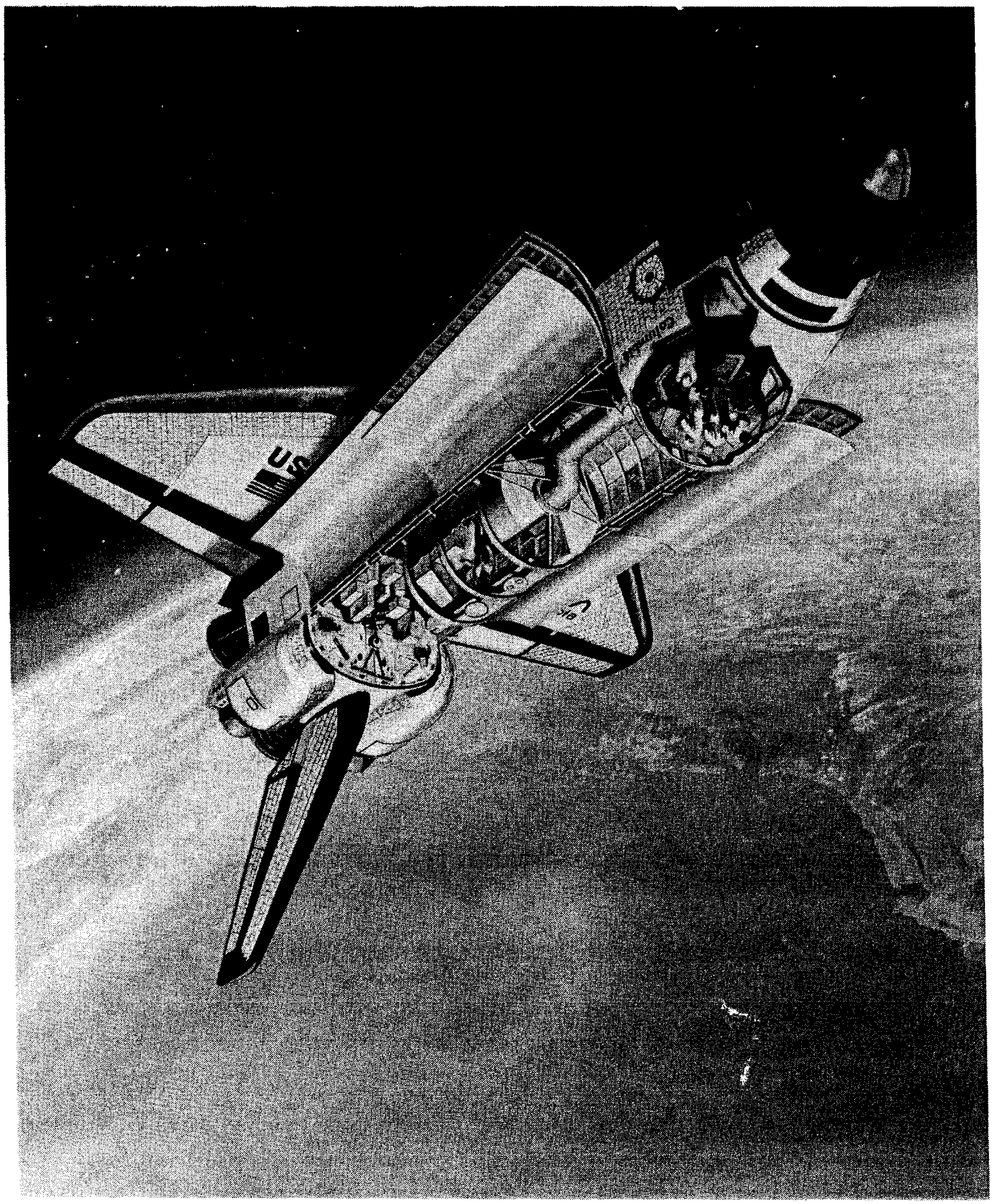

STS-9
PRESS
INFORMATION

November 1983

Rockwell International
Space Transportation &
Systems Group

Office of Public Relations

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PAGE

NEWS About Space Flight

...it comes from Rockwell International

The STS-9 flight of *Columbia* in its sixth flight into space will chalk up additional firsts — the first flight crew of six, the first Spacelab flight, the first continuous 24 hour payload operations in space and the first flight to use operationally, the Tracking and Data Relay Satellite System.

The flight crew of six are divided into two, three man teams. The teams have been designated RED and BLUE. The RED team consists of Commander John Young, Mission Specialist Robert Parker and Payload Specialist Ulf Merbold. The BLUE team consists of Pilot Brewster Shaw, Mission Specialist Owen Garriott and Payload Specialist Byron Lichtenberg.

Each team once on orbit is on duty for 12 hours each day. The Mission Specialist and Payload Specialist conduct payload operations eight and ten hours, respectively, per shift. The remaining time is allotted to contingency operations, lunch, handover, daily planning with the ground and post and pre sleep activities (PSA).

Since all flight crew members must be awake and alert on launch and entry days and with the 12 hour work day on orbit for payload operations requiring alternating eight hour sleep periods, all flight crew members will establish a circadian rhythm several days before launch to approximate their inflight scheduling on day two. This should minimize their inflight adjustment.

The RED team will begin their first eight hour sleep period approximately five hours after launch and the BLUE team approximately 14 hours after launch. The RED team will complete their last on orbit eight hour sleep period approximately 12 hours prior to landing and the BLUE team approximately four hours prior to landing.

