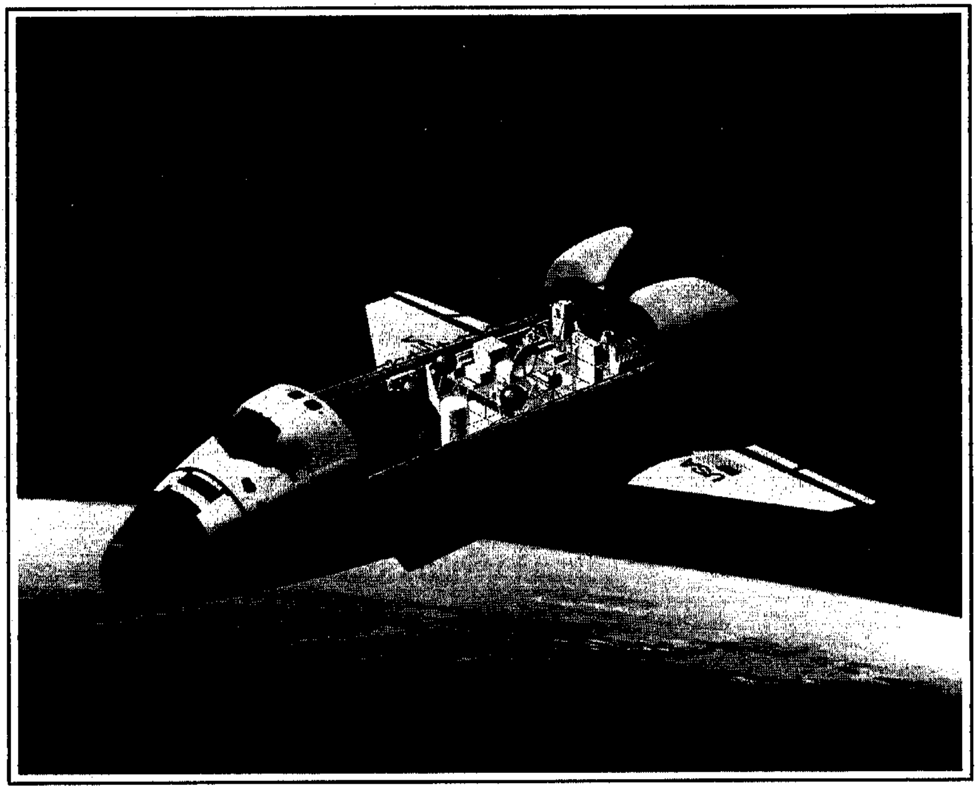

STS-45

PRESS INFORMATION

March 1992

Rockwell International
Space Systems Division

Office of Media Relations

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CONTENTS

MISSION OVERVIEW

This is the 11th flight of Atlantis and the 46th for the space shuttle.

The flight crew for the STS-45 mission is commander Charles F. Bolden; pilot Brian Duffy; mission specialists Kathryn (Kathy) D. Sullivan, David (Dave) C. Leestma, and C. Michael (Mike) Foale; and payload specialists D. Dirk Frimout of the European Space Agency and Byron K. Lichtenberg. The crew will be divided into a blue team, consisting of Duffy, Sullivan, and Frimout, and a red team, comprising Leestma, Foale, and Lichtenberg. Bolden is not assigned to a team and is free to adjust his hours, as necessary. Each team will work consecutive 12-hour shifts, providing for around-the-clock operations.

STS-45's primary mission objective is to provide the orbiter Atlantis and the Spacelab pallet as a science platform for experiments on the Atmospheric Laboratory for Applications and Science (ATLAS) 1 payload. ATLAS-1's objective is to conduct science investigations to measure the variation in solar output and its effect on the Earth's atmosphere. It consists of a series of 12 atmospheric physics, solar physics, space plasma physics, and astronomy experiments.

Atmospheric Physics

- Atmospheric Trace Molecule Spectroscopy (ATMOS) will map trace molecules in the middle atmosphere by measuring the absorption of infrared radiation. The sunlight that passes through the Earth's atmosphere during orbital sunrises and sunsets will be recorded. The wavelengths of light will identify molecules and their locations.

- Millimeter Wave Atmospheric Sounder (MAS) will make simultaneous measurements of day/night concentrations of ozone, middle atmosphere temperature, and trace molecules involved in the creation/destruction of ozone.

- Atmospheric Lyman-Alpha Emissions (ALAE) will spectroscopically measure common hydrogen and deuterium in the terrestrial atmosphere in order to understand the evolution of atmospheres and their dynamics.

- Grille Spectrometer will study global atmospheric composition between 9 miles and 90 miles. High-resolution infrared spectroscopy measurements are made primarily in solar occultation.

- Imaging Spectrometric Observatory (ISO) will determine upper atmosphere photochemistry, composition of energetics, and stratospheric OH by emission spectroscopy. ISO will measure airglow over a wavelength range extending from extreme ultraviolet to near infrared.

- Energetic Neutral Atom Precipitation (ENAP) will measure faint emissions at nighttime arising from fluxes of energetic neutral atoms in the thermosphere. ENAP measurements will be made using the ISO hardware.

Solar Physics

- Active Cavity Radiometer (ACR) and Solar Constant (SOLCON) will use precise instruments to measure ultraviolet light through infrared radiation. Through slightly different techniques, each experiment will determine a value for the solar constant, and the values will be compared. Instrument accuracy and solar variations will be determined.

- Solar Spectrum (SOLSPEC) will measure ultraviolet through infrared solar radiation to determine how the amounts of these energies change over time and where they are absorbed in the atmosphere.

- Solar Ultraviolet Spectral Irradiance Monitor (SUSIM) will determine both long-term and short-term variations of the total ultraviolet flux emitted by the sun.

Space Plasma Physics

- Atmospheric Emissions and Photometric Imaging (AEPI) will study selected atmospheric phenomena, together with natural and artificial auroras. It will use visible imaging with a Z-axis gimbaled photometer.

- Space Experiments With Particle Accelerators (SEPAC) will carry out active experiments on Earth's ionosphere and magnetosphere including vehicle charge neutralization, beam plasma physics, and beam-ionosphere interactions.

Astronomy

- Far Ultraviolet Space Telescope (FAUST) will observe faint astronomical sources in the far ultraviolet (extended and point sources).

STS-45 is the first Spacelab mission dedicated to NASA's Mission to Planet Earth, a large-scale, unified study of Earth as a single dynamic system. ATLAS-1 represents the first of up to nine ATLAS missions to study the composition of the middle atmosphere and its possible variations due to solar changes over the course of an 11-year solar cycle. During that period, solar flares, sunspots, and other magnetic activity in the sun change from one extreme to the other and back. Throughout the ATLAS series, scientists will gather new information to better understand how the atmosphere reacts to natural and human-induced atmospheric changes. The knowledge will help man identify measures that will keep Earth suitable for life for future generations.

ATLAS-1 instruments were originally flown on the Spacelab 1 and Spacelab 3 missions, demonstrating the shuttle's capability to return sophisticated instruments to the ground for refurbishment and updating and to refly multimission instruments at intervals required by their scientific goals.

ATLAS-1 is a NASA mission with an international payload; the European Space Agency provides operational support for the European investigations. ATLAS is managed by NASA's Marshall Space Flight Center, Huntsville, Ala.

Secondary objectives for STS-45 include the following: Shuttle Solar Backscatter Ultraviolet (SSBUV) 4 experiment; Space Tissue Loss (STL) 1; Radiation Monitoring Equipment (RME) III; Visual Function Tester (VFT) II; Cloud Logic To Optimize Use of Defense Systems (CLOUDS) 1A; getaway special experiment G-229; Investigations Into Polymer Membrane Processing (IPMP); Shuttle Amateur Radio Experiment (SAREX) II; and the Ultraviolet Plume Instrument (UVPI), a payload of opportunity.

The SSBUV-4 experiment, managed by NASA's Goddard Space Flight Center, will provide readings of global ozone to aid in the calibration of solar backscatter ultraviolet instruments being flown concurrently on free-flying satellites, including the Upper Atmosphere Research Satellite.

STL-1 is an Air Force experiment designed to study the effects of weightlessness on body tissues. Drugs to prevent tissue loss will be tested to determine their effectiveness.

Attached cargo operations will be performed with one getaway special (GAS) canister experiment, G-229, sponsored by GTE Laboratories. It will compare gallium arsenide crystals melted and regrown in space with those grown on Earth under a variety of conditions that modify convective effects.

The research objective of the IPMP payload, sponsored by the Battelle Advanced Materials Center, a NASA center for the commercial development of space, is to investigate the formation of polymer membranes in microgravity. IPMP research could lead to possible advances in filtering technologies.

SAREX-II, sponsored by NASA, the American Radio Relay League/Amateur Radio Satellite Corporation, and the Johnson Space Center Amateur Radio Club, will establish crew voice communication with amateur radio stations within the line of sight of the orbiter.

VFT-II is an Air Force experiment that will study the effects of weightlessness on human vision. The crew will look into a hand-held, battery-powered testing device.

RME-III, also sponsored by the Air Force, will measure the ionizing radiation levels in the orbiter crew compartment.

CLOUDS-1A is a DOD-sponsored payload that will quantify variations in apparent cloud cover as a function of the angle at which clouds of various types are viewed and develop meteorological observation models for various cloud formations. The data will be used to provide a more efficient assessment of relevant cloud characteristics that impact DOD systems.

The UVPI is a DOD payload of opportunity located on the Low-Power Atmospheric Compensation Experiment (LACE) satellite, a Strategic Defense Initiative Organization satellite in low Earth orbit. UVPI's sensors will be trained on the orbiter to obtain imagery and/or signature data to calibrate the sensors and to observe orbiter jet firings during cooperative encounters of the orbiter with the LACE satellite.

Ten detailed test objectives and 14 detailed supplementary objectives are scheduled to be flown on STS-45.

Mission Insignia

MISSION STATISTICS

Vehicle: Atlantis (OV-104), 11th flight

Launch Date/Time:

3/23/92 8:01 a.m., EST
7:01 a.m., CST
5:01 a.m., PST

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

Launch Window: 2 hours, 30 minutes

Mission Duration: 7 days, 22 hours, 7 minutes

Landing: Nominal end-of-mission landing on orbit 127

3/31/92 6:08 a.m., EST
5:08 a.m., CST
3:08 a.m., PST

Runway: Nominal end-of-mission landing on runway 15, Kennedy Space Center, Fla. Weather alternates are Edwards Air Force Base (EAFB), Calif., and Northrup Strip (NOR), White Sands, N.M.

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

Return to Launch Site: KSC

Abort-Once-Around: NOR; alternate is EAFB

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: 160-nautical-mile (184-statute-mile) circular orbit

Space Shuttle Main Engine Thrust Level During Ascent: 104 percent

Space Shuttle Main Engine Locations:

No. 1 position: Engine 2024
No. 2 position: Engine 2012
No. 3 position: Engine 2028

Total Lift-off Weight: Approximately 4,500,696 pounds

Orbiter Weight, Including Cargo, at Lift-off: Approximately 233,069 pounds

Orbiter (Atlantis) Empty, and 3 SSMEs: Approximately 172,293 pounds

Payload Weight Up: Approximately 17,734 pounds

Payload Weight Down: Approximately 17,734 pounds

Orbiter Weight at Landing: Approximately 205,276 pounds

Payloads—Payload Bay (*denotes primary payload): Atmospheric Laboratory for Applications and Science (ATLAS) 1,* Shuttle Solar Backscatter Ultraviolet (SSBUV) 4, getaway special experiment G-229

Payloads—Middeck: Space Tissue Loss (STL) 1, Radiation Monitoring Equipment (RME) III, Visual Function Tester (VFT) II, Cloud Logic To Optimize Use of Defense Systems (CLOUDS) 1A, Investigations Into Polymer Membrane Processing (IPMP), Shuttle Amateur Radio Experiment (SAREX) II

Flight Crew Members:

Commander: Charles F. Bolden, third space shuttle flight

The commander is not assigned to a team and may adjust his hours, as necessary.

Blue Team:

Pilot: Brian Duffy, first space shuttle flight

Mission Specialist 1: Kathryn (Kathy) D. Sullivan, third space shuttle flight

Payload Specialist 1: D. Dirk Frimout, European Space Agency, first space shuttle flight

Red Team:

Mission Specialist 2: David (Dave) C. Leestma, third space shuttle flight

Mission Specialist 3: C. Michael (Mike) Foale, first space shuttle flight

Payload Specialist 2: Byron K. Lichtenberg, second space shuttle flight

Each team works approximately 12 hours followed by 12 hours off duty. Bolden, Duffy, and Leestma make up the orbiter crew, which will operate the shuttle and Spacelab systems monitored by the Mission Control Center at Johnson Space Center (JSC). Sullivan, Frimout, Foale, and Lichtenberg form the science crew, which will operate the ATLAS-1 experiments monitored by the Payload Operations Control Center at Marshall Space Flight Center (MSFC).

Ascent Seating:

Flight deck, front left seat, commander Charles F. Bolden
Flight deck, front right seat, pilot Brian Duffy
Flight deck, aft center seat, mission specialist David (Dave) C. Leestma
Flight deck, aft right seat, mission specialist C. Michael (Mike) Foale
Middeck, mission specialist Kathryn (Kathy) D. Sullivan
Middeck, payload specialist D. Dirk Frimout
Middeck, payload specialist Byron K. Lichtenberg

Entry Seating:

Flight deck, front left seat, commander Charles F. Bolden
Flight deck, front right seat, pilot Brian Duffy
Flight deck, aft center seat, mission specialist Kathryn (Kathy) D. Sullivan
Flight deck, aft right seat, mission specialist David (Dave) C. Leestma
Middeck, mission specialist C. Michael (Mike) Foale
Middeck, payload specialist D. Dirk Frimout
Middeck, payload specialist Byron K. Lichtenberg

Extravehicular Activity Crew Members, If Required:

Extravehicular (EV) astronaut 1: Kathryn (Kathy) D. Sullivan
EV-2: C. Michael (Mike) Foale

Intravehicular Astronaut: David (Dave) C. Leestma

STS-45 Flight Directors:

Ascent/Entry: Jeff Bantle
Orbit 1 Team: Bob Castle
Orbit 2 Team (lead): Rob Kelso
Orbit 3 Team: Linda Ham

Entry: Automatic mode until subsonic, then control stick steering

Notes:

- The remote manipulator system is not installed in Atlantis's payload bay for this mission
- The gally is installed in Atlantis's middeck
- CLOUDS-1A observation opportunities will be evaluated in real time for the actual flight profile
- Exercise for the payload specialists is scheduled once mid-flight and once near the end of flight

MISSION OBJECTIVES

- Primary Payload
  - — Atmospheric Laboratory for Applications and Science (ATLAS) 1
- Secondary Payloads
  - — Payload Bay
    - Shuttle Solar Backscatter Ultraviolet (SSBUV) 4
    - Getaway special experiment G-229
  - — Middeck
    - Space Tissue Loss (STL) 1
    - Radiation Monitoring Equipment (RME) III
    - Visual Function Tester (VFT) II
    - Cloud Logic To Optimize Use of Defense Systems (CLOUDS) 1A
    - Investigations Into Polymer Membrane Processing (IPMP)
    - Shuttle Amateur Radio Experiment (SAREX) II
- Development Test Objectives/Detailed Supplementary Objectives

FLIGHT ACTIVITIES OVERVIEW

Flight Day 1

Launch
OMS-2
Unstow cabin
Priority Group B powerdown
Spacelab activation
Payload activation
SAREX setup
STL-1 initiation
RME-III activation
SAREX operations
Group A GAS
VFT-II operations
SSBUV activation
RCS burn
ATLAS-1 operations

Flight Day 2

ATLAS-1 operations
VFT-II operations
SAREX operations

Flight Day 3

ATLAS-1 operations
IPMP operations
VFT-II operations
SAREX operations
RCS burn

Flight Day 4

ATLAS-1 operations
VFT-II operations
SAREX operations
Group B GAS

Flight Day 5

ATLAS-1 operations
VFT-II operations

Flight Day 6

ATLAS-1 operations
VFT-II operations
SAREX operations
RCS burn

Flight Day 7

ATLAS-1 operations
VFT-II operations
Crew press conference
RCS hot-fire test
FCS checkout

Flight Day 8

ATLAS-1 operations
VFT-II operations
Payload deactivation
Cabin stow
Spacelab deactivation
SSBUV deactivation

Priority Group B powerup
Deorbit preparation
Deorbit burn
Landing

Notes:

Each flight day includes a number of scheduled housekeeping activities. These include inertial measurement unit alignment, supply water dumps (as required), waste water dumps (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 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 Atlantis's four CRTs, placing three of Atlantis's five general-purpose computers on standby, placing one of Atlantis's three inertial measurement units on standby mode, and powering off three of Atlantis's eight flight-critical multiplexers (two forward, one aft).

STS-45 CREW ASSIGNMENTS

* Denotes primary responsibility

Commander (Charles F. Bolden):

Overall mission decisions
Orbiter—APU/hydraulics, caution and warning, DPS,* ECLSS,* FDF, GN&C,* IFM, medical, OMS/RCS
Payload—VFT, IPMP, CLOUDS,* G-229
DTOs/DSOs—DTO 623; DSOs 317, 473, 603B, 608, 611, 614, and 621

Pilot (Brian Duffy):

Orbiter—APU/hydraulics,* caution and warning,* communications/instrumentation,* EPS,* FDF,* GN&C, mechanical, medical, MPS,* OMS/RCS*, PGSC
Payload—SSBUV, RME, VFT, IPMP,* SAREX*
DTOs/DSOs—DTO 728;* DSOs 473, 611, 613, and 614
Other—Earth observations

Mission Specialist 1 (Kathryn [Kathy] D. Sullivan):

Orbiter—crew equipment,* photo/TV
Payload—ATLAS,* STL*
DTOs/DSOs—DTOs 633 and 648*; DSOs 473, 603B, 614, and 621
Other—Earth observations,* extravehicular astronaut

Mission Specialist 2 (David [Dave] C. Leestma):

Orbiter—communications/instrumentation, DPS, ECLSS, EPS, IFM,* mechanical,* medical,* MPS, photo/TV*
Payload—SSBUV,* VFT, SAREX, CLOUDS, G-229*
DTOs/DSOs—DTOs 623, 633,* and 648; DSOs 473, 611, 612, and 621
Other—Earth observations, intravehicular astronaut*

Mission Specialist 3 (C. Michael [Mike] Foale):

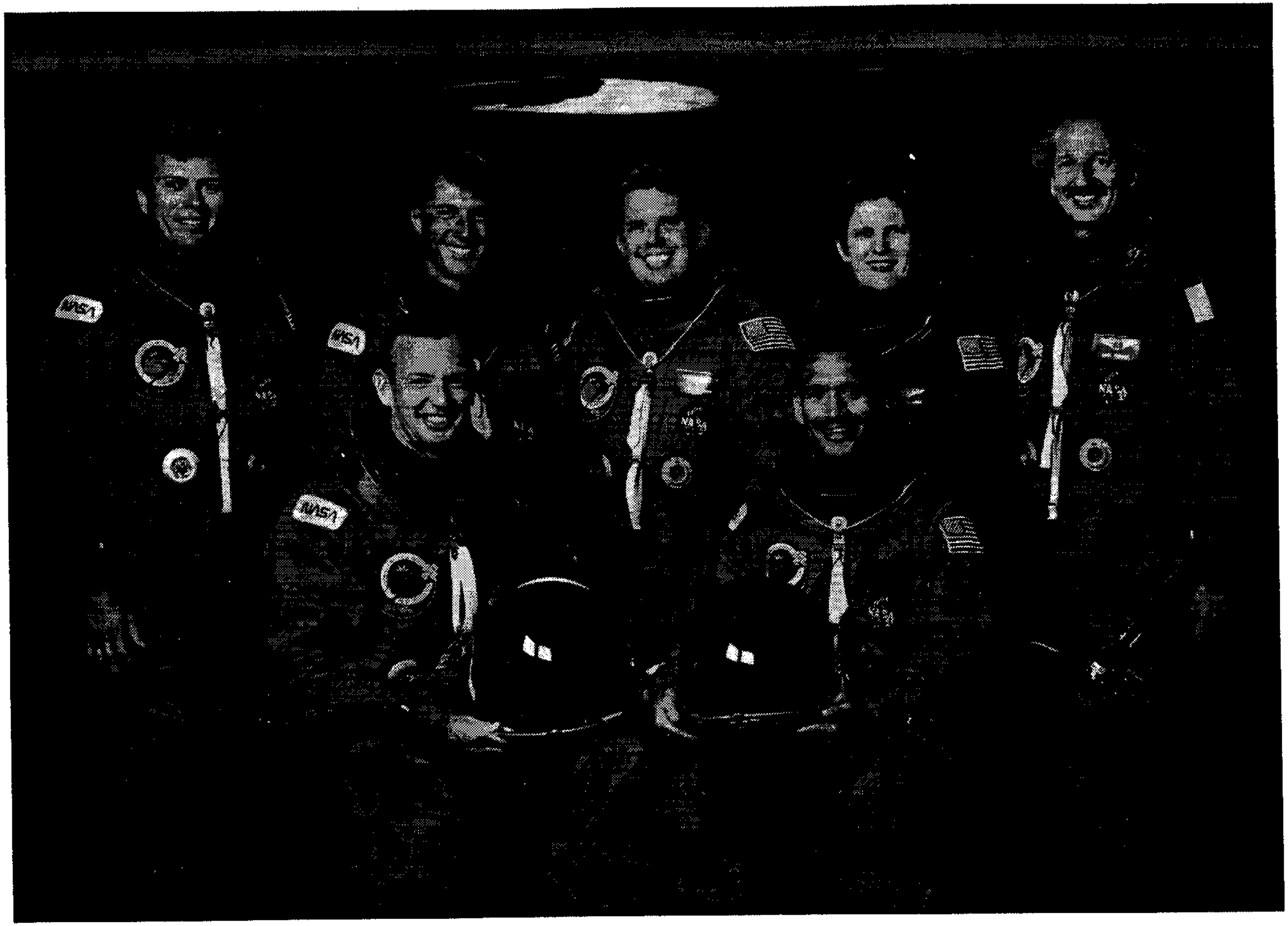
Orbiter—crew equipment, IFM, PGSC
Payload—ATLAS, STL, RME,* VFT*
DTOs/DSOs—DTO 728; DSO 417, 473, 603B, and 621
Other—extravehicular astronaut

Payload Specialist 1 (D. Dirk Frimout):

Payload—ATLAS
DTOs/DSOs—DSOs 473, 604, 607, 612, 613, and 621

Payload Specialist 2 (Byron K. Lichtenberg):

Payload—ATLAS
DTOs/DSOs—DSOs 473, 603B, 604, 614, and 621



Members of the STS-45 crew (front row, from left) are mission commander Charles F. Bolden and pilot Brian Duffy. In the back row are payload specialist Byron K. Lichtenberg, mission specialists C. Michael Foale and David C. Leestma, payload commander Kathryn D. Sullivan, and payload specialist D. Dirk Frimout

DEVELOPMENT TEST OBJECTIVES/DETAILED SUPPLEMENTARY OBJECTIVES

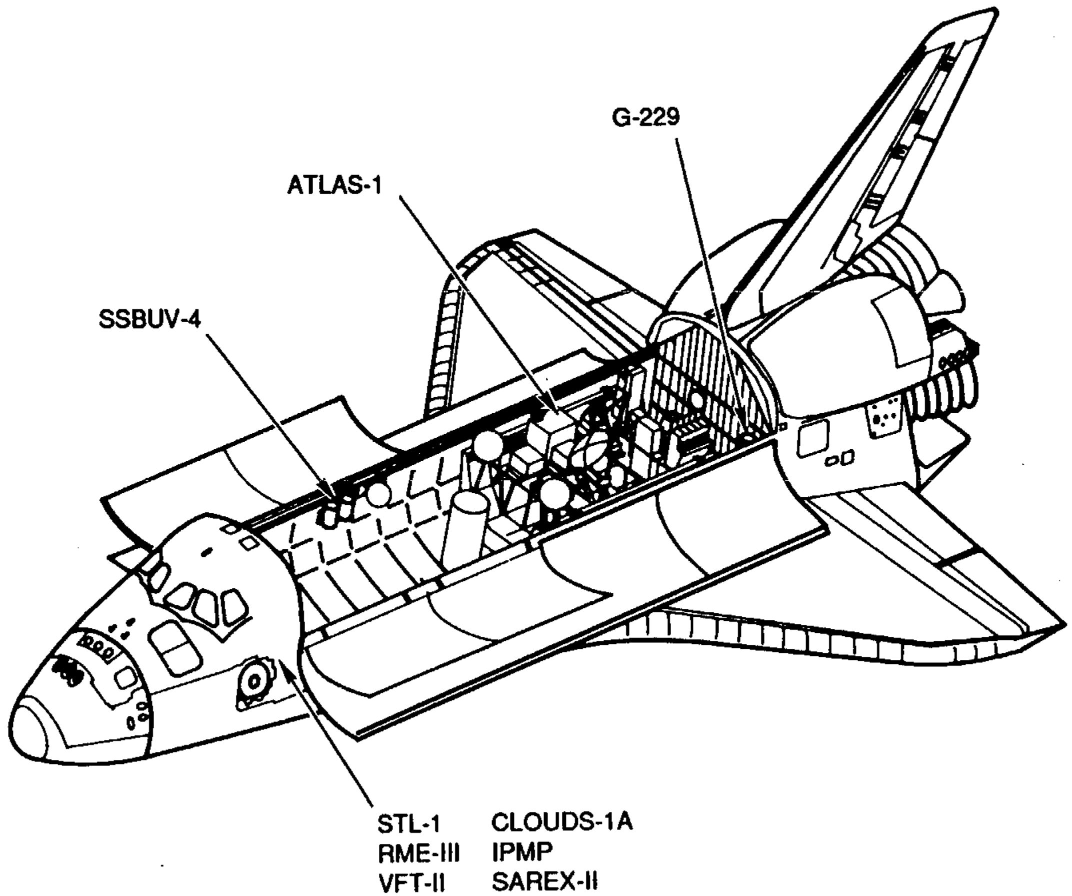
DTOs

- Forward RCS flight test—control surface effects (DTO 250)
- Ascent structural capability evaluation (DTO 301D)
- ET TPS performance—method 2 (DTO 312)
- Edwards lakebed runway bearing strength and rolling friction assessment for orbiter landing (DTO 319D)—DTO of opportunity
- Cabin air monitoring (DTO 623)
- Radiator performance (DTO 624)
- VTR demonstration (DTO 633)
- Electronic still photography test (without the playback downlink unit and the downlink capability) (DTO 648)
- Ku-band antenna friction (DTO 728)
- Crosswind landing performance evaluation (DTO 805)—DTO of opportunity

DSOs

- Collection of shuttle humidity condensate for analytical evaluation (DSO 317)
- Orthostatic function during entry, landing, and egress (DSO 603B)
- Visual vestibular integration—OI-1 (DSO 604)
- Lower body negative pressure following space flight (DSO 607)
- Effects of space flight on aerobic and anaerobic metabolism at rest and during exercise (DSO 608)
- Air monitoring instrument evaluation and atmosphere characterization (DSO 611)
- Energy utilization (DSO 612)
- Changes in endocrine regulation of orthostatic tolerance (DSO 613)
- Head and gaze stability during locomotion (DSO 614)
- In-flight use of florinef to improve orthostatic intolerance after flight (two of the three entry crew members will not take the florinef) (DSO 621)
- Educational activities (the atmosphere below) (DSO 802)
- Documentary television (DSO 901)
- Documentary motion picture photography (DSO 902)
- Documentary still photography (DSO 903)

PAYLOAD CONFIGURATION



This space shuttle mission is the first flight for the Atmospheric Laboratory for Applications and Science (ATLAS), which carries an international payload of experiments that will gather data to help scientists better understand how the Earth's endangered, fragile atmosphere reacts to natural and human-induced changes. Up to nine ATLAS missions will be flown on the shuttle to observe variations in the atmosphere over the course of an 11-year solar cycle. The ATLAS series is part of NASA's Mission to Planet Earth, an integrated study of the Earth, from its depths to the outer layer of the atmosphere.

The Earth's atmosphere is vital to life as we know it. We depend on the atmosphere to maintain the proper atmospheric pressure, temperature, and oxygen levels to sustain life. When radiation from the sun reacts with atmospheric gases—mainly oxygen and nitrogen—or charged particles streaming from the sun interact in the atmosphere with the Earth's magnetic field, energy is absorbed and cycled.

The atmosphere is a gaseous envelope made up of five layers which are classified by their temperature, pressure, and chemical composition. The bottom layer, the troposphere, extends from the surface of the Earth to an altitude of 6.8 miles. Above the troposphere are the stratosphere, the mesosphere, the thermosphere, and the exosphere. The distinction between layers of the atmosphere is not clearly defined. They are interconnected, and whatever happens in the upper layers affects life on the ground.

Within the mesosphere and thermosphere is an electrically charged region called the ionosphere. The magnetosphere is a charged-particle region that separates the Earth's magnetic field from interplanetary space.

The fragility of the atmosphere can be seen in the effects of human activities on its complex processes. We know, for example, that chlorofluorocarbons, used for refrigeration and in other industries, are depleting the stratosphere's ozone layer, which protects the Earth from the harmful ultraviolet rays of the sun. Concentrations of carbon dioxide, which is produced by the burning of fossil fuels and can cause changes in atmospheric temperature, are increasing, as are the concentrations of naturally occurring chemicals that can lead to ozone depletion or inhibit CFC-induced depletion of the ozone layer.

To protect the envelope that surrounds and sustains the Earth, it is necessary to learn how its complex processes work—not an easy

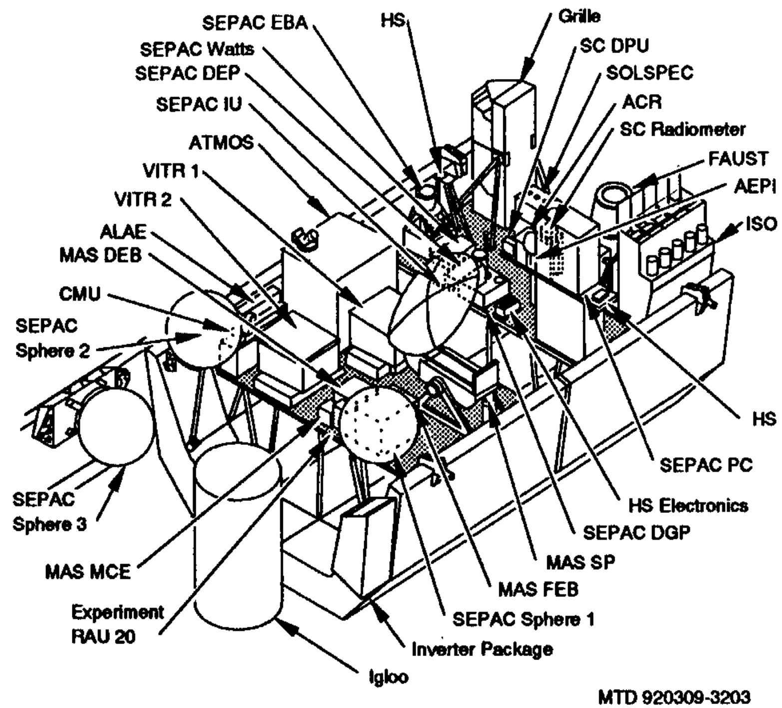
ATLAS-1 Payload in Payload Bay of Atlantis (Looking Forward) in Orbiter Processing Facility at Kennedy Space Center task since the atmosphere is always changing and responding to activities on Earth that threaten to disrupt its life-sustaining processes.

The ATLAS-1 payload consists of 12 instruments that will gather information about the chemical composition of the atmosphere between approximately 8 to 330 miles above the Earth's surface, investigate how Earth's electric and magnetic fields and atmosphere influence one another, measure the energy in sunlight and how that energy varies during the mission, and examine sources of ultraviolet light in the universe. Over the course of the nine-mission ATLAS investigations, scientists will be able to formulate a more detailed description of the Earth's atmosphere and its response to changes in the sun.

The ATLAS-1 payload is carried in the payload bay of Atlantis on two Spacelab pallets, provided by the European Space Agency. These open, U-shaped platforms are used for payloads that require direct exposure to space. A pressurized container, called an igloo, houses the power supply, temperature control system, and the data handling and command system for the ATLAS-1 instruments.

The orbiter's 186-mile-altitude above the Earth will place the experiments in an advantageous position for observing the atmosphere, sun and other astronomical targets. The ATLAS experiments will be conducted around the clock; two teams of astronauts working in 12-hour shifts will control and monitor the experiments under the direction of investigators and planners on the ground. A Spacelab computer has been programmed to automatically operate most of the atmospheric and solar instruments, and the data will be sent directly to scientists at Spacelab Mission Operations Control. The crew will perform other experiments manually and ensure that the computer-controlled experiments function properly from the ATLAS-1 control station on the aft flight deck of the shuttle.

Most of the ATLAS-1 instruments were used on two earlier Spacelab flights and many will be used on future ATLAS missions,



ATLAS-1 Payload Configuration

reducing the cost of this space-based research and demonstrating the capability to return sophisticated equipment from space to Earth for refurbishment and reuse.

Data collected during the mission will be organized at a special data processing facility at NASA's Goddard Space Flight Center in Greenbelt, Md. The information will be used as the foundation for other ATLAS missions and will be made available to researchers studying global change.

ATLAS-1 is sponsored by NASA's Office of Space Science and Applications in Washington, D.C. NASA's Spacelab Mission

Operations Control facility at the Marshall Space Flight Center in Huntsville, Ala., controls science activities during the mission.

Other countries participating in this international mission are Belgium, France, Germany, Japan, the Netherlands, Switzerland, and the United Kingdom.

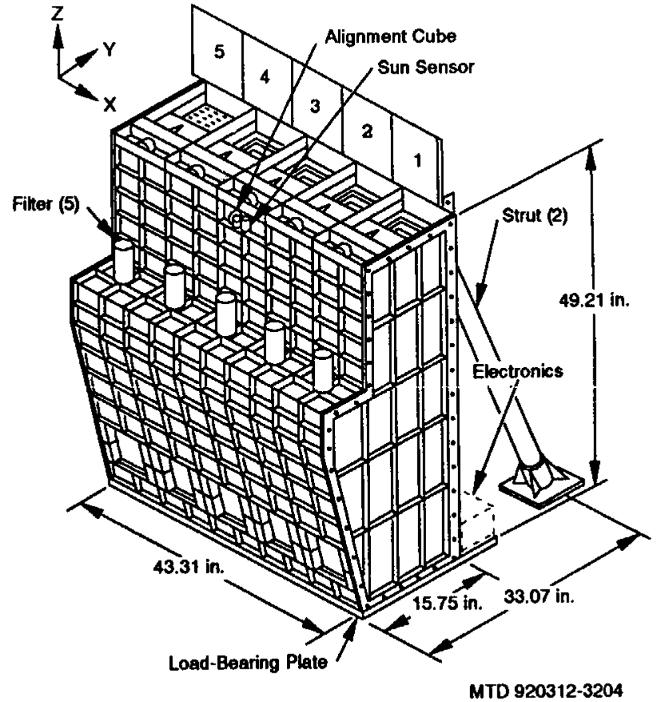
The ATLAS-1 investigations are divided into four broad areas: atmospheric science, solar science, space plasma physics, and astronomy.

ATMOSPHERIC SCIENCE

Researchers will use a variety of instruments to correlate atmospheric composition, temperature, and pressure in the middle and upper atmosphere with altitude, latitude, longitude, and changes in solar radiation. They will examine environmental phenomena such as the global distribution of atmospheric components and temperatures and the atmospheric reaction to such external influences as solar input and geomagnetic storms. They may also examine the effects at high altitudes of terrestrial environmental episodes, such as forest fires, volcanic eruptions, and the massive oil field fires in Kuwait. The data collected will help scientists monitor short- and long-term changes in the atmosphere, the goal of the ATLAS investigations.

The Imaging Spectrometric Observatory (ISO) determines the chemical composition of the atmosphere, including trace amounts of chemicals, which are an important part of atmospheric chemistry. It does this by measuring the light signatures, or spectral features, that are produced when atoms and molecules absorb sunlight and radiate colors of light in the airglow, a layer in the atmosphere approximately 44 to 372 miles above the Earth. The ultimate objective of this experiment is to study the composition and processes governing targets that are observed at different altitudes, latitudes, and longitudes.

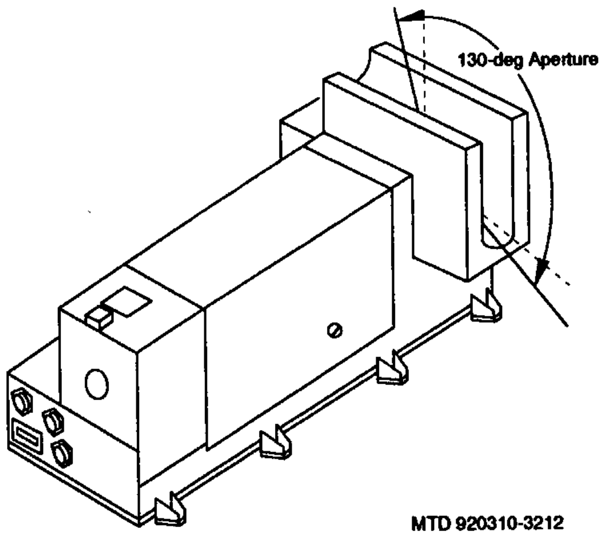
The ISO experiment is sponsored by the NASA Office of Space Sciences and Applications.



ISO Spectrometer Module Array

Scientists expect to increase their understanding of how the slow leak of hydrogen, an important atmospheric gas, from the atmosphere may be affecting the atmosphere's chemistry by measuring the distribution of two forms of hydrogen in the upper atmosphere. A spectrometer on the Atmospheric Lyman-Alpha Emission (ALAE) experiment detects the ultraviolet light, or Lyman-alpha, emissions from common hydrogen and deuterium (heavy hydrogen), which are commonly found in water. Water evaporating into the atmosphere from Earth is broken down into hydrogen and deuterium atoms. The lighter hydrogen atoms rise and some escape from the atmosphere. Determining the ratio of deuterium to hydrogen at the altitudes studied by ALAE will give scientists an indication of atmospheric turbulence and help them study the rate of water evolution in the atmosphere.

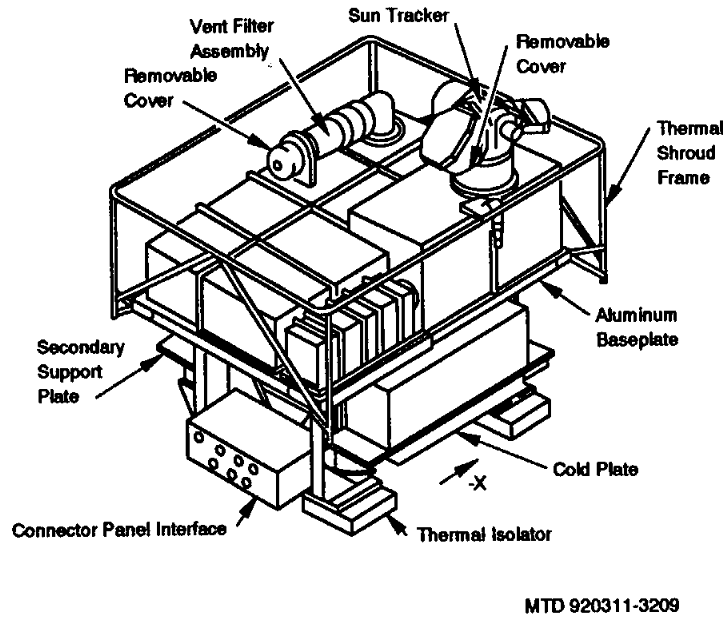
This experiment is sponsored by the Service d'Aeronomie du Centre National de le Recherche Scientifique of France.



