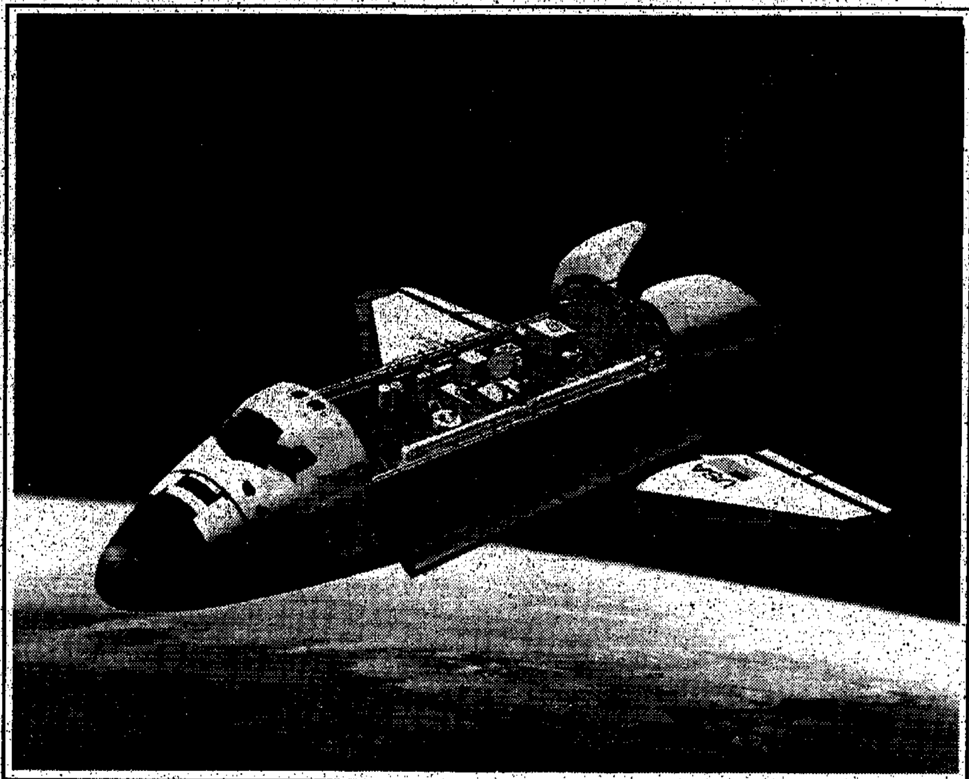

STS-56

PRESS INFORMATION AND MISSION TIME LINE

April 1993

Rockwell International

Space Systems Division

Office of External Communications & Media Relations

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CONTENTS

CONTENTS (CONT)

MISSION OVERVIEW

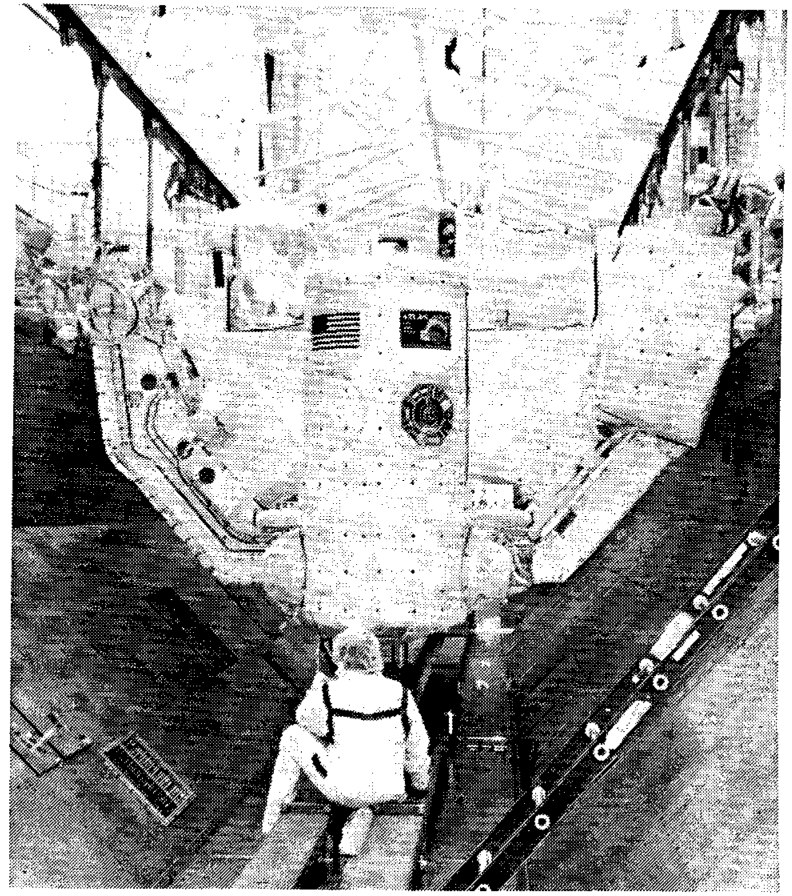
This is the 16th flight of Discovery and the 54th for the space shuttle.

The flight crew for the eight-day STS-56 mission is commander Kenneth (Ken) D. Cameron; pilot Stephen (Steve) S. Oswald; and mission specialists Kenneth (Ken) D. Cockrell, Michael (Mike) Foale, and Ellen Ochoa. The crew will be divided into a blue team, consisting of Cameron, Oswald, and Ochoa, and a red team, comprising Cockrell and Foale. Each team will work 12-hour shifts, allowing for around-the-clock operations.

PRIMARY OBJECTIVE

STS-56's primary mission objective is to provide the orbiter Discovery and the Spacelab pallet as a science platform for experiments on the Atmospheric Laboratory for Applications and Science (ATLAS) 2 payload. The second in a series of up to nine NASA shuttle-borne Spacelab missions designed to measure the variation in solar output and its effect on the Earth's atmosphere, ATLAS-2 is a vital part of NASA's Mission to Planet Earth, a large-scale, unified study of Earth as a single, dynamic system. ATLAS-2 will 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 another 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 is also intended to supplement measurements made by the Upper Atmosphere Research Satellite (UARS).

The space shuttle provides an ideal platform for the ATLAS-2 payload because the flight crew can maneuver the orbiter to point the ATLAS-2 instruments precisely toward the atmosphere, the sun, or



NASA Photo

ATLAS-2 Is Placed in Transporter for Move to Orbiter Processing Facility, Where It Will Be Installed in Cargo Bay of Discovery the Earth's surface for observations. In addition, the shuttle's large payload capacity and power supply permit it to carry an assembly of large instruments that make simultaneous remote observations.

The ATLAS-2 payload consists of a Spacelab pallet system and includes six instruments that are controlled via ground commanding. The instruments will conduct investigations in atmospheric and solar physics.

Atmospheric Physics

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

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

Solar Physics

The Active Cavity Radiometer Irradiance Monitor (ACRIM) and Solar Constant (SOLCON) experiments will use precise instruments to measure ultraviolet light through infrared radiation. Using slightly different techniques, the experiments 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 changes over time and where they are absorbed in the atmosphere.

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

ATLAS-2 is a NASA mission; however, France, Belgium, and Germany are providing three of the ATLAS-2 instruments. 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

The Shuttle Solar Backscatter Ultraviolet (SSBUV) A experiment is designed to provide more accurate and reliable readings of global ozone to aid in the calibration of backscatter ultraviolet instruments being flown concurrently on free-flying satellites. The payload configuration consists of two getaway special (GAS) canisters, one of which contains the SSBUV spectrometer. Payload operations are controlled by ground commands. SSBUV-A is manifested with ATLAS-2 and will provide calibrated ozone data contributing to the Mission to Planet Earth data set.

The Shuttle Pointed Autonomous Research Tool for Astronomy (SPARTAN) 201, or Solar Wind Generation Experiment, is a free-flying payload housed in Discovery's payload bay that will study the velocity and acceleration of the solar wind and will observe aspects of the sun's corona. Results should help scientists understand the physics of the sun's corona and the solar wind. SPARTAN will be deployed and retrieved by the shuttle's remote manipulator system (RMS). SPARTAN is deployed from the shuttle so it can operate independently, turning and pointing at the sun, while leaving the orbiter free for other activities. Deployment is scheduled for orbit 49; with retrieval on orbit 81. SPARTAN has two instruments: the ultraviolet coronal spectrometer and the white light coronagraph. All housekeeping and science data will be recorded on board the deployed hardware.

The Solar Ultraviolet Experiment (SUVE) will use two spectrometers to measure extreme ultraviolet and far ultraviolet solar irradiance as it affects the Earth's ionosphere. SUVE was developed by students at the Colorado Space Grant Consortium, a group of 14 colleges and universities, with funding from NASA.

The Commercial Material Dispersion Apparatus Minilab/ Instrumentation Technology Associates Experiment (CMIX) will collect data on scientific methods and the commercial potential of biomedical and fluid science applications in microgravity. Specifically, CMIX will study protein crystal growth, collagen polymerization, fibrin clot formation, liquid-solid diffusion, and the formation of thin-film membranes.

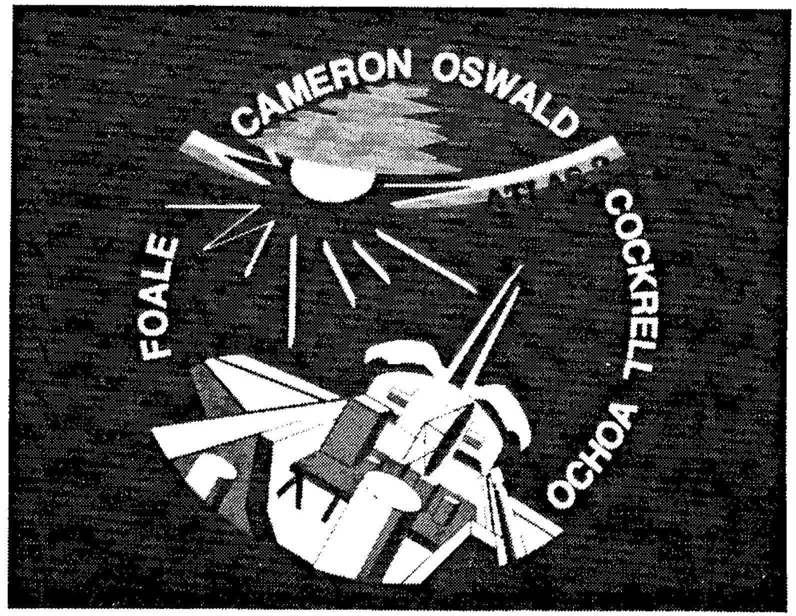
The Physiological and Anatomical Rodent Experiment (PARE) is a series of experiments designed to determine whether exposure to microgravity results in physiological or anatomical changes in rodents. The rodents will be contained in two animal enclosure modules, which are designed so that the flight crew will not come into direct contact with the animals.

The objective of the Space Tissue Loss (STL) experiment is to validate models of muscle, bone, and endothelial biochemical and functional loss induced by microgravity stress. STL will evaluate cytoskeleton, metabolism, membrane integrity, and protease activity in target cells in addition to testing tissue loss pharmaceuticals for efficacy.

The Shuttle Amateur Radio Experiment (SAREX), sponsored by NASA, the American Radio Relay League/Amateur Radio Satellite Corporation, and the Johnson Space Center Amateur Radio Club, is a middeck payload that will establish two-way communication with amateur radio stations within the line of sight of the orbiter. An antenna is mounted in a crew cabin window. Configuration D is planned for this mission and can operate in one of four modes: voice, slow-scan television (SSTV), data, or fast-scan television (FSTV, uplink only). The voice mode is an attended mode; SSTV, data, or FSTV can be operated in either an attended or unattended mode. The SAREX will be operated at the discretion of the licensed crew members (Ken Cameron, Ken Cockrell, Mike Foale, and Ellen Ochoa).

The Hand-held, Earth-oriented, Real-time, Cooperative, User-friendly, Location-targeting, and Environmental System (HERCULES) will provide an on-orbit capability to geolocate a ground target to within one nautical mile. The crew will have the ability to view electronic images on board and downlink images through the Ku-band system.

The Air Force Maui Optical Site (AMOS) uses the orbiter during cooperative overflights of Maui, Hawaii, and Arecibo to obtain imagery and/or signature data to support the calibration of ground-based sensors and to observe plume phenomenology. No unique on-board hardware is associated with the AMOS test; however, crew and orbiter participation may be required to establish the controlled conditions for cooperative overflights. Only tests over Maui are planned for STS-56.

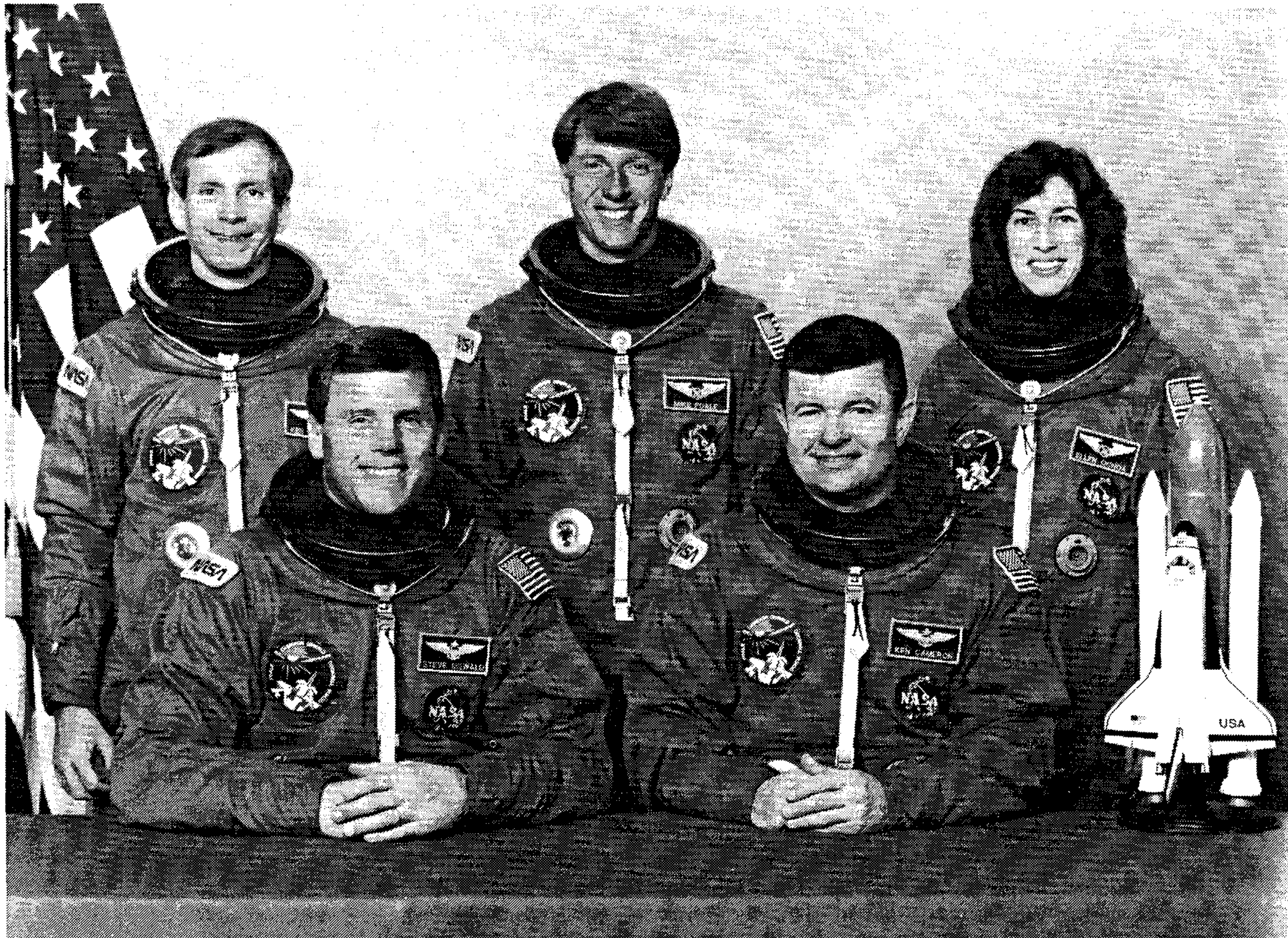


Crew Insignia

The Cosmic Ray Effects and Activation Monitor (CREAM) will collect data on cosmic ray energy loss spectra, neutron fluxes, and induced radioactivity. Data will be collected with one active monitor and passive monitors placed at various locations within the crew compartment.

Radiation Monitoring Equipment (RME) III consists of a hand-held instrument with replaceable memory modules that takes measurements of the radiation environment at a specified sample rate.

Twelve development test objectives and 15 detailed supplementary objectives are scheduled to be flown on STS-56.



NASA Photo

STS-56 crew members (from left) are Kenneth D. Cockrell, Stephen S. Oswald, Michael Foale, Kenneth D. Cameron, and Ellen Ochoa. Cameron is the mission commander and Oswald is the pilot. The others are mission specialists.

MISSION STATISTICS

Vehicle: Discovery (OV-103), 16th flight

Launch Date/Time:

4/6/93	1:32 a.m., EDT
	12:32 a.m., CDT
4/5/93	10:32 p.m., PDT

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

Launch Window: Two hours, 25 minutes

Mission Duration: Eight days, five hours, 58 minutes. An additional day is highly desirable and may be added if consumables (e.g., fuel oxygen) allow. Planning will accommodate the longer duration wherever appropriate. The mission can be extended two additional days for contingency operations and to avoid adverse weather.

Landing: Nominal end-of-mission landing on orbit 132

4/14/93	7:30 a.m., EDT
	6:30 a.m., CDT
	4:30 a.m., PDT

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

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

Return to Launch Site: KSC

Abort-Once-Around: NOR

Inclination: 57 degrees

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

The OMS-1 thrusting maneuver approximately two minutes after main engine cutoff 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:

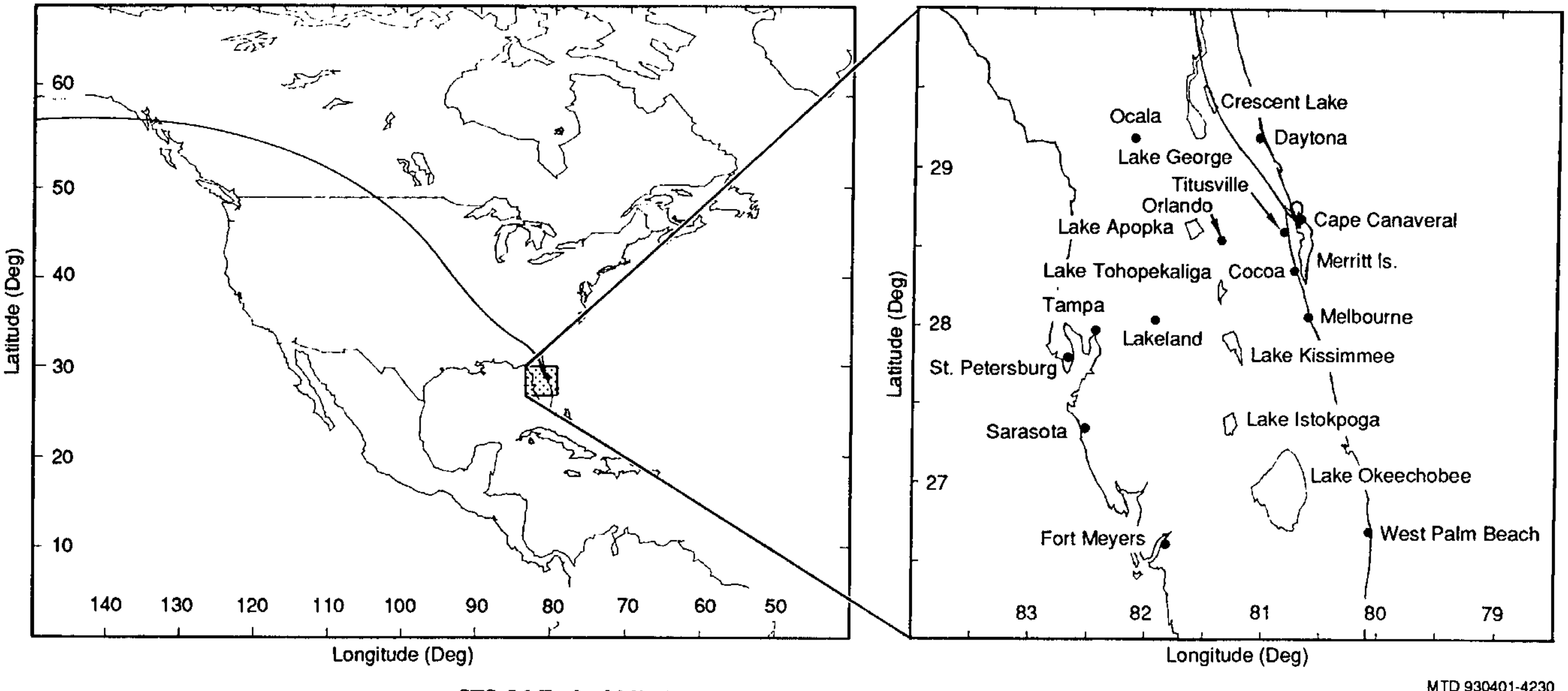
No. 1 position: Engine 2024
No. 2 position: Engine 2033
No. 3 position: Engine 2018

External Tank: ET-54

Solid Rocket Boosters: BI-058

Mobile Launcher Platform: 1

Editor's Note: The following weight data are current as of March 29, 1993.



STS-56 End-of-Mission Descent Trajectory to KSC Runway 15

Total Lift-off Weight: Approximately 4,500,815 pounds

Orbiter Weight, Including Cargo, at Lift-off: Approximately 236,659 pounds

Orbiter (Discovery) Empty and 3 SSMEs: Approximately 173,227 pounds

Payload Weight Up: Approximately 16,406 pounds

Payload Weight Down: Approximately 16,406 pounds

Orbiter Weight at Landing: Approximately 206,855 pounds

Payloads—Payload Bay (* denotes primary payload): Atmospheric Laboratory for Applications and Science (ATLAS) 2*; Shuttle Solar Backscatter Ultraviolet (SSBUV) A; Shuttle Pointed Autonomous Research Tool for Astronomy (SPARTAN) 201 (Solar Wind Generation Experiment); Solar Ultraviolet Experiment (SUVE)

Payloads—Middeck: Commercial Material Dispersion Apparatus (CMIX); Physiological and Anatomical Rodent Experiment (PARE); Hand-held, Earth-oriented, Real-time, Cooperative, User-friendly, Location-targeting, and Environmental System (HERCULES); Shuttle Amateur Radio Experiment (SAREX) II; Space Tissue Loss (STL); Air Force Maui Optical Site (AMOS); Cosmic Radiation Effects and Activation Monitor (CREAM); Radiation Monitoring Equipment (RME) III

Flight Crew Members:

Blue Team:

Commander: Kenneth (Ken) D. Cameron, second space shuttle flight
Pilot: Stephen (Steve) S. Oswald, second space shuttle flight
Mission Specialist 3: Ellen Ochoa, first space shuttle flight

Red Team:

Mission Specialist 2: Kenneth (Ken) D. Cockrell, first space shuttle flight
Mission Specialist 1: Michael (Mike) Foale, second space shuttle flight

The commander's duty time is adjusted to allow time with both teams, but closely follows the blue team.

Cameron, Oswald, and Ochoa make up the orbiter crew, which operates the shuttle and ATLAS systems monitored by the Mission Control Center at NASA's Johnson Space Center, Houston, Texas. Cockrell and Foale form the science crew and will operate the ATLAS-2 experiments, which will be monitored by the Payload Operations Control Center (POCC) at NASA's Marshall Space Flight Center, Huntsville, Ala.

Ascent and Entry Seating:

Flight deck, front left seat, commander Kenneth D. Cameron
Flight deck, front right seat, pilot Stephen S. Oswald
Flight deck, aft center seat, mission specialist Kenneth D. Cockrell
Flight deck, aft right seat, mission specialist Michael Foale
Middeck, mission specialist Ellen Ochoa

Extravehicular Activity Crew Members, If Required:

Extravehicular (EV) astronaut 1: Michael Foale
EV-2: Kenneth D. Cockrell

Intravehicular Astronaut: Stephen S. Oswald

STS-56 Flight Directors:

Ascent: Jeff Bantle
Entry: Rich Jackson
Orbit 1: Chuck Shaw
Orbit 2: John Muratore
Orbit 3: Bob Castle

Entry: Automatic mode until subsonic, then control stick steering

Notes:

- The remote manipulator system is installed in Discovery's payload bay for this mission.
- The shuttle orbiter repackaged galley is installed in Discovery's middeck.
- ODERACS was originally scheduled for STS-56 but was later removed from the manifest. The payload has been replaced with a getaway special ballast payload of equivalent weight.

MISSION OBJECTIVES

- Primary objective
  - — Atmospheric Laboratory for Applications and Science (ATLAS) 2 operations
- Secondary objectives
  - — Payload bay
    - Deployment and retrieval of Shuttle Pointed Autonomous Research Tool for Astronomy (SPARTAN) 201 Solar Wind Generation Experiment
    - Solar Ultraviolet Experiment (SUVE) operations
    - Shuttle Solar Backscatter Ultraviolet (SSBUV) A operations
  - — Middeck
    - Commercial Material Dispersion Apparatus (CMIX)
    - Physiological and Anatomical Rodent Experiment (PARE)
    - Hand-held, Earth-oriented, Real-time, Cooperative, User-friendly, Location-targeting, and Environmental System (HERCULES)
    - Shuttle Amateur Radio Experiment (SAREX) II
    - Space Tissue Loss (STL)
    - Air Force Maui Optical Site (AMOS)
    - Cosmic Radiation Effects and Activation Monitor (CREAM)
    - Radiation Monitoring Equipment (RME) III
- 12 development test objectives/15 detailed supplementary objectives

FLIGHT ACTIVITIES OVERVIEW

Flight Day 1

Launch
OMS-2
Payload bay doors open
RMS checkout
RMS payload bay survey
SAREX setup
HERCULES setup
RME activation
Shuttle Solar Backscatter Ultraviolet activation
Unstow cabin

Flight Day 2

ATLAS-2 activation/operations
CMIX activation
SUVE activation/operations

Flight Day 3

ATLAS-2 operations
SUVE operations
Laser range finder checkout
HERCULES operations

Flight Day 4

ATLAS-2 operations
SUVE operations
SPARTAN-201 checkout/deployment
Separation burns

Flight Day 5

ATLAS-2 operations
SUVE operations
SPARTAN-201 stationkeeping

Flight Day 6

ATLAS-2 operations
SUVE operations
SPARTAN-201 rendezvous, grapple, and berth

Flight Day 7

ATLAS-2 operations
SUVE operations
FCS checkout

Flight Day 8

ATLAS-2 operations
HERCULES operations
SUVE operations
RMS power-down and berth
RME deactivation
SAREX deactivation

Flight Day 9

ATLAS-2 deactivation
SSBUV deactivation
SUVE deactivation
Cabin stow
Deorbit preparations
Deorbit burn
Landing

Note:

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.

DEVELOPMENT TEST OBJECTIVES/DETAILED SUPPLEMENTARY OBJECTIVES

DTOs

- Entry aerodynamic control surfaces test (Part 5) (DTO 251)
- Ascent structural capability evaluation (DTO 301D)
- Ascent compartment venting evaluation (DTO 305D)
- Descent compartment venting evaluation (DTO 306D)
- Vibration and acoustic evaluation (DTO 308D)
- Orbiter/payload acceleration and acoustic environment data (DTO 319D)
- Edwards lakebed runway bearing strength and rolling friction assessment for orbiter landings (DTO 520)
- Orbiter drag chute system (DTO 521)
- Evaluation of MK1 rowing machine (DTO 653)
- PGSC single–event upset monitoring (DTO 656)
- Laser range and range rate device (DTO 700-2)
- Crosswind landing performance (DTO 805)

DSOs

- Frequency interference measurement (DSO 321)
- Human lymphocyte locomotion in microgravity (DSO 322)
- In-flight radiation dose distribution (DSO 469)
- In-flight aerobic exercise (DSO 476)
- Inter-Mars tissue equivalent proportional counter (ITEPC) (DSO 485)
- Measurement of formaldehyde using passive dosimetry (DSO 488)
- Orthostatic function during entry, landing, and egress (DSO 603B*)
- Posture equilibrium control during landing and egress (DSO 605*)
- Evaluation of functional skeletal muscle performance following space flight (DSO 617*)
- Pre- and postflight measurement of cardiorespiratory responses to submaximal exercises (DSO 624*)
- Cardiovascular and cerebrovascular responses to standing before and after space flight (DSO 626*)
- Educational activities (DSO 802)
- Documentary television (DSO 901)
- Documentary motion picture photography (DSO 902)
- Documentary still photography (DSO 903)

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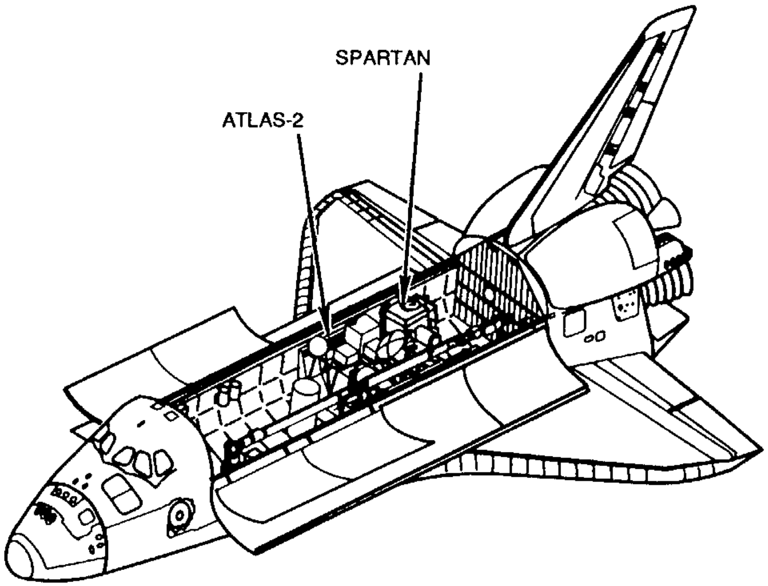
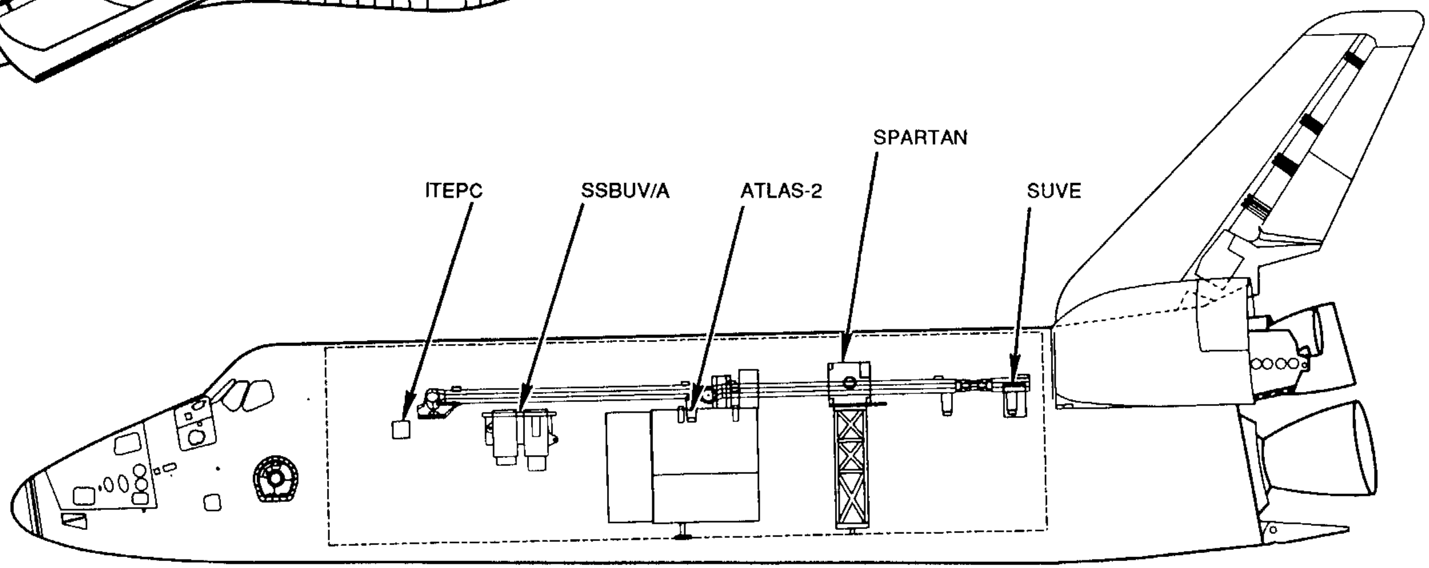
*EDO buildup medical evaluation

PAYLOAD CONFIGURATION





MTD 930324-4209

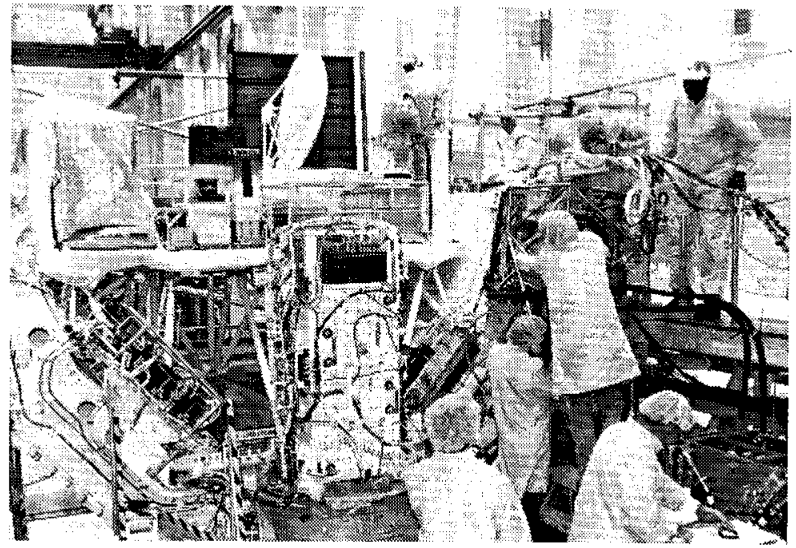
This is the second flight on the space shuttle of the Atmospheric Laboratory for Applications and Science (ATLAS), which carries an international payload of experiments that will gather data to help scientists better understand how the Earth's endangered, fragile atmosphere reacts to natural and human-induced changes. Up to nine ATLAS missions will be flown on the shuttle to observe variations in the atmosphere during an 11-year solar cycle.