STS-9 will be launched from Kennedy Space Center, Florida, and will land at Edwards Air Force Base, California.

The payload for STS-9 is the long pressurized Spacelab-1 (SL-1) module and a three meter (9.8 feet) pallet. The primary mission objectives of STS-9 are the verification of the SL system, subsystems performance capabilities, Spacelab *Columbia* and Spacelab/experiment compatibilities and to determine the SL induced environments. The experiments conduct on STS-9 in SL-1 and on the pallet represent plasma, solar, atmospheric physics, astronomy, earth observations, material science, life science, and technology.

Columbia's mid deck in STS-9 includes the first flight of the galley and the bunk type sleep stations.

The remote manipulator system is not installed on *Columbia* for STS-9.

There will be approximately 192 maneuvers of the *Columbia* during the STS-9 mission. This is equivalent to all the maneuvers performed in the first three flights plus half way through the fourth flight of *Columbia*. The vernier reaction control system (VRCS) engines will be used to accomplish the majority of these maneuvers in the STS-9 mission. The orbital maneuvering system propellants will be interconnected to the aft reaction control system to support these maneuvers in the flight.

THE SPACECRAFT THAT LANDS ON EARTH...

NEWS About Space Flight

...it comes from Rockwell International

STS-9 MISSION STATISTICS

Launch: Monday, November 28, 1983 — 11:00 A.M. E.S.T.
10:00 A.M. C.S.T.
8:00 A.M. P.S.T.

Mission Duration: 216 hours (9 days), 11 minutes

Landing: Wednesday, December 7, 1983 — 11:11 A.M. E.S.T.
10:11 A.M. C.S.T.
8:11 A.M. P.S.T.

Inclination: 57 degrees

SSME Throttling: 104 to 85 to 104 to 3 "g" limit to 65 percent

Spacecraft Altitude in Orbit: 135 nautical miles (155 statute miles)

Payload Weight "Up": Approximately 15,233 kilograms (33,584 pounds)

Payload Weight "Down": Approximately 15,233 kilograms (33,584 pounds)

Payload: Spacelab-1 plus Spacelab Pallet

Entry Angle of Attack: 40 degrees

Maximum Q (aerodynamic pressure): 699.2 pounds per square foot

Crew Members:
- Commander (CDR) John W. Young
- Pilot (PLT) Brewster A. Shaw
- Mission Specialist (MS) Robert Allen Ridley Parker
- Mission Specialist (MS) Owen K. Garriott
- Payload Specialist (PS) Byron K. Lichtenberg (USA)
- Payload Specialist (PS) Ulf Merbold European Space Agency (ESA), West Germany

Crew Seating: CDR, PLT and MS Robert Parker are on flight deck. MS Owen Garriott and both Payload Specialists are in the mid deck.

Crew Attire: Blue extravehicular activity (IVA) flight suits, helmets will be worn for launch and entry. Anti "g" (gravity) suit worn (lower extremity) for entry over IVA flight suit.

Cross Range: 688 nautical miles (791 statute miles)

Runway: Edwards Air Force Base (lakebed runway 17)

FLIGHT TEST AND MISSION OBJECTIVES

FLIGHT TEST

- External tank and solid rocket booster ascent performance
- External tank thermal protection system performance
- Solid rocket booster recovery
- Spacelab ascent environment verification
- Cabin atmosphere verification
- Tracking and Data Relay Satellite (TDRS) navigation test
- Ku-band communication link performance test No. 3
- On-orbit TACAN (Tactical Air Navigation) test
- Spacelab activation/transition tests
- Normal Spacelab heating test
- Spacelab controlled contamination monitoring deep space attitude
- Spacelab controlled contamination monitoring, half-orbit
- Spacelab cold thermal attitude test
- Spacelab hot thermal attitude test
- Spacelab command and data management system tests
- Spacelab habitability subsystem test
- Spacelab environment test
- Spacelab electrical power system validation
- Spacelab scientific airlock functional test
- Spacelab deactivation/transition verification
- Spacelab entry conditions response
- Spacelab on-orbit environment test
- Ten programmed test inputs (PTI's) at various dynamic pressure and Mach numbers during entry to precisely measure aerodynamic response to reaction control system and/or aerosurface inputs. This is a continuing test program for center of gravity envelope expansion and entry propellant usage
- Speed brake sweep between Mach 2.2 to 1.5 due to air surface separation at about Mach 1.8 occurring on previous flight
- Crosswind landing test (15 to 20 knots) if conditions available and will switch runways at Edwards Air Force Base, California to obtain or if no crosswind, will do nosewheel steering tests with *Columbia's* brakes

MISSION OBJECTIVES

- First high inclination launch of 57 degrees
- Longest mission to date
- First flight of European Space Agency (ESA) Spacelab
- First use of the bunk type sleeping stations and the galley in the mid-deck of *Columbia's* crew compartment
- Spacelab-1 Experiments

The Spacelab-1 payload is a joint NASA/European Space Agency (ESA) venture. ESA provides roughly one half the experiments and NASA the other half.

Spacelab-1 has a multidisciplinary payload of 73 experiments

Thirty eight of these are various materials science sample types that are processed in one of five different processing devices. The other thirty-five fit into one of seven science disciplines: atmospheric physics, space plasma physics, astronomy, solar physics, Earth observations, technology, and life sciences.

