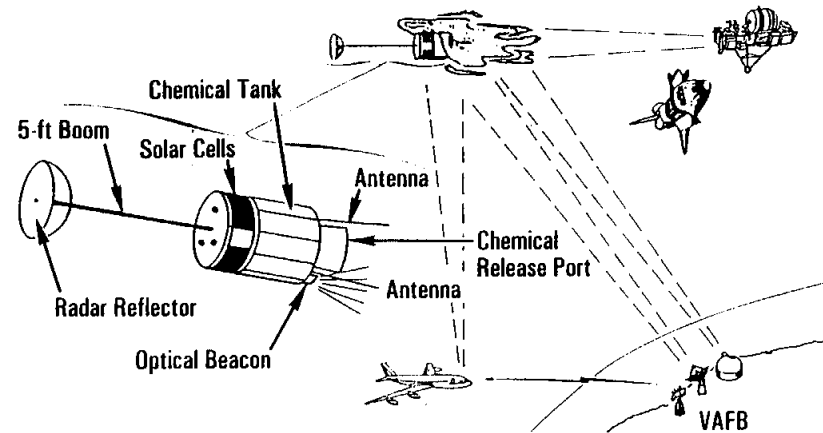
Chemical Release Observation Experiment

and airborne sensors to take spectral, spatial, and temporal measurements of the chemical cloud. Spectral information will permit characterization of the chemical interactions with the atmosphere and solar energy, and determine the aerosol distribution of the chemicals with respect to particle size and

expansion rate. Each subsatellite is loaded with a different chemical: 15 pounds of nitrogen tetroxide (CRO C), 52 pounds of unsymmetrical dimethyl hydrazine (CRO B), and 60 pounds of monomethyl hydrazine (CRO A), released in that order. The selected chemicals are representative of potential obscurants. Data from these observations will assist SDIO in characterizing the signatures expected from liquid fuel clouds escaping from damaged ICBM boosters.

Since the three chemical releases will produce short-lived clouds of vapor and frozen particles in orbit near the shuttle, it is possible that a faint glow of visible light may occur due to the interaction of the vapor cloud with oxygen atoms in the upper atmosphere. It is not expected, however, that the vapor glow from any of the releases will be bright enough to be detected by the unaided eye on the ground. The chances of observers near Vandenberg Air Force Base seeing the first and only nighttime scheduled release experiment are very remote.

The cloud of frozen particles, however, can scatter sunlight, producing visible light with much greater intensity. The sunlight scattered from the particle cloud will not be as intense as the daytime sky, however, so it is unlikely that the releases can be viewed from the ground if they occur in sunlight. Should the first



Chemical Release Observation

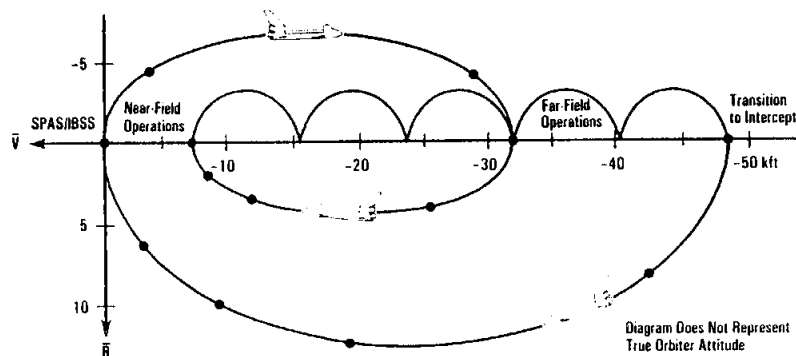
scheduled release occur under predawn twilight conditions on the West Coast, optimal viewing conditions would exist, as the release would occur in sunlight while a West Coast observer would be in darkness. Under these conditions, the release would initially appear as a disk of white light approximately the size of the full moon, although somewhat dimmer. The cloud will continue to grow and gradually dim after the flow of liquid ends. The remnants of the bright cloud will last only a few minutes.

STS-39 SPAS-II/IBSS RENDEZVOUS AND TRACKING OPERATIONS

STS-39 rendezvous and tracking maneuvers in support of IBSS operations present a number of significant challenges to space shuttle mission operations. More than 60 orbiter maneuvers are planned to support the various phases of SPAS-II/IBSS rendezvous, including IBSS calibrations, deployment, separation, far-field observations, near-field observations, CRO subsatellite deployments and observations, SPAS-II retrieval, and berthing.

Separation to Far-Field

Following deployment of the SPAS-II/IBSS imaging platform, the crew will perform an acceleration, or posigrade burn, firing Discovery's reaction control system (RCS) thrusters to raise its orbit above the SPAS-II. This maneuver will drift Discovery to a point about 10 km behind the SPAS-II, the required distance for



SPAS-II/IBSS Rendezvous and Tracking Operations

far-field observations. Arriving at that point one orbit after the separation burn, the crew will fire the RCS to brake Discovery and place it again in the same orbit with the SPAS-II. Deployment and separation are scheduled to occur while both crew shifts are awake.

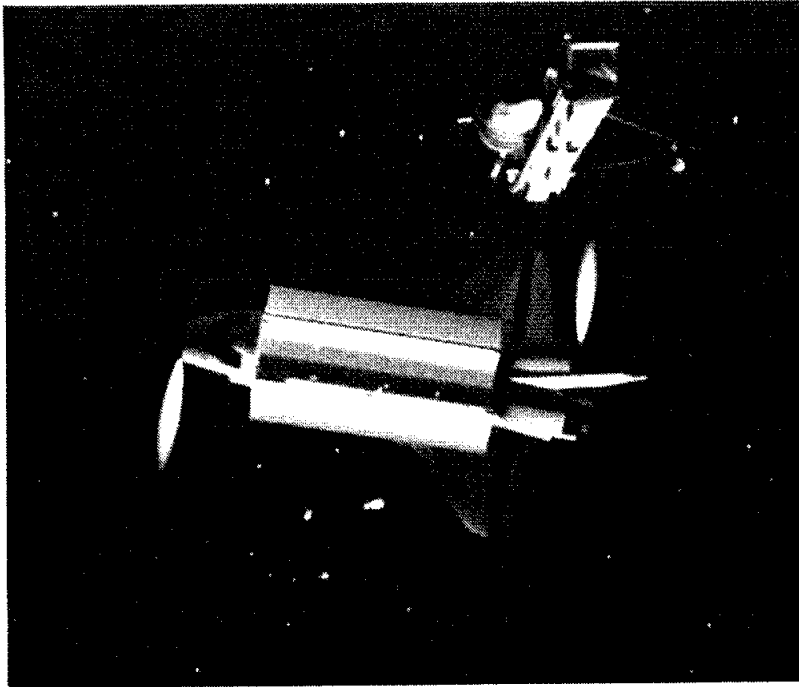
Far-Field Operations

Following a crew shift handover, at the far-field position, the Red Team will maneuver Discovery to point its nose north, with the payload bay pointed in the direction of orbital travel—toward SPAS-II, 10 km ahead.

OMS Plume Observation

From this position, the crew will remotely command the SPAS-II/IBSS to point its imaging systems at Discovery for the first plume observation. Once the experiments are properly trained on Discovery, one OMS engine will be fired for 20 seconds. The result of the burn will be to propel Discovery north, off of its previous orbital groundtrack, without changing the spacecraft's altitude. A burn with this lateral effect is known as "out-of-plane." In order to set up the next observation and remain aligned with the SPAS-II for precise rendezvous maneuvers, immediately following the burn, the crew will perform a "fast-flip" yaw maneuver, using RCS jets to turn Discovery's nose around 180 degrees to the south. A single-engine OMS braking burn will then be performed to stop Discovery's travel at a point less than a mile north of its previous groundtrack. Using RCS jets, the crew will return Discovery to its starting position, on its original groundtrack behind the SPAS-II. As Discovery drifts back to the starting point, a "fast-flip" reversal will turn the spacecraft's nose back to the north. This unique series of multiple OMS and RCS maneuvers has been dubbed the "Malarkey Milkshake" in recognition of John Malarkey, the JSC rendezvous guidance team leader who developed the back-and-forth sequence. Throughout this sequence, the crew will point the SPAS-II/IBSS by remote control to record data on the engine plumes.

Far-field observations will continue following the Blue Team's sleep shift. Due to the complexities involved, all OMS burns will



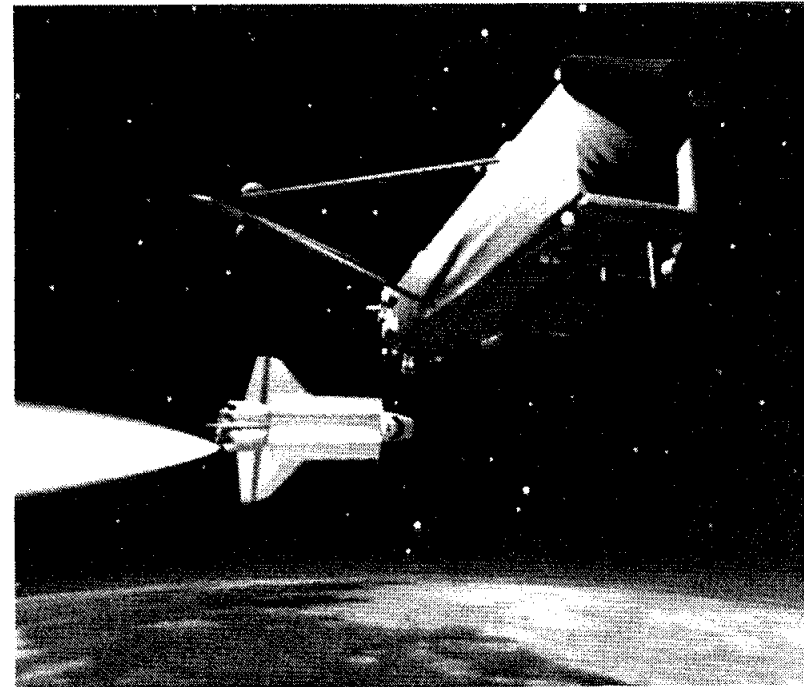
SPAS-II/IBSS Observation of Orbital Maneuvering System/Primary Reaction Control System Plume Firings

be conducted only when both crew shifts are awake and able to participate.

Discovery will remain at the far-field position during the Blue Team's sleep, and the Red Team will continue SPAS-II/IBSS operations, conducting Earth limb observations by remote control.

Following the Blue Team's sleep shift, while both teams are awake, the same sequence of maneuvers will be repeated twice in support of two additional plume observations.

The single-engine OMS firings for these observations represent the first time such firings have been attempted in space by the orbiter.



SPAS-II/IBSS Observation of Single-Engine Orbital Maneuvering System Plume Firings

PRCS Plume Observation

The final IBSS objective at the far-field position will be to observe Discovery's primary RCS jets firing. In the same attitude used for OMS plume observations, the crew will again align SPAS-II/IBSS to train its optics on the vehicle and then ignite one of the PRCS thrusters for 25 seconds.

Far-Field CRO Release

After the far-field plume observations have been completed, and while the Red Team sleeps, the Blue Team will eject the first CRO canister from the payload bay, at a rate of 3.5 feet per second (fps) and allow it to separate until the subsatellite trails the SPAS-II by 50 to 200 km in orbit.

Release will be timed so that the CRO subsatellite will pass over Vandenberg Air Force Base (VAFB), Calif. Just after it is ejected from the payload bay, antennae on the canister will deploy, providing a remote command link to investigators at VAFB. The canister will drift during several orbits to the desired distance for IBSS imaging. After a ground CRO team at VAFB has determined the health and status of the subsatellite, VAFB investigators will remotely command the canister to release a stream of chemical that will quickly vaporize into a cloud. CRO chemical releases and observations will begin after near-field operations have been completed.

Transition to Near-Field

To reach the near-field observations position, the crew will perform a slowing, or retrograde, RCS burn to slightly lower Discovery's orbit. The effect of the burn, over the next orbit, will move Discovery to within approximately one and one-half statute miles behind the SPAS-II. As Discovery approaches that point, another RCS burn will brake the orbiter, placing it directly behind SPAS-II on the same orbital path, approximately 2 km behind.

Near-Field Operations: OMS Plume Observations

At the near-field position, with both crew teams awake, Discovery will again be maneuvered to the "nose-north" start attitude that was used for far-field observations. The same out-of-plane OMS burn sequence will be repeated twice for near-field plume observations. The crew will continue to point the SPAS-II/IBSS imaging systems by remote control to set up and record each observation.

Near-Field Operations: CIV Observations

Before leaving the near-field position, the crew will train SPAS-II/IBSS imaging systems on Discovery's payload bay to observe and document a sequence of gas releases from CIV canisters mounted in the bay.

CRO Observations

Following completion of near-field operations, while the Blue Team sleeps, the Red Team will conduct a series of maneuvers to set up IBSS imaging and tracking of the CRO chemical-release canisters ejected from Discovery's payload bay.

A combination burn, both posigrade and out-of-plane, will be made to further separate Discovery from the SPAS-II and avoid obscuring its view of the already deployed canister. The posigrade component of the RCS burn will provide for a slow separation from the SPAS-II, over seven and a half hours and five orbits, to a distance of approximately 14.5 km behind SPAS-II for the start of retrieval operations. The lateral component will move Discovery off of the direct track between SPAS-II and the CRO canister so it will not block the line of sight of the SPAS-II imaging experiments.

During this five-orbit separation phase, the crew will remotely command the SPAS-II/IBSS to track and observe the first CRO canister as VAFB ground controllers remotely command the chemical release.

Following completion of the first CRO observation, the crew will perform an RCS burn to move Discovery back into alignment with the flight path of the SPAS-II, but continuing to separate. The crew will then eject a second canister, and command the SPAS-II/IBSS to track and observe another ground-commanded chemical release.

SPAS/IBSS Retrieval

After separating to more than 14.5 km, and with both crew shifts awake again, a retrograde burn will slightly lower Discovery's orbit to overtake the SPAS-II/IBSS. Several course adjustment burns may be conducted as Discovery nears its target, in order to arrive directly in front of the SPAS-II, on the same flight path. The crew will then manually maneuver Discovery to within range of the remote manipulator system for capture.

AIR FORCE PROGRAM 675

Air Force Program (AFP)-675 is a Department of Defense-sponsored collection of experiments whose objective is to gather data on the Earth's atmosphere (aurora, Earth limb, and airglow), celestial objects, and the environment in and around the shuttle payload bay. Infrared, ultraviolet, X-ray, and contamination data will be collected during the mission. Data will be used in the development of sensors used to detect targets of interest.

The AFP-675 payload is approximately 15 feet long, 15 feet wide, and 15 feet high and will occupy a shuttle payload bay length of approximately 17 feet. It weighs approximately 10,400 pounds. It is mounted in the aft-most quarter of the shuttle payload bay via four longeron trunnions and a keel fitting.

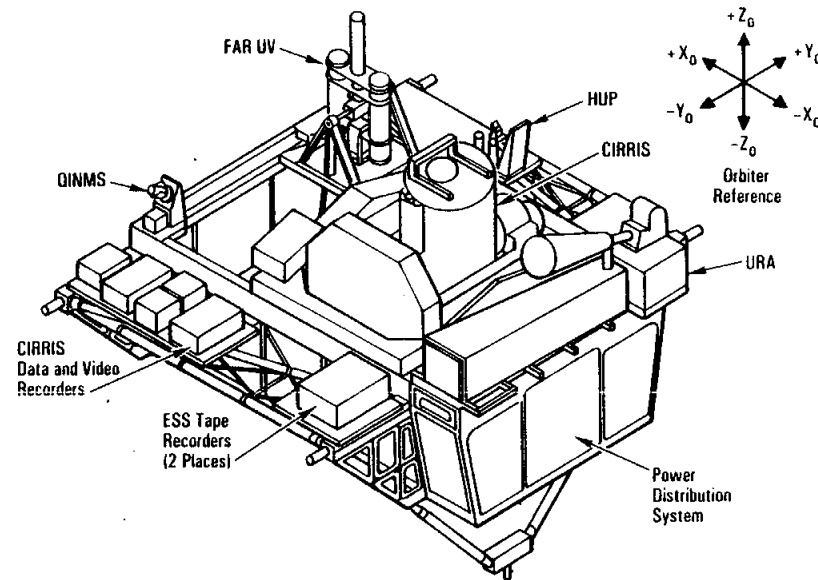
AFP-675 will require precision attitude control using Discovery as the course pointing system. Innovative uses of the shuttle communications network will provide unique insight on the ground for DOD investigators in the Mission Control Center.

AFP-675 consists of five experiments:

- Cryogenic Infrared Radiance Instrumentation for Shuttle (CIRRIS)-1A
- Far Ultraviolet Camera (FAR UV) Experiment
- Horizon Ultraviolet Program (HUP)
- Quadrupole Ion Neutral Mass Spectrometer (QINMS)
- Uniformly Redundant Array (URA)

EXPERIMENT SUPPORT SYSTEM (ESS) PALLET

The experiments are integrated into a non-deployable experiment support system (ESS) pallet and will remain within the payload bay throughout the mission. The pallet provides the



AFP-675 Configuration

mechanical support for the experiments and is the interface between the shuttle and the experiments for electrical power and avionics. The ESS pallet is comprised of the power distribution subsystem, command and data handling subsystem, command and telemetry units, and data tape recorders. AFP-675 is a unique demonstration of the ability to command, control, and evaluate a system of experiments without ground commands or telemetry data. Voice will be included on this mission for communication between the crew and the ground to discuss the experiments.