ATLAS missions will provide a record of variations in solar activity and the composition of the Earth's atmosphere. By comparing the voluminous data gathered on the first ATLAS mission, which was conducted in March 1992, to the data gathered on this and subsequent missions, scientists will be able to formulate a more detailed description of our atmosphere and its response to changes in the sun.

The ATLAS series is part of NASA's Mission to the Planet Earth, an integrated study of the Earth, from its depths to the outer layer of the atmosphere, that will provide the information we need to make decisions about protecting our environment. Data from the ATLAS missions about the interaction of land, water, the atmosphere, and the biosphere will be distributed worldwide for use by researchers who are studying global change.

The Earth's atmosphere is vital to life as we know it. We depend on the atmosphere to maintain the proper pressure, temperature, and oxygen levels to sustain life.

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



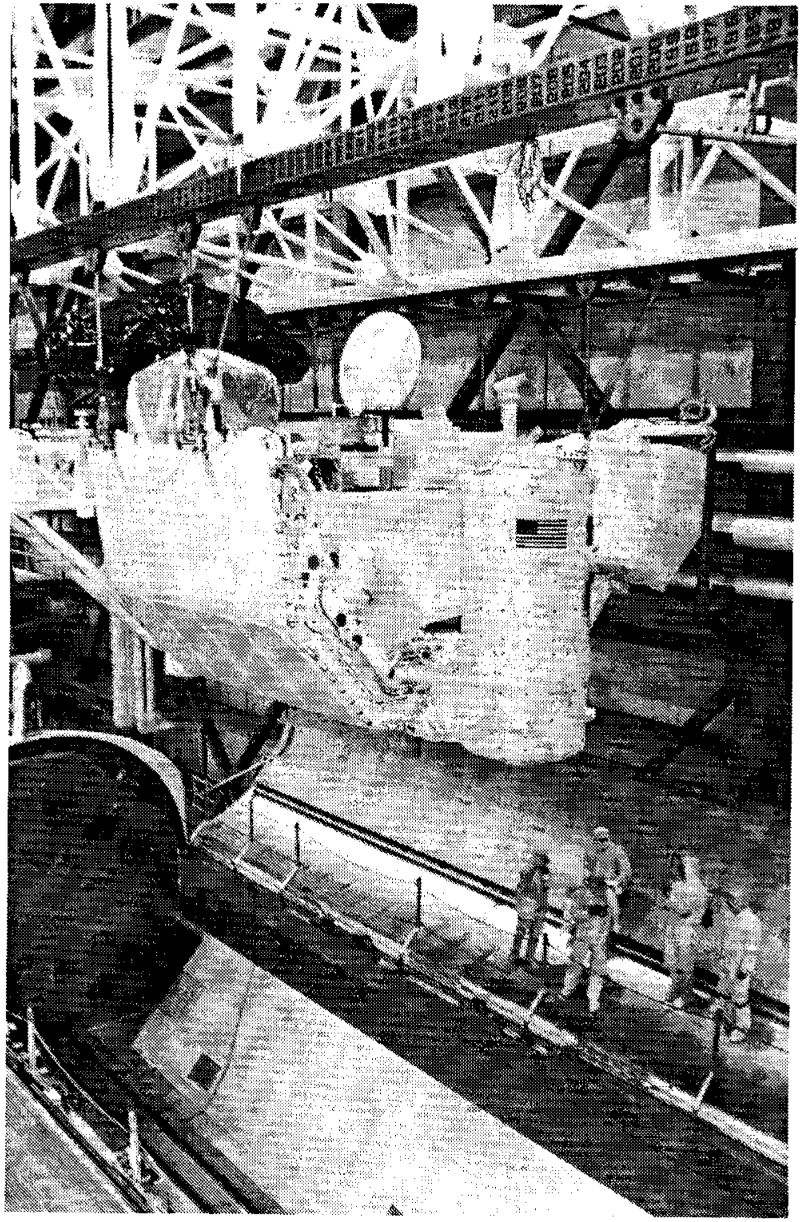
NASA Photo

Workers Assemble ATLAS-2 Payload in Operations and Checkout Building

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.

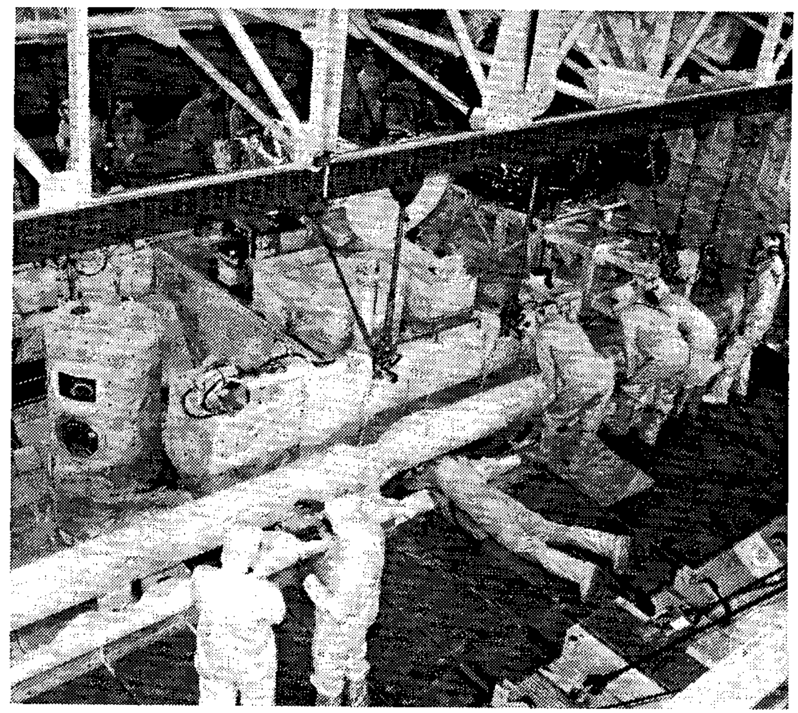
The fragility of the atmosphere can be seen in the effects of human activities on its complex processes. We know, for example, that chlorofluorocarbons, used for refrigeration and in other industries, are depleting the stratosphere's ozone layer, which protects the Earth from the harmful ultraviolet rays of the sun. Concentrations of carbon dioxide, which is produced by the burning of fossil fuels



NASA Photo

LEFT: ATLAS-2, mounted on U-shaped Spacelab pallet, and Shuttle Pointed Autonomous Research Tool for Astronomy (behind ATLAS) are removed from payload transporter in Orbiter Processing Facility prior to installation in orbiter's payload bay.

BELOW: Workers oversee placement of ATLAS-2 and SPARTAN payloads in cargo bay of Discovery.



NASA Photo

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.

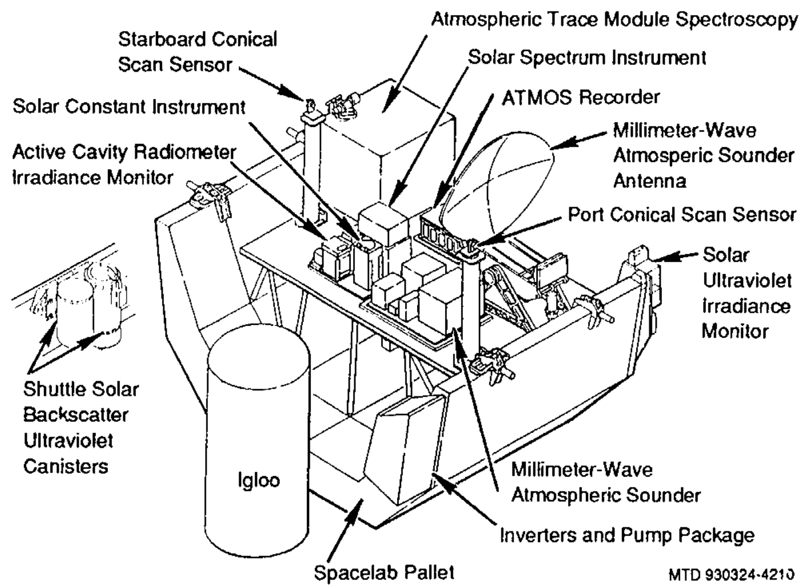
To protect the envelope that surrounds and sustains the Earth, it is necessary to learn how its complex processes work—not an easy task, since the atmosphere is always changing and responding to activities on Earth that threaten to disrupt its life-sustaining processes.

Scientists know that ozone is created and destroyed by complex reactions that involve the sun's ultraviolet radiation and gases in the Earth's middle atmosphere (10 to 50 miles above the Earth). ATLAS investigations of atmospheric chemistry and solar energy are expected to help them answer questions about the exact mechanisms of ozone depletion.

The ATLAS-2 payload consists of seven instruments that will gather information about the chemical composition of the atmosphere, study the distribution of solar energy, measure the energy in sunlight and how that energy varies during the mission, and examine the sun's ultraviolet radiation.

The precisely calibrated ATLAS instruments are also used to double check data that is being collected continuously by similar instruments on satellites. The comparison allows scientists to correct for any degradation in the accuracy of the satellite-borne instruments caused by exposure to the harsh space environment and assures that the satellites' instruments are returning very accurate data.

Six of the ATLAS experiments are carried in Discovery's payload bay on one Spacelab pallet, 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



ATLAS-2 Configuration in Cargo Bay

data handling and command system for the pallet-mounted experiments. A seventh experiment is contained in two getaway special canisters attached to the side of the cargo bay.

The orbiter's 185-mile altitude above the Earth will place the experiments in an advantageous position for observing the atmosphere and sun, and the orbiter can be maneuvered so that the instruments are pointed precisely. Scientists will be able to obtain measurements over most of the globe because Discovery's orbital trajectory will take the spacecraft 57 degrees north and south of the equator.

The ATLAS experiments will be conducted around the clock under the control of the planners and investigators at NASA's Spacelab Mission Operations Control at the Marshall Space Flight Center in Huntsville, Ala. The ground team can monitor the experiments, collect data, send commands to the instruments, and talk to the shuttle crew members who are monitoring the experiments. Most of the instruments have been programmed to operate automatically, but the astronauts can intervene with manual commands.

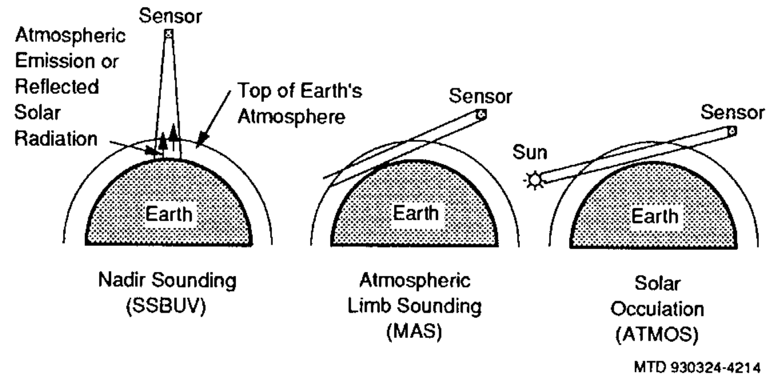
ATLAS remote-sensing operations will be interrupted only two times during the eight-day mission: when the shuttle crew deploys and retrieves the Shuttle Pointed Autonomous Research Tool for Astronomy, a free-flying satellite mounted behind the ATLAS payload in Discovery's cargo bay. ATLAS operations will be suspended during the deployment and retrieval because shuttle maneuvers would interfere with the proper pointing of the ATLAS instruments.

All of the ATLAS-2 instruments were used on the first ATLAS mission and all of them will be reused on the ATLAS-3 mission in 1994. This reduces the cost of this space-based research and demonstrates 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.

NASA's Office of Space Science and Applications is the sponsor of the ATLAS program. Countries participating in the ATLAS-2 mission are Belgium, France, Germany, the Netherlands, Switzerland, and the United States.

The ATLAS-2 investigations are divided into two broad areas: atmospheric science and solar science. Four periods of solar observations are planned, interspersed among periods devoted to atmospheric investigations.



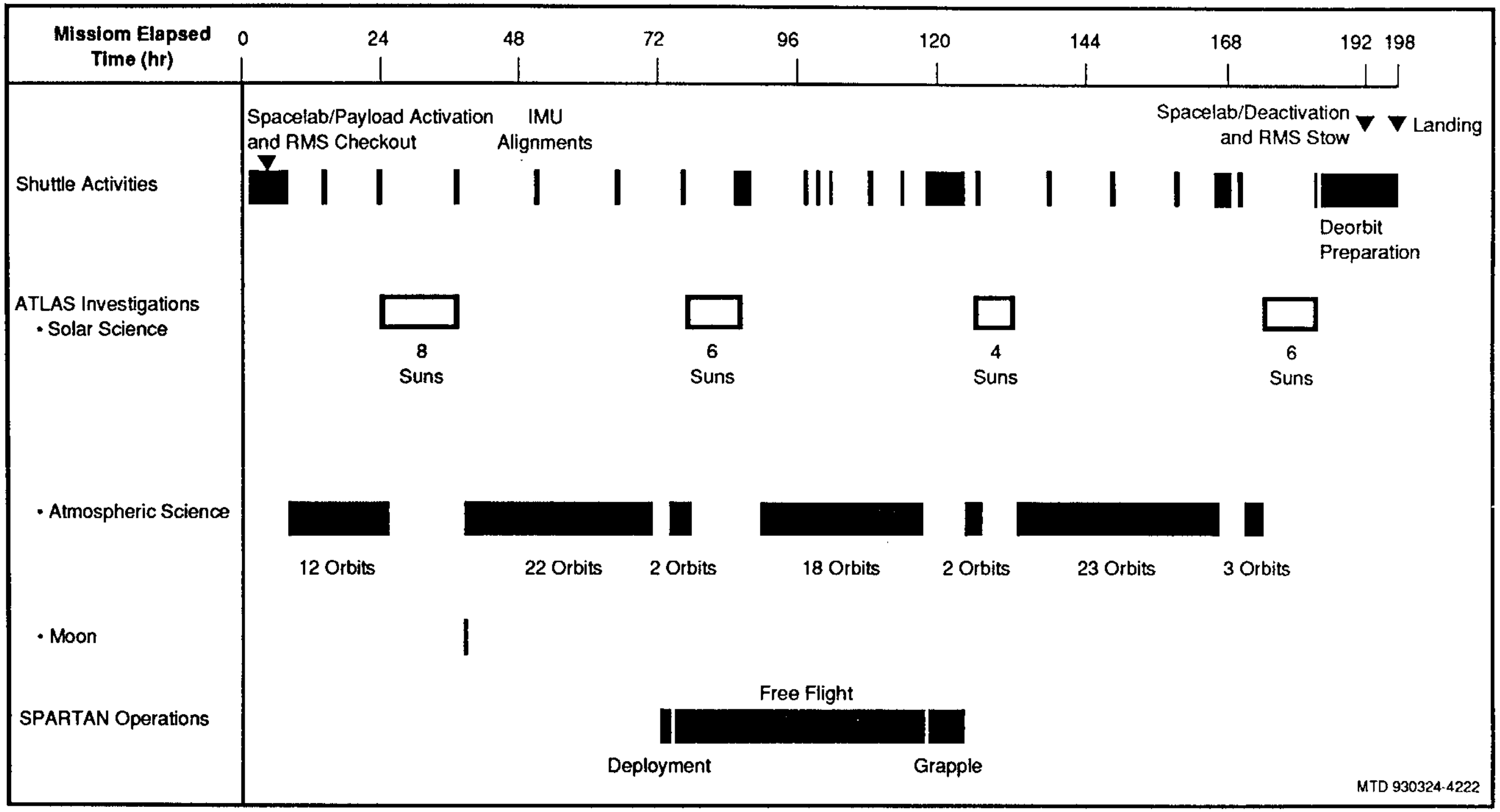
Space Remote Sounding Techniques

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. The data collected will help scientists monitor short- and long-term changes in the atmosphere, the goal of the ATLAS investigations.

The Atmospheric Trace Molecule Spectroscopy (ATMOS) experiment 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.

ATMOS will map the distribution, by altitude, of 30 to 40 gases in the atmosphere from 6 to 85 miles above the Earth so that scientists can get a better understanding of the physics and chemistry of



Scheduled Activities for Nominal Eight-Day Mission

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. The measurement of numerous compounds will allow detailed studies of the amount of hydrogen, nitrogen, chlorine, and fluorine in the stratosphere.

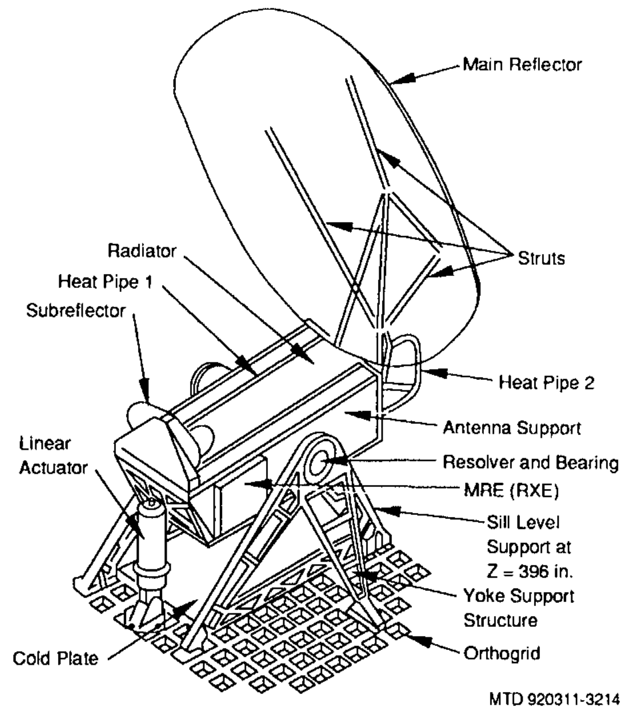
The data from ATMOS will be compared with information from other missions to determine global, seasonal, and long-term changes in the atmosphere. In addition, the high-resolution, calibrated spectral information obtained by ATMOS is needed to improve the design of similar instruments in the future.

ATMOS is sponsored by NASA's Jet Propulsion Laboratory.

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. Earth-limb radiation received by an antenna, captured by a reflector, and sent to MAS electronics will enable scientists to infer temperature, pressure, and concentrations of ozone, water vapor, and chlorine monoxide.

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 will take measurements of microwave emissions from the Earth's limb throughout each orbit.

MAS is a joint German/Swiss/U.S. experiment sponsored by the German Institute for Aeronomy.



MAS Sensor Package Hardware Layout

SOLAR SCIENCE

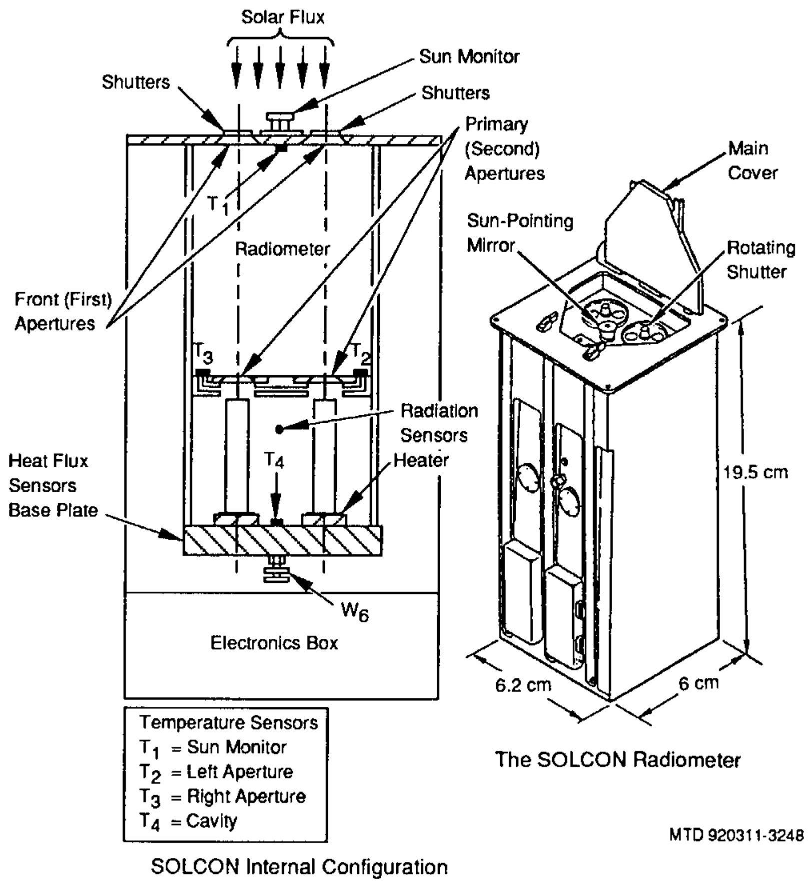
Energy from the sun, interacting with the atmosphere, plays a major role in determining the Earth's climate and weather. Sunlight filtering through the atmosphere heats it and causes chemical reactions to take place. The sunlight that reaches the Earth's surface is either absorbed or reflected. These 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 in the solar constant, the total amount of energy emitted by the sun onto the atmosphere.

The ATLAS-2 solar science package comprises 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.

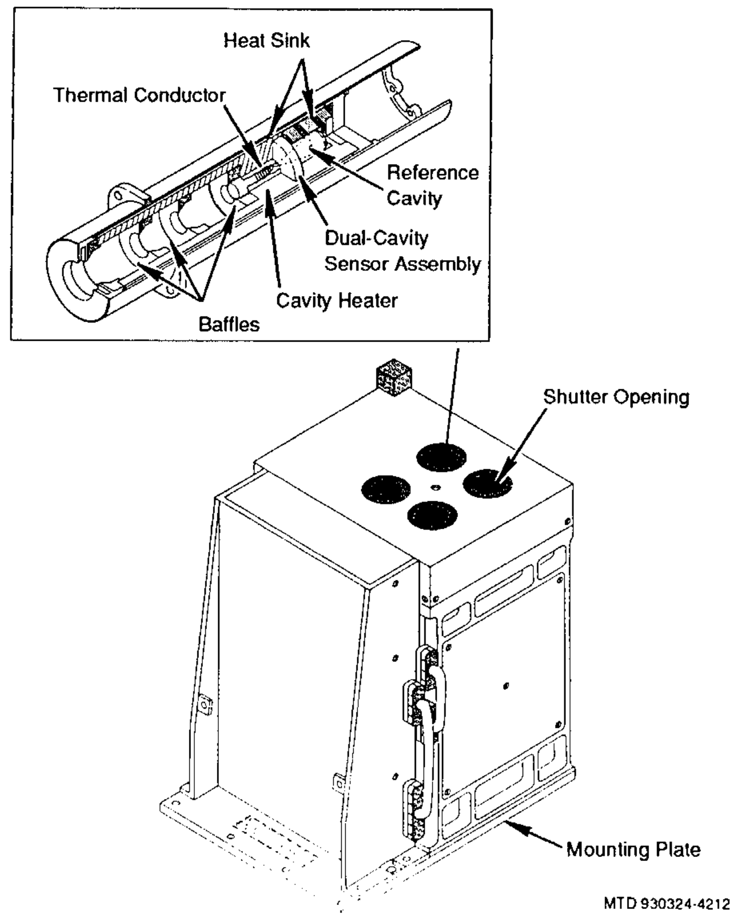
Evidence indicates that the solar constant fluctuates. The Measurement of Solar Constant (SOLCON) experiment will help scientists determine the range and variability of the solar constant over the course of a solar cycle. SOLCON's radiometer is a precise instrument that measures the absolute value of the solar constant to an accuracy of 0.1 percent and with a sensitivity that is better than 0.05 percent. By comparing SOLCON readings with the measurements of similar instruments on satellites, scientists will be able to refine their estimates of the total solar energy flux.

SOLCON is a project of the Belgian Royal Institute for Meteorology.

Although it uses slightly different techniques than SOLCON, the Active Cavity Radiometer Irradiance Monitor (ACRIM) experiment also gathers data on short- and long-term variations in the total energy the Earth receives from the sun and determines a value for the solar constant. The values obtained by the two experiments will be compared. The two instruments will be used on subsequent flights of the ATLAS series to obtain a long-range record of the solar constant and its variations.



Solar Constant Instrument

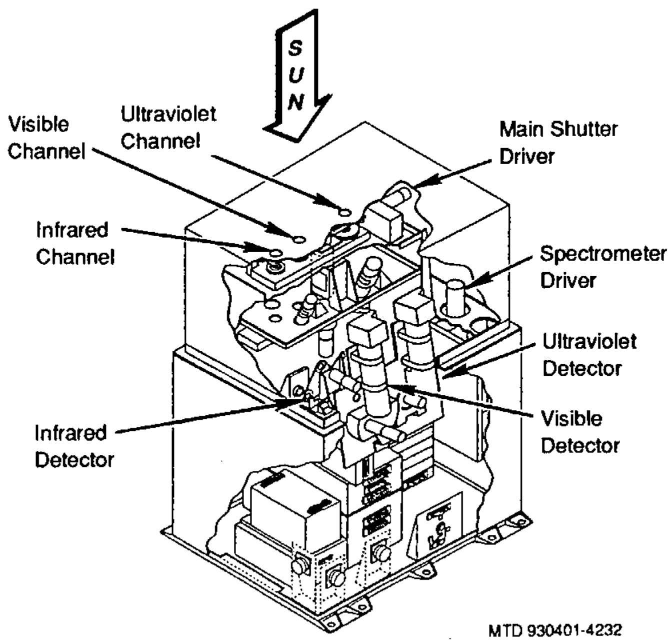


Active Cavity Radiometer Irradiance Monitor (ACRIM)

NASA's JPL is the sponsor of the ACRIM 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. The data collected, as well as data from other solar observation instruments on ATLAS and satellites, will help scientists who are studying the effects of variations in the solar radiation on the atmosphere.

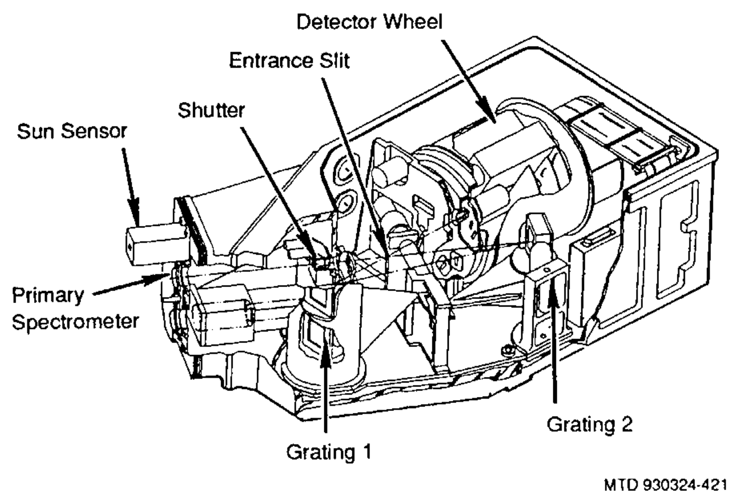


SOLSPEC Experiment

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. Because the wavelengths that SUSIM observes are absorbed by the atmosphere before they reach the surface of the Earth, this experiment will give scientists data on the sun they cannot get from Earth-based instruments. Data obtained by the ATLAS-2 instrument will be compared to data from the identical instrument on the Upper Atmosphere Research Satellite to calibrate the UARS instrument.

The sponsor of SOLSPEC is the French Aeronomy Service of the National Center for Scientific Research. SUSIM is sponsored by the U.S. Naval Research Laboratory.

The data gathered by the SOLSPEC, ACRIM, 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.



Solar Ultraviolet Irradiance Monitor (SUSIM)

Spacelab is 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. One pallet will be used on STS-56.

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. On Sept. 24, 1973, ESA and NASA signed a memorandum of understanding to design and develop Spacelab with NASA's George C. Marshall Space Flight Center as lead center for ESA.

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-56 crew will work two 12-hour shifts.