SOLID ROCKET BOOSTER AND EXTERNAL TANK CONFIGURATION

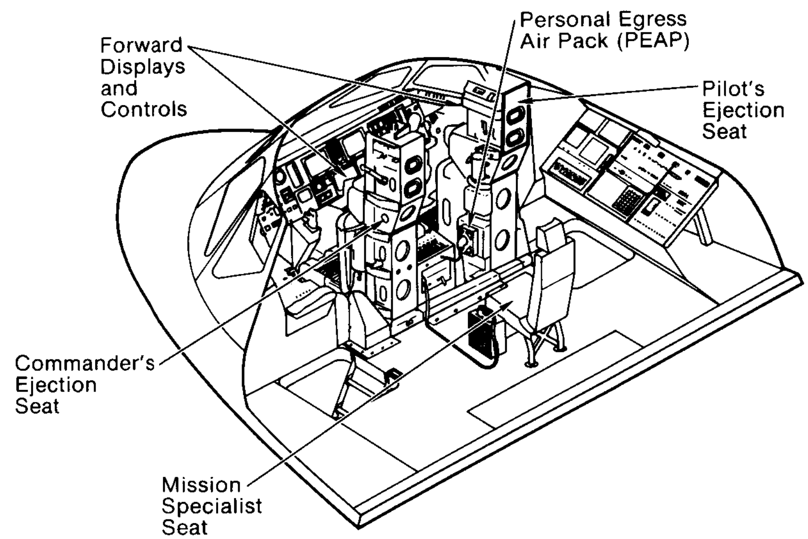
- **Solid Rocket Boosters**

  High performance solid rocket motors with light weight shaved casings. The high performance solid rocket motors increase the initial thrust by four percent, adding about 1,360 kilograms (3,000 pounds) to the Space Shuttle's payload carrying capability. The increase in thrust was achieved by lengthening the exit cone of the solid rocket motors nozzles by 254 millimeters (10 inches) and decreasing the solid rocket motors nozzles throat diameter by 101 millimeters (4 inches) which increases the velocity of the solid rocket motors gases as they exit through the nozzle. Also, some of the solid rocket motors propellant inhibitor used in the four motor segments in each solid rocket motor is omitted, thus causing the propellant to burn faster. These high performance motors will be used on future flights. The shaved light weight casings were first used in the STS-6 mission which reduced the weight of each solid rocket booster by 1,814 kilograms (4,000 pounds).

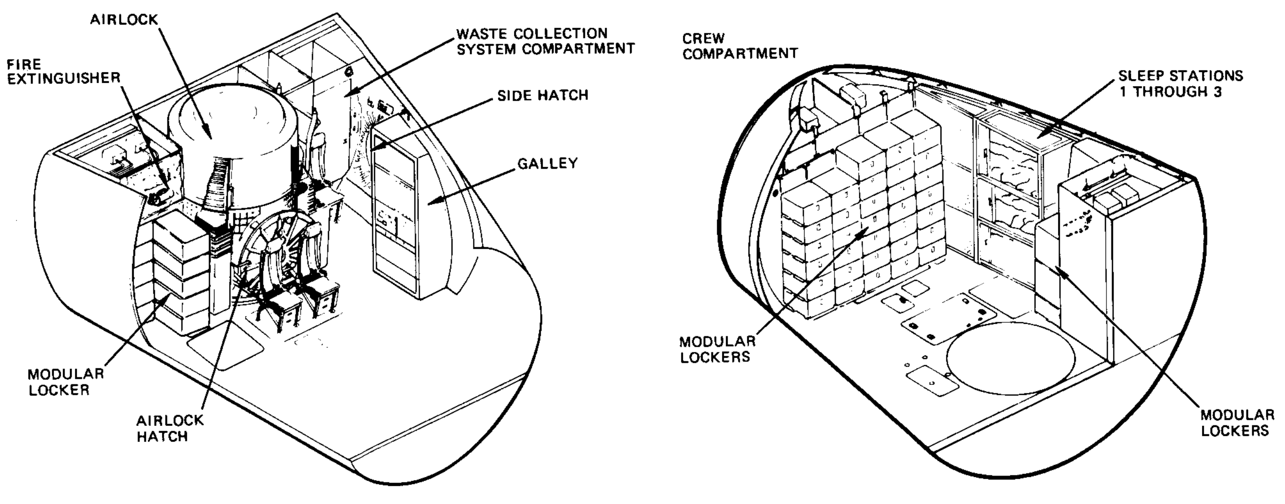
- **Lightweight External Tank**

  Weighs approximately 4,536 kilograms (10,000 pounds) less than the last heavy weight tank used in the STS-7 flight