The pallet and its instruments are operated by the flight crew via input to a computer called the command and monitor panel (CMP) located in the orbiter crew cabin aft flight deck payload station. The CMP issues all commands to, monitors the health of, and receives data from the payload. The NASA mission specialist (MS) operates the payload element from the CMP using

procedures developed prior to the flight. A backup or spare CMP is located in the aft flight deck in the event the primary CMP requires changeout.

The CIRRIS-1A and FAR UV experiment sensors are gimbaled so that they can rotate in pitch (forward and aft) and in roll (left and right). The gimbals movements of both experiments are controlled by inputs from the mission specialists using manual pointing controllers (MPCs). In addition, the CIRRIS-1A experiment gimbal can be controlled by preprogrammed commands originating from the CMP. There is an MPC for each of the two gimbaled experiments and a separate connector on the face of the CMP for each of them. The CIRRIS-1A and FAR UV experiments contain low light level television cameras with their images displayed on the orbiter closed-circuit television monitors. The mission specialists will use these images when using the MPCs to point the experiments at specific targets. These images can also be recorded on the orbiter video recorders or downlinked to the POCC.

ESS tape recorders will record data throughout the flight. AFP-675 is essentially an autonomous payload with all commanding performed on board and all science data stored on the pallet tape recorders for postflight processing and evaluation.

AFP-675 is sponsored by the U.S. Air Force Systems Command's Space Systems Division. It is managed by the Space Test and Transportation Directorate of the U.S. Air Force Space Systems Division, Los Angeles Air Force Base, Calif. Lockheed Missiles and Space Company, Sunnyvale, Calif., developed the ESS pallet and CMP system, and is under contract to SSD for the integration of the experiments onto the ESS pallet and for the integration of the AFP-675 with the shuttle. Experiments are sponsored by the Phillips Laboratory's Geophysics Directorate, the Naval Research Laboratory, and the Los Alamos National Laboratory.

CIRRIS-1A

Cryogenic Infrared Radiance Instrumentation for Shuttle is the primary experiment on the AFP-675 payload. The experiment

operates in the infrared portion of the electromagnetic spectrum and is designed to observe the Earth's atmospheric limb and auroras. The primary objective is to obtain simultaneous spectral and spatial measurements of infrared atmospheric emissions over an altitude range of 30 to 300 km.

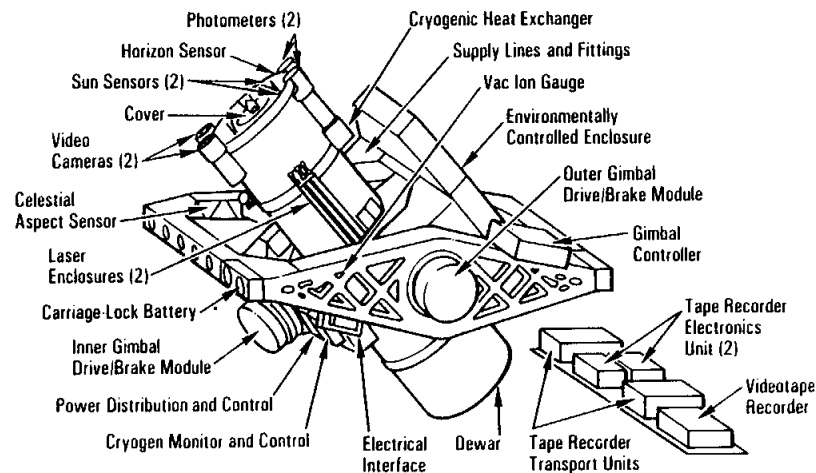
Data from this mission should help answer questions regarding the optimum atmospheric windows for detecting cold body targets, the background radiance levels in various regions, the spatial structure (clutter) of the background, and the variability of Earth limb emissions during day/night airglow and auroral events. CIRRIS-1A will provide the first comprehensive infrared global data base for the development of next-generation sensor systems.

One of the primary mission objectives is to measure the spectral and spatial characteristics of auroral emissions. Auroras are created by solar activity. When a solar flare, sun spot, or coronal hole occurs within a particular area of the sun's disk, an increased number of energetic particles are directed toward the Earth. As the solar wind accelerates with the Earth's magnetosphere, a generator effect is produced, accelerating electrons down the Earth's magnetic field lines. As these electrons impinge upon the Earth's atmosphere, oxygen and nitrogen are excited and ionized, producing aurorae. Aurorae emit visible, ultraviolet, infrared, and radio frequencies. Because the electrons precipitate down the geomagnetic field lines, aurorae are produced in an oval-shaped zone roughly centered around the magnetic pole regions of the north and south pole. The shape and size of the oval are dependent upon the intensity of the solar wind. The intensity of the aurora within the oval is variable.

The two primary indicators for predicting when an active aurora might appear are solar activity and geomagnetic disturbance. These events will both be monitored during the mission. The pre-midnight/midnight sector of the Northern and Southern auroral oval is expected to exhibit the most intense infrared emissions and is therefore of particular interest. An auroral watch will be maintained by a network of ground personnel to monitor the level of auroral activity. In the event of an intense auroral display, this team would alert the orbiter crew of the location and intensity of the aurora.

CIRRIS-1A consists of eight sensors: an interferometer, radiometer, two photometers, two low light level TVs (LLLTV), a celestial aspect sensor, and a horizon sensor. These sensors are mounted to a two-axis gimbaling platform that is attached to the ESS. The instrument can gimbal 28 degrees forward, 9 degrees aft, and plus or minus 41 degrees side-to-side. Telemetry will be recorded on CIRRIS-1A dedicated tape and video recorders located on the ESS. The experiment is designed to be operated by the orbiter crew from a command panel in the aft flight deck.

The interferometer and radiometer are the primary sensors for CIRRIS-1A. The interferometer will be used to locate spectral windows, while the radiometer will serve to measure the spatial structure (clutter) of the background. Both are contained in a cryogenically cooled (liquid helium) housing and share common collecting optics. The two photometers support the main sensors by detecting radiation at two independent levels. One photometer acts as an airglow and aurora monitor; the other acts as an aurora monitor as well, but also provides quick diagnosis for atmospheric energy disposition. Both photometers incorporate sun sensors to warn the mission specialist via a CMP alarm that the sun is within 20 degrees halfcone of CIRRIS-1A line-of-sight (LOS).



CIRRIS-1A Experiment Configuration

The two LLLTVs (one with a wide field of view and the other with a narrow field of view) aid the crew in real-time pointing of CIRRIS-1A using the manual pointing controller (MPC) on the CMP. The LLLTV image will be displayed on one of the three closed circuit TVs in the aft flight deck of the orbiter and will be recorded on an onboard videotape recorder.

The celestial aspect sensor is a 16mm camera, oriented 45 degrees from CIRRIS-1A centerline field of view. This orientation enables the sensor to record starfields for postflight determination of the precise direction that the main sensors were pointing.

The horizon sensor detects 15-micron emissions from the Earth's 40 km height carbon dioxide layer. This layer serves as a reference to sense pitch and roll data to the crew. In addition, this information is provided to the CIRRIS-1A gimbal controller, which maintains a constant pitch angle with respect to the horizon.

Gravity gradient is the primary attitude for CIRRIS-1A data collection. It is the only attitude the orbiter can maintain without the use of the reaction control system, which produces unacceptable contaminates.

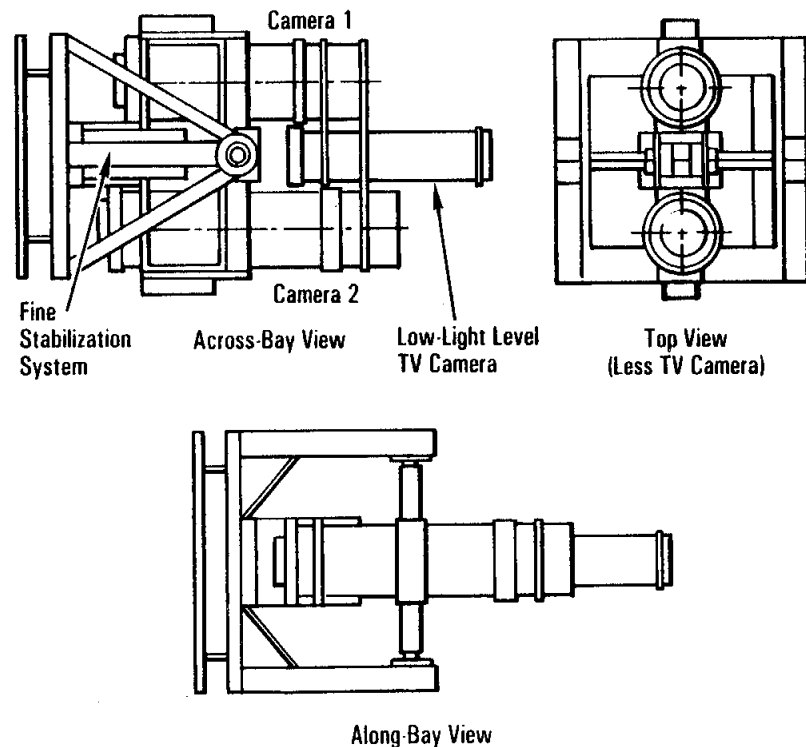
CIRRIS-1A is sponsored by the SDIO. Phillips Laboratory's Geophysics Directorate, Hanscom Air Force Base, Mass., is responsible for the program. The sensor prime contractor is the Space Dynamics Laboratory of Utah State University, Logan, Utah. Major subcontractors include Space Data Corp., Sensor System Group, and Boston College.

FAR UV EXPERIMENT

The Far Ultraviolet experiment is a camera system that observes natural and man-made emission phenomena in near-Earth space in the far ultraviolet spectrum (1050-1600 and 1230-2000 angstrom wavelength ranges). Phenomena to be observed include day and night airglow, auroras, and the ultraviolet emissions associated with the environment around the shuttle (OMS/PRCS thruster plumes and surface glow effects). Secondary interests are shuttle contamination effects such as fuel

cell purges, flash evaporator events, and water dumps. The experiment will also make observations of interplanetary and interstellar media, stars, extragalactic objects, effects of chemical deposition, and atmospheric density measurements by stellar occultations.

The FAR UV experiment consists of two electrographic Schmidt cameras and a low light level TV camera mounted on a two-axis gimbaling platform that is attached to the ESS pallet. The instrument can gimbal plus or minus 80 degrees forward-and-aft, and plus or minus 22 degrees side-to-side, allowing pointing of FAR UV to be somewhat independent of orbiter attitude. Each FAR UV imaging camera has a film transport loaded with 150 feet of film, which can yield up to 900 frames for photography. The experiment is commanded by a crew member who views the



FAR UV Instrument

TV monitor to determine where the camera is pointing as he moves the camera into position. Images can be taken either by programmed sequences executed from the CMP or by manual inputs from the MPCs. The low light level TV can be used to assist the crew in real-time pointing verification of the FAR UV. The instrument also has a stabilization system for long exposures on celestial objects. It weighs approximately 550 pounds.

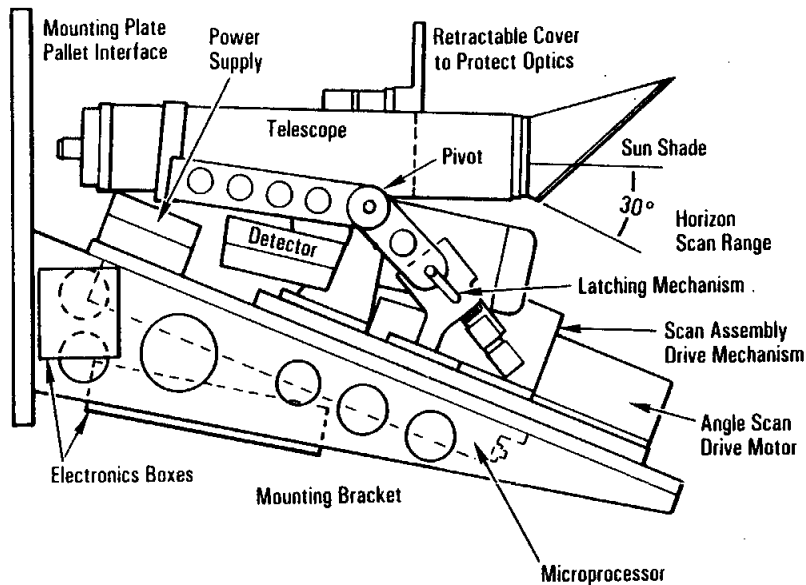
The FAR UV experiment is sponsored by the Naval Research Laboratory in Washington, D.C.

HUP

The Horizon Ultraviolet Program is a spectrometer sensor designed to measure the spatial and spectral characteristics of the Earth's horizon as observed in the ultraviolet wavelength region. HUP will measure the atmospheric radiance as a function of tangent altitude. The radiance is due to solar scattering, airglow, and auroral excitation. Mission objectives include observations of aurora, the Earth limb, and background clutter. Shuttle contamination will also be analyzed. Horizon limb profiles are necessary to develop attitude sensors for spacecraft and to obtain atmospheric background data for above-the-horizon missile detection techniques.

The HUP spectrometer sensor is mounted on a single-axis gimbaling platform and attached to the ESS. The experiment can gimbal 20 degrees from the orbiter Z-axis toward the nose. The field of view can be varied from local horizontal to a few degrees below the hard Earth horizon. The sensor can be operated in fixed pointing or scanning mode. Unlike the infrared instruments aboard STS-39, the HUP ultraviolet sensor does not require cooling. The experiment will run continuously during the mission and will be controlled by a mission specialist via the CMP, which will display health and status telemetry. All HUP data will be recorded on the ESS tape recorders in the payload bay. The instrument weighs less than 40 pounds.

To prevent damage from the sun, a solar protection sensor closes the spectrometer shutter when the sun is within 3 degrees of the line of sight. The spectrometer then automatically starts a



HUP Instrument

calibration cycle, and resumes data taking when the sun is no longer in the field of view.

The HUP experiment is sponsored by the Phillips Laboratory's Geophysics Directorate at Hanscom Air Force Base, Mass.

QINMS

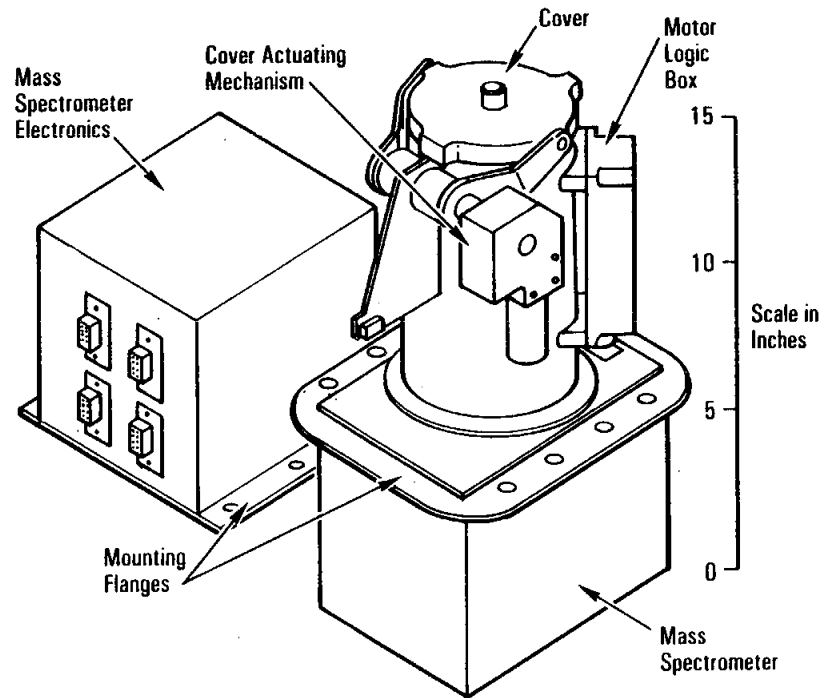
The Quadrupole Ion Neutral Mass Spectrometer is designed to measure gaseous contamination in and around the orbiter. The primary objective of the QINMS experiment is to support the CIRRIS-IA experiment by measuring the amount and nature of contamination in the orbiter environment, particularly concentrations of water. The CIRRIS-IA experiment will not be operated until contamination levels are low. Additional data will be collected while passing through the auroral zone and polar latitude. Levels of hydrogen, oxygen, water vapor, and other gases will be measured. The experiment will also be used to determine the constraints of using the orbiter for future optical observations.

The QINMS experiment consists of a mass spectrometer and its electronics package. The 28-pound instrument is mounted to the ESS pallet and does not gimbal. QINMS will collect data continuously throughout the flight. Operations are controlled by a mission specialist via the CMP.

The QINMS experiment is sponsored by the Phillips Laboratory's Geophysics Directorate, Hanscom Air Force Base, Mass.