PRESSURIZED MODULE

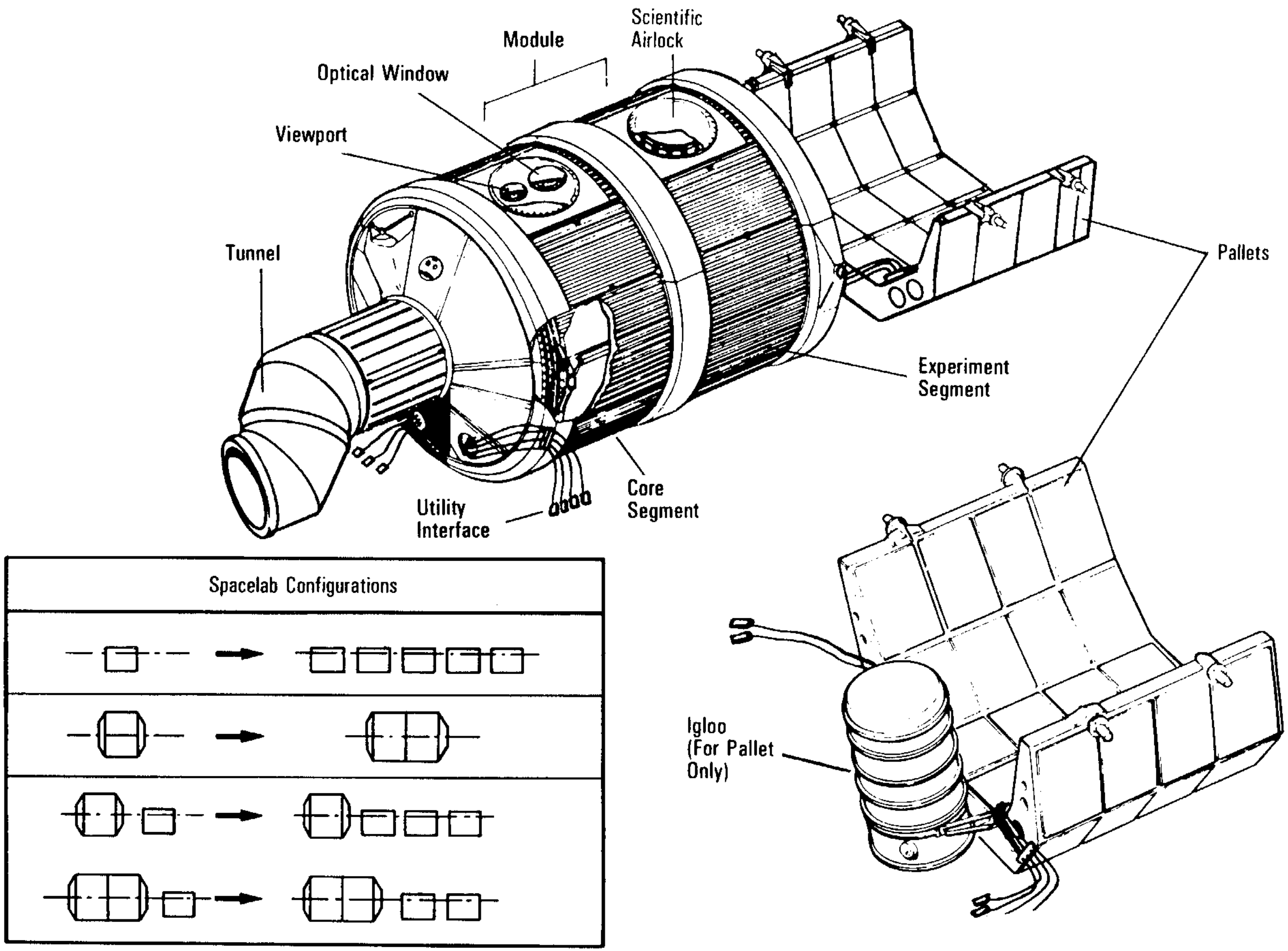
The pressurized module, or laboratory, is available in two segments. One, called the core segment, contains supporting systems, such as data processing equipment and utilities for the pressurized modules and pallets (if pallets are used in conjunction with the pressurized modules). The laboratory has 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.

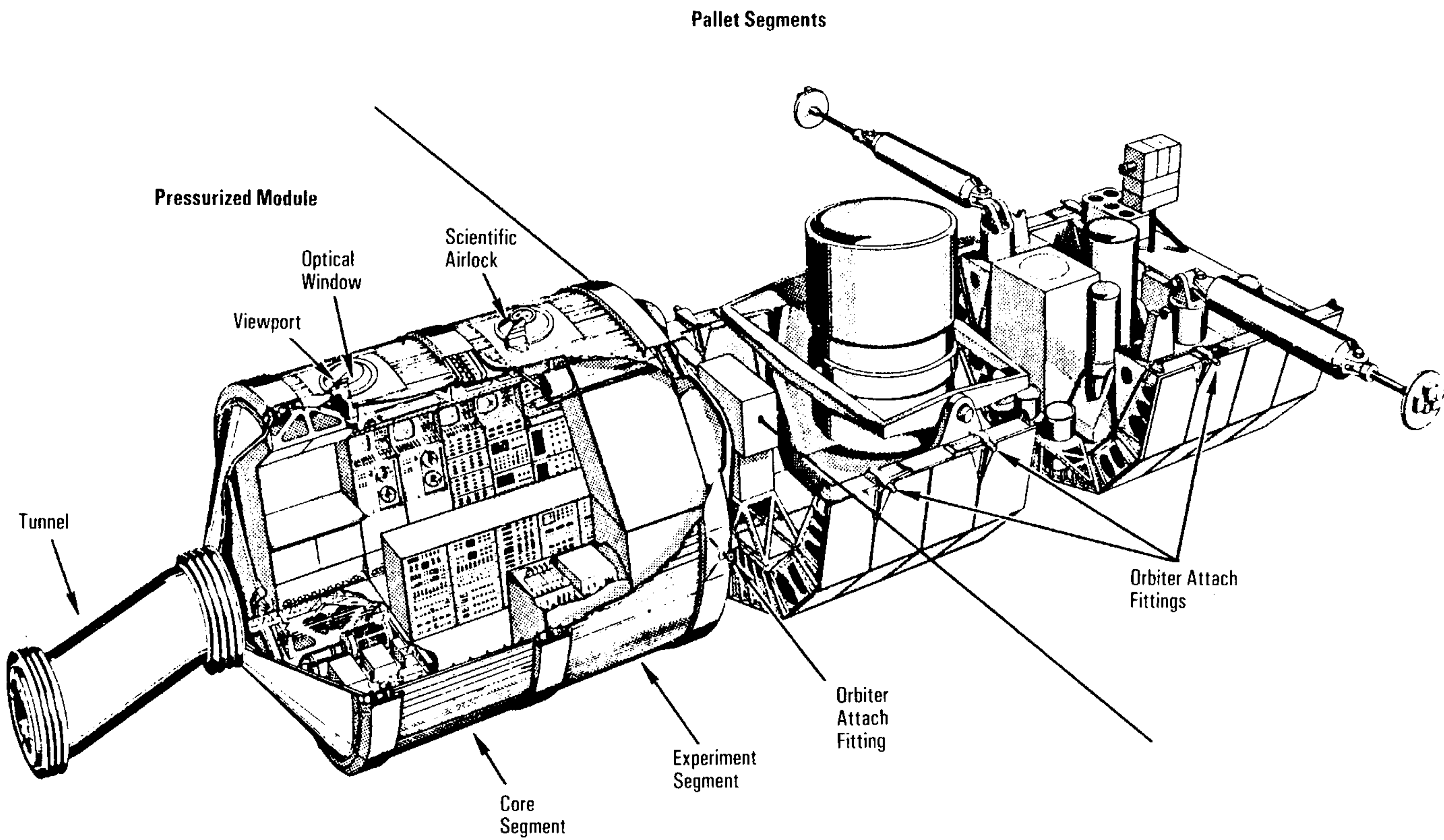
The ceiling skin panel of each segment contains a 51.2-inch-diameter opening for mounting a viewport adapter assembly, a Spacelab window adapter assembly, or scientific airlock; if none of these items are used, the openings are closed with cover plates that are bolted in place. The module shell is made 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.

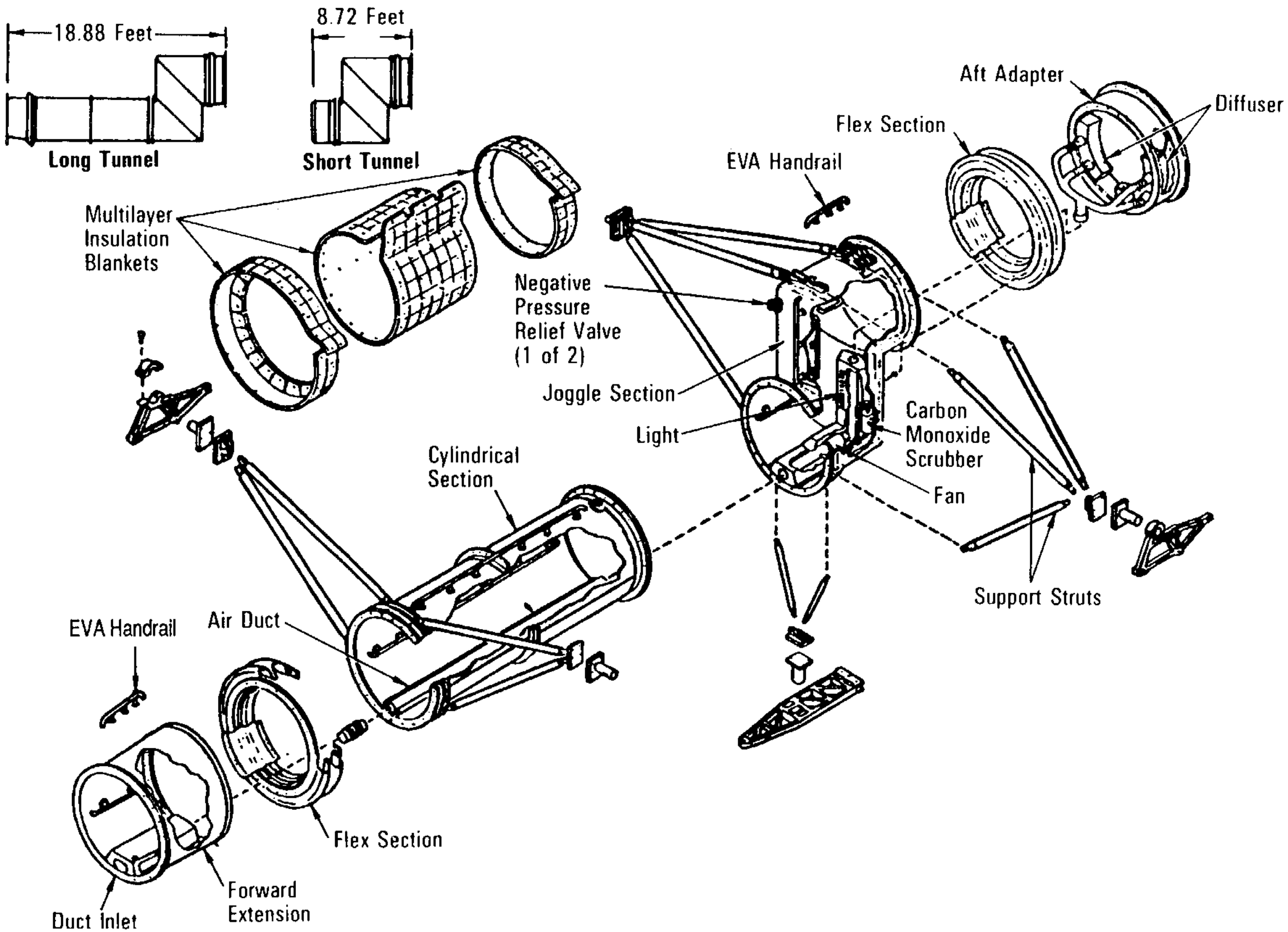
Because of the orbiter's center-of-gravity conditions, the Spacelab pressurized modules cannot be installed at the forward end of the payload bay. Therefore, a pressurized tunnel is provided for equipment and crew transfer between the orbiter's pressurized crew compartment and the Spacelab pressurized 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 pressurized module's centerline. There are flexible sections on each end of the tunnel near the orbiter and Spacelab interfaces. The tunnel is



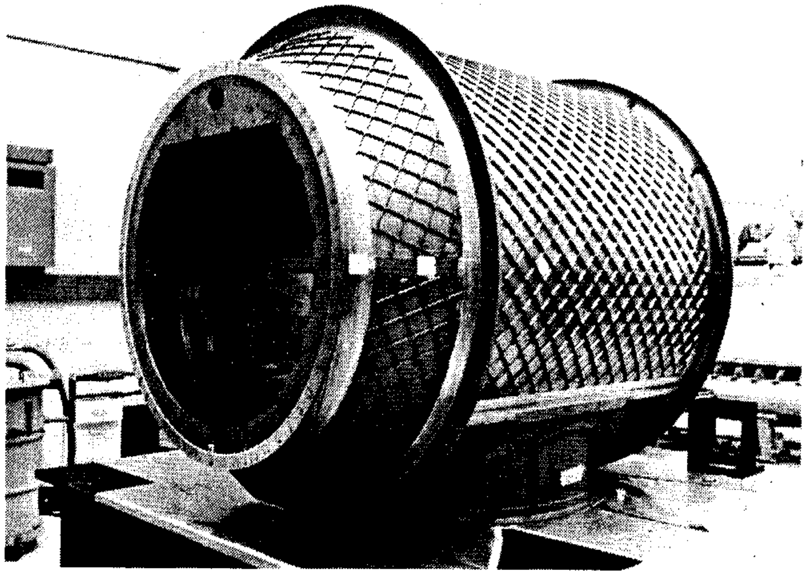
Spacelab External Design Features



European Space Agency's Spacelab



Spacelab Transfer Tunnel



Tunnel Adapter

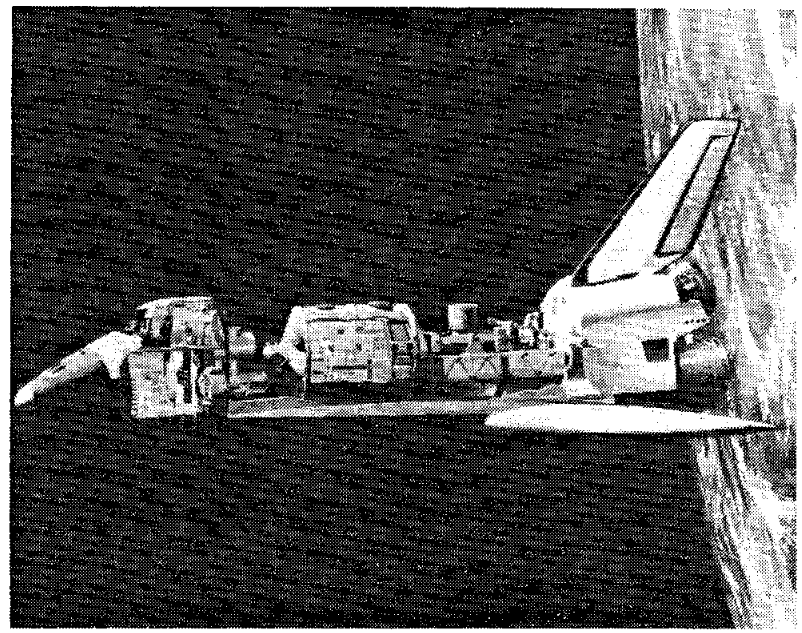
built by McDonnell Douglas Astronautics Company, Huntington Beach, Calif.

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,

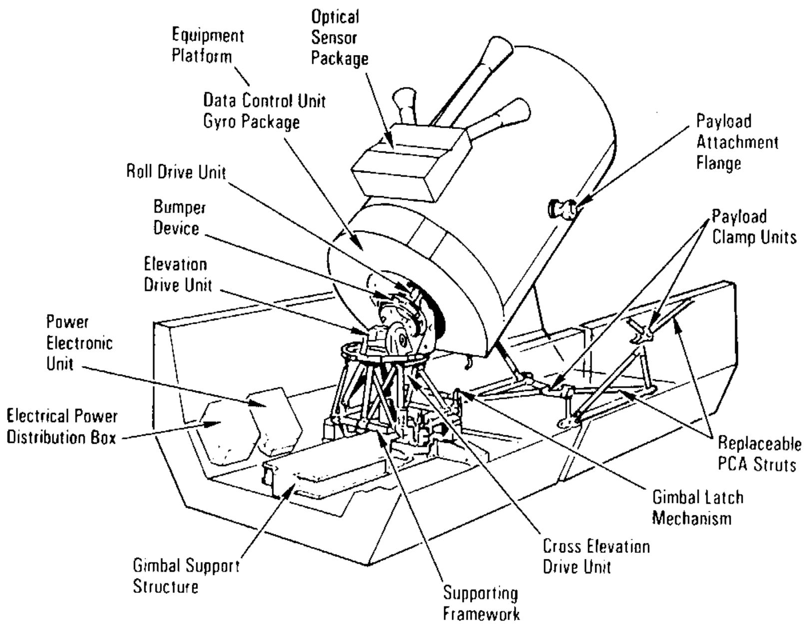


Spacelab

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.

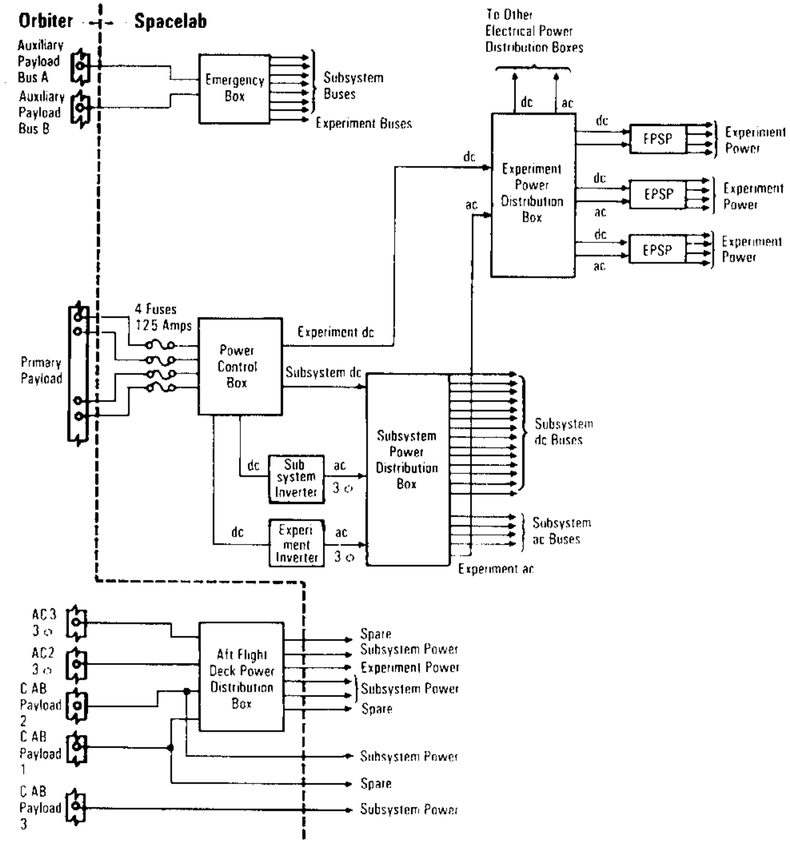
Cable ducts and cable support trays can be bolted to the forward and aft frame of each pallet to support and route electrical cables to and from the experiments and subsystem equipment mounted on the pallet. All ducts mounted on the right side of the pallet are used to route subsystem cables, and all 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.

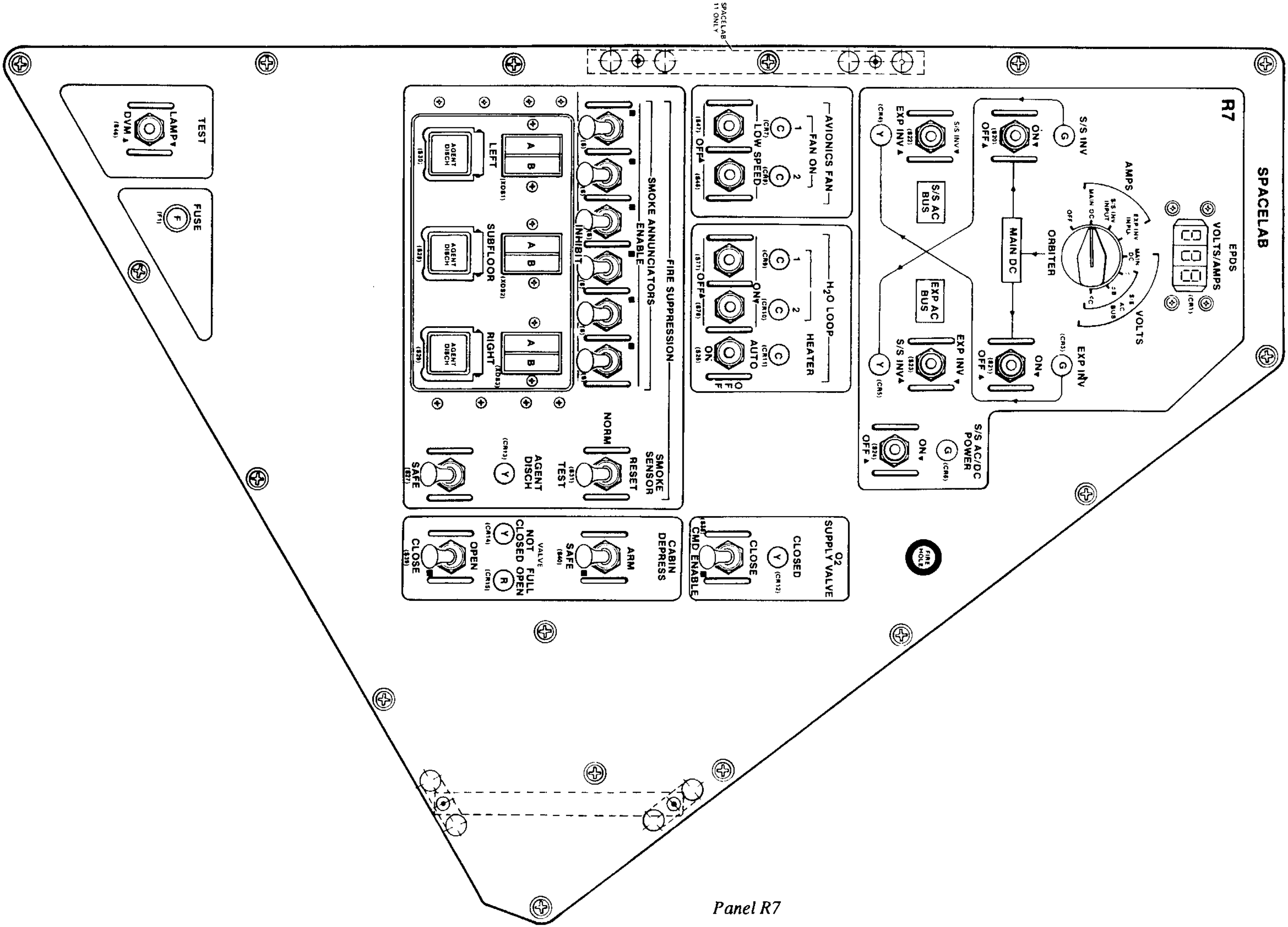
ELECTRICAL POWER

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.

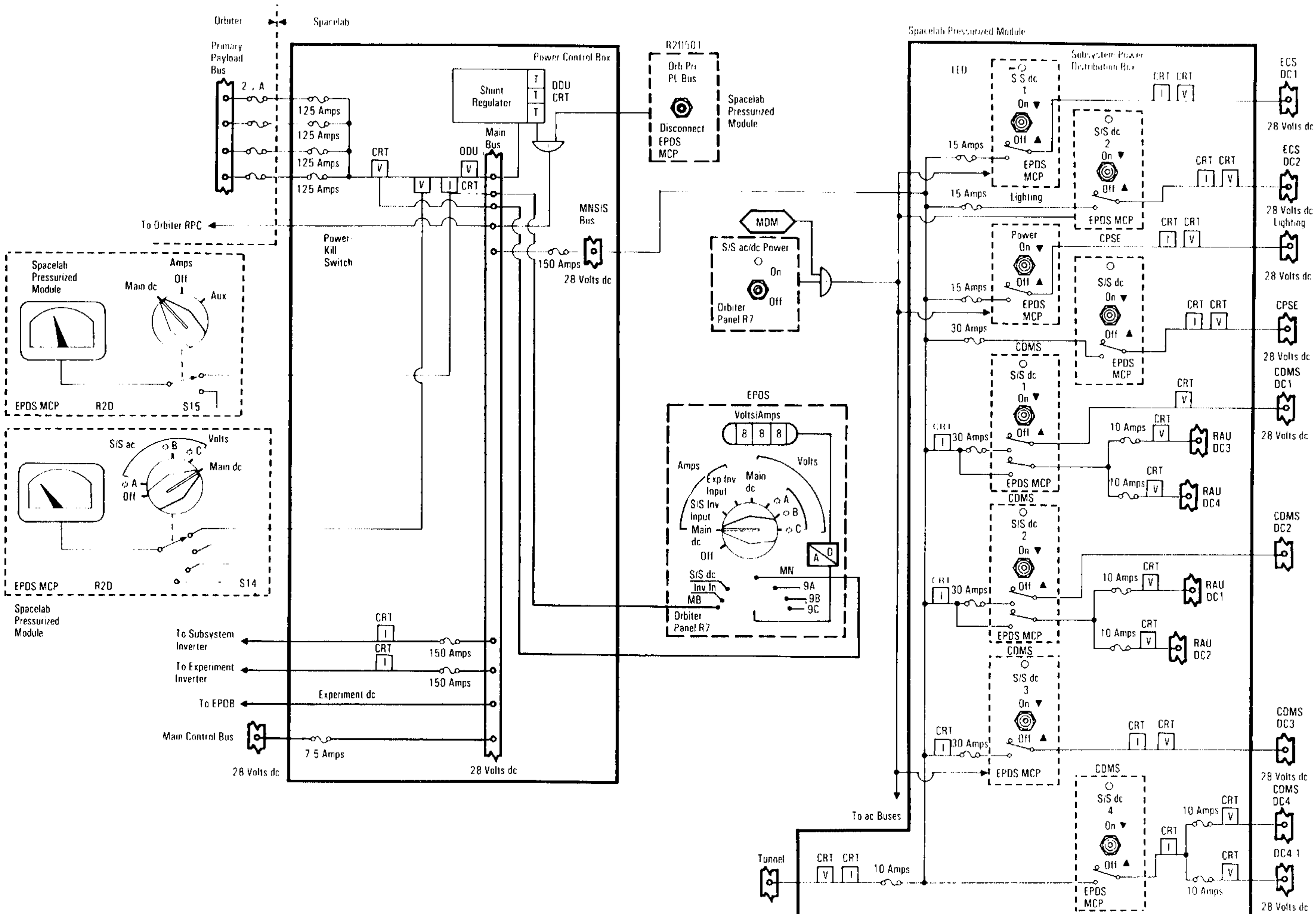
The primary dc power received in the Spacelab from the orbiter primary payload bus is nominally 28 volts, a maximum of 32 volts,



Orbiter Spacelab Electrical Power Distribution


SPACELAB
R7
EPDS
VOLTS/AMPS
S/S INV
EXP INV
ORBITER
MAIN DC
S/S AC BUS
EXP AC BUS
AMPS
VOLTS
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
TEST
NORM
SAFE
CABIN DEPRESS
ARM
OPEN
CLOSE
NOT CLOSED
FULL OPEN
O2 SUPPLY VALVE
CLOSED
CMD ENABLE
TEST
LAMP
DVM
FUSE
SPACELAB 11 ONLY

Panel R7



Orbiter-to-Spacelab Electrical Power Distribution—Subsystem dc Power Distribution and a worst-case minimum of 23 volts. The four redundant power 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.

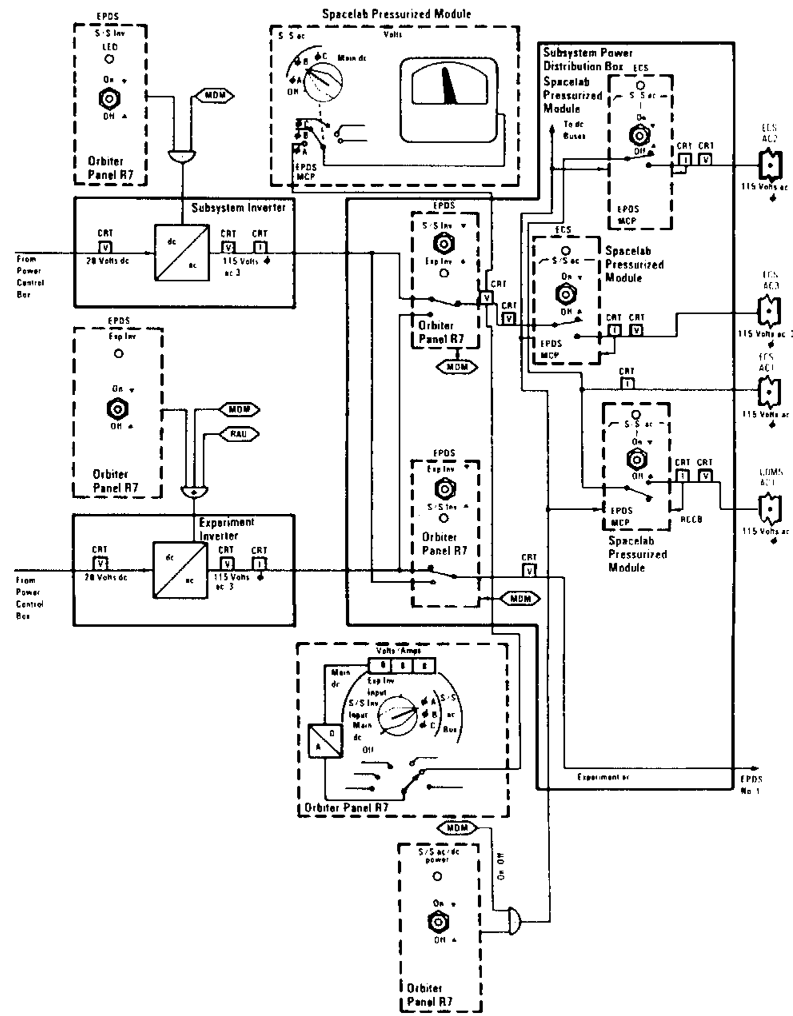
The Spacelab subsystem inverter is activated by the *S/S inv on/off* switch on panel R7 or by orbiter Spacelab CRT command. Positioning the switch to *on* activates the subsystem inverter, and a green LED above the switch on panel R7 is illuminated, indicating the inverter is operating. Positioning the 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 functions on this panel can be initiated simultaneously by the *S/S ac/dc*



Spacelab Electric Power Distribution—
Subsystem ac Power Distribution

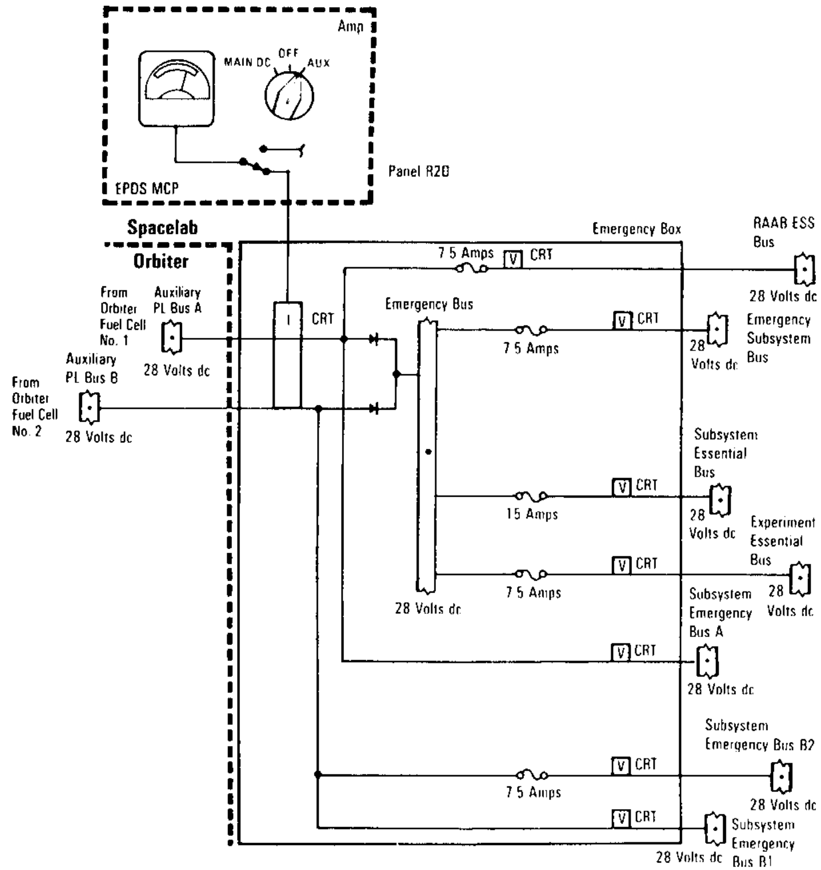
power on/off switch on orbiter panel R7 or by item commands from the orbiter CRT Spacelab displays. The status of the commanded relays is available via orbiter CRT Spacelab displays and indicated by the green LED light above the respective switch on panel R7.