ALAE Hardware Layout

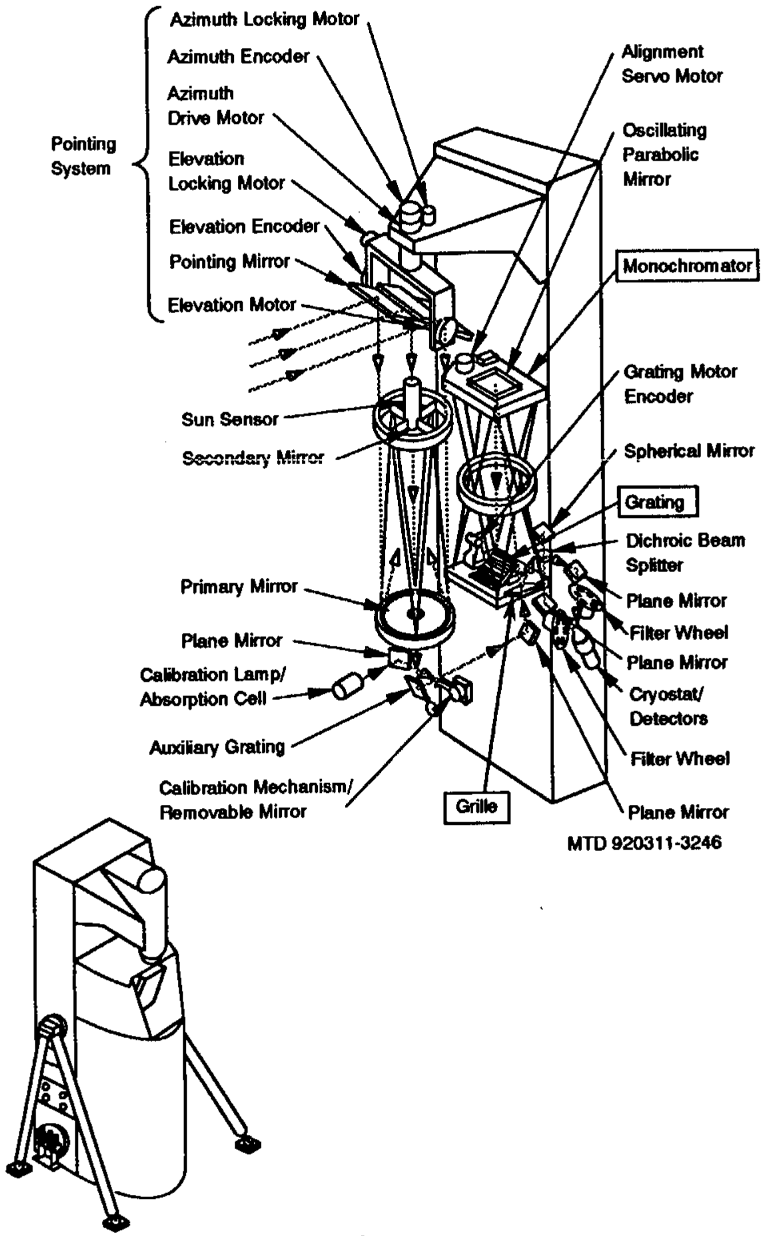
Two instruments on this mission will give scientists information on the concentrations of pollutants from Earth in the atmosphere and their influence. This information will enable scientists to monitor atmospheric changes and predict their consequences.

The Atmospheric Trace Molecule Spectroscopy (ATMOS) experiment maps trace elements in the upper atmosphere so that scientists can get a better understanding of the physics and chemistry of the middle atmosphere. An infrared spectrometer aimed at the Earth's limb during sunrise and sunset (an orbital "day," with sunrise and sunset, occurs approximately every 90 minutes) measures the infrared radiation absorbed by these trace molecules.



ATMOS Instrument With MLI Blanket Removed

The Grille Spectrometer also studies gases in the upper atmosphere. Its main objectives are to measure trace constituents and determine profiles of their vertical distribution and to clarify the relevant chemical, transport, and thermodynamic processes involved in controlling the properties of the Earth's homosphere.



Grille Spectrometer

The data from ATMOS and Grille will be compared with information from other missions to determine global, seasonal, and long-term changes in the atmosphere.

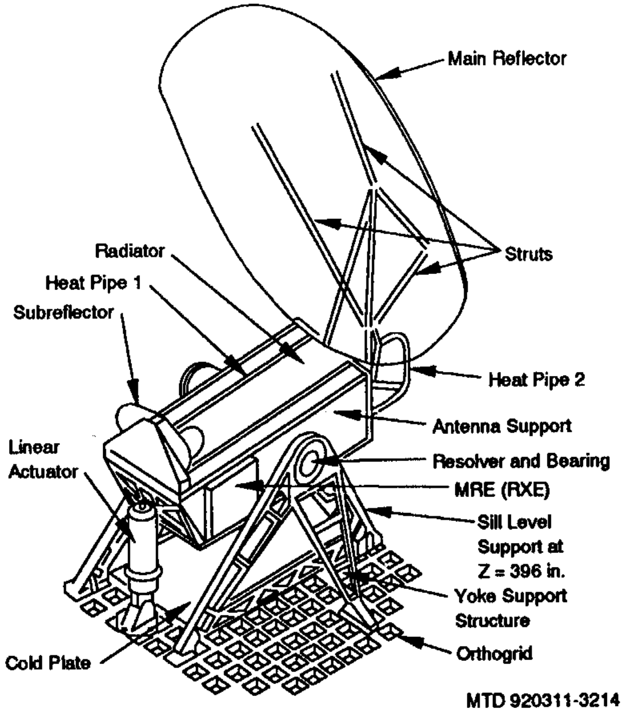
NASA's Office of Space Sciences and Applications is sponsoring ATMOS. Grille is sponsored by the Institute D'Aeronomie Spatiale of Belgium and the Office National d'Etudes et de Recheres Aerospatiales of France.

The Earth's ozone layer, which blocks out harmful solar radiation and serves as a source of heat for chemical reactions in the middle atmosphere, is being threatened by pollutants, such as CFCs, released into the atmosphere from Earth. The Millimeter-Wave Atmospheric Sounder (MAS) measures ozone concentrations and trace molecules involved in the creation and destruction of ozone and records the kinetic temperature and pressure of the middle atmosphere. By comparing measurements from this mission with other MAS missions, scientists can note changes in the ozone layer and monitor the effects of human activities on the middle atmosphere.

MAS is sponsored by the Deutsche Agentur fur Raumfahrtangelegen-Heiten GmbH, Bonn, Germany.

SOLAR PHYSICS

Energy from the sun, interacting with the atmosphere, plays a major role in determining the Earth's climate and weather. Sunlight filtering through the atmosphere heats it and causes chemical reactions to take place. The sunlight that reaches the Earth's surface is either absorbed or reflected. These processes are crucial to life on Earth. Anything that interferes with this efficient exchange of energy could have drastic consequences. An increase or decrease of just a few degrees in the temperature of the Earth's atmosphere brought on by changes in the absorption or radiation of the sun's energy could produce dramatic changes in the Earth's climate and weather. The thermal conditions that have caused droughts or little ice ages in the past would be created by a variation of just 1 percent

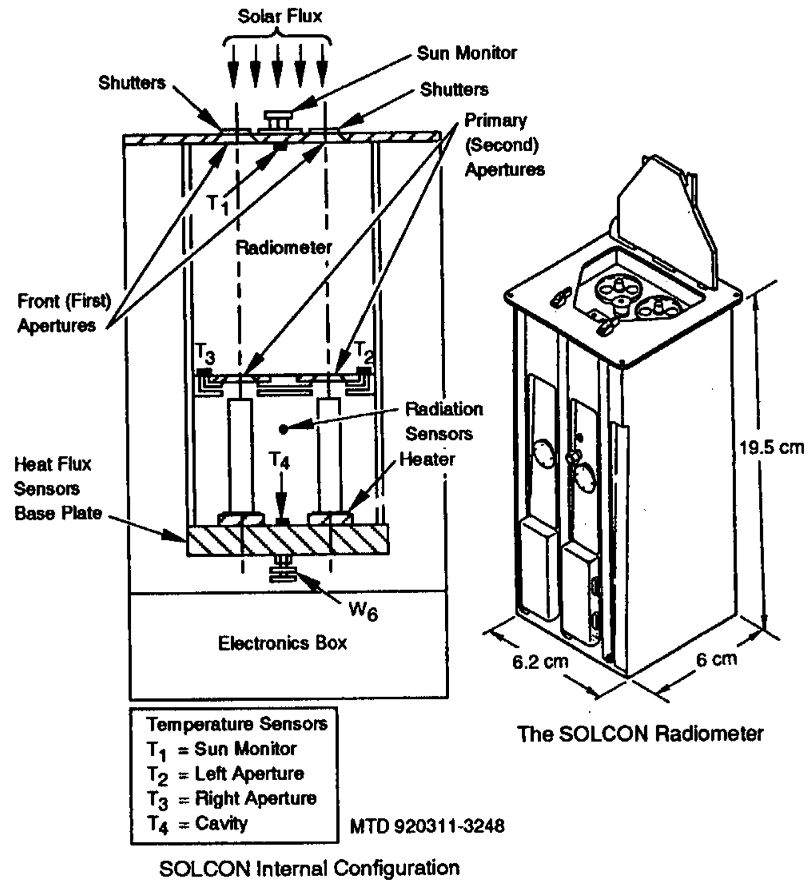


MAS Sensor Package Hardware Layout

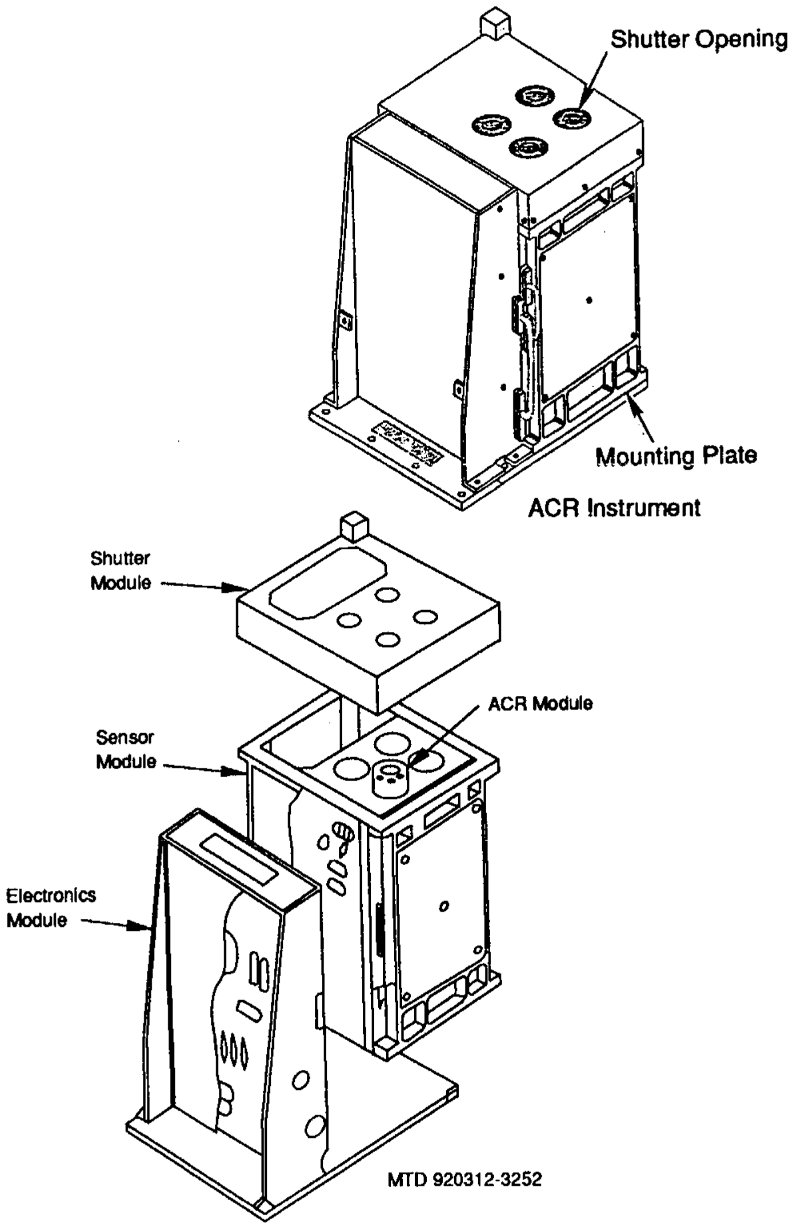
in the solar constant, the steady amount of energy emitted by the sun onto the atmosphere.

The Spacelab ATLAS-1 payload contains four experiments that measure variations in the sun's energy output, an important factor in understanding the effect of solar radiation on the composition of the Earth's atmosphere and ionosphere. The information is also useful to scientists investigating the Earth's climate and solar processes.

Evidence indicates that the solar constant fluctuates. The Measurement of Solar Constant (SOLCON) experiment will help scientists determine the range and variability of the solar constant over the course of a solar cycle. SOLCON's radiometer is a precise instrument that measures the absolute value of the solar constant to an accuracy of 0.1 percent and with a sensitivity that is better than 0.05 percent. Although it uses slightly different techniques, the Active Cavity Radiometer (ACR) experiment also gathers data on short- and long-term variations in total solar output and determines a value for the solar constant, and the values obtained by the two experiments are compared. The two instruments will be used on subse-



Solar Constant Instrument



ACR Equipment Modules

quent flights of the ATLAS series to obtain a long-range record of the solar constant and its variations.

SOLCON is a project of the Belgian Institute Royal Meterologique. NASA's Office of Space Sciences and Applications is the sponsor of the ACR experiment.

Scientists will also collect spectral data on solar radiation to add to their understanding of how variations in the sun's energy output affect the chemistry of the atmosphere. Because atmospheric components absorb different wavelength ranges at different altitudes, scientists need spectral information to study atmospheric reactions.

One of the spectral radiation experiments, Solar Spectrum Measurement (SOLSPEC), measures ultraviolet, visible, and infrared solar radiation to observe the changes in the amounts of these energies and the point in the atmosphere at which they are absorbed.

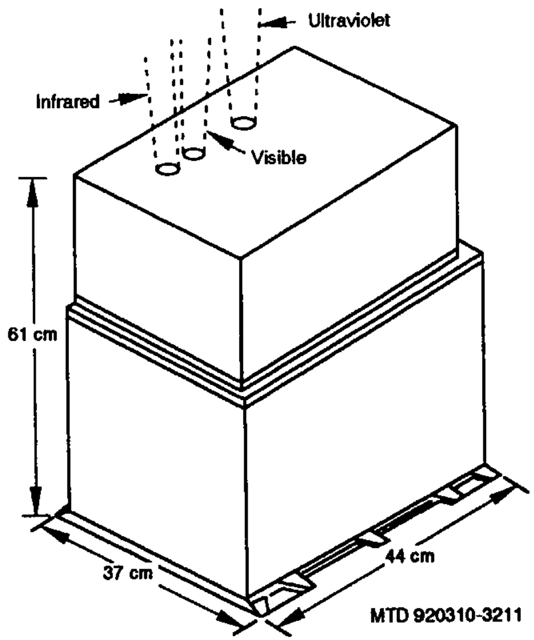
Supplementing SOLSPEC is the Solar Ultraviolet Spectral Irradiance Monitor (SUSIM), which determines long- and short-term variations in the total ultraviolet flux emitted by the sun.

The SOLSPEC sponsor is the French Service d'Aeronomie du Centre National de le Recherche Scientifique.

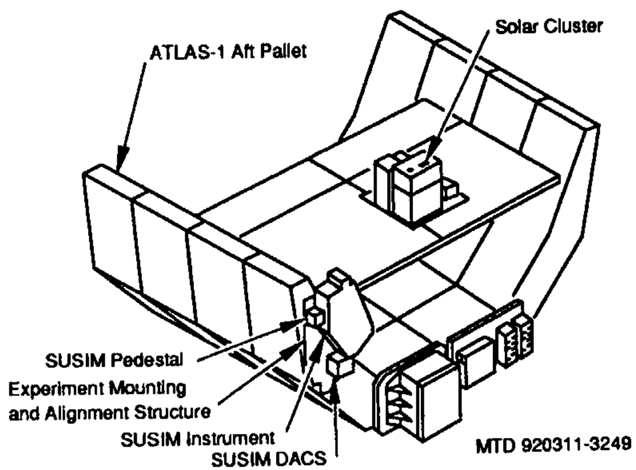
The data gathered by the SOLSPEC, ACR, and SOLCON instruments will be compared to give scientists a better understanding of how the atmosphere may respond to variations in the solar radiation and how that may affect the Earth's climate.

SPACE PLASMA PHYSICS

Sunlight is not the only form of energy streaming from the sun and interacting with the atmosphere. The solar wind is a blast of high-energy charged particles traveling from the sun at a million miles per hour. The Earth's magnetosphere and ionosphere respond to these incoming particles, transferring energy from the sun to the Earth. Disturbances evident on the Earth, such as brilliant auroras,



SOLSPEC Experiment



SUSIM Pallet Installation

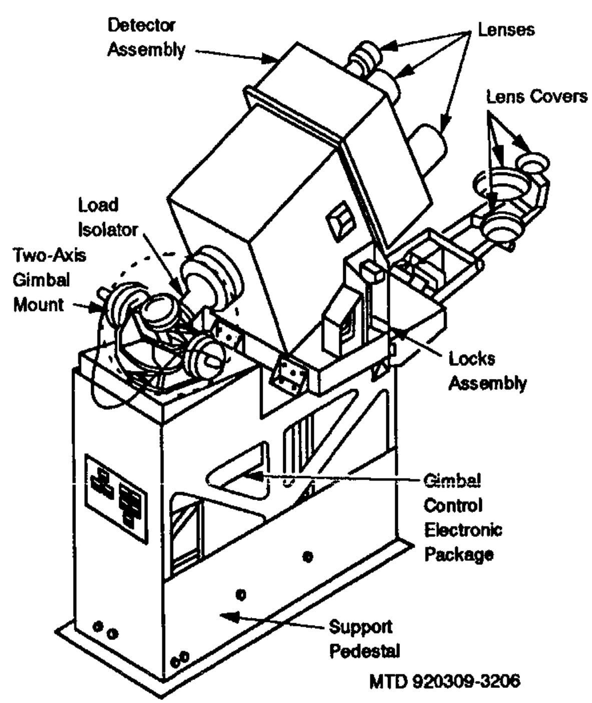
power blackouts, and interruptions of radio and television broadcasts are familiar effects of solar wind storms, when the strongest mingling of matter, energy, and magnetism occurs.

In the space plasma physics investigations, scientists hope to uncover the key cause and effect relationships that link the upper atmosphere and the plasma regions, the magnetosphere and ionosphere. They will study aurora and spacecraft glow, which is a recently discovered phenomenon that could interfere with sensitive data-collecting instruments like those carried in the ATLAS-1 payload. These investigations will also help researchers understand the effects of solar energy on our weather, communications, and spacecraft technologies.

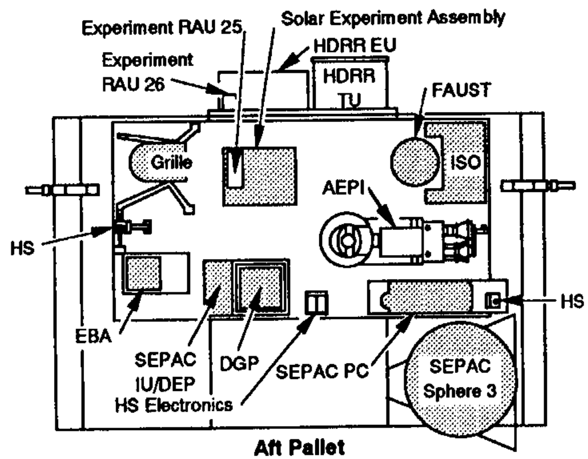
The Atmospheric Emissions Photometric Imaging (AEPI) experiment measures the light emitted by natural auroras, which are curtains of light that form around polar areas when accelerated electrons entering the atmosphere strike atoms and molecules and cause them to glow, and by artificial auroras created by the Space Experiments With Particle Accelerators (SEPAC). The purpose is to determine the energies that solar electrons carry.

SEPAC creates auroras by firing beams from an electron gun down through the atmosphere. Firing the beam upwards enables investigators to locate electric fields.

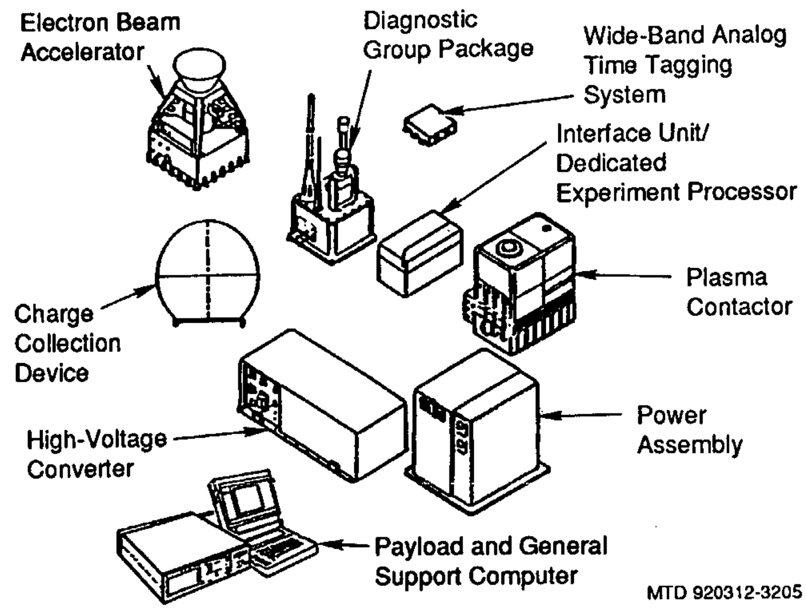
SEPAC also explores the electrical interactions between the shuttle and the ionosphere as the shuttle sails through the plasma region like a boat through water. As the shuttle moves through the plasma, it takes on an electrical charge. Ways of using artificial plasmas and neutral gases to neutralize an artificial charge created on the shuttle are investigated. SEPAC also fires its electron gun into the plasma around the shuttle, creating very low frequency to high-frequency waves. If ground stations detect the waves, it may prove that the electron beam can be used as an antenna.



AEPI Configuration



Atmospheric Emissions Photometric Imaging Instrument



SEPAC Subsystem

The Institute of Space and Astronautical Science of Japan is sponsoring the SEPAC experiment. The AEPI experiment is a project of NASA's Office of Space Sciences and Application.

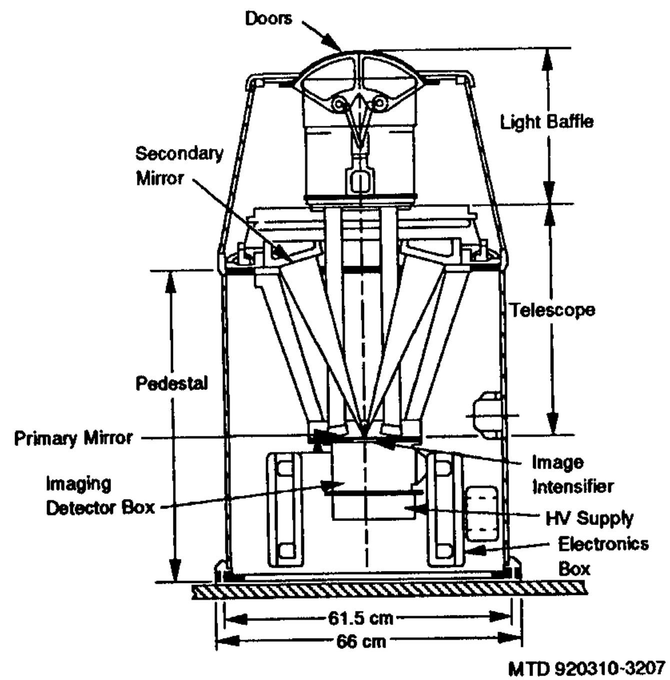
The ring current is a band of ions and electrons from the solar wind and ionosphere that drifts around the Earth high in the magnetosphere. Many of these ions lose the charges, but not their energies, when they encounter areas of hydrogen gas and fall into the upper atmosphere, where they give off very faint light emissions. The emissions are clues to the structure of the ring current, its location, the relative abundance and energies of the ions, and its growth and decay.

The Energetic Neutral Atom Precipitation (ENAP) investigation measures the faint emissions and determines how much energy the neutralized ions deposit in the upper atmosphere. The data is gathered at nighttime because the emissions are too faint to be recorded in sunlight. The ENAP data is gathered by ISO instruments.

ASTRONOMY

Ultraviolet radiation could enable scientists to explain with more certainty what is happening in certain areas of the universe. Ultraviolet light is produced by hot temperatures and high energies, which are associated with comets, star winds, hot plasmas, and gas flows between stars. Since most ultraviolet light is absorbed by the atmosphere before it reaches Earth, however, telescopes that are sensitive to ultraviolet light must operate above the atmosphere to detect these radiations.

The Far Ultraviolet Space Telescope (FAUST), an astronomical telescope that was previously used on the Spacelab 1 mission, examines 24 sources of ultraviolet radiation in the Milky Way Galaxy and other galaxies where faint sources of ultraviolet radiation have been detected to learn more about the formation of stars. FAUST has a wide field of view and is so sensitive that it can detect the very faint ultraviolet emissions that scientists predict exist just before a star dies. FAUST will also examine quasars and other astronomical phenomena, such as the diffuse ultraviolet background of the universe.



FAUST Assembly

FAUST is sponsored by the NASA Office of Space Sciences and Applications.

SPACELAB

On Sept. 24, 1973, a memorandum of understanding was signed between the European Space Agency, formerly known as the European Space Research Organization, and NASA with NASA's George C. Marshall Space Flight Center as lead center for ESA to design and develop Spacelab, a unique laboratory facility carried in the cargo bay of the space shuttle orbiter that converts the shuttle into a versatile on-orbit research center.

The reusable laboratory can be used to conduct a wide variety of experiments in such fields as life sciences, plasma physics, astronomy, high-energy astrophysics, solar physics, atmospheric physics, materials sciences, and Earth observations.

Spacelab is developed on a modular basis and can be varied to meet specific mission requirements. Its four principal components are the pressurized module, which contains a laboratory with a shirt-sleeve working environment; one or more open pallets that expose materials and equipment to space; a tunnel to gain access to the module; and an instrument pointing subsystem. Spacelab is not deployed free of the orbiter. The pressurized module will not be used on STS-45.

The European Space Agency developed Spacelab as an essential part of the United States' Space Transportation System. Eleven European nations are involved: Germany, Belgium, Denmark, Spain, France, United Kingdom, Ireland, Italy, the Netherlands, Switzerland, and, as an observer state, Austria.

An industrial consortium headed by ERNO-VFW Fokker (Zentralgesellschoft VFW-Fokker mbh) was named by ESA in June 1974 to build the pressurized modules. Five 10-foot-long, unpressurized, U-shaped pallet segments were built by the British Aerospace Corporation under contract to ERNO-VFW Fokker. The IPS is built by Dornier.

Spacelab is used by scientists from countries around the world. Its use is open to research institutes, scientific laboratories, industrial companies, government agencies, and individuals. While many missions are government sponsored, Spacelab is also intended to provide services to commercial customers.

Each experiment accepted has a principal investigator assigned as the single point of contact for that particular scientific project. The principal investigators for all experiments on a given mission form what is called the Investigators Working Group. This group coordinates scientific activities before and during the flight.

The investigators prepare the equipment for their experiments in accordance with size, weight, power, and other limitations established for the particular mission.

Responsibility for experiment design, development, operational procedures, and crew training rests with the investigator. Only after it is completed and checked out is the equipment shipped to the Kennedy Space Center for installation on Spacelab.

Each mission has a mission scientist, a NASA scientist who, as chairman of the Investigators Working Group, serves as the interface between the science-technology community and NASA's payload management people. Through the mission scientist, the science-technology needs of the mission and the investigators' goals are injected into the decision-making process.

NASA astronauts called mission specialists, as well as non-career astronauts called payload specialists, fly aboard Spacelab to operate experiments. Payload specialists are nominated by the scientists sponsoring the experiments aboard Spacelab. They are accepted, trained, and certified for flight by NASA. Their training includes familiarization with experiments and payloads as well as information and procedures to fly aboard the space shuttle. From one to four payload specialists can be accommodated for a Spacelab flight. These specialists ride into space and return to Earth in the orbiter crew compartment cabin, but they work with Spacelab on orbit. Because Spacelab missions, once on orbit, may operate on a 24-hour basis, the flight crew is usually divided into two teams. The STS-45 crew will work two 12-hour shifts.

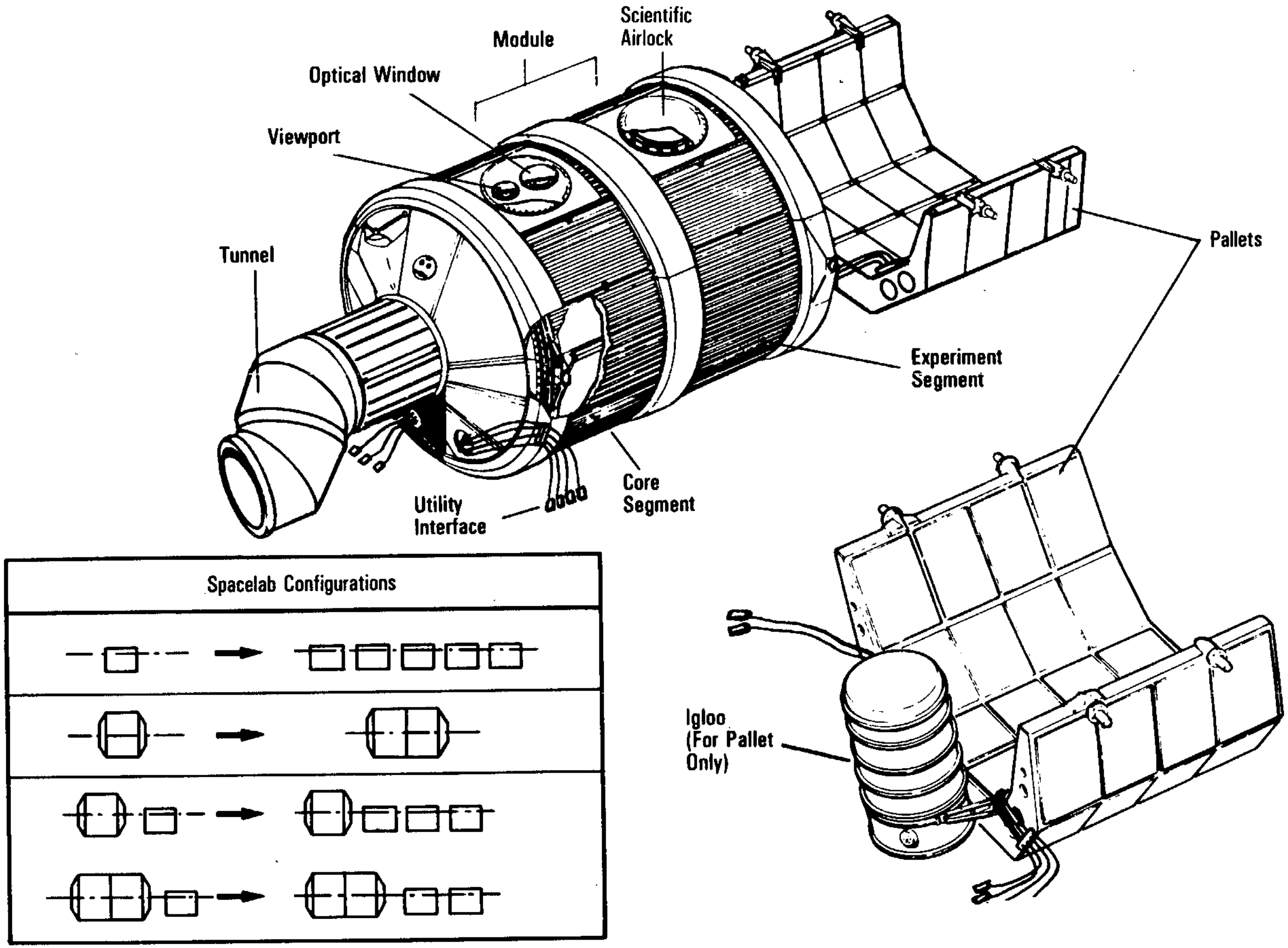
PRESSURIZED MODULE. The pressurized module, or laboratory, is available in two segments. One, called the core segment, contains supporting systems, such as data processing equipment and utilities for the pressurized modules and pallets (if pallets are used in conjunction with the pressurized modules). The laboratory has fixtures, such as floor-mounted racks and a workbench. The second, called the experiment segment, provides more working laboratory space and contains only floor-mounted racks. When only one segment is needed, the core segment is used. Each pressurized segment is a cylinder 13.1 feet in outside diameter and 9 feet long. When both segments are assembled with end cones, their maximum outside length is 23 feet.

The pressurized segment or segments are structurally attached to the orbiter payload bay by four attach fittings consisting of three longeron fitting sets (two primary and one stabilizing) and one keel fitting. The segments are covered with passive thermal control insulation.

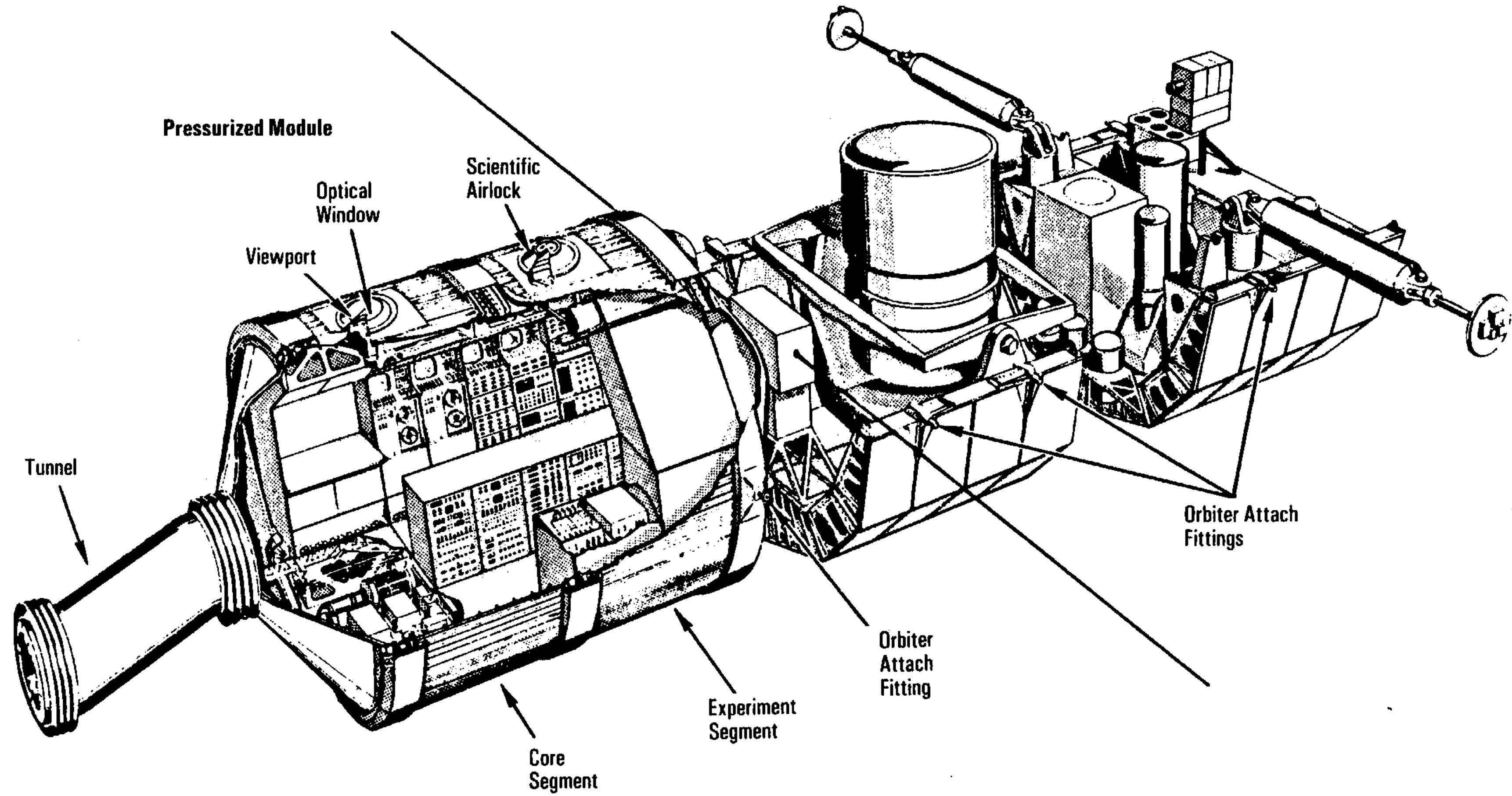
The ceiling skin panel of each segment contains a 51.2-inch-diameter opening for mounting a viewport adapter assembly, a Spacelab window adapter assembly, or scientific airlock; if none of these items are used, the openings are closed with cover plates that are bolted in place. The module shell is made from 2219-T851 aluminum plate panels. Eight rolled integral-machined waffle patterns are butt-welded together to form the shell of each module segment. The shell thickness ranges from 0.6 of an inch to 0.14 of an inch. Rings machined from aluminum-roll ring forgings are butt-welded to the skin panels at the end of each shell. Each ring is 20 inches long and 195.8 inches in diameter at the outer skin line. Forward and aft cones bolted to the cylinder segments consist of six aluminum skin panels machined from 2219-T851 aluminum plate and butt-welded to each other and to the two end rings. The end rings are machined from aluminum-roll ring forgings. The end cones are 30.8-inch-long truncated cones whose large end is 161.9 inches in outside diameter and whose small end is 51.2 inches in outside diameter. Each cone has three 16.4-inch-diameter cutouts: two located at the bottom of the cone and one at the top. Feedthrough plates for routing utility cables and lines can be installed in the lower cutouts of both end cones. The Spacelab viewport assembly can be installed in the upper cutout of the aft end cone, and the upper cutout of the forward end cone is for the pressurized module vent and relief valves. The pressurized modules are designed for a lifetime of 50 missions. Nominal mission duration is seven days.

Racks for experiment equipment that goes into the habitable module are standardized. The 19-inch-wide (48-centimeter) racks are arranged in single and double assemblies. Normally, the racks and floor are put together outside the module, checked out as a unit, and slid into the module where connections are made between the rack-mounted experiment equipment, the subsystems in the core segment, and the primary structure.