URA

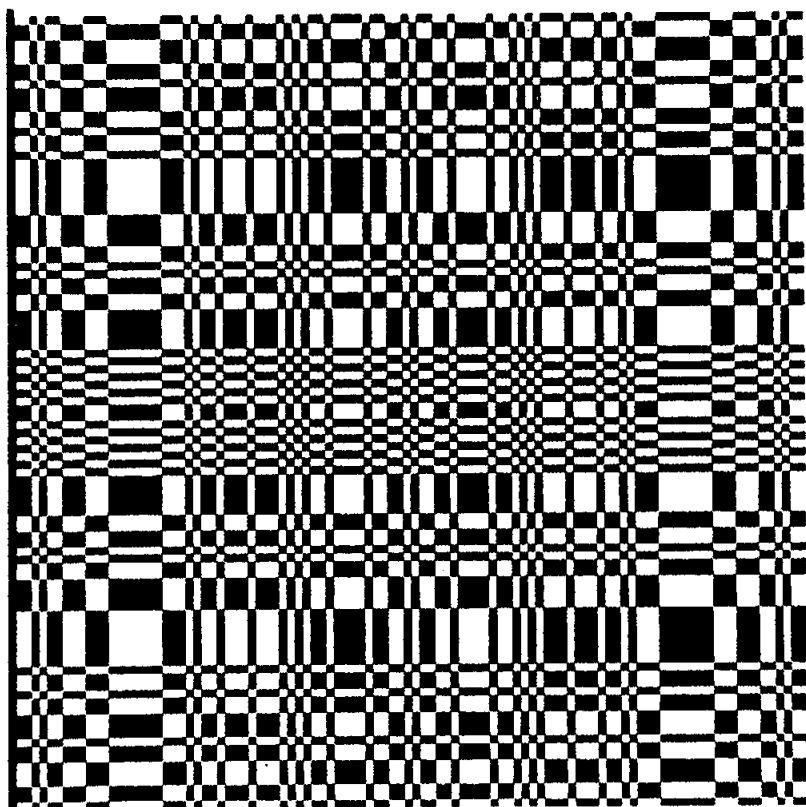
The Uniformly Redundant Array is an experiment designed to demonstrate the capabilities of X-ray coded aperture imaging technology for studying astrophysical sources of X-ray radiation. Unlike low-energy X-ray imaging systems that use nested mirrors,



QINMS Experiment Configuration

the URA experiment uses an aperture plate containing 26,534 hexagonal pinholes to collect the X-ray photons. Postflight data processing is used to obtain an image. Objects will be selected to test the capability of the URA to image point sources, complex collections of point sources, and extended objects. The URA experiment will observe astronomical X-ray sources in both a staring mode at specific targets (such as the center of the galaxy) and slow scans for wide field imaging.

The URA experiment consists of a detector, an electronics package, and a 35mm celestial aspect camera. X-rays from a source form an image through each of the pinholes. The detector system senses these images by determining the location and



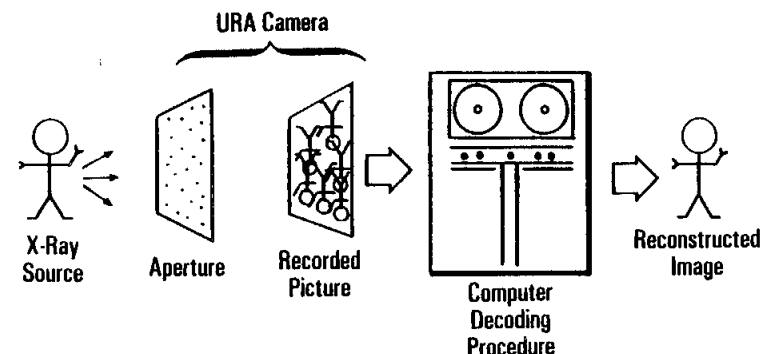
A URA Coded Aperture Pattern

energy of each X-ray, which is stored on the ESS tape recorders. The aspect camera will photograph the star field being targeted. The assembly is mounted to the ESS pallet and does not gimbal. The URA experiment will observe objects over the starboard wing of the orbiter. The URA experiment will be controlled by a mission specialist via the CMP.

The URA must not only detect X-rays of interest but must also suppress detection of particles that are present as background. The backgrounds of concern are mainly cosmic rays (relativistic protons and alpha particles) and charged particles (electrons above a 50 keV energy) trapped within the Earth's magnetic field. Because such particles penetrate the detector walls or window, the backgrounds are rejected by anticoincidence, second moment, and rise time discrimination techniques.

The extended charge distribution from an energetic charged particle, as opposed to an X-ray photon, produces a slower amplifier pulse, because it is collected over a finite period of time. Rise time discrimination is thus an independent means of background rejection.

Despite the background rejection provisions, URA will not operate usefully at high levels of background. Cosmic ray background is less at low latitude and altitude because of the shielding effect of the Earth's magnetic field. X-ray experiments are not successful in high background regions, which are found at



The Basic Steps in Coded Aperture Imaging

high altitude, and high magnetic latitude, and in the South Atlantic Anomaly. Low altitude, low latitude will increase the success of the URA observations.

The URA experiment is sponsored by the Department of Energy and the Los Alamos National Laboratory, Los Alamos, New Mexico.

SPACE TEST PAYLOAD 1

The Space Test Payload (STP)-1 is a complex secondary payload sponsored by the U.S. Air Force Space Systems Division. It consists of a collection of experiments designed to collect ultraviolet, infrared, zero-gravity, and data management information. Phenomena to be observed include the Earth's airglow and limb, liquid feed and collection systems, and electronic data. It is housed in Discovery's payload bay.

As a secondary payload, STP-1 may not interfere with the two primary STS-39 payloads. Only a short portion of dedicated time is allocated to the payload, and at other times the experiments are conducted on a non-interference basis. The crew will power-on the payload once the shuttle is in orbit. STP-1 will then be controlled and operated from the ground by the Goddard Space Flight Center Payload Operations Control Center. The control centers for the two primary payloads are located at JSC. There will be constant coordination between the control centers during the flight to execute the mission and to replan should the need arise.

NASA's Goddard Space Flight Center, Greenbelt, Md., is responsible for integration of STP-1 flight hardware, production of flight and ground safety packages, and performance of all integrated systems testing.

Hitchhiker

The Hitchhiker carrier consists of a multipurpose experiment support structure (MPRESS) with STP-1 unique mounting hardware that provides for the attachment of standard mounting plates or canisters. The canisters can be equipped with commandable pressure doors or sealed with an internal atmosphere. A carrier avionics unit provides standard command, data, timing, and power interfaces for up to six instruments.

The carrier systems generate data at 8 kb/s for transmission via the payload data interleaver, and 2 mb/s for transmission via Ku-

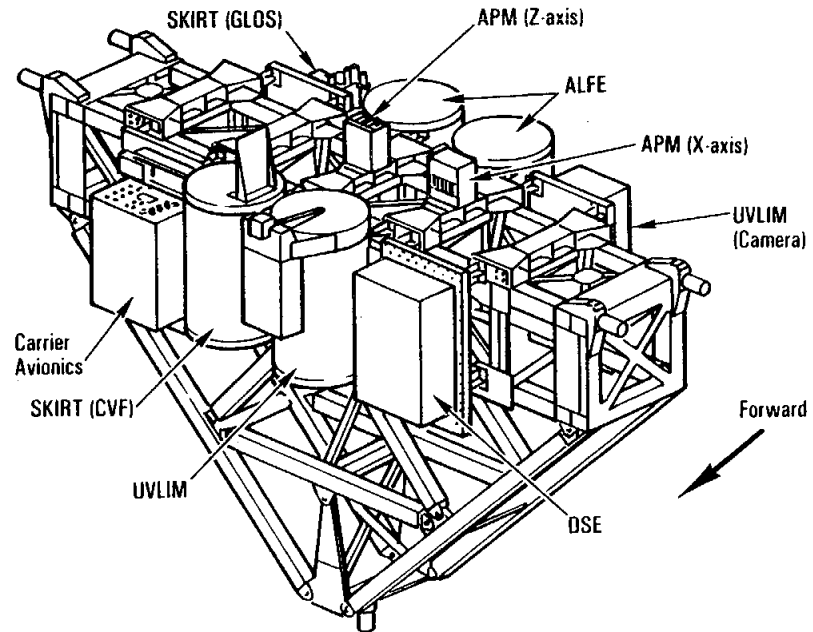
band Channel 2. Uplink commands are via the payload signal processor. The crew switch panel is used for carrier activation and deactivation.

Seventeen additional Hitchhiker payloads are currently manifested.

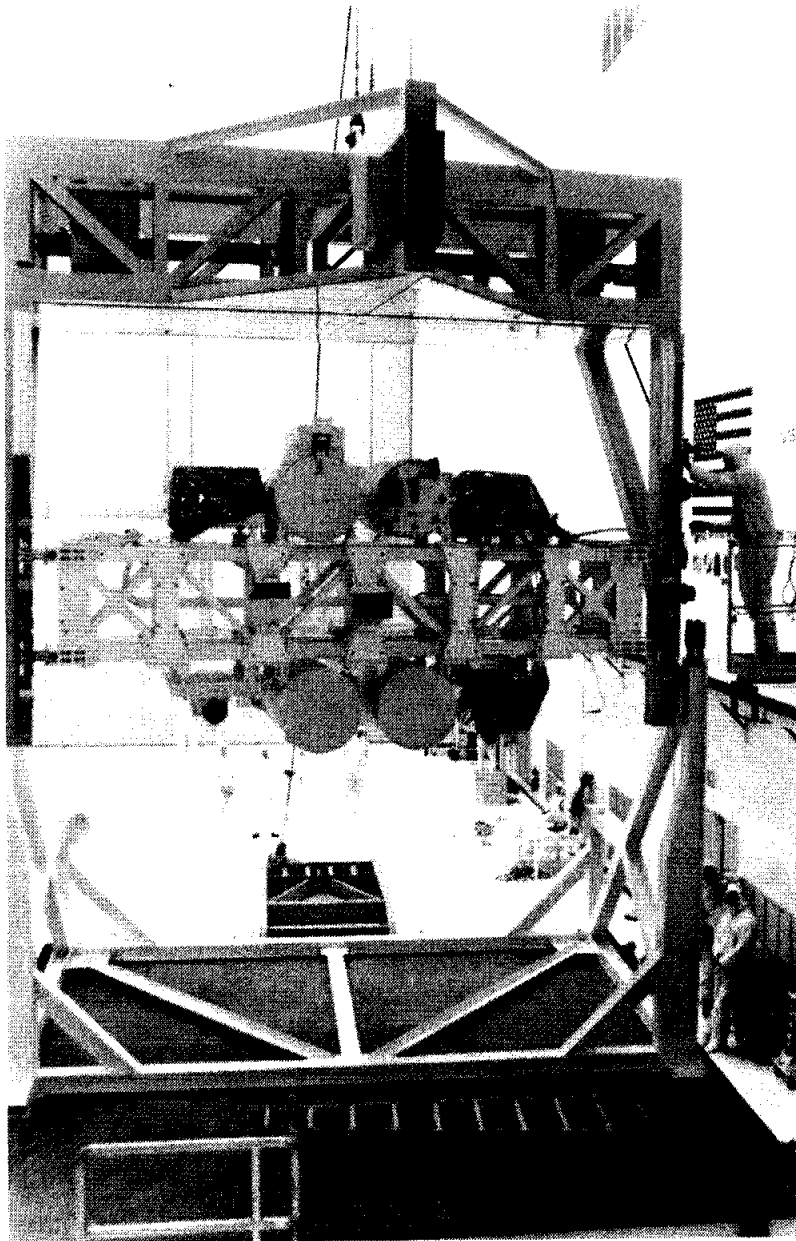
The STP-1 payload is a standard hitchhiker-M across-the-bay carrier structure consisting of an MPRESS, avionics, and Get-Away Special (GAS) experiment canisters. It weighs approximately 4,100 pounds.

STP-1 is composed of five separate experiments:

- **Ultraviolet Limb Imaging Experiment (UVLIM)**—UVLIM will study the composition of the upper atmosphere



STP-1 Configuration



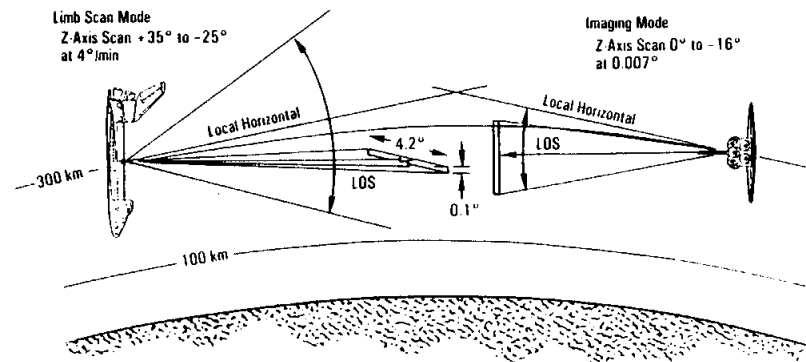
Space Test Payload (STP)-1

- **Advanced Liquid Feed Experiment (ALFE)**—ALFE will evaluate advanced propellant management systems
- **Spacecraft Kinetic Infrared Test (SKIRT)**—SKIRT will collect infrared, ultraviolet, and visible data on the shuttle atomic oxygen glow effect
- **Data System Experiment (DSE)**—DSE will test advanced data management concepts
- **Ascent Particle Monitor (APM)**—APM will collect particles to study particulate contamination in the shuttle payload bay

UVLIM

The objective of the Ultraviolet Limb Imaging experiment is to measure the vertical and geographic distribution of the ultraviolet airglow in the wavelength region from 575 to 1900 angstroms. These measurements will be used to determine the daily and seasonal variation of the composition of the ionosphere and neutral atmosphere between the altitudes of 100 and 500 kilometers.

The UVLIM experiment requires a five-cubic-foot gas canister with a motorized, commandable door, and a mounting plate to house a 35mm celestial aspect camera. The camera, which will be



UVLIM Experiment

aligned with the experiment aperture plate, will take visible-light pictures of stars or other objects near the spectrometer field of view, providing simultaneous data that will be correlated with postflight data to aid in data analysis.

The experiment uses an extreme ultraviolet imaging spectrometer with a two-dimensional detector to make images of the horizon from the airglow emissions that characterize the composition of the ionosphere. The far ultraviolet spectrometer measures emissions indicative of the temperature and composition of the neutral atmosphere.

The investigator for UVLIM is the Naval Research Laboratory, Washington, D.C.

ALFE

The Advanced Liquid Feed Experiment is designed to evaluate the performance of key components of an advanced spacecraft propulsion system designed and built by McDonnell Douglas Astronautics Company under contract to the Phillips Laboratory's Astronautics Directorate of the U.S. Air Force Systems Command. The experiment will provide the first space flight demonstration of an electronic pressure regulator and series of ultrasonic propellant level and flow sensing systems. These components will provide the capability to remotely and electronically control the pressurization schedule of spacecraft propellant tanks, accurately gauge available on-board propellants, and reliably track propellant usage throughout the mission. In addition, the experiment will also demonstrate the capability to integrate all storable propellant on-board spacecraft by transferring attitude control system propellants into main engine tanks, and vice versa.

ALFE consists of two hardware modules weighing approximately 250 pounds each. The experiments are housed in pressurized hitchhiker canisters. The first module is an electronic package that will function as the remote test conductor aboard the space shuttle. It contains an on-board computer and associated electronics necessary for performing the experiment and recording

data. A color TV camera observes tank and sight glasses to determine liquid location and bubble content of pumped fluid. Instrumentation includes a videotape recorder; and pressure, temperature, and flow sensors. The module will provide experiment command and control, as well as the communication link to transfer experiment telemetry and video signals to the ground-based operator located at Goddard Space Flight Center.

The second module is the self-contained fluid system module. It contains two test tanks; an electronic pressure regulator; ultrasonic liquid gaging system; and associated instrumentation, pumps, valves, and Freon 113 fluid. The test tanks are made of plexiglass and are scaled to one-quarter scale of the actual system. Internally, each tank is fitted with a liquid acquisition device for liquid position monitoring in the low-gravity environment of space, and a screen device to preclude ingestion of gas bubbles into the lines. During the experiment, various quantities of fluid will be transferred between these two tanks to simulate a hypothetical resupply scenario in space.

The electronic pressure regulator, built by Parker Hannifin, Irvine, Calif., will control the pressure of the test tank during flight. It has a unique capability to provide a smooth ramp-up of tank pressure when commanded in contrast with the typical burst disk system. The regulator also has the capability to control the downstream pressure to different pressure settings. This will enable better management of the limited quantity of the precious pressurant gas carried by the spacecraft.

The ultrasonic liquid gaging system, supplied by Panametrics, Waltham, Mass., will provide an advanced approach to measure and track liquid propellant usage. The system consists of a group of six ultrasonic point sensors and an ultrasonic flowcell. The point sensors, using the pulse-echo effect, measure the time delays for the ultrasonic pulses and their echoes to transit through the fluid to the gas-liquid interface. From these time measurements, the amount of the liquid contained within the tank can be calculated. Using a similar approach, the ultrasonic flowcell measures the time delay between two simultaneous ultrasonic pulses along a fluid line to calculate the propellant flow.

On orbit, the ALFE on-board computer will accept commands from the ground-based operator at GSFC and will configure the payload for the desired test sequence. An internal wide-angle television camera will record the fluid settling characteristics under various acceleration loads. Experiment data will be stored on-board in the electronic module and also transmitted to the ground-based operator. The results will be used to further update the design of advanced spacecraft feed systems in an effort to bring the next generation of spacecraft one step closer to autonomous operation and longer life.

The investigating organization for ALFE is Phillips Laboratory's Astronautics Directorate, Edwards Air Force Base, Calif.

SKIRT

The objective of the SKIRT experiment is to obtain infrared spectral measurements of the shuttle glow at a resolution and sensitivity that will allow identification of the chemical species associated with this phenomenon. Since the shuttle glow effect is thought to be caused by the impact of atomic oxygen on the orbiter surfaces, it is only necessary that surfaces near the SKIRT field-of-view be exposed to the velocity vector at various times during the mission.