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.

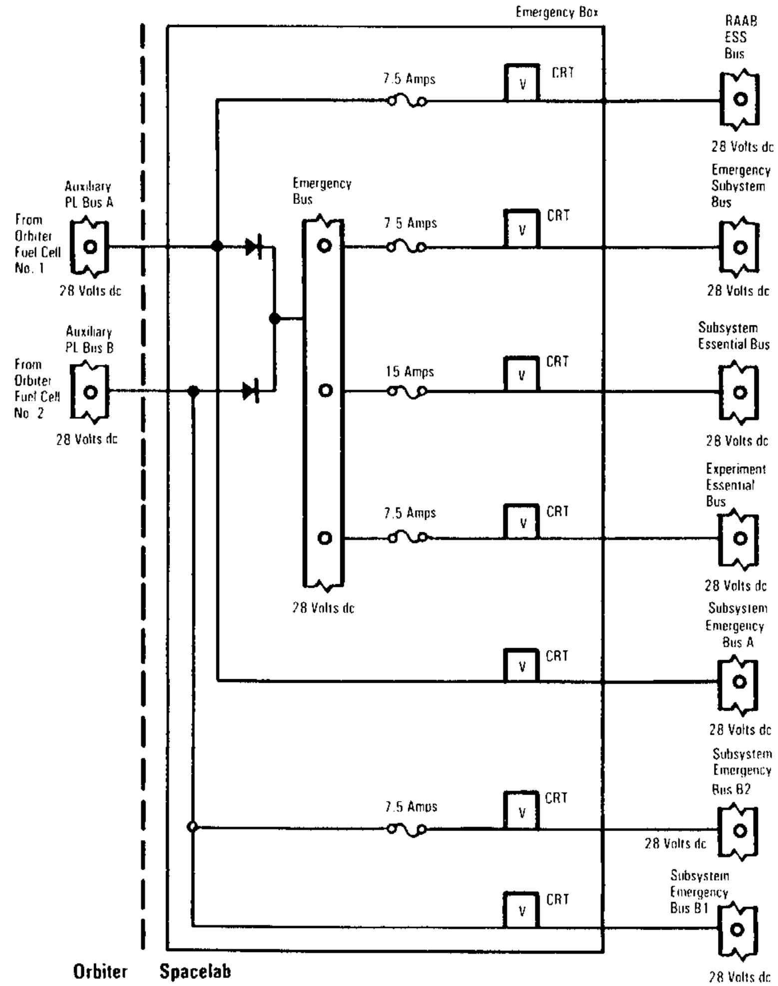
In the Spacelab pressurized module configuration, experiment power distribution boxes provide distribution, control, and monitoring facilities for the experiment electrical power distribution system, which consists of a nominal redundant 28-volt experiment main dc supply and a 115-volt, 400-hertz ac 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,



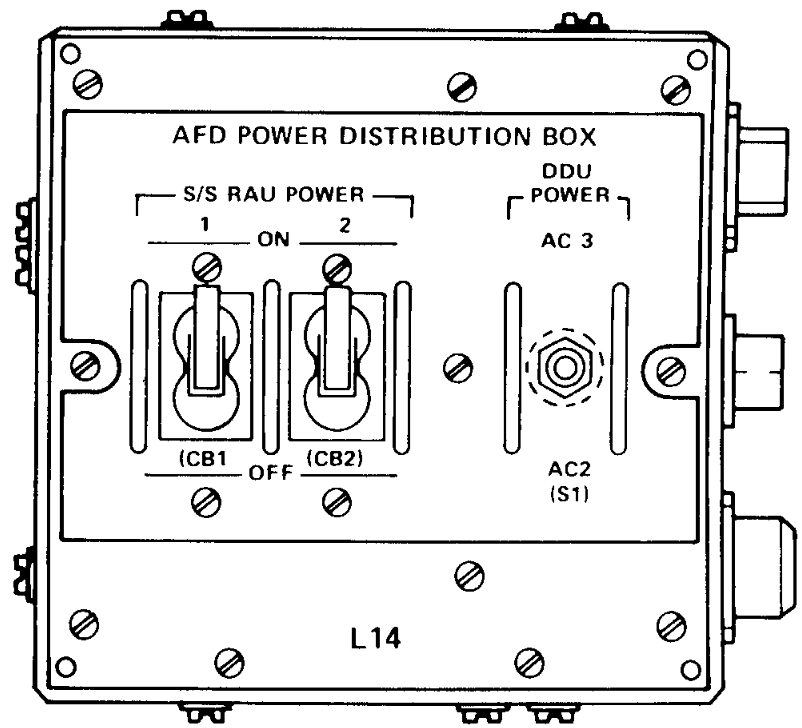
Spacelab Pressurized Module Emergency and Essential Power Distribution the experiment power distribution box is mounted with other assemblies with an adapter plate on a cold plate that is fitted on a support structure and attached to the pallet.

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.

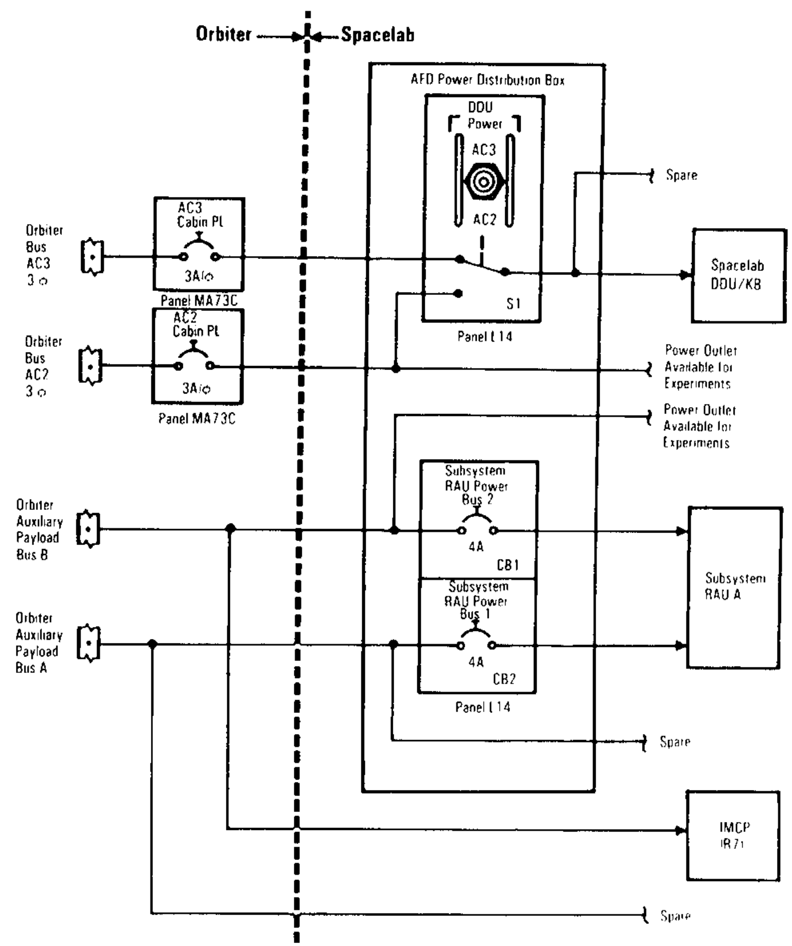
The Spacelab power distribution box at the orbiter aft flight deck payload station distributes dc and ac power to the Spacelab subsystem remote acquisition unit and the Spacelab data display system (a data display unit and keyboard). When a Spacelab data display system is installed at the mission station, 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 RAUs (dc only). The number of switching panels and their locations depend on the mission configuration.



Pressurized Module Configuration—Orbiter Aft Flight Deck Power Distribution

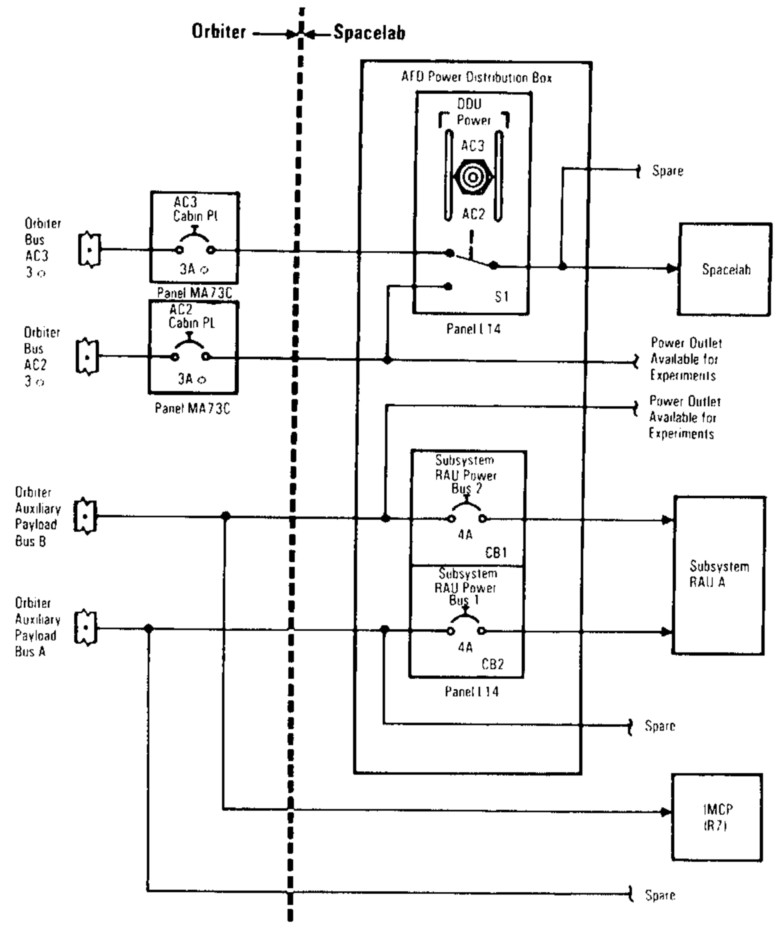
The orbiter crew compartment aft flight deck panel configurations vary for Spacelab pressurized module configurations and pallet-only configurations. A Spacelab pressurized module configuration may consist of a payload specialist station data display unit at panel L11, a standard switch panel at panel 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

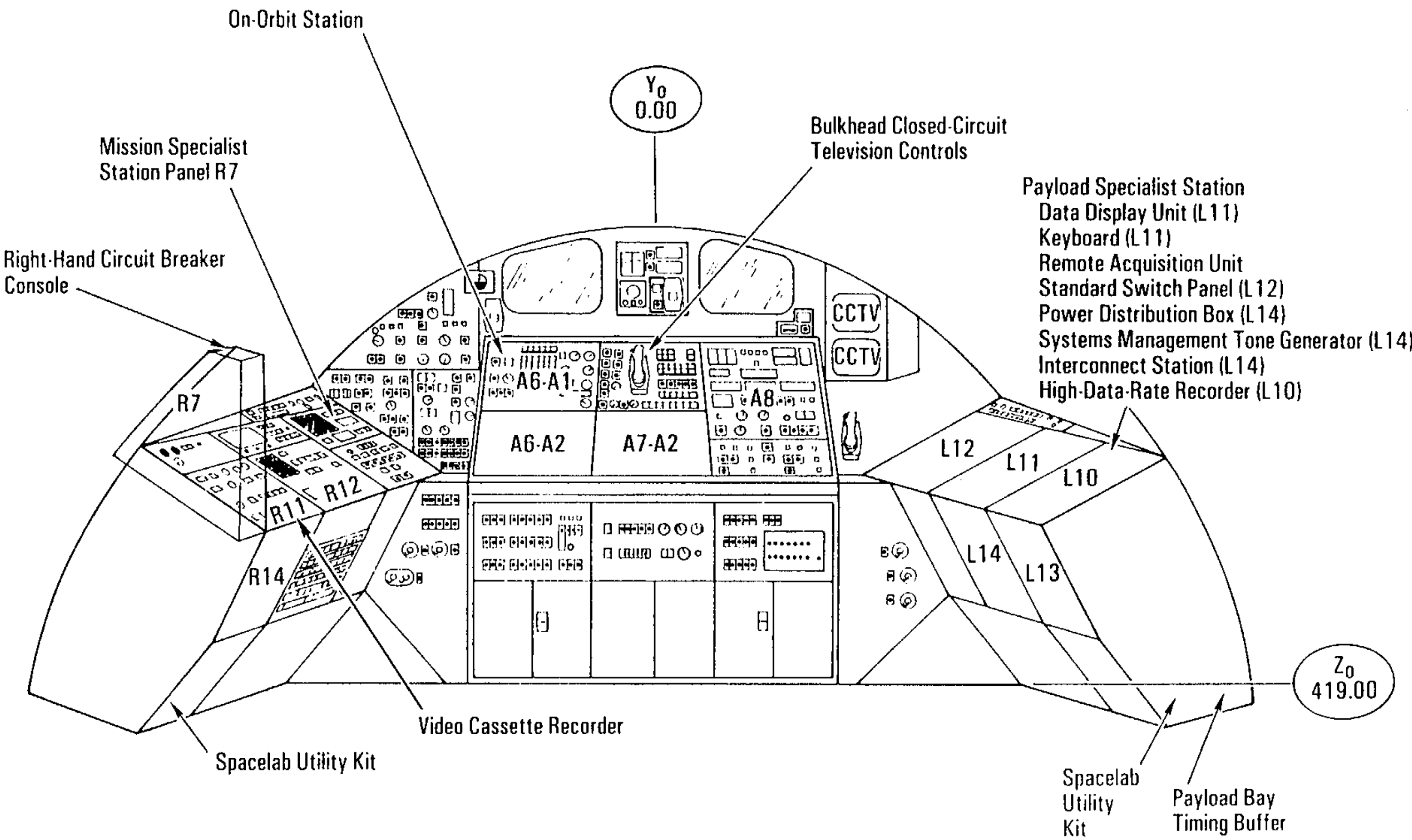
The Spacelab command and data management system provides a variety of services to Spacelab experiments and subsystems. Most of the CDMS commands are carried out through the use of the computerized system aboard Spacelab, called the data processing assembly. The DPA formats telemetry data and transfers 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 previously used three identical MATRA 125/MS computers have been

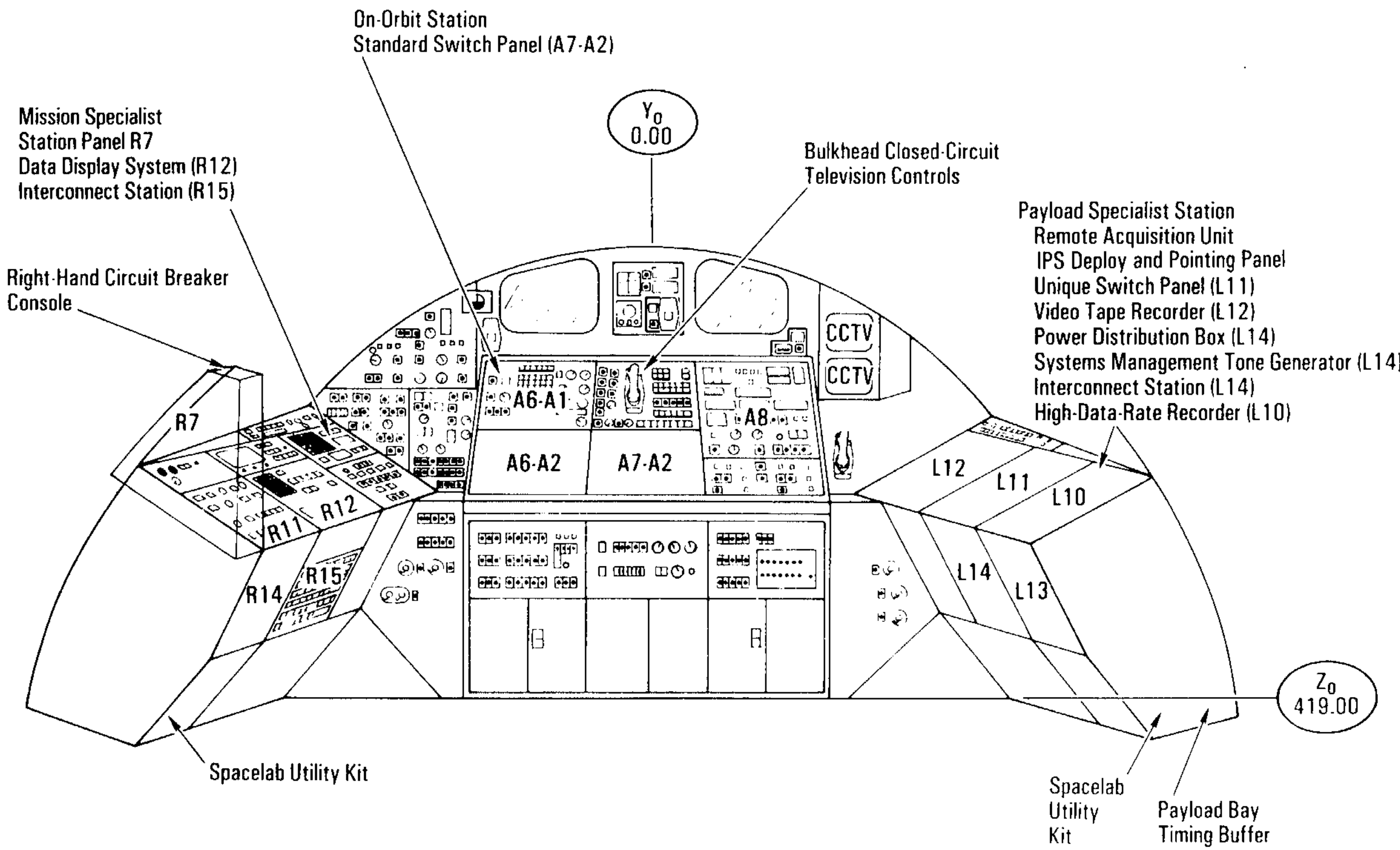


Pallet-Only Configuration—Orbiter Aft Flight Deck Power Distribution

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.

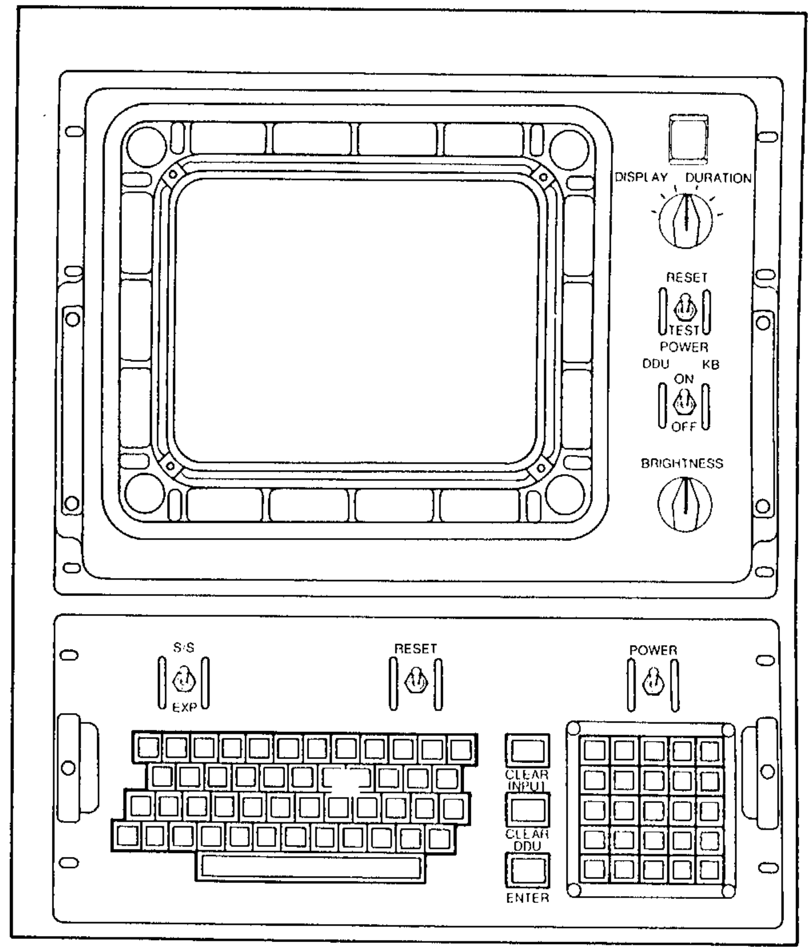
Mass Memory Unit

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)



Data Display Unit and Keyboard

in three colors (green, yellow, and red). In addition to 128 alphanumeric symbols, the unit can also display vector graphics (1,024 different 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.

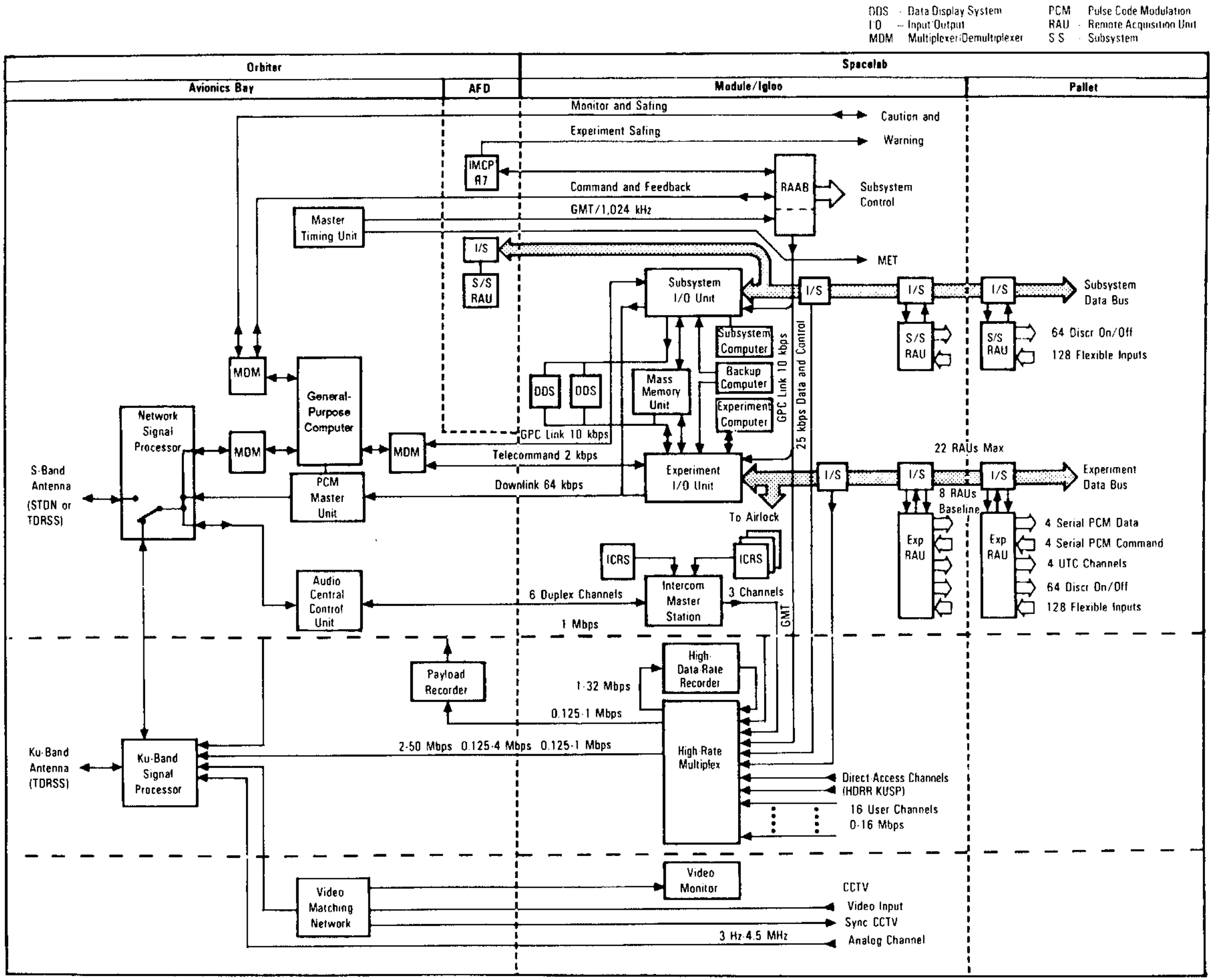
The subsystem computer functions mainly to monitor and control other Spacelab subsystems and equipment, such as the electrical power distribution subsystem and the environmental control subsystem. These functions are performed by the subsystem computer operating software.

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.

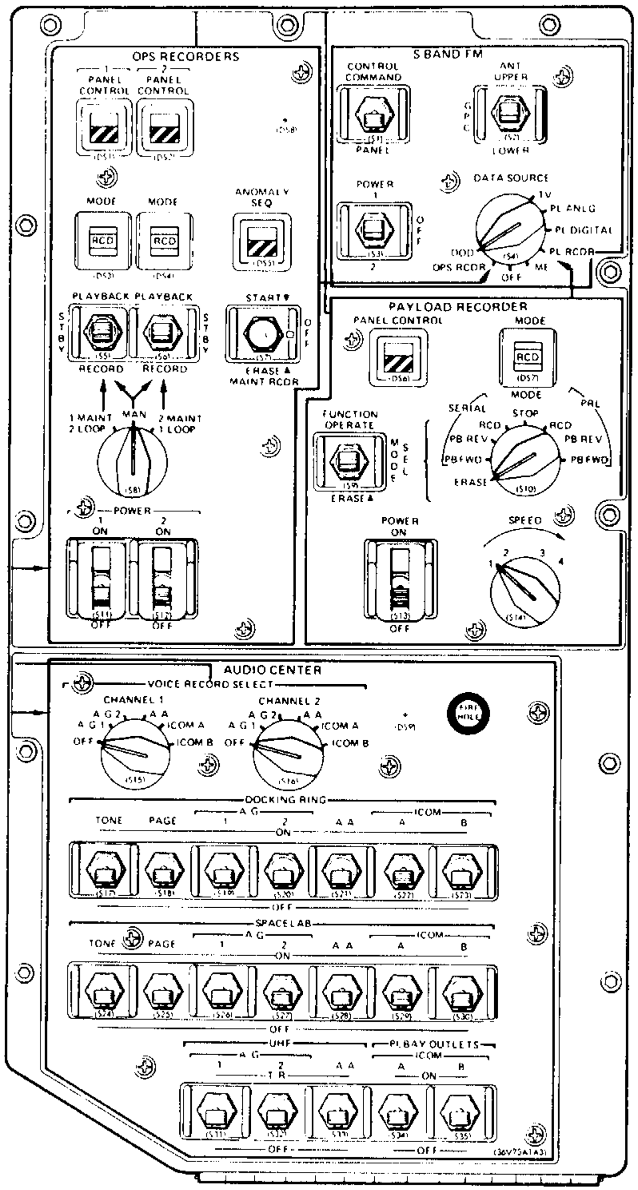
The Spacelab experiment computer interfaces with two telemetry systems. The orbiter PCMMU allows the orbiter to acquire data for on-board monitoring of systems and provides the Mission Control Center in Houston with system performance data for real-time display and recording through the orbiter network 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



Spacelab Command and Data Management System Interfaces With the Orbiter



Panel AIA3

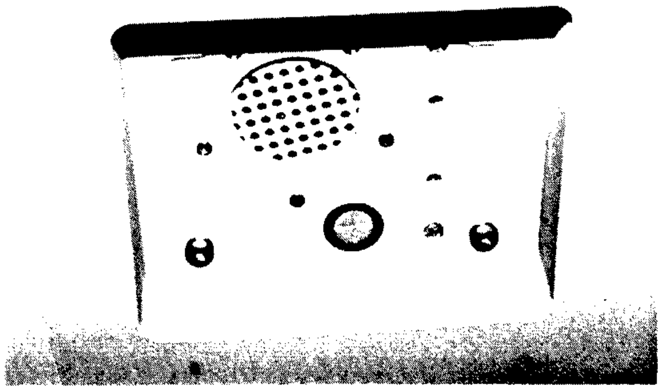
periods with no downlink capability or degraded downlink capability for playback when the capability is available. The HDRR dumps in reverse order at 2, 4, 8, 12, 16, 24, or 32 Mbps. At a rate of 32 Mbps, a tape runs for 20 minutes. The recorder can be changed manually by the flight crew; however, no 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.



Spacelab Pressurized Module Aural Annunciator Located Below Panel L14

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 channel 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.

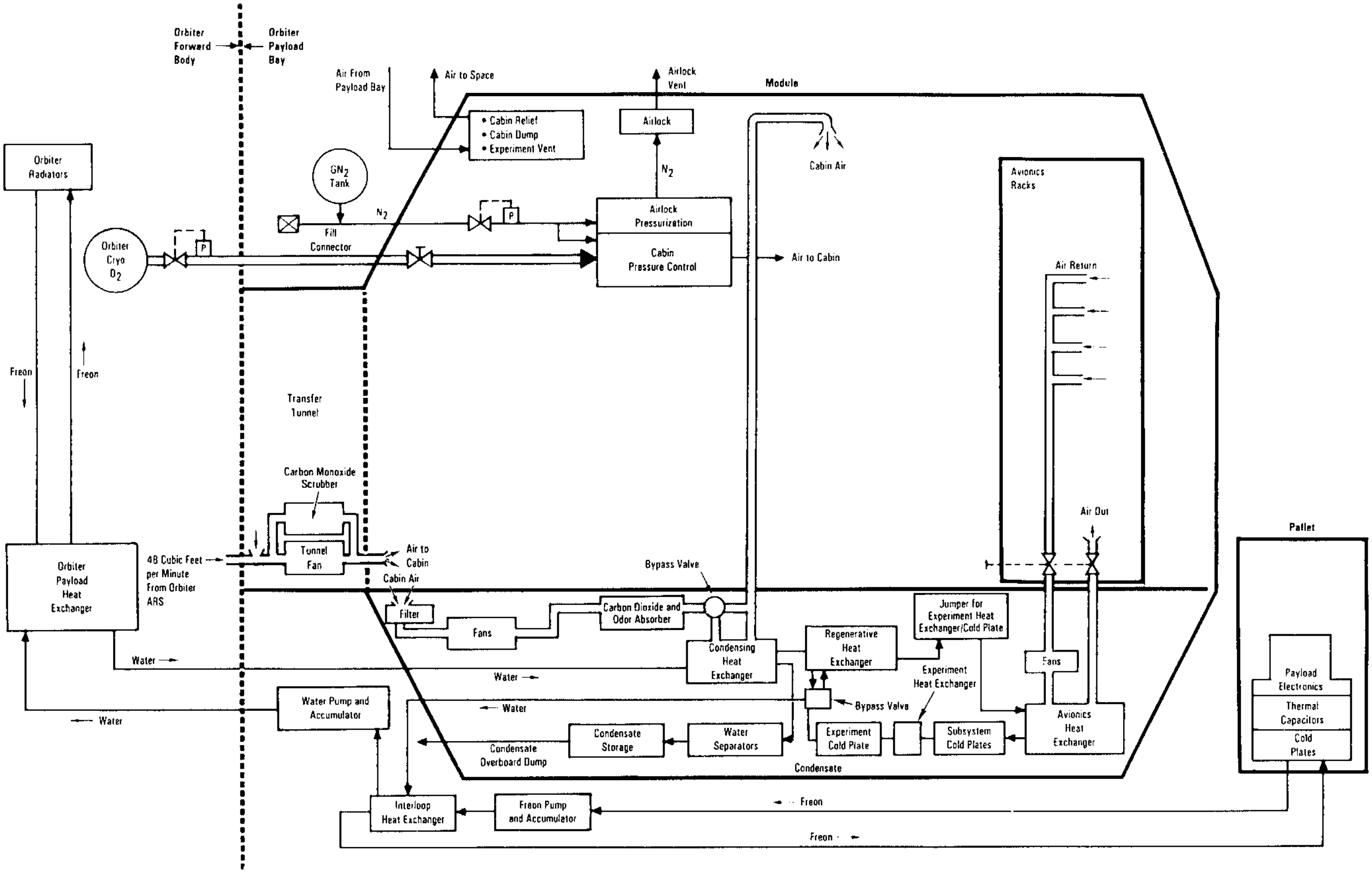
PRESSURIZED MODULE ENVIRONMENTAL CONTROL SUBSYSTEM AND LIFE SUPPORT

The Spacelab environmental control subsystem consists of the atmosphere storage and control subsystem and the atmosphere revitalization system.