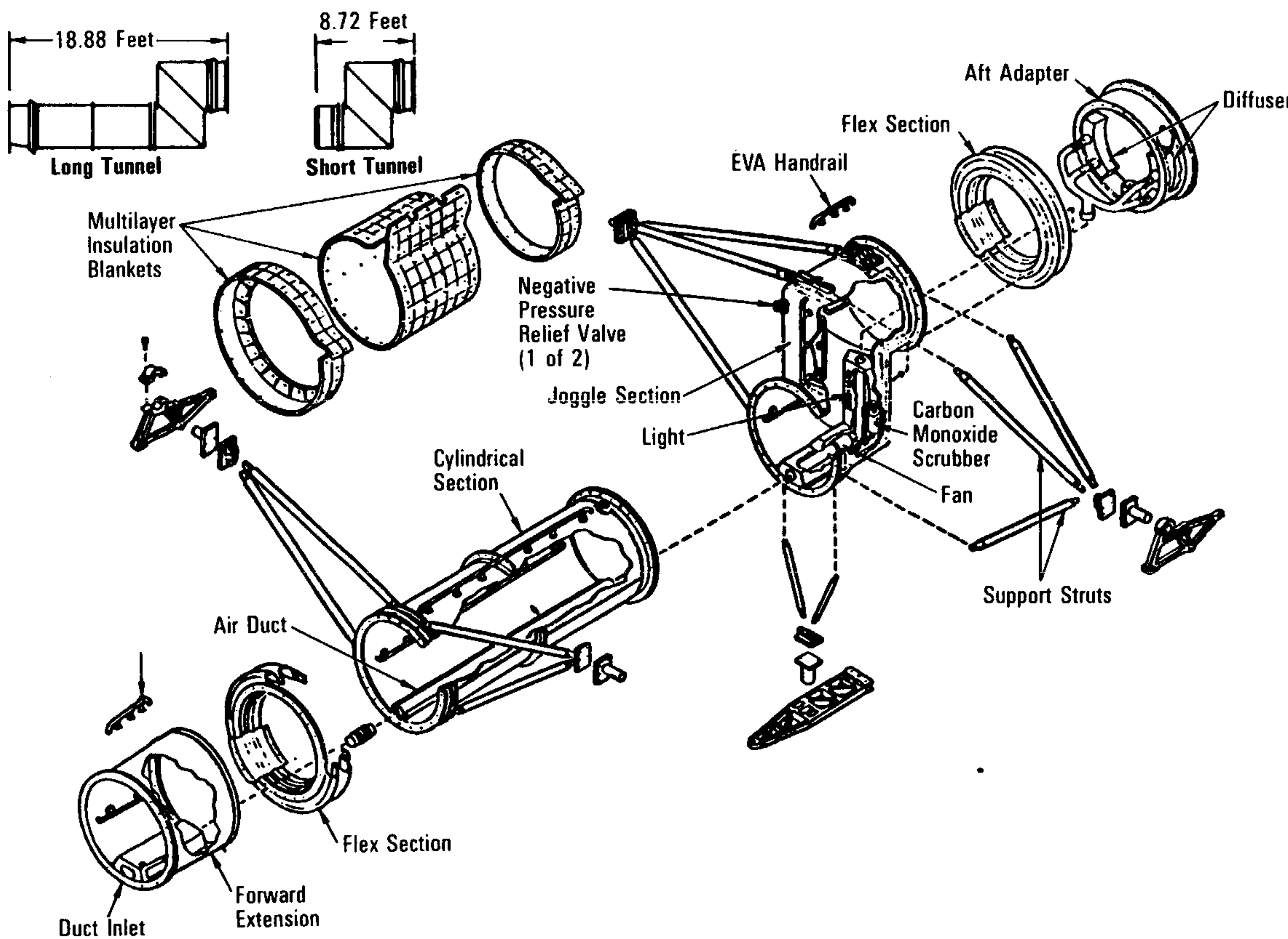
Because of the orbiter's center-of-gravity conditions, the Spacelab pressurized modules cannot be installed at the forward end of the payload bay. Therefore, a pressurized tunnel is provided for equipment and crew transfer between the orbiter's pressurized crew compartment and the Spacelab pressurized modules. The transfer tunnel is a cylindrical structure with an internal unobstructed diameter of 40 inches. The cylinder is assembled in sections to allow length adjustment for different module configurations. Two tunnel lengths can be used—a long tunnel of 18.88 feet and a short tunnel of 8.72 feet. The joggle section of the tunnel compensates for the 42.1-inch vertical offset of the orbiter middeck to the Spacelab pres-



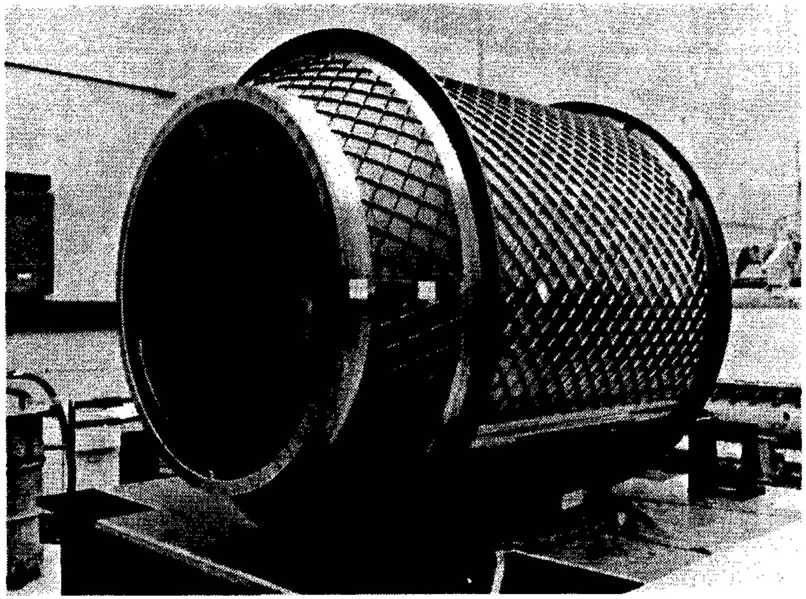
Spacelab External Design Features



European Space Agency's Spacelab



Spacelab Transfer Tunnel



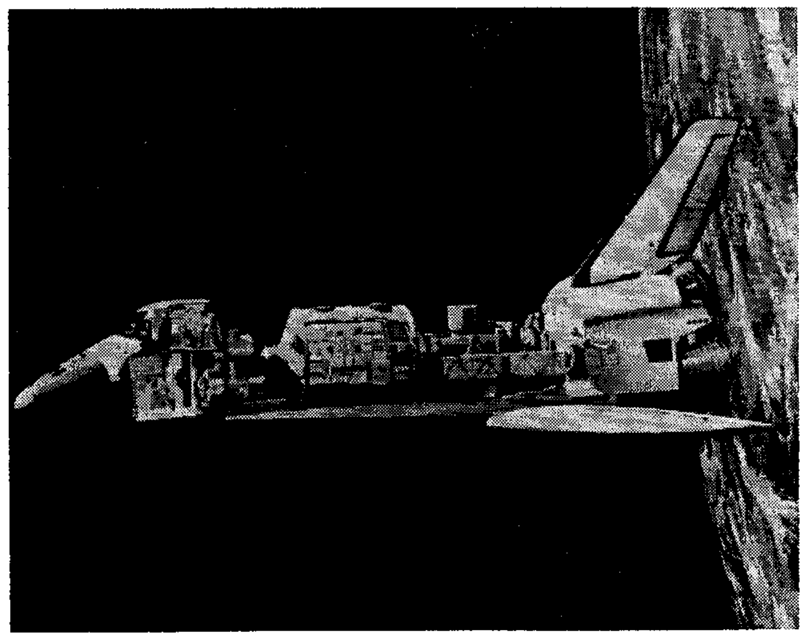
Tunnel Adapter

surized module's centerline. There are flexible sections on each end of the tunnel near the orbiter and Spacelab interfaces. The tunnel is built by McDonnell Douglas Astronautics Company, Huntington Beach, Calif.

The airlock in the middeck of the orbiter, the tunnel adapter, hatches, the tunnel extension, and the tunnel itself permit the flight crew members to transfer from the orbiter middeck to the Spacelab pressurized module or modules in a pressurized shirt-sleeve environment. The airlock, tunnel adapter, tunnel, and Spacelab pressurized modules are at ambient pressure before launch. In addition, the middeck airlock, tunnel adapter, and hatches permit crew members outfitted for extravehicular activity to transfer from the airlock/ tunnel adapter in space suits to the payload bay without depressurizing the orbiter crew compartment and Spacelab modules. If an EVA is required, no flight crew members are permitted in the Spacelab tunnel or module.

INSTRUMENT POINTING SUBSYSTEM. Some research to be accomplished on Spacelab missions requires that instruments be pointed with very high accuracy and stability at stars, the sun, the Earth, or other targets of observation. The IPS provides precision pointing for a wide range of payloads, including large single instruments or a cluster of instruments or a single small-rocket-class instrument. The pointing mechanism can accommodate instruments of diverse sizes and weights (up to 15,432 pounds) and can point them to within 2 arc seconds and hold them on target to within 1.2 arc seconds.

The IPS consists of a three-axis gimbal system mounted on a gimbal support structure connected to the pallet at one end and to the aft end of a payload at the other, a payload clamping system to support the mounted experiment elements during launch and landing,

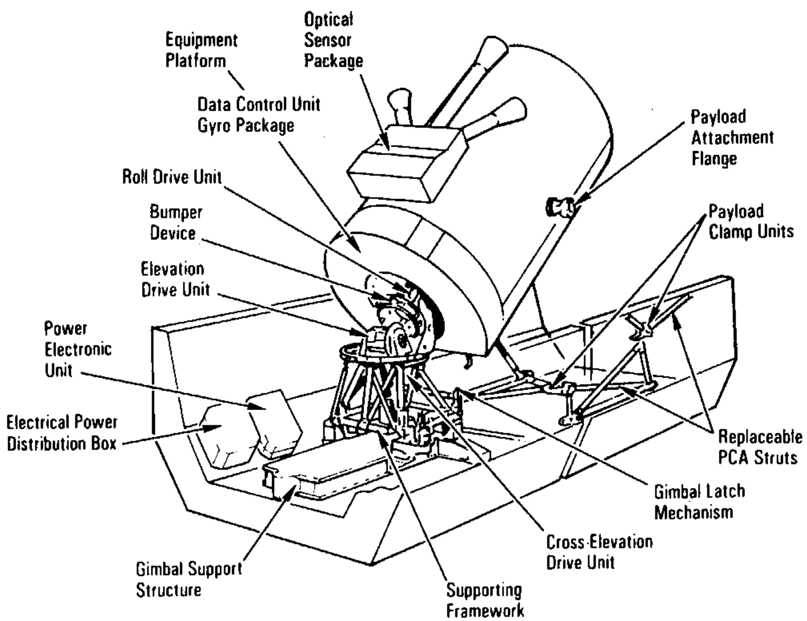


Spacelab

and a control system based on the inertial reference of a three-axis gyro package and operated by a gimbal-mounted minicomputer.

The basic structural hardware is the gimbal system, which includes three bearing/drive units, a payload/gimbal separation mechanism, a replaceable extension column, an emergency jettisoning device, a support structure and rails, and a thermal control system. The gimbal structure itself is minimal, consisting only of a yoke, an inner gimbal, and an outer gimbal to which the payload is attached by the payload-mounted integration ring.

The three identical drive units are so arranged that their axes intersect at one point. From pallet to payload, the order of the axes is elevation, cross-elevation, and azimuth. Each drive assembly includes three wet-lubricated ball bearings, two brushless dc-torquers, and two single-speed/multispeed resolvers.



Instrument Pointing Subsystem

The gimbal/payload separation mechanism is located between the outer gimbal and the payload integration ring. This device prevents the payload and the pointing mechanism from exerting excessive loads on each other during launch and landing. For orbital operations, the outer gimbal and integration ring are pulled together and locked.

The operating modes of the different scientific investigations vary considerably. Some require manual control capability; others require long periods of pointing at a single object, slow scan mapping, or high angular rates and accelerations. Performance in all these modes requires flexibility, which is achieved by computer software. The IPS is controlled through the Spacelab subsystem computer and a data display unit and keyboard. It can be operated either automatically or by the Spacelab crew from the pressurized module and also from the payload station on the orbiter aft flight deck.

The IPS has two operating modes, which depend on whether the gimbal resolver or gyro is used for feedback control of attitude. An optical sensor package consisting of one boresighted fixed-head star tracker and two skewed fixed-head star trackers is used for attitude correction and also for configuring the IPS for solar, stellar, or Earth viewing.

PALLET ONLY. Each pallet is more than a platform for mounting instrumentation; with an igloo attached, it can also cool equipment, provide electrical power, and furnish connections for commanding and acquiring data from experiments. When only pallets are used, the Spacelab pallet portions of essential systems required for supporting experiments (power, experiment control, data handling, communications, etc.) are protected in a pressurized, temperature-controlled igloo housing.

The pallets are designed for large instruments, experiments requiring direct exposure to space, or systems needing unobstructed or broad fields of view, such as telescopes, antennas, and sensors (e.g., radiometers and radars). The U-shaped pallets are covered with aluminum honeycomb panels. A series of hard points attached to the main pallet structure is provided for mounting heavy payload equipment. Up to five segments can be flown on a single mission. Each pallet train is held in place in the payload bay by a set of five attach fittings, four longeron sill fittings, and one keel fitting. Pallet-to-pallet joints are used to connect the pallets to form a single rigid structure called a pallet train. Twelve joints are used to connect two pallets.

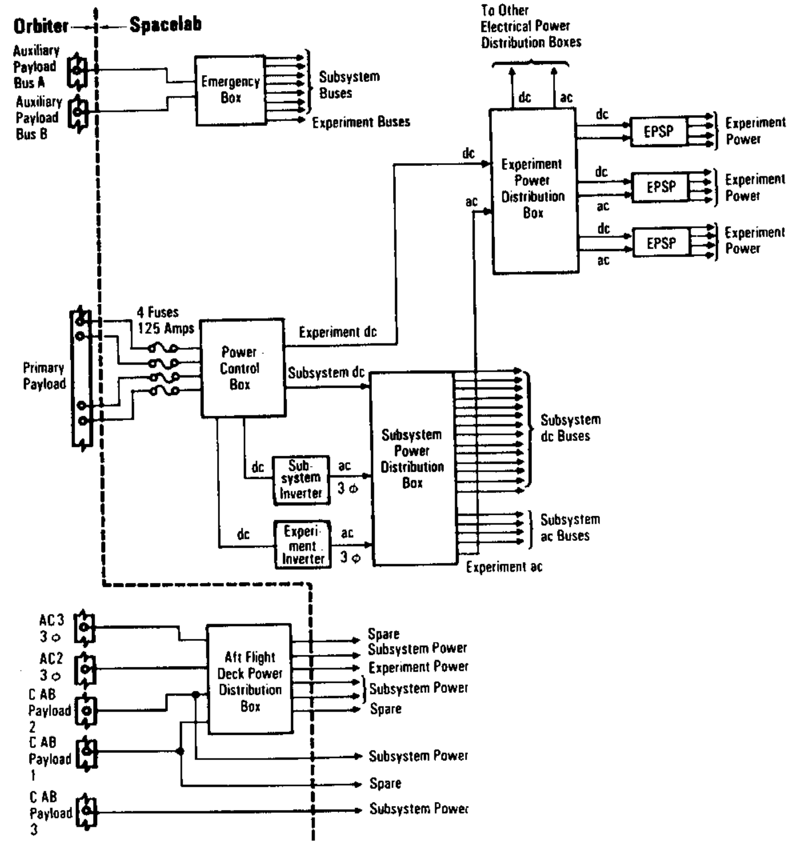
The pallets are uniform. Each is a U-shaped aluminum frame and panel platform 13.1 feet wide and 10 feet long.

Cable ducts and cable support trays can be bolted to the forward and aft frame of each pallet to support and route electrical cables to and from the experiments and subsystem equipment mounted on the pallet. All ducts mounted on the right side of the pallet are used to route subsystem cables, and all ducts on the left side carry experiment utility cables. The ducts and cable trays are made of aluminum alloy sheet metal. In addition to basic utilities, some special accommodations are available for pallet-mounted experiments.

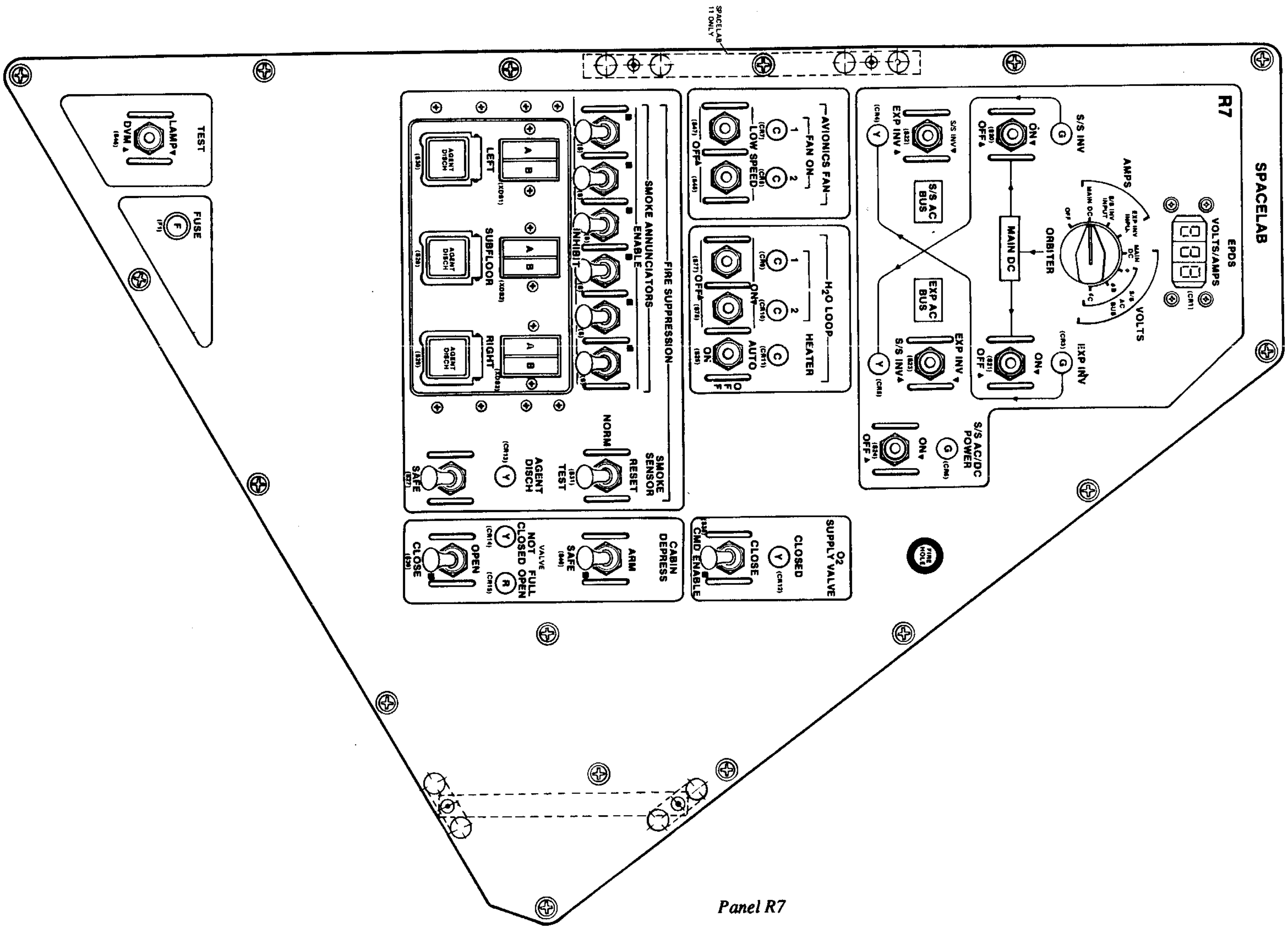
The igloo is attached vertically to the forward end frame of the first pallet. Its outer dimensions are approximately 7.9 feet in height and 3.6 feet in diameter. The igloo is a closed cylindrical shell made of aluminum alloy. A removable cover allows full access to the interior. The igloo houses subsystems and equipment in a pressurized, dry-air environment at sea-level atmospheric pressure (14.7 psia). Two feedthrough plates accommodate utility lines and a pressure relief valve. The igloo is covered with multilayer insulation.

ELECTRICAL POWER. The Spacelab electrical power distribution subsystem controls and distributes main, essential, and emergency dc and ac power to Spacelab subsystems and experiment equipment. Orbiter fuel cell power plants 2 and 3 provide dc power to orbiter main buses B and C, respectively. In addition, through the orbiter main bus tie system (managed and controlled from orbiter display and control panels R1 and F9), dc power is distributed from orbiter main bus C to the orbiter primary payload 1 bus and the Spacelab power control box through four (redundant) main dc power feeders. The orbiter electrical power distribution system is capable of distributing 7 kilowatts maximum continuous (12 kilowatts peak) power to Spacelab subsystems and experiments during on-orbit phases. This is equivalent to supplying 14 average homes with electrical power. If a single fuel cell fails on orbit, the system remains operational with a maximum power level of 5 kilowatts continuous and 8 kilowatts peak.

The primary dc power received in the Spacelab from the orbiter primary payload bus is nominally 28 volts, a maximum of 32 volts, and a worst-case minimum of 23 volts. The four redundant power



Orbiter Spacelab Electrical Power Distribution


SPACELAB 11 ONLY
R7
SPACELAB
EPDS
VOLTS/AMPS
AMPS
VOLTS
ORBITER
MAIN DC
S/S INV
EXP INV
S/S AC BUS
EXP AC BUS
S/S AC/DC POWER
AVIONICS FAN
FAN ON
LOW SPEED
H2O LOOP
HEATER
AUTO
FIRE SUPPRESSION
SMOKE ANNUNCIATORS
ENABLE
INHIBIT
LEFT
SUBFLOOR
RIGHT
AGENT DISCH
SMOKE SENSOR
RESET
NORM
TEST
SAFE
CABIN DEPRESS
ARM
VALVE
NOT CLOSED
FULL OPEN
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O2 SUPPLY VALVE
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CMD ENABLE
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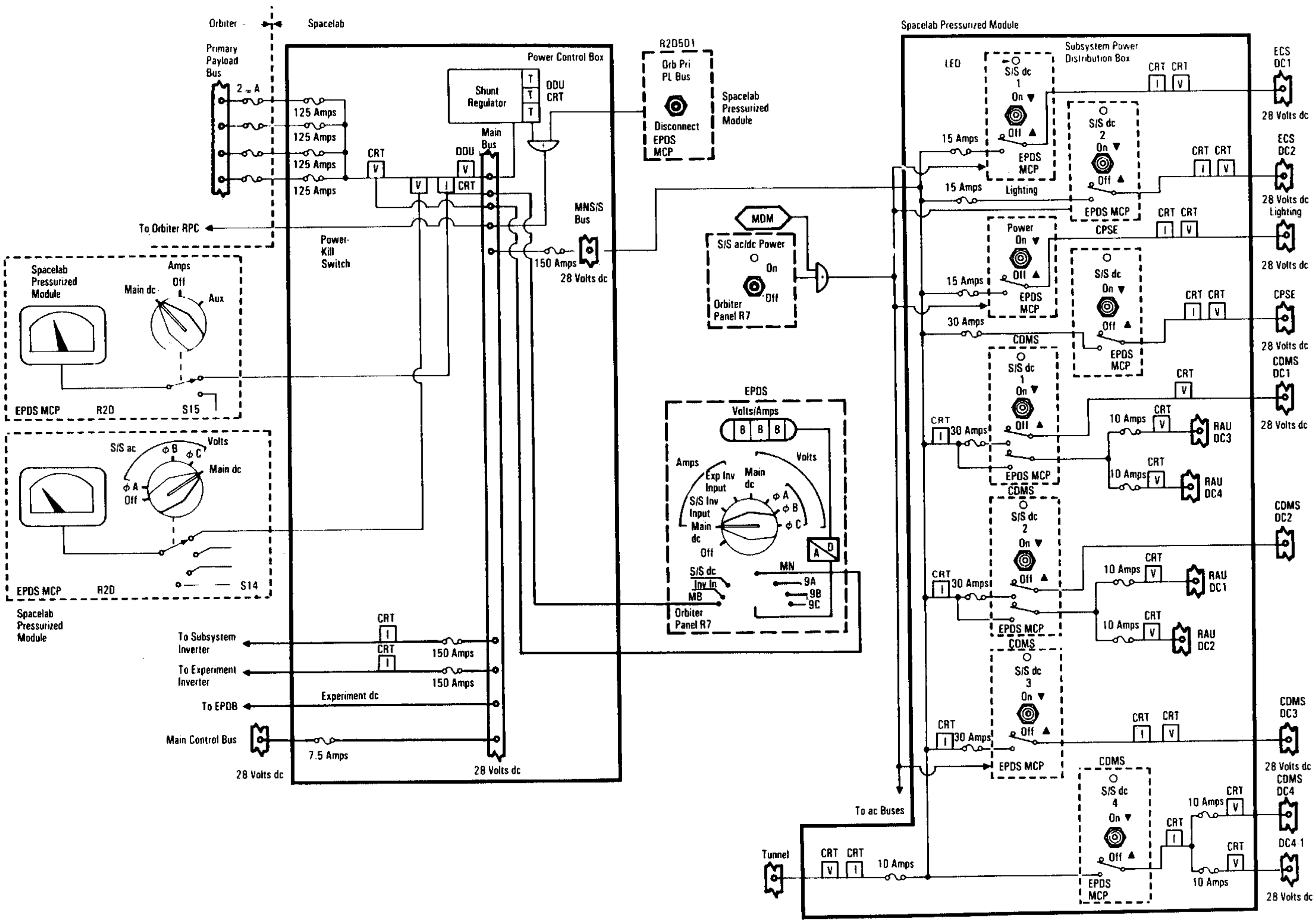
Panel R7



Orbiter-to-Spacelab Electrical Power Distribution—Subsystem dc Power Distribution feeders from the orbiter supply the Spacelab power control box with power through 125-amp fuses. Spacelab main bus voltage and current readings are available on orbiter CRT Spacelab displays. For the igloo/pallet configuration, the main bus dc voltage and amperage are also available to the flight crew from the EPDS *volts/amps* digital meter and rotary switch on panel R7 at the orbiter crew compartment aft flight deck mission specialist station. The Spacelab power control box is installed in the subfloor of the Spacelab pressurized core segment and in the igloo of the pallet-only configuration.

In the Spacelab pressurized module configuration, the main dc voltage and amperage are available in the pressurized module on the control center rack EPDS monitoring and control panel. The voltage reading is obtained by setting the *volts* rotary switch on the EPDS MCP to the *main dc* position, and the amperage reading is obtained by setting the amps rotary switch to the *main dc* position. The meters on the EPDS MCP panel have only colored zones to indicate nominal (green) or off-nominal (red) readings. The amp readout for main dc power has an additional color field (yellow) to indicate a peak power loading condition.

In the pressurized module configuration, the EPDS MCP provides a manually operated *orb PRI PL bus* disconnect switch, which acts as a kill-power switch for the main dc power to the module. When this switch is positioned momentarily to the *disconnect* position, all Spacelab subsystem functions supplied by normal dc and ac power cease to operate, and the Spacelab water pump, Freon pump, and avionics delta pressure caution channels are activated.

The Spacelab subsystem power distribution box distributes the subsystem dc bus and ac bus power into subsystem-dedicated feeders. In the pressurized module configuration, all outputs except the tunnel and environmental control subsystem ac and experiment ac outputs are remotely switched by latching relays. Power protection circuits and command activation are controlled by the remote amplification and advisory box. In the subsystem power distribution box, the dc power line feeds several subsystem power buses controlled by switches on the electrical power distribution subsystem monitoring and control panel. In the pallet-only configuration, all outputs are remotely switched by latching relays.

Various Spacelab systems' operations are controlled on orbit from panel R7 in the orbiter crew compartment aft flight station. In either the pallet-only or pressurized module configuration, Spacelab power protection circuits and command activation are controlled from the remote amplification and advisory box. The subsystem power distribution box is controlled by the *S/S ac/dc power on/off* switch on the orbiter aft flight deck panel R7 or by an item command on several orbiter CRT Spacelab displays. The status of this switch on panel R7 is displayed on the orbiter CRT and indicated by a green LED above the manual switch on panel R7. The voltages and currents of the various Spacelab subsystem buses are also available to the flight crew on the orbiter CRT Spacelab subsystem power display.

The dc power in the Spacelab power control box is directed through two parallel 150-amp fuses, one to the Spacelab subsystem dc/ac inverter and the other to a Spacelab experiment dc/ac inverter. Normally, only the subsystem inverter is used to power both subsystem and experiment ac requirements, and the experiment inverter is used as a backup. Each inverter generates three-phase ac power at 117/203 volts, 400 hertz. It is possible to connect the ac experiment bus to the subsystem inverter and, conversely, the subsystem ac bus to the experiment inverter.

In the Spacelab pressurized module configuration, the inverters are mounted on cold plates in the control center rack of the core segment. In the pallet-only configuration, the inverters are mounted on cold plates on the first (forward) pallet in the orbiter payload bay.

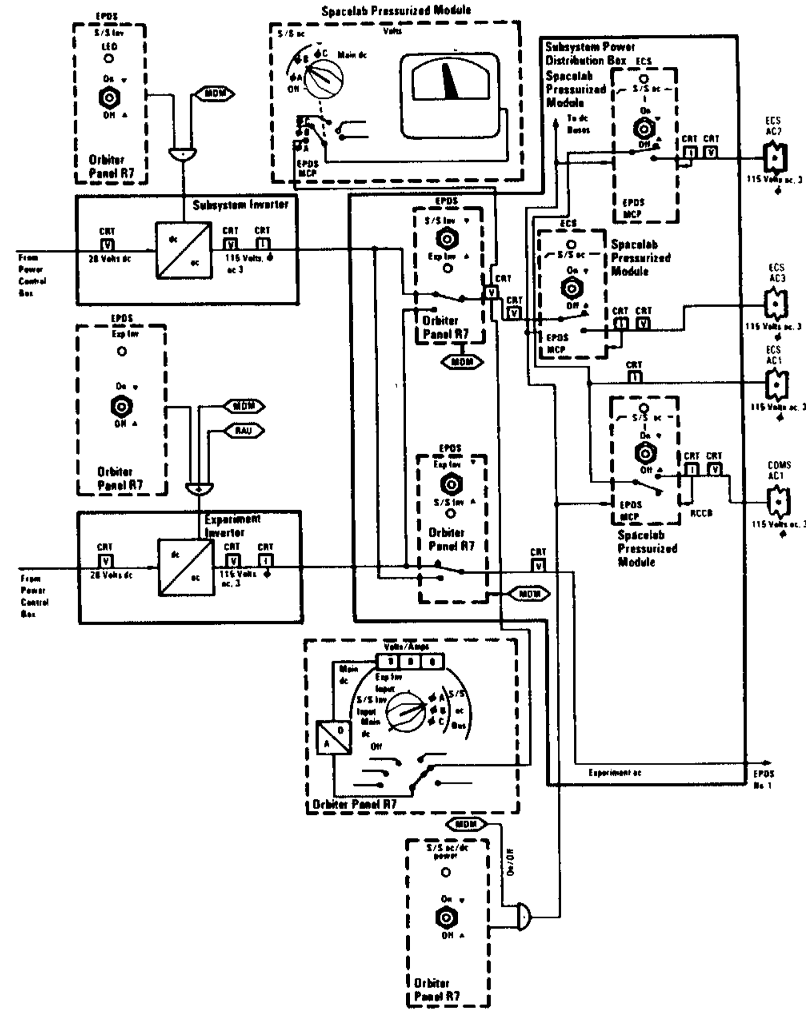
The Spacelab subsystem inverter is activated by the *S/S inv on/off* switch on panel R7 or by orbiter Spacelab CRT command. Positioning the switch to *on* activates the subsystem inverter, and a green LED above the switch on panel R7 is illuminated, indicating the inverter is operating. Positioning the momentary left *S/S inv, exp inv* switch to *S/S inv* permits the subsystem inverter to supply ac power to the Spacelab subsystem ac bus. Similarly, positioning the momentary right *S/S inv, exp inv* switch to *S/S inv* supplies ac power to the experiment ac bus, and the yellow light below the switch is illuminated to indicate the subsystem inverter is supplying the experiment ac bus.

The Spacelab experiment inverter is activated by the *exp inv on/off* switch on panel R7 or by orbiter Spacelab CRT command. Positioning the switch to *on* activates the experiment inverter, and a green LED light above the switch is illuminated, indicating the inverter is in operation. Positioning the momentary right *exp inv, S/S inv* switch to *exp inv* supplies ac power to the experiment ac bus. Positioning the momentary left *S/S inv, exp inv* switch to *exp inv* supplies ac power to the subsystem ac bus, and the yellow light below the switch is illuminated to indicate the experiment inverter is supplying the subsystem ac bus.

The switching of Spacelab inverters between the two ac power buses may also be commanded and monitored through the orbiter CRT Spacelab subsystem ac power supply. Readings presented on the orbiter CRT display include inverter on/off status, inverter output voltage, inverter input voltage, and inverter output current. The subsystem inverter input, experiment inverter input, and main dc amps are available via the digital readout and rotary switch on panel R7. The main dc and subsystem ac bus phase A, B, and C volts also are available via the digital readout and rotary switch on panel R7. In the Spacelab pressurized module configuration, the Spacelab EPDS monitoring and control panel provides a color readout of each subsystem ac phase.

The Spacelab inverters are protected against overvoltage and overcurrent. They are shut down automatically if the voltage exceeds 136 volts root mean square per phase. Current levels are limited to 12 amps rms per phase, and all three phases are shut down if one phase draws a current of 10 amps rms for 120 seconds.

In the pressurized module configuration, the subsystem power distribution box ac bus feeds several Spacelab subsystem power buses controlled by switches on the Spacelab EPDS MCP. All func-



Spacelab Electric Power Distribution—
Subsystem ac Power Distribution

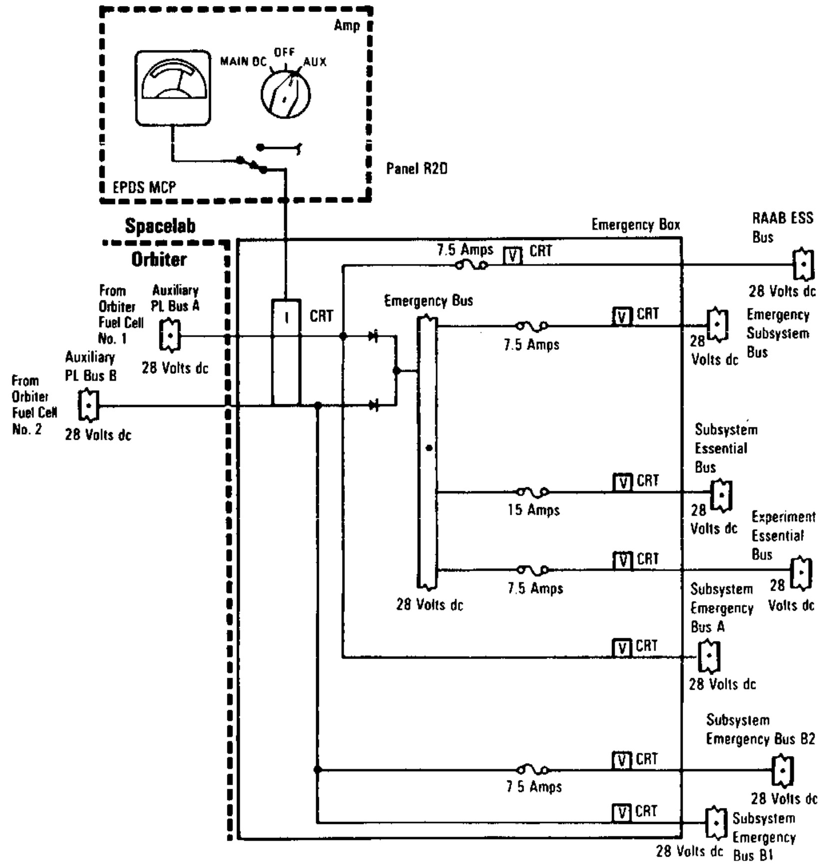
tions on this panel can be initiated simultaneously by the *S/S ac/dc power on/off* switch on orbiter panel R7 or by item commands from the orbiter CRT Spacelab displays. The status of the commanded relays is available via orbiter CRT Spacelab displays and indicated by the green LED light above the respective switch on panel R7.

In the pallet-only configuration, subsystem ac bus power feeds several Spacelab subsystems' power buses, which can be initiated by the *S/S ac/dc power on/off* switch on orbiter panel R7 or by item commands from the orbiter CRT Spacelab displays. The status of the commanded relays is available via orbiter CRT Spacelab displays and the green LED light above the respective switches on panel R7.

Emergency and essential dc power for the pressurized module configuration is provided by the orbiter auxiliary payload buses A and B to the Spacelab emergency box. The Spacelab emergency box supplies emergency and essential power for Spacelab critical environmental control subsystem sensors and valves, fire and smoke suppression equipment, ECS water line heaters, module emergency lighting, tunnel emergency lighting, the Spacelab intercom system, and the Spacelab caution and warning panel. The outputs are protected by fuses. One separately fused outlet, an experiment essential bus, is dedicated to experiments. This power is available during all flight phases and when degraded power is delivered to Spacelab. The Spacelab emergency box is located in the subfloor of the core segment.

Emergency and essential dc power for the pallet-only configuration is also provided by orbiter auxiliary payload buses A and B, which send dc power to the Spacelab emergency box located in the igloo. The Spacelab emergency box provides emergency or essential power to Spacelab subsystem equipment. The outputs are protected by fuses. One separately fused outlet, an experiment essential bus, is dedicated to experiments. The Spacelab emergency box is in the igloo. This power is available during all flight phases and when degraded power is delivered to Spacelab.