The Spacecraft Kinetic Infrared Test payload consists of two separate and independent components: Gaseous Luminosity of Optical Surface (GLOS) and Circular Variable Filter (CVF). GLOS consists of six infrared, visible, and ultraviolet radiometers mounted on a plate and combined into one package weighing approximately 50 pounds. The photometers have windows on which glow will be measured. The field of view is 2 by 2 degrees in the Z direction. CVF is a solid nitrogen-cooled infrared spectrometer/radiometer mounted in a sealed hitchhiker canister with an aperture in the top plate. A motor-driven cover is commanded open and closed on-orbit to cover the aperture as needed. A "glow plate" is attached to the top of the canister near the field of view, which is 4 by 4 degrees in the Z direction. The glow plate provides a surface for impingement of the residual

atmosphere to produce the glow, which is then observed by the spectrometer. CVF weighs approximately 150 pounds with cryogen.

The investigating organization for SKIRT is Phillips Laboratory's Geophysics Directorate, Hanscom Air Force Base, Mass.

DSE

The objective of the Data System Experiment is to evaluate the performance of an advanced MILVAX computer and an erasable optical disk in a zero-gravity environment. DSE also consists of associated simulators and interfaces. The simulators will generate data to be used to exercise the computer and optical disk. The optical disk system consists of an erasable optical disk drive unit and a removable cartridge media. Both are designed for reliable use under a variety of environmental conditions. DSE will be operated by ground command.

The investigating organization for DSE is NASA GSFC.

APM

The Ascent Particle Monitor is an automatic system mounted in the orbiter payload bay to measure particle detachment, fallout, transportability, and deposition during the immediate prelaunch period and ascent. It will determine the influence of initial cleanliness of the ascent environment. The payload consists of a small box with a fixed door and a moving door mounted in a clamshell arrangement atop an aluminum housing. Each door contains six sample coupons. The door is closed preflight to protect the coupons from the environment. It is opened after ground operations are completed and the payload bay doors are about to be closed in preparation for launch. A motor/gearbox assembly, two battery packs, and launch detection and door opening circuitry are contained within an aluminum housing. The electric motor is used to open and close the door so that particles can be collected at specific times during shuttle ascent. An internal timing circuit set prior to installation of the APM into the

orbiter payload bay controls the door movement. The timer circuit is acoustically actuated by orbiter main engine start.

The concept of the APM experiment evolved as a direct response to concerns by the spacecraft community about the fallout of particles in the shuttle payload bay during the ascent portion of flight. Particulate contaminants on shuttle bay surfaces and on surfaces of payloads in the bay may be released during launch and ascent by vibroacoustic, gravitational, and aerodynamic forces. These particles can be deposited on surfaces from which they were released or on other surfaces depending on location acceleration, and velocity vectors with respect to such surfaces.

Many analytical models of particle redistribution have been made using assumed ascent forces during launch, but most models are based on uniform redistribution of particles. Insufficient experiment data exist on particle fallout and deposition during shuttle ascent to verify current models. The understanding of particle redistribution on surfaces and releases of particles into the field of view of instruments incorporating critical sensors is important in view of the influence the particles may have on the

properties of the surfaces on which they are deposited and on the optical degradation of the environment into which they may escape. Some of the effects of particles on surfaces and in the environment are physical obscuration of the surface, scattering of radiation which changes the transmitting or reflecting properties, increased diffuse reflection of the surface, and emission of radiation by the particles, which may be detrimental to certain sensors.

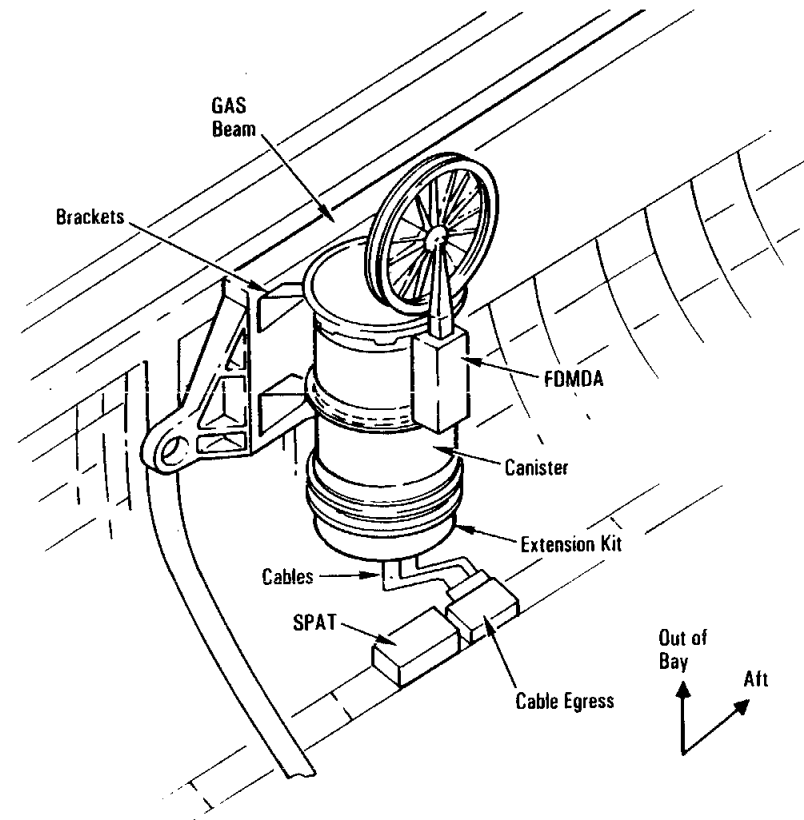
The first APM flew on the STS-28 mission and the flight coupons were analyzed in the Materials Science Laboratory of The Aerospace Corp., Los Angeles, Calif. Various analytical techniques were used to evaluate the contaminants, including optical and scanning electron microscopy, infrared spectroscopy, and energy dispersive X-ray spectroscopy. The coupons were also examined at NASA GSFC using bidirectional reflectance distribution function scatter measurements. The APM also flew on STS-31 and on STS-37.

The investigating organization for the APM is the U.S. Air Force Space Systems Division's Operating Location Detachment, Houston, Texas.

MULTI-PURPOSE EXPERIMENT CANISTER

The Multi-Purpose Experiment Canister (MPEC) carries a classified payload sponsored by the U.S. Air Force Space Systems Division. The canister, a modified Get-Away Special (GAS) container, is mounted on a beam attached to the starboard sidewall of Discovery's Cargo Bay 6. The canister includes a 9-inch extension containing an ejection kit, electronics, and a full-diameter motorized door assembly.

The experiment is scheduled to be deployed from the cargo bay on the final day of the mission, although deployment can occur earlier on a contingency basis. The crew provides power to the MPEC canister via the Standard Switch Panel located in the crew compartment. The crew will send a command to open the canister door. After verifying that the door is open, the crew will arm the ejection mechanism and send the deployment command. The experiment is ejected with a relative velocity of approximately 2.7 ft/sec by a spring mechanism. After ejection, the canister door will be closed and power removed from the canister.



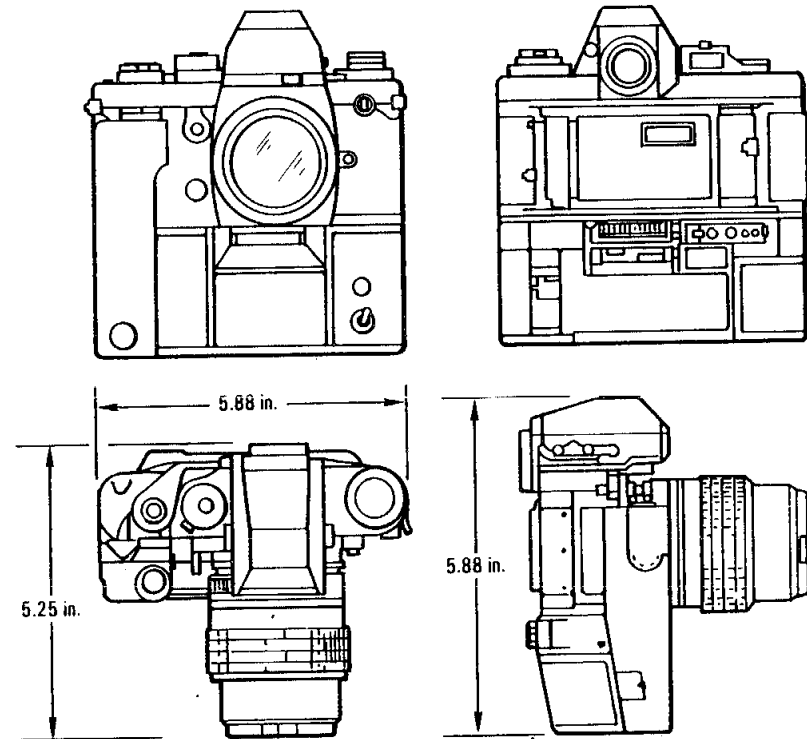
MPEC Payload Configuration

CLOUD LOGIC TO OPTIMIZE USE OF DEFENSE SYSTEMS 1A

Cloud Logic to Optimize Use of Defense Systems (CLOUDS)-IA is a DOD-sponsored payload whose objective is to obtain photographic sequences of cloud fields over various ground sites (targets of opportunity) to provide a more efficient assessment of relevant cloud characteristics that impact DOD systems. The variation in apparent cloud cover as a function of the angle at which clouds of various types are viewed will be quantified.

Cloud types of particular interest include middle- and upper-layer atmosphere broken cirrus cloud fields and lower- and middle-layer atmosphere broken cumulus cloud fields exhibiting a vertical structure.

The CLOUDS-IA experiment is stowed in a middeck locker and consists of a Nikon F3/T 35mm camera assembly with 105mm f/2.5 lens, data recording system, motor drive, and infrared filter. Ten packs of 36-exposure Kodacolor Gold 100 film will be used during the flight. All photographic operations will be performed by the crew members.



CLOUDS-IA Camera Configuration

RADIATION MONITORING EQUIPMENT III

The Radiation Monitoring Equipment (RME)-III will measure and record the crew's exposure to ionizing radiation (gamma ray, neutron, and proton radiation) in Discovery's crew compartment. RME-III measures gamma ray, electron, neutron, and proton radiation and calculates in real-time exposure in RADS-tissue equivalent. It consists of a hand-held instrument with replaceable memory modules. The equipment contains a liquid crystal display for real-time data presentation and a keyboard for controlling its functions. The experiment is self-contained with four zinc-air and five AA batteries in each memory module and two zinc-air batteries in the main module.

RME-III will be stored in a middeck locker during flight except for when it is turned on and when memory modules are being

replaced. It will be activated as soon as possible following orbit insertion and will be programmed to operate throughout the entire mission. A crew member will be required only to enter the correct Mission Elapsed Time (MET) upon activation and to change the memory module every two days. All data stored in the memory modules will be analyzed upon return.

RME-III, which has flown on STS-31, STS-41, and STS-37, is the current configuration, replacing the earlier RME-I and RME-II units. The Department of Defense, in cooperation with NASA, sponsors the data gathering instrument.

DEVELOPMENT TEST OBJECTIVES

ENTRY AERODYNAMIC CONTROL SURFACES TEST, PART 7 (performed only if reaction control system propellant is available). The purpose of the DTO is to perform a series of programmed test input maneuvers and one manual body flap maneuver during the entry and TAEM phases to obtain aerodynamic response data. This data will be used to evaluate the effectiveness of various aerodynamic control surfaces.

ASCENT STRUCTURAL CAPABILITY EVALUATION. The purpose of this DTO is to collect data only to expand the data base of ascent dynamics for various weights.

ASCENT COMPARTMENT VENTING EVALUATION. This DTO is intended solely to collect data to expand the data base to verify vent models.

DESCENT COMPARTMENT VENTING EVALUATION. The purpose of this DTO is to expand the data base to verify vent models.

ENTRY STRUCTURAL CAPABILITY. This DTO will collect data to expand the data base of flight loads during entry.

VIBRATION AND ACOUSTIC EVALUATION. This DTO is for the collection of data to expand the data base vibration and acoustic data during ascent.

- Hot nosewheel steering runway evaluation
- Carbon brake systems test, condition 3
- Crosswind landing performance

DETAILED SUPPLEMENTARY OBJECTIVES

IN-FLIGHT AEROBIC EXERCISE. This objective investigates the effects of regular aerobic exercise on the maintenance of aerobic power and economy. Daily aerobic exercise should inhibit the decrease in cardiac dimensions observed during space flight, improve orthostatic tolerance, and minimize postflight aerobic capacity loss.

BLOOD PRESSURE VARIABILITY DURING SPACE FLIGHT. This objective will determine whether arterial blood pressure and heart rate exhibit less variability in a microgravity environment than on Earth, and if variability in blood pressure can be correlated to any baroflex attenuation measured postflight.

ORTHOSTATIC FUNCTION DURING ENTRY, LANDING, AND EGRESS. This objective will document the orthostatic function of crew members during entry, landing, and egress to assess the need for additional countermeasures in the event of an emergency egress.

VISUAL-VESTIBULAR INTEGRATION AS A FUNCTION OF ADAPTATION. This objective investigates visual vestibular and perceptual adaptive responses to determine the operational impacts of longer missions on performance during entry, landing, and egress.

EFFECTS OF SPACE FLIGHT ON AEROBIC AND ANAEROBIC METABOLISM DURING REST AND EXERCISE: THE ROLE OF BODY COMPOSITION. This objective quantifies the changes in aerobic and anaerobic metabolism and relates those changes to alterations in total body water, dry lean tissue, fat mass, and fluid volume intake during space flight. The data obtained will be used to develop nutrition, fluid, and exercise countermeasures for extended missions.

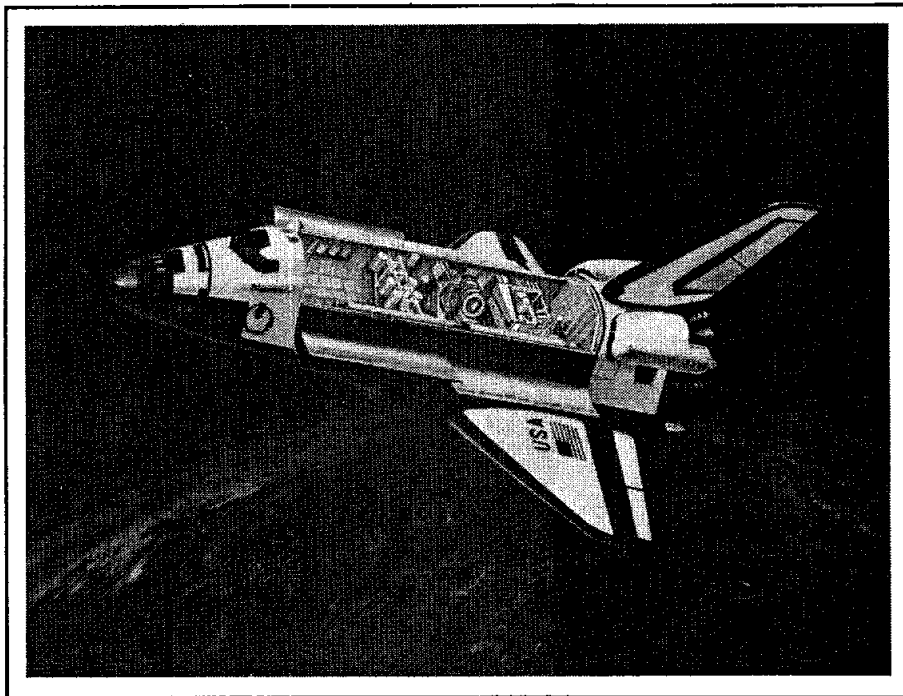
DOCUMENTARY TELEVISION. This objective provides live television or VTR dumps of crew activities, orbiter opera-

tions, payload deployment/retrieval and operations, Earth views, rendezvous and proximity operations. Telecasts are planned for communication periods with seven or more minutes of uninterrupted viewing time. The broadcasts are accompanied with operational air-to-ground and/or operational intercom audio. VTR recording may be used when live television is not possible.

DOCUMENTARY MOTION PICTURE PHOTOGRAPHY. This objective provides documentary and public affairs motion picture photography of the orbiter's basic capabilities and key flight objectives. Documentation will include launch, crew activities, payload deployment, landing, and unscheduled activities of special interest.

DOCUMENTARY STILL PHOTOGRAPHY. This objective provides still photography of crew activities, orbiter operations, payload deployment/retrieval and operation, Earth views, and unscheduled items of interest.

- Variations in supin and standing heart rate, blood pressure, and cardiac size as a function of space flight duration and time postflight
- Changes in baroreceptor reflex function
- Postural equilibrium control during entry, landing, and egress
- Lower body negative pressure following space flight
- Changes in the endocrine regulation of orthostatic tolerance following space flight



STS-39

MISSION STATISTICS

PRELAUNCH COUNTDOWN TIMELINE

MISSION TIMELINE

April 1991



Rockwell International

Space Systems Division

Office of Media Relations

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MISSION OVERVIEW

This is the 12th flight of Discovery and the 40th for the space shuttle.

The flight crew for the STS-39 mission consists of commander Michael (Mike) L. Coats; pilot L. Blaine Hammond, Jr.; and mission specialists Guion (Guy) S. Bluford, Jr.; Gregory (Greg) J. Harbaugh; Richard (Rick) J. Hieb; Donald (Don) R. McMonagle; and Charles L. (Lacy) Veach.

STS-39 is the eighth dedicated Department of Defense (DOD) shuttle mission, and is the first such mission to be unclassified. STS-39's primary mission objective is to collect infrared, visible, ultraviolet, and X-ray data on orbiter plumes (orbital maneuvering system and reaction control system), the Earth background (aurora, Earth limb, airglow), chemical and gas releases, the orbiter environment, and celestial objects (stars, nebulae, galaxies, etc.). The mission is expected to provide valuable data essential to the design and development of Strategic Defense Initiative (SDI) systems.