COLUMBIA FLIGHT DECK AND MID DECK CONFIGURATION FOR STS-9

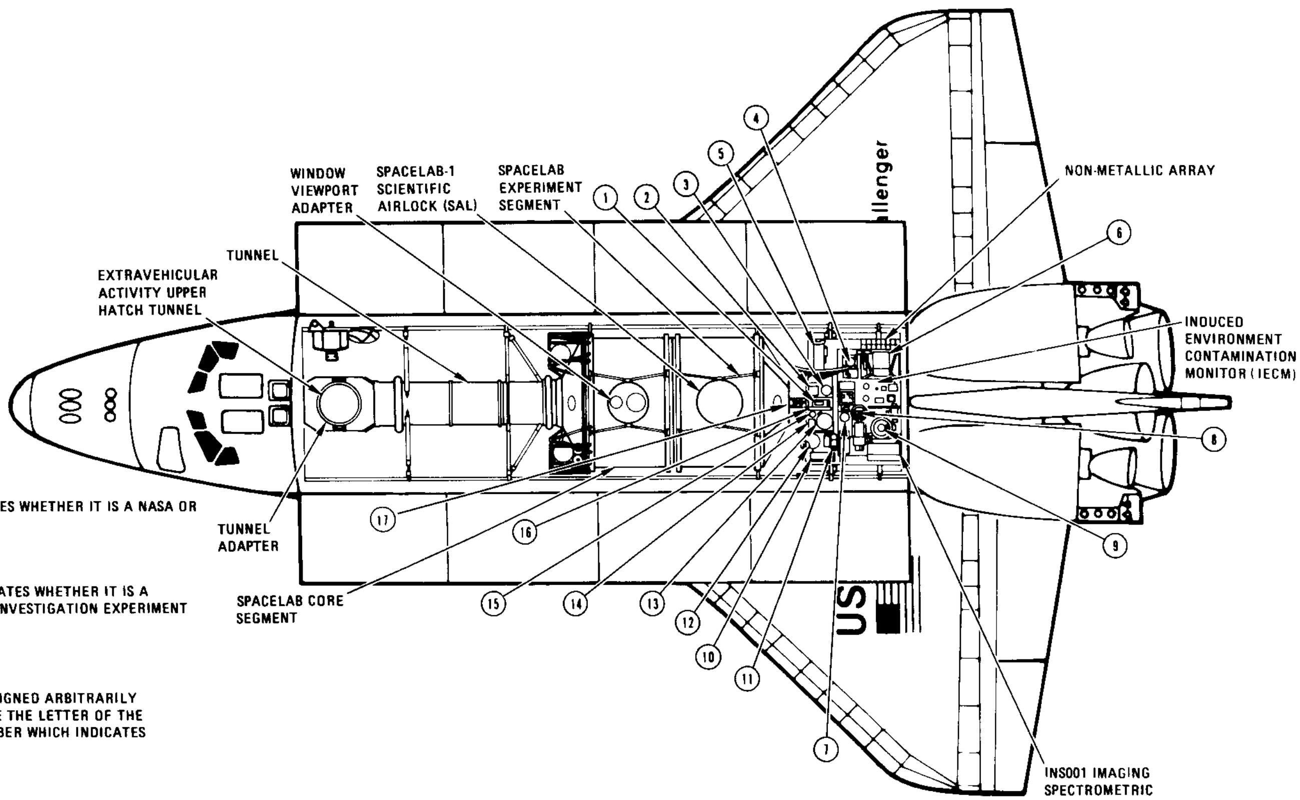


Orbiter 102 — STS-9 Crew Compartment Flight Deck



Orbiter 102 — STS-9 Mid Deck

STS-9 PAYLOAD CONFIGURATION



FIRST LETTER OF EXPERIMENT NUMBER INDICATES WHETHER IT IS A NASA OR A EUROPEAN SPACE AGENCY (ESA) EXPERIMENT

N - NASA SPONSORED EXPERIMENT
E - EUROPEAN SPONSORED EXPERIMENT

SECOND LETTER OF EXPERIMENT NUMBER INDICATES WHETHER IT IS A SCIENTIFIC, TECHNOLOGICAL OR APPLICATIONS INVESTIGATION EXPERIMENT

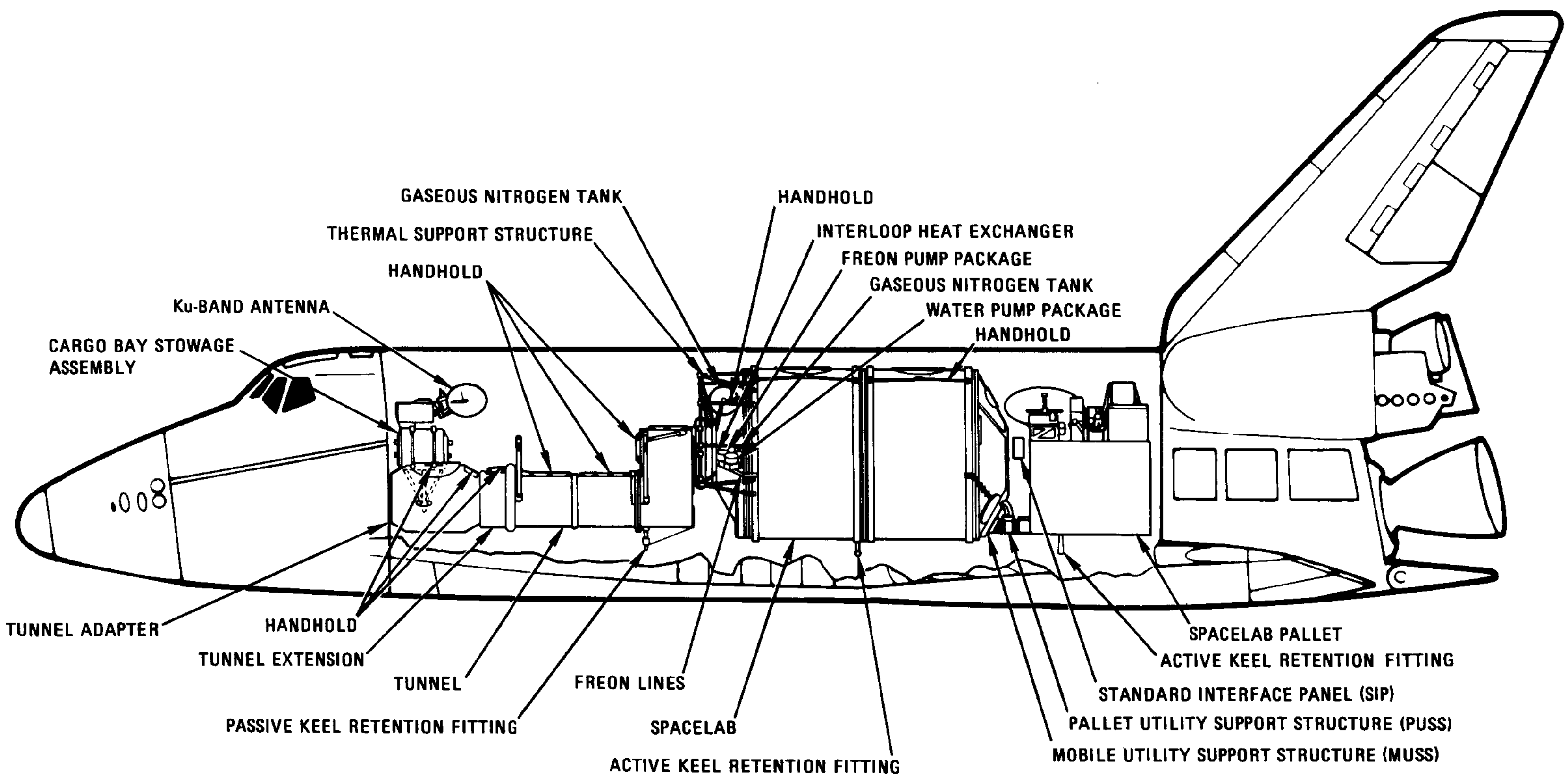
S - SCIENTIFIC
T - TECHNOLOGICAL
A - APPLICATIONS