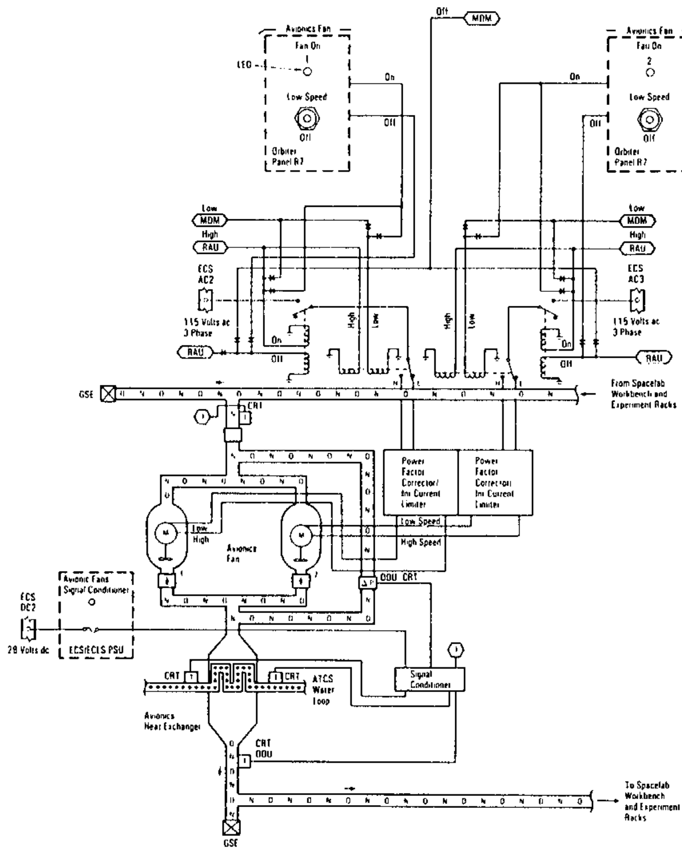
The atmosphere storage and control subsystem receives gaseous oxygen from the orbiter power reactant storage and distribution system and gaseous nitrogen from a tank located on the Spacelab module's exterior. The Spacelab ASCS regulates the gaseous oxygen and nitrogen pressure and flow rates to provide 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 *O_2 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



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



Spacelab Avionics Loop

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 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.

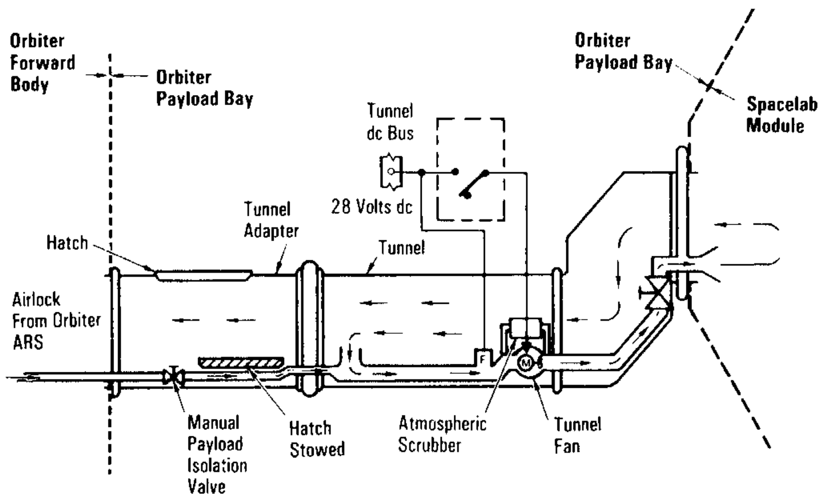
The fans are designed to switch from four-pole to eight-pole operation. The air flow through one fan is reduced from 1,923 to 639 pounds per hour, and the power is reduced from 643 to 110 watts. The two fans, powered by separate 115-volt ac buses, are activated and deactivated at low speed (eight-pole) 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.

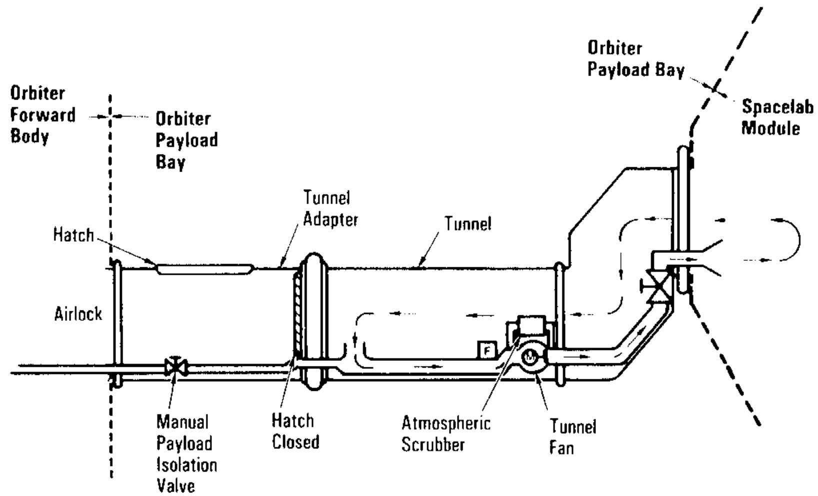
Pressurized Module/Tunnel Air Loop

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



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



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

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 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.

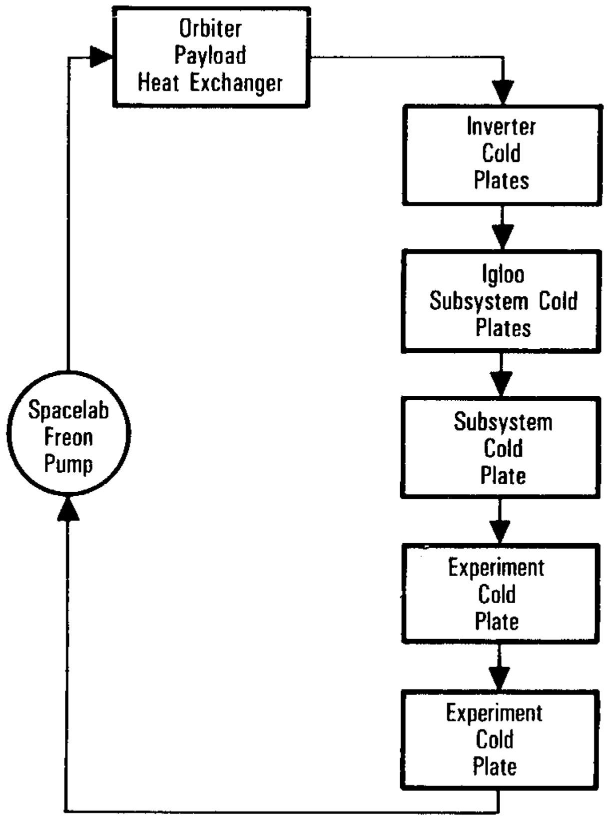
Two methods are provided for extinguishing a fire in the Spacelab module: discharging a fire suppressant into the affected area or dumping the Spacelab cabin atmosphere, when appropriate. The fire suppressant discharge consists of 15 orbiter-common fire suppression modules, each filled with the Freon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

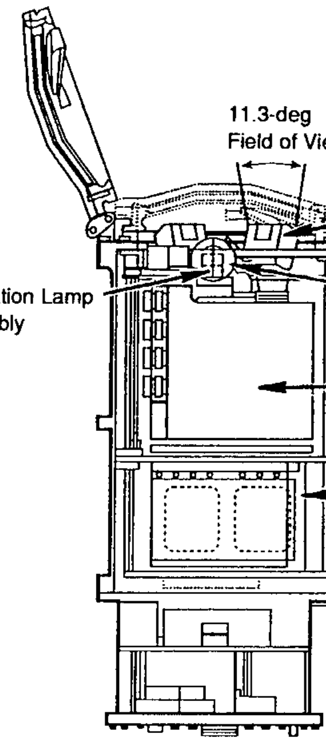
SHUTTLE SOLAR BACKSCATTER ULTRAVIOLET (SSBUV/A)

The SSBUV/A 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 and Meteor-3 satellites. 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, -43, and -45 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, 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 the performance of identical instruments on other spacecraft by directly comparing its atmospheric ozone and solar irradiance data with data from the other instruments as the shuttle and the satellites pass over the same Earth location within a one-hour period. These orbital coincidences can occur 17 times a day.

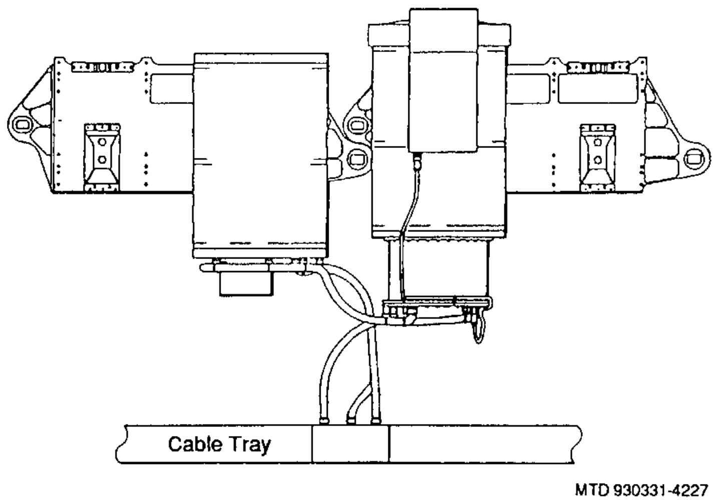
Solar backscatter ultraviolet instruments measure the amount of ozone and its height distribution in the upper atmosphere by measuring incident solar ultraviolet radiation and ultraviolet radiation backscattered from the Earth's atmosphere. These parameters are measured in 12 discrete wavelength channels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



Shuttle Solar Backscatter Ultraviolet Instrument

wavelengths, providing an index of the vertical distribution of ozone in the atmosphere.

The STS-56 SSBUV configuration, although physically separate from the ATLAS-2 payload, is included as part of the ATLAS-2 experiment complement and is equal in priority to the ATLAS-2 science requirements. The SSBUV spectrometer, five supporting optical sensors, and an in-flight calibration system are contained in a getaway special canister in Discovery's payload bay. An 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 commands from the Payload Operations Control Center at NASA's Johnson Space Center. SSBUV data will be received at JSC and the Marshall Space Flight Center. The backup flight crew interface is through an autonomous payload controller on the aft flight deck.



Shuttle Solar Backscatter Ultraviolet Experiment Configuration

The SSBUV ozone-measuring instrument is a 1/4mm double Ebert-Fastie spectrometer that uses a holographic grating and a single detector. The spectrometer collects data when the lid of the GAS canister is opened. A "bottom hat" subcontainer has been added to the lower end plate.

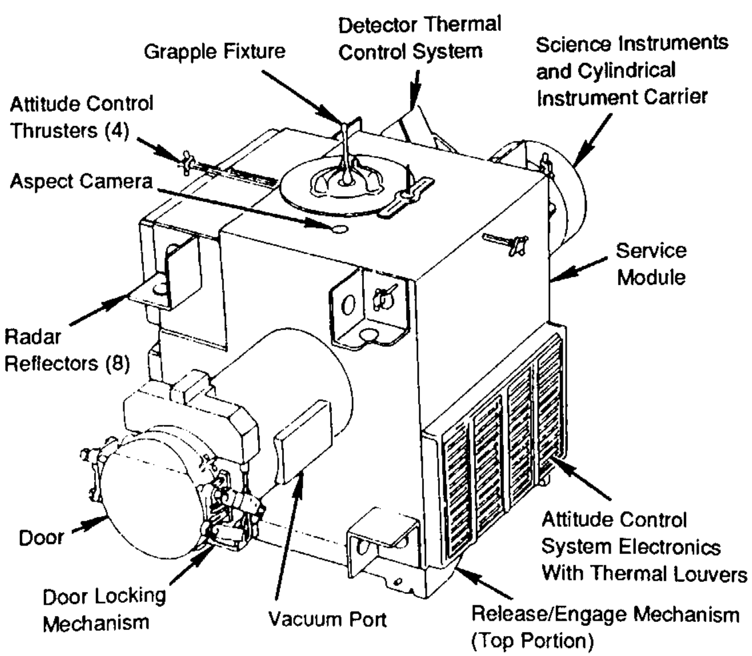
The instrument will be operated in three modes: Earth viewing, solar viewing, and calibration. Up to 29 orbits of Earth-viewing observations will be made to measure backscatter radiances of the Earth horizon. In the solar-viewing mode, observations of solar irradiance will be conducted for 30 minutes at the beginning, middle, and end of the experiment. 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 five 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.

SPARTAN-201, a free-flying payload that will study the solar wind and the sun's corona, is the second of a series of astrophysics experiments that evolved from NASA's sounding rocket program. The SPARTAN project was conceived in the late 1970s to take advantage of the opportunity offered by the space shuttle to provide more observation time for the increasingly more sophisticated experiments than the five to 10 minutes that sounding rocket flights could provide. On this flight, for example, SPARTAN-201 will conduct its observations of the sun for up to 40 hours.

The SPARTAN carrier is a simple, reusable vehicle that can carry a variety of scientific instruments at a relatively low cost. After it is deployed from the orbiter in space, it provides its own power, pointing, and data recording as it performs a preprogrammed mission.



SPARTAN-201 Spacecraft

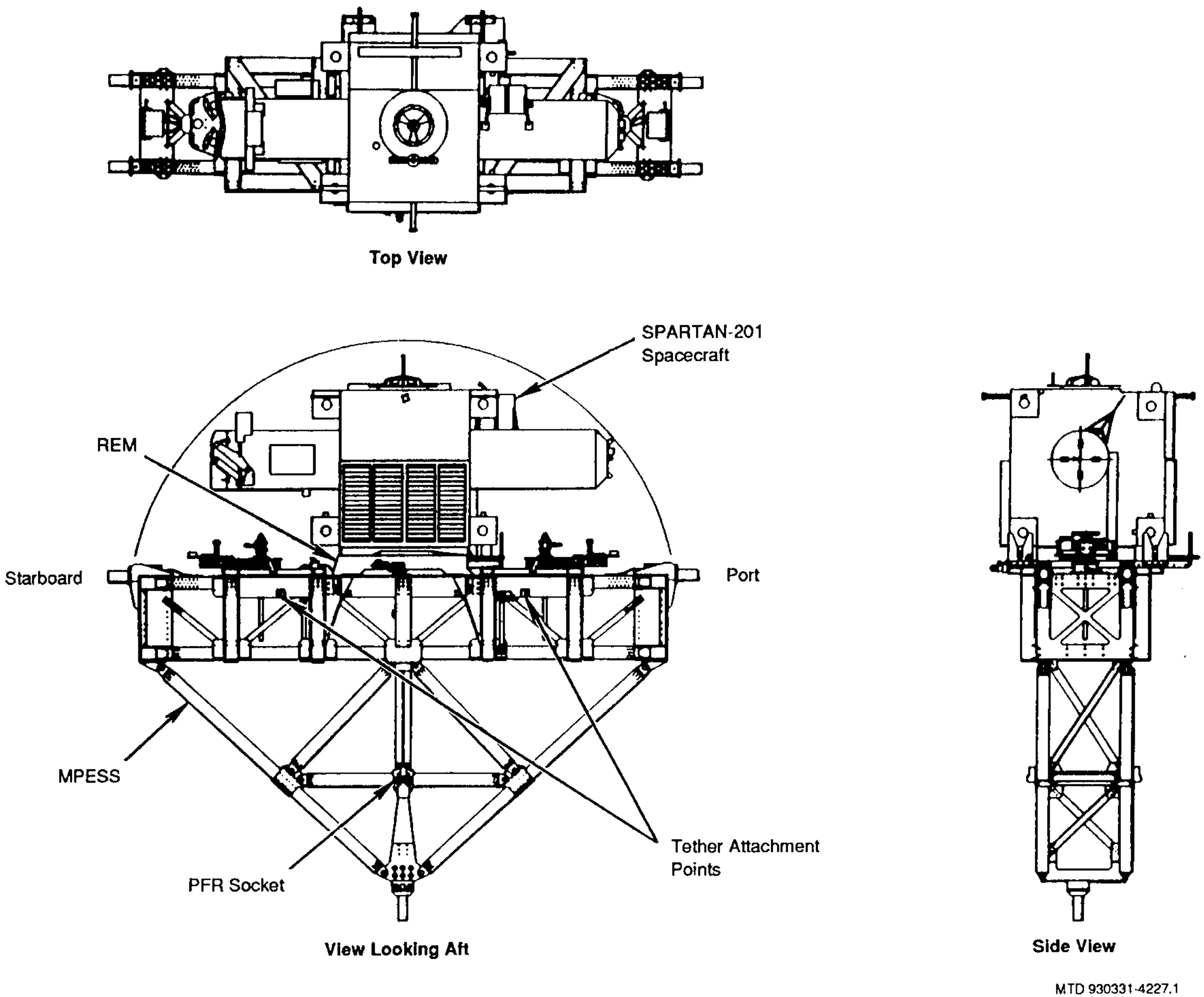
The SPARTAN project offers the scientific community an additional capability for conducting investigations in space between that offered by small payloads that are not deployed from the space shuttle and larger satellites that remain in orbit for long periods of time.

The SPARTAN-201 science module, which consists of two telescopes, and the SPARTAN carrier will be deployed from the cargo bay of the orbiter Discovery on the third day of the mission. A crew member will lift the spacecraft from its support structure with the remote manipulator system, the shuttle's Canadian-built, 50-foot-long robotic arm, and release it in space. The astronauts will then maneuver the orbiter to a position about 20 nautical miles behind the satellite.

After the experiments have been completed, Discovery will catch up with the spacecraft, and a crew member will grasp it with the RMS and replace it in the payload bay for the return to Earth.

The aim of the SPARTAN-201 experiment is to try to discover how the sun generates the solar wind, which is a continuous stream of electrons, heavy protons, and heavy ions ejected from the sun and traveling through space at speeds of almost 1 million miles per hour. The solar wind frequently causes problems on Earth by disrupting navigation, communications, and electrical power.

SPARTAN-201 will aim its two telescopes at the corona of the sun, the outermost layer of the solar atmosphere where the solar wind is generated. The white light coronagraph telescope, provided by the High-Altitude Observatory in Boulder Colo., will measure the density of the electrons in the corona. The ultraviolet coronal

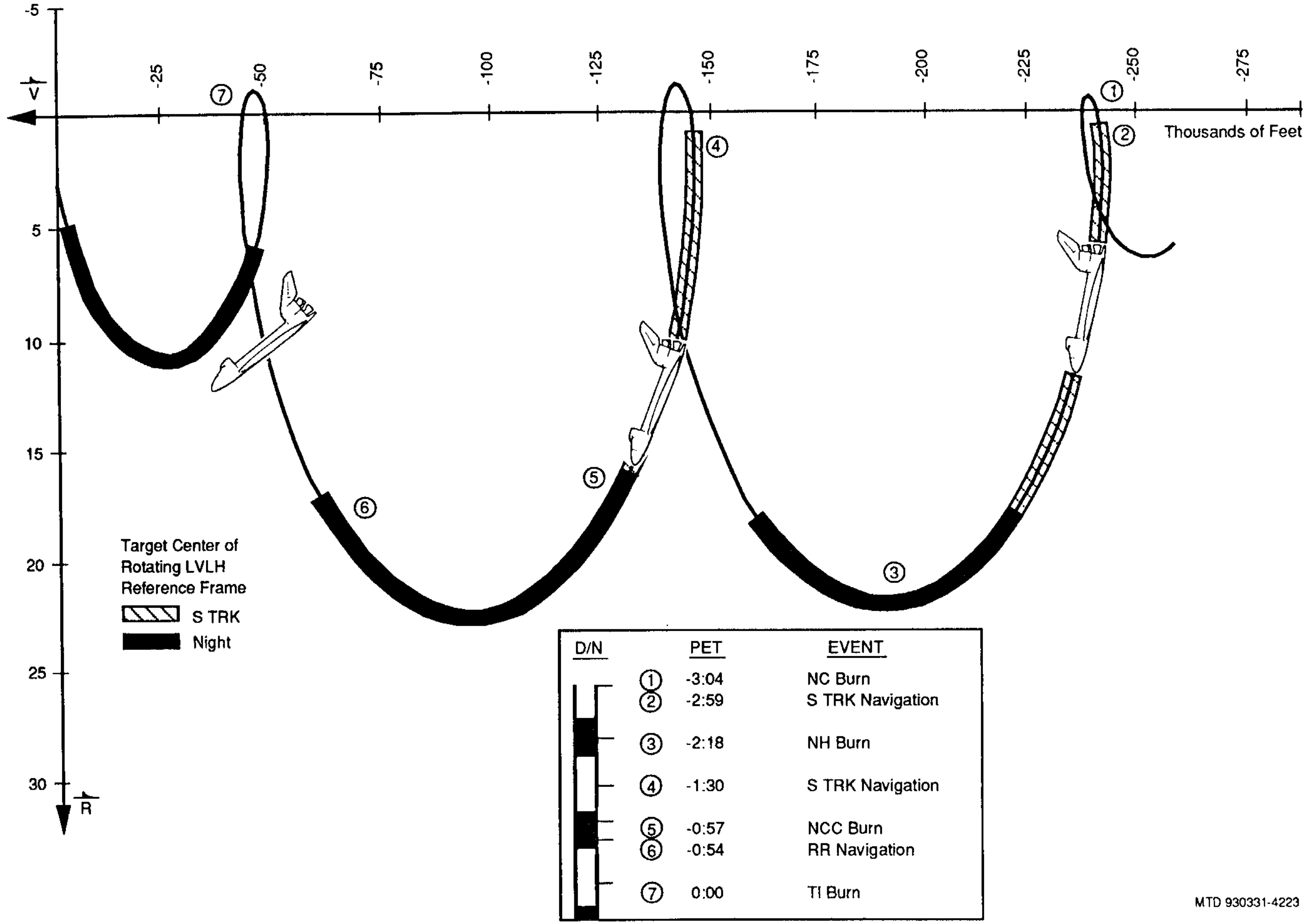


SPARTAN-201 Flight Configuration

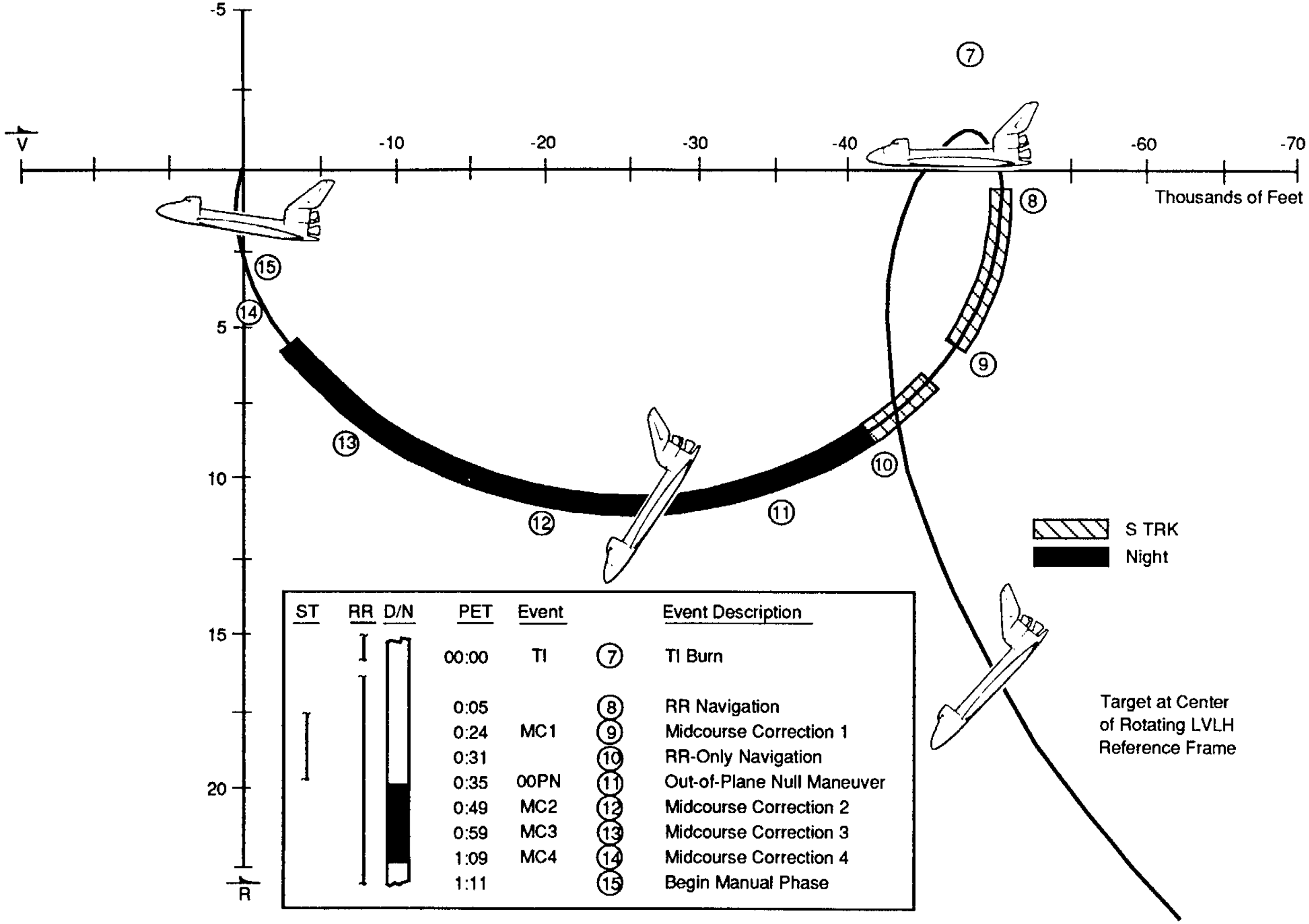
spectrometer from the Smithsonian Astrophysical Observatory at Harvard will study the distribution and temperatures of hydrogen atoms and protons in the corona.

By comparing the data collected by the two telescopes, scientists will be able to measure the temperatures and densities of electrons and protons in the corona. They also hope to test theories about how the corona reaches a temperature of 1 million degrees.

The Goddard Space Flight Center in Greenbelt, Md., is responsible for managing the SPARTAN program for NASA's Office of Space Science and Applications.



Initial Phase of Shuttle Rendezvous With SPARTAN-201



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			0:31		10	RR-Only Navigation
			0:35	00PN	11	Out-of-Plane Null Maneuver
			0:49	MC2	12	Midcourse Correction 2
			0:59	MC3	13	Midcourse Correction 3
			1:09	MC4	14	Midcourse Correction 4
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Intermediate Phase of Shuttle Rendezvous With SPARTAN-201

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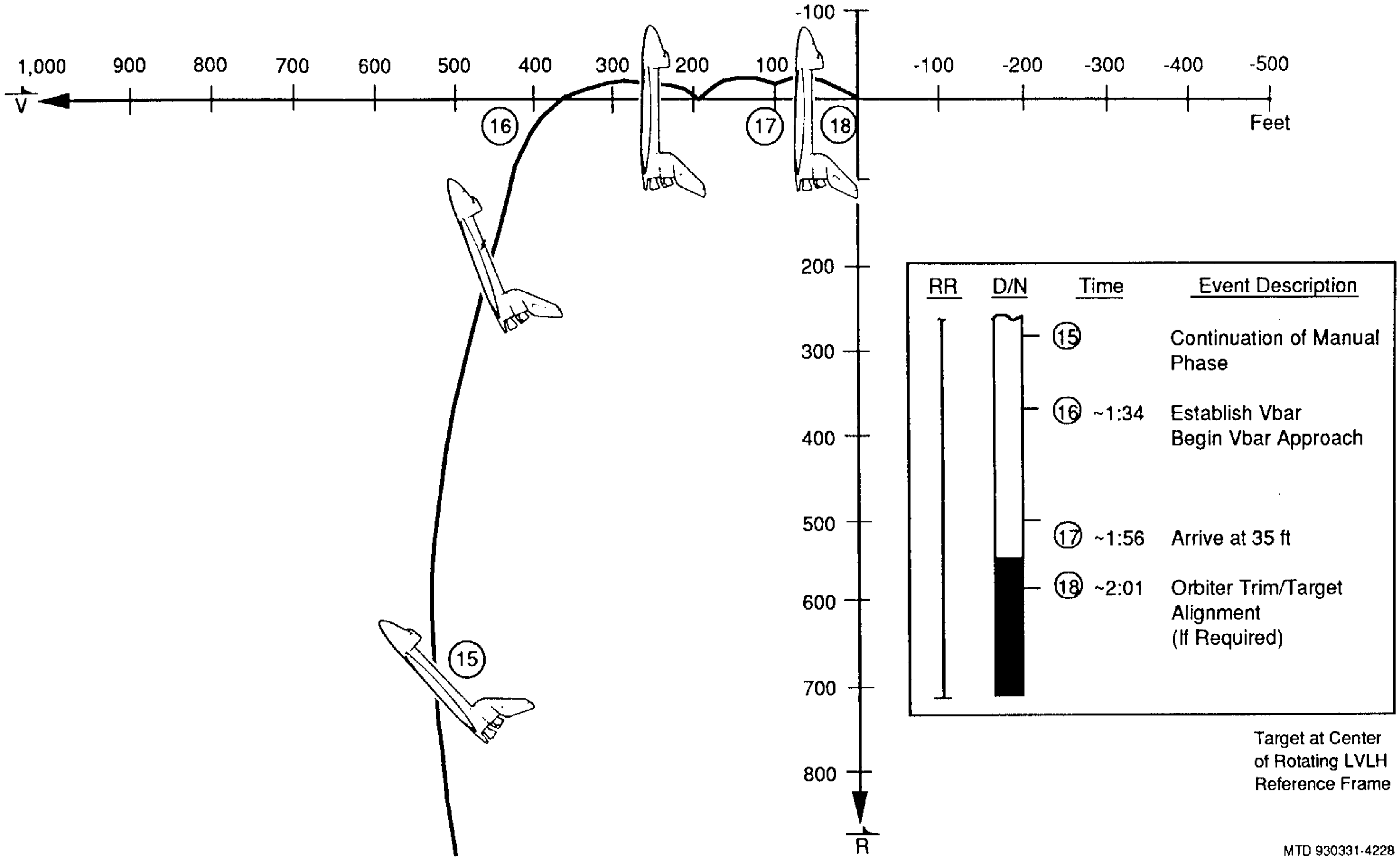


Final Phase of Shuttle Rendezvous With SPARTAN-201

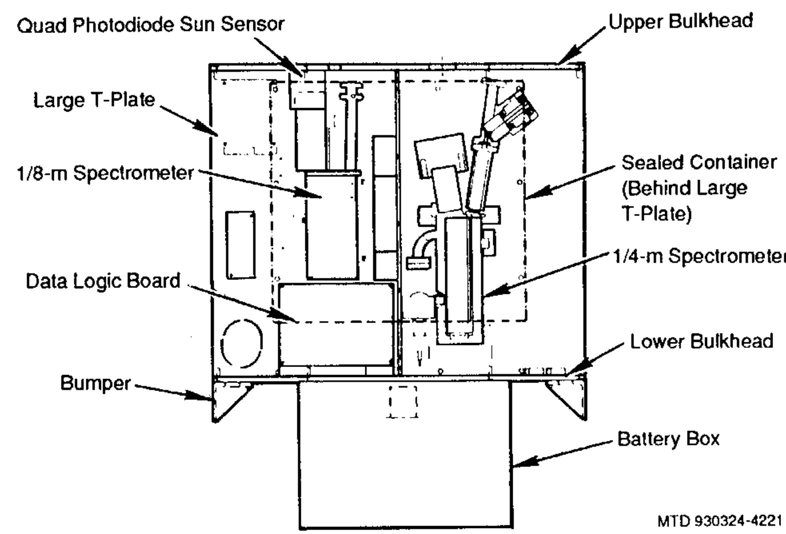
SOLAR ULTRAVIOLET EXPERIMENT (SUVE)

This experiment, which was designed, built, and managed entirely by students at the University of Colorado, will investigate the effects of extreme and far ultraviolet radiation on the Earth's ionosphere. The data obtained by the SUVE instruments will be compared with data from the four solar instruments on the ATLAS-2 payload.