The most complex shuttle mission to date, STS-39 showcases a wide variety of shuttle capabilities, encompassing rendezvous, multiple translational maneuvers, extended station keeping, and deployment and retrieval of a satellite. The mission involves challenging coordination tasks involving precision orbiter maneuvers/payload spacecraft commanding and observation sequences, multibody management, and a crew intensive timeline. Challenging new techniques will be employed to maximize data gathering. At times, Discovery's entire crew of seven astronauts will be required to work in careful coordination on the flight deck, synchronizing orbiter and Shuttle Pallet Satellite (SPAS)-II maneuvers and documenting key events. In all, approximately 36 hours of detached rendezvous and proximity operations are scheduled.

STS-39 consists of two primary payloads: the Infrared Background Signature Survey (IBSS), and Air Force Program (AFP)-675. Secondary payloads include the Space Test Payload (STP)-1, Multi-Purpose Experiment Canister (MPEC), and two middeck experiments: Cloud Logic To Optimize Use of Defense Systems (CLOUDS)-1A, and Radiation Monitoring Equipment (RME)-III. IBSS and AFP-675 observations are scheduled throughout the mission. STP-1 and MPEC both have a small amount of dedicated time on the last day of the mission.

IBSS is a Strategic Defense Initiative Organization (SDIO)-sponsored experiment designed to collect infrared, ultraviolet, and visible data for use in the development of ballistic missile defense sensor systems. Phenomena to be observed include orbital maneuvering system (OMS) and primary reaction control system (PRCS) engine firing exhaust plumes, the orbiter environment, the Earth and its backgrounds, chemicals and gases released into space, and celestial calibration sources.

The IBSS payload is composed of three separate hardware elements: the Shuttle Pallet Satellite (SPAS)-II, the Critical Ionization Velocity (CIV) package, and the Chemical Release Observation (CRO) package.

The deployable SPAS-II platform incorporates a cryogenically cooled infrared sensor, an ultraviolet multispectral sensor, pressure gauge, and two low light level television cameras. Following SPAS-II deployment from the orbiter, the SPAS-II IBSS sensors will observe orbiter attitude control rocket plumes, providing spatial and temporal plume phenomenology data that will be used to design SDI sensors and seekers. The orbiter will be maneuvered repeatedly for the SPAS-II experiments. SPAS-II can be commanded by the orbiter crew or by the ground.

The Critical Ionization Velocity (CIV) and Chemical Release Observation (CRO) subexperiments are mounted in the payload bay. The CIV experiment is composed of four separate gas canisters, each containing a different gas. The canisters remain in the orbiter payload bay and release gases upon command. The gases will be observed by SPAS-II while it is deployed and on the RMS, as well as by the CIV monitor package mounted in the payload bay as part of the CIV payload element. CIV is intended to provide on-orbit spectral data to examine a theory that many neutral gaseous molecules, including rocket combustion products, will be ionized when they travel through a magnetized plasma at velocities such that their kinetic energy exceeds their ionization potential. If this theory is correct, such ionization will provide additional observables on objects of interest. The three CRO subsatellites are deployed and their chemicals released later via ground commands. Two deployed and one RMS SPAS-II CRO observations will be made. Each subsatellite is loaded with a different chemical.

The nominal IBSS/SPAS-II deploy opportunity is on Orbit 31 with a backup opportunity on Orbit 32. Nominal retrieve is planned for Orbit 56 with a backup on Orbit 57.

The AFP-675 is a DOD-sponsored collection of experiments designed to measure background infrared and ultraviolet emissions, identify contamination in the orbiter environment, and demonstrate X-ray imaging proof of concept. Phenomena to be observed include the Earth's limb and airglow, auroras, celestial objects, orbiter surface glow, and contamination events. Results are critical to understanding how an SDI detection and tracking system will operate in space.

The five AFP-675 experiments [Cryogenic Infrared Radiance Instrument for Shuttle (CIRRIS)-1A; Far Ultraviolet Camera (FARUV); Uniformly Redundant Array (URA); Horizon Ultraviolet Program (HUP); and Quadrupole Ion Neutral Mass Spectrometer (QINMS)] are mounted on the nondeployable experiment support structure (ESS) in the payload bay. They are completely controlled by a mission specialist through a unique aft flight deck command and monitor panel.

STP-1 is a collection of five diverse experiments designed to collect ultraviolet, infrared, zero-gravity, and data management data. The Advanced Liquid Feed Experiment (ALFE) will evaluate the performance of advanced propellant management systems (tanks and liquid collection systems) in microgravity. The Shuttle Kinetic Infrared Test (SKIRT) will collect infrared, visible, and ultraviolet data on shuttle atomic oxygen glow effects. The Ultraviolet Limb Measurement (UVLIM) will investigate atmospheric composition. The Data System Experiment (DSE) will conduct the first space test of a 2.25-Mips super-mini-computer with an erasable optical disk data storage system. The Ascent Particle Monitor (APM) will collect particles to study contamination in the shuttle payload bay. The STP-1 experiments and their associated electronics and control systems are mounted on a Hitchhiker-M across-the-bay carrier.

MPEC is a DOD-sponsored classified payload housed in a Get-Away Special (GAS) canister. The payload will be deployed by the crew on the last day of the mission.

CLOUDS-1A is a DOD-sponsored middeck payload consisting of a 35mm camera assembled with a motor drive, data recording system, 105mm lens, and infrared filter. The objective of CLOUDS-1A is to photograph sequences of cloud fields over various ground sites (targets of opportunity) in order to provide a more efficient assessment of relevant cloud characteristics that impact DOD systems.

The RME-III payload in Discovery's middeck measures the ionizing radiation exposure in the orbiter crew compartment. The unit contains a liquid crystal display (LCD) for real-time data display and a keyboard for controlling its functions.

Nine development test objectives (DTOs) and 13 detailed supplementary objectives (DSOs) are scheduled to be conducted.

The STS-39 flight crew is divided into a red team and blue team working 12-hour shifts followed by 12 hours off duty. This allows for continuous payload operations 24 hours a day. The commander is not assigned to a team and is free to adjust his hours real-time as necessary. The red team consists of pilot L. Blaine Hammond, Jr.; and mission specialists Charles L. (Lacy) Veach and Richard J. Hieb. The blue team consists of mission specialists Gregory J. Harbaugh, Donald R. McMonagle, and Guion S. Bluford, Jr.

Rockwell International, under management of the Air Force Space Systems Division Space Test and Transportation Office, is integrating the entire STS-39 cargo. As contractor for the Space Test Integration Contract (STIC), Rockwell is responsible for support of STS-39 integration, operations, training, logistics, and communication systems activities at Rockwell's Space Systems Division in Downey, Calif.; NASA Johnson Space Center in Houston, Texas; and the Cape Canaveral Air Force Station and NASA Kennedy Space Center in Florida.

MISSION STATISTICS

Vehicle: Discovery (OV-103), 12th flight

Launch Date/Time:

4/23/91 7:05 a.m., EDT
6:05 a.m., CDT
4:05 a.m., PDT

Launch Site: Kennedy Space Center (KSC), Fla.--Launch Pad 39A

Launch Window: 3 hours, 26 minutes

Mission Duration: 8 days, 7 hours, 24 minutes

Landing: Nominal end of mission on Orbit 134

5/1/91 2:29 p.m., EDT
1:29 p.m., CDT
11:29 a.m., PDT

Runway: Nominal end-of-mission landing on concrete runway 22, Edwards Air Force Base (EAFB), Calif. Backup: EAFB (lakebed). Weather alternates are Northrup Strip (NOR), White Sands, New Mexico; and KSC.

Transatlantic Abort Landing: Zaragoza, Spain; Alternates are Moron, Spain; and Ben Guerir, Morocco

Return to Launch Site: KSC

Abort-Once-Around: NOR

Inclination: 57 degrees

Ascent: The ascent profile for this mission is a direct insertion. Only one orbital maneuvering system thrusting maneuver, referred to as OMS-2, is used to achieve insertion into orbit. This direct-insertion profile lofts the trajectory to provide the earliest opportunity for orbit in the event of a problem with a space shuttle main engine.

The OMS-1 thrusting maneuver after main engine cutoff plus approximately 2 minutes is eliminated in this direct-insertion ascent profile. The OMS-1 thrusting maneuver is replaced by a 5 foot-per-second reaction control system maneuver to facilitate the main propulsion system propellant dump.

Altitude: 140 nautical miles (161 statute miles) circular orbit

Space Shuttle Main Engine Thrust Level During Ascent: 104 percent

Total Lift-off Weight: Approximately 4,512,698 pounds

Orbiter Weight, Including Cargo, at Lift-off: Approximately 246,986 pounds

Payload Weight Up: Approximately 21,413 pounds

Payload Weight Down: Approximately 20,586 pounds

Orbiter Weight at Landing: Approximately 211,577 pounds

Payloads--Cargo Bay (* denotes primary payload): Infrared Background Signature Survey (IBSS)*, Air Force Program (AFP)-675*, Space Test Payload (STP)-1, Multi-Purpose Experiment Canister (MPEC)

Payloads--Middeck: Cloud Logic to Optimize Use of Defense Systems (CLOUDS)-1A, Radiation Monitoring Equipment (RME)-III

Flight Crew Members:

Commander: Michael L. Coats, third space shuttle flight
Pilot: L. Blaine Hammond, Jr., first space shuttle flight
Mission Specialist 1: Gregory J. Harbaugh, first space shuttle flight
Mission Specialist 2: Donald R. McMonagle, first space shuttle flight
Mission Specialist 3: Guion S. Bluford, Jr., second space shuttle flight
Mission Specialist 4: Charles L. (Lacy) Veach, first space shuttle flight
Mission Specialist 5: Richard J. Hieb, first space shuttle flight

Ascent Seating:

Flight deck, front left seat, commander Michael L. Coats
Flight deck, front right seat, pilot L. Blaine Hammond, Jr.
Flight deck, aft center seat, mission specialist Donald R. McMonagle
Flight deck, aft right seat, mission specialist Gregory J. Harbaugh
Middeck, mission specialist Guion S. Bluford, Jr.
Middeck, mission specialist Charles L. (Lacy) Veach
Middeck, mission specialist Richard J. Hieb

Entry Seating:

Flight deck, aft center seat, Donald R. McMonagle
Flight deck, aft right seat, Charles L. (Lacy) Veach
Middeck, mission specialist Gregory J. Harbaugh
Middeck, mission specialist Guion S. Bluford, Jr.
Middeck, mission specialist Richard J. Hieb

Extravehicular Activity Crew Members, If Required:

Extravehicular (EV) astronaut-1 is Gregory J. Harbaugh; EV-2 is Donald R. McMonagle

Intravehicular Astronaut: Guion S. Bluford, Jr.

Entry: Automatic mode until subsonic, then control-stick steering

Notes:

- . The flight crew is divided into a red team and blue team working 12-hour shifts followed by 12 hours off duty. This allows for continuous payload operations 24 hours a day. The commander is not assigned to a team and is free to adjust his hours real-time as necessary.
- . The red team consists of pilot L. Blaine Hammond, Jr.; and mission specialists Charles L. (Lacy) Veach and Richard J. Hieb. The blue team consists of mission specialists Gregory J. Harbaugh, Donald R. McMonagle, and Guion S. Bluford, Jr.
- . The remote manipulator system is installed in Discovery's payload bay for this mission. The galley and the four-tier-bunk sleep stations are installed in Discovery's middeck.
- . STS-39 marks the Discovery debut of new, upgraded general-purpose computers (IBM AP-101S) that are replacing the existing GPCs aboard the space shuttle orbiter fleet. The upgraded computers allow NASA to incorporate more capabilities into the orbiters and apply advanced computer technologies that were not available when the orbiter was first designed. The new computer design began in January 1984, whereas the older design began in January 1972. The set of five upgraded GPCs, plus a spare, provides 2.5 times the existing memory capacity and up to three times the existing processor speed with minimum impact on flight software. They are half the size, weigh approximately half as much, and require less power to operate. The central processor unit and the input/output processor, previously installed as two separate boxes, are now a single unit.

The new GPCs use the existing shuttle software with only subtle changes. However, the increases in memory and processing speed allow for future innovations in the shuttle's data processing system.

Although there is no real difference in the way the crew will operate with the new computers, the upgrade increases the reliability and efficiency in commanding the shuttle systems. The predicted "mean time between failures" (MTBF) for the advanced GPCs is 6,000 hours, and it is hoped to reach 10,000 hours. The MTBF for the original GPCs is 5,200 hours.

Specifications:

Dimensions: 19.55 in. by 7.62 in. by 10.2 in.
Weight: 64 lb.
Memory capacity: 262,000 words (32-bits each)
Processing rate: 1 million instructions per second
Power requirements: 550 watts

MISSION OBJECTIVES

- . Primary Payloads
 - Infrared Background Signature Survey (IBSS)
 - Air Force Program (AFP)-675

- . Secondary Payloads
 - Space Test Payload (STP)-1
 - Multi-Purpose Experiment Canister (MPEC) deploy
 - Cloud Logic To Optimize Use of Defense Systems (CLOUDS)-1A
 - Radiation Monitoring Equipment (RME)-III

- . Development Test Objectives (DTOs)/Detailed Supplementary Objectives (DSOs)

FLIGHT ACTIVITIES OVERVIEW

Flight Day 1

Red Team:

- Ku-band antenna deploy
- Priority Group B powerdown
- RMS powerup and checkout
- Aft controller checkout
- STP-1 activation
- AFP-675 initialization and checkout
- RME-III activation
- IBSS checkout

Blue Team:

- AFP-675 operations

Flight Day 2

Red Team:

- AFP-675 operations

Blue Team:

- AFP-675 operations
- SPAS-II/IBSS predeploy checkout
- SPAS-II/IBSS grapple, unberth

Flight Day 3

Red Team:

- SPAS-II/IBSS release, attitude control checkout
- Separation to far field (10 km)
- OMS plume sequence 1
- Far-field station keeping
- IBSS operations: Earth scan, Earth limb, carbon dioxide Earth sweep

Blue Team:

- Far-field OMS plume sequences 2, 3
- Far-field primary RCS plume sequence
- IBSS experiment operations
- CRO C deploy
- Transition to near field (2 km)
- Near-field OMS plume sequences 4, 5

Flight Day 4

Red Team:

Orbiter systems redundant component checkout
IBSS experiment operations
CIV operations
Phase out to rendezvous initiation range
CRO C observation
CRO B deploy
SPAS-II/IBSS rendezvous operations
CRO B observation
SPAS-II/IBSS capture

Blue Team:

SPAS-II/IBSS berth
Orbit adjust - CRO C avoidance
STP-1 operations
AFP-675 operations

Flight Day 5

Red Team:

AFP-675

Blue Team:

AFP-675
CRO A deploy

Flight Day 6

Red Team:

AFP-675
SPAS-II/IBSS predeploy checkout
SPAS-II/IBSS attached operations
CRO A observation
STP-1 operations

Blue Team:

SPAS-II/IBSS attached operations
CIV operations
Orbiter environment
SPAS-II/IBSS berth

Flight Day 7

Red Team:

SPAS-II/IBSS in-bay operations
AFP-675

Blue Team:

AFP-675

Flight Day 8

Red Team:

Flight control system checkout
AFP-675 operations
STP-1 dedicated operations

Blue Team:

STP-1 dedicated operations
AFP-675 deactivation
MPEC deploy
Cabin stow

Flight Day 9

Payload deactivation
Deorbit prep
Landing

Notes:

- . Each flight day includes a number of scheduled housekeeping activities. These include inertial measurement unit alignment, supply water dump (as required), waste water dump (as required), fuel cell purge, Ku-band antenna cable repositioning, and a daily private medical conference.
- . Due to power requirements and the length of the mission, an equipment powerdown (referred to as a Group B powerdown), is executed by the Red Team on Flight Day 1 to conserve cryogenics for a full mission duration plus two extension days (if required). Powerdown activities include powering off three of Discovery's four CRTs, placing three of Discovery's five general purpose computers on standby mode, placing one of Discovery's three inertial measurement units on standby mode, and powering off three of Discovery's eight flight-critical multiplexers (two forward, one aft).