LAST THREE NUMBERS OF EXPERIMENT ARE ASSIGNED ARBITRARILY SOMETIMES THERE IS A NUMBER ONE (1) BEFORE THE LETTER OF THE NORMALLY FIVE CHARACTER EXPERIMENT NUMBER WHICH INDICATES IT IS THE FIRST SPACELAB MISSION

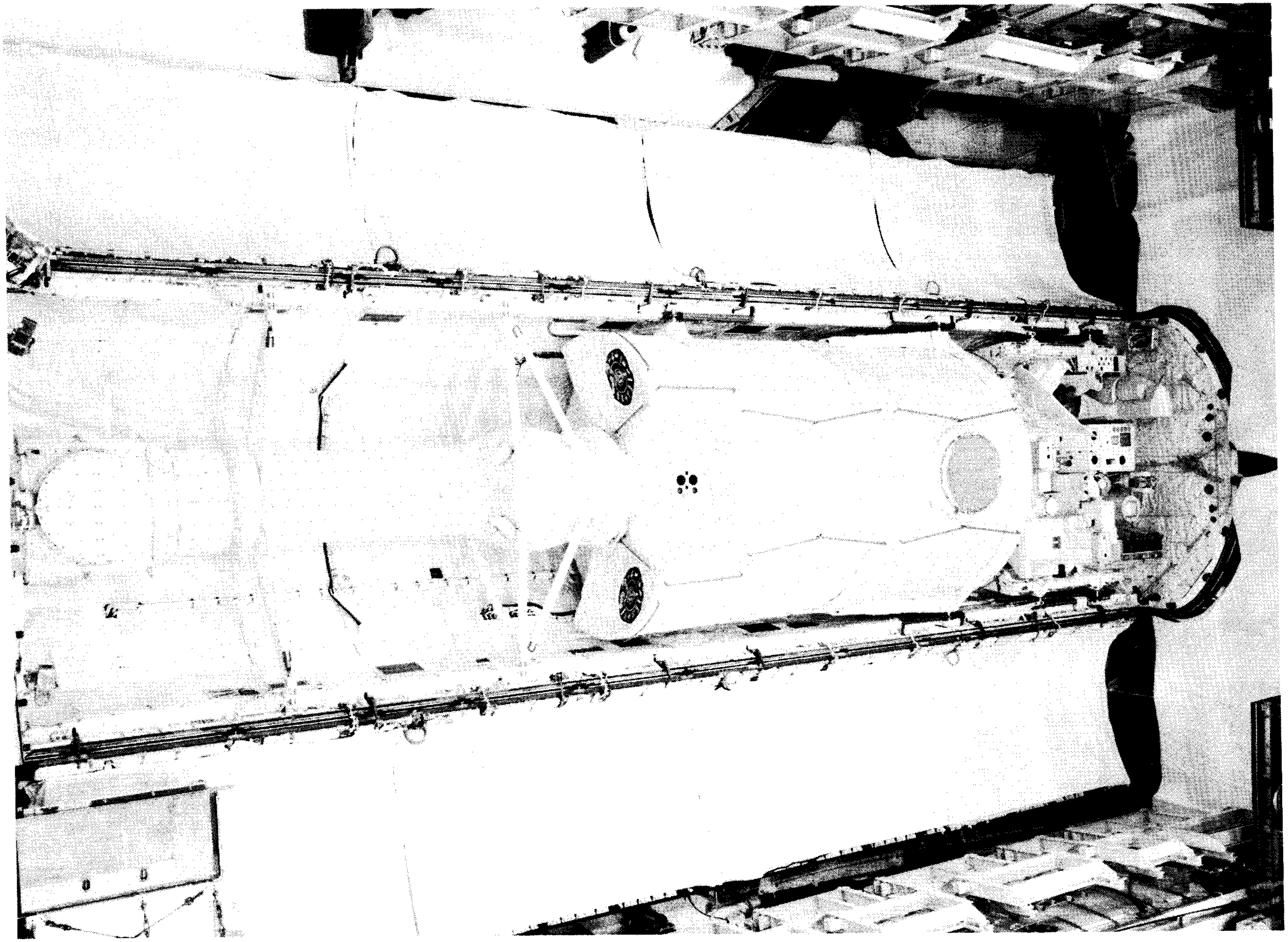
EXAMPLE - INS001

(1)	IES016	MEASUREMENT OF THE SOLAR SPECTRUM FROM 190 NAUTICAL MILES (218 STATUTE MILES) 400 NAUTICAL MILES (460 STATUTE MILES)
(2)	IES023	ASTRONOMICAL X-RAY SPECTROSCOPY USING A GAS SCINTILLATION PROPORTIONAL COUNTER
(3)	IES020	PHENOMENA INDUCED BY CHARGED PARTICLE BEAMS (PICPAB)
(4)	INS002	SPACE EXPERIMENTS WITH PARTICLE ACCELERATORS (SEPAC)
(5)	IEA034	MICROWAVE REMOTE SENSING FACILITY
(6)	IES013	GRILLE SPECTROMETER
(7)	INA008	ACTIVE CAVITY RADIOMETER SOLAR IRRADIANCE MONITOR
(8)	INS003	ATMOSPHERE EMISSIONS PHOTOMETRIC IMAGING (AEPI)
(9)	INS005	FAR ULTRAVIOLET ASTRONOMY - OBSERVATIONS USING THE FAUST TELESCOPE
(10)	IES017	INVESTIGATION ON ATMOSPHERE HYDROGEN (H) AND DEUTERIUM (D) THROUGH THE MEASUREMENT OF THEIR LYMAN-a EMISSION
(11)	IES014	WAVES IN THE OXYGEN HYDROGEN (OH) EMISSIVE LAYER
(12)	INS019	STUDY OF LOW ENERGY ELECTRON FLUX AND ITS REACTION TO ACTIVE EXPERIMENTATION ON SPACELAB
(13)	IES024	ISOTOPE STACK MEASUREMENT OF HEAVY COSMIC RAY ISOTOPES
(14)	IES029	MICRO-ORGANISMS AND BIOMOLECULES IN SPACE ENVIRONMENT
(15)	IES027	ADVANCED BIOSTACK EXPERIMENT
(16)	IES021	ABSOLUTE MEASUREMENT OF SOLAR CONSTANT
(17)		SPACELAB ELECTRICAL INTERFACE POWER AND SIGNAL

Top View


GASEOUS NITROGEN TANK
THERMAL SUPPORT STRUCTURE
HANDHOLD
Ku-BAND ANTENNA
CARGO BAY STOWAGE ASSEMBLY
HANDHOLD
INTERLOOP HEAT EXCHANGER
FREON PUMP PACKAGE
GASEOUS NITROGEN TANK
WATER PUMP PACKAGE
HANDHOLD
TUNNEL ADAPTER
HANDHOLD
TUNNEL EXTENSION
TUNNEL
FREON LINES
PASSIVE KEEL RETENTION FITTING
SPACELAB
ACTIVE KEEL RETENTION FITTING
SPACELAB PALLET
ACTIVE KEEL RETENTION FITTING