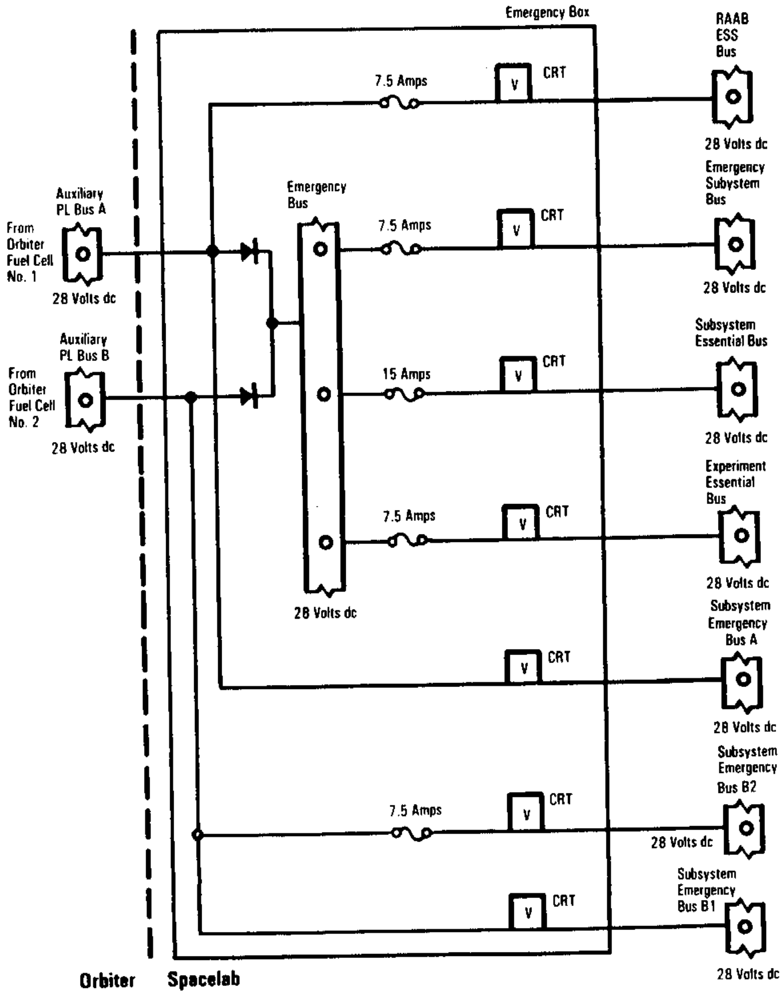
In the Spacelab pressurized module configuration, experiment power distribution boxes provide distribution, control, and monitoring facilities for the experiment electrical power distribution system, which consists of a nominal redundant 28-volt experiment main dc supply and a 115-volt, 400-hertz ac experiment supply. One distribution box (EPDB 1) is located under the core segment floor on a support structure; for the long module configuration, two additional units (EPDBs 2 and 3) are installed. In the pallet-only configuration, the experiment power distribution box is mounted with other assem-



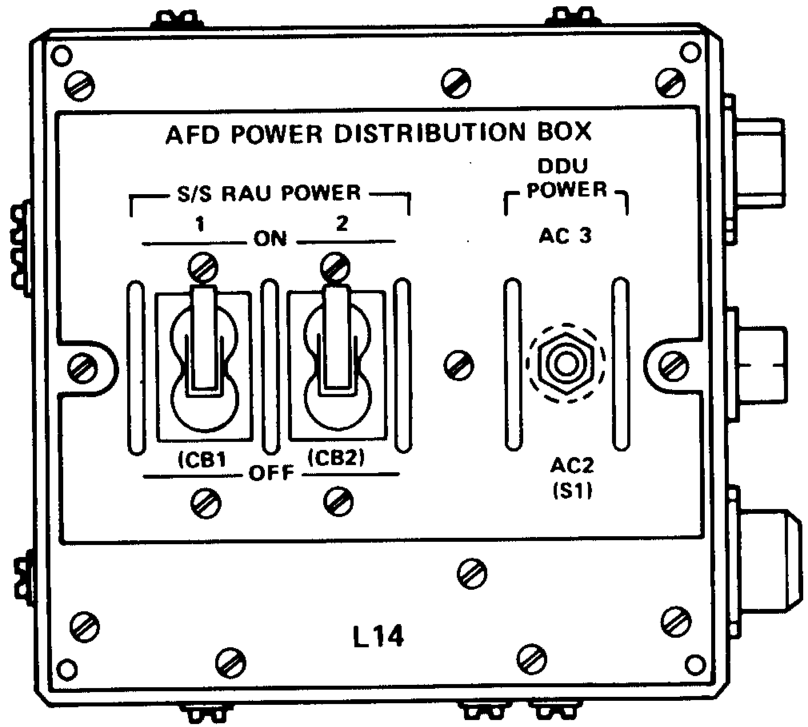
Spacelab Pressurized Module Emergency and Essential Power Distribution blies with an adapter plate on a cold plate that is fitted on a support structure and attached to the pallet.

The orbiter pressurized module CRT Spacelab displays present emergency and essential bus current, voltages for auxiliary buses A and B, output voltages for Spacelab subsystem emergency buses, output voltage for the Spacelab subsystem essential bus, and output voltage for the Spacelab remote amplification and advisory box essential bus. The orbiter CRT Spacelab displays for activation/deactivation, subsystem dc power, and system summary indicate an undervoltage condition for auxiliary buses A and B. Nominal auxiliary bus amperage from the orbiter can be monitored on the *amps* meter (color zone only) of the Spacelab EPDS monitoring and control panel.

In the pallet-only configuration, the orbiter CRT Spacelab displays include emergency and essential bus current, voltages for auxiliary buses A and B, output voltages for Spacelab subsystem emergency buses, output voltage for the Spacelab subsystem essential



Spacelab Pallet Emergency and Essential Power Distribution



Panel L14

bus, and output voltage for the Spacelab remote amplification and advisory box essential bus. The orbiter CRT Spacelab activate/deactivate, Spacelab subsystem dc power, and Spacelab system summary displays will indicate an undervoltage condition for auxiliary buses A and B.

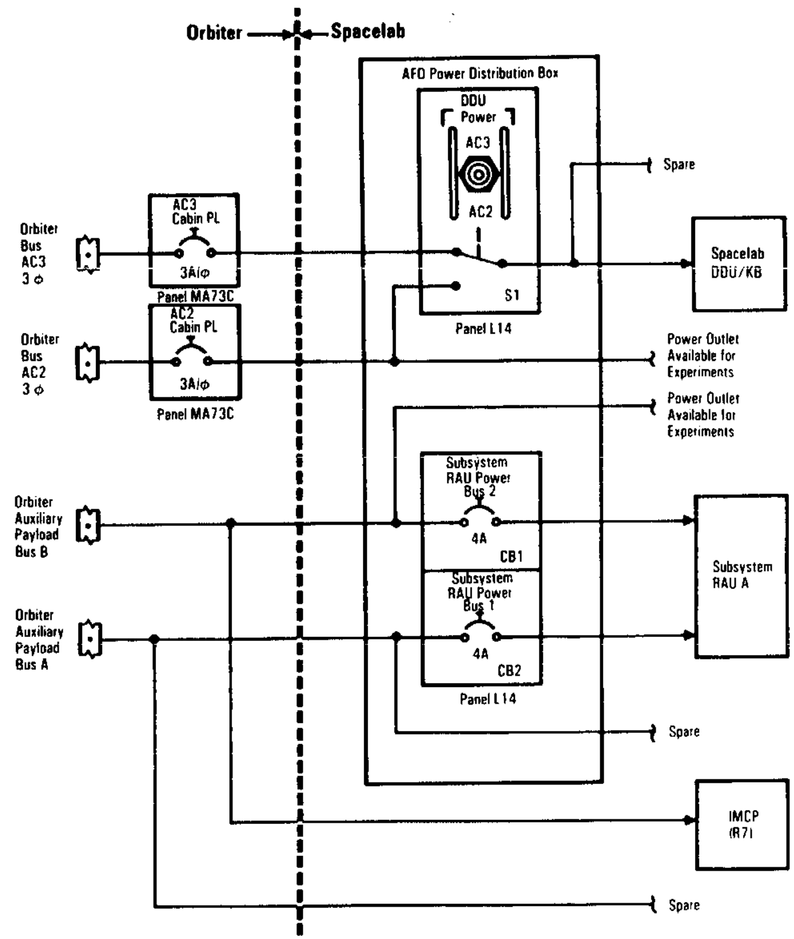
The Spacelab power distribution box at the orbiter aft flight deck payload station distributes dc and ac power to the Spacelab subsystem remote acquisition unit and the Spacelab data display system (a data display unit and keyboard). When a Spacelab data display system is installed at the mission station, ac power is provided from orbiter ac bus 2 or 3 via the orbiter mission station distribution panel.

Spacelab subsystem remote acquisition unit dc power comes from orbiter fuel cell 1 main bus A through auxiliary payload bus A and from orbiter fuel cell 2 main bus B to auxiliary payload bus B through the payload station distribution panel. This power is not affected by the kill switch of the primary payload bus. The aft flight deck power distribution panel L14 *S/S RAU power 1 on/off* and *S/S RAU power 2 on/off* circuit breakers are used to feed power to the RAU from either bus.

Control of the ac power supplied to the Spacelab DDU and keyboard from orbiter ac buses 2 and 3 is made possible by positioning the panel L14 *DDU power* switch to *AC2* or *AC3*. This 115-volt ac, three-phase, 400-hertz power is available only during on-orbit flight phases. Panel L14 provides no fuse protection.

In the pallet-only configuration, ac power is supplied to the Spacelab pallet or pallets from orbiter ac buses 2 and 3 by positioning the panel L14 *DDU power* switch to *AC2* or *AC3*. This power (115 volts ac, three phase, 400 hertz) is available only during on-orbit flight phases.

In the Spacelab module, the experiment power switching panel provides facilities for branching and switching dc and ac power delivered by a dedicated experiment power control box. The dc and ac output is distributed to experiments and experiment-supporting



Pressurized Module Configuration—Orbiter Aft Flight Deck Power Distribution

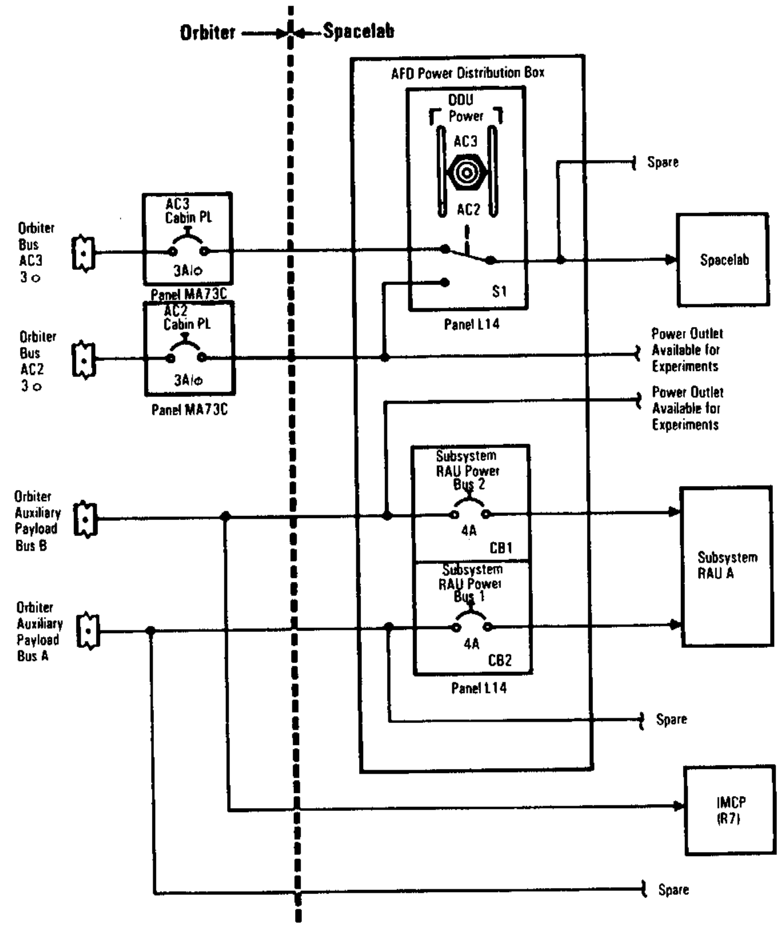
RAUs (dc only). The number of switching panels and their locations depend on the mission configuration.

The orbiter crew compartment aft flight deck panel configurations vary for Spacelab pressurized module configurations and pallet-only configurations. A Spacelab pressurized module configuration may consist of a payload specialist station data display unit at panel L11, a standard switch panel at panel L12, a keyboard at panel L11, a systems management tone generator and interconnect station at panel L14, a mission specialist station with a data display system and interconnect station at panel R14, and a floor-mounted remote acquisition unit at the payload station.

A pallet-only configuration may consist of a payload specialist station data display system at panel L11, a Spacelab-unique switch panel at panel L12, a video tape recorder at panel R11, a high-data-rate recorder at panel L10, a systems management tone generator and interconnect station at panel L14, a Spacelab power distribution box at panel L14, and a floor-mounted Spacelab RAU at the payload station.

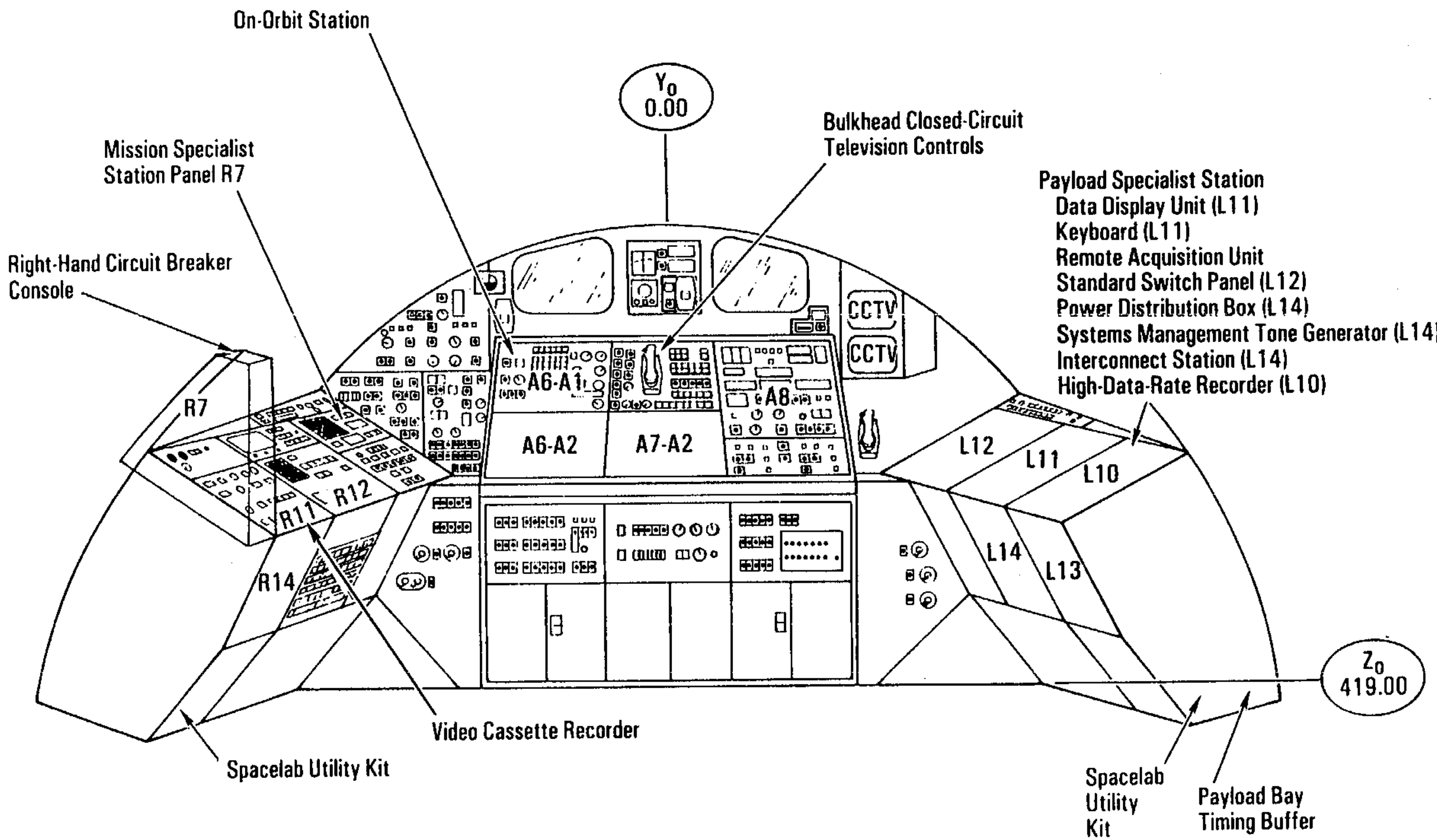
COMMAND AND DATA MANAGEMENT SYSTEM. The Spacelab command and data management system provides a variety of services to Spacelab experiments and subsystems. Most of the CDMS commands are carried out through the use of the computerized system aboard Spacelab, called the data processing assembly. The DPA formats telemetry data and transfers the information to the orbiter for transmission, receives command data from the orbiter and distributes them to Spacelab subsystems, transfers data from the orbiter to experiments, and distributes timing signals from the orbiter to experiments.

The CDMS includes three identical computers and assorted peripherals. One computer is dedicated to Spacelab experiments, one supports Spacelab subsystems, and the third is a backup. The flight crew monitors and operates Spacelab subsystems and payload experiments through data display and keyboard units. The pre-

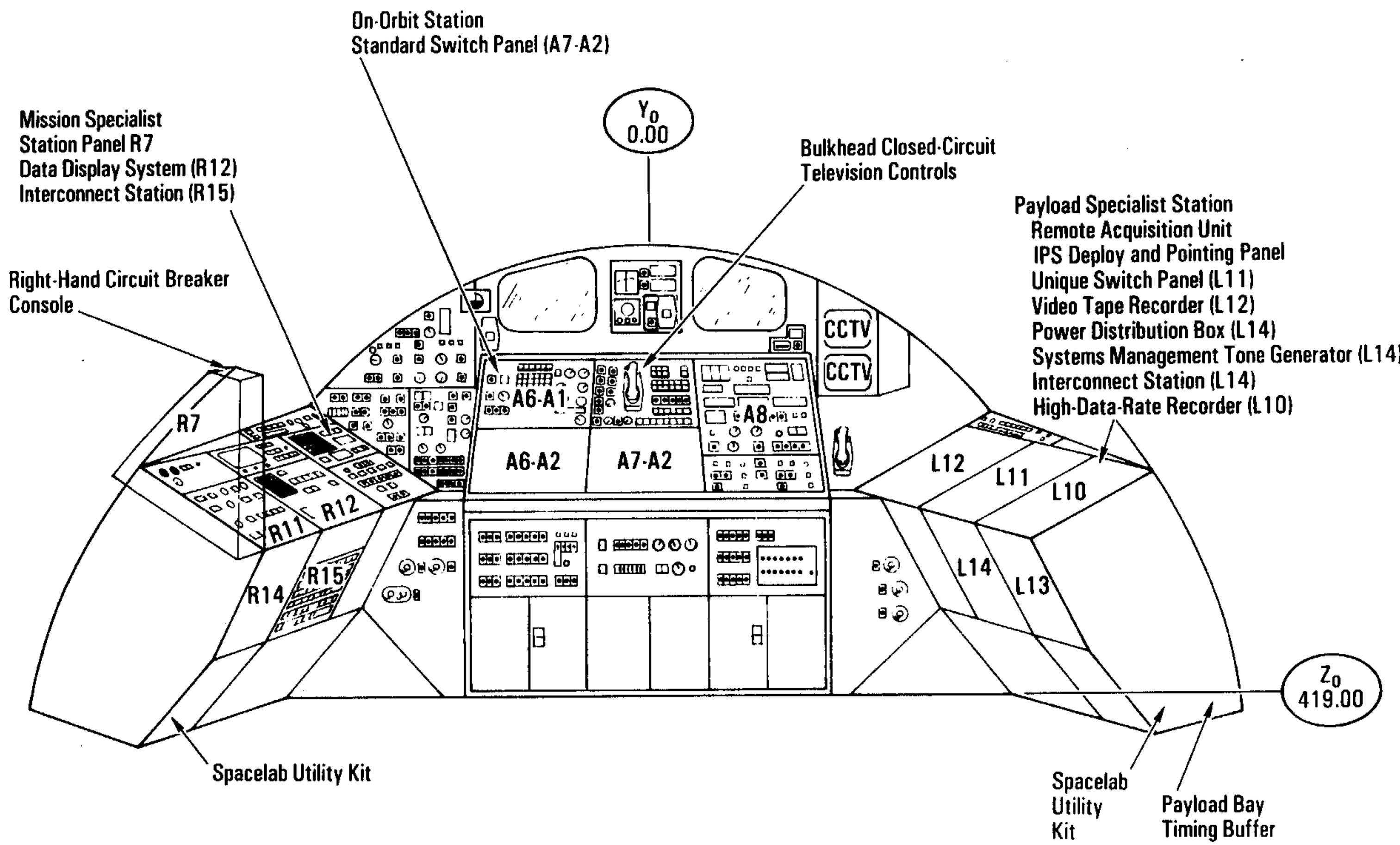


Pallet-Only Configuration—Orbiter Aft Flight Deck Power Distribution

viously used three identical MATRA 125/MS computers have been changed to the upgraded AP-101SL orbiter computers. The experiment computer activates, controls, and monitors payload operations and provides experiment data acquisition and handling. The subsystem computer provides control and data management for basic Spacelab services that are available to support experiments, such as electrical power distribution, equipment cooling, and scientific air-



Example of a Spacelab Pressurized Module Aft Flight Deck Panel Configuration



Example of a Spacelab Pallet-Only Aft Flight Deck Panel Configuration lock operations (in the case of the pressurized module). The backup computer can function in the place of either computer.

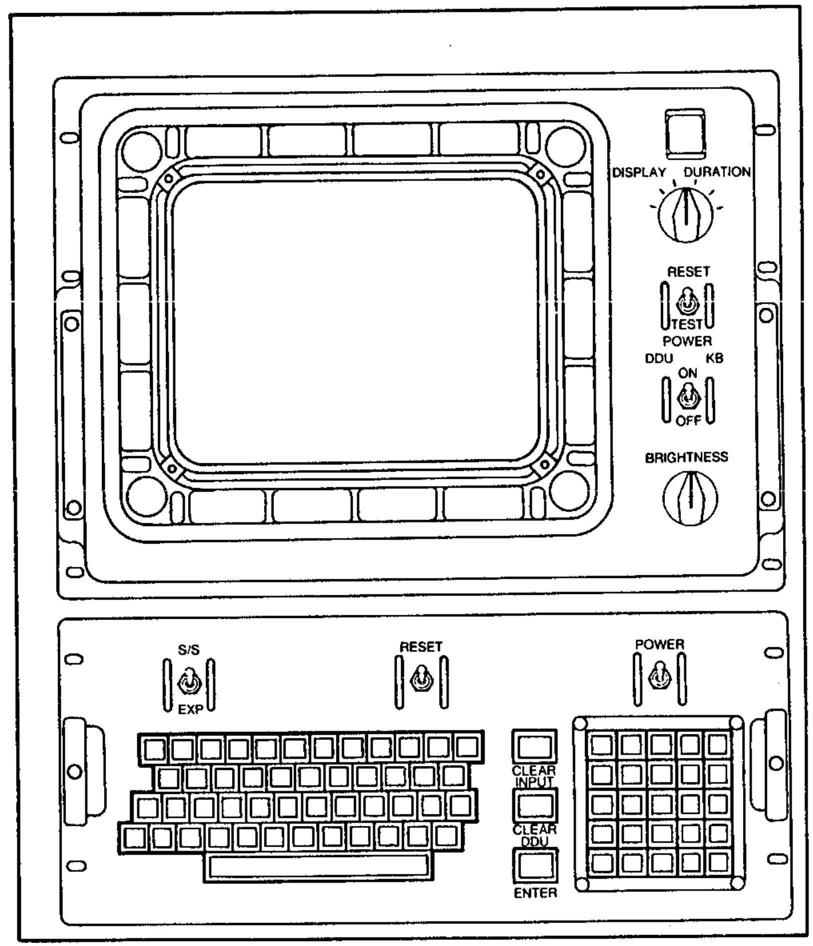
An input/output unit buffers all communications between the computer and the rest of the subsystem. The experiment computer also has at least one RAU (and as many as eight, depending on the payload) for interfacing between experiments and the subsystem. The subsystem computer may have as many as nine acquisition units, depending on the Spacelab configuration.

The experiment and subsystem computers and their associated input/output units, as well as the shared mass memory unit and backup computer, are located in the workbench rack of the pressurized module core segment. In the pallet-only configuration, they are located in the igloo.

Mass Memory Unit. The MMU is a tape recorder that contains all of the operating system and applications software for the subsystem and experiment computers. The memory unit provides the initial program load for the Spacelab subsystem, experiment, and backup computers; it can also be used to completely reload computer memory if required. The MMU stores various files, time lines, and displays. Writing onto the unit during flight is possible. Approximately half of the unit's storage capability is available for software and data supporting Spacelab experiments.

Data Display Systems. The data display systems are the primary on-board interface between the CDMS and the Spacelab flight crew. Each display system consists of a keyboard and a CRT data display unit. One display is located at the orbiter aft flight deck station, one at the control center rack in the pressurized module, and, possibly, one at the experiment rack in the pressurized module. In the pallet-only configuration, two CRTs and DDUs can be located at the crew compartment aft flight deck station.

The keyboard consists of 25 function keys and 43 alphabet, numeral, punctuation, and symbol keys of the familiar standard typewriter keyboard as well as the standard typewriter action keys, such as space and backspace. The data display unit is a 12-inch diagonal CRT screen providing a 22-line display (47 characters per line) in three colors (green, yellow, and red). In addition to 128 alphanumeric symbols, the unit can also display vector graphics (1,024 dif-



Data Display Unit and Keyboard

ferent lengths and 4,096 angles). A high-intensity green flashing mode is also provided.

The display units are connected to the experiment and subsystem input/output units. Each data display unit can present information from both computers simultaneously, and each keyboard can communicate with either computer. Flight crew members can call various displays onto the screen from the keyboard for experiment evaluation and control.

Command and data management system software consists of experiment computer software and subsystem computer software, each of which includes operating systems and applications. Within the experiment computer, both the operating system and the application software are wholly dedicated to the direct support of Spacelab payload experiments. The operating system provides such general services as activation, control, monitoring, and deactivation of experiments as well as experiment data acquisition, display, and formatting for transmission. Application software is developed for experiments that have data handling requirements beyond the capabilities of the operating system.

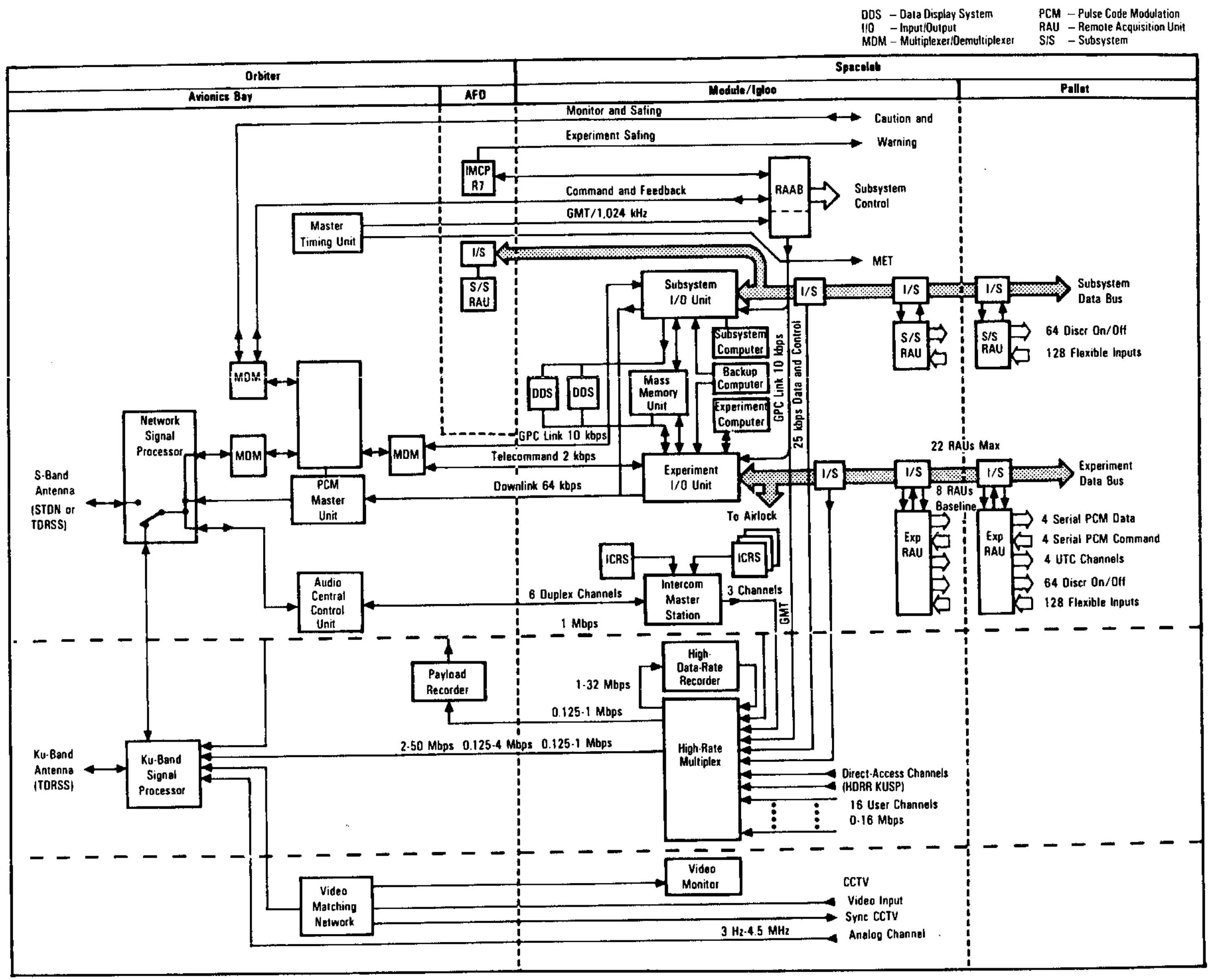
The subsystem computer functions mainly to monitor and control other Spacelab subsystems and equipment, such as the electrical power distribution subsystem and the environmental control subsystem. These functions are performed by the subsystem computer operating software.

Two orbiter payload multiplexers/demultiplexers (PF1 and PF2) are used for data communications between the orbiter general-purpose computers and the Spacelab CDMS computers. The payload MDMs are under orbiter GPC control. The orbiter pulse code modulation master units under control of the orbiter computers can access Spacelab data for performance monitoring and limit sensing. The PCMMUs contain a fetch command sequence and a random-access memory for storing fetched data. Data from the PCMMU RAM are combined with orbiter pulse code modulation data and sent to the orbiter network signal processors for transmission on the return link (previously referred to as downlink) through S-band or Ku-band. The 192-kbps data stream normally carries 64 kbps of Spacelab experiment and subsystem data.

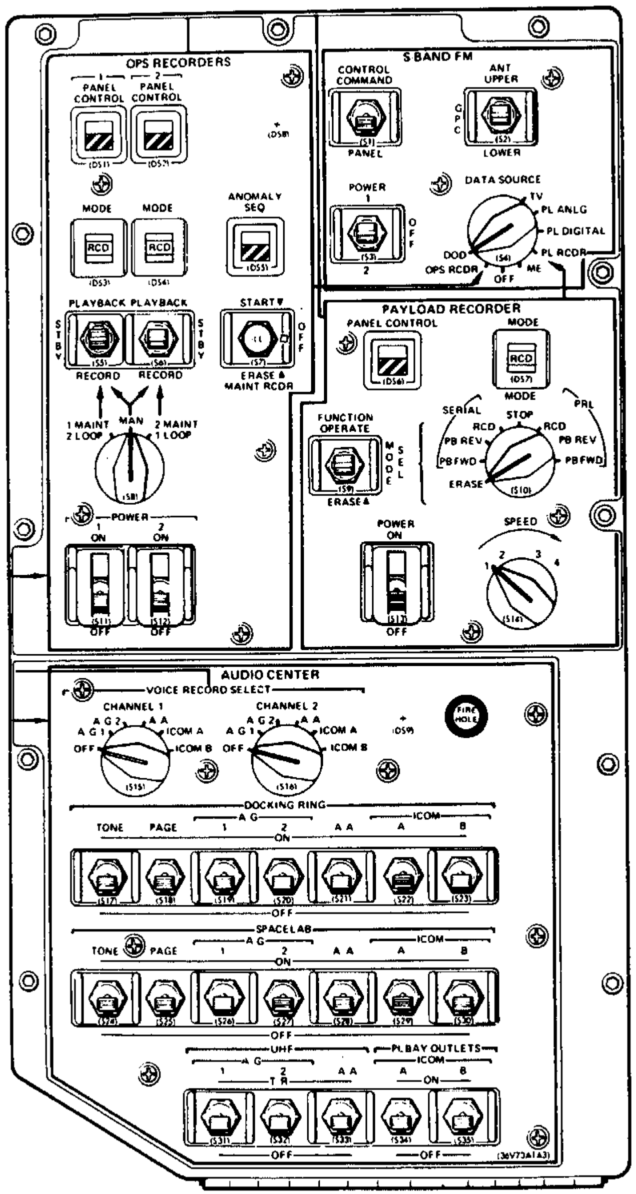
The Spacelab experiment computer interfaces with two telemetry systems. The orbiter PCMMU allows the orbiter to acquire data for on-board monitoring of systems and provides the Mission Control Center in Houston with system performance data for real-time display and recording through the orbiter network signal processor and S-band or Ku-band. The other telemetry system, the Spacelab high-rate multiplexer, is a high-rate link to the Ku-band signal processors that sends scientific data to the Payload Operations Control Center for real-time display and to the Goddard Space Flight Center for recording.

Spacelab high-rate data acquisition is provided by a high-rate multiplexer and a high-data-rate recorder. The HRM multiplexes up to 16 experiment channels, each with a maximum of 16 Mbps, two direct-access channels with data rates up to 50 Mbps, data from the Spacelab subsystem computer, experiment data from the Spacelab experiment computer, and up to three analog voice channels from the Spacelab intercom master station in the pressurized module configuration. The three digitized channels are premultiplexed onto a single 128-kbps channel for interleaving in the format along with Greenwich Mean Time signals from the orbiter master timing unit. This composite output data stream is routed to the Ku-band signal processor for transmission on Ku-band or is sent to one of the two recorders. The HRM is located on the control center rack in the pressurized module and in the igloo for the pallet-only configuration.

In the pressurized module, the high-data-rate recorder is located at the control center rack next to the data display system; in the pallet-only configuration, it is at the aft flight deck panel L10. It records real-time, multiplexed data or data from two direct-access channels and stores the information at rates from 1 to 32 Mbps during mission periods with no downlink capability or degraded downlink capability for playback when the capability is available. The HDRR dumps



Spacelab Command and Data Management System Interfaces With the Orbiter



Panel AIA3

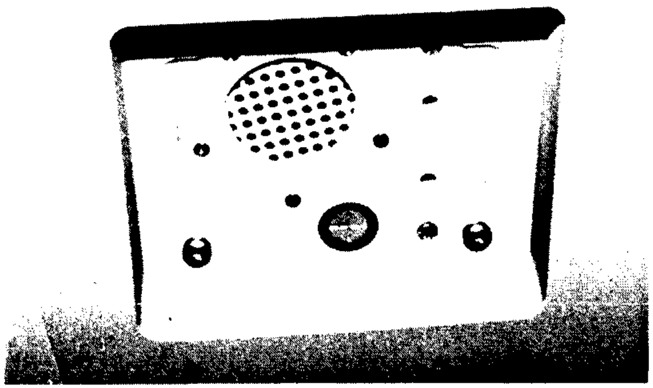
in reverse order at 2, 4, 8, 12, 16, 24, or 32 Mbps. At a rate of 32 Mbps, a tape runs for 20 minutes. The recorder can be changed manually by the flight crew; however, no tape changes are planned because the time required to change tapes is very long and it is much more efficient to dump the tape.

The orbiter payload recorder serves as a backup for the Spacelab HDRR for data rates from 0.125 to 1 Mbps and can record only real-time, multiplexed data. The orbiter payload timing buffer provides mission elapsed time and Greenwich Mean Time; and the master timing unit provides 100-hertz, 1-kHz, 1,024-kHz, and 4,608-kHz timing signals to the Spacelab data processing assembly. Activation of the Spacelab DPA is controlled and monitored from the orbiter CRT Spacelab displays.

Closed-Circuit Television. The Spacelab pressurized module video system interfaces with the orbiter closed-circuit television system and the orbiter Ku-band signal processor. The orbiter CCTV system accepts three video inputs from the Spacelab system. The orbiter monitors the TV received and/or transmits it to telemetry. A sync command signal provided by the orbiter synchronizes and remotely controls cameras within Spacelab. The orbiter also has one video output for a Spacelab TV monitor. The Spacelab accommodates a video switching unit that enables Spacelab video recorder capability. The Spacelab analog channel for experiments is directed to the orbiter Ku-band signal processor at 3 to 4.5 MHz.

In the pallet-only configuration, the orbiter's CCTV can be used along with a video tape recorder. The TV cameras installed in the payload bay vary according to mission requirements. Television data downlinked on Ku-band channel 3 are time-shared by the orbiter's CCTV system, the Spacelab TV/analog output, and the Spacelab high-rate multiplexer data.

Pressurized Module Intercom. The Spacelab intercom master station interfaces with the orbiter audio central control unit and the orbiter EVA/ATC transceiver for communications through orbiter duplex (simultaneous talk and listen) audio channels. Audio chan-



Spacelab Pressurized Module Aural Annunciator
Located Below Panel L14

nel 1 is air-to-ground 2, channel 2 is intercom B, and channel 3 is air-to-ground 1.

Each orbiter channel, with the exception of page, may be selected on each of the three Spacelab full-duplex channels—A/G 1 for the Payload Operations Control Center, Spacelab and A/G 2 for the orbiter/Mission Control Center—using rotary switches on the Spacelab intercom master station. The page channel is used for general address and calling purposes. Page signals can originate in the orbiter, Spacelab, or both.