STS-39 CREW ASSIGNMENTS

Commander (Michael L. Coats): Overall mission decisions; deploy, separation, and rendezvous; orbiter systems; detailed test objectives

Pilot (L. Blaine Hammond, Jr.): Orbiter systems, piloting tasks

Mission Specialist 1 (Gregory J. Harbaugh): IBSS, RMS

Mission Specialist 2 (Donald R. McMonagle): Orbiter systems, piloting tasks, RME-III

Mission Specialist 3 (Guion S. Bluford, Jr.): AFP-675, STP-1, MPEC

Mission Specialist 4 [Charles L. (Lacy) Veach]: AFP-675, CLOUDS-1A

Mission Specialist 5 (Richard J. Hieb): IBSS, RMS

DEVELOPMENT TEST OBJECTIVES/DETAILED SUPPLEMENTARY OBJECTIVES

DTOs

- . Entry aerodynamic control surfaces test, part 7 (performed only if reaction control system propellant is available)
- . Ascent structural capability evaluation
- . Ascent compartment venting evaluation
- . Descent compartment venting evaluation
- . Entry structural capability
- . Vibration and acoustic evaluation
- . Hot nosewheel steering runway evaluation
- . Carbon brake systems test, condition 3
- . Crosswind landing performance

DSOs

- . Variations in supin and standing heart rate, blood pressure, and cardiac size as a function of space flight duration and time postflight
- . In-flight aerobic exercise
- . Changes in baroreceptor reflex function
- . Blood pressure variability during space flight
- . Orthostatic function during entry, landing, and egress
- . Visual-vestibular integration as a function of adaptation
- . Postural equilibrium control during entry, landing, and egress
- . Lower body negative pressure following space flight
- . Effects of space flight on aerobic and anaerobic metabolism during rest and exercise: the role of body composition
- . Changes in the endocrine regulation of orthostatic tolerance following space flight
- . Documentary television
- . Documentary motion picture photography
- . Documentary still photography

STS-39 PRELAUNCH COUNTDOWN

T - (MINUS)
HR:MIN:SEC

TERMINAL COUNTDOWN EVENT

- 06:00:00 Verification of the launch commit criteria is complete at this time. The liquid oxygen and liquid hydrogen systems chill-down commences in order to condition the ground line and valves as well as the external tank (ET) for cryo loading. Orbiter fuel cell power plant activation is performed.
- 05:50:00 The space shuttle main engine (SSME) liquid hydrogen chill-down sequence is initiated by the launch processing system (LPS). The liquid hydrogen recirculation valves are opened and start the liquid hydrogen recirculation pumps. As part of the chill-down sequence, the liquid hydrogen pre valves are closed and remain closed until T minus 9.5 seconds.
- 05:30:00 Liquid oxygen chill-down is complete. The liquid oxygen loading begins. The liquid oxygen loading starts with a "slow fill" in order to acclimate the ET. Slow fill continues until the tank is 2-percent full.
- 05:15:00 The liquid oxygen and liquid hydrogen slow fill is complete and the fast fill begins. The liquid oxygen and liquid hydrogen fast fill will continue until that tank is 98-percent full.
- 05:00:00 The calibration of the inertial measurement units (IMUs) starts. The three IMUs are used by the orbiter navigation systems to determine the position of the orbiter in flight.
- 04:30:00 The orbiter fuel cell power plant activation is complete.
- 04:00:00 The Merritt Island (MILA) antenna, which transmits and receives communications, telemetry and ranging information, alignment verification begins.
- 03:45:00 The liquid hydrogen fast fill to 98 percent is complete, and a slow topping-off process is begun and stabilized to 100 percent.
- 03:30:00 The liquid oxygen fast fill is complete to 98 percent.
- 03:20:00 The main propulsion system (MPS) helium tanks begin filling from 2,000 psi to their full pressure of 4,500 psi.
- 03:15:00 Liquid hydrogen stable replenishment begins and continues until just minutes prior to T minus zero.

T - (MINUS)
HR:MIN:SEC

TERMINAL COUNTDOWN EVENT

03:10:00 Liquid oxygen stable replenishment begins and continues until just minutes prior to T-0.

03:00:00 The MILA antenna alignment is completed.

03:00:00 The orbiter closeout crew goes to the launch pad and prepares the orbiter crew compartment for flight crew ingress.

03:00:00 Begin 2-hour planned hold. An inspection team examines the ET for ice or frost formation on the launch pad during this hold.
Holding

03:00:00 Two-hour planned hold ends.
Counting

02:55:00 Flight crew departs Operations and Checkout (O&C) Building for launch pad.

02:25:00 Flight crew orbiter and seat ingress occurs.

02:10:00 Post ingress software reconfiguration occurs.

02:00:00 Checking of the launch commit criteria starts at this time.

02:00:00 The ground launch sequencer (GLS) software is initialized.

01:50:00 The solid rocket boosters' (SRBs') hydraulic pumping units' gas generator heaters are turned on and the SRBs' aft skirt gaseous nitrogen purge starts.

01:50:00 The SRB rate gyro assemblies (RGAs) are turned on. The RGAs are used by the orbiter's navigation system to determine rates of motion of the SRBs during first-stage flight.

01:35:00 The orbiter accelerometer assemblies (AAs) are powered up.

01:35:00 The orbiter reaction control system (RCS) control drivers are powered up.

01:35:00 The flight crew starts the communications checks.

01:25:00 The SRB RGA torque test begins.

01:20:00 Orbiter side hatch is closed.

01:10:00 Orbiter side hatch seal and cabin leak checks are performed.

01:01:00 IMU preflight align begins. Flight crew functions from this point on will be initiated by a call from the orbiter test conductor (OTC) to proceed. The flight crew will report back to the OTC after completion.

T - (MINUS)
HR:MIN:SEC

TERMINAL COUNTDOWN EVENT

01:00:00 The orbiter RGAs and AAs are tested.

00:50:00 The flight crew starts the orbiter hydraulic auxiliary power units' (APUs') water boilers preactivation.

00:45:00 Cabin vent redundancy check is performed.

00:45:00 The GLS mainline activation is performed.

00:40:00 The eastern test range (ETR) shuttle range safety system (SRSS) terminal count closed-loop test is accomplished.

00:40:00 Cabin leak check is completed.

00:32:00 The backup flight control system (BFS) computer is configured.

00:30:00 The gaseous nitrogen system for the orbital maneuvering system (OMS) engines is pressurized for launch. Crew compartment vent valves are opened.

00:26:00 The ground pyro initiator controllers (PICs) are powered up. They are used to fire the SRB hold-down posts, liquid oxygen and liquid hydrogen tail service mast (TSM), and ET vent arm system pyros at lift-off and the SSME hydrogen gas burn system prior to SSME ignition.

00:25:00 Simultaneous air-to-ground voice communications are checked. Weather aircraft are launched.

00:22:00 The primary avionics software system (PASS) is transferred to the BFS computer in order for both systems to have the same data. In case of a PASS computer system failure, the BFS computer will take over control of the shuttle vehicle during flight.

00:21:00 The crew compartment cabin vent valves are closed.

00:20:00 A 10-minute planned hold starts.

Hold 10
Minutes All computer programs in the firing room are verified to ensure that the proper programs are available for the final countdown. The test team is briefed on the recycle options in case of an unplanned hold.

The landing convoy status is again verified and the landing sites are verified ready for launch.

The IMU preflight alignment is verified complete.

Preparations are made to transition the orbiter onboard computers to Major Mode (MM)-101 upon coming out of the hold. This configures the computer memory to a terminal countdown configuration.

T - (MINUS)
HR:MIN:SEC

TERMINAL COUNTDOWN EVENT

00:20:00 The 10-minute hold ends.

Counting Transition to MM-101. The PASS onboard computers are dumped and compared to verify the proper onboard computer configuration for launch.

00:19:00 The flight crew configures the backup computer to MM-101 and the test team verifies the BFS computer is tracking the PASS computer systems. The flight crew members configure their instruments for launch.

00:18:00 The Mission Control Center-Houston (MCC-H) now loads the onboard computers with the proper guidance parameters based on the pre-stated lift-off time.

00:16:00 The MPS helium system is reconfigured by the flight crew for launch.

00:15:00 The OMS/RCS crossfeed valves are configured for launch.

All test support team members verify they are "go for launch."

00:12:00 Emergency aircraft and personnel are verified on station.

00:10:00 All orbiter aerosurfaces and actuators are verified to be in the proper configuration for hydraulic pressure application. The NASA test director gets a "go for launch" verification from the launch team.

00:09:00 A planned 10-minute hold starts.

Hold 10
Minutes NASA and contractor project managers will be formally polled by the deputy director of NASA, Space Shuttle Operations, on the Space Shuttle Program Office communications loop during the T minus 9-minute hold. A positive "go for launch" statement will be required from each NASA and contractor project element prior to resuming the launch countdown. The loop will be recorded and maintained in the launch decision records.

All test support team members verify that they are "go for launch."

Final GLS configuration is complete.

00:09:00 The GLS auto sequence starts and the terminal countdown begins.

Counting From this point, the GLSs in the integration and backup consoles are the primary control until T-0 in conjunction with the onboard orbiter PASS redundant-set computers.

T - (MINUS)
HR:MIN:SEC

TERMINAL COUNTDOWN EVENT

- 00:09:00 Operations recorders are on. MCC-H, Johnson Space Center, sends a command to turn these recorders on. They record shuttle system performance during ascent and are dumped to the ground once orbit is achieved.
- 00:08:00 Payload and stored prelaunch commands proceed.
- 00:07:30 The orbiter access arm (OAA) connecting the access tower and the orbiter side hatch is retracted. If an emergency arises requiring flight crew activation, the arm can be extended either manually or by GLS computer control in approximately 30 seconds or less.
- 00:06:00 APU prestart occurs.
- 00:05:00 Orbiter APUs start. The orbiter APUs provide pressure to the three orbiter hydraulic systems. These systems are used to move the SSME engine nozzles and aerosurfaces.
- 00:05:00 ET/SRB range safety system (RSS) is armed. At this point, the firing circuit for SRB ignition and destruct devices is mechanically enabled by a motor-driven switch called a safe and arm device (S&A).
- 00:04:30 As a preparation for engine start, the SSME main fuel valve heaters are turned off.
- 00:04:00 The final helium purge sequence, purge sequence 4, on the SSMEs is started in preparation for engine start.
- 00:03:55 At this point, all of the elevons, body flap, speed brake, and rudder are moved through a preprogrammed pattern. This is to ensure that they will be ready for use in flight.
- 00:03:30 Transfer to internal power is done. Up to this point, power to the space vehicle has been shared between ground power supplies and the onboard fuel cells.
- The ground power is disconnected and the vehicle goes on internal power at this time. It will remain on internal power through the rest of the mission.
- 00:03:25 The SSMEs' nozzles are moved (gimbaled) through a preprogrammed pattern to ensure that they will be ready for ascent flight control. At completion of the gimbal profile, the SSMEs' nozzles are in the start position.
- 00:02:55 ET liquid oxygen prepressurization is started. At this point, the liquid oxygen tank vent valve is closed and the ET liquid oxygen tank is pressurized to its flight pressure of 21 psi.

T - (MINUS)
HR:MIN:SEC

TERMINAL COUNTDOWN EVENT

00:02:50 The gaseous oxygen arm is retracted. The cap that fits over the ET nose cone to prevent ice buildup on the oxygen vents is raised off the nose cone and retracted.

00:02:35 Up until this time, the fuel cell oxygen and hydrogen supplies have been adding to the onboard tanks so that a full load at lift-off is assured. This filling operation is terminated at this time.

00:02:30 The caution/warning memory is cleared.

00:01:57 Since the ET liquid hydrogen tank was filled, some of the liquid hydrogen has turned into gas. In order to keep pressure in the ET liquid hydrogen tank low, this gas was vented off and piped out to a flare stack and burned. In order to maintain flight level, liquid hydrogen was continuously added to the tank to replace the vented hydrogen. This operation terminates, the liquid hydrogen tank vent valve is closed, and the tank is brought up to a flight pressure of 44 psia at this time.

00:01:15 The sound suppression system will dump water onto the mobile launcher platform (MLP) at ignition in order to dampen vibration and noise in the space shuttle. The firing system for this dump, the sound suppression water power bus, is armed at this time.

00:01:00 The SRB joint heaters are deactivated.

00:00:55 The SRB MDM critical commands are verified.

00:00:47 The liquid oxygen and liquid hydrogen outboard fill and drain valves are closed.

00:00:40 The external tank bipod heaters are turned off.

00:00:38 The onboard computers position the orbiter vent doors to allow payload bay venting upon lift-off and ascent in the payload bay at SSME ignition.

The SRB forward MDM is locked out.

00:00:37 The gaseous oxygen ET arm retract is confirmed.

00:00:31 The GLS sends "go for redundant set launch sequence start." At this point, the four PASS computers take over main control of the terminal count. Only one further command is needed from the ground, "go for main engine start," at approximately T minus 9.7 seconds. The GLS in the integration console in the launch control center still continues to monitor several hundred launch commit criteria and can issue a cutoff if a discrepancy is observed. The GLS also sequences ground equipment and sends selected vehicle commands in the last 31 seconds.

T - (MINUS)
HR:MIN:SEC

TERMINAL COUNTDOWN EVENT

- 00:00:28 Two hydraulic power units in each SRB are started by the GLS. These provide hydraulic power for SRB nozzle gimbaling for ascent first-stage flight control.
- The orbiter vent door sequence starts.
- 00:00:21 The SRB gimbal profile is complete. As soon as SRB hydraulic power is applied, the SRB engine nozzles are commanded through a preprogrammed pattern to assure that they will be ready for ascent flight control during first stage.
- 00:00:21 The liquid hydrogen high-point bleed valve is closed.
- The SRB gimbal test begins.
- 00:00:18 The onboard computers arm the explosive devices, the pyrotechnic initiator controllers, that will separate the T-0 umbilicals, the SRB hold-down posts, and SRB ignition, which is the final electrical connection between the ground and the shuttle vehicle.
- 00:00:16 The sound suppression system water is activated.
- 00:00:15 If the SRB pyro initiator controller (PIC) voltage in the redundant-set launch sequencer (RSLs) is not within limits in 3 seconds, SSME start commands are not issued and the onboard computers proceed to a countdown hold.
- 00:00:13 The aft SRB MDM units are locked out. This is to protect against electrical interference during flight. The electronic lock requires an unlock command before it will accept any other command.
- SRB SRSS inhibits are removed. The SRB destruct system is now live.
- 00:00:12 The MPS helium fill is terminated. The MPS helium system flows to the pneumatic control system at each SSME inlet to control various essential functions.
- 00:00:10 LPS issues a "go" for SSME start. This is the last required ground command. The ground computers inform the orbiter onboard computers that they have a "go" for SSME start. The GLS retains hold capability until just prior to SRB ignition.
- 00:00:09.7 Liquid hydrogen recirculation pumps are turned off. The recirculation pumps provide for flow of fuel through the SSMEs during the terminal count. These are supplied by ground power and are powered in preparation for SSME start.

T - (MINUS)
HR:MIN:SEC

TERMINAL COUNTDOWN EVENT

- 00:00:09.7 In preparation for SSME ignition, flares are ignited under the SSMEs. This burns away any free gaseous hydrogen that may have collected under the SSMEs during prestart operations.
- The orbiter goes on internal cooling at this time; the ground coolant units remain powered on until lift-off as a contingency for an aborted launch. The orbiter will redistribute heat within the orbiter until approximately 125 seconds after lift-off, when the orbiter flash evaporators will be turned on.
- 00:00:09.5 The SSME engine chill-down sequence is complete and the onboard computers command the three MPS liquid hydrogen prevalues to open. (The MPSs three liquid oxygen prevalues were opened during ET tank loading to permit engine chill-down.) These valves allow liquid hydrogen and oxygen flow to the SSME turbopumps.
- 00:00:09.5 Command decoders are powered off. The command decoders are units that allow ground control of some onboard components. These units are not needed during flight.
- 00:00:06.6 The main fuel and oxidizer valves in each engine are commanded open by the onboard computers, permitting fuel and oxidizer flow into each SSME for SSME start.
- All three SSMEs are started at 120-millisecond intervals (SSME 3, 2, then 1) and throttle up to 100-percent thrust levels in 3 seconds under control of the SSME controller on each SSME.
- 00:00:04.6 All three SSMEs are verified to be at 100-percent thrust and the SSMEs are gimballed to the lift-off position. If one or more of the three SSMEs does not reach 100-percent thrust at this time, all SSMEs are shut down, the SRBs are not ignited, and an RSLs pad abort occurs. The GLS RSLs will perform shuttle and ground systems safing.
- Vehicle bending loads caused by SSME thrust buildup are allowed to initialize before SRB ignition. The vehicle moves towards ET including ET approximately 25.5 inches.
- 00:00:00 The two SRBs are ignited under command of the four onboard PASS computers, the four hold-down explosive bolts on each SRB are initiated (each bolt is 28 inches long and 3.5 inches in diameter), and the two T-0 umbilicals on each side of the spacecraft are retracted. The onboard timers are started and the ground launch sequence is terminated. All three SSMEs are at 104-percent thrust. Boost guidance in attitude hold.
- 00:00 Lift-off.

MISSION HIGHLIGHTS TIMELINE

Editor's Note: The following timeline lists selected highlights only. For full detail, please refer to the NASA Mission Operations Directorate STS-39 Flight Plan, IBSS Rendezvous Checklist, Deorbit Prep Checklist, and Entry Checklist.

| <u>T+ (PLUS)</u> <u>DAY/</u> <u>HR:MIN:SEC</u> | <u>EVENT</u> |
|--|---|
| <u>DAY ZERO</u> | |
| 0/00:00:06.8 | Tower is cleared (SRBs above lightning-rod tower). |
| 0/00:00:09 | Positive roll maneuver (right-clockwise) is started. Pitch profile is heads down (astronauts), wings level. |
| 0/00:00:16 | Roll maneuver ends. |
| 0/00:00:20 | All three SSMEs throttle down from 104 to 93 percent for maximum aerodynamic load (max q). |
| 0/00:00:29 | All three SSMEs throttle down from 93 to 70 percent for max q. |
| 0/00:01:01 | All three SSMEs throttle to 104 percent. |
| 0/00:01:02 | Max q occurs. |
| 0/00:02:06 | SRBs separate. |

When chamber pressure (P_c) of the SRBs is less than 50 psi, automatic separation occurs with manual flight crew backup switch to the automatic function (does not bypass automatic circuitry). SRBs descend to approximately 15,400 feet, when the nose cap is jettisoned and drogue chute is deployed for initial deceleration. At approximately 6,600 feet, drogue chute is released and three main parachutes on each SRB provide final deceleration prior to splashdown in Atlantic Ocean, where the SRBs are recovered for reuse on another mission. Flight control system switches from SRB to orbiter RGAs.

T+ (PLUS)
DAY/
HR:MIN:SEC

EVENT

0/00:04:08 Negative return. The vehicle is no longer capable of return-to-launch site abort at Kennedy Space Center runway.

0/00:06:54 Single engine press to main engine cutoff (MECO).