STANDARD INTERFACE PANEL (SIP)
PALLET UTILITY SUPPORT STRUCTURE (PUSS)
MOBILE UTILITY SUPPORT STRUCTURE (MUSS)

Side View



Spacelab in Columbia's Payload Bay

MODIFICATIONS TO *COLUMBIA* FOR STS-9 SPACELAB MISSION

1982

Dec. 20	Start Spacelab-1 modifications

1983

May 13	Install Forward Reaction Control System
May 16	Install Right Hand Orbital Maneuvering System/Reaction Control System pod
May 23	Post modification power up
June 8	Install Left Hand Orbital Maneuvering System/Reaction Control System pod
June 25	Install Space Shuttle Main Engine (SSME) No. 1
July 18	Install SSME No. 2
July 19	Install SSME No. 3
Aug. 16	Install Spacelab-1
Sept. 23	Transfer *Columbia* from Orbiter Processing Facility to Vehicle Assembly Building for mating with External Tank and Solid Rocket Boosters
Sept. 28	Transfer Space Shuttle *(Columbia)* from Vehicle Assembly Building to Launch Complex 39A
Oct. 28	Launch STS-9 Spacelab-1

MODIFICATIONS COMPLETED

NOTE: Ejection seats remain for commander and pilot Ejection seats however are safed

Thermal Protection System

Densification of remaining high temperature reusable surface insulation (HRSI) tiles, bottom of mid-fuselage and wings
- Approximately 314 tiles wing
- Approximately 2,156 tiles mid-fuselage

Elevon ablators replaced with HRSI tiles

Seat floor beefup at attach point of mission specialist and scientist operational seats on crew compartment flight-deck and mid-deck floor to support 20 "g" crash load requirements

Complete catalytic surface coating experiment removal

Aerosurface servo amplifier removal and replacement update to operational configuration

Complete aft flight deck distribution panel redesign to relocate existing wiring and connectors to be compatible with Standard Mixed Cargo Harness (SMCH). Added 36 holes to support wire harness.