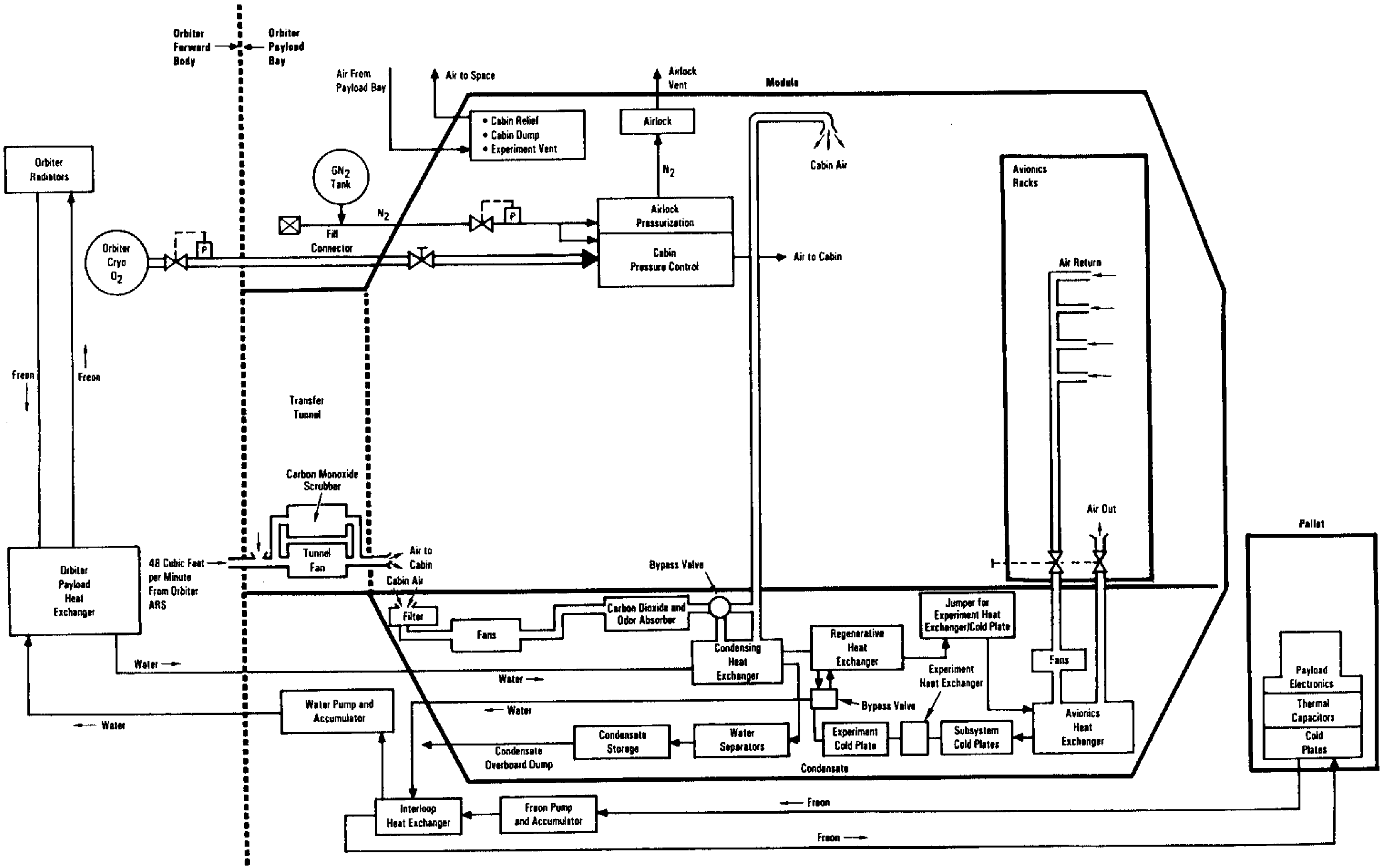
Access to orbiter channels is controlled within the orbiter. Normal voice recordings are made on the orbiter operations recorders. The Spacelab talk and listen lines are combined for distribution to the Spacelab voice digitizer in the Spacelab high-rate multiplexer for all three Spacelab channels.

PRESSURIZED MODULE ENVIRONMENTAL CONTROL SUBSYSTEM AND LIFE SUPPORT. The Spacelab environmental control subsystem consists of the atmosphere storage and control subsystem and the atmosphere revitalization system.

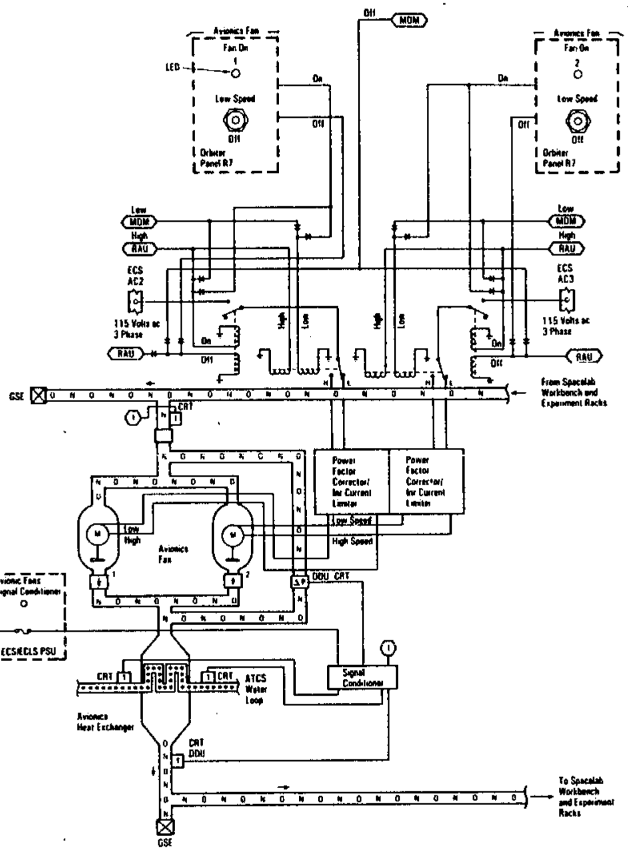
The atmosphere storage and control subsystem receives gaseous oxygen from the orbiter power reactant storage and distribution system and gaseous nitrogen from a tank located on the Spacelab module's exterior. The Spacelab ASCS regulates the gaseous oxygen and nitrogen pressure and flow rates to provide a shirt-sleeve environment for the Spacelab module compatible with the orbiter cabin atmosphere.

Gaseous oxygen from the orbiter PRSD enters the Spacelab module through the upper feedthrough in the Spacelab forward end cone at 100 psi and a maximum flow rate of 14 pounds per hour. A motor-controlled valve in the Spacelab module controls the flow of gaseous oxygen. This valve, operated by Spacelab RAU commands, opens when the *O2 supply valve* switch on panel R7 is in the *cmd enable* position. It closes when the switch is in the *close* position for such situations as contingency cabin atmosphere dump. A yellow LED above the switch on panel R7 is illuminated to indicate that the valve is closed. The oxygen supply valve receives 28 volts from the Spacelab emergency bus.

The Spacelab cabin depressurization assembly is primarily for contingency dump of Spacelab cabin atmosphere in case of fire that cannot be handled by the Spacelab fire suppression system. It consists of a vent with two filters, a manual shutoff valve, and a motor-driven shutoff valve. The motor-driven shutoff valve is powered by the Spacelab environmental control subsystem emergency bus and controlled by the *cabin depress valve open/close* switch, a *cabin depress arm/safe* switch, and valve status LEDs on orbiter panel R7. The *cabin depress arm* switch arms the Spacelab cabin depressurization motor-driven valve; and when the *cabin depress valve* switch is positioned to *open*, the Spacelab cabin depressurization assembly in the Spacelab forward end cone opens, depressurizing the Spacelab module at 0.4 pound per second. The red LED above the switch on



Spacelab Pressurized Module and Orbiter Environmental Control and Life Support System Interface



Spacelab Avionics Loop

panel R7 is illuminated to indicate that the motor-operated depressurization valve is fully open. The yellow LED above the switch on panel R7 is illuminated to indicate that the Spacelab cabin depressurization valve is not closed when the *cabin depress* switch is in *arm* and the *cabin depress valve* switch is in the *closed* position.

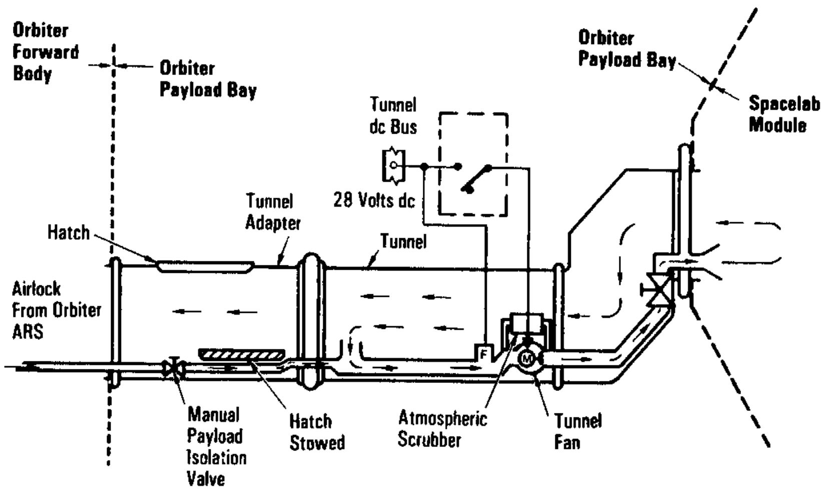
Air in the Spacelab avionics air loop is circulated by one of two dual-redundant fans, with check valves to prevent recirculation through the inactive fan and a filter upstream to protect both fans. For ascent and descent flight phases, as well as low-power modes on orbit, the avionics fans operate when only a few experiments are operating and require cooling.

The fans are designed to switch from four-pole to eight-pole operation. The air flow through one fan is reduced from 1,923 to 639 pounds per hour, and the power is reduced from 643 to 110 watts. The two fans, powered by separate 115-volt ac buses, are activated and deactivated at low speed (eight-pole) by the *avionics fan 1/2 low speed/off* switches on orbiter panel R7. Each switch has a yellow LED that is illuminated above the respective switch to indicate that the respective fan is activated. The fans' on/off status is also available on orbiter CRT displays and the Spacelab DDU avionics power/cooling display.

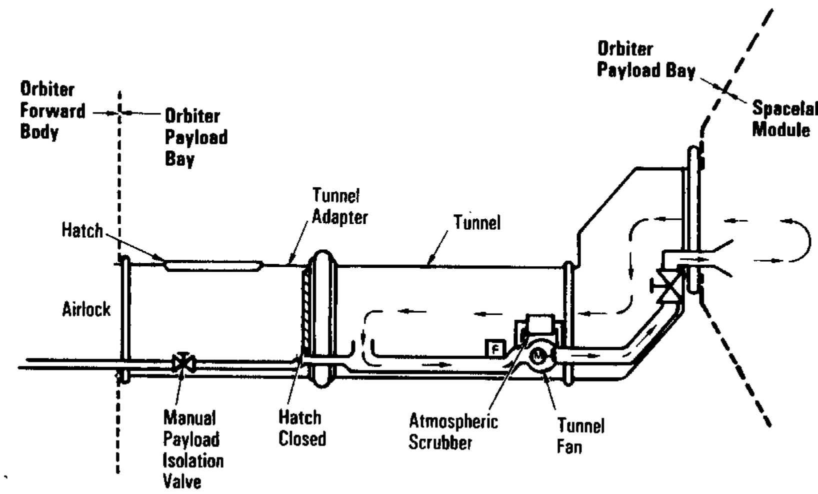
The Spacelab avionics fans can also be activated in the low-speed mode by commands from the orbiter CRT keyboard. The fans are activated in the high-speed mode (four-pole) by commands from the orbiter CRT keyboards. The orbiter MDM deactivation command deactivates both fans simultaneously, and the Spacelab RAU deactivation command turns off each fan separately. The high-speed status of the Spacelab avionics fans is available on the orbiter CRT display and the Spacelab DDU display.

Pressurized Module/Tunnel Air Loop. The switch for the fan located in the transfer tunnel cannot be accessed until the tunnel/Spacelab hatch is opened and the flight crew initially transfers to the Spacelab from the orbiter.

When the airlock hatch and the tunnel adapter/Spacelab hatches are open, the orbiter air revitalization system provides air at 48 cubic feet per minute through a duct that branches off of the orbiter cabin air loop downstream of the orbiter cabin heat exchanger and enters the tunnel adapter. In the tunnel adapter, the duct can be controlled by a manual shutoff valve before it passes into the transfer tunnel itself. For the transfer tunnel to be entered, the tunnel adapter/Spacelab hatch must be opened and the duct passed through the tunnel hatch, where the duct expands. The fan located in the transfer tunnel



Tunnel Adapter Hatch Open—48-Cubic-Feet-Per-Minute Duct Operating



Tunnel Adapter Hatch Closed—48-Cubic-Feet-Per-Minute Duct Not Operating

draws additional air into the duct through an air inlet located just on the tunnel side of the tunnel adapter hatch.

The fan draws in additional air at a rate of 77 cubic feet per minute for a total nominal duct flow of 125 cubic feet per minute. This flow rate is delivered to the Spacelab cabin. The return air passes through the transfer tunnel itself, initially at 125 cubic feet per minute. However, 77 cubic feet per minute of air is sucked into the duct inlet at the Spacelab side of the tunnel/adapter hatch, and 48 cubic feet per minute of air enters the orbiter cabin through the tunnel adapter and airlock hatch. A scrubber in the tunnel duct removes carbon monoxide. The scrubber, located in parallel with the tunnel fan, produces an air flow of 1.5 to 4 cubic feet per minute.

The tunnel fan receives dc power from the Spacelab electrical power distribution subsystem. A delta pressure sensor located in the tunnel provides telemetry data for calculating air flow. If the Spacelab module is operating with the tunnel adapter hatch closed, air exchange is not possible. In this case, the tunnel fan can be used to circulate air at 125 cubic feet per minute in the tunnel.

Pressurized Module Active Thermal Control Subsystem. The Spacelab active thermal control subsystem consists of a water loop to remove heat from the Spacelab module and a Freon loop to remove heat from equipment on any pallets that may be flown with the pressurized module. The water loop is normally active only during on-orbit flight phases, but the need to cool experiments during ascent and descent requires operation of the water loop in a degraded performance mode during these phases.

The Spacelab water loop is circulated by a water pump package consisting of dual-redundant pumps (primary and backup) with inlet filters, manually adjustable bypass valves, check valves to prevent recirculation through the inactive pump, and an accumulator assembly to compensate for thermal expansion within the loop and maintain a positive pump inlet pressure.

The pump package is contained in a housing and mounted on the outside of the Spacelab module's forward end cone. The nominal flow rate through one pump is 500 pounds per hour.

The Spacelab water pumps are powered by separate 115-volt buses. They are activated and deactivated by the *H_2O loop pump 1/2 on/off* switches on orbiter panel R7 or by commands from the orbiter CRT keyboards. The green LED above each switch on panel R7 is illuminated to indicate that the pump is in operation. The on/off status of the Spacelab water pumps is also shown on the orbiter CRT displays.

The Spacelab Freon coolant loop removes heat from any pallets that may be flown with the pressurized module and transfers the heat of the interloop heat exchanger to the Spacelab water loop system. The flow rate is approximately 3,010 pounds per hour. From the Spacelab water loop system, the water passes through the orbiter payload heat exchanger, which transfers all the heat it has collected to the orbiter Freon coolant loops.

Pressurized Module Caution and Warning. The orbiter receives caution and warning inputs from Spacelab through the orbiter payload MDMs. Four channels in the Spacelab systems are dedicated to sending payload warning signals to the orbiter, and four channels in the Spacelab systems send payload caution signals to the orbiter. Nineteen remaining caution and warning input channels to the orbiter payload MDMs are available for Spacelab experiment limit sensing in the orbiter GPCs. The orbiter provides a maximum of 36 safing commands for use in response to Spacelab caution and warning conditions with 22 reserved for experiment safing commands. All safing commands are initiated at the orbiter CRT and keyboard.

The orbiter GPC can obtain data from the Spacelab command and data management system through the orbiter PCMMU as an alternative source for caution and warning.

Pressurized Module Emergency Conditions. There are two categories of Spacelab emergency conditions: fire/smoke in the Spacelab module and rapid Spacelab cabin depressurization. The orbiter and Spacelab annunciate these conditions and can issue safing commands if they occur. These signals are available during all flight phases.

Redundant Spacelab fire/smoke inputs are generated by two ionization chamber smoke sensors at three locations in the Spacelab. The six fire/smoke discrete signals are hard-wired to six annunciator indicators located on panel R7. These indicators are divided into three pairs labeled *left A&B*, *subfloor A&B*, and *right A&B*. The six *smoke annunciators enable/inhibit* switches on panel R7 can be used to inhibit each fire/smoke sensor's output individually. The *smoke sensor reset/norm/test* switch on panel R7 is used to reset or test all six sensors simultaneously.

Three signals, each from a different sensor location, are ORed (run through an OR gate) and connected to orbiter panel L1, which has a payload fire/smoke detection light. The three remaining signals are treated in the same manner.

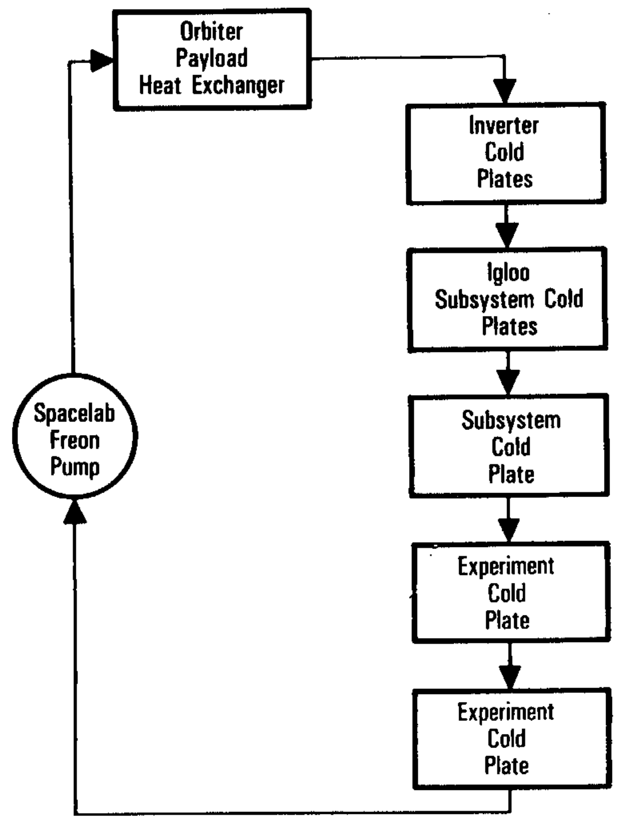
When a Spacelab fire/smoke signal is detected, an emergency tone (siren) generated by the orbiter caution and warning circuitry is transmitted by the orbiter audio central control unit and announced in the Spacelab module by the loudspeaker, and the Spacelab *master alarm* light is illuminated. The six fire/smoke signals are also connected to six orbiter MDM inputs for display as emergency alert parameters on the orbiter CRT and for telemetry.

Two methods are provided for extinguishing a fire in the Spacelab module: discharging a fire suppressant into the affected area or dumping the Spacelab cabin atmosphere, when appropriate. The fire suppressant discharge consists of 15 orbiter-common fire suppression modules, each filled with the Freon 1301 suppressant agent.

The *agent discharge arm/safe* switch on orbiter panel R7 or the panel in the Spacelab module is used to safe or arm the discharge function. Each panel has a yellow indicator light that is illuminated when the discharge circuit is armed. The arming of the suppressant discharge function also shuts off the Spacelab module cabin and avionics fans to avoid diluting the suppressant's concentration. The agent can be discharged from either orbiter panel R7 or the panel in the Spacelab module by three identical sets of *agent discharge* switches, one each for the left, subfloor, and right areas. The switches are protected by individual guards. Positioning one of these switches completely discharges the contents of all suppressant bottles in the indicated area of the Spacelab module. In addition, the Spacelab module *O_2 supply valve close/cmd enable* switch on orbiter panel R7 can be used to close off the oxygen supply from the orbiter oxygen system to deprive the fire of oxygen. Spacelab cabin atmosphere dumping is controlled by the *cabin depress arm/safe* and *valve open/close* switches on orbiter panel R7. The Spacelab motor-controlled cabin dump valve's status is indicated by the yellow *not closed* and the red *full open* indicators on orbiter panel R7 as well as by the orbiter CRT.

PALLET-ONLY ENVIRONMENTAL CONTROL SUBSYSTEM. The environmental control subsystem provides thermal control of Spacelab experiments and subsystems. The Spacelab Freon-21 coolant loop services the pallet systems and collects heat dissipated by the subsystem and experiment equipment. The Spacelab Freon-21 coolant loop collects heat from the pallet-mounted subsystems and experiments through cold plates, some of which have thermal capacitors to store peak heat loads. The cold plates in the Freon loop are bolted to an intermediate support structure that is attached to the pallet. A maximum of eight cold plates can be used on the pallets for a particular mission.

The subsystem equipment mounted in the igloo is also serviced by the Freon loop, which interfaces directly with the orbiter's payload heat exchanger. The Freon pump package is mounted on the front frame of the first pallet (forward) in the orbiter payload bay. Thermal coatings are applied to minimize heat leakage and the effects of solar radiation. A special paint is used to reduce the hot-case temperature of the pallet structure itself. An insulated shield installed between the pallet-mounted cold plates and the pallet structure reduces radiation exchange between them. Multilayer insulation thermal tents also protect pallet-mounted subsystems; any unused tents are available for experiments.



Freon-21 Coolant Loop for Spacelab Pallets

SHUTTLE SOLAR BACKSCATTER ULTRAVIOLET 4

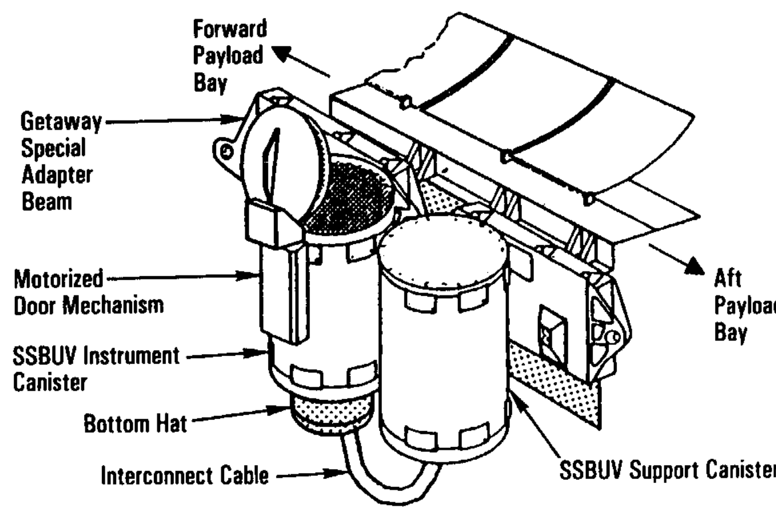
The SSBUV-4 experiment was developed by NASA to provide more accurate and reliable readings of global ozone. SSBUV aids in the calibration of similar ozone-measuring instruments on the National Oceanic and Atmospheric Administration's TIROS satellites (NOAA-9 and -11) and NASA's Nimbus-7 satellite. SSBUV data can also be compared to data obtained by the Upper Atmosphere Research Satellite (UARS) to study the processes that lead to ozone depletion. SSBUV flew previously on the STS-34, -41, and -43 missions.

Global concern over the depletion of the ozone layer has sparked increased emphasis on developing and improving ozone measurement methods and instruments. Accurate, reliable measurements from space are critical for detecting ozone trends and assessing the potential effects of ozone depletion and developing corrective measures.

SSBUV data will help scientists solve the problem of data reliability caused by the calibration drift of solar backscatter ultraviolet instruments on orbiting spacecraft. The SSBUV instrument assesses instrument performance by directly comparing its atmospheric ozone and solar irradiance data with data from identical instruments on other spacecraft as the shuttle and the satellites pass over the same Earth location within a one-hour window. These orbital coincidences can occur 17 times a day.

Solar backscatter ultraviolet instruments measure the amount and height distribution of ozone in the upper atmosphere by measuring incident solar ultraviolet radiation and ultraviolet radiation backscattered from the Earth's atmosphere. These parameters are measured in 12 discrete wavelength channels in the ultraviolet. Because ozone is absorbed in the ultraviolet, an ozone measurement can be derived from the ratio of backscatter radiation at different wavelengths, providing an index of the vertical distribution of ozone in the atmosphere.

The STS-45 payload configuration, although physically separate from the ATLAS-1 payload, is included as part of the ATLAS-1 experiment complement and is equal in priority to the ATLAS-1 experiment science requirements. It consists of two getaway special canisters interconnected by cables mounted in Atlantis's payload bay. The canister containing the SSBUV spectrometer, five supporting optical sensors, and an in–flight calibration system is equipped with a motorized door assembly. The adjacent support canister contains data, command, and power systems. Together, the canisters weigh approximately 720 pounds. The primary method of experiment operation is via ground commanding from the Payload Operations Control Center at NASA's Johnson Space Center (JSC). SSBUV data will be received at JSC and the Marshall Space Flight

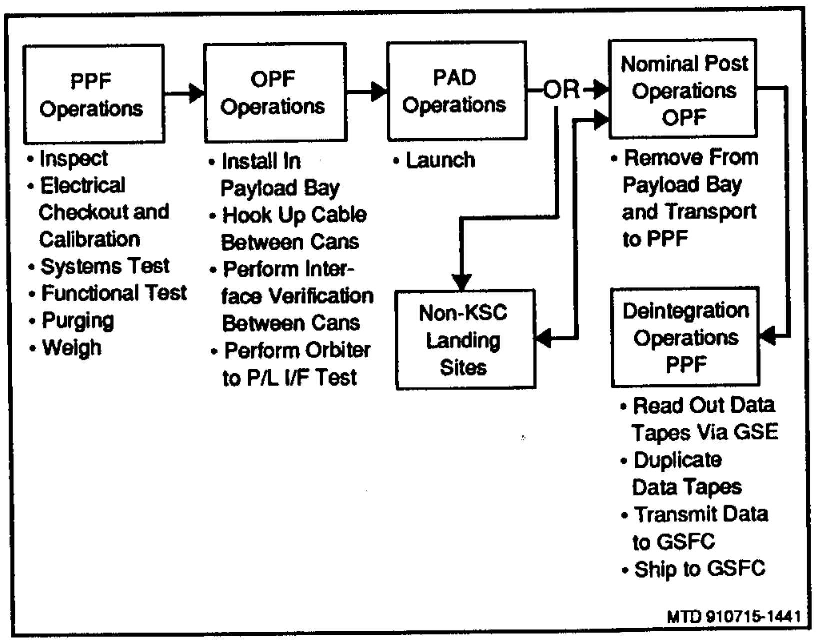


Shuttle Solar Backscatter Ultraviolet Experiment Configuration

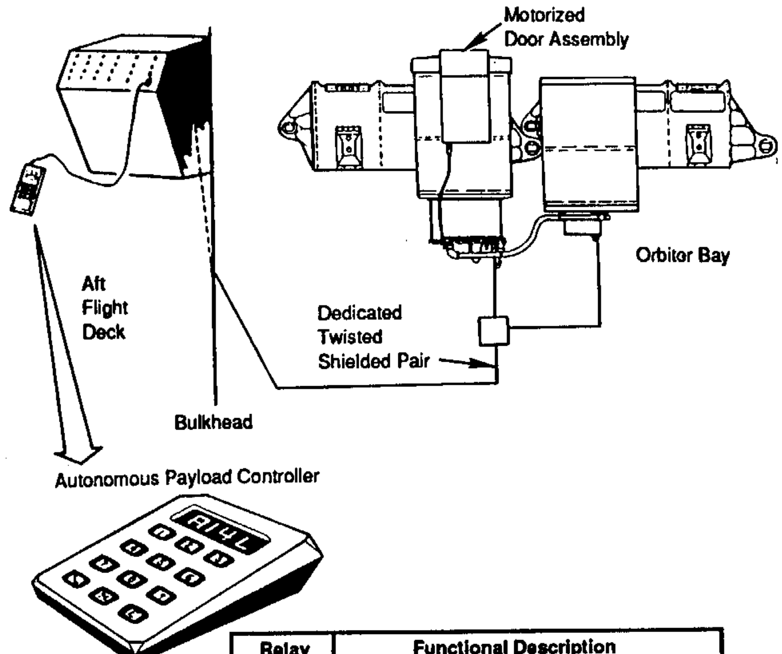
Center. The backup flight crew interface is through a GAS autonomous payload controller on the aft flight deck. This is the first flight of an orbiter-powered configuration.

The SSBUV ozone-measuring instrument is identical to the SBUV/2 instruments that are flown operationally. It is a 1/4mm double Ebert-Fastie spectrophotometer that uses a holographic grating and a single detector. The spectrophotometer collects data when the lid of the GAS canister is opened by the motorized door mechanism. A "bottom hat" subcontainer has been added to the lower end plate.

After an outgassing period, the instrument will be operated in three modes: Earth viewing, solar viewing, and calibration. Up to 29 orbits of Earth-viewing observations will be made to measure backscatter radiances of the Earth horizon. In the solar view mode,



SSBUV Processing



	Relay Address	Functional Description (Hot State/Latent State)
Support Canister	00	Main power on/off
	01	Main power (backup) on/off
	02	Power circuit initialization on/off
Instrument Canister	03	Door enable/disable
	04	Earth view mode on/off
	05	Solar view mode on/off
	06	Door motor inhibit on/off
	07	Door open/close
	08	Calibration mode on/off
SRU in Instrument	60	Base go/no-go address
	61	Diffuser plate position go/no-go
	62	PMT high-voltage go/no-go
	63	Door position go/no-go
	64	Experiment pressure go/no-go
	65	Experiment power go/no-go
	66	Not used
	68	Not used
	67	Not used

MTD 910716-1444

Shuttle Solar Backscatter Ultraviolet Experiment Command and Status Monitoring observations of solar irradiance will be conducted for a 30-minute period at the beginning, middle, and end of payload operation. Seventy-minute calibrations are also required at the beginning, middle, and end of SSBUV operation.

The SSBUV missions are so important to the support of Earth science that six additional missions have been included in the shuttle manifest through 1995 to calibrate ozone instruments on future TIROS satellites, supporting a NASA commitment to making precise measurements of global ozone and solar irradiance. The SSBUV may be reflown every eight months.

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

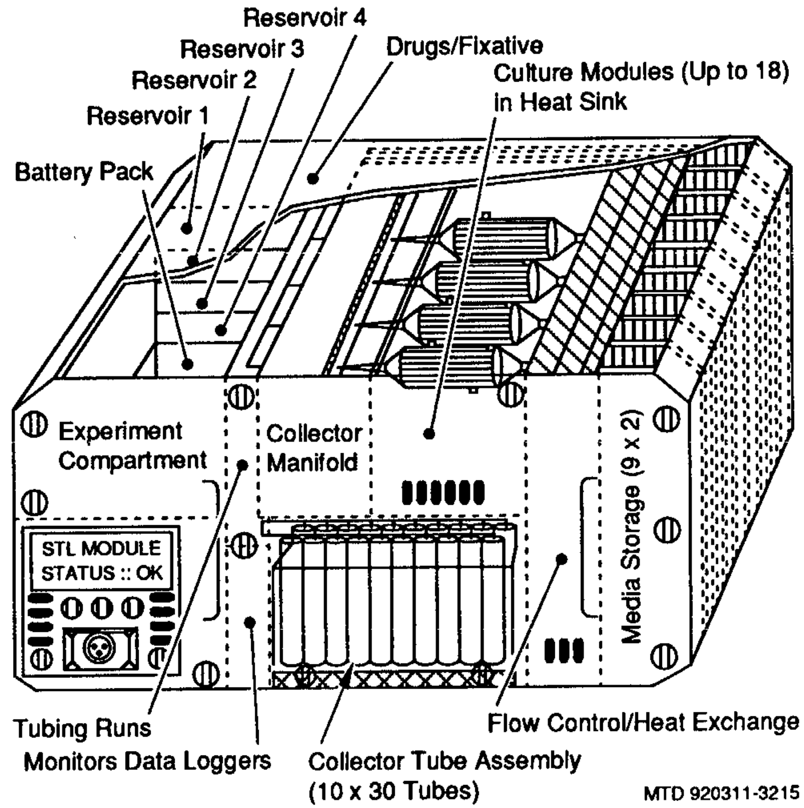
SPACE TISSUE LOSS 1

The Space Tissue Loss (STL) 1 life sciences payload will study cell growth during space flight. Specifically, STL-1 will study the response of muscle, bone, and endothelial cells to microgravity by evaluating various parameters, including shape, cytoskeleton, membrane integrity and metabolism, activity of enzymes that inactivate proteins, and the effects or change of response to various drugs on these parameters. Findings from this and other studies will be used to develop pharmaceutical products and physical treatment regimens to limit the extent of muscle tissue loss after fractures/cast immobilization and surgery. Anticipated benefits include savings from the reduced need for physical therapy and more rapid return to activity following injury.

The payload, which is stowed in a middeck locker, has a large tray assembly that can be refurbished and replaced. A triply contained, hermetically sealed fluid path assembly holds the cells under study, all media for sustained growth, and automated drug delivery provisions for testing candidate pharmaceuticals. A self-contained computer system is preprogrammed for medium and gas delivery to the cells, environmental monitoring of temperature and other important parameters, timed collection of medium and/or cells, and cell fixation. STL-1 operates on orbiter power.

The crew will activate the payload shortly after orbital insertion. Before operations begin, the crew will enter a reference time tag using a push-button input on the front panel of the payload. Throughout the remainder of the flight, the crew will periodically check the equipment. Analysis of the samples will be performed immediately after landing.

The STL-1 experiment is sponsored by the Walter Reed Army Institute of Research, Washington, D.C.



Space Tissue Loss Module Configuration

RADIATION MONITORING EQUIPMENT III

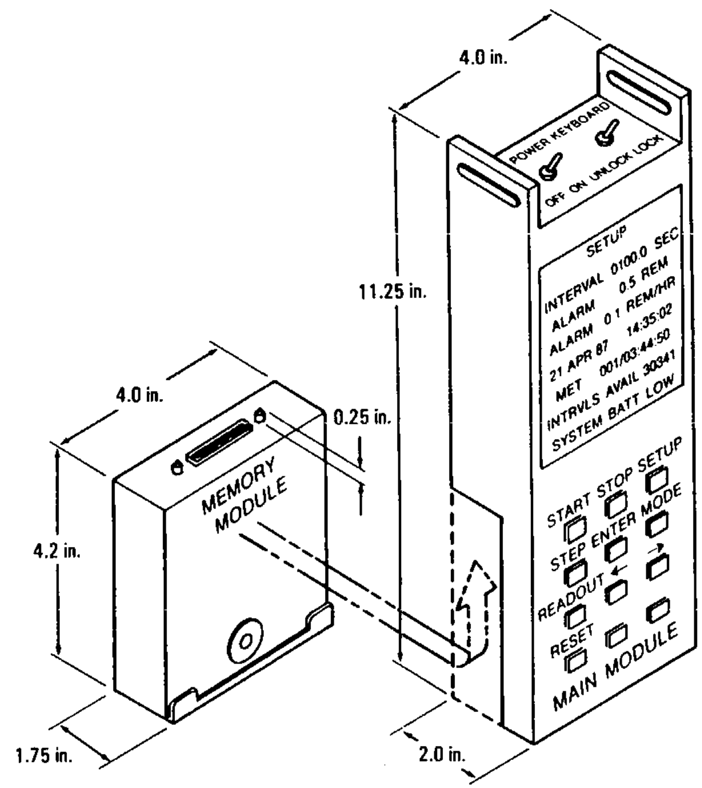
Radiation Monitoring Equipment (RME) III will measure and record the rate and total dosage of the crew's exposure to ionizing radiation at different locations in Atlantis's crew compartment. RME-III measures gamma ray, electron, neutron, and proton radiation and calculates, in real time, exposure in RADS-tissue equivalent.

RME-III 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 self-contained experiment has four zinc-air and five AA batteries in each memory module and four zinc-air batteries in the main module. RME weighs approximately 23 pounds.

RME-III will be stored in a middeck locker during flight except when it is activated and when memory modules are being replaced. It will be activated as soon as possible following orbit insertion and programmed to operate throughout the entire mission. A crew member will be required only to enter the correct mission elapsed time upon activation and to change the memory module every two days. The equipment takes measurements of the radiation environment at a specified sample rate. All data stored in the memory modules will be analyzed upon return.

RME-III, which was flown on STS-31, -41, -37, -39, -48, -44, and -42, replaces two earlier configurations.

RME-III is sponsored by the Department of Defense in cooperation with the Human Systems Division of NASA's Space Radiation Advisory Group.



RME Configuration

VISUAL FUNCTION TESTER II

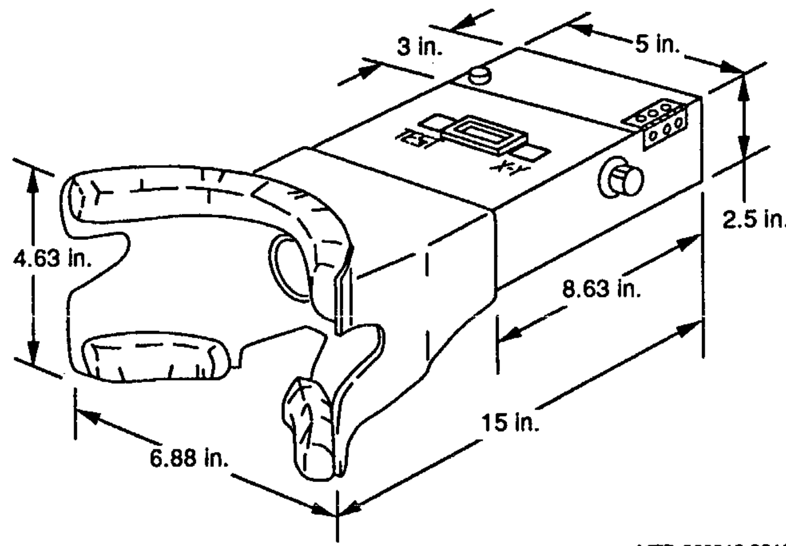
The Visual Function Tester (VFT) II experiment will measure changes in the vision of astronauts in microgravity. The VFT is a hand-held, battery-powered device with a binocular eyepiece that uses controlled illumination to present a variety of visual targets that are used to test visual acuity and eye interaction effects, such as stereopsis and eye dominance.

The subjects on this mission will be tested two weeks and one week before the flight, every day during the flight, after the landing, on the day of landing, and two and seven days after the landing. Testing will be performed at the same time in the morning, when the subjects' eyes are rested. The procedure takes about 30 minutes and may be performed anywhere in the crew cabin during the mission.

Test data are read on device displays and recorded on data sheets. The experiment is stowed in one middeck locker.

VFT--II has flown previously on shuttle missions STS-27, -28, and -36.

The VFT is sponsored by the U.S. Air Force Space Systems Division, Los Angeles, Calif.



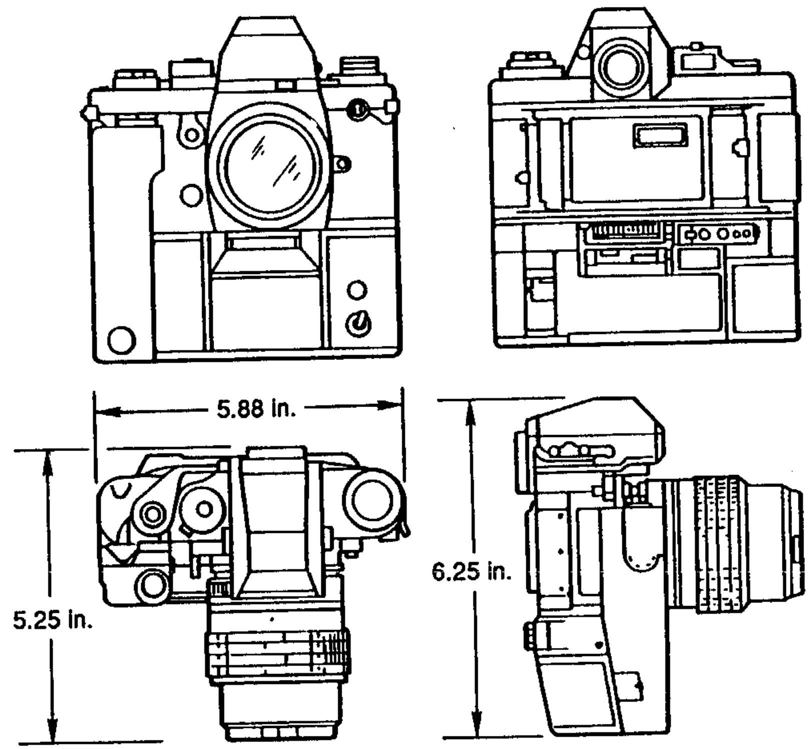
Visual Function Tester Configuration

CLOUD LOGIC TO OPTIMIZE USE OF DEFENSE SYSTEMS 1A

Cloud Logic To Optimize Use of Defense Systems (CLOUDS) 1A is a DOD-sponsored payload whose objectives are to quantify variations in apparent cloud cover as a function of the angle at which clouds of various types are viewed and to develop meteorological observation models for various cloud formations. Photographic sequences of cloud fields over various ground sites (targets of opportunity) will be obtained. The data will be used to provide a more efficient assessment of relevant cloud characteristics that impact DOD systems.