0/00:07:32 All three SSMEs throttle down from 104 percent-- vehicle acceleration capability no greater than 3g's.

0/00:08:31 All three SSMEs throttle down to 70 percent for MECO.

0/00:08:33 MECO occurs at approximate velocity 25,803 feet per second, 137 by 24 nautical miles (158 by 28 statute miles).

0/00:08:51 ET separation is automatic with flight crew manual backup switch to the automatic function (does not bypass automatic circuitry).

The orbiter forward and aft RCSs, which provide attitude hold and negative Z translation of 11 fps to the orbiter for ET separation, are first used.

Orbiter/ET liquid oxygen/liquid hydrogen umbilicals are retracted.

Negative Z translation is complete.

In conjunction with this thrusting period, approximately 1,700 pounds of liquid hydrogen and 3,700 pounds of liquid oxygen are trapped in the MPS ducts and SSMEs, which results in an approximate 7-inch center-of-gravity shift in the orbiter. The trapped propellants would sporadically vent in orbit, affecting guidance and creating contaminants for the payloads. During entry, liquid hydrogen could combine with atmospheric oxygen to form a potentially explosive mixture. As a result, the liquid oxygen is dumped out through the SSME combustion chamber nozzles, and the liquid hydrogen is dumped out through the right-hand T-minus-zero umbilical overboard fill and drain valves.

MPS dump terminates.

APUs shut down.

MPS vacuum inerting occurs.

--Remaining residual propellants are vented to space vacuum, inerting the MPS.

T+ (PLUS)
DAY/
HR:MIN:SEC

EVENT

--Orbiter/ET umbilical doors close (one door for liquid hydrogen and one door for liquid oxygen) at bottom of aft fuselage, sealing the aft fuselage for entry heat loads.

--MPS vacuum inerting terminates.

0/00:38 OMS-2 thrusting maneuver is performed, approximately 2 minutes, 9 seconds in duration, at 209.9 fps, 141 by 139 nautical miles.

0/00:51 Commander closes all current breakers, panel L4.

0/00:53 Mission specialist (MS) seat egress.

0/00:54 Commander and pilot configure GPCs for OPS-2.

0/00:57 MS configures preliminary middeck.

0/00:59 MS configures aft flight station.

0/01:02 MS unstows, sets up, and activates portable general service computer.

0/01:07 Pilot activates payload bus (panel R1).

0/01:10 Commander and pilot don and configure communications.

0/01:12 Pilot maneuvers vehicle to payload bay door opening attitude, biased negative Z local vertical, positive Y velocity vector attitude.

0/01:18 Commander activates radiators.

0/01:19 MS configures for payload bay door operations.

0/01:26 Orbit 2 begins.

0/01:28 Pilot opens payload bay doors.

0/01:30 Commander loads payload data interleaver decommutator format.

0/01:35 Commander switches star tracker (ST) power 2 (panel 06) to ON.

0/01:36 Mission Control Center (MCC), Houston (H), informs crew to "go for orbit operations."

| <u>T+ (PLUS)</u> <u>DAY/</u> <u>HR:MIN:SEC</u> | <u>EVENT</u> |
|--|--|
| 0/01:37 | Commander and pilot seat egress. |
| 0/01:38 | Commander and pilot clothing configuration. |
| 0/01:39 | MS clothing configuration. |
| 0/01:50 | Pilot initiates fuel cell auto purge. |
| 0/01:51 | MS activates teleprinter. |
| 0/01:52 | Commander starts post-payload bay door operations and radiator configuration. |
| 0/01:55 | MS remove and stow seats. |
| 0/01:56 | Commander starts ST self-test and opens door. |
| 0/01:57 | MS configures middeck. |
| 0/01:58 | Pilot closes main B supply water dump isolation circuit breaker, panel ML86B, opens supply water dump isolation valve, panel R12L, talkback barber pole. |
| 0/02:00 | Pilot activates auxiliary power unit steam vent heater, panel R2, boiler controller/heater, 3 to A, power, 3 to ON. |
| 0/02:00 | Blue team presleep activity. |
| 0/02:10 | Commander configures for RCS vernier control. |
| 0/02:12 | Commander and pilot configure controls for on-orbit operations. |
| 0/02:19 | MS configures remote manipulator system. |
| 0/02:21 | Pilot enables hydraulic thermal conditioning. |
| 0/02:24 | MS resets caution/warning (C/W). |
| 0/02:25 | MS unstows and installs treadmill. |
| 0/02:26 | Pilot switches APU coolant system (panel R2), APU fuel pump/valve cool, A to OFF and B to AUTO. |
| 0/02:28 | Pilot plots fuel cell performance. |
| 0/02:30 | Unstow cabin equipment. |

| <u>T+ (PLUS)</u> <u>DAY/</u> <u>HR:MIN:SEC</u> | <u>EVENT</u> |
|--|---|
| 0/02:30 | Maneuver vehicle to inertial measurement unit (IMU) alignment attitude. |
| 0/02:50 | Maneuver vehicle to +ZSI attitude. |
| 0/02:55 | Orbit 3 begins. |
| 0/03:00 | AFP-675 initialization and checkout/STP-1 activation. |
| 0/03:10 | Ku-band antenna deployment. |
| 0/03:20 | Ku-band activation. |
| 0/03:20 | Lamp and fire suppression test. |
| 0/03:30 | Blue team begins sleep period. |
| 0/03:35 | Remote manipulator system (RMS) powerup. |
| 0/03:45 | Priority power-down, group B. |
| 0/03:45 | RMS checkout. |
| 0/04:00 | RME-III activation. |
| 0/04:25 | Orbit 4 begins. |
| 0/05:05 | Maneuver vehicle to -ZSI attitude. |
| 0/05:45 | Maneuver vehicle to +ZSI attitude. |
| 0/05:45 | RMS powerdown. |
| 0/05:55 | Orbit 5 begins. |
| 0/05:55 | SPAS-II/IBSS checkout. |
| 0/07:00 | Begin AFP-675 operations. |
| 0/07:25 | Orbit 6 begins. |
| 0/08:00 | Maneuver vehicle to -ZLV, +YVW attitude. |
| 0/08:30 | Red team presleep activity. |
| 0/08:55 | Orbit 7 begins. |
| 0/09:30 | Maneuver vehicle to -ZSI attitude. |

| <u>T+ (PLUS)</u> <u>DAY/</u> <u>HR:MIN:SEC</u> | <u>EVENT</u> |
|--|--|
| 0/09:30 | Blue team post sleep activity. |
| 0/10:24 | Orbit 8 begins. |
| 0/10:30 | Red team handover to blue team. |
| 0/10:45 | Private medical conference. |
| 0/11:00 | AFP-675 operations. |
| 0/11:00 | Red team begins sleep period. |
| 0/11:54 | Orbit 9 begins. |
| 0/12:55 | Maneuver vehicle to -ZLV, +YVV attitude. |
| 0/13:23 | Orbit 10 begins. |
| 0/13:43 | Assorted AFP-675 maneuvers. |
| 0/14:53 | Orbit 11 begins. (AFP-675 operations continue). |
| 0/16:23 | Orbit 12 begins. |
| 0/17:52 | Orbit 13 begins. |
| 0/18:15 | Maneuver vehicle to -ZLV, -YVV attitude. |
| 0/19:00 | Red team post sleep activity. |
| 0/19:22 | Orbit 14 begins. |
| 0/19:58 | Gravity gradient free drift (biased +ZLV, +YVV). |
| 0/20:51 | Orbit 15 begins. |
| 0/21:40 | Blue team handover to red team. |
| 0/22:00 | CIRRIS-1A maneuver. |
| 0/22:21 | Orbit 16 begins. |
| 0/22:57 | Gravity gradient free drift (biased +XLV, +YVV) and AFP-675 (CIRRIS-1A operations). |
| 0/23:45 | Blue team presleep activity. |
| 0/23:51 | Orbit 17 begins. |

| <u>T+ (PLUS)</u> <u>DAY/</u> <u>HR:MIN:SEC</u> | <u>EVENT</u> |
|--|--|
| <u>MET DAY ONE</u> | |
| 1/00:46 | AFP-675 (FAR UV, CIRRIS-1A, and URA operations). |
| 1/01:20 | Orbit 18 begins. |
| 1/02:00 | Blue team begins sleep period. |
| 1/02:50 | Orbit 19 begins. |
| 1/03:31 | Gravity gradient free drift (biased +XLV, -YVV). |
| 1/04:20 | Orbit 20 begins. |
| 1/05:16 | AFP-675 (aurora observations). |
| 1/05:49 | Orbit 21 begins. |
| 1/07:19 | Orbit 22 begins. |
| 1/08:27 | AFP-675 (URA operations). |
| 1/08:48 | Orbit 23 begins. |
| 1/09:30 | Red team presleep activity. |
| 1/09:55 | Maneuver vehicle to IMU align attitude. |
| 1/10:00 | Blue team post sleep activity. |
| 1/10:15 | IMU align. |
| 1/10:18 | Orbit 24 begins. |
| 1/10:40 | Red team handover to blue team. |
| 1/10:55 | Private medical conference. |
| 1/11:47 | Orbit 25 begins. |
| 1/12:00 | Red team begins sleep period. |
| 1/12:21 | Gravity gradient free drift (biased +XLV, +YVV). |
| 1/12:36 | AFP-675 (CIRRIS-1A operations). |
| 1/13:17 | Orbit 26 begins. |
| 1/14:47 | Orbit 27 begins. |

| <u>T+ (PLUS)</u> <u>DAY/</u> <u>HR:MIN:SEC</u> | <u>EVENT</u> |
|--|--|
| 1/16:17 | Orbit 28 begins. |
| 1/16:19 | RCS orbit adjust burn. |
| 1/16:25 | SPAS-II deploy preparation. |
| 1/17:47 | Orbit 29 begins. |
| 1/18:05 | Maneuver vehicle to SPAS-II/IBSS initial attitude (predeploy checkout operations). |
| 1/19:16 | Orbit 30 begins. |
| 1/19:20 | RMS powerup. |
| 1/19:30 | Red team post sleep activity. |
| 1/19:45 | SPAS-II grapple. |
| 1/19:50 | Maneuver vehicle to deploy attitude. |
| 1/20:05 | Unberth SPAS-II/IBSS to low hover. |
| 1/20:25 | RMS maneuver to SPAS-II release. |
| 1/20:30 | Blue team handover to red team. |
| 1/20:45 | Orbit 31 begins. |
| 1/21:03 | SPAS-II/IBSS release, attitude control checkout. |
| 1/21:10 | SPAS-II/IBSS maneuver/separation burn to 10 km. |
| 1/21:20 | RMS powerdown. |
| 1/21:45 | Maneuver vehicle to -YLV, -ZVV attitude. |
| 1/22:15 | Orbit 32 begins. |
| 1/23:15 | Blue team presleep activity. |
| 1/23:45 | Orbit 33 begins. |

MET DAY TWO

| | |
|---------|---|
| 2/00:45 | Maneuver vehicle to OMS observation attitude. |
| 2/01:05 | OMS plume burn sequence 1. |

| <u>T+ (PLUS)</u> <u>DAY/</u> <u>HR:MIN:SEC</u> | <u>EVENT</u> |
|--|---|
| 2/01:14 | Orbit 34 begins. |
| 2/01:30 | Blue team begins sleep period. |
| 2/02:43 | Orbit 35 begins. |
| 2/03:30 | On-orbit RCS burn. |
| 2/04:13 | Orbit 36 begins. |
| 2/04:45 | SPAS-II/IBSS Earth limb scan. |
| 2/05:43 | Orbit 37 begins. |
| 2/06:15 | On-orbit RCS burn. |
| 2/07:13 | Orbit 38 begins. |
| 2/07:50 | SPAS-II/IBSS carbon dioxide Earthsweep. |
| 2/08:30 | Blue team post sleep activity. |
| 2/08:35 | Far-field operations. |
| 2/08:42 | Orbit 39 begins. |
| 2/09:30 | Red team presleep activity. |
| 2/09:50 | Red team handover to blue team. |
| 2/10:00 | Maneuver vehicle to OMS observation attitude. |
| 2/10:09 | Perform OMS burn sequences 2, 3. |
| 2/10:12 | Orbit 40 begins. |
| 2/11:00 | Maneuver vehicle to PRCS burn observation attitude. |
| 2/11:07 | Perform PRCS burn observations. |
| 2/11:30 | Maneuver vehicle to -YLC, -ZVV attitude. |
| 2/11:41 | Orbit 41 begins. |
| 2/11:45 | Private medical conference. |
| 2/12:00 | Red team begins sleep period. |
| 2/12:20 | SSP/spatial scan. |

| <u>T+ (PLUS)</u> <u>DAY/</u> <u>HR:MIN:SEC</u> | <u>EVENT</u> |
|--|--|
| 2/13:11 | Orbit 42 begins. |
| 2/14:05 | On-orbit RCS burn. |
| 2/14:07 | CRO C deployment. |
| 2/14:40 | Orbit 43 begins. |
| 2/14:50 | On-orbit RCS burn. |
| 2/16:00 | Earth limb observations. |
| 2/16:10 | Orbit 44 begins. |
| 2/17:39 | Orbit 45 begins. |
| 2/17:50 | Transition to near field. |
| 2/18:40 | SPAS-II maneuver/OFVR (IBSS). |
| 2/19:09 | Orbit 46 begins. |
| 2/20:00 | Red team post sleep activity. |
| 2/20:25 | Maneuver vehicle to OMS observation attitude. |
| 2/20:34 | OMS burn plume sequences 4, 5. |
| 2/20:38 | Orbit 47 begins. |
| 2/21:50 | RMS powerup. |
| 2/22:08 | Orbit 48 begins. |
| 2/22:10 | Blue team handover to red team. |
| 2/22:40 | Maneuver vehicle to CIV observation attitude. |
| 2/22:55 | CIV observations. |
| 2/23:15 | Blue team presleep activity. |
| 2/23:37 | Orbit 49 begins. |
| <u>MET DAY THREE</u> | |
| 3/00:20 | Maneuver vehicle to -YLV, -ZVV/end CIV operations. |

| <u>T+ (PLUS)</u> <u>DAY/</u> <u>HR:MIN:SEC</u> | <u>EVENT</u> |
|--|--|
| 3/00:50 | RMS powerdown. |
| 3/01:00 | SPAS-II/IBSS carbon dioxide Earth limb operations. |
| 3/01:07 | Orbit 50 begins. |
| 3/01:30 | Blue team begins sleep period. |
| 3/02:25 | SPAS-II CRO C observations. |
| 3/02:37 | Orbit 51 begins. |
| 3/03:00 | Maneuver vehicle to +YLV, -ZVV attitude. |
| 3/03:00 | ALFE activation. |
| 3/03:35 | On-orbit RCS burn and maneuver. |
| 3/04:07 | Orbit 52 begins. |
| 3/05:36 | Orbit 53 begins. |
| 3/06:56 | CRO B deploy. |
| 3/07:06 | Orbit 54 begins. |
| 3/07:55 | SPAS-II/IBSS Earth scan observations. |
| 3/08:00 | Commence SPAS-II retrieve rendezvous operations. |
| 3/08:25 | OFVR operations (IBSS). |
| 3/08:35 | Orbit 55 begins. |
| 3/09:20 | RMS powerup. |
| 3/09:30 | Blue team post sleep activity. |
| 3/10:05 | Orbit 56 begins. |
| 3/10:30 | CRO B observations. |
| 3/10:45 | SPAS-II safing. |
| 3/10:53 | Begin V-bar approach (final rendezvous approach). |
| 3/11:18 | SPAS-II/IBSS grapple. |
| 3/11:30 | Red team handover to blue team. |

| <u>T+ (PLUS)</u> <u>DAY/</u> <u>HR:MIN:SEC</u> | <u>EVENT</u> |
|--|---------------------------------|
| 3/11:34 | Orbit 57 begins. |
| 3/11:45 | Red team presleep activity. |
| 3/11:50 | SPAS-II berthing. |
| 3/12:00 | On-orbit RCS burn. |
| 3/12:20 | ALFE (STP-1) operations. |
| 3/12:35 | RMS powerdown. |
| 3/12:50 | On-orbit RCS burn. |
| 3/13:04 | Orbit 58 begins. |
| 3/13:05 | ALFE operations. |
| 3/13:15 | Private medical conference. |
| 3/13:22 | AFP-675 operations continue. |
| 3/13:45 | Red team begins sleep period. |
| 3/14:33 | Orbit 59 begins. |
| 3/15:08 | Gravity gradient free drift. |
| 3/16:03 | Orbit 60 begins. |
| 3/17:33 | Orbit 61 begins. |
| 3/19:03 | Orbit 62 begins. |
| 3/20:33 | Orbit 63 begins. |
| 3/21:45 | Red team post sleep activity. |
| 3/22:03 | Orbit 64 begins. |
| 3/23:32 | Orbit 65 begins. |
| 3/23:50 | Blue team handover to red team. |