The experiment is activated when a sensor detects the sun. Two spectrometers will measure the sun's ultraviolet radiation, and a camera equipped with a hydrogen filter will photograph the sun to help researchers determine a correlation between extreme ultraviolet flux and sunspot activity.

SUVE is a project of the Colorado Space Grant Consortium, which comprises 14 colleges and universities. The NASA-funded consortium was established to educate students in the engineering and science areas of space exploration.

SUVE is housed in a getaway special canister in the payload bay of the orbiter.



Solar Ultraviolet Experiment

COMMERCIAL MATERIAL DISPERSION APPARATUS MINILAB/INSTRUMENTATION TECHNOLOGY ASSOCIATES, INC., EXPERIMENT (CMIX)

CMIX, which occupies one middeck locker, consists of four material dispersion apparatus minilabs housed in a commercial refrigerator/incubator module (CRIM). Initially developed to grow protein crystals in space, the minilabs were redesigned to accommodate additional research areas. During STS-56, they will be used to conduct more than 30 different experiments to obtain information on how microgravity can be used to aid research in the development and delivery of drugs, biotechnology, basic cell biology, protein and inorganic crystal growth, bone and invertebrate development, immune deficiencies, manufacturing processes, and fluid sciences.

CMIX is an innovative program of the Consortium for Materials Development in Space (CMDS), a NASA Center for the Commercial Development of Space (CCDS), based at the University of Alabama in Huntsville (UAH), and Instrumentation Technology Associates (ITA), Inc., of Exton, Pa., to allow the CCDS community to have greater access to space.

The material dispersion apparatus minilab—the size of a brick—is an automated, self-contained processing device able to bring into contact and mix up to 100 different samples of fluids and solids at precisely timed intervals. It operates on the principles of liquid-to-liquid diffusion, vapor diffusion, magnetic mixing, and reverse gradient diffusion.

Two of the minilabs contain experiments developed by the UAH CMDS and its industry affiliates. The other two contain experiments developed by ITA's commercial customers, which include U.S. biomedical technology and biomaterials companies, international users, and university research institutions. Some of ITA's MDA capacity is allocated to high school student experiments as part of the company's program to increase awareness and interest in science and space technology.

Throughout the flight, the MDAs remain in a thermally controlled CRIM. The four minilabs inside the apparatus each have upper and lower blocks containing an equal number of reservoirs filled with different substances. As early as possible in the mission, the shuttle crew will open the CRIM door, operate switches to activate each lab, and then close the door. Microgravity disturbances must be kept at a minimum for at least the next eight hours.

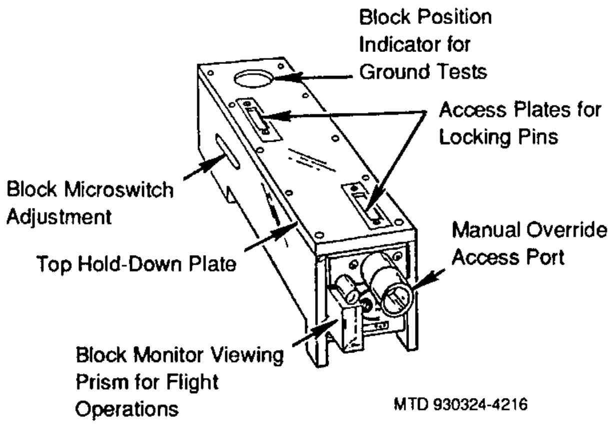
Investigations involving live cells will be conducted in ten bioprocessing modules (BPMs), which have up to 100 times more fluid volume than the MDAs. The BPMs use available space in the CRIM between the MDAs.

Each BPM contains four plastic syringes interconnected by tubing to a four-way valve attached to an aluminum tray. The first syringe contains live cells; the second, a mediator of cell growth or function (e.g., an activator); and the other two syringes, a chemical fixative. The crew will activate the BPM by opening the valve to mix the cells with growth mediator. The crew will terminate each BPM test at specified times by turning the valve to mix the cells with the fixative, which preserves their cellular structures. Cell growth and the production of materials, including interferons, will be evaluated after the flight.

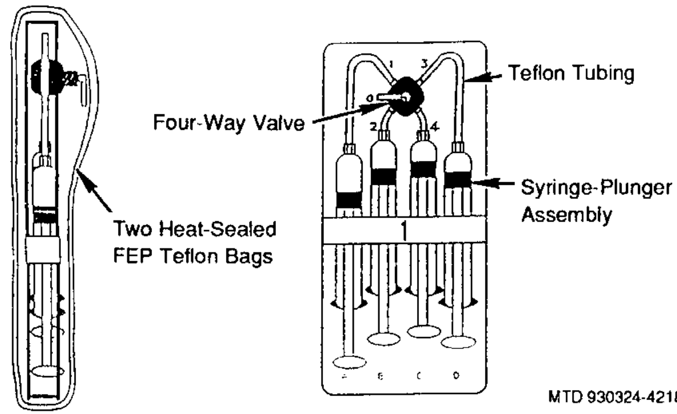
When the shuttle mission is over, samples will be returned to researchers for postflight analyses.

Experiments Developed by UAH CMDS and Its Affiliates

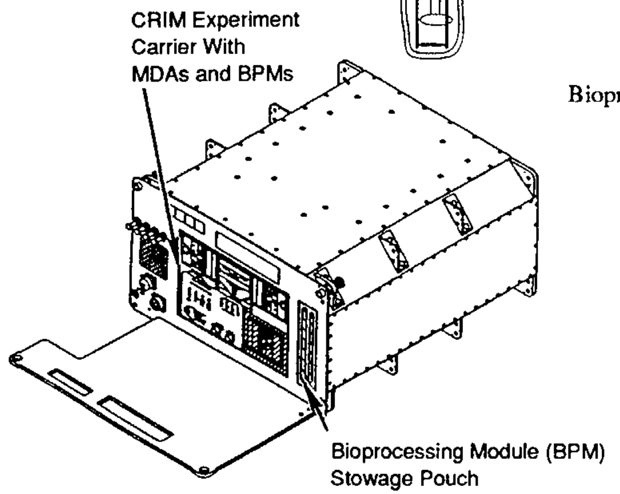
- Bone Cell Differentiation (MDA): Researchers will evaluate how well mouse bone cells grow and produce collagen in microgravity and will develop a data base on potential areas for treating osteoporosis with drugs. This research may have commercial applications in three to 10 years in enhancing the

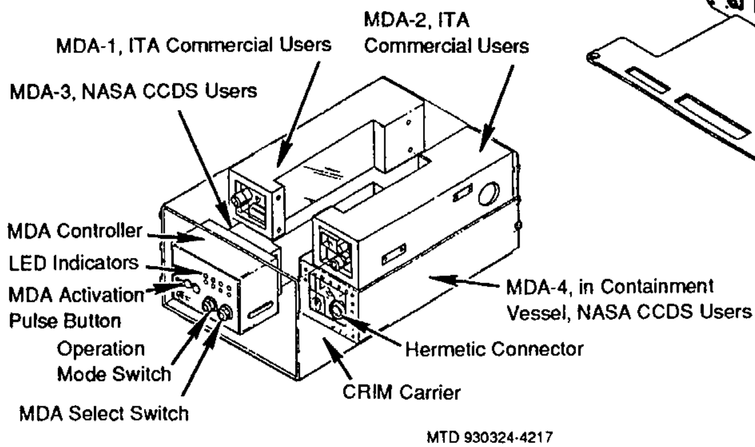


Material Dispersion Apparatus (MDA) Minilab

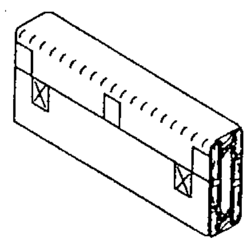


Bioprocessing Module





MDA Minilab Assembly



BPM Stowage Pouch (Closed)

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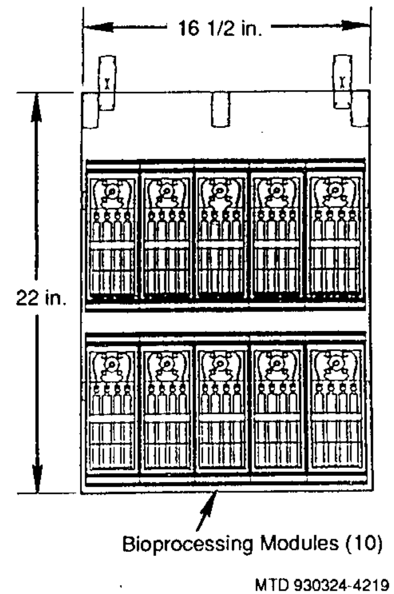


BPM Stowage Pouch (Open)

Commercial MDA Minilab/ITA, Inc. Experiment Payload growth of bone cells and preventing the deterioration of the bones of astronauts and the elderly.

- Immune Cell Response (MDA): This experiment will study why some cells are more sensitive to microgravity than others. This may lead to the development of techniques for stimulating immune system cells for use in treating immune suppressed patients and in developing and testing drugs to reduce some of the undesirable effects of microgravity.

- Diatoms (MDA): This experiment will investigate the effect of microgravity on diatoms, minute one-celled plants, to determine if they can be used commercially to regenerate oxygen.

- Mouse Bone Marrow Cells (MDA): This experiment will study whether manipulating desirable cells with growth factors in microgravity might enhance the cells' expansion. This technology could be used for bone marrow transplants and reconstituting the immune system of patients who undergo radiation therapy and chemotherapy for leukemia, lymphoma, and breast cancers.

- Nerve/Muscle Cell Interactions: This experiment will study the effects of microgravity on the development of nerve cell communication, which is essential for brain function, in frog eggs. The results may provide information about the ability of higher organisms to undergo normal brain development in space.

- Phagocytosis (MDA): This experiment will investigate phagocytosis, the body's mechanism for fighting infection in which certain cells engulf and destroy foreign materials. Researchers hope the experiment will give them a better understanding of the behavior of these disease-fighting cells.

Other MDA experiments will evaluate fluids mixing, invertebrate and bone development, virus subunit assembly and collagen self-assembly, and formation of drug-encapsulated liposomes. Commercial applications of these experiments will increase as the data base on cell response and control grows.

- Live Cell Investigations (BPMs): These experiments will gather information on how cells of the human immune system may be induced to grow when they are exposed to certain compounds. This information may be useful in the development of treatments for certain types of cancer.

Experiments Developed by ITA and Its Affiliates

- Collagen Reconstitution (MDA): This experiment will study collagen fibril growth to develop unique, complex products that mimic natural tissue structures. Potential applications are corneal and intraocular implants, bone repair materials, and tendon/ligament grafts.

- Microencapsulation (MDA): This experiment will study techniques for the microencapsulation of drugs to improve chemotherapy drug delivery, encapsulate inhalant medications, and enhance X-ray procedures.

- Urokinase Protein Crystal Growth (MDA): Crystals of urokinase will be grown to help determine the enzyme's three-dimensional structure. The information will be used to develop a blocking or therapeutic drug that prevents the spread of breast cancer.

- Bacterial Aldolase and Rabbit Muscle Aldolase Protein Crystal Growth (MDA): Two types of aldolase will be used to grow crystals to determine the enzymes' three-dimensional structures for use in research on genetic illnesses.

- HIV Reverse Transcriptase (MDA): Crystals of reverse transcriptase will be grown to determine the enzyme's three-dimensional structure for use in AIDS research.

- RNA Protein Crystal Growth (MDA): Crystals of ribonucleic acid (RNA) will be grown to determine the enyzme's three-dimensional structure for use in cell pharmacology and in designing continuous catalytic reactors.

- Methylase Protein Crystal Growth (MDA): Crystals of methylase will be grown to study the interaction between methylase and deoxyribonucleic acid (DNA). The information will be used to identify potential biomedical/biotechnology applications.

- Lysozyme Protein Crystal Growth (MDA): Lysozyme crystals will be grown to confirm the quality of flight conditions and to extend continuing studies of lysozyme crystallization for biomedical applications.

- DNA-Heme Protein Crystal Growth (MDA): This experiment will grow crystals to study their three-dimensional structure. The results will be used to identify potential biomedical/biotechnology applications.

- Brine Shrimp Development (MDA): *Artemia salina* shrimp eggs will be hatched in space to determine how microgravity affects their early development. These shrimp are being studied as a possible source of food in space.

- Cell Research (MDA): This experiment will explore fluids and cell mixing for cell culturing on space station Freedom.

Some of the other commercial MDA experiments are inorganic assembly (proprietary), myoglobin protein crystal growth, dye and yeast cell diffusion, and engineering tests.

Student Experiments

- Mustard Seed Germination (MDA): Dry seeds and newly developing reproductive tissue of *Brassica rapa* will be flown. After the mission, they will be used to propagate successive generations of the plant to assess any long-term effects of exposure to microgravity on heredity patterns.

- Fish Egg Hatching (MDA): This experiment will examine the effects of microgravity on the hatching process of the annual killifish of Zanzibar, Africa.

- Heart Cells in Culture (MDA): This experiment will study the effects of microgravity on the morphology and rate of heart "beats" of heart muscle cells.

- Mushroom Spore Generation (MDA): This experiment will investigate the effects of microgravity on the development of mushroom spores. Eventually, the investigation will lead to the growth of new and improved mushrooms.

- Mustard-Spinach Seed Germination (MDA): Student experimenters will evaluate the effects of microgravity on the mustard-spinach seed germination process by comparing the germinated seeds with Earth-grown sprouts.

The CMIX principal investigator is Dr. Marian Lewis of the UAH CMDS. The flight hardware is supplied by ITA, Inc., an industry partner of the university consortium. John Cassanto, president of ITA, is the program manager for the MDAs.

ITA is providing its MDA minilab under a "value exchange" agreement with the university consortium. NASA flies the lab for five missions or five years, whichever comes first, and receives a certain percentage of the capacity for use by its commercial development researchers. This is the minilabs' second mission.

The privately financed minilab offers users general turnkey space experiment equipment at a low cost. Users focus on their experiments and ITA handles the payload integration and documentation. This arrangement supports one of the aims of NASA's Centers for the Commercial Development of Space—to provide opportunities for materials development projects that can benefit from the unique attributes of space.

PHYSIOLOGICAL AND ANATOMICAL RODENT EXPERIMENT 03

The space shuttle program has made it possible to expose both humans and animals to the unique environment of microgravity. In this way, scientists can begin to partition out the specific effects of gravity in regulating the structural and functional properties of the organ systems of the body.

The shuttle makes it possible for life to exist in a new environment that is entirely foreign to the body, thereby enabling scientists to understand how the force of gravity normally impacts health and well-being.

The Physiological and Anatomical Rodent Experiment (PARE) is a series of investigations designed to determine whether exposure to microgravity results in physiological or anatomical changes in rodents. The object of this experiment is to understand the importance of gravity on the metabolism, size, and shape of the skeletal system. Space offers the only environment where the influence of gravity can be eliminated.

When individuals are exposed to the microgravity of space, there appears to be a significant loss in muscle mass. This appears to be because the muscle must no longer exert a sufficient level of force, which produces a signal to the body to conserve mass. However, the loss of muscle mass hinders astronauts' ability to function when they return to Earth. All movement patterns are difficult, and they may be prone to accidents because of this instability. Scientists need to find the extent to which muscles atrophy, what impact the atrophy process has on muscle performance, and how to prevent atrophy from occurring.

Second, muscle atrophy is similar in part to what occurs during normal aging on Earth. As people age, they become less active plhysically and the degree of muscle disuse is exaggerated. This leads to the same problems that occur during exposure to microgravity. Thus, if scientists can solve the problem of atrophy in space, they should have a good idea of how to maintain the muscle system in a more viable condition as humans age.

Millions of dollars are spent annually to treat older individuals, particularly women, with injuries and disabilities resulting from the general problem of muscle and bone weakness. The information derived from this project has obvious practical relevance to the entire health care industry. Any insights that can prevent body dysfunction and injury and rehabilitate the musculoskeletal system from the effects of disuse atrophy are very important to the entire population.

This is the second phase of this research experiment. In the first phase, investigators studied the effects of microgravity on how human muscle cells process food and transform it into the energy necessary to enable the muscles to function. The experiment determined that the muscles isolated from animals exposed to zero gravity had a reduced capacity to process fat substrate but retained a normal capacity to process carbohydrate for energy.

This finding has important implications. If it is true for humans, a person would have to use his energy stores of carbohydrate at a faster rate. When this occurs, the muscles lose their stamina, and the individual cannot sustain physical activity as long.

PARE.03 comprises two fully compatible experiments that seek to provide a cohesive survey of bone biology during and after space flight.

PARE.03A, Acute Adaptation of Bone to Space Flight, will study the extent of the changes in the bone-forming cells of rats in space and confirm the bone defects noted in past experiments. After the flight, researchers will determine whether the defects are corrected within three days of returning to Earth.

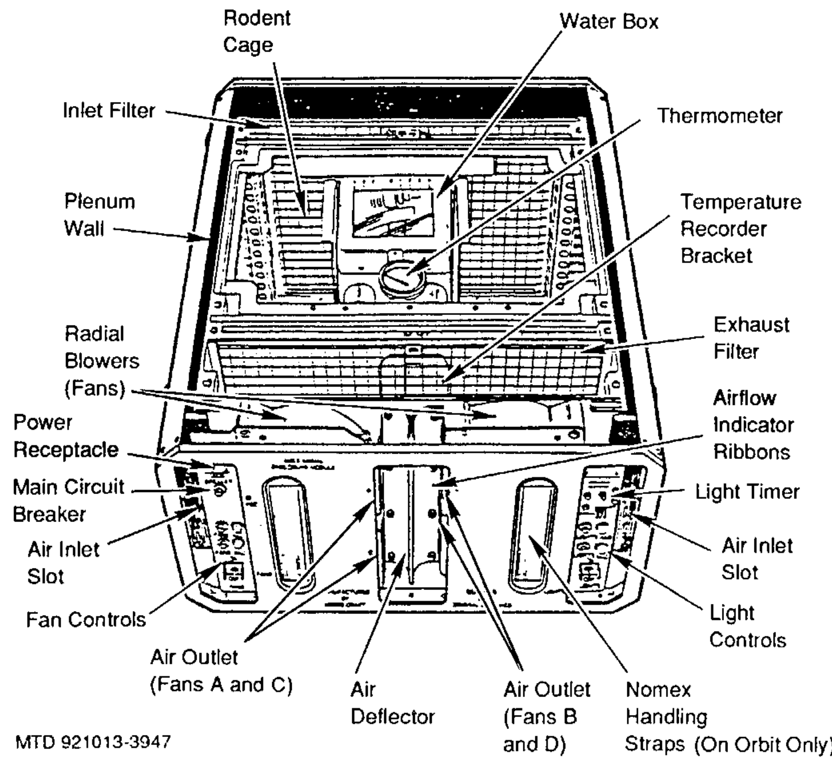
This experiment is designed to help researchers determine which parts of the bone structure are altered during space flight, the extent of alteration, the impact of changes on the strength of bones, and how to prevent them. This information is important because the ability of astronauts to function after space flight is hindered by changes in bone structure.

The second part of the experiment will examine the imbalance in the normal ordered array of bone structure caused by the absence of gravity in space and the removal of gravitational loading on the skeletal structure on Earth. This experiment will be performed on rats in space and on Earth to determine whether the imbalance, which causes bone weakness, is different in space than on Earth. If there is a difference, different treatments would be necessary to prevent the changes in the production of bone products that cause the imbalance.

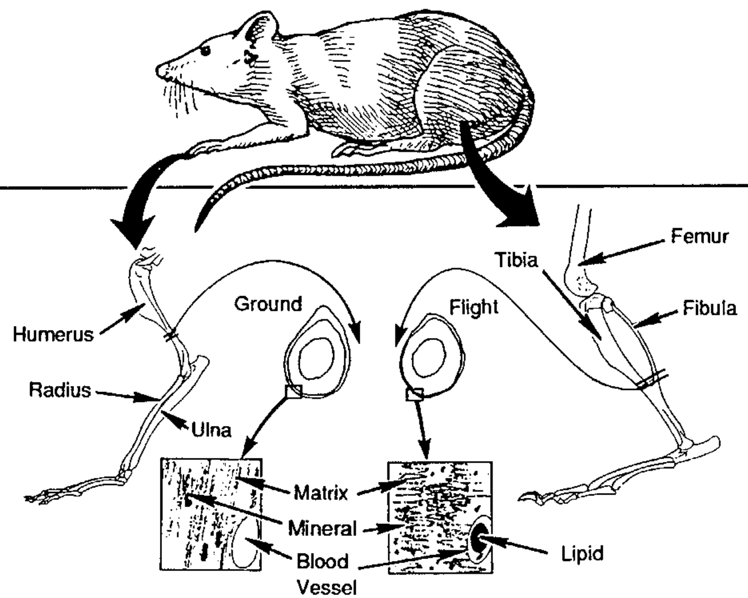
PARE.03B, Cell Kinetic Histomorphometric Analysis of Microgravitational Ostopenia, will study the effect of microgravity on the production of bone-forming cells, or osteoblasts. Weight-bearing and non-weight-bearing bones of the rats will be examined to determine whether the interference with the production of osteoblasts found in previous microgravity experiments occurs throughout the rats' skeletons or is localized. Researchers will also study the bones in the rats' lower backs, which are continually being renewed, to confirm that exposure to space inhibits the renewal process.

The rats will be examined immediately after the flight and at intervals of 36 and 72 hours to determine how soon the production of osteoblasts recovers after space flight.

Insights from PARE.03B about the mechanisms of osteoblast production and function may provide valuable information that can be used for the successful treatment of bone diseases in humans. The experiment will also help scientists answer questions about the ability of humans to adapt to other environments, such as weightlessness, and the role of mechanical forces in maintaining the human skeleton on Earth.

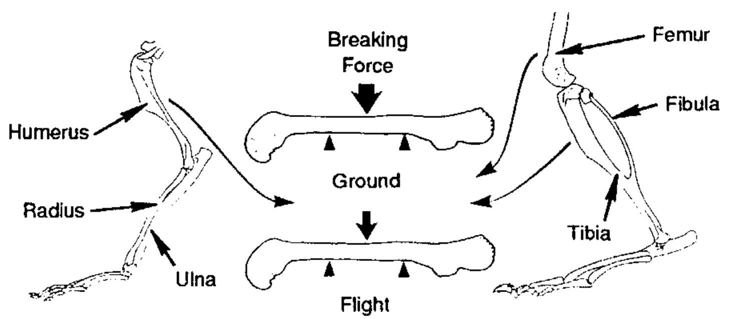


The PARE Configuration



Bone Structure

- A bone marker is used to measure the amount of bone growth in the rats' legs during the flight. The area between the marker and outer bone surface shown in the cross section indicates the amount of growth.
- Ground control animals form about 45% more bone than the flight animals during the same period of time.
- Changes in the bones' blood vessels and structure may cause changes in strength. The surface blood vessels appear clogged with debris and deposits of lipids, minerals may form smaller crystals, and collagen may be disorganized.



Bone Strength

- Although the humerus, femur, and tibia of the flight animals are about the same size as the ground control animals', significantly less force is required to break the flight animals' bones.
- Evidence also suggests that the bone formed during flight does not add to the strength of the bone.

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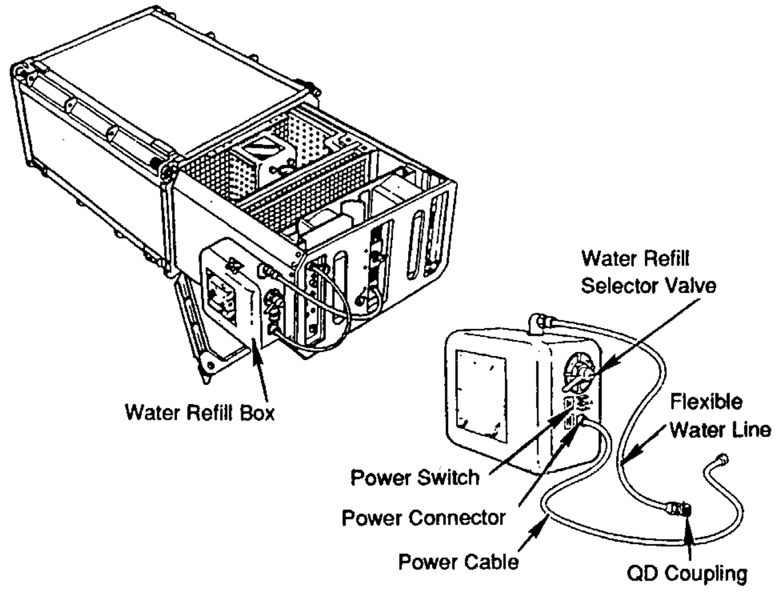


Water Refill Box Assembly

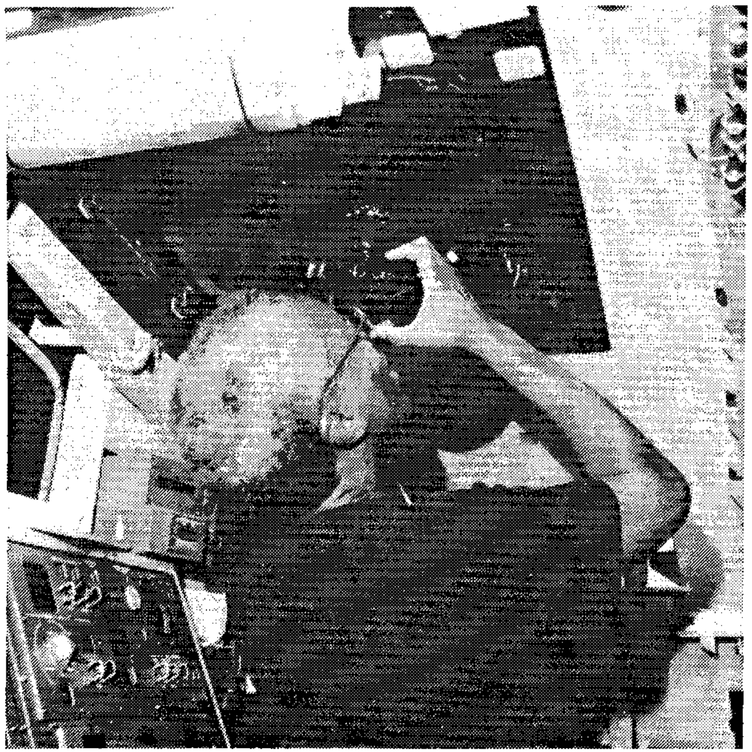
For these experiments, rodents will be placed in individual housings in an animal enclosure module (AEM) and will be monitored daily by the crew through a window in the AEM during AEM light cycles. The AEM is designed so that crew members will not have to come into direct contact with the animals. A log of daily animal health observations will be maintained. Photographs will also be taken. No testing will be performed on the animals during flight. The rodents will have constant access to both food and water.

Housekeeping tasks will include observing that the AEM fans are operating, checking that the air inlet slots are unobstructed, and checking the lights. If the light timer fails, crew activity will be required to override the light cycle. The PARE payload requires 28 volts of dc power and weighs approximately 70 pounds. The AEM hardware has been successfully tested on previous shuttle flights.

This study is managed by NASA's Ames Research Center, Mountain View, Calif. The project is sponsored by the Life Sciences Division of NASA's Office of Space Science and Applications.

HAND-HELD, EARTH-ORIENTED, REAL-TIME, COOPERATIVE, USER-FRIENDLY, LOCATION-TARGETING, AND ENVIRONMENTAL SYSTEM (HERCULES)

HERCULES is a device that makes it simple for shuttle crew members to take pictures of Earth: they just point and shoot any interesting feature, whose latitude and longitude are automatically determined in real time.



Astronauts Point HERCULES Camera Through Orbiter's Overhead Window To Obtain Bearings and Photograph Earth

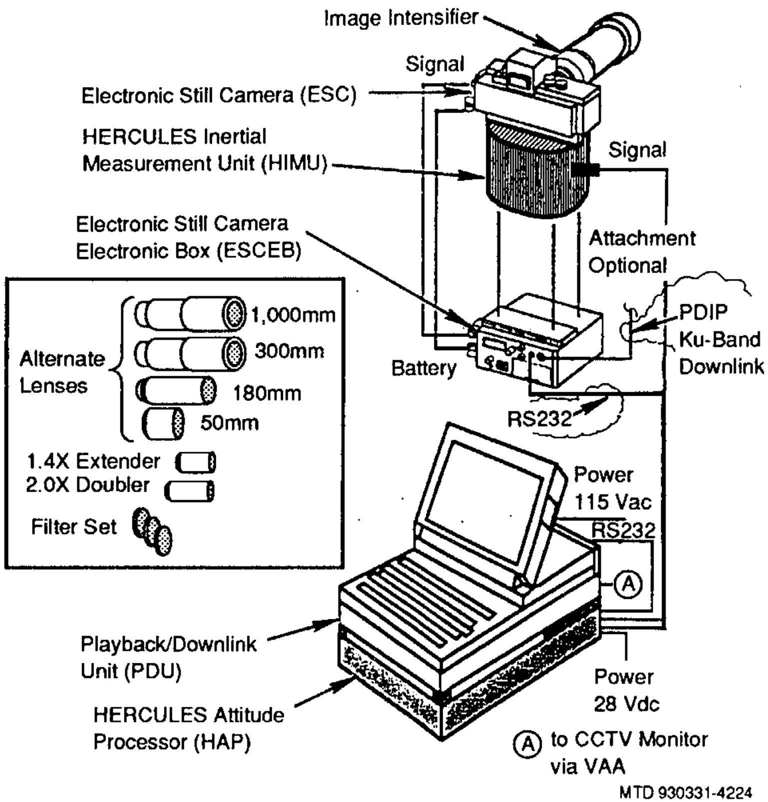
The camera system was first flown on STS-53 in December 1992. Although the images and geolocation data obtained on STS-53 are still being studied, geolocation accuracies of about three nautical miles have been achieved.