On orbit, a crew member will take a series of high-resolution photographs of individual cloud scenes. 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. Photos will be taken from a wide range of viewing angles.

The CLOUDS-1A 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.



CLOUDS-1A Camera Configuration

NASA's Getaway Special program, officially known as the Small, Self-Contained Payloads program, offers interested individuals or groups opportunities to fly small experiments aboard the space shuttle. To assure that diverse groups have access to space, NASA rotates payload assignments among three major categories of users: educational, foreign and commercial, and U.S. government.

Since the program was first announced in the fall of 1976, payloads have been reserved by foreign governments and individuals; U.S. industrialists, foundations, high schools, colleges and universities; professional societies; service clubs; and many others. Although persons and groups involved in space research have obtained many of the reservations, a large number of spaces have been reserved by persons and organizations outside the space community.

To date, 77 GAS cans have been flown on 17 missions. The GAS program began in 1982 and is managed by the Goddard Space Flight Center, Greenbelt, Md.

There are no stringent requirements to qualify for space flight. However, each payload must meet specific safety criteria and be screened for its propriety as well as its educational, scientific, or technological objectives. These guidelines preclude commemorative items, such as medallions, that are intended for sale as objects that have flown in space.

GAS requests must first be approved at NASA Headquarters in Washington, D.C., by the director of the Transportation Services Office. At that point NASA screens the propriety objectives of each request. To complete the reservation process for GAS payloads, each request must be accompanied or preceded by the payment of $500 earnest money.

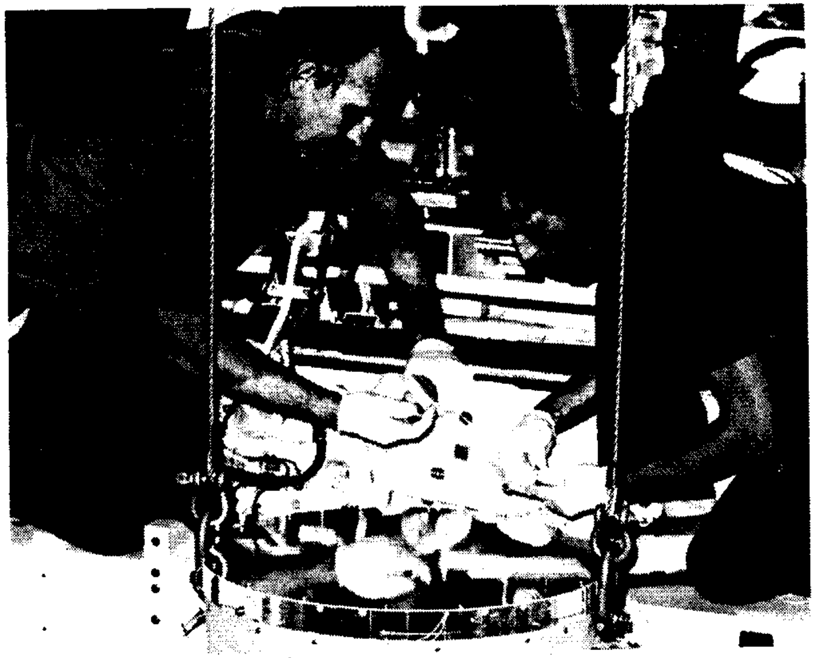
Approved requests are assigned an identification number and referred to the GAS team at the Goddard Space Flight Center, the designated lead center for the project. The GAS team screens the proposals for safety and provides advice and consultation on payload design. It certifies that proposed payloads are safe and will not harm or interfere with the operations of the space shuttle, its crew, or other experiments on the flight. The costs of any physical testing required to answer safety questions before launch are borne by the GAS customer.

NASA's space shuttle program has specific standards and conditions relating to GAS payloads. Payloads must fit NASA standard containers and weigh no more than 200 pounds. However, two or more experiments may be included in a single container if they fit in it and do not exceed weight limitations. The payload must be self-powered and not draw on the shuttle orbiter's electricity. In addition, payload designs should consider that the crew's involvement with GAS payloads will be limited to six simple activities (such as turning on and off up to three payload switches) because crew activity schedules do not provide opportunities to either monitor or service GAS payloads in flight.

The cost of this unique service depends on the size and weight of the experiment. Getaway specials of 200 pounds and 5 cubic feet cost $10,000; 100 pounds and 2.5 cubic feet, $5,000; and 60 pounds and 2.5 cubic feet, $3,000. The weight of the GAS container, experiment mounting plate and its attachment screws, and all hardware regularly supplied by NASA is not charged to the experimenter's weight allowance.

The GAS container provides internal pressure, which can be varied from near vacuum to about one atmosphere. The bottom and sides of the container are always thermally insulated, and the top may be insulated or not, depending on the specific experiment. A lid that can be opened or one with a window may be required. These may also be offered as options at additional cost.

The GAS container is made of aluminum, and the circular end plates are 0.625-inch-thick aluminum. The bottom 3 inches of the

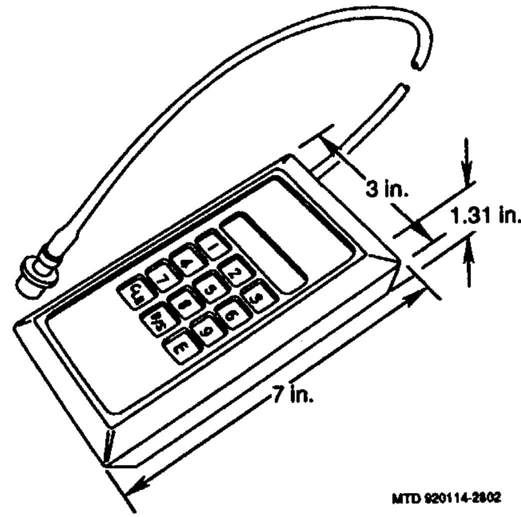


Getaway Special Container in Payload Bay

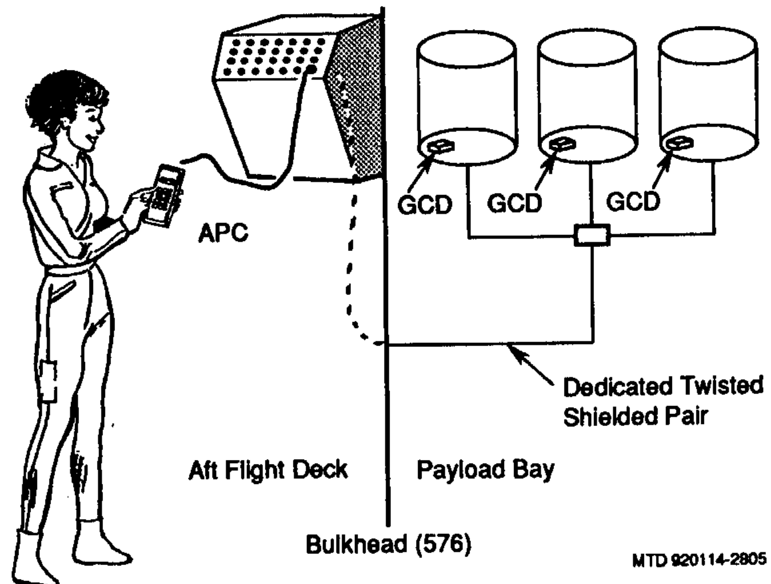
container are reserved for NASA interface equipment, such as command decoders and pressure regulating systems. The container is a pressure vessel that can be evacuated before or during launch or on orbit and can be repressurized during reentry or on orbit, as required by the experimenter.

The getaway bridge, which is capable of holding 12 canisters, made its maiden flight on STS 61-C. The aluminum bridge fits across the payload bay of the orbiter and offers a convenient and economical way of flying several GAS canisters.

For additional information about NASA's Getaway Special program contact the program manager, Code MC, NASA Headquarters, Washington, D.C. 20546. The primary contact for payload users is the technical liaison, Code 740, NASA Goddard Space Flight Center, Greenbelt, Md. 20771.



GAS Autonomous Payload Controller



Getaway Special Control Concept

GETAWAY SPECIAL EXPERIMENT G-229

Attached cargo operations will be performed with the one GAS canister experiment, G-229.

G-229 is part of a comprehensive program that involves a comparative study of crystal growth under a variety of terrestrial conditions in addition to crystal growth in microgravity aboard the space shuttle. Scientists from various research institutions will contribute to the characterization of the space-grown crystals.

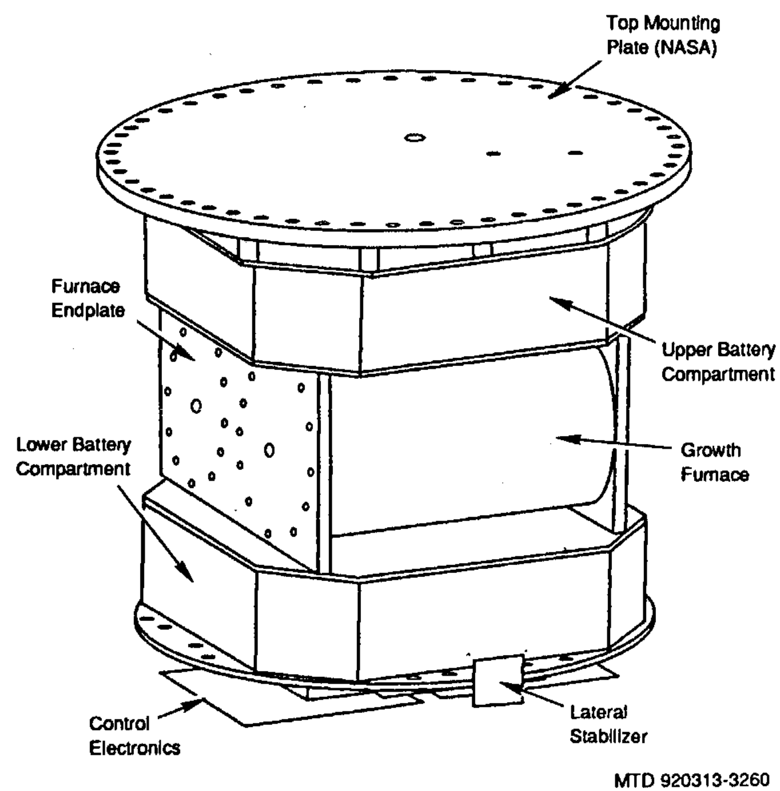
Specifically, G-229 will compare gallium arsenide (GaAs) crystals melted and regrown in the absence of buoyancy-driven convection to other crystals grown on Earth, where buoyancy-driven convection is present under a variety of conditions that modify convective effects. This objective is fulfilled by two identical experiments.

The experiments, which are mounted on the port side of the orbiter payload bay, aft of the ATLAS-1 payload, consist of a single crystal boule enclosed in a hermetic quartz ampoule mounted in a furnace. A preprogrammed heat cycle remelts approximately 75 percent of the length of the boule and resolidifies it progressively from the unmelted seed. Collected data include temperature at various points, battery voltage, furnace power, and payload acceleration. The payload is completely self-sufficient and includes its own power system, growth system, and control and data acquisition systems. G-229 weighs approximately 200 pounds.

GaAs is a versatile electronic material used in high-speed electronics and optoelectronics. The crystal grown on STS-45 will be 1 inch in diameter by 3.5 inches long and will be grown using a gradient freeze growth technique. The crystal growth will last approximately 11 hours and will be initiated by the flip of a switch by a crew member. No other human interaction will be required.

This experiment is a reflight of a successful GAS experiment conducted on STS-40 in June 1991, but additional features have been included to enhance the ability to analyze convection effects on crystal growth in microgravity.

G-229 is jointly sponsored by GTE Laboratories; the U.S. Air Force Wright Research and Development Center Materials Laboratory, Dayton, Ohio; and the Microgravity Science and Applications Division of the NASA Office of Space Science and Applications. The Space Experiment Division of NASA's Lewis Research Center, Cleveland, Ohio, manages the project. The project manager is Dr. Richard W. Lauver.



G-229 Payload Configuration

INVESTIGATIONS INTO POLYMER MEMBRANE PROCESSING

Investigations Into Polymer Membrane Processing will make its sixth space shuttle flight for the Office of Commercial Programs-sponsored Battelle Advanced Materials Center for the Commercial Development of Space in Columbus, Ohio. IPMP flew previously on STS-31, -41, -43, -48, and -42. The objective of the IPMP is to investigate the physical and chemical processes that occur during the formation of polymer membranes in microgravity so that the improved knowledge base can be applied to commercial membrane-processing techniques. Supporting the overall program objective, the STS-45 mission will provide additional data on the polymer precipitation process.

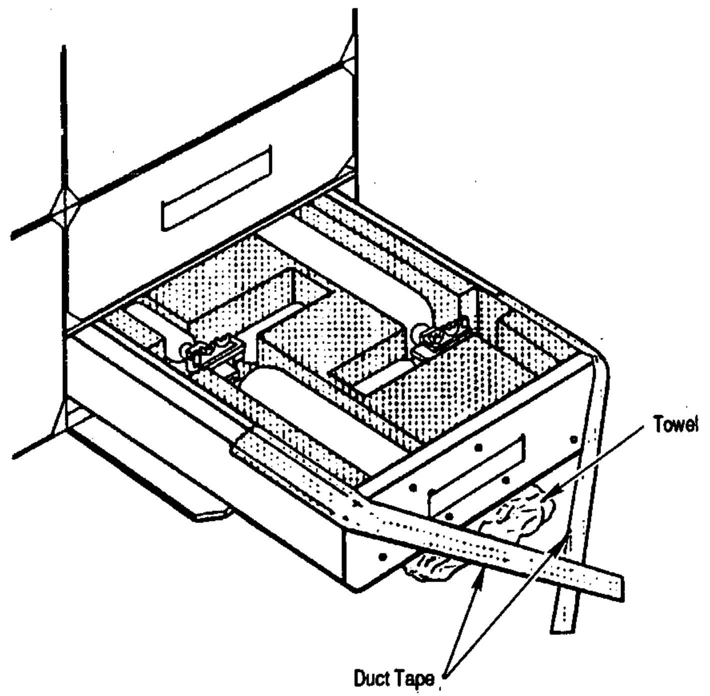
Polymer membranes have been used in the separation industry for many years for such applications as desalination of water, filtration during the processing of food products, atmospheric purification, purification of medicines, and dialysis of kidneys and blood.

Polymer membranes frequently are made using a two-step process. A sample mixture of polymer and solvents is applied to a casting surface. The first step involves the evaporation of solvents from the mixture. In the second step, the remaining sample is immersed in a fluid bath (typically water) to precipitate the membrane from the solution and complete the process. Previous flights of IPMP have involved the complete process (STS-41, -43, -48, and -42) and the evaporation step alone (STS-31). On the STS-45 mission, only the precipitation step will be performed.

The IPMP payload on STS-45 consists of two experimental units containing different solvent solutions that occupy a single small stowage tray (half of a middeck locker). Each unit consists of two 304L stainless steel sample cylinders measuring 4 inches and 2 inches in diameter. The cylinders are connected to each other by a stainless steel packless valve with an aluminum cap. The IPMP payload weighs approximately 17 pounds.

Before the mission, a thin-film polymer membrane is swollen in a solvent solution, rolled, and inserted into the smaller canisters and then sealed at ambient pressure (approximately 14.7 psia). The valve is sealed with Teflon tape. The larger canister is evacuated and sealed with threaded stainless steel plugs using a Teflon tape threading compound.

STS-45 crew members will first gain access to the units in their stowage location. When the valve on each unit is turned, water vapor is infused into the sample container, initiating the process. Previous



IPMP Configuration

work indicates that the precipitation process should be complete after approximately 10 minutes, and the resulting membrane will not be influenced by gravitational accelerations at that time. The stowage tray containing the two units is then restowed for the duration of the flight.

Following the flight, the samples will be retrieved and returned to Battelle for testing. Portions of the samples will be sent to the CCDS's industry partners for quantitative evaluation consisting of comparisons of the membranes' permeability and selectivity characteristics with those of laboratory-produced membranes.

The principal investigator for the IPMP is Dr. Vince McGinness of Battelle. Lisa A. McCauley, associate director of the Battelle CCDS, is program manager.

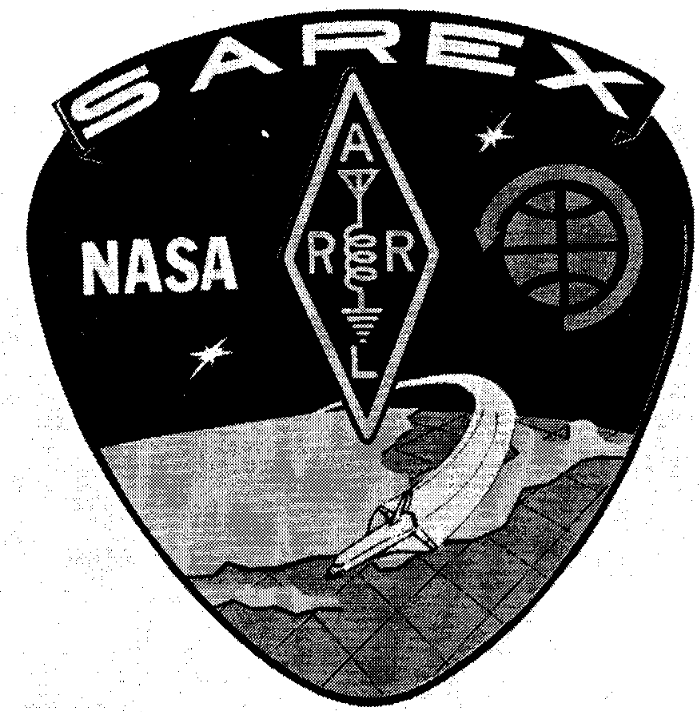
The Shuttle Amateur Radio Experiment (SAREX) was established by NASA, the American Radio Relay League/Amateur Radio Satellite Corporation, and the Johnson Space Center Amateur Radio Club to encourage public participation in the space program through a program to demonstrate the effectiveness of conducting shortwave radio transmissions between the shuttle and ground-based amateur radio operators at low-cost ground stations using amateur and digital techniques. SAREX also is an educational opportunity for students around the world to learn about space firsthand by speaking directly to astronauts aboard the shuttle via ham radio. Contacts with certain schools are included in the planning for the mission.

SAREX has been flown on missions STS-9, 51F, STS-35, and STS-37 in different configurations. STS-45 SAREX hardware consists of a low-power hand-held FM transceiver, a spare battery set, an interface module, a headset assembly, an equipment assembly cabinet, and an antenna that will be mounted in a forward flight deck side window. The equipment complement is stowed in one and a half middeck lockers.

SAREX communicates with amateur stations within Atlantis's line of sight in one of four transmission modes: voice, slow-scan TV (SSTV), data, or fast-scan TV (FSTV) (uplink only). The voice transmissions are operated in the attended mode, while the SSTV, data, and FSTV transmissions can be operated in either the attended or unattended mode.

SAREX-II will demonstrate voice, packet, and SSTV radio contact with an Earth-orbiting vehicle using the 2-meter band and FSTV uplink using the 70-centimeter band.

During the mission, SAREX-II will be operated at the discretion of four licensed amateur radio operators who are members of the STS-45 crew: mission specialist David Leestma (call sign



SAREX Insignia

N5WQC), mission specialist Kathy Sullivan (call sign N5YVV), pilot Brian Duffy (call sign N5WQW), and payload specialist Dirk Frimout (call sign ON1AFD). Frimout and Sullivan are fluent in several European languages and hope to make contact with ham operators in Europe. However, STS-45's 57-degree inclination will place the spacecraft in an orbit that will allow worldwide contact, including high-latitude areas not normally on the shuttle's ground track. There may also be opportunities for direct contact between the shuttle and the Soviet space station, Mir.

SAREX-II will be operated during periods when the crew members are not scheduled for orbiter or other payload activities. The antenna's window location does not affect communications and therefore does not require a specific orbiter attitude for operations.

Ham operators may communicate with the shuttle using VHF FM voice transmissions, a mode that makes contact widely available without the purchase of more expensive equipment.

The primary pair of frequencies intended for use during the missions is 145.55 MHz for downlink from Atlantis and 144.95 MHz for uplink. A spacing of 600 kHz was deliberately chosen for this primary pair to accommodate those whose split-frequency capability is limited to the customary repeater offset.

STS-45 (ATLANTIS) SAREX FREQUENCIES (MHz)

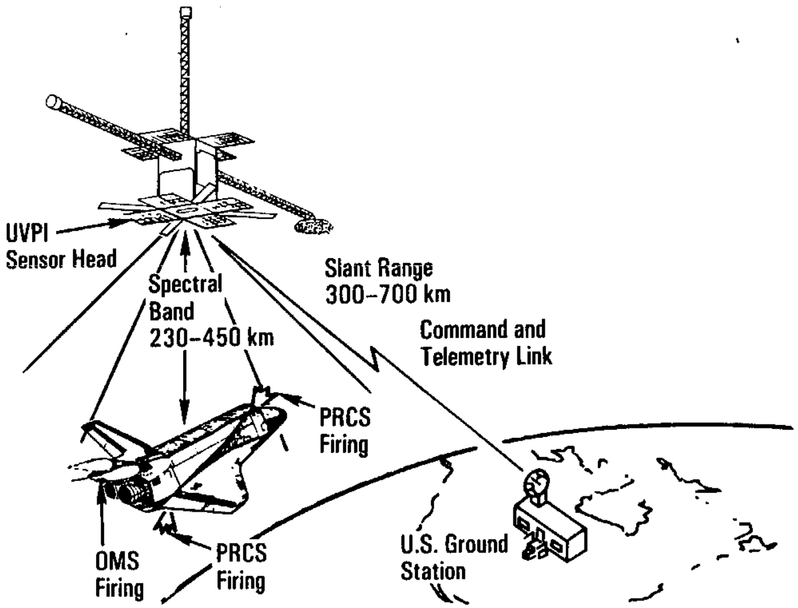
	Shuttle Transmit Frequency	Accompanying Shuttle Receive Frequency
U.S./Africa	145.55	144.95
South America	145.55	144.97
Asia	145.55	144.91
Europe	145.55	144.95
	145.55	144.75
	145.55	144.70

ULTRAVIOLET PLUME INSTRUMENT

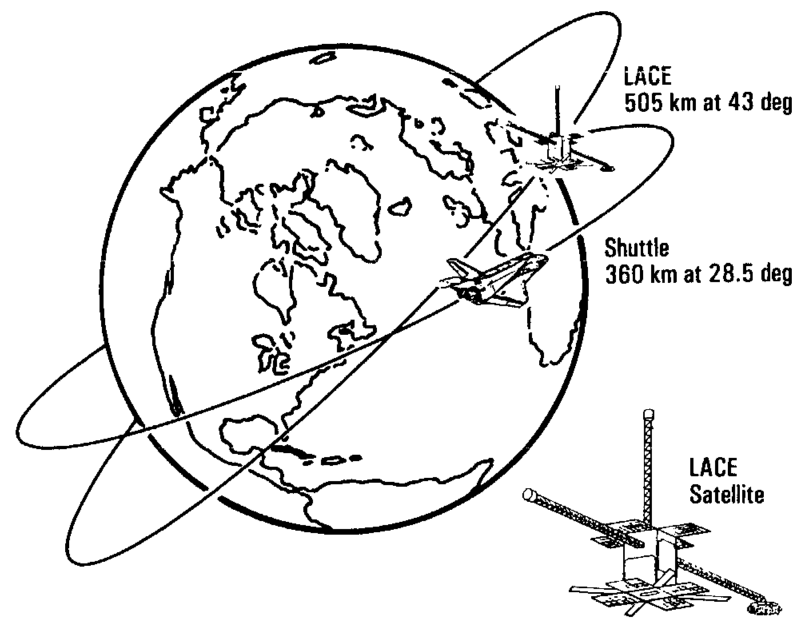
The Ultraviolet Plume Instrument is located on the Low-Power Atmospheric Compensation Experiment satellite, a Strategic Defense Initiative Organization satellite in low Earth orbit at an inclination of 43 degrees and an altitude of approximately 273 nautical miles. The UVPI's sensors will be trained on the orbiter to obtain imagery and/or signature data to calibrate the sensors and to observe orbiter jet firings during cooperative encounters of the orbiter with the LACE satellite.

A UVPI test will be scheduled late in the mission if an orbiter encounter with the satellite fits within the crew's scheduling constraints and the orbiter has enough propellant.

UVPI is sponsored by the Strategic Defense Initiative Organization.



LACE/Shuttle UVPI Encounter



LACE (UVPI)/Shuttle Encounter

FORWARD RCS FLIGHT TEST—CONTROL SURFACE EFFECTS (DTO 250). This is the fourth in a series of FRCS flight test maneuvers showing the aerodynamic effects created when the FRCS side-firing jets are used as a means of eliminating RCS propellant. This FRCS test will include programmed aero control surface deflections between Mach 4 and Mach 2.6. The data will be used to expand aerodynamic models.

ASCENT WING STRUCTURAL CAPABILITY EVALUATION (DTO 301D). The purpose of this DTO is to collect data to expand the data base of ascent dynamics for various weights.

ET TPS PERFORMANCE—METHOD 2 (DTO 312). This DTO will photograph the external tank after separation to document overall thermal protection system performance.

EDWARDS LAKEBED RUNAWAY BEARING STRENGTH AND ROLLING FRICTION ASSESSMENT FOR ORBITER LANDING (DTO 520) (IF EDWARDS LANDING). The purpose of this DTO is to obtain data to better understand the rolling friction of orbiters on Edwards dry lakebeds as this data relates to heavyweight orbiters with a forward center of gravity.

CABIN AIR MONITORING (DTO 623). This DTO will use the solid sorbent sampler to continuously sample the orbiter atmosphere throughout the flight.

RADIATOR PERFORMANCE (DTO 624). This DTO will obtain radiator performance data with the radiators stowed and deployed in similar attitudes. This DTO will use the defined ATLAS-1 attitude time line to obtain data.

VTR DEMONSTRATION (DTO 633). The purpose of this DTO is to evaluate the operational characteristics of off-the-shelf VCRs in zero-g.

ELECTRONIC STILL PHOTOGRAPHY (DTO 648). Electronic still photography is a new technology that allows a hand-held camera to electronically capture and digitize an image with resolution approaching film quality. The digital image is stored on disks and can be converted to a format suitable for downlink transmission or enhanced using image-processing software. The ability to enhance and/or downlink high-resolution images in real time will greatly improve Earth observation capabilities. The objective of this DTO is to determine the camera's response to the photographic conditions encountered on orbit using a variety of lenses and camera settings. There will be no downlink from this flight.

KU-BAND ANTENNA FRICTION (DTO 728). This DTO will provide Ku-band antenna gimbal friction data by performing several high-speed scans in radar mode.

CROSSWIND LANDING PERFORMANCE EVALUATION (DTO 805). This DTO will continue to gather data for landing with a crosswind.

COLLECTION OF SHUTTLE HUMIDITY CONDENSATE FOR ANALYTICAL EVALUATION (DSO 317). This DSO will characterize the quantity and composition of the shuttle's humidity condensate. Condensate will be collected in a modified beverage container by special plumbing on four flight days and analyzed after the flight.

ORTHOSTATIC EQUILIBRIUM CONTROL DURING LANDING/EGRESS (DSO 603B). The purpose of this DSO is to document the changes in the orthostatic function of crew members during the actual stresses of entry, landing, and egress from the seat and from the cabin as mission duration increases. These data will be used to determine whether precautions and countermeasures are needed to protect crew members in the event of an emergency egress. It will also be used to determine the effectiveness of proposed in-flight countermeasures. Crew members will don equipment prior to donning the LES during deorbit preparation. Equipment consists of a blood pressure monitor, accelerometers, an impedance cardiograph, and transcranial Doppler hardware. The crew members wear the equipment and record verbal comments through entry.

VISUAL VESTIBULAR INTEGRATION—OI-1 (DSO 604). The objectives of this DSO are to investigate visual, vestibular, and perceptual adaptive responses as a function of longer missions and to determine the operational impact on performance of entry, landing, and egress procedures. DSO procedure OI-1 will be performed on STS-45. Crew members will report sensations of self-motion and surround motion using the motion perception checklist vocabulary.

LOWER BODY NEGATIVE PRESSURE FOLLOWING SPACE FLIGHT (DSO 607). This DSO will reintroduce lower body negative pressure testing before and immediately following long flights to determine whether additional countermeasures for orthostatic intolerance are required. On STS-45, crew members will keep a log of their physical activities (e.g., exercise, EVA).

EFFECTS OF SPACE FLIGHT ON AEROBIC AND ANAEROBIC METABOLISM AT REST AND DURING EXERCISE (DSO 608). This DSO will quantify the changes in aerobic and anaerobic metabolism during graded treadmill exercise performed before and after flight and relate those changes to alterations in total body water, dry lean tissue, fat mass, and fluid volume intake. The data obtained will be used to develop nutrition, fluid, and exercise countermeasures for use on extended missions. On STS-45, the commander will perform a modified exercise routine during his scheduled exercise period.

AIR MONITORING INSTRUMENT EVALUATION AND ATMOSPHERE CHARACTERIZATION (DSO 611). The purpose of this DSO is to evaluate and verify air monitoring equipment to ensure proper function and operation in flight. Data will be collected on contaminant levels during missions of varying durations to be used to establish baseline levels and to evaluate potential risks to crew health and safety. The archival organic sampler (AOS) and microbial air sampler (MAS) configurations will be flown on STS-45.

ENERGY UTILIZATION (DSO 612). This DSO will be used to develop, verify, and optimize appropriate countermeasures for maintaining entry, landing, and egress capabilities after extended-duration flights. This requires prevention of muscle atrophy, weight loss, and negative nitrogen and potassium balances. Crew members will provide urine and saliva samples and will keep a log of all exercise and food and fluid intake. Measurements will also be taken on the crew members' blood glucose levels.

CHANGES IN ENDOCRINE REGULATION OF ORTHOSTATIC TOLERANCE FOLLOWING SPACE FLIGHT (DSO 613). This DSO will characterize the extent and pattern of changes in plasma volume during space flights of up to 16 days. It will also determine whether resting levels of catecholamines are elevated immediately after flight and whether catecholamine release in response to varying degrees of orthostatic and cardiovascular stresses is impaired after space flight. There are no on-orbit activities for this DSO.

THE EFFECT OF PROLONGED SPACE FLIGHT ON HEAD AND GAZE STABILITY DURING LOCOMOTION (DSO 614). The purpose of this DSO is to characterize preflight and postflight head and body movement along with gaze stability during walking, running, and jumping, all of which are relevant to egress from the shuttle. There are no on-orbit activities for this DSO.

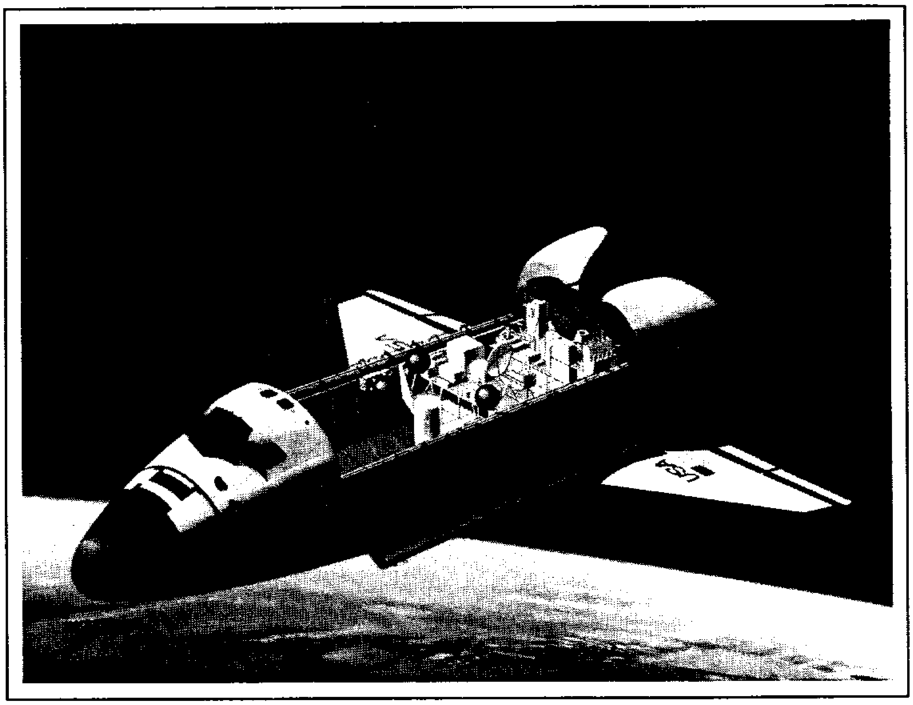
IN-FLIGHT USE OF FLORINEF TO IMPROVE ORTHOSTATIC INTOLERANCE AFTER FLIGHT (TWO OF THE THREE ENTRY CREW MEMBERS WILL NOT TAKE THE FLORINEF) (DSO 621). The purpose of this DSO is to evaluate the efficacy of florinef on postflight orthostatic tolerance using heart rate, blood pressure, stroke volume, and other cardiovascular responses to orthostatic stress. A cardiovascular profile will be determined both before and after flight for the participating crew member.

EDUCATIONAL ACTIVITIES (THE ATMOSPHERE BELOW) (DSO 802). The purpose of this DSO is to produce an educational video product from scenes recorded on orbit and on the ground. The crew will film several scenes on orbit using the camcorder.

DOCUMENTARY TELEVISION (DSO 901). This DSO requires live television transmission or VTR dumps of crew activities and spacecraft functions, including payload bay views, shuttle and payload crew activities, VTR downlink of crew activities, in-flight crew press conference, and unscheduled TV activities.

DOCUMENTARY MOTION PICTURE PHOTOGRAPHY (DSO 902). This DSO requires documentary and public affairs motion picture photography of significant activities that best depict the basic capabilities of the space shuttle and key objectives. This DSO includes motion picture photography of Spacelab module activities, flight deck activities, middeck activities, and any unscheduled motion picture photography.

DOCUMENTARY STILL PHOTOGRAPHY (DSO 903). This DSO requires still photography of crew activities in the orbiter and Spacelab and mission-related scenes of general public and historical interest. Still photography with 70mm format for exterior photography and 35mm format for interior photography is required.



STS-45

MISSION STATISTICS

PRELAUNCH COUNTDOWN TIMELINE

MISSION TIMELINE

March 1992

Rockwell International
Space Systems Division

Office of Media Relations

CONTENTS

MISSION OVERVIEW

This is the 11th flight of Atlantis and the 46th for the space shuttle.

The flight crew for the STS-45 mission is commander Charles F. Bolden; pilot Brian Duffy; mission specialists Kathryn (Kathy) D. Sullivan, David (Dave) C. Leestma, and C. Michael (Mike) Foale; and payload specialists D. Dirk Frimout of the European Space Agency and Byron K. Lichtenberg. The crew will be divided into a blue team, consisting of Duffy, Sullivan, and Frimout; and a red team, comprising Leestma, Foale, and Lichtenberg. Bolden is not assigned to a team and is free to adjust his hours, as necessary. Each team will work consecutive 12-hour shifts, providing for around-the-clock operations.

STS-45 is the first Spacelab mission dedicated to NASA's Mission to Planet Earth, a large-scale, unified study of Earth as a single dynamic system. STS-45's primary mission objective is to provide the orbiter Atlantis and the Spacelab pallet as a science platform for experiments on the Atmospheric Laboratory for Applications and Science (ATLAS) 1 payload. ATLAS-1's objective is to conduct science investigations to measure the variation in solar output and its effect on the Earth's atmosphere. It consists of a series of 12 atmospheric physics, solar physics, space plasma physics, and astronomy experiments.

Atmospheric Physics

- Atmospheric Trace Molecule Spectroscopy (ATMOS) will map trace molecules in the middle atmosphere by measuring the absorption of infrared radiation. The sunlight that passes through the Earth's atmosphere during orbital sunrises and sunsets will be recorded. The wavelengths of light will identify molecules and their locations.

- Millimeter Wave Atmospheric Sounder (MAS) will make simultaneous measurements of day/night concentrations of ozone, middle-atmosphere temperature, and trace molecules involved in the creation/destruction of ozone.

- Atmospheric Lyman-Alpha Emissions (ALAE) will spectroscopically measure common hydrogen and deuterium in the terrestrial atmosphere in order to understand the evolution of atmospheres and their dynamics.

- Grille Spectrometer (Grille) will study global atmospheric composition between 9 miles and 90 miles. High-resolution infrared spectroscopy measurements will be made primarily in solar occultation.

- Imaging Spectrometric Observatory (ISO) will use emission spectroscopy to determine upper atmosphere photochemistry, composition of energetics, and stratospheric OH. ISO will measure airglow over a wavelength range extending from extreme ultraviolet to near infrared.

- Energetic Neutral Atom Precipitation (ENAP) will measure faint emissions at nighttime arising from fluxes of energetic neutral atoms in the thermosphere. ENAP measurements will be made using the ISO hardware.

Solar Physics

- Active Cavity Radiometer (ACR) and Solar Constant (SOLCON) will use precise instruments to measure ultraviolet light through infrared radiation. Through slightly different techniques, each experiment will determine a value for the solar constant, and the values will be compared. Instrument accuracy and solar variations will be determined.

- Solar Spectrum (SOLSPEC) will measure ultraviolet through infrared solar radiation to determine how the amount of these energies change over time and where they are absorbed in the atmosphere.

- Solar Ultraviolet Spectral Irradiance Monitor (SUSIM) will determine both long-term and short-term variations of the total ultraviolet flux emitted by the sun.

Space Plasma Physics

- Atmospheric Emissions and Photometric Imaging (AEPI) will study selected atmospheric phenomena, together with natural and artificial auroras. It will use visible imaging with a Z-axis gimbaled photometer.

- Space Experiments With Particle Accelerators (SEPAC) will carry out active experiments on Earth's ionosphere and magnetosphere, including vehicle charge neutralization, beam plasma physics, and beam-ionosphere interactions.

Astronomy

- Far Ultraviolet Space Telescope (FAUST) will observe faint astronomical sources in the far ultraviolet wavelength (extended and point sources).

ATLAS-1 represents the first of up to nine ATLAS missions to study the composition of the middle atmosphere and its possible variations due to solar changes over the course of an 11-year solar cycle. During that period, solar flares, sunspots, and other magnetic activity in the sun change from one extreme to the other and back. Throughout the ATLAS series, scientists will gather new information to better understand how the atmosphere reacts to natural and human-induced atmospheric changes. The knowledge will help man identify measures that will keep Earth suitable for life for future generations.