Removed one payload timing buffer in aft flight deck and replaced with modified timing buffer and installed one modified operational configuration orbiter timing buffer at aft flight deck

Added attachments in secondary aft flight station for SMCH and added payload console access panel

Removed, reworked and installed two orbital Maneuvering System Engines for replacement of bi-propellant valve due to shaft seal leaks

Provided various supports for Ku-band antenna installation in mid-fuselage structure

Removed and replaced six forward radiators and two aft mission set radiators with diffusion coated radiators for extra-vehicular activities and Ku-band reflection

Removed and replaced ammonia boiler

Relocated wiring at SSME engine interface (30 wires) to be compatible with SSME's for skin temperature measurement of SSME's in prelaunch

Water dump valve replaced with updated configuration

Removed and replaced two retention bolts at main hydraulic pump solenoid isolation valve with high strength bolts on valve mounting flange

Ground support equipment addition for active keel latch wiring with Spacelab-1 installed

Replaced three signal conditioners for lightweight external tank, heavyweight external tank required 33 to 35 psia, lightweight external tank required 32 to 34 psia

Two sky genies installed aft of overhead ejection panels for emergency egress provision in horizontal position at panels R7 and R15

Removed and replaced accelerometer assemblies

Provided four payload feeders from orbiter power supply. Added four fuse/fuse holders, one connector and two new harnesses

Removed and replaced Orbital Maneuvering System high pressure helium isolation valves

Stowed 16 wire segments, added 16 wire segments, avionics bay 3 to Panel R12A2 for communications modifications

Added 20 wires in avionics bay 3A and 3B, relocated 16 wires for communications modifications

Relocated Ku-band rigid coax to facilitate Ku-band antenna installation

Removed and replaced expansion hinges at No. 1 left hand (port) and right hand (starboard) radiator panels and removed and replaced silver plated nuts at mid-aft and aft radiator panels

Removed and replaced four structural retract box assemblies and hose line clamp at interface of radiators to eliminate torsion load with redesigned clamp

Orbital Maneuvering System Engine gimbal actuator replacement

Added Flight Acceleration Monitoring System (FAMOS) to the Operational Instrumentation (OI) multiplexer/demultiplexers (MDM's). Install 12 accelerometers on SSME's (four per engine) and coax cables routed through engine interface to 12 signal conditioners mounted in aft avionics bays 4 and 5.

Added eight wires from T-O umbilical to external tank umbilical to be compatible with lightweight external tank

Removed and replaced forward Orbital Maneuvering System propellant (fuel and oxidizer) gauging probe, also added brackets for helium line support at helium line/probe flange weld point

Installed new panel in aft face of flight deck center console for providing reduced oxygen breathing supply to 100 psi regulator for Launch/Entry Helmets (LEH), Personal Egress Air Packs (PEAP)

Modified left hand Orbital Maneuvering System fuel pressure transducer fitting

Replaced aft Orbital Maneuvering System aft fuel probe in fuel tanks

Modification of timing buffer power supply

Incorporation of payload timing signal distribution

Relocation of treadmill in crew compartment mid-deck

SSME electrical panel FASCO rework at aft thrust structure for SSME changeout from 100% to 104%

Microwave Scan Beam Landing System (MSBLS) decoder update

Removal and replacement of main hydraulic pump bolt/washer

Removed Development Flight Instrumentation (DFI) container in mid-deck, relocated panels MO42F and MO58F, interchanged panels R11 and R12. Removed DFI pallet in payload bay and DFI wiring and wire trays in mid-fuselage. The instruments were not removed but sensor pigtails were stowed. All unused connectors have protective caps. Wiring and sensors on payload bay doors remain.

Main propulsion system 17 inch external tank disconnect flow liner modification

Orbital Maneuvering System helium pressure regulators changed out

Modification of screw in Star Tracker Light shade

Change of location of two payload and payload interrogator data buses and wires from orbiter station X_O 693 to X_O 603 for new SMCH cable trays near forward end of cable trays, left hand (port) and right hand (starboard) sides

Add cabin oxygen flow restrictors to provide oxygen flow capability for crew size of two to seven

Multiplexer/demultiplexer (MDM) rechannelization of payload data interleaver and pulse code modulation master unit (PCMMU) programmable read only memory (PROM) requirements and OI MDM rewire to insure compatibility with onboard flight software

Addition of switched beam S-band antenna system. Adds switch beam control assembly in avionics bay 3B, adds rotary antenna select switch on panel C3A7, adds 250 wire segments.

Removal and installation of updated operational configuration flash evaporator system

Installation of galley in crew compartment of mid-deck and water dispenser provisions

Removal of 20 payload "U" channel wire trays (10 each side of mid-fuselage) along with tray covers to allow replacement of approximately 500 nut plates with DZUS fasteners. Wire tray dividers will have cutouts added for wire egress. Provide six thermal control system blankets on lower side of mid-fuselage wire trays.

Inlet fittings of Freon coolant loop flow proportional valve change

Removal of atmospheric revitalization system diffusers

Removal of two substack fuel cells (three fuel cell powerplants) and replace with three substack fuel cells (three fuel cell powerplants). To provide increased voltage margins and incorporates changes to fuel cell powerplants hydrogen pump/separator, thermal control valve and flowmeter. Also requires beef-up mounting of mounting shelves and wire harness modifications.