The system components—HERCULES attitude processor (HAP); alignment, geolocation, and human interface software; and ring-laser gyro—are attached to a modified Nikon F-4 electronic still camera (ESC). To activate the system in space, a crew member points the camera, with its attached gyro, at two known stars to obtain the bearing and enters state vectors, star identifications, and commands into a portable computer connected to the HAP. Then pictures are taken in the normal way, by aiming at Earth and operating the shutter.

The HAP processes the data from the gyro, determines the image's absolute orientation in space, and passes this pointing information to software operating on the portable computer, which calculates the latitude and longitude. The HAP sends this geolocation information back to the camera, which appends it to the image data. Images and geolocation data are stored in the ESC for analysis after the mission, but they can also be transmitted to the Mission Control Center for real-time analysis.

HERCULES will greatly simplify picture-taking on board the shuttle. It is a big improvement over the previous system, which required the crew to take multiple shots of the same subject while keeping the edge of the Earth in view. With HERCULES, the crew can use any Nikon-compatible lens for daytime photography and an image intensifier at night. Even areas of the Earth that have no distinguishing topographical features can be photographed and geolocated at any magnification. Since the images are captured digitally, computers can analyze them and disseminate the data—an important improvement over the previous system.

The Naval Research Laboratory (NRL) in Washington, D.C., developed HERCULES under a joint Navy, Army, and NASA project. Already, NRL scientists are working on future improvements for HERCULES, such as the addition of Global Positioning System hardware to enhance geolocation accuracy to less than a nautical mile and a gimbal system that would allow the camera to track points on Earth automatically.



HERCULES Configuration

SPACE TISSUE LOSS 3

When gravity is reduced or eliminated, as it is in space travel, life systems degrade at a remarkable rate. The Space Tissue Loss (STL) life sciences payload studies cell growth during space flight, specifically the response of muscle, bone, and endothelial and white blood 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 stimulants, hormones, and drugs on these parameters.

STL will help scientists understand more about how white cells respond to antigens from infectious agents and tumors. It will also show how space flight can cause a tremendous loss of calcium and minerals from bones and find ways to prevent or minimize bone failure in space and on Earth. Findings from tests of muscle disintegration could yield more information about similar muscle failure that occurs in forms of muscular dystrophy and the loss of muscle mass after severe injury, prolonged bed rest, and aging.

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 reducing the need for physical therapy and more rapid return to activity following injury.

On this mission, researchers will attempt to reproduce and verify the changes in the function of cells that were seen when the STL experiment was flown on STS-45 and STS-53. They will study the cells after the flight for an extended period of time and will determine the validity and applicability of their cellular model by comparing the results of the STL-3 experiment with changes noted in animals exposed to microgravity.

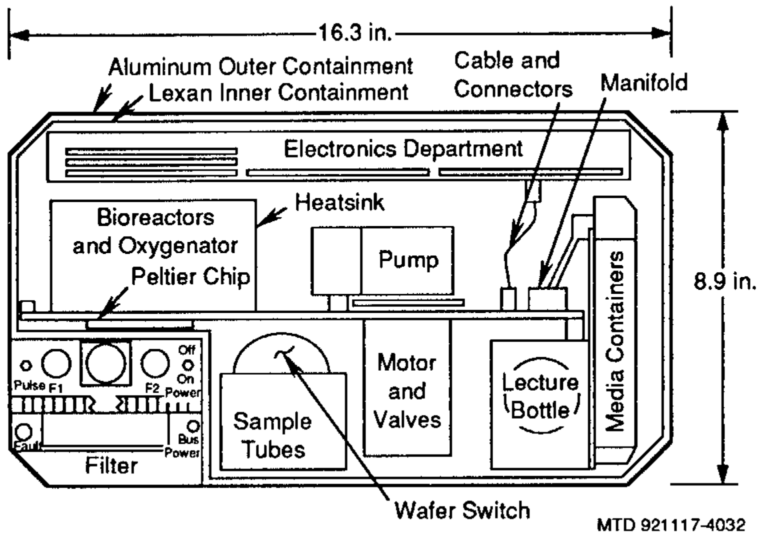
On the two previous flights of the STL experiment, researchers found evidence that microgravity causes the metabolism of bone-forming cells to change and impairs the mineralization of bone fibers, leading to a decrease in bone strength. After this eight-day mission, the investigators will determine the amount and type of bone products in the cells that were exposed to the space environment and will determine whether changes induced by space flight can be reversed.

The bone products found in the cell culture will also be compared to data obtained in the shuttle experiment involving live rats to see if the bones in the rats undergo changes like those in the bone cell cultures. Researchers hope that analyzing changes in the cells will help them determine whether the cellular changes trigger changes in the strength of bones.

The study of alterations in muscle cells during space flight will look into the previously noted inability of precursor cells exposed to microgravity to fuse to form muscle fibers. Although cells failed to fuse for 35 days after space flight, most of the changes in their function lasted hours or days in normal gravity conditions. Researchers believe that they may be able to speed up the recovery of muscle mass and strength in astronauts after space flight if these cells are fully functional during the repair process.

The STL research may also have application in the treatment of disorders that affect muscle tissue, such as muscular dystrophy. Blocking the natural fusion of muscle cells may allow satellite cells that contain desirable genetic properties to be produced for use as gene transplants in sufferers of Duchenne muscular dystrophy.

The payload, a cell culture device that replaces a standard locker double tray inside one standard 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.



Space Tissue Loss Assembly

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. The samples will be analyzed immediately after the landing.

The STL-3 experiment is sponsored by the Department of Space Biosciences at the Walter Reed Army Institute of Research, Washington, D.C., in conjunction with NASA's Life Sciences Division. It is being integrated with and flown on the shuttle under the direction of the DOD's Space Test Program.

Dr. George Kearney, research scientist at Walter Reed Army Institute of Research, is the principal investigator. Col. Bill Wiesmann, M.D., director of the Division of Surgery at WRAIR, is the program manager. Tom Cannon, of the WRAIR Department of Space Biosciences, is the project manager. The three are supported by collaborative partners at WRAIR, the Armed Forces Institute of Pathology, NASA's Ames Research Center, the University of Louisville Medical School, and a DOD Space Test Program team of personnel from the Air Force, Aerospace Corporation, and Rockwell International.

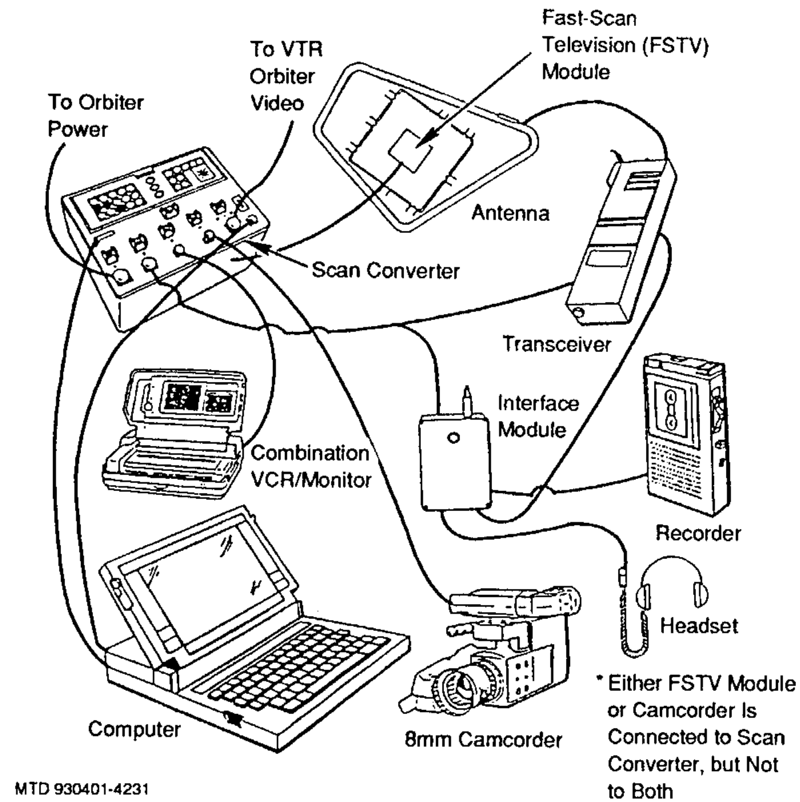
The Shuttle Amateur Radio Experiment (SAREX) was established by NASA, the American Radio Relay League/Amateur Radio Satellite Corporation, and the Johnson Space Center Amateur Radio Club to encourage public participation in the space program through a program to demonstrate the effectiveness of conducting shortwave radio transmissions between the shuttle and ground-based amateur radio operators at low-cost ground stations with 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, -35, -37, -45, -50, and -47 in different configurations. A modified configuration D will be flown on STS-56. The equipment complement is stowed in one and one-half middeck lockers.

SAREX communicates with amateur stations within Discovery'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.

During the mission, SAREX-II will be operated at the discretion of four crew members who are licensed amateur radio operators: Ken Cameron (call sign N5AWP), Ken Cockrell (KB5UAH), Mike Foale (KB5UAC), and Ellen Ochoa (KB5TZZ).

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.



SAREX-II Configuration

Because of this mission's high-inclination orbit, ham radio operators from northern Canada to southern Australia will be able to hear SAREX when the shuttle passes overhead.

Ham operators may communicate with the shuttle by using 2-meter digital packet and VHF FM voice transmissions, a mode that makes contact widely available without the purchase of more expensive equipment.

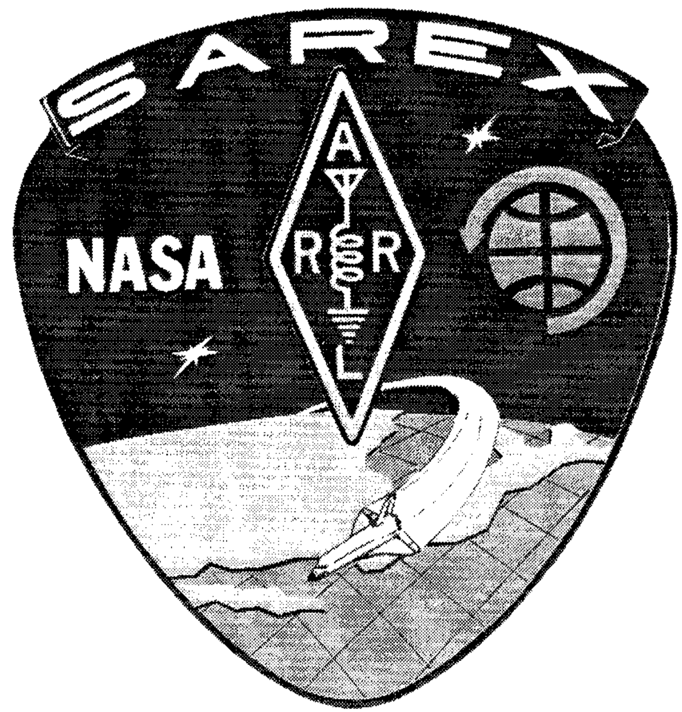
The primary voice and packet frequencies intended for use during the mission are 145.55 MHz for downlink from Discovery and 144.95 MHz for uplink.

Information about orbital elements, contact times, frequencies, and crew operating schedules will be available during the mission from NASA, ARRL, AMSAT, and other amateur radio clubs at other NASA centers.

The ham radio club at JSC (W5RRR) will be operating on amateur shortwave frequencies, and the ARRL station (W1AW) will include SAREX information in its regular voice and teletype bulletins.

SAREX information may be obtained during the mission from the sponsoring groups, NASA JSC's Public Affairs Office, and amateur radio clubs at other NASA centers. SAREX information may also be obtained from the Johnson Space Center computer bulletin board (JSC BBS), 8 N1 1200 baud, by dialing (713) 483-2500 and then typing 62511.

The amateur radio station at the Goddard Space Flight Center (WA3NAN) will operate around the clock during the mission, providing information and restransmitting live shuttle air-to-ground audio.



SAREX Insignia

AIR FORCE MAUI OPTICAL SITE (AMOS) CALIBRATION TEST

The AMOS tests allow ground-based electro-optical sensors located on Mt. Haleakala in Maui, Hawaii, to collect imagery and/or signature data of the space shuttle orbiters during cooperative overflights. Cooperative overflights are defined as those planned times when AMOS test conditions can be met and the STS mission timeline and propellant budget permit the requested orbiter activities to be performed.

This experiment is a continuation of tests made during the STS-29, -30, -34, -32, -31, -41, -35, -37, -43, -48, -44, and -49 missions. The scientific observations of the orbiters during those missions consisted of reaction control system thruster firings and water dumps or activation of payload bay lights. They were used to support the calibration of the AMOS ground-based infrared and optical sensors, using the shuttle as a well-characterized calibration target, and to validate spacecraft contamination models through observations of contamination/exhaust plume phenomenology under a variety of orbiter attitude and lighting conditions.

No unique on-board hardware is associated with the AMOS test. Crew and orbiter participation may be required to establish the controlled conditions for the Maui overflights. AMOS is being flown as a payload of opportunity and will be conducted if crew time permits.

The AMOS facility was developed by the Air Force Systems Command through its Rome Air Development Center at Griffiss Air Force Base, N.Y. It is administered and operated by the AVCO Everett Research Laboratory on Maui. The principal investigators for the AMOS tests on the space shuttle are from AFSC's Air Force Geophysical Laboratory at Hanscom Air Force Base, Mass., and AVCO.

Flight planning and mission support activities for the AMOS test opportunities are performed by a detachment from AFSC's Space Systems Division at the Johnson Space Center in Houston. Flight operations are conducted at the JSC Mission Control Center in coordination with the AMOS facilities in Hawaii.

COSMIC RADIATION EFFECTS AND ACTIVATION MONITOR (CREAM)

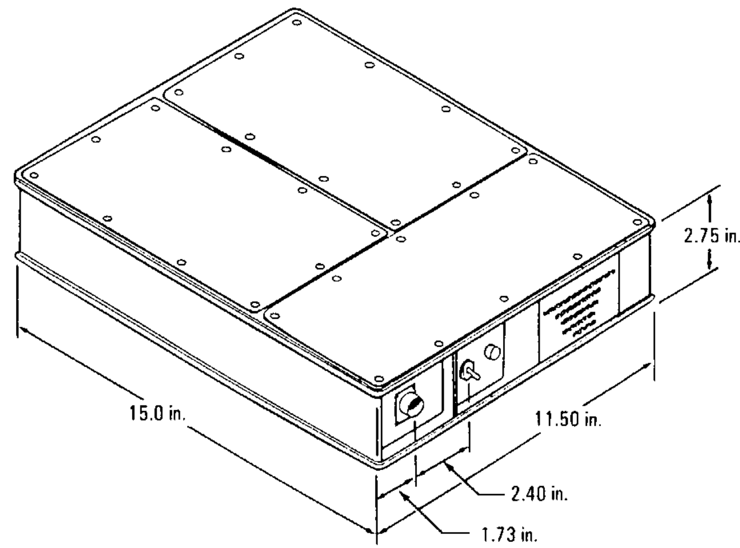
CREAM is designed to collect data on cosmic ray energy loss spectra, neutron fluxes, and induced radioactivity. The data is collected as a function of geomagnetic coordinates and detector location within the orbiter.

The CREAM data will be collected by active and passive monitors placed throughout the orbiter's cabin. CREAM data will be obtained from the same locations that will be used to gather data for the Radiation Monitoring Equipment experiment in an attempt to correlate the two experiments' data.

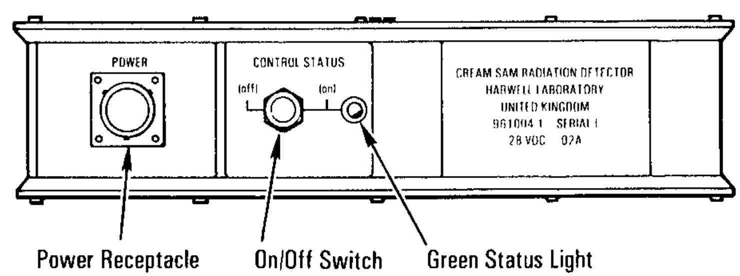
This is the fourth flight for this experiment. On previous flights, CREAM provided important information on the buildup of secondary radiation with increased shielding and identified a new region of trapped radiation over the South Atlantic.

The CREAM payload flight hardware consists of an active cosmic ray monitor, a passive sodium iodide detector, and up to five passive foil detector packages. The active monitor will obtain real-time spectral data, and the passive monitors will obtain data integrated over the duration of the mission to be analyzed after the flight. A passive sodium iodide detector will be used as a control to obtain background data before launch. It will accompany the flight packages until the CREAM locker is installed in the middeck. The control package will rejoin the flight detector packages as soon as possible after the landing.

The CREAM active monitor is a box containing sensors, electrical power interface, and associated electronics and solid-state memory.



CREAM Active Monitor

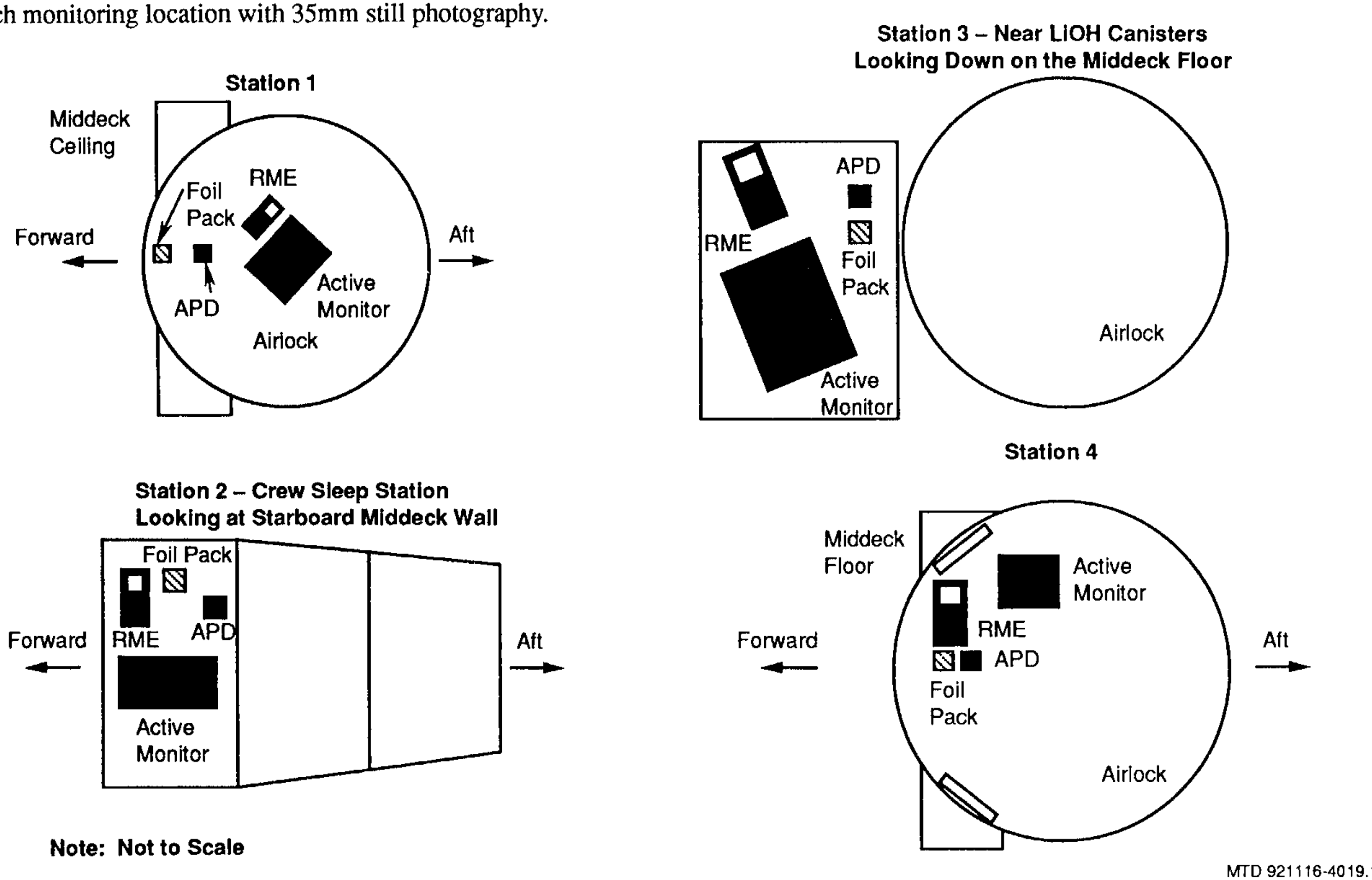


Detail of CREAM Active Monitor Front Panel

CREAM operates on 28 volts of dc power from the shuttle orbiter. It weighs approximately 48 pounds and is stowed in one middeck locker.

The payload will be unstowed and operated by the crew approximately 2-1/2 hours after launch. A crew member will be available at regular intervals to monitor the payload/experiment. The crew will be required to document the placement and setup of the payload in each monitoring location with 35mm still photography.

CREAM is sponsored by the Department of Defense. The experiment is provided by the United Kingdom Defense Research Agency, Farnborough, England. CREAM is being integrated with and flown on the space shuttle under the direction of the DOD's Space Test Program.



CREAM Detector Decal Locations

The Radiation Monitoring Equipment (RME) III microdosimeter will display and record the dose rate and total accumulated dosage of the STS-56 crew's exposure to ionizing radiation at different locations in Discovery's crew compartment. RME-III measures gamma ray, electron, neutron, and proton radiation and uses a tissue-equivalent proportional counter spatial ionization chamber radiation detector, which effectively simulates a target size of a few microns of tissue (the dimensions of a typical human cell) and calculates, in real time, exposure in RADS-tissue equivalent.

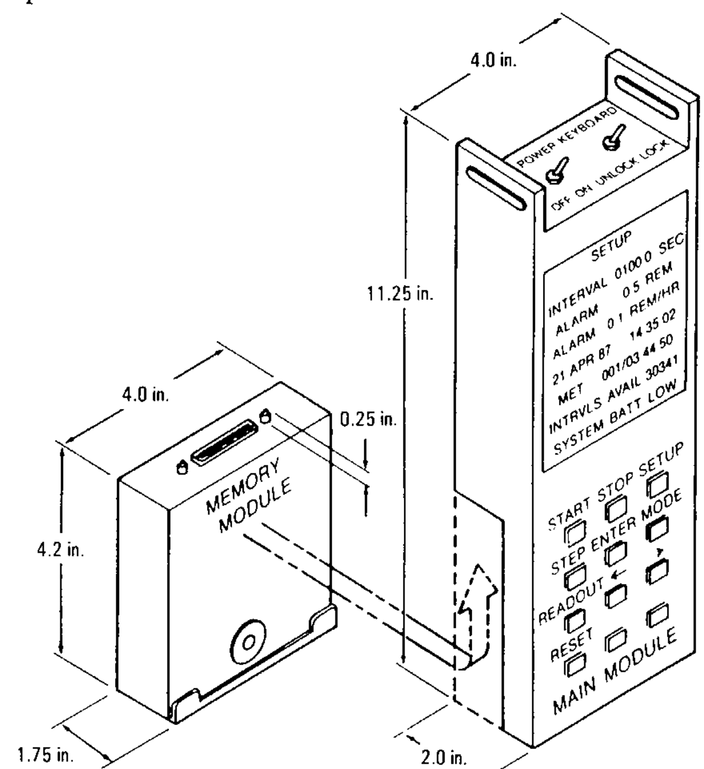
RME-III data is being archived and used to update and refine models of the space radiation environment in low Earth orbit. This will help space mission planners to more accurately assess risk and safety factors for future long-term space missions, such as space station Freedom. Next-generation instruments will be flown on Freedom and on future manned and unmanned missions to the moon, Mars, and beyond. RME-III is also being used to measure radiation exposure in high-altitude aircraft, such as the Concorde.

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 has been flown on 13 shuttle missions since STS-26. It replaces two earlier configurations. It has been flown in conjunction with other radiation experiments, such as the CREAM and Shuttle Activation Monitor. RME will be flown on several future shuttle missions.

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



RME Configuration

Entry aerodynamic control surfaces test (Part 5) (DTO 251). This DTO will perform preprogrammed test input (PTI) maneuvers and one body flap maneuver during entry and terminal area energy management (TAEM) to obtain aerodynamic response data for evaluating the effectivity of aerodynamic control surfaces. Analysis may enhance vehicle performance and safety. This DTO uses the alternate forward elevon schedule and contains six parts. This flight will fly Part 5, which contains the body flap maneuvers at Mach 16 to Mach 14 and Mach 5 to Mach 3.5.

Ascent wing structural capability evaluation (DTO 301D). The purpose of this DTO is to verify that the orbiter wing structure is at or near its design condition during lift-off and ascent with payloads near maximum weight. The DTO will determine flight loads and structural capability and will determine if any unacceptable dynamic effects exist.

Ascent compartment venting evaluation (DTO 305D). This DTO will collect data under operational conditions to validate/upgrade the ascent venting math model and verify the capability of the vent system to maintain compartment pressures within design limits.

Descent compartment venting evaluation (DTO 306D). This DTO will collect data under operational conditions to validate/upgrade the descent venting math model and verify the capability of the vent system to maintain compartment pressures within design limits.

Vibration and acoustic evaluation (DTO 308D). This DTO will obtain vibration and acoustic data during ascent to define the operational vibroacoustic input environment for payloads and the PDRS.

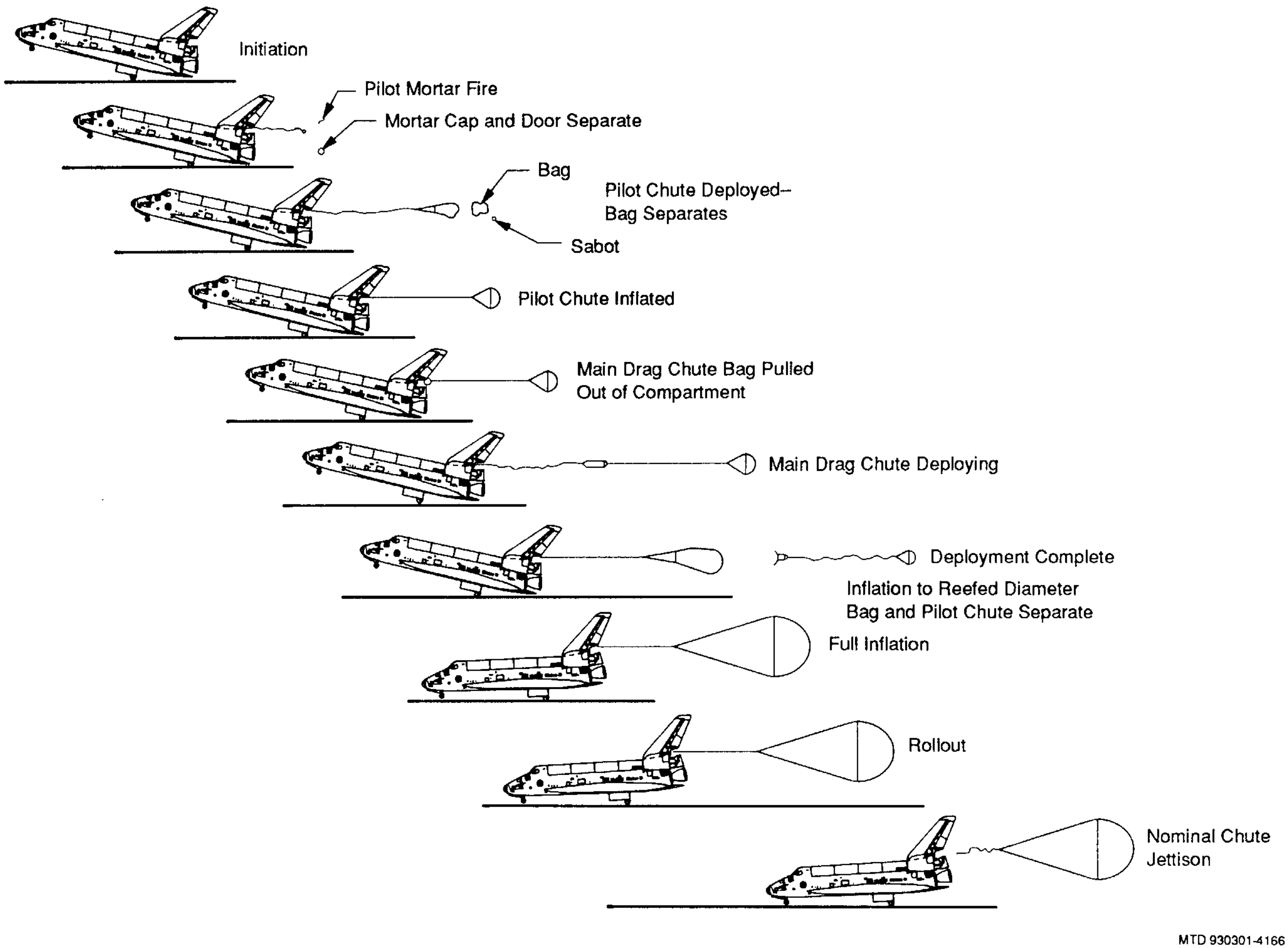
Orbiter/payload acceleration and acoustic environment data (DTO 319D). This DTO will obtain low-frequency (0 to 50 Hz) payload/orbiter interface data to develop computer prediction techniques to validate math models and forcing functions.

Edwards lakebed runway bearing strength and rolling friction assessment for orbiter landings (DTO 520). This DTO will evaluate the strength of the runways at the Edwards lakebed complex. Reduced bearing strength could cause high rolling coefficients with resultant orbiter nose gear exposure for heavy-weight, forward-center-of-gravity landings.

Orbiter drag chute system (DTO 521). This DTO will evaluate the orbiter drag chute system performance through a series of landings with increasing deployment speeds. The DTO will be performed on vehicles equipped to measure drag forces imposed by the drag chute system. This DTO has two phases. Phase I consisted of two flights, with the first drag chute deployment at nose gear touchdown (STS-49) and the second deployment at initiation of derotation. Now that Phase I testing is complete, the drag chute is cleared for deployment under the same conditions for subsequent missions. Phase II consists of seven additional flights, each flight gradually increasing in speed from initiation at derotation of 185 knots equivalent airspeed (KEAS) to 205 KEAS. Concrete runways will be used whenver possible.

Evaluation of the MK1 rowing machine (DTO 653). This DTO will evaluate the MK1 rowing machine as an alternative to the shuttle treadmill. The MK1 is expected to produce significantly less noise and vibration than the treadmill. Additionally, in-flight simulated rowing is anticipated to provide total body exercise, including aerobic and anaerobic conditioning.

PGSC single-event upset monitoring (DTO 656). This DTO will evaluate the payload and general-support computer's random-



Nominal Sequence of Drag Chute Deployment, Inflation, and Jettison access memory susceptibility to single-event upset cased by cosmic radiation. This information could lead to improved procedures, hardware, or software to reduce radiation effects.