MET DAY FOUR

| | |
|---------|------------------------------|
| 4/00:06 | Gravity gradient free drift. |
| 4/00:06 | AFP-675 operations. |

| <u>T+ (PLUS)</u> <u>DAY/</u> <u>HR:MIN:SEC</u> | <u>EVENT</u> |
|--|---------------------------------|
| 4/01:02 | Orbit 66 begins. |
| 4/01:15 | Blue team presleep activity. |
| 4/02:31 | Orbit 67 begins. |
| 4/03:30 | Blue team begins sleep period. |
| 4/04:01 | Orbit 68 begins. |
| 4/05:30 | Orbit 69 begins. |
| 4/06:05 | Gravity gradient free drift. |
| 4/07:00 | Orbit 70 begins. |
| 4/08:30 | Orbit 71 begins. |
| 4/09:02 | AFP-675 operations. |
| 4/09:59 | Orbit 72 begins. |
| 4/10:20 | AFP-675 operations. |
| 4/11:29 | Orbit 73 begins. |
| 4/11:30 | Blue team post sleep activity. |
| 4/12:58 | Orbit 74 begins. |
| 4/13:00 | Red team handover to blue team. |
| 4/13:15 | Red team presleep activity. |
| 4/13:30 | AFP-675 operations. |
| 4/13:35 | Private medical conference. |
| 4/14:28 | Orbit 75 begins. |
| 4/15:03 | Gravity gradient free drift. |
| 4/15:30 | Red team begins sleep period. |
| 4/15:58 | Orbit 76 begins. |
| 4/17:28 | Orbit 77 begins. |
| 4/18:57 | Orbit 78 begins. |

| <u>T+ (PLUS)</u> <u>DAY/</u> <u>HR:MIN:SEC</u> | <u>EVENT</u> |
|--|-------------------------------|
| 4/20:27 | Orbit 79 begins. |
| 4/21:15 | CRO A deployment. |
| 4/21:57 | Orbit 80 begins. |
| 4/23:27 | Orbit 81 begins. |
| 4/23:30 | Red team post sleep activity. |

MET DAY FIVE

| | |
|---------|---|
| 5/00:02 | Gravity gradient free drift. |
| 5/00:56 | Orbit 82 begins. |
| 5/02:00 | Blue team handover to red team. |
| 5/02:26 | Orbit 83 begins. |
| 5/03:10 | Gravity gradient free drift. |
| 5/03:15 | Blue team presleep activity. |
| 5/03:55 | Orbit 84 begins. |
| 5/04:30 | RMS powerup. |
| 5/05:15 | AFP-675 RMS EE glow test. |
| 5/05:25 | Orbit 85 begins. |
| 5/05:30 | Blue team begins sleep period. |
| 5/06:25 | Maneuver vehicle to SPAS-II initial attitude. |
| 5/06:55 | Orbit 86 begins. |
| 5/08:25 | Orbit 87 begins. |
| 5/08:30 | SPAS-II grapple. |
| 5/08:40 | ALFE activated. |
| 5/09:00 | SPAS-II unberth. |
| 5/09:30 | Maneuver vehicle to RMS observation start. |
| 5/09:54 | Orbit 88 begins. |

| <u>T+ (PLUS)</u> <u>DAY/</u> <u>HR:MIN:SEC</u> | <u>EVENT</u> |
|--|---|
| 5/10:05 | Maneuver vehicle to CRO observation attitude. |
| 5/10:31 | CRO A observations. |
| 5/10:35 | SPAS-II berth/safing. |
| 5/11:05 | On-orbit RCS burn. |
| 5/11:24 | Orbit 89 begins. |
| 5/11:40 | AFP-675 (CIRRIS-1A deactivation). |
| 5/12:00 | On-orbit RCS burn. |
| 5/12:30 | SPAS-II unberth. |
| 5/12:53 | Orbit 90 begins. |
| 5/13:00 | RMS maneuver to observation attitude. |
| 5/13:20 | Ground truth operations (AFP-675). |
| 5/13:30 | Blue team post sleep activity. |
| 5/14:00 | RMS maneuver to observation start (Earth limb). |
| 5/14:23 | Orbit 91 begins. |
| 5/14:30 | Private medical conference. |
| 5/14:48 | AFP-675 operations. |
| 5/15:00 | Red team handover to blue team. |
| 5/15:15 | Red team presleep activity. |
| 5/15:25 | MWIR operations. |
| 5/15:53 | Orbit 92 begins. |
| 5/17:23 | Orbit 93 begins. |
| 5/17:30 | Red team begins sleep period. |
| 5/17:50 | OFVR operations. |
| 5/18:00 | AFP-675 operations. |
| 5/18:10 | OFVR operations. |

| <u>T+ (PLUS)</u> <u>DAY/</u> <u>HR:MIN:SEC</u> | <u>EVENT</u> |
|--|----------------------------|
| 5/18:53 | Orbit 94 begins. |
| 5/19:45 | CIV operations initiation. |
| 5/20:23 | CIV gas release. |
| 5/20:23 | Orbit 95 begins. |
| 5/21:30 | AFP-675 operations. |
| 5/21:52 | Orbit 96 begins. |
| 5/23:22 | Orbit 97 begins. |

MET DAY SIX

| | |
|---------|--|
| 6/00:30 | SPAS-II berthed. |
| 6/00:52 | Orbit 98 begins. |
| 6/01:15 | RMS powerdown. |
| 6/01:30 | Red team post sleep activity. |
| 6/02:22 | Orbit 99 begins. |
| 6/03:52 | Orbit 100 begins. |
| 6/04:00 | Blue team handover to red team. |
| 6/04:13 | AFP-675 operations (aurora, airglow, FAR UV, and URA). |
| 6/05:15 | Blue team presleep activity. |
| 6/05:21 | Orbit 101 begins. |
| 6/06:51 | Orbit 102 begins. |
| 6/07:30 | Blue team begins sleep period. |
| 6/08:21 | Orbit 103 begins. |
| 6/09:50 | Orbit 104 begins. |
| 6/11:20 | Orbit 105 begins. |
| 6/12:50 | Orbit 106 begins. |
| 6/14:20 | Orbit 107 begins. |

| <u>T+ (PLUS)</u> <u>DAY/</u> <u>HR:MIN:SEC</u> | <u>EVENT</u> |
|--|---------------------------------|
| 6/15:30 | Blue team post sleep activity. |
| 6/15:50 | Orbit 108 begins. |
| 6/16:00 | Red team presleep activity. |
| 6/16:45 | Private medical conference. |
| 6/17:00 | Red team handover to blue team. |
| 6/17:15 | AFP-675 operations. |
| 6/17:19 | Orbit 109 begins. |
| 6/18:30 | Red team begins sleep period. |
| 6/18:49 | Orbit 110 begins. |
| 6/20:19 | Orbit 111 begins. |
| 6/21:48 | Orbit 112 begins. |
| 6/23:18 | Orbit 113 begins. |

MET DAY SEVEN

| | |
|---------|---|
| 7/00:48 | Orbit 114 begins. |
| 7/02:18 | Orbit 115 begins. |
| 7/02:30 | Red team post sleep activity. |
| 7/03:45 | Reaction jet driver reconfiguration and APU steam vent heater initiation. |
| 7/03:47 | Orbit 116 begins. |
| 7/04:00 | Blue team handover to red team. |
| 7/04:30 | Crew press conference |
| 7/04:45 | Flight control system checkout. |
| 7/05:17 | Orbit 117 begins. |
| 7/06:10 | RCS hot fire test. |
| 7/06:47 | Orbit 118 begins. |

| <u>T+ (PLUS)</u> <u>DAY/</u> <u>HR:MIN:SEC</u> | <u>EVENT</u> |
|--|--|
| 7/07:15 | Blue team presleep activity. |
| 7/08:17 | Orbit 119 begins. |
| 7/09:30 | Blue team begins sleep period. |
| 7/09:47 | Orbit 120 begins. |
| 7/11:00 | STP-1 operations (UVLIM, SKIRT). |
| 7/11:16 | Orbit 121 begins. |
| 7/11:53 | UVLIM limb scan. |
| 7/12:46 | Orbit 122 begins. |
| 7/14:16 | Orbit 123 begins. |
| 7/15:33 | SKIRT CVF inertial. |
| 7/15:45 | Orbit 124 begins. |
| 7/15:45 | FAR UV and HUP deactivation (AFP-675). |
| 7/16:00 | Red team presleep activity. |
| 7/16:10 | Gravity gradient free drift. |
| 7/16:30 | ALFE operations. |
| 7/17:15 | Orbit 125 begins. |
| 7/17:30 | Blue team post sleep activity. |
| 7/17:45 | Private medical conference. |
| 7/18:00 | Red team handover to blue team. |
| 7/18:10 | STP-1/ALFE operations. |
| 7/18:29 | SKIRT CVF inertial. |
| 7/18:30 | Red team begins sleep period. |
| 7/18:45 | Orbit 126 begins. |
| 7/19:20 | URA, QINMS deactivation (AFP-675). |
| 7/19:25 | UVLIM limb scan. |

| <u>T+ (PLUS)</u> <u>DAY/</u> <u>HR:MIN:SEC</u> | <u>EVENT</u> |
|--|---|
| 7/19:59 | SKIRT CVF inertial. |
| 7/20:15 | Orbit 127 begins. |
| 7/20:35 | Maneuver vehicle to MPEC deploy attitude. |
| 7/21:00 | MPEC deployment. |
| 7/21:44 | Orbit 128 begins. |
| 7/22:00 | Ku-band stow. |
| 7/23:14 | Orbit 129 begins. |
| 7/23:25 | Cabin configuration/stow. |

MET DAY EIGHT

| | |
|---------|---|
| 8/00:30 | Red team post sleep activity. |
| 8/00:43 | Orbit 130 begins. |
| 8/01:00 | Maneuver vehicle to -XSI attitude. |
| 8/02:00 | Private medical conference. |
| 8/02:13 | Orbit 131 begins. |
| 8/02:15 | Priority Group B powerup. |
| 8/02:15 | STP-1 deactivation. |
| 8/02:25 | AFP-675 deactivation. |
| 8/02:28 | CRT timer setup. |
| 8/02:33 | Commander initiates coldsoak. |
| 8/02:43 | Stow radiators, if required. |
| 8/03:01 | Commander configures DPS for deorbit preparation. |
| 8/03:04 | Mission Control Center updates IMU star pad, if required. |
| 8/03:13 | MS configures for payload bay door closure. |
| 8/03:23 | Pilot stows Ku-band antennae, if required. |
| 8/03:31 | Commander maneuvers vehicle to IMU align attitude. |

| <u>T+ (PLUS)</u> <u>DAY/</u> <u>HR:MIN:SEC</u> | <u>EVENT</u> |
|--|--|
| 8/03:41 | MCC-H gives "go/no-go" command for payload bay door closure. |
| 8/03:43 | Orbit 132 begins. |
| 8/03:45 | Commander and MS align IMU using ST. |
| 8/03:48 | Pilot and MS close payload bay doors. |
| 8/04:08 | Commander and pilot configure dedicated displays for entry. |
| 8/04:11 | MCC gives the crew the "go" for OPS 3. |
| 8/04:14 | Maneuver vehicle to Comm attitude. |
| 8/04:18 | Pilot starts repressurization of SSME systems. |
| 8/04:23 | Commander and pilot perform DPS entry configuration. |
| 8/04:32 | MS deactivates ST and closes ST doors. |
| 8/04:34 | Verify entry payload switch list. |
| 8/04:48 | Crew reviews entry. |
| 8/04:51 | Crew begins fluid loading, 32 fluid ounces of water with salt over next 1.5 hours (2 salt tablets per 8 ounces). |
| 8/05:03 | Commander and pilot configure clothing. |
| 8/05:13 | Orbit 133 begins. |
| 8/05:18 | MS configure clothing. |
| 8/05:28 | Commander and pilot seat ingress. |
| 8/05:30 | Commander and pilot set up heads-up display (HUD). |
| 8/05:32 | Commander and pilot adjust seat, exercise brake pedals. |
| 8/05:40 | Final entry deorbit update/uplink. |
| 8/05:46 | OMS thrust vector control gimbal check is performed. |
| 8/05:48 | APU prestart. |

| <u>T+ (PLUS)</u> <u>DAY/</u> <u>HR:MIN:SEC</u> | <u>EVENT</u> |
|--|---|
| 8/06:03 | Close vent doors. |
| 8/06:06 | MCC-H gives "go" for deorbit thrusting period. |
| 8/06:12 | Maneuver vehicle to deorbit thrusting attitude. |
| 8/06:13 | MS ingress seats. |
| 8/06:22 | First APU is activated. |
| 8/06:28 | Deorbit thrusting period, 3 minutes, 13 seconds in duration, 271 fps. |
| 8/06:32 | Initiate post-deorbit thrusting period attitude. |
| 8/06:32 | Dump forward RCS, if required. |
| 8/06:36 | Terminate post-deorbit thrusting attitude. |
| 8/06:40 | Activate remaining APUs. |
| 8/06:52 | Entry interface, 400,000 feet altitude. |
| 8/06:55 | Enter communication blackout. |
| 8/06:57 | Automatically deactivate RCS roll thrusters. |
| 8/07:05 | Initiate preprogrammed test inputs. |
| 8/07:05 | Automatically deactivate RCS pitch thrusters. |
| 8/07:06 | Altitude 200,000 feet. |
| 8/07:09 | Initiate first roll reversal. |
| 8/07:11 | Exit communications blackout. |
| 8/07:13 | Initiate second roll reversal. |
| 8/07:15 | Initiate ammonia boilers. |
| 8/07:16 | Altitude 100,000 feet. |
| 8/07:16 | Initiate air data system (ADS) probe deploy. |
| 8/07:16 | Initiate third roll reversal. |
| 8/07:17 | Begin entry/terminal area energy management (TAEM). |
| 8/07:18 | Initiate payload bay venting. |

T+ (PLUS)
DAY/
HR:MIN:SEC

EVENT

| | |
|---------|---|
| 8/07:20 | Automatically deactivate RCS yaw thrusters. |
| 8/07:22 | Begin TAEM/approach/landing (A/L) interface. |
| 8/07:23 | Initiate landing gear deployment. |
| 8/07:24 | Vehicle has weight on main landing gear. |
| 8/07:24 | Vehicle has weight on nose landing gear. |
| 8/07:24 | Initiate main landing gear braking. |
| 8/07:24 | Wheel stop. |
| 8/07:38 | Flight crew safes OMS/RCS. |
| 8/07:41 | Sniff checks are performed. |
| 8/07:43 | Aft vehicles are positioned. |
| 8/07:53 | Ground purge unit (transport) is connected to right-hand (starboard) T-0 orbiter umbilical, and ground cooling unit (transporter) is connected to left-hand (port) T-0 orbiter umbilical. |
| 8/07:53 | Crew compartment side hatch access vehicle is positioned. |
| 8/08:00 | Orbiter crew egress/ingress side hatch is opened. |
| 8/08:28 | Orbiter flight crew and ground crew exchange. |

GLOSSARY

AA accelerometer assembly
ADS air data system
AFP Air Force Program
ALFE Advanced Liquid Feed Experiment
APM ascent particle monitor
APU auxiliary power unit

BFS backup flight control system

CIRRIS Cryogenic Infrared Radiance Instrument for Shuttle
CIV Critical Ionization Velocity
CLOUDS Cloud Logic To Optimize Use of Defense Systems
CRO Chemical Release Observation
CRT cathode-ray tube
C/W caution/warning

DAP digital autopilot
DDS data display system
DOD Department of Defense
DPS data processing system
DSE Data System Experiment
DSO detailed supplementary objective
DTO detailed test objective

EAFB Edwards Air Force Base
ESS experiment support structure
ET external tank
ETR Eastern Test Range
EV extravehicular
EVA extravehicular activity

FAR UV Far Ultraviolet Camera
FDF flight data file
fps feet per second

GAS get-away special
GLS ground launch sequencer
GPC general-purpose computer

HUD head-up display
HUP Horizon Ultraviolet Program

IBSS Infrared Background Signature Survey
IMU inertial measurement unit
IV intravehicular

JSC Johnson Space Center

kpbs kilobits per second
KSC Kennedy Space Center

LCD liquid crystal display
LPS launch processing system

MCC-H Mission Control Center-Houston
MDM multiplexer/demultiplexer
MECO main engine cutoff
MET mission elapsed time
MILA Merritt Island antenna
MLP mobile launcher platform
MM major mode
MOD Mission Operations Directorate
MPEC Multi-Purpose Experiment Canister
MPS main propulsion system
MS mission specialist
MSFC Marshall Space Flight Center

NCC normal corrective combination maneuver
NH normal height adjust maneuver
nmi nautical mile
NOR Northrup Strip

O&C operations and checkout
OAA orbiter access arm
OMS orbital maneuvering system
OV orbiter vehicle

PASS primary avionics software system
PDI payload data interleaver
PIC pyro initiator controller
PL payload
POCC Payload Operations Control Center
PRCS primary reaction control system
PS payload specialist
PTI preprogrammed test input

QINMS Quadrapole Ion Neutral Mass Spectrometer

RCS reaction control system
RGA rate gyro assembly
RME radiation monitoring equipment
RMS remote manipulator system
RSLs redundant-set launch sequencer
RSS range safety system
RTLs return to launch site

| | |
|-------|---|
| S&A | safe and arm |
| SDI | Strategic Defense Initiative |
| SDIO | Strategic Defense Initiative Organization |
| SKIRT | Shuttle Kinetic Infrared Test |
| sm | statute mile |
| SPAS | Shuttle Pallet Satellite |
| SRB | solid rocket booster |
| SRSS | shuttle range safety system |
| SSME | space shuttle main engine |
| ST | star tracker |
| STIC | Space Test Integration Contract |
| STP | Space Test Payload |
| STS | space transportation system |
| | |
| TACAN | tactical air navigation |
| TAEM | terminal area energy management |
| TAL | transatlantic landing |
| TI | terminal phase initiation |
| TIG | time of ignition |
| TPI | terminal phase initiation maneuver |
| TSM | tail service mast |
| TV | television |
| | |
| URA | Uniformly Redundant Array |
| UVLIM | Ultraviolet Limb Measurement |
| | |
| VTR | videotape recorder |
| | |
| WCS | waste collection system |