ATLAS-1 instruments were originally flown on the Spacelab 1 and Spacelab 3 missions, demonstrating the shuttle's capability to return sophisticated instruments to the ground for refurbishment and updating and to refly multimission instruments at intervals required by their scientific goals.

ATLAS-1 is a NASA mission with an international payload; the European Space Agency provides operational support for the European investigations. ATLAS is managed by NASA's Marshall Space Flight Center, Huntsville, Ala.

Secondary objectives for STS-45 include the following: Shuttle Solar Backscatter Ultraviolet (SSBUV) 4 experiment; Space Tissue Loss (STL) 1; Radiation Monitoring Equipment (RME) III; Visual Function Tester (VFT) II; Cloud Logic To Optimize Use of Defense Systems (CLOUDS) 1A; getaway special experiment G-229; Investigations Into Polymer Membrane Processing (IPMP); Shuttle Amateur Radio Experiment (SAREX) II; and the Ultraviolet Plume Instrument (UVPI), a payload of opportunity.

The SSBUV-4 experiment, managed by NASA's Goddard Space Flight Center, will provide readings of global ozone to aid in the calibration of solar backscatter ultraviolet instruments being flown concurrently on free-flying satellites, including the Upper Atmosphere Research Satellite.

STL-1 is an Air Force experiment designed to study the effects of weightlessness on body tissues. Drugs to prevent tissue loss will be tested to determine their effectiveness.

Attached cargo operations will be performed with one getaway special (GAS) canister experiment, G-229, sponsored by GTE Laboratories. It will compare melted and regrown gallium arsenide crystals in space with those grown on Earth under a variety of conditions that modify convective effects.

The research objective of the IPMP payload, sponsored by the Battelle Advanced Materials Center, a NASA center for the commercial development of space, is to investigate the formation of polymer membranes in microgravity. IPMP research could lead to possible advances in filtering technologies.

SAREX-II, sponsored by NASA, the American Radio R ɩy League/Amateur Radio Satellite Corporation, and the Johnson Space Center A ateur Radio Club, will establish crew voice communication with amateur radio stations thin the line of sight of the orbiter.

VFT-II is an Air Force experiment that will study the eft_s of weightlessness on human vision. The crew will look into the hand-held, battery-powered testing device.

RME-III, also sponsored by the Air Force, will measure the ionizing radiation levels in the orbiter crew compartment.

CLOUDS-1A is a DOD-sponsored payload that will quantify variations in apparent cloud cover as a function of the angle at which clouds of various types are viewed and develop meteorological observation models for various cloud formations. The data will be used to provide a more efficient assessment of relevant cloud characteristics that impact DOD systems.

UVPI is a DOD payload of opportunity located on the Low-Power Atmospheric Compensation Experiment (LACE) satellite, a Strategic Defense Initiative Organization satellite in low Earth orbit. UVPI's sensors will be trained on the orbiter to obtain imagery and/or signature data to calibrate the sensors and to observe orbiter jet firings during cooperative encounters of the orbiter with the LACE satellite.

Ten detailed test objectives and 14 detailed supplementary objectives are scheduled to be flown on STS-45.

MISSION STATISTICS

Vehicle: Atlantis (OV-104), 11th flight

Launch Date/Time:

3/23/92 8:01 a.m., EST
7:01 a.m., CST
5:01 a.m., PST

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

Launch Window: 2 hours, 30 minutes

Mission Duration: 7 days, 22 hours, 7 minutes

Landing: Nominal end-of-mission landing on orbit 127

3/31/92 6:08 a.m., EST
5:08 a.m., CST
3:08 a.m., PST

Runway: Nominal end-of-mission landing on runway 15, Kennedy Space Center, Fla. Weather alternates are Edwards Air Force Base (EAFB), Calif., and Northrup Strip (NOR), White Sands, New Mexico.

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

Return to Launch Site: KSC

Abort-Once-Around: NOR; alternate is EAFB

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: 160-nautical-mile (184-statute-mile) circular orbit

Space Shuttle Main Engine Thrust Level During Ascent: 104 percent

Space Shuttle Main Engine Locations:

No. 1 position: Engine 2024
No. 2 position: Engine 2012
No. 3 position: Engine 2028

Editor's Note: The following weight data are current as of March 18, 1992 and differ slightly from the figures published in the Rockwell STS-45 Press Information Book.

Total Lift-off Weight: Approximately 4,496,035 pounds

Orbiter Weight, Including Cargo, at Lift-off: Approximately 233,650 pounds

Orbiter (Atlantis) Empty, and 3 SSMEs: Approximately 172,140 pounds

Payload Weight Up: Approximately 17,683 pounds

Payload Weight Down: Approximately 17,683 pounds

Orbiter Weight at Landing: Approximately 205,042 pounds

Payloads--Payload Bay (* denotes primary payload): Atmospheric Laboratory for Applications and Science (ATLAS) 1,* Shuttle Solar Backscatter Ultraviolet (SSBUV) 4, getaway special experiment G-229

Payloads--Middeck: Space Tissue Loss (STL) 1, Radiation Monitoring Equipment (RME) III, Visual Function Tester (VFT) II, Cloud Logic To Optimize Use of Defense Systems (CLOUDS) 1A, Investigations Into Polymer Membrane Processing (IPMP), Shuttle Amateur Radio Experiment (SAREX) II

Flight Crew Members:

Commander:
Charles F. Bolden, third space shuttle flight
The commander is not assigned to a team and may adjust his hours, as necessary.

Blue Team:

Pilot: Brian Duffy, first space shuttle flight
Mission Specialist 1: Kathryn (Kathy) D. Sullivan, third space shuttle flight
Payload Specialist 1: D. Dirk Frimout, European Space Agency, first space shuttle flight

Red Team:

Mission Specialist 2: David (Dave) C. Leestma, third space shuttle flight
Mission Specialist 3: C. Michael (Mike) Foale, first space shuttle flight
Payload Specialist 2: Byron K. Lichtenberg, second space shuttle flight

Each team works approximately 12 hours followed by 12 hours off duty. Bolden, Duffy, and Leestma make up the orbiter crew, which will operate the shuttle and Spacelab systems monitored by the Mission Control Center at Johnson Space Center (JSC). Sullivan, Frimout, Foale, and Lichtenberg form the science crew, which will operate the ATLAS-1 experiments monitored by the Payload Operations Control Center at Marshall Space Flight Center (MSFC).

Ascent Seating:

Flight deck, front left seat, commander Charles F. Bolden
Flight deck, front right seat, pilot Brian Duffy
Flight deck, aft center seat, mission specialist David (Dave) C. Leestma
Flight deck, aft right seat, mission specialist C. Michael (Mike) Foale
Middeck, mission specialist Kathryn (Kathy) D. Sullivan
Middeck, payload specialist D. Dirk Frimout
Middeck, payload specialist Byron K. Lichtenberg

Entry Seating:

Flight deck, front left seat, commander Charles F. Bolden
Flight deck, front right seat, pilot Brian Duffy
Flight deck, aft center seat, mission specialist Kathryn (Kathy) D. Sullivan
Flight deck, aft right seat, mission specialist David (Dave) C. Leestma
Middeck, mission specialist C. Michael (Mike) Foale
Middeck, payload specialist D. Dirk Frimout
Middeck, payload specialist Byron K. Lichtenberg

Extravehicular Activity Crew Members, If Required:

Extravehicular (EV) astronaut 1: Kathryn (Kathy) D. Sullivan
EV-2: C. Michael (Mike) Foale

Intravehicular Astronaut: David (Dave) C. Leestma

STS-45 Flight Directors:

Ascent/Entry: Jeff Bantle
Orbit 1 Team: Bob Castle
Orbit 2 Team (lead): Rob Kelso
Orbit 3 Team: Linda Ham

Entry: Automatic mode until subsonic, then control stick steering

Notes:

. The remote manipulator system is not installed in Atlantis's payload bay for this mission

. The galley is installed in Atlantis's middeck

. CLOUDS-1A observation opportunities will be evaluated in real time for the actual flight profile

. Exercise for the payload specialists is scheduled once midflight and once near the end of flight

. STS-45 marks the first flight of the enhanced multiplexer-demultiplexer (EMDM) in a flight-critical position. The EMDM uses state-of-the-art components to replace obsolete parts and improve maintenance requirements. The new components have simplified the structure of the EMDM by more than 50 parts in some instances. The MDMs, 19 located throughout each orbiter, act as a relay for the onboard computer system as it attains data from the shuttle's equipment and relays commands to the various controls and systems. The EMDMs are manufactured by Honeywell Space Systems Group, Phoenix, Az.

. STS-45 marks the first flight of the improved auxiliary power units. The IAPUs are three identical units that provide power to operate the shuttle's hydraulic system. The IAPU is lighter than the original system, saving about 134 pounds. The weight savings are due to the use of passive cooling for the IAPUs, eliminating an active water spray cooling system required by the original units. The redesigned APUs are expected to extend the life of the units from the current 20 hours or 12 flights to 75 hours or 50 flights. The increased lifetime is anticipated to result in fewer APU changeouts and improved ground turnaround time between flights. Components of the APU that have been redesigned to improve reliability include the gas generator, fuel pump, redundant seals between the fuel system and gearbox lubricating oil, and a materials change in the turbine housings.

. Atlantis will fly with two High Accuracy Inertial Navigation System (HAINS) inertial measurement units and one KT-70 model. The HAINS IMUs are being incorporated into the orbiter fleet on an attrition basis as replacements for the KT-70 model IMUs. The three IMUs on each shuttle orbiter are four-gimbal, inertially stabilized, all-attitude platforms that each measure changes in the spacecraft's speed used for navigation and provide spacecraft attitude information of flight control. The HAINS IMU for the space shuttle is a derivative of IMUs used in the Air Force's B-1B aircraft. It includes an improved gyroscope model and microprocessor and has demonstrated in testing improved abilities to hold an accurate alignment for longer periods of time. The new IMUs require no software changes on the orbiter or changes in electrical or cooling connections. The HAINS IMU is manufactured by Kearfott, Inc., of Little Falls, N.J.

. Atlantis's radiators will be deployed on STS-45 to provide additional cooling to support the ATLAS mission.

MISSION OBJECTIVES

. Primary Payload
  - Atmospheric Laboratory for Applications and Science (ATLAS) 1
. Secondary Payloads
  - Payload Bay
    . Shuttle Solar Backscatter Ultraviolet (SSBUV) 4
    . Getaway special experiment G-229
  - Middeck
    . Space Tissue Loss (STL) 1
    . Radiation Monitoring Equipment (RME) III
    . Visual Function Tester (VFT) II
    . Cloud Logic To Optimize Use of Defense Systems (CLOUDS) 1A
    . Investigations Into Polymer Membrane Processing (IPMP)
    . Shuttle Amateur Radio Experiment (SAREX) II
. Development Test Objectives/Detailed Supplementary Objectives

FLIGHT ACTIVITIES OVERVIEW

Flight Day 1

Launch
OMS-2
Unstow cabin
Priority Group B powerdown
Spacelab activation
Payload activation
SAREX setup
STL-1 initiation
RME-III activation
SAREX operations
G-229 operations
VFT-II operations
SSBUV activation
RCS burn
ATLAS-1 operations

Flight Day 2

ATLAS-1 operations
VFT-II operations
SAREX operations

Flight Day 3

ATLAS-1 operations
IPMP operations
VFT-II operations
SAREX operations
RCS burn

Flight Day 4

ATLAS-1 operations
VFT-II operations
SAREX operations
G-229 operations

Flight Day 5

ATLAS-1 operations
VFT-II operations

Flight Day 6

ATLAS-1 operations
VFT-II operations
SAREX operations
RCS burn

Flight Day 7

ATLAS-1 operations
VFT-II operations
Crew press conference
RCS hot-fire test
FCS checkout

Flight Day 8

ATLAS-1 operations
VFT-II operations
Payload deactivation
Cabin stow
Spacelab deactivation
SSBUV deactivation
Priority Group B powerup
Deorbit preparation
Deorbit burn
Landing

Notes:

. Each flight day includes a number of scheduled housekeeping activities. These include inertial measurement unit alignment, supply water dumps (as required), waste water dumps (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 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 Atlantis's four CRTs, placing three of Atlantis's five general-purpose computers on standby, placing one of Atlantis's three inertial measurement units on standby mode, and powering off three of Atlantis's eight flight-critical multiplexers (two forward, one aft).

STS-45 CREW ASSIGNMENTS

* Denotes primary responsibility

Commander (Charles F. Bolden):

Overall mission decisions

Orbiter--APU/hydraulics, caution and warning, DPS,* ECLSS,* FDF, GN&C,* IFM, medical, OMS/RCS

Payload--VFT, IPMP, CLOUDS,* G-229

DTOs/DSOs--DTO 623; DSOs 317, 473, 603B, 608, 611, 614, and 621

Pilot (Brian Duffy):

Orbiter--APU/hydraulics,* caution and warning,* communications/instrumentation,* EPS,* FDF,* GN&C, mechanical, medical, MPS,* OMS/RCS*, PGSC

Payload--SSBUV, RME, VFT, IPMP,* SAREX*

DTOs/DSOs--DTO 728*; DSOs 473, 611, 613, and 614

Other--Earth observations

Mission Specialist 1 (Kathryn [Kathy] D. Sullivan):

Orbiter--crew equipment*, photo/TV

Payload--ATLAS,* STL*

DTOs/DSOs--DTOs 633 and 648*; DSOs 473, 603B, 614, and 621

Other--Earth observations,* extravehicular astronaut*

Mission Specialist 2 (David [Dave] C. Leestma):

Orbiter--communications/instrumentation, DPS, ECLSS, EPS, IFM,* mechanical,* medical,* MPS, photo/TV*

Payload--SSBUV,* VFT, SAREX, CLOUDS, G-229*

DTOs/DSOs--DTOs 623, 633,* and 648; DSOs 473, 611, 612, and 621

Other--Earth observations, intravehicular astronaut*

Mission Specialist 3 (C. Michael [Mike] Foale):

Orbiter--crew equipment, IFM, PGSC*

Payload--ATLAS, STL, RME,* VFT*

DTOs/DSOs--DTO 728; DSO 417, 473, 603B, and 621

Other--extravehicular astronaut

Payload Specialist 1 (D. Dirk Frimout):

Payload--ATLAS

DTOs/DSOs--DSOs 473, 604, 607, 612, 613, and 621

Payload Specialist 2 (Byron K. Lichtenberg):

Payload--ATLAS

DTOs/DSOs--DSOs 473, 603B, 604, 614, and 621

DEVELOPMENT TEST OBJECTIVES/DETAILED SUPPLEMENTARY OBJECTIVES

DTOs

. Forward RCS flight test -- control surface effects (DTO 250)
. Ascent structural capability evaluation (DTO 301D)
. ET TPS performance--method 2 (DTO 312)
. Edwards lakebed runway bearing strength and rolling friction assessment for orbiter landing (DTO 520)--DTO of opportunity
. Cabin air monitoring (DTO 623)
. Radiator performance (DTO 624)
. VTR demonstration (DTO 633)
. Electronic still photography test (without the playback downlink unit and the downlink capability) (DTO 648)
. Ku-band antenna friction (DTO 728)
. Crosswind landing performance evaluation (DTO 805)--DTO of opportunity

DSOs

. Collection of shuttle humidity condensate for analytical evaluation (DSO 317)
. Orthostatic function during entry, landing, and egress (DSO 603B)
. Visual vestibular integration--OI-1 (DSO 604)
. Lower body negative pressure following space flight (DSO 607)
. Effects of space flight on aerobic and anaerobic metabolism at rest and during exercise (DSO 608)
. Air monitoring instrument evaluation and atmosphere characterization (DSO 611)
. Energy utilization (DSO 612)
. Changes in endocrine regulation of orthostatic tolerance (DSO 613)
. Head and gaze stability during locomotion (DSO 614)
. In-flight use of florinef to improve orthostatic intolerance after flight (2 of the 3 entry crew members will not take the florinef) (DSO 621)
. Educational activities (the atmosphere below) (DSO 802)
. Documentary television (DSO 901)
. Documentary motion picture photography (DSO 902)
. Documentary still photography (DSO 903)

STS-45 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 prevalves 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.

T - (MINUS) HR:MIN:SEC	TERMINAL COUNTDOWN EVENT
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.
03:10:00	Liquid oxygen stable replenishment begins and continues until just minutes prior to T minus zero.
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 Holding	Begin 2-hour planned hold. An inspection team examines the ET for ice or frost formation on the launch pad during this hold.
03:00:00 Counting	Two-hour planned hold ends.
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.

T - (MINUS) HR:MIN:SEC	TERMINAL COUNTDOWN EVENT
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.
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.

T - (MINUS) HR:MIN:SEC	TERMINAL COUNTDOWN EVENT
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.
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 prestated 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."

T - (MINUS) HR:MIN:SEC	TERMINAL COUNTDOWN EVENT
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 Counting	The GLS auto sequence starts and the terminal countdown begins.
	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.
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.

T - (MINUS) HR:MIN:SEC	TERMINAL COUNTDOWN EVENT
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.
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.

T - (MINUS) HR:MIN:SEC	TERMINAL COUNTDOWN EVENT
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.

T - (MINUS) HR:MIN:SEC	TERMINAL COUNTDOWN EVENT
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.
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 prevalves to open. (The MPSs three liquid oxygen prevalves 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 gimbaled 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.

T - (MINUS) HR:MIN:SEC	TERMINAL COUNTDOWN EVENT
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.

STS-45 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-45 Flight Plan, Ascent Checklist, Post Insertion Checklist, Spacelab Activation/Deactivation Checklist, Deorbit Prep Checklist, and Entry Checklist. CLOUDS observation opportunities will be evaluated real-time for the actual flight profile and are not identified in this timeline.

T+ (PLUS) DAY/ HR:MIN:SEC	EVENT
DAY ZERO	
0/00:00:07	Tower is cleared (SRBs above lightning-rod tower).
0/00:00:10	180-degree positive roll maneuver (right-clockwise) is started. Pitch profile is heads down (astronauts), wings level.
0/00:00:18	Roll maneuver ends.
0/00:00:29	All three SSMEs throttle down from 104 to 72 percent for maximum aerodynamic load (max q).
0/00:00:59	All three SSMEs throttle to 104 percent.
0/00:01:04	Max q occurs.
0/00:02:08	SRBs separate.
	When chamber pressure (Pc) 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.

T+ (PLUS) DAY/ HR:MIN:SEC	EVENT
	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.
0/00:04:11	Negative return. The vehicle is no longer capable of return-to-launch site abort at Kennedy Space Center runway.
0/00:06:45	Single engine press to main engine cutoff (MECO).
0/00:08:26	All three SSMEs throttle down to 67 percent for MECO.
0/00:08:31	MECO occurs at approximate velocity 25,829 feet per second, 20 by 156 nautical miles (23 by 180 statute miles).
0/00:08:49	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.

T+ (PLUS) DAY/ HR:MIN:SEC	EVENT
	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.
	--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.
0/00:39	OMS-2 thrusting maneuver is performed, approximately 2 minutes, 29 seconds in duration, at 252.3 fps, 159 by 161 nautical miles.
0/00:51	Commander closes all current breakers, panel L4.
0/00:53	Mission specialist (MS)/payload specialist (PS) seat egress.
0/00:54	Commander and pilot configure GPCs for OPS-2.
0/00:57	MS configures preliminary middeck.

T+ (PLUS) DAY/ HR:MIN:SEC	EVENT
0/00:59	MS configures aft flight station.
0/01:02	MS unstows, sets up, and activates PGSC.
0/01:06	Pilot activates payload bus (panel R1).
0/01:08	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.
0/01:17	Commander activates radiators.
0/01:19	If go for payload bay door operations, MS configures for payload bay door operations.
0/01:27	Orbit 2 begins.
0/01:28	Pilot opens payload bay doors.
0/01:33	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."
0/01:37	Commander and pilot seat egress.
0/01:38	Commander and pilot clothing configuration.
0/01:39	MS/PS clothing configuration.
0/01:50	Pilot initiates fuel cell auto purge.
0/01:51	MS activates teleprinter (if flown).
0/01:52	Commander begins post-payload bay door operations and radiator configuration.

T+ (PLUS) DAY/ HR:MIN:SEC	EVENT
0/01:55	MS/PS 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.
0/02:01	Pilot activates auxiliary power unit steam vent heater, panel R2, boiler controller/heater, 3 to A, power, 3 to ON.
0/02:05	Commander configures vernier drivers.
0/02:07	Mission Control Center gives the "go" for Spacelab activation.
0/02:09	Pilot configures controls for on-orbit operations.
0/02:10	Commander maneuvers to IMU alignment attitude.
0/02:10	MS1 powers up Spacelab.
0/02:12	Commander checks COAS off, mounts COAS in forward station.
0/02:15	MS1 loads Spacelab telemetry format.
0/02:16	Pilot enables hydraulic thermal conditioning.
0/02:18	MS resets caution/warning (C/W).
0/02:20	Commander performs IMU alignment using star tracker.
0/02:22	MS1 performs Spacelab subsystem command and data management subsystem initial activation.

T+ (PLUS) DAY/ HR:MIN:SEC	EVENT
0/02:22	MS unstows and installs treadmill.
0/02:23	Pilot switches APU coolant system (panel R2) fuel pump/ valve A to OFF, B to AUTO.
0/02:25	Commander maneuvers vehicle to COAS calibration attitude.
0/02:27	Commander performs COAS calibration, forward station.
0/02:29	Pilot plots fuel cell performance.
0/02:30	Red team begins presleep activities.
0/02:35	Maneuver vehicle to -ZLV, +YVV attitude.
0/02:35	Commander performs cockpit systems management.
0/02:35	MS1 activates high-rate multiplexer.
0/02:38	MS1 activates data display system.
0/02:40	Ku-band antenna deployment.
0/02:40	Initiate waste dump.
0/02:43	MS1 performs experiment command and data management subsystem initial activation.
0/02:55	Ku-band antenna activation.
0/02:55	MS1 configures experiment power and control.
0/02:57	Orbit 3 begins.
0/03:05	Unstow cabin.
0/03:05	MS1 configures orbiter audio.
0/03:10	Priority Group B powerdown.

T+ (PLUS) DAY/ HR:MIN:SEC	EVENT
0/03:10	Air-to-ground check 1.
0/03:10	Payload activation.
0/03:30	Red team begins sleep period.
0/03:35	P/TV12 setup.
0/03:40	ATLAS operations (SEPAC).
0/03:50	APU heater deactivation.
0/04:00	Terminate waste dump.
0/04:05	ATLAS operations (AEPI).
0/04:05	APU cool B.
0/04:10	Vehicle maneuver.
0/04:10	P/TV12 activation.
0/04:15	STL initiation.
0/04:25	ATLAS operations (AEPI).
0/04:27	Orbit 4 begins.
0/04:30	SAREX setup.
0/04:30	DTO 623--cabin air monitoring.
0/04:35	DSO 611--AOS.
0/04:45	DSO 611-MAS.
0/04:55	ATLAS operations (Grille).
0/05:15	PCS configuration.

T+ (PLUS) DAY/ HR:MIN:SEC	EVENT
0/05:30	Meal.
0/05:45	Vehicle maneuver.
0/05:58	Orbit 5 begins.
0/06:30	APU heater reconfiguration.
0/06:40	Vehicle maneuver.
0/07:00	Vehicle maneuver.
0/07:20	RME-III activation.
0/07:28	Orbit 6 begins.
0/07:30	VFT-II operations.
0/07:40	DTO 633 setup--VTR demonstration.
0/07:45	ATLAS operations (AEPI).
0/07:45	APC unstow.
0/07:55	ATLAS operations (AEPI).
0/08:10	Vehicle maneuver.
0/08:20	ATLAS operations (AEPI).
0/08:25	ATLAS operations (AEPI).
0/08:45	SSBUV operations.
0/08:58	Orbit 7 begins.
0/09:00	PS1 begins presleep activities.
0/09:00	APU heater reconfiguration-A.

T+ (PLUS) DAY/ HR:MIN:SEC	EVENT
0/09:00	Pre RCS burn preparation.
0/09:05	MS1 begins presleep activities.
0/09:30	Red team begins postsleep activities.
0/09:30	On-orbit +X RCS burn (orbit adjust).
0/09:35	Pilot begins presleep activities.
0/09:35	Maneuver vehicle to IMU alignment attitude.
0/09:50	IMU alignment: ST.
0/09:55	COAS calibration--aft station.
0/10:00	Vehicle maneuver.
0/10:15	Private medical conference.
0/10:29	Orbit 8 begins.
0/10:30	Blue team handover to red team.
0/10:45	Commander begins presleep activities.
0/11:00	SAREX operations--Houston, Texas, radio check.
0/11:05	Blue team begins sleep period.
0/11:10	ATLAS operations (AEPI).
0/11:25	Post RCS burn operations.
0/11:45	G-229 operations.
0/11:55	P/TV10.
0/11:55	ATLAS operations (ISO).

T+ (PLUS) DAY/ HR:MIN:SEC	EVENT
0/11:59	Orbit 9 begins.
0/12:05	Vehicle maneuver.
0/12:10	ATLAS operations (SUSIM).
0/12:30	Vehicle maneuver.
0/12:35	ATLAS operations (AEPI).
0/13:00	ATLAS operations (ISO).
0/13:15	Vehicle maneuver.
0/13:30	DTO 648--electronic still camera setup.
0/13:30	Orbit 10 begins.
0/13:55	Vehicle maneuver.
0/14:00	TV93.
0/14:30	Meal.
0/15:00	Orbit 11 begins.
0/15:30	VFT-II operations.
0/16:31	Orbit 12 begins.
0/16:50	DSO 604--visual vestibular response.
0/17:10	TV99.
0/18:00	P/TV01.
0/18:02	Orbit 13 begins.
0/18:30	SAREX operations--Saipan.

T+ (PLUS) DAY/ HR:MIN:SEC	EVENT
0/18:50	Vehicle maneuver.
0/18:55	IMU alignment.
0/19:00	MS3 exercise.
0/19:00	ATLAS operations (AEPI).
0/19:05	Vehicle maneuver.
0/19:05	Blue team begins postsleep activities.
0/19:32	Orbit 14 begins.
0/19:55	ATLAS operations (SEPAC).
0/20:00	ATLAS operations (SEPAC).
0/20:00	Vehicle maneuver.
0/20:20	ATLAS operations (SEPAC).
0/20:30	MS2 exercise.
0/21:03	Orbit 15 begins.
0/21:10	SAREX operations--Cardif, Wales.
0/21:30	Red team handover to blue team.
0/21:45	Red team begins presleep activities.
0/21:45	DSO 608--effects of space flight.
0/21:50	ATLAS operations (AEPI).
0/22:20	ATLAS operations (SEPAC).
0/22:30	Vehicle maneuver.

T+ (PLUS) DAY/ HR:MIN:SEC	EVENT
0/22:32	Orbit 16 begins.
0/22:50	SAREX operations--Halden, Norway.
0/23:00	Filter cleaning.
0/23:15	ATLAS operations (FAUST).
0/23:45	ATLAS operations (SOLCON).

MET DAY ONE

1/00:00	Red team begins sleep period.
1/00:00	ATLAS operations (AEPI).
1/00:03	Orbit 17 begins.
1/00:20	Vehicle maneuver.
1/00:30	TV90.
1/00:40	ATLAS operations (AEPI).
1/00:50	Vehicle maneuver.
1/00:50	ATLAS operations (AEPI).
1/01:00	DSO 317 setup.
1/01:05	Vehicle maneuver.
1/01:15	DSO 317 observations.
1/01:20	Vehicle maneuver.
1/01:30	ATLAS operations (SEPAC).
1/01:30	SAREX operations--San Diego.

T+ (PLUS) DAY/ HR:MIN:SEC	EVENT
1/01:33	Orbit 18 begins.
1/01:55	DSO 317 stow.
1/01:55	ATLAS operations (SEPAC).
1/02:10	ATLAS operations (AEPI).
1/02:10	Meal (PS1).
1/02:25	Vehicle maneuver.
1/02:35	Vehicle maneuver.
1/02:50	Vehicle maneuver.
1/02:55	Meal.
1/03:03	Orbit 19 begins.
1/03:10	ATLAS operations (SEPAC).
1/03:15	ATLAS operations (SEPAC).
1/03:35	ATLAS operations (SEPAC).
1/03:40	ATLAS operations (SEPAC).
1/03:55	Vehicle maneuver.
1/04:05	Vehicle maneuver.
1/04:20	Vehicle maneuver.
1/04:30	SAREX operations--Devon, Alberta.
1/04:33	Orbit 20 begins.
1/04:50	P/TV12 setup.

T+ (PLUS) DAY/ HR:MIN:SEC	EVENT
1/05:10	ATLAS operations (AEPI).
1/05:25	Vehicle maneuver.
1/05:35	Maneuver vehicle to IMU alignment attitude.
1/05:50	IMU alignment.
1/05:55	Vehicle maneuver.
1/06:00	VFT-II operations.
1/06:00	P/TV12 activation.
1/06:04	Orbit 21 begins.
1/06:30	DTO 623--cabin air monitoring.
1/06:45	ATLAS operations (AEPI).
1/06:55	Vehicle maneuver.
1/06:55	ATLAS operations (AEPI).
1/07:05	Vehicle maneuver.
1/07:25	Vehicle maneuver.
1/07:35	Orbit 22 begins.
1/07:55	SAREX operations--Indianola, Iowa.
1/08:00	MS1 exercise.
1/08:00	Red team begins postsleep activities.
1/08:15	ATLAS operations (AEPI).
1/08:25	Vehicle maneuver.

T+ (PLUS) DAY/ HR:MIN:SEC	EVENT
1/08:30	Pilot exercise.
1/08:35	Vehicle maneuver.
1/08:55	Vehicle maneuver.
1/09:05	Orbit 23 begins.
1/09:15	Blue team handover to red team.
1/09:30	Blue team begins presleep activities.
1/09:40	ATLAS operations (AEPI).
1/09:55	Vehicle maneuver.
1/09:55	Private medical conference.
1/10:10	Vehicle maneuver.
1/10:25	ATLAS operations (SUSIM).
1/10:30	ATLAS operations (SUSIM).
1/10:35	Orbit 24 begins.
1/11:10	Vehicle maneuver.
1/11:15	ATLAS operations (AEPI).
1/11:25	Vehicle maneuver.
1/11:25	ATLAS operations (SEPAC).
1/11:30	Blue team begins sleep period.
1/11:30	ATLAS operations (SEPAC).
1/11:35	Vehicle maneuver.

T+ (PLUS) DAY/ HR:MIN:SEC	EVENT
1/11:45	TV97.
1/11:50	ATLAS operations (SEPAC).
1/12:00	P/TV15 setup.
1/12:00	ATLAS operations (SEPAC).
1/12:00	VFT-II operations.
1/12:05	ATLAS operations (SEPAC).
1/12:06	Orbit 25 begins.
1/12:35	ATLAS operations (SEPAC).
1/12:40	ATLAS operations (SEPAC).
1/12:55	TV97.
1/13:00	ATLAS operations (SEPAC).
1/13:10	ATLAS operations (SEPAC).
1/13:15	DSO 802--educational photography.
1/13:36	Orbit 26 begins.
1/14:20	TV89.
1/14:25	ATLAS operations (FAUST).
1/14:45	Meal.
1/14:55	Vehicle maneuver.
1/15:07	Orbit 27 begins.
1/15:45	ATLAS operations (SEPAC).

T+ (PLUS) DAY/ HR:MIN:SEC	EVENT
1/16:00	ATLAS operations (FAUST).
1/16:25	Vehicle maneuver.
1/16:30	ATLAS operations (MAS).
1/16:40	ATLAS operations (SEPAC).
1/16:37	Orbit 28 begins.
1/17:15	ATLAS operations (SEPAC).
1/17:45	ATLAS operations (AEPI).
1/17:50	Vehicle maneuver.
1/17:55	ATLAS operations (ISO).
1/18:00	IMU alignment.
1/18:07	Orbit 29 begins.
1/18:10	ATLAS operations (ISO).
1/18:15	ATLAS operations (SEPAC).
1/18:30	ATLAS operations (ISO).
1/18:35	Vehicle maneuver.
1/18:50	ATLAS operations (FAUST).
1/19:15	ATLAS operations (AEPI).
1/19:20	Vehicle maneuver.
1/19:30	MS2 exercise.
1/19:30	Blue team begins postsleep activities.

T+ (PLUS) DAY/ HR:MIN:SEC	EVENT
1/19:37	Orbit 30 begins.
1/19:50	SSBUV operations.
1/20:00	MS3 exercise.
1/20:10	Vehicle maneuver.
1/20:30	ATLAS operations (FAUST).
1/21:00	Vehicle maneuver.
1/21:00	Red team handover to blue team.
1/21:08	Orbit 31 begins.
1/21:15	Red team begins presleep activities.
1/21:45	ATLAS operations (SEPAC).
1/21:50	ATLAS operations (AEPI).
1/21:55	DSO 608--effects of space flight.
1/22:15	ATLAS operations (SEPAC).
1/22:20	TV88.
1/22:30	RME III memory module replacement.
1/22:38	Orbit 32 begins.
1/22:40	ATLAS operations (AEPI).
1/22:55	SAREX operations--Braband, Denmark.
1/23:10	ATLAS operations (SEPAC).
1/23:15	ATLAS operations (SEPAC).

T+ (PLUS) DAY/ HR:MIN:SEC	EVENT
1/23:20	ATLAS operations (AEPI).
1/23:25	Vehicle maneuver.
1/23:30	Red team begins sleep period.
1/23:35	Vehicle maneuver.
1/23:45	Vehicle maneuver.
1/23:50	ATLAS operations (SEPAC).

MET DAY TWO

2/00:09	Orbit 33 begins.
2/00:20	DSO 317 setup.
2/00:30	ATLAS operations (MAS).
2/00:30	SAREX operations--Augsburg, Germany.
2/00:35	DSO 317 observation.
2/00:35	P/TV15 setup.
2/00:50	ATLAS operations (SEPAC).
2/00:55	ATLAS operations (AEPI).
2/01:00	ATLAS operations (AEPI).
2/01:00	Vehicle maneuver.
2/01:15	DSO 317 stow.
2/01:20	Vehicle maneuver.
2/01:25	DSO 802--educational photography.

T+ (PLUS) DAY/ HR:MIN:SEC	EVENT
2/01:39	Orbit 34 begins.
2/02:10	P/TV12 setup.
2/02:15	ATLAS operations (SEPAC).
2/02:20	ATLAS operations (AEPI).
2/02:30	P/TV12 activation.
2/02:30	IPMP operations.
2/02:50	ATLAS operations (SEPAC).
2/02:55	MS1, PS1 meal.
2/03:00	Commander, pilot meal.
2/03:10	Orbit 35 begins.
2/03:45	ATLAS operations (SEPAC).
2/03:55	ATLAS operations (SEPAC).
2/04:00	ATLAS operations (AEPI).
2/04:00	DSO 611--AOS.
2/04:25	ATLAS operations (SEPAC).
2/04:35	ATLAS operations (ISO).
2/04:40	VFT-II operations.
2/04:40	Orbit 36 begins.
2/05:00	ATLAS operations (ISO).
2/05:25	ATLAS operations (SEPAC).

T+ (PLUS) DAY/ HR:MIN:SEC	EVENT
2/05:30	ATLAS operations (ISO).
2/05:40	Maneuver vehicle to IMU alignment attitude.
2/05:55	IMU alignment.
2/06:00	Vehicle maneuver.
2/06:10	Orbit 37 begins.
2/06:20	ATLAS operations (SEPAC).
2/06:25	ATLAS operations (AEPI).
2/06:30	DTO 623--cabin air monitoring.
2/06:30	SAREX operations--Maynard, Mass.
2/06:50	ATLAS operations (SEPAC).
2/06:55	ATLAS operations (AEPI).
2/07:30	MS1 exercise.
2/07:30	Red team begins postsleep activities.
2/07:30	DSO 612 control 1--energy utilization.
2/07:40	ATLAS operations (SEPAC).
2/07:41	Orbit 38 begins.
2/07:45	ATLAS operations (SEPAC).
2/08:00	Pilot exercise.
2/08:05	SAREX operations--Orangeburg, South Carolina.
2/08:20	SAREX operations--Sao Paulo, Brazil.

T+ (PLUS) DAY/ HR:MIN:SEC	EVENT
2/08:40	Pre RCS burn operations.
2/08:45	Blue team handover to red team.
2/09:00	Commander, MS1, PS1 begin presleep activities.
2/09:05	On-orbit +X RCS translation burn (orbit adjust).
2/09:12	Orbit 39 begins.
2/09:15	Pilot begins presleep activities.
2/09:20	On-orbit +X RCS translation burn (orbit adjust).
2/09:20	ATLAS operations (SEPAC).
2/09:35	Post RCS burn operations.
2/09:35	Private medical conference.
2/09:40	SAREX operations--Houston, Texas.
2/09:50	ATLAS operations (SEPAC).
2/10:00	ATLAS operations (AEPI).
2/10:00	Vehicle maneuver.
2/10:10	Vehicle maneuver.
2/10:20	Vehicle maneuver.
2/10:25	ATLAS operations (SEPAC).
2/10:40	Vehicle maneuver.
2/10:42	Orbit 40 begins.
2/10:50	ATLAS operations (ISO).

T+ (PLUS) DAY/ HR:MIN:SEC	EVENT
2/11:00	Blue team begins sleep period.
2/11:20	ATLAS operations (ISO).
2/11:30	DSO 612 control 2--energy utilization.
2/11:35	ATLAS operations (ISO).
2/11:35	ATLAS operations (SEPAC).
2/11:40	ATLAS operations (SEPAC).
2/11:45	ATLAS operations (AEPI).
2/11:45	Vehicle maneuver.
2/12:05	Vehicle maneuver.
2/12:12	Orbit 41 begins.
2/13:40	Vehicle maneuver.
2/13:43	Orbit 42 begins.
2/13:45	ATLAS operations (ISO).
2/14:10	ATLAS operations (ISO).
2/14:30	ATLAS operations (ISO).
2/14:35	ATLAS operations (FAUST).
2/14:50	ATLAS operations (SEPAC).
2/15:00	Meal.
2/15:05	Vehicle maneuver.
2/15:13	Orbit 43 begins.

T+ (PLUS) DAY/ HR:MIN:SEC	EVENT
2/16:00	VFT-II operations.
2/16:05	ATLAS operations (FAUST).
2/16:35	Vehicle maneuver.
2/16:40	ATLAS operations (ISO).
2/16:43	Orbit 44 begins.
2/17:05	ATLAS operations (ISO).
2/17:30	ATLAS operations (ISO).
2/17:35	Vehicle maneuver.
2/18:05	Vehicle maneuver.
2/18:10	ATLAS operations (ISO).
2/18:13	Orbit 45 begins.
2/18:35	ATLAS operations (ISO).
2/19:00	Blue team begins postsleep activities.
2/19:00	DSO 612 control 1--energy utilization.
2/19:00	ATLAS operations (ISO).
2/19:00	MS2 exercise.
2/19:05	Vehicle maneuver.
2/19:20	ATLAS operations (AEPI).
2/19:30	MS3 exercise.
2/19:30	Vehicle maneuver.