Laser range and range rate device (DTO 700-2). The laser range and range rate DTO will demonstrate the capability to provide the orbiter flight crew with range and range rate data for rendezvous, proximity operations, and deployment operations. The DTO will assess the usefulness of the data in helping the pilot to achieve the desired trajectory conditions.

Crosswind landing performance (DTO 805). This DTO will continue to gather data for a manually controlled landing with a crosswind.

Frequency interference measurement (DSO 321). The Department of Defense has requested that NASA abandon the use of the present extravehicular activity and wireless crew communications system (WCCS) frequency bands. The National Telecommunications and Information Administration (NTIA) has recommended the use of frequencies in the 400- to 470-MHz band for EVA communications. The on-orbit interference levels in this band are unknown and may affect the performance of hardware to be developed for EVA communications and the WCCS. A spectrum analysis will be used to collect data in the recommended frequency band to determine the optimum EVA and WCCS frequencies and to determine whether interference mitigation circuitry must be included in the EVA and WCCS hardware. Data collection over European airspace is desired.

Human lymphocyte locomotion in microgravity (DSO 322). The data collected by DTO 322 will be used in the study of the effect of long-term weightlessness on the immune system. Specifically, DSO 322 will collect data on the locomotion and migration of human lymphocytes through intercellular matrix. The DSO will additionally test the rotating wall vessel and the specimen temperature controller.

In-flight radiation dose distribution (DSO 469). This DSO will provide data to establish, evaluate, and verify analytical and measurement methods for assessing and managing health risks from exposure to space radiation.

In-flight aerobic exercise (DSO 476). The objectives of this DSO are to document the effects of daily aerobic exercise on (1) protection of left ventricular dimensions, (2) postflight orthostatic function, and (3) the rate at which these factors return to their preflight baseline values after the flight. In addition, the effects of regular aerobic exercise on the maintenance of aerobic power and economy will be determined.

Inter-Mars tissue equivalent proportional counter (ITEPC) (DSO 485). The purpose of this DSO is to demonstrate the ability of hardware to withstand the radiation environment of space flight in preparation for the Mars '94 mission and to demonstrate the expanded capability of experiment software over the previously flown middeck TEPC. In addition, the experiment will gather key data on the radiation environment for future EVA and single-event upset data that affect the orbiter's hardware. This experiment will be flown on an adaptive payload carrier and is mounted on the starboard side of bay 2. It consists of a spectrometer, radiation detector, and support electronics. The equipment is activated by a barometric pressure switch and requires no crew involvement.

Measurement of formaldehyde using passive dosimetry (DSO 488). DSO 488 consists of personal and area samples that will be used to measure formaldehyde levels on board the shuttle to establish baseline levels and to evaluate potential risks to crew health and safety from exposure to this chemical. Formaldehyde air samplers will be placed throughout the middeck and will be worn by crew members.

Orthostatic function during entry, landing, and egress (DSO 603B*). Heart rate and rhythm, blood pressure, cardiac output, and peripheral resistance of crew members will be monitored during entry, landing, seat egress, and orbiter egress in order to develop and assess countermeasures designed to improve orthostatic tolerance upon return to Earth. This 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

*Indicates EDO buildup medical evaluation DSO be used to determine the effectiveness of proposed in-flight countermeasures. Crew members will don the equipment before putting on their launch and entry suits during deorbit preparation. Equipment consists of a blood pressure monitor, accelerometers, an impedance cardiograph, and transcranial Doppler hardware. The crew members record verbal comments throughout entry. This will be flown as a DSO of opportunity.

Posture equilibrium control during landing and egress (DSO 605*). This DSO will quantify the effects that in-flight neurosensory adaptations to zero-g have on postflight control of postural equilibrium.

Evaluation of functional skeletal muscle performance following space flight (DSO 617*). The purpose of this DSO is to determine the physiological effect of long-duration space flight on skeletal muscle strength, endurance, and power. Specific objectives are (1) to evaluate the concentric and eccentric functional changes before and after flight for the trunk and upper and lower limbs and (2) to determine the etiology of neuromuscular dysfunction as measured by EMG. The rationale for the DSO is that altered motor function and control resulting from the muscular deconditioning associated with adaptation to weightlessness could have negative implications for the effective completion of many operational tasks, including landing and egress. Isokinetic testing and different velocities are used to assess skeletal muscle integrity at different rates of tension and functional speeds. Velocity spectrum testing can provide a valuable means of identifying functional deficits in the musculoskeletal system. Additionally, it will provide knowledge necessary to support the development of future countermeasure prescriptions essential for nominal performance. On-orbit activities consist of maintaining an exercise log.

Pre- and postflight measurement of cardiorespiratory responses to submaximal exercises (DSO 624*). A smaller decline between pre- and postflight aerobic capacity has been detected in individuals who perform regular in-flight aerobic activity. To assist in the development of optimal exercise prescriptions, assigned crew members will maintain a log of exercise activities.

Cardiovascular and cerebrovascular responses to standing before and after space flight (DSO 626*). The overall objective of this DSO is to characterize the integrated response of an arterial pressure control system to standing before and after space flight.

Educational activities (DSO 802). The first objective of this DSO is to produce educational products that will capture the interest of students and motivate them to pursue careers in science, engineering, and mathematics. These products will include video lessons approximately 20 minutes long with scenes recorded both on orbit and on the ground. The on-orbit video will be approximately one third of the finished video product. This DSO will support the videotaping of on-orbit educational activities performed by the flight crew as well as other educational activities that are deemed appropriate by the Educational Working Group and the flight crew. The second objective of this DSO is to support the live TV downlink of educational activities performed by the flight crew. Typically, these activities will be limited to one or two 30-minute live downlinks.

Documentary television (DSO 901). This purpose of DSO 901 is to provide live television transmissions or VTR dumps of crew activities and spacecraft functions, including payload bay views, shuttle and payload crew activities, in-flight crew press conference, and unscheduled activities. Telecasts are planned for communication periods with seven or more minutes of uninterrupted viewing time. The broadcast is accomplished using operational air-to-ground and/or operational intercom audio. VTR recording may be used when live television is not possible.

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 flight objectives. This DSO includes photography of payload bay activities, flight deck activities, middeck activities, and unscheduled activities. This photography provides a historical record of the flight as well as material for release to the news media, independent publishers, and film producers.

Documentary still photography (DSO 903). This DSO requires still photographs of crew activities in the orbiter, spacecraft functions, and mission-related scenes of general public and historical interest. Still photographs of exertior and interior scenes will be taken in 70mm and 35mm formats, respectively.

STS-56 PRELAUNCH COUNTDOWN

T - (MINUS) HR:MIN:SEC	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.
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.

T - (MINUS) HR:MIN:SEC	EVENT
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	Postingress software reconfiguration occurs.
02:00:00	Checking of the launch commit criteria starts at this time.
02:00:00	The ground launch sequencer (GLS) software is initialized.
01:50:00	The solid rocket boosters' (SRBs') hydraulic pumping units' gas generator heaters are turned on and the SRBs' aft skirt gaseous nitrogen purge starts.
01:50:00	The SRB rate gyro assemblies (RGAs) are turned on. The RGAs are used by the orbiter's navigation system to determine rates of motion of the SRBs during first-stage flight.
01:35:00	The orbiter accelerometer assemblies (AAs) are powered up.
01:35:00	The orbiter reaction control system (RCS) control drivers are powered up.

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

T - (MINUS) HR:MIN:SEC	EVENT
00:30:00	The gaseous nitrogen system for the orbital maneuvering system (OMS) engines is pressurized for launch. Crew compartment vent valves are opened.
00:26:00	The ground pyro initiator controllers (PICs) are powered up. They are used to fire the SRB hold-down posts, liquid oxygen and liquid hydrogen tail service mast (TSM), and ET vent arm system pyros at lift-off and the SSME hydrogen gas burn system prior to SSME ignition.
00:25:00	Simultaneous air-to-ground voice communications are checked. Weather aircraft are launched.
00:22:00	The primary avionics software system (PASS) is transferred to the BFS computer in order for both systems to have the same data. In case of a PASS computer system failure, the BFS computer will take over control of the shuttle vehicle during flight.
00:21:00	The crew compartment cabin vent valves are closed.
00:20:00	A 10-minute planned hold starts.
Hold 10 Minutes	All computer programs in the firing room are verified to ensure that the proper programs are available for the final countdown. The test team is briefed on the recycle options in case of an unplanned hold.

T - (MINUS) HR:MIN:SEC	EVENT
	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 on-board 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 on-board computers are dumped and compared to verify the proper on-board 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 on-board 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.

T - (MINUS) HR:MIN:SEC	EVENT
00:15:00	The OMS/RCS crossfeed valves are configured for launch.
	All test support team members verify they are "go for launch."
00:12:00	Emergency aircraft and personnel are verified on station.
00:10:00	All orbiter aerosurfaces and actuators are verified to be in the proper configuration for hydraulic pressure application. The NASA test director gets a "go for launch" verification from the launch team.
00:09:00	A planned 10-minute hold starts.
<u>Hold 10 Minutes</u>	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 <u>Counting</u>	The GLS auto sequence starts and the terminal countdown begins.

T - (MINUS) HR:MIN:SEC	EVENT
	From this point, the GLSs in the integration and backup consoles are the primary control until T-0 in conjunction with the on-board 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.
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).

T - (MINUS) HR:MIN:SEC	EVENT
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 on-board 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 on-board tanks so that a full load at lift-off is assured. This filling operation is terminated at this time.
00:02:30	The caution/warning memory is cleared.
00:01:57	Since the ET liquid hydrogen tank was filled, some of the liquid hydrogen has turned into gas. In order to keep pressure in the ET liquid hydrogen tank low, this gas was vented off and piped out to a flare stack and burned. In order to maintain flight level, liquid hydrogen was continuously added to the tank to replace the vented hydrogen. This operation terminates, the liquid hydrogen tank vent valve is closed, and the tank is brought up to a flight pressure of 44 psia at this time.
00:01:15	The sound suppression system will dump water onto the mobile launcher platform (MLP) at ignition in order to dampen vibration and noise in the space shuttle. The firing system for this dump, the sound suppression water power bus, is armed at this time.
00:01:00	The SRB joint heaters are deactivated.
00:00:55	The SRB MDM critical commands are verified.

T - (MINUS) HR:MIN:SEC	EVENT
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 on-board 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.
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.

T - (MINUS) HR:MIN:SEC	EVENT
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 on-board 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 on-board 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.

T - (MINUS) HR:MIN:SEC	EVENT
	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 on-board computers that they have a "go" for SSME start. The GLS retains hold capability until just prior to SRB ignition.
00:00:09.7	Liquid hydrogen recirculation pumps are turned off. The recirculation pumps provide for flow of fuel through the SSMEs during the terminal count. These are supplied by ground power and are powered in preparation for SSME start.
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 on-board computers command the three MPS liquid hydrogen prevalves to open. (The MPS's 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 on-board 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 on-board 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	EVENT
00:00:00	The two SRBs are ignited under command of the four on-board 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 on-board 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-56 MISSION HIGHLIGHTS TIME LINE

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, wings level.
0/00:00:19	Roll maneuver ends.
0/00:00:28	All three SSMEs throttle down from 100 to 70 percent for maximum aerodynamic load (max q).
0/00:00:58	Max q occurs.
0/00:01:02	All three SSMEs throttle to 104 percent.
0/00:02:06	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.
	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.
0/00:03:58	Negative return. The vehicle is no longer capable of return-to-launch site abort at Kennedy Space Center runway.
0/00:07:02	Single engine press to main engine cutoff (MECO).
0/00:08:26	All three SSMEs throttle down to 67 percent for MECO.
0/00:08:34	MECO occurs at approximate velocity 25,830 feet per second, 19 by 155 nautical miles (22 by 178 statute miles).
0/00:08:42	Zero thrust.
0/00:08:52	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

Editor's Note: This time line lists selected highlights only. For full detail, please refer to the NASA Mission Operations Directorate STS-56 flight plan, ascent checklist, postinsertion checklist, rendezvous, deorbit prep checklist, and entry checklist.

T + (PLUS) DAY/ HR:MIN:SEC	EVENT
	11 fps to the orbiter for ET separation, are first used.
	Orbiter/ET liquid oxygen/liquid hydrogen umbilicals are retracted.
	Negative Z translation is complete.
	In conjunction with this thrusting period, approximately 1,700 pounds of liquid hydrogen and 3,700 pounds of liquid oxygen are trapped in the MPS ducts and SSMEs, which results in an approximate 7-inch center-of-gravity shift in the orbiter. The trapped propellants would sporadically vent in orbit, affecting guidance and creating contaminants for the payloads. During entry, liquid hydrogen could combine with atmospheric oxygen to form a potentially explosive mixture. As a result, the liquid oxygen is dumped out through the SSME combustion chamber nozzles, and the liquid hydrogen is dumped out through the right-hand T-minus-zero umbilical overboard fill and drain valves.
	MPS dump terminates.
	APUs shut down.
	MPS vacuum inerting occurs.
	— Remaining residual propellants are vented to space vacuum, inerting the MPS.
	— 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.
0/00:37	OMS-2 thrusting maneuver is performed, approximately 2 minutes, 30 seconds in duration, at 253 fps, 159 by 161 nautical miles.
0/00:51	Commander closes all current breakers, panel L4.
0/00:53	Mission specialist (MS) seat egress.
0/00:54	Commander and pilot configure GPCs for OPS-2.
0/00:57	MS configures preliminary middeck.
0/00:59	MS configures aft flight station.
0/01:00	MS unstows, sets up, and activates PGSC.
0/01:04	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.

T + (PLUS) DAY/ HR:MIN:SEC	EVENT
0/01:18	If go for payload bay door operations, MS configures for payload bay door operations.
0/01:28	MS opens payload bay doors.
0/01:30	Commander loads payload data interleaver DFL.
0/01:33	Commander switches star tracker 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.
0/01:51	MS activates teleprinter (if flown).
0/01:53	Commander begins post-payload bay door operations and radiator configuration.
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.

T + (PLUS) DAY/ HR:MIN:SEC	EVENT
0/02:01	Pilot activates auxiliary power unit steam vent heater, panel R2, boiler controller/heater, 3 to A, power, 3 to ON.
0/02:07	Mission Control Center tells crew to "go for Spacelab activation."
0/02:10	Spacelab activation.
0/02:10	Commander configures vernier controls.
0/02:12	Commander, pilot configure controls for on orbit.
0/02:20	MS performs on-orbit initialization.
0/02:21	MS enables hydraulic thermal conditioning.
0/02:26	MS resets caution/warning (C/W).
0/02:28	Pilot plots fuel cell performance.
0/02:30	Ku-band antenna deployment.
0/02:40	Ku-band antenna activation.
0/02:50	Red team begins presleep activities.
0/03:10	Payload activation.
0/03:15	Priority Group B powerdown.

T + (PLUS) DAY/ HR:MIN:SEC	EVENT
0/03:20	Nodal shift.
0/03:35	Ku-band antenna deployment.
0/03:45	STL initialization.
0/04:30	TEPC setup—DSO 469.
0/04:30	AMOS.
0/04:30	DSO 322.
0/07:05	HERCULES unstow.
0/07:30	PARE operations.
0/07:40	SAREX setup.
0/08:00	SSBUV activation.
0/09:00	CREAM activation—Station 2 (sleep station).
0/09:15	RME activation.
0/09:20	Blue team begins presleep activities.
0/10:30	DSO 476.
0/10:30	Red team begins postsleep activities.
0/10:45	Blue team handover to red team.
0/11:05	Blue team begins sleep period.
0/12:35	SUSIM activation.

T + (PLUS) DAY/ HR:MIN:SEC	EVENT
0/14:30	MAS television.
0/15:30	CMIX operations.
0/18:00	DSO 321.
0/19:05	Blue team begins postsleep activities.
0/19:05	DSO 476.
0/19:50	DSO 476.
0/21:25	HERCULES image.
0/21:35	DSO 488.
0/21:55	HERCULES downlink.
0/22:00	SUVE activation.
0/22:05	DSO 476.
0/23:05	DSO 321.
0/23:15	Red team handover to blue team.
0/23:30	Red team begins presleep activities.
	MET DAY ONE
1/00:20	SAREX operations—Royal Gram School.
1/01:30	Red team begins sleep period.

T + (PLUS) DAY/ HR:MIN:SEC	EVENT
1/01:55	SAREX operations—Royal Gram School backup.
1/03:00	SAREX operations—FSTV pass 1.
1/06:25	SAREX operations—Unatego School.
1/07:00	PARE operations.
1/07:53	SUSIM alignment.
1/08:55	DSO 488.
1/09:30	Red team begins postsleep activities.
1/09:30	DSO 476.
1/10:05	SOLCON television.
1/10:20	SSBUV monitoring.
1/11:00	Blue team handover to red team.
1/11:15	Blue team begins presleep activities.
1/11:55	SUVE deactivation.
1/13:00	Blue team begins sleep period.
1/13:20	HERCULES observations.
1/16:30	CMIX photo/TV.
1/18:00	HERCULES observations.

T + (PLUS) DAY/ HR:MIN:SEC	EVENT
1/19:00	DSO 476.
1/19:10	ATMOS photo/TV.
1/20:00	HERCULES observations.
1/20:45	DSO 488.
1/21:00	Blue team begins postsleep activities.
1/21:00	DSO 476.
1/22:00	DTO 700-2.
1/22:45	Red team handover to blue team.

MET DAY TWO

2/00:00	Red team begins presleep activities.
2/00:00	HERCULES observations.
2/00:10	SAREX FSTV—pass 2.
2/00:25	SAREX operations—Sedbergh School.
2/00:50	RME III memory module replacement.
2/01:00	DTO 653.
2/02:00	Red team begins sleep period.
2/02:45	HERCULES observations.

T + (PLUS) DAY/ HR:MIN:SEC	EVENT
2/03:35	SAREX operations—Portugal school.
2/03:55	SAREX operations—S. Africa school.
2/04:15	HERCULES observations.
2/04:30	DSO 322.
2/06:00	HERCULES observations.
2/06:24	MAS photo/TV.
2/06:30	SAREX FSTV—pass 3.
2/06:50	PARE operations.
2/08:05	SAREX operations—Tishomingo School.
2/08:45	DSO 476.
2/09:40	SAREX—McWhirter School.
2/10:00	Red team begins postsleep activities.
2/10:00	DSO 476.
2/10:40	HERCULES image.
2/11:10	HERCULES downlink.
2/11:45	Blue team handover to red team.
2/12:00	Blue team begins presleep activities.
2/12:00	DSO 476.
2/13:00	HERCULES operations.
2/14:00	Blue team begins sleep period.
2/16:21	CMIX operations.
2/16:40	HERCULES observations.
2/19:00	HERCULES observations.
2/20:45	DSO 488.
2/21:00	Blue team begins postsleep activities.
2/21:00	DSO 476.
2/22:30	Red team handover to blue team.
2/22:45	Priority Group B powerup.
2/23:45	SPARTAN deploy.
2/23:50	SPARTAN grapple.
	MET DAY THREE
3/00:05	SPARTAN unberth.
3/00:15	DTO 700-2.
3/00:30	SPARTAN deridge 2.
3/00:55	SPARTAN separation 1 burn.
3/01:15	SPARTAN separation 2 burn.

T + (PLUS) DAY/ HR:MIN:SEC	EVENT
3/01:30	Red team begins presleep activities.
3/01:35	SPARTAN separation 3 burn.
3/02:00	Priority Group B powerdown.
3/02:30	DSO 476.
3/03:00	Red team begins sleep period.
3/03:20	AMOS.
3/04:00	SUVE activation.
3/06:40	SAREX—Lehigh School.
3/07:00	PARE operations.
3/08:15	SAREX operations—Armand Bayou School.
3/08:45	DSO 488.
3/10:20	SOLSPEC television.
3/11:00	Red team begins postsleep activities.
3/11:00	DSO 476.
3/12:45	Blue team handover to red team.
3/13:00	Blue team begins presleep activities.
3/13:25	SUVE deactivation.
3/13:50	HERCULES operations.

T + (PLUS) DAY/ HR:MIN:SEC	EVENT
3/14:30	Blue team begins sleep period.
3/16:30	CMIX operations.
3/16:30	AMOS television.
3/16:40	RME III memory module replacement.
3/16:45	HERCULES observations.
3/18:00	DSO 476.
3/20:00	HERCULES observations.
3/20:40	SAREX operations—Australian school.
3/21:00	DSO 488.
3/22:30	Blue team begins postsleep activities.
3/22:30	DSO 476.
3/22:50	SAREX FSTV—pass 4.
	MET DAY FOUR
4/00:10	Multiple axis RCS burn.
4/00:35	NPC.
4/01:00	Red team handover to blue team.
4/01:15	RCS burn.
4/01:40	NSR.

T + (PLUS) DAY/ HR:MIN:SEC	EVENT
4/01:50	DSO 321.
4/01:55	HERCULES observations.
4/02:00	Red team begins presleep activities.
4/02:31	AMOS.
4/02:35	SAREX operations—S. African school.
4/02:50	HERCULES observations.
4/03:50	RCS burn.
4/04:00	Red team begins sleep period.
4/04:15	NC1.
4/04:25	HERCULES observations.
4/04:30	DSO 476.
4/06:45	SAREX FSTV—pass 5.
4/07:30	PARE operations.
4/07:30	AMOS television.
4/08:15	SAREX operations—Bellingham school.
4/08:35	HERCULES observations.
4/09:25	HERCULES image.
4/09:50	SAREX operations—Parkway school.

T + (PLUS) DAY/ HR:MIN:SEC	EVENT
4/09:55	HERCULES downlink.
4/10:30	HERCULES observations.
4/11:00	Red team begins postsleep activities.
4/11:00	DSO 476.
4/11:20	RCS burn.
4/11:50	NC2.
4/12:00	Blue team begins presleep activities.
4/12:45	Blue team handover to red team.
4/13:00	HERCULES observations.
4/13:45	Blue team begins sleep period.
4/14:15	MAS television.
4/14:45	CMIX operations.
4/14:55	DSO 476.
4/16:30	HERCULES observations.
4/18:30	Priority Group B powerup.
4/20:05	SPARTAN rendezvous.
4/20:20	DTO 700-2.
4/20:30	Blue team begins postsleep activities.

T + (PLUS) DAY/ HR:MIN:SEC	EVENT
4/20:30	DSO 476.
4/20:50	NC3.
4/21:35	NH.
4/22:55	NCC.
4/23:15	Red team handover to blue team.
4/23:50	Ti.
	MET DAY FIVE
5/02:00	SPARTAN grapple.
5/02:00	SPARTAN berth.
5/02:30	Red team begins presleep activities.
5/02:50	Priority Group B powerdown.
5/04:30	HERCULES observations.
5/04:30	Red team begins sleep period.
5/04:30	DSO 476.
5/05:20	SAREX operations—pass 1 backup.
5/05:40	SUVE activation.
5/06:50	SAREX operations—Billings West High School.

T + (PLUS) DAY/ HR:MIN:SEC	EVENT
5/07:17	PARE operations.
5/08:25	SAREX operations—Laurel Middle School.
5/09:00	RME III memory module replacement.
5/09:20	SSBUV monitoring.
5/10:40	ACR television.
5/12:25	SUVE deactivation.
5/12:30	Red team begins postsleep activities.
5/12:30	DSO 476.
5/12:45	Blue team begins presleep activities.
5/13:45	Blue team handover to red team.
5/14:35	HERCULES observations.
5/15:00	Blue team begins sleep period.
5/17:25	DSO 321.
5/17:30	HERCULES observations.
5/19:20	SAREX operations—Australian school.
5/21:35	SAREX FSTV—pass 6.
5/21:45	DSO 488.

T + (PLUS) DAY/ HR:MIN:SEC	EVENT
5/21:52	MAS photo/television.
5/22:00	HERCULES observations.
5/22:50	HERCULES image.
5/23:00	Blue team begins postsleep activities.
5/23:00	DSO 476.
5/23:05	SAREX FSTV—pass 2 backup.
5/23:20	HERCULES downlink.
	MET DAY SIX
6/00:00	DSO 476.
6/00:50	DSO 321.
6/01:00	Red team handover to blue team.
6/01:15	FCS checkout.
6/02:35	HERCULES observations.
6/03:40	Crew press conference.
6/04:00	Red team begins presleep activities.
6/04:00	HERCULES observations.
6/05:30	SAREX FSTV; operations—pass 3 backup; Franklin Institute.
6/06:00	Red team begins sleep period.
6/07:00	SAREX operations—Laurel Middle School backup; Tishomingo School backup
6/07:40	PARE operations.
6/08:00	HERCULES observations.
6/08:30	SAREX operations—Bellingham School backup; Parkway School backup.
6/10:30	DSO 488.
6/11:00	DSO 476.
6/14:00	Red team begins postsleep activities.
6/14:00	DSO 476.
6/14:15	Blue team begins presleep activities.
6/15:00	Blue team handover to red team.
6/16:30	Blue team begins sleep period.
6/16:39	HERCULES observations.
6/21:20	HERCULES image.
6/21:40	SAREX FSTV—pass 4 backup.
6/21:50	HERCULES downlink.

T + (PLUS) DAY/ HR:MIN:SEC	EVENT
6/23:40	CMIX operations.
6/23:45	DSO 488.
	MET DAY SEVEN
7/00:10	HERCULES observations.
7/00:30	Blue team begins postsleep activities.
7/00:30	DSO 476.
7/02:05	RME III memory module replacement.
7/02:08	AMOS operations.
7/02:25	HERCULES observations.
7/03:30	Red team handover to blue team.
7/03:45	DSO 476.
7/03:45	HERCULES observations.
7/04:15	SUVE activation.
7/04:45	DSO 476.
7/05:30	HERCULES stow.
7/05:35	SAREX operations—Hudson School.
7/06:00	Red team begins presleep activities.
7/06:00	RMS powerdown.

T + (PLUS) DAY/ HR:MIN:SEC	EVENT
7/07:05	SAREX operations—Billings W. High School backup; Armand Bayou School backup; McWhirter School backup.
7/07:50	SUSIM television.
7/08:00	Red team begins sleep period.
7/08:00	PARE operations.
7/08:40	SAREX FSTV—pass 5 backup.
7/10:55	SSBUV television.
7/12:00	CREAM deactivation.
7/13:05	SAREX stow.
7/14:05	SUVE deactivation.
7/14:45	Blue team begins presleep activities.
7/16:00	Red team begins postsleep activities.
7/16:00	DSO 476.
7/16:15	Blue team handover to red team.
7/16:45	Blue team begins sleep period.
7/18:35	Priority Group B powerup.
7/19:05	DSO 469.
7/19:35	Cabin stow.

T + (PLUS) DAY/ HR:MIN:SEC	EVENT
7/21:30	SSBUV deactivation.
7/21:30	Payload deactivation.
7/23:00	Blue team begins postsleep activities.
7/23:00	DSO 476.
7/23:15	Spacelab deactivation.
	MET DAY EIGHT
8/00:20	DSO 603B.
8/00:50	RCS hot fire.
8/00:58	Begin deorbit preparation.
8/01:00	CRT timer setup.
8/01:03	Commander initiates cold soak.
8/01:12	Stow radiators, if required.
8/01:20	Ku-band antenna stow.
8/01:30	Commander configures DPS for deorbit preparation.
8/01:33	Mission Control Center updates IMU star pad, if required.
8/01:42	MS configures for payload bay door closure.

T + (PLUS) DAY/ HR:MIN:SEC	EVENT
8/01:53	MCC-H gives “go/no-go” command for payload bay door closure.
8/02:03	Maneuver vehicle to IMU alignment attitude.
8/02:18	IMU alignment/payload bay door operations.
8/02:41	MCC gives the crew the go for OPS 3.
8/02:48	Pilot starts repressurization of SSME systems.
8/02:52	Commander and pilot perform DPS entry configuration.
8/03:01	MS deactivates ST and closes ST doors.
8/03:03	All crew members verify entry payload switch list.
8/03:18	All crew members perform entry review.
8/03:20	Crew begins fluid loading, 32 fluid ounces of water with salt over next 1.5 hours (2 salt tablets per 8 ounces).
8/03:33	Commander and pilot configure clothing.
8/03:48	MS/PS configure clothing.
8/03:59	Commander and pilot seat ingress.
8/04:01	Commander and pilot set up heads-up display (HUD).

T + (PLUS) DAY/ HR:MIN:SEC	EVENT
8/04:03	Commander and pilot adjust seat, exercise brake pedals.
8/04:11	Final entry deorbit update/uplink.
8/04:17	OMS thrust vector control gimbal check is performed.
8/04:18	APU prestart.
8/04:33	Close vent doors.
8/04:37	MCC-H gives "go" for deorbit burn period.
8/04:43	Maneuver vehicle to deorbit burn attitude.
8/04:46	MS/PS ingress seats.
8/04:53	First APU is activated.
8/04:58	Deorbit burn.
8/05:01	Initiate post-deorbit burn period attitude.
8/05:05	Terminate post-deorbit burn attitude.
8/05:13	Dump forward RCS, if required.
8/05:21	Activate remaining APUs.
8/05:26	Entry interface, 400,000 feet altitude.
8/05:31	Automatically deactivate RCS roll thrusters.

T + (PLUS) DAY/ HR:MIN:SEC	EVENT
8/05:38	Automatically deactivate RCS pitch thrusters.
8/05:41	Initiate first roll reversal.
8/05:46	Initiate second roll reversal.
8/05:47	TACAN acquisition.
8/05:49	Initiate air data system (ADS) probe deploy.
8/05:50	Initiate third roll reversal.
8/05:52	Begin entry/terminal area energy management (TAEM).
8/05:52	Initiate payload bay venting.
8/05:53	Automatically deactivate RCS yaw thrusters.
8/05:57	Begin TAEM/approach/landing (A/L) interface.
8/05:57	Initiate landing gear deployment.
8/05:58	Vehicle has weight on main landing gear.
8/05:58	Vehicle has weight on nose landing gear.
8/05:58	Initiate main landing gear braking.
8/05:59	Wheel stop.

ABBREVIATIONS

A/G	air-to-ground
AG	airglow
AA	accelerometer assembly
ACS	active cooling system
ADS	air data system
AFB	Air Force base
A/L	approach and landing
AOS	acquisition of signal
APC	autonomous payload controller
APCS	autonomous payload control system
APU	auxiliary power unit
ASE	airborne support equipment
BFS	backup flight control system
CCD	charge-coupled device
CCDS	Center for the Commercial Development of Space
CDMS	command and data management subsystem
CMDS	Consortium for Materials Development in Space
COAS	crewman optical alignment sight
CRT	cathode ray tube
C/W	caution/warning
DACA	data acquisition and control assembly
DA	detector assembly
DC	detector controller
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
EDOMP	extended-duration orbiter medical project
EHF	extremely high frequency
ELV	expendable launch vehicle
EMP	enhanced multiplexer/demultiplexer pallet
EMU	extravehicular mobility unit
EOM	end of mission
EPS	electrical power system
ESC	electronic still camera
ESA	European Space Agency
ESS	equipment support section
ET	external tank
ETR	Eastern Test Range
EV	extravehicular
EVA	extravehicular activity
FC	fuel cell
FCP	fuel cell power plant
FCS	flight control system
FDF	flight data file
FES	flash evaporator system
FPA	fluid processing apparatus
fps	feet per second
FRCS	forward reaction control system
GAP	group activation pack
GAS	getaway special
GLS	ground launch sequencer
GN&C	guidance, navigation, and control
GPC	general-purpose computer
GSFC	Goddard Space Flight Center
HAINS	high-accuracy inertial navigation system
HRM	high-rate multiplexer