T+ (PLUS) DAY/ HR:MIN:SEC	EVENT
2/19:44	Orbit 46 begins.
2/19:45	IMU alignment.
2/20:15	Vehicle maneuver.
2/20:20	Red team handover to blue team.
2/20:35	Initiate waste dump.
2/20:35	Maneuver vehicle to -ZLV, +YVV attitude.
2/20:45	PS1 exercise.
2/20:45	Red team begins presleep activities.
2/20:55	DSO 608--effects of space flight.
2/21:14	Orbit 47 begins.
2/22:05	Waste dump termination.
2/22:10	Vehicle maneuver.
2/22:10	ATLAS operations (AEPI).
2/22:40	Vehicle maneuver.
2/22:45	Orbit 48 begins.
2/23:00	Red team begins sleep period.
2/23:05	DSO 612 control 2--energy utilization.
2/23:05	SSBUV operations.
2/23:20	Vehicle maneuver.
2/23:20	ATLAS operations (SEPAC).

T+ (PLUS) DAY/ HR:MIN:SEC	EVENT
2/23:30	ATLAS operations (AEPI).
2/23:40	P/TV15 setup.
2/23:55	ATLAS operations (SEPAC).

MET DAY THREE

3/00:00	DSO 802--educational photography.
3/00:15	Orbit 49 begins.
3/00:35	SAREX operations--Antwerp, Belgium.
3/00:55	ATLAS operations (SEPAC).
3/01:00	ATLAS operations (AEPI).
3/01:05	ATLAS operations (AEPI).
3/01:10	Vehicle maneuver.
3/01:25	Vehicle maneuver.
3/01:30	Meal.
3/01:45	Orbit 50 begins.
3/02:05	SSBUV operations.
3/02:30	ATLAS operations (SEPAC).
3/02:30	ATLAS operations (AEPI).
3/02:45	DSO 317 setup.
3/03:00	DSO 317 observations.
3/03:00	ATLAS operations (SEPAC).

T+ (PLUS) DAY/ HR:MIN:SEC	EVENT
3/03:16	Orbit 51 begins.
3/03:20	SSBUV operations.
3/03:40	DSO 317 stow.
3/03:40	ATLAS operations (AEPI).
3/03:55	ATLAS operations (SEPAC).
3/04:00	ATLAS operations (SEPAC).
3/04:00	ATLAS operations (AEPI).
3/04:20	ATLAS operations (AEPI).
3/04:30	ATLAS operations (SEPAC).
3/04:40	ATLAS operations (ISO).
3/04:47	Orbit 52 begins.
3/04:50	SSBUV operations.
3/05:00	VFT-II operations.
3/05:05	ATLAS operations (ISO).
3/05:20	SSBUV operations.
3/05:35	ATLAS operations (SEPAC).
3/05:35	ATLAS operations (ISO).
3/05:45	Maneuver vehicle to IMU alignment attitude.
3/06:00	IMU alignment.
3/06:05	Vehicle maneuver.

T+ (PLUS) DAY/ HR:MIN:SEC	EVENT
3/06:17	Orbit 53 begins.
3/06:20	SSBUV operations.
3/06:20	ATLAS operations (SEPAC).
3/06:25	ATLAS operations (AEPI).
3/06:30	DTO 623--cabin air monitoring.
3/07:00	Pilot exercise.
3/07:00	DSO 612 test--energy utilization.
3/07:00	Red team begins postsleep activities.
3/07:05	ATLAS operations (SEPAC).
3/07:10	ATLAS operations (AEPI).
3/07:40	MS1 exercise.
3/07:47	Orbit 54 begins.
3/07:50	ATLAS operations (SEPAC).
3/08:15	SAREX operations--Longwood, Fla.
3/08:20	ATLAS operations (SEPAC).
3/08:30	Blue team handover to red team.
3/08:45	Private medical conference.
3/08:45	Blue team begins presleep activities.
3/09:00	PS2 exercise.
3/09:15	Fuel cell purge--manual.

T+ (PLUS) DAY/ HR:MIN:SEC	EVENT
3/09:18	Orbit 55 begins.
3/09:20	ATLAS operations (SEPAC).
3/09:25	ATLAS operations (SEPAC).
3/09:30	SSBUV operations.
3/09:40	SAREX operations--San Jose, Calif.
3/10:00	ATLAS operations (SEPAC).
3/10:00	ATLAS operations (AEPI).
3/10:05	Vehicle maneuver.
3/10:15	Vehicle maneuver.
3/10:25	Vehicle maneuver.
3/10:30	ATLAS operations (SEPAC).
3/10:48	Orbit 56 begins.
3/10:50	Vehicle maneuver.
3/11:00	Blue team begins sleep period.
3/11:30	ATLAS operations (SEPAC).
3/11:35	ATLAS operations (SEPAC).
3/11:45	Vehicle maneuver.
3/11:55	P/TV06.
3/12:05	ATLAS operations (SEPAC).
3/12:05	Vehicle maneuver.

T+ (PLUS) DAY/ HR:MIN:SEC	EVENT
3/12:18	Orbit 57 begins.
3/12:20	P/TV15 setup.
3/12:40	DSO 802--educational photography.
3/13:45	Vehicle maneuver.
3/13:48	Orbit 58 begins.
3/13:50	RME III memory module replacement.
3/14:00	Meal.
3/14:40	Vehicle maneuver.
3/15:10	Vehicle maneuver.
3/15:19	Orbit 59 begins.
3/15:20	ATLAS operations (ISO).
3/15:45	ATLAS operations (ISO).
3/15:45	G-229 operations.
3/16:00	ATLAS operations (SEPAC).
3/16:05	ATLAS operations (ISO).
3/16:15	Vehicle maneuver.
3/16:40	Vehicle maneuver.
3/16:45	ATLAS operations (ISO).
3/16:50	Orbit 60 begins.
3/17:05	ATLAS operations (ISO).

T+ (PLUS) DAY/ HR:MIN:SEC	EVENT
3/17:35	ATLAS operations (ISO).
3/17:40	Vehicle maneuver.
3/17:40	VFT-II operations.
3/18:00	ATLAS operations (AEPI).
3/18:10	Vehicle maneuver.
3/18:15	ATLAS operations (ISO).
3/18:20	IMU alignment.
3/18:20	Orbit 61 begins.
3/18:30	ATLAS operations (ISO).
3/18:50	ATLAS operations (ISO).
3/18:55	Vehicle maneuver.
3/19:00	Blue team begins postsleep activities.
3/19:00	DSO 612 test--energy utilization.
3/19:00	MS3 exercise.
3/19:10	Vehicle maneuver.
3/19:15	ATLAS operations (AEPI).
3/19:30	MS2 exercise.
3/19:50	Vehicle maneuver.
3/19:50	Orbit 62 begins.
3/19:55	ATLAS operations (AEPI).

T+ (PLUS) DAY/ HR:MIN:SEC	EVENT
3/20:00	SAREX operations--Harrogate, England.
3/20:20	SSBUV operations.
3/20:20	Red team handover to blue.
3/20:30	ATLAS operations (SEPAC).
3/20:35	Vehicle maneuver.
3/20:45	DSO 608--effects of space flight.
3/20:45	Red team begins presleep activities.
3/20:55	Vehicle maneuver.
3/21:21	Orbit 63 begins.
3/21:40	ATLAS operations (MAS).
3/22:00	ATLAS operations (AEPI).
3/22:15	Filter cleaning (inspection).
3/22:15	ATLAS operations (ISO).
3/22:30	ATLAS operations (ISO).
3/22:50	ATLAS operations (ISO).
3/22:51	Orbit 64 begins.
3/23:00	Crew begins sleep period.
3/23:30	DSO 611--MAS.
3/23:30	ATLAS operations (SEPAC).
3/23:35	ATLAS operations (AEPI).

T+ (PLUS) DAY/ HR:MIN:SEC	EVENT
MET DAY FOUR	
4/00:10	ATLAS operations (SEPAC).
4/00:22	Orbit 65 begins.
4/00:35	SSBUV operations.
4/00:35	ATLAS operations (SEPAC).
4/00:45	DSO 317 setup.
4/00:55	SSBUV operations.
4/01:00	DSO 317 observations.
4/01:05	ATLAS operations (AEPI).
4/01:10	ATLAS operations (AEPI).
4/01:15	Vehicle maneuver.
4/01:35	Vehicle maneuver.
4/01:40	DSO 317 stow.
4/01:50	SSBUV operations.
4/01:52	Orbit 66 begins.
4/02:05	ATLAS operations (SEPAC).
4/02:15	SSBUV operations.
4/02:30	RCS regulator.
4/02:30	ATLAS operations (AEPI).
4/02:35	ATLAS operations (AEPI).

T+ (PLUS) DAY/ HR:MIN:SEC	EVENT
4/03:00	Meal.
4/03:22	Orbit 67 begins.
4/04:00	DSO 611--AOS.
4/04:10	ATLAS operations (SEPAC).
4/04:15	ATLAS operations (AEPI).
4/04:15	Heater configuration.
4/04:25	ECLSS checkout.
4/04:35	Cabin temperature control reconfiguration.
4/04:45	ATLAS operations (SEPAC).
4/04:50	PCS configuration.
4/04:50	ATLAS operations (ISO).
4/04:53	Orbit 68 begins.
4/04:55	SSBUV operations.
4/05:10	VFT-II operations.
4/05:15	ATLAS operations (ISO).
4/05:30	SSBUV operations.
4/05:40	ATLAS operations (ISO).
4/05:50	ATLAS operations (SEPAC).
4/05:55	Maneuver vehicle to IMU alignment attitude.
4/06:10	IMU alignment.

T+ (PLUS) DAY/ HR:MIN:SEC	EVENT
4/06:15	Vehicle maneuver.
4/06:20	DTO 623--cabin air monitoring.
4/06:23	Orbit 69 begins.
4/06:30	ATLAS operations (SEPAC).
4/07:00	MS1 exercise.
4/07:00	ATLAS operations (SEPAC).
4/07:00	DSO 612 test--energy utilization.
4/07:00	Red team begins postsleep activities.
4/07:05	ATLAS operations (AEPI).
4/07:30	Exercise.
4/07:53	Orbit 70 begins.
4/07:55	ATLAS operations (SEPAC).
4/08:00	ATLAS operations (SEPAC).
4/08:05	ATLAS operations (AEPI).
4/08:25	SSSBUV operations.
4/08:30	Blue team handover to red team.
4/08:45	Private medical conference.
4/08:45	Blue team begins presleep activities.
4/08:45	Radiator deploy.
4/08:45	ATLAS operations (AEPI).

T+ (PLUS) DAY/ HR:MIN:SEC	EVENT
4/09:24	Orbit 71 begins.
4/09:45	Humidity separator configuration A.
4/09:45	SSBUV operations.
4/10:05	ATLAS operations (SEPAC).
4/10:10	ATLAS operations (AEPI).
4/10:10	Vehicle maneuver.
4/10:20	Vehicle maneuver.
4/10:30	Vehicle maneuver.
4/10:35	ATLAS operations (SEPAC).
4/10:50	ATLAS operations (MAS).
4/10:55	Orbit 72 begins.
4/11:00	Crew begins sleep period.
4/11:10	SSBUV operations.
4/11:35	ATLAS operations (AEPI).
4/11:55	ATLAS operations (ISO).
4/12:00	SSBUV operations.
4/12:05	ATLAS operations (ISO).
4/12:15	ATLAS operations (ISO).
4/12:20	Vehicle maneuver.
4/12:25	Orbit 73 begins.

T+ (PLUS) DAY/ HR:MIN:SEC	EVENT
4/12:40	SSBUV operations.
4/12:45	ATLAS operations (SEPAC).
4/13:05	TV87.
4/13:05	ATLAS operations (AEPI).
4/13:15	Vehicle maneuver.
4/13:30	Vehicle maneuver.
4/13:50	Vehicle maneuver.
4/13:55	Orbit 74 begins.
4/14:00	Meal (MS2).
4/14:15	SSBUV operations.
4/14:35	ATLAS operations (AEPI).
4/14:50	Vehicle maneuver.
4/14:50	Meal (MS3).
4/15:05	Meal (PS2).
4/15:05	Vehicle maneuver.
4/15:25	Vehicle maneuver.
4/15:25	Orbit 75 begins.
4/15:50	SSBUV operations.
4/16:05	ATLAS operations (AEPI).
4/16:20	Vehicle maneuver.

T+ (PLUS) DAY/ HR:MIN:SEC	EVENT
4/16:35	Vehicle maneuver.
4/16:50	Vehicle maneuver.
4/16:55	Orbit 76 begins.
4/17:10	SSBUV operations.
4/17:15	VFT-II operations.
4/17:35	ATLAS operations (AEPI).
4/17:50	Vehicle maneuver.
4/18:00	Vehicle maneuver.
4/18:10	ATLAS operations (AEPI).
4/18:20	ATLAS operations (ISO).
4/18:25	IMU alignment.
4/18:26	Orbit 77 begins.
4/18:35	ATLAS operations (ISO).
4/18:55	ATLAS operations (ISO).
4/19:00	Blue team begins postsleep activities.
4/19:00	DSO 612 test--energy utilization.
4/19:00	MS3 exercise.
4/19:05	Vehicle maneuver.
4/19:25	Vehicle maneuver.
4/19:30	MS2 exercise.

T+ (PLUS) DAY/ HR:MIN:SEC	EVENT
4/19:35	ATLAS operations (AEPI).
4/19:50	Vehicle maneuver.
4/19:56	Orbit 78 begins.
4/20:20	SSBUV operations.
4/20:20	Red team handover to blue team.
4/20:35	ATLAS operations (SEPAC).
4/20:40	Vehicle maneuver.
4/20:45	Humidity separator configuration B.
4/20:45	ATLAS operations (AEPI).
4/20:45	Red team begins presleep activities.
4/21:05	Vehicle maneuver.
4/21:10	MS1 exercise.
4/21:27	Orbit 79 begins.
4/21:30	SSBUV operations.
4/21:40	ATLAS operations (AEPI).
4/21:45	DSO 608--effects of space flight.
4/21:45	ATLAS operations (MAS).
4/22:10	ATLAS operations (SEPAC).
4/22:15	ATLAS operations (AEPI).
4/22:45	ATLAS operations (SEPAC).

T+ (PLUS) DAY/ HR:MIN:SEC	EVENT
4/22:57	Orbit 80 begins.
4/23:00	Red team begins sleep period.
4/23:20	SSBUV operations.
4/23:35	ATLAS operations (SEPAC).
4/23:40	ATLAS operations (SEPAC).
4/23:45	ATLAS operations (AEPI).
4/23:50	Vehicle maneuver.

MET DAY FIVE

5/00:05	Vehicle maneuver.
5/00:10	Vehicle maneuver.
5/00:15	ATLAS operations (SEPAC).
5/00:28	Orbit 81 begins.
5/00:40	SSBUV operations.
5/01:05	SSBUV operations.
5/01:10	ATLAS operations (SEPAC).
5/01:10	ATLAS operations (AEPI).
5/01:20	ATLAS operations (SEPAC).
5/01:25	Vehicle maneuver.
5/01:40	Vehicle maneuver.
5/01:50	ATLAS operations (SEPAC).

T+ (PLUS) DAY/ HR:MIN:SEC	EVENT
5/01:58	Orbit 82 begins.
5/02:25	ATLAS operations (AEPI).
5/02:40	ATLAS operations (SEPAC).
5/02:45	ATLAS operations (SEPAC).
5/02:45	ATLAS operations (AEPI).
5/03:00	ATLAS operations (AEPI).
5/03:10	ATLAS operations (SEPAC).
5/03:15	Meal.
5/03:28	Orbit 83 begins.
5/04:10	ATLAS operations (SEPAC).
5/04:15	VFT-II operations.
5/04:15	RME III memory module replacement.
5/04:15	ATLAS operations (SEPAC).
5/04:20	ATLAS operations (AEPI).
5/04:58	Orbit 84 begins.
5/05:05	ATLAS operations (SEPAC).
5/05:40	ATLAS operations (SEPAC).
5/06:00	Maneuver vehicle to IMU alignment attitude.
5/06:15	IMU alignment.
5/06:20	Vehicle maneuver.

T+ (PLUS) DAY/ HR:MIN:SEC	EVENT
5/06:29	Orbit 85 begins.
5/06:30	DTO 623--cabin air monitoring.
5/06:30	ATLAS operations (SEPAC).
5/06:35	ATLAS operations (SEPAC).
5/06:45	ATLAS operations (AEPI).
5/06:55	SAREX operations--MSFC, Ala.
5/07:00	DSO 612 test--energy utilization.
5/07:00	Red team begins postsleep activities.
5/07:15	ATLAS operations (AEPI).
5/07:25	ATLAS operations (SEPAC).
5/07:30	Pilot exercise.
5/07:45	ATLAS operations (SEPAC).
5/07:59	Orbit 86 begins.
5/08:10	ATLAS operations (SEPAC).
5/08:20	SSBUV operations.
5/08:25	Pre RCS burn operations.
5/08:30	Blue team handover to red team.
5/08:45	Private medical conference.
5/08:45	Blue team begins presleep activities.
5/08:55	ATLAS operations (AEPI).

T+ (PLUS) DAY/ HR:MIN:SEC	EVENT
5/09:05	On-orbit + X RCS translation burn (orbit adjust).
5/09:15	MS3 exercise.
5/09:30	Orbit 87 begins.
5/09:35	Post RCS burn operations.
5/09:45	ATLAS operations (SEPAC).
5/10:10	ATLAS operations (SEPAC).
5/10:15	ATLAS operations (AEPI).
5/10:30	ATLAS operations (ISO).
5/10:45	ATLAS operations (ISO).
5/11:00	ATLAS operations (ISO).
5/11:00	Blue team begins sleep period.
5/11:01	Orbit 88 begins.
5/11:15	TV94.
5/11:25	SSBUV operations
5/11:40	ATLAS operations (SEPAC).
5/11:45	ATLAS operations (SEPAC).
5/11:45	SSBUV operations.
5/11:50	ATLAS operations (AEPI).
5/12:05	Vehicle maneuver.
5/12:15	Vehicle maneuver.

T+ (PLUS) DAY/ HR:MIN:SEC	EVENT
5/12:15	ATLAS operations (SEPAC).
5/12:31	Orbit 89 begins.
5/13:50	Meal (MS2).
5/14:00	Meal (MS3, PS2).
5/14:02	Orbit 90 begins.
5/14:05	Vehicle maneuver.
5/14:50	Vehicle maneuver.
5/15:15	Maneuver vehicle to -XLV, +YVV attitude.
5/15:20	Waste dump initiation.
5/15:30	VFT-II operations.
5/15:32	Orbit 91 begins.
5/16:30	ATLAS operations (SEPAC).
5/16:50	Waste dump termination.
5/17:00	Vehicle maneuver.
5/17:03	Orbit 92 begins.
5/17:25	ATLAS operations (ISO).
5/17:40	ATLAS operations (ISO).
5/17:50	ATLAS operations (ISO).
5/18:00	Vehicle maneuver.
5/18:15	ATLAS operations (AEPI).

T+ (PLUS) DAY/ HR:MIN:SEC	EVENT
5/18:20	Vehicle maneuver.
5/18:30	ATLAS operations (ISO).
5/18:33	Orbit 93 begins.
5/18:35	IMU alignment.
5/18:45	ATLAS operations (ISO).
5/19:00	Blue team begins postsleep activities.
5/19:00	DSO 612 test--energy utilization.
5/19:00	MS2 exercise.
5/19:10	ATLAS operations (ISO).
5/19:15	Vehicle maneuver.
5/19:30	ATLAS operations (SEPAC).
5/19:35	Vehicle maneuver.
5/19:40	ATLAS operations (AEPI).
5/20:03	Orbit 94 begins.
5/20:05	Vehicle maneuver.
5/20:15	ATLAS operations (AEPI).
5/20:30	Red team handover to blue team.
5/20:45	DSO 608--effects of space flight.
5/20:45	Red team begins presleep activities.
5/21:05	ATLAS operations (SEPAC).

T+ (PLUS) DAY/ HR:MIN:SEC	EVENT
5/21:15	Vehicle maneuver.
5/21:15	ATLAS operations (AEPI).
5/21:33	Orbit 95 begins.
5/21:35	Vehicle maneuver.
5/21:45	Conference audio/TV check.
5/22:00	Crew press conference.
5/22:15	Filter cleaning.
5/22:30	SSBUV operations.
5/22:30	ATLAS operations (FAUST).
5/22:45	SSBUV operations.
5/22:55	Vehicle maneuver.
5/23:00	Red team begins sleep period.
5/23:04	Orbit 96 begins.
5/23:10	SSBUV operations.
5/23:20	SSBUV operations.
5/23:45	ATLAS operations (SEPAC).
5/23:50	ATLAS operations (AEPI).

MET DAY SIX

6/00:15	ATLAS operations (SEPAC).

T+ (PLUS) DAY/ HR:MIN:SEC	EVENT
6/00:15	ATLAS operations (AEPI).
6/00:34	Orbit 97 begins.
6/01:00	SSBUV operations.
6/01:15	ATLAS operations (SEPAC).
6/01:20	ATLAS operations (AEPI).
6/01:20	ATLAS operations (AEPI).
6/01:30	Vehicle maneuver.
6/01:45	Vehicle maneuver.
6/01:50	Meal.
6/02:05	Orbit 98 begins.
6/02:30	SSBUV operations.
6/02:50	ATLAS operations (SEPAC).
6/02:50	ATLAS operations (AEPI).
6/03:20	ATLAS operations (SEPAC).
6/03:20	ATLAS operations (AEPI).
6/03:30	VFT-II operations.
6/03:35	Orbit 99 begins.
6/04:15	ATLAS operations (SEPAC).
6/04:20	ATLAS operations (SEPAC).
6/04:25	ATLAS operations (AEPI).

T+ (PLUS) DAY/ HR:MIN:SEC	EVENT
6/04:30	DSO 611--AOS.
6/05:06	Orbit 100 begins.
6/05:10	ATLAS operations (SEPAC).
6/05:40	SSBUV operations.
6/05:45	ATLAS operations (SEPAC).
6/06:10	Maneuver vehicle to IMU alignment attitude.
6/06:20	TV98.
6/06:25	IMU alignment.
6/06:30	DTO 623--cabin air monitoring.
6/06:30	Vehicle maneuver.
6/06:35	ATLAS operations (SEPAC).
6/06:36	Orbit 101 begins.
6/06:40	ATLAS operations (SEPAC).
6/06:45	ATLAS operations (MAS).
6/07:00	Pilot exercise.
6/07:00	DSO 612 test--energy utilization.
6/07:00	Red team begins postsleep period.
6/07:10	ATLAS operations (SEPAC).
6/07:25	ATLAS operations (AEPI).
6/07:30	MS1 exercise.

T+ (PLUS) DAY/ HR:MIN:SEC	EVENT
6/08:06	Orbit 102 begins.
6/08:20	SSBUV operations.
6/08:30	Blue team handover to red team.
6/08:45	Blue team begins presleep activities.
6/08:45	Private medical conference.
6/09:10	ATLAS operations (SEPAC).
6/09:10	ATLAS operations (AEPI).
6/09:15	PS2 exercise.
6/09:37	Orbit 103 begins.
6/09:55	SSBUV operations.
6/10:20	ATLAS operations (AEPI).
6/10:25	ATLAS operations (AEPI).
6/10:30	P/TV15 setup.
6/10:30	Blue team begins sleep period.
6/10:45	DSO 802--educational photography.
6/11:07	Orbit 104 begins.
6/11:45	SSBUV operations.
6/11:50	ATLAS operations (SEPAC).
6/11:55	ATLAS operations (AEPI).
6/12:10	Vehicle maneuver.

T+ (PLUS) DAY/ HR:MIN:SEC	EVENT
6/12:15	Vehicle maneuver.
6/12:20	ATLAS operations (SEPAC).
6/12:35	ATLAS operations (ISO).
6/12:37	Orbit 105 begins.
6/12:45	DSO 604--visual vestibular response.
6/13:00	ATLAS operations (ISO).
6/13:20	ATLAS operations (ISO).
6/13:25	ATLAS operations (SEPAC).
6/13:30	Vehicle maneuver.
6/14:00	Vehicle maneuver.
6/14:05	MS2 meal.
6/14:08	Orbit 106 begins.
6/14:30	VFT-II operations.
6/15:00	MS3, PS2 meal.
6/15:05	ATLAS operations (FAUST).
6/15:30	Vehicle maneuver.
6/15:38	Orbit 107 begins.
6/16:35	ATLAS operations (FAUST).
6/17:00	Vehicle maneuver.
6/17:05	ATLAS operations (ISO).

T+ (PLUS) DAY/ HR:MIN:SEC	EVENT
6/17:08	Orbit 108 begins.
6/17:35	ATLAS operations (ISO).
6/18:05	ATLAS operations (ISO).
6/18:10	Vehicle maneuver.
6/18:15	APU heater activation.
6/18:25	ATLAS operations (AEPI).
6/18:30	Blue team begins postsleep activities.
6/18:30	DSO 612 test--energy utilization.
6/18:30	Vehicle maneuver.
6/18:38	Orbit 109 begins.
6/18:40	ATLAS operations (ISO).
6/18:45	IMU alignment.
6/18:50	MS2 exercise.
6/18:50	ATLAS operations (ISO).
6/18:50	TV96.
6/19:15	ATLAS operations (ISO).
6/19:20	Vehicle maneuver.
6/19:30	RME III memory module replacement.
6/19:35	ATLAS operations (SEPAC).
6/19:40	Vehicle maneuver.

T+ (PLUS) DAY/ HR:MIN:SEC	EVENT
6/19:45	ATLAS operations (AEPI).
6/19:50	Pre RCS burn operations.
6/19:55	FCS checkout.
6/20:09	Orbit 110 begins.
6/20:10	ATLAS operations (SEPAC).
6/20:15	ATLAS operations (ISO).
6/20:15	MS3 exercise.
6/20:35	ATLAS operations (ISO).
6/20:45	ATLAS operations (SEPAC).
6/20:50	ATLAS operations (ISO).
6/21:15	RCS hot fire.
6/21:15	ATLAS operations (SEPAC).
6/21:15	ATLAS operations (AEPI).
6/21:30	Aft controller checkout.
6/21:40	Post RCS burn operations.
6/21:40	Vehicle maneuver.
6/21:40	Orbit 111 begins.
6/21:45	Red team handover to blue team.
6/21:54	Commander and pilot configure dedicated displays for entry.
6/22:00	APU cool A.

T+ (PLUS) DAY/ HR:MIN:SEC	EVENT
6/22:00	Red team begins presleep activities.
6/22:20	DSO 608--effects of space flight.
6/22:40	ATLAS operations (SEPAC).
6/22:50	ATLAS operations (AEPI).
6/23:00	Vehicle maneuver.
6/23:10	Orbit 112 begins.
6/23:10	Vehicle maneuver.
6/23:15	PS1 exercise.
6/23:30	ATLAS operations (AEPI).
6/23:45	TV91.

MET DAY SEVEN

7/00:05	Heater configuration.
7/00:10	Vehicle maneuver.
7/00:15	Red team begins sleep period.
7/00:25	Vehicle maneuver.
7/00:35	SSBUV operations.
7/00:40	Orbit 113 begins.
7/01:00	SSBUV operations.
7/01:25	ATLAS operations (AEPI).
7/01:30	ATLAS operations (AEPI).

T+ (PLUS) DAY/ HR:MIN:SEC	EVENT
7/01:35	Vehicle maneuver.
7/01:55	Vehicle maneuver.
7/02:11	Orbit 114 begins.
7/02:15	TV92.
7/02:30	SSBUV operations.
7/02:45	Meal.
7/03:10	ATLAS operations (FAUST).
7/03:30	Vehicle maneuver.
7/03:42	Orbit 115 begins.
7/04:00	VFT-II operations.
7/04:00	Radiator stow.
7/04:00	SSBUV operations.
7/04:25	ATLAS operations (AEPI).
7/04:30	ATLAS operations (AEPI).
7/04:35	Vehicle maneuver.
7/04:40	DTO 623--cabin air monitoring.
7/05:00	Vehicle maneuver.
7/05:12	Orbit 116 begins.
7/05:20	ATLAS operations (SUSIM).
7/06:00	Vehicle maneuver.

T+ (PLUS) DAY/ HR:MIN:SEC	EVENT
7/06:10	Maneuver vehicle to IMU alignment attitude.
7/06:20	Vehicle maneuver.
7/06:25	IMU alignment.
7/06:42	Orbit 117 begins.
7/06:45	ATLAS operations (SOLCON).
7/07:10	Vehicle maneuver.
7/07:15	Blue team begins presleep activities.
7/07:40	Vehicle maneuver.
7/08:05	Vehicle maneuver.
7/08:12	Orbit 118 begins.
7/08:15	Red team begins postsleep activities.
7/09:00	Blue team handover to red team.
7/09:05	ATLAS operations (FAUST).
7/09:15	Red team begins postsleep activities.
7/09:15	Blue team begins presleep activities.
7/09:20	Private medical conference.
7/09:35	Blue team begins sleep period.
7/09:40	Vehicle maneuver.
7/09:43	Orbit 119 begins.
7/10:15	Electronic still camera stow (DTO 648).

T+ (PLUS) DAY/ HR:MIN:SEC	EVENT
7/10:40	SSBUV deactivation.
7/10:45	Vehicle maneuver.
7/11:00	APC stow.
7/11:00	VFT-II operations.
7/11:13	Orbit 120 begins.
7/11:15	ATLAS operations (SEPAC).
7/11:20	Vehicle maneuver.
7/11:25	DTO 633 stow--VTR stow.
7/11:30	DTO 728--Ku-band antenna friction.
7/11:50	SAREX stow.
7/12:15	DSO 611--AOS.
7/12:20	DSO 611--MAS.
7/12:30	Payload deactivation.
7/12:40	MS2 meal.
7/12:43	Orbit 121 begins.
7/13:00	MS3, PS2 meal.
7/13:40	Maneuver and initiate passive thermal control.
7/14:00	Cabin stow.
7/14:05	P/TV12 setup.
7/14:14	Orbit 122 begins.

T+ (PLUS) DAY/ HR:MIN:SEC	EVENT
7/14:25	P/TV12 activation.
7/14:30	STL entry preparation.
7/15:35	Blue team begins postsleep activities.
7/15:35	Spacelab deactivation.
7/15:44	Orbit 123 begins.
7/15:45	MS3 deactivates high-rate multiplexer.
7/15:55	MS3 deactivates electrical power distribution box.
7/16:00	MS3 deactivates experiment computer.
7/16:05	MS3 deactivates Spacelab subsystem command and data management subsystem.
7/16:15	MS3 powers down Spacelab.
7/16:25	MS3 loads PCMMU orbit formats.
7/16:30	MS3 configures orbiter audio.
7/16:35	DSO 603B entry preparation--orthostatic function.
7/16:55	Priority Group B powerup.
7/17:05	Terminate passive thermal control.
7/17:07	Begin deorbit preparation.
7/17:07	CRT timer setup.
7/17:10	Maneuver vehicle to -XSI attitude.
7/17:12	Commander initiates coldsoak.
7/17:15	Orbit 124 begins.

T+ (PLUS) DAY/ HR:MIN:SEC	EVENT
7/17:21	Stow radiators, if required.
7/17:39	Commander configures DPS for deorbit preparation.
7/17:42	Mission Control Center updates IMU star pad, if required.
7/17:51	MS configures for payload bay door closure.
7/18:00	Ku-band stow.
7/18:05	Maneuver vehicle to IMU alignment attitude.
7/08:12	Orbit 118 begins.
7/18:12	Maneuver vehicle to IMU alignment attitude.
7/18:13	MCC-H gives "go/no-go" command for payload bay door closure.
7/18:20	IMU alignment--payload bay door operations.
7/18:27	IMU alignment: ST/payload bay door closing operations.
7/18:45	Orbit 125 begins.
7/18:50	MCC gives the crew the go for OPS 3.
7/18:53	Maneuver vehicle to deorbit burn attitude.
7/18:57	Pilot starts repressurization of SSME systems.
7/19:01	Commander and pilot perform DPS entry configuration.
7/19:10	MS deactivates ST and closes ST doors.
7/19:12	All crew members verify entry payload switch list.
7/19:27	All crew members perform entry review.

T+ (PLUS) DAY/ HR:MIN:SEC	EVENT
7/19:29	Crew begins fluid loading, 32 fluid ounces of water with salt over next 1.5 hours (2 salt tablets per 8 ounces).
7/19:42	Commander and pilot configure clothing.
7/19:57	MS/PS configure clothing.
7/20:07	Commander and pilot seat ingress.
7/20:09	Commander and pilot set up heads-up display (HUD).
7/20:11	Commander and pilot adjust seat, exercise brake pedals.
7/20:15	Orbit 126 begins.
7/20:19	Final entry deorbit update/uplink.
7/20:25	OMS thrust vector control gimbal check is performed.
7/20:27	APU prestart.
7/20:42	Close vent doors.
7/20:46	MCC-H gives "go" for deorbit burn period.
7/20:50	Maneuver vehicle to deorbit burn attitude.
7/20:53	MS/PS ingress seats.
7/21:02	First APU is activated.
7/21:07	Deorbit burn period, approximately 2 minutes, 28 seconds in duration, at 266 fps, 159 by 160 nm.
7/21:12	Initiate post-deorbit burn period attitude.
7/21:16	Terminate post-deorbit burn attitude.

T+ (PLUS) DAY/ HR:MIN:SEC	EVENT
7/21:24	Dump forward RCS, if required.
7/21:32	Activate remaining APUs.
7/21:36	Entry interface, 400,000 feet altitude.
7/21:39	Enter communication blackout.
7/21:40	Automatically deactivate RCS roll thrusters.
7/21:45	Orbit 127 begins.
7/21:47	Automatically deactivate RCS pitch thrusters.
7/21:52	Initiate first roll reversal.
7/21:56	Exit communications blackout.
7/21:56	Initiate second roll reversal.
7/21:57	TACAN acquisition.
7/22:00	Initiate third roll reversal.
7/22:01	Begin PTI sequence.
7/22:01	Initiate air data system (ADS) probe deploy.
7/22:02	Begin entry/terminal area energy management (TAEM).
7/22:02	Initiate payload bay venting.
7/22:02	End PTI sequence.
7/22:03	Automatically deactivate RCS yaw thrusters.
7/22:06	Begin TAEM/approach/landing (A/L) interface.
7/22:06	Initiate landing gear deployment.

T+ (PLUS) DAY/ HR:MIN:SEC	EVENT
7/22:07	Vehicle has weight on main landing gear.
7/22:07	Vehicle has weight on nose landing gear.
7/22:08	Wheel stop.
7/22:07	Initiate main landing gear braking.

GLOSSARY

A/G	air-to-ground
AA	accelerometer assembly
ACS	active cooling system
ACR	active cavity radiometer
ADS	air data system
AEPI	atmospheric emissions and photometric imaging
AFB	Air Force base
A/L	approach and landing
ALAE	atmospheric Lyman-Alpha emissions
AMU	attitude match update
AOS	acquisition of signal
APC	autonomous payload controller
APU	auxiliary power unit
ASE	airborne support equipment
ATLAS	atmospheric laboratory for applications and science
ATMOS	atmospheric trace molecule spectroscopy
BFS	backup flight control system
CCD	charge-coupled device
CDMS	command and data management subsystem
CLOUDS	cloud logic to optimize use of defense systems
COAS	crewman optical alignment sight
CRT	cathode ray tube
C/W	caution/warning
DAP	digital autopilot
DOD	Department of Defense
DPS	data processing system
DSO	detailed supplementary objective
DTO	development test objective
EAFB	Edwards Air Force Base
ECLSS	environmental control and life support system
EDO	extended duration orbiter
EHF	extremely high frequency
ELV	expendable launch vehicle
EMU	extravehicular mobility unit
ENAP	energetic neutral atom precipitation

EOM	end of mission
EPS	electrical power system
ESA	European Space Agency
ET	external tank
ETR	Eastern Test Range
EV	extravehicular
EVA	extravehicular activity
FAUST	far ultraviolet space telescope
FC	fuel cell
FCS	flight control system
FES	flash evaporator system
FES	fluids experiment system
FDF	flight data file
FPS	feet per second
FRCS	forward reaction control system
FTA	fluid test article
GAS	getaway special
GBA	GAS bridge assembly
GLS	ground launch sequencer
GN&C	guidance, navigation, and control
GPC	general-purpose computer
GRILLE	Grille spectrometer
GSFC	Goddard Space Flight Center
HAINS	high accuracy inertial navigation system
HRM	high-rate multiplexer
HUD	heads-up display
IFM	in-flight maintenance
IMU	inertial measurement unit
IPMP	investigations into polymer membrane processing
IR	infrared
ISO	imaging spectrometric observatory
IV	intravehicular
JSC	Johnson Space Center
KSC	Kennedy Space Center

LACE	low-power atmospheric compensation experiment
LCD	liquid crystal display
LES	launch escape system
LPS	launch processing system
LRU	line replaceable unit
MAS	millimeter wave atmospheric sounder
MCC-H	Mission Control Center--Houston
MDM	multiplexer/demultiplexer
MECO	main engine cutoff
MET	mission elapsed time
MILA	Merritt Island
MLP	mobile launcher platform
MM	major mode
MPS	main propulsion system
MS	mission specialist
MSFC	Marshall Space Flight Center
NMI	nautical miles
NOR	Northrup Strip
O&C	operations and checkout
OAA	orbiter access arm
OMS	orbital maneuvering system
OTC	orbiter test conductor
PASS	primary avionics software system
PCMMU	pulse code modulation master unit
PCS	pressure control system
PGSC	payload and general support computer
PI	payload interrogator
PIC	pyro initiator controller
POCC	Payload Operations Control Center
PRLA	payload retention latch assembly
PS	payload specialist
PTI	preprogrammed test input
P/TV	photo/TV
RAAN	right ascension of the ascending node
RCS	reaction control system
RF	radio frequency
RGA	rate gyro assembly

RME	radiation monitoring equipment
RMS	remote manipulator system
ROEU	remotely operated electrical umbilical
RSLS	redundant-set launch sequencer
RSS	range safety system
RTLS	return to launch site
S&A	safe and arm
SA	solar array
SAF	Secretary of the Air Force
SAREX	shuttle amateur radio experiment
SEPAC	space experiments with particle accelerators
SHF	superhigh frequency
SM	statute miles
SOLCON	solar constant
SOLSPEC	solar spectrum
SRB	solid rocket booster
SRM	solid rocket motor
SRSS	shuttle range safety system
SSBUV	shuttle solar backscatter ultraviolet experiment
SSME	space shuttle main engine
SSP	standard switch panel
SSPP	solar/stellar pointing platform
ST	star tracker
STA	structural test article
STL	space tissue loss
STS	Space Transportation System
SURS	standard umbilical retraction/retention system
SUSIM	solar ultraviolet spectral irradiance monitor
TAEM	terminal area energy management
TAGS	text and graphics system
TAL	transatlantic landing
TDRS	tracking and data relay satellite
TDRSS	tracking and data relay satellite system
TFL	telemetry format load
TI	thermal phase initiation
TIG	time of ignition
TPS	thermal protection system
TSM	tail service mast
TT&C	telemetry, tracking, and communications
TV	television
TVC	thrust vector control

UHF	ultrahigh frequency
USAF	U.S. Air Force
UVPI	ultraviolet plume instrument
VFT	visual function tester
VTR	videotape recorder
WCS	waste collection system

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