Removal and replacement of four quad and two hemi S-band antennas to provide higher gain, narrow beam, switchable fore and aft (nose to tail) for tracking data relay satellite S-band

Partial incorporation of 100 Development Flight Instrumentation (DFI) measurements to Operational Instrumentation (OI)

Modification of main landing gear door thermal barrier

Removal of ablators on inboard edge of right outboard elevon and outboard edge of inboard elevon and replace with High Temperature Reusable Surface Insulation (HRSI) tiles. Left hand elevons ablators were removed and replaced with HRSI tiles in turnaround from STS-4 to STS-5.

Redesign of Orbital Maneuvering System/Reaction Control System pods forward facing tile

Removal secondary structure from X_O 1307 and add new thermal control system configuration and add bulkhead to wire tray transition structure to accommodate SMCH cable

Airlock in mid-deck tunnel adapter in payload bay, hatch on payload bay side of airlock moved to Spacelab side of tunnel adapter, new hatch at top of tunnel adapter. For extravehicular activity (EVA) depressurizes airlock and tunnel adapter, repressurize same on ingress from EVA. EVA from hatch in top of tunnel adapter. New ducting ventilation. Add antenna to tunnel adapter.

Addition of strut pad for Spacelab unique crew stations

Avionics bay 6 strut rework

Installation of three bunk type sleep stations in mid deck of crew compartment with sleeping bag in bunk for restraint and three hammock type sleeping bags in mid-deck of crew compartment (includes eyes and ear covers)

Addition of permanent stowage compartments under mid-deck crew compartment floor, hygiene kit in waste management system area, also lockers above avionics bays 1 and 2 and adds locker outboard of avionics bay 3A

Changing of materials used for manufacture of solar shields from Tedlar to Goldize Kapton to prevent overheating of payload bay multilayer insulation material

Addition of power reactant storage distribution (PRSD) cryogenic oxygen and hydrogen tank set No. 5 in mid-fuselage

Add text and graphics for government furnished equipment (GFE) supplied units. This is basically a hard copy machine that operates via telemetry. The system provides the capability to transmit text material, maps, schematics, and photographs to the orbiter through a two-way Ku-band link using the Tracking and Data Relay Satellite (TDRS). The hard copier is installed on a dual coldplate in avionics bay 3 of the Orbiter. Consists of secondary shelf supports in avionics bay 3B, installation of 94 wire segments on closeout doors and installation of 94 wire segments between unit on avionics bay 3B shelf 3 and closed circuit television and MDM OF4 on the flight deck.

Replacement of one S-band network signal processor, one switch, add on switch on panel A1A2 panel and add 26 wires external to panel for NASA communications security

Provide stabilizing links between longeron bridges and sill longeron at points having "Y" deflection from maximum loads to meet Spacelab load requirements. Install in payload bays 3, 5, 7, 10, 12 and 13

Partial pressure oxygen sensor and amplifier removal and replacement

Removal and replacement of gaseous oxygen flow control valve

Main landing gear brake line bracket installation

Aerodynamic coefficient package (ACIP) recording capability to operational recorders in orbiter

Addition of fuel cell instrumentation

Relocation of crew compartment mid-deck fire extinguisher from avionics bay 3A to on the airlock and installation of multiple headset adapter to crew compartment mid-deck ceiling

Air data transducer assembly removal and replacement

UHF transceiver removal and replacement

CHANGES TO *COLUMBIA* IN ORBITER PROCESSING FACILITY DURING ROLLBACK IN PREPARATION FOR STS-9

- Removed and replaced forward master event timer (MET)
- Removed and replaced aft power controller (APC) No. 6
- Removal and replacement of SSME engine interface unit (EIU) No. 1
- Removal and replacement of multiplexer/demultiplexer (MDM) FA3
- Removal and replacement of waste collection system (WCS)
- Removal and replacement of SSME No. 3 helium interconnect valve
- Removal and replacement of H_2 (hydrogen) separator
- Removal and replacement of fuel cell power plants No. 1, No. 2, and No. 3
- Addition of acoustics for noise suppression in crew cabin for sleep stations and the waste collection system (WCS)
- Removal and replacement of computer processor unit (CPU) No. 1
- Removal and replacement of SSME controllers on SSME's No. 2 and No. 3
- Addition of check valves in fill side of power reactant storage distribution (PRSD) hydrogen, tank sent No. 4 and No. 5
- Removal and replacement of umbilical disconnect seal in T-O eight inch hydrogen disconnect
- Tack welding of orifices in water spray boilers (WSB's)
- Removal and replacement of engine cutoff sensor (ECO) electronics box

COLUMBIA, S-BAND, Ku-BAND AND TRACKING DATA RELAY SATELLITE (TDRS-A)

The STS-9 flight of *Columbia* will use the TDRS-A communications satellite when in view, operationally for the flight of STS-9 *Columbia* with Spacelab-1.

The Ku-band antenna is a 914 millimeter (36 inch) diameter antenna mounted on the starboard forward portion of *Columbia's* payload bay. The Ku-band antenna is stowed in this area and after payload bay door opening on-orbit, the Ku-band antenna is deployed. If the Ku-band antenna cannot be stowed, provisions are incorporated to jettison the assembly so the payload bay doors can be closed for entry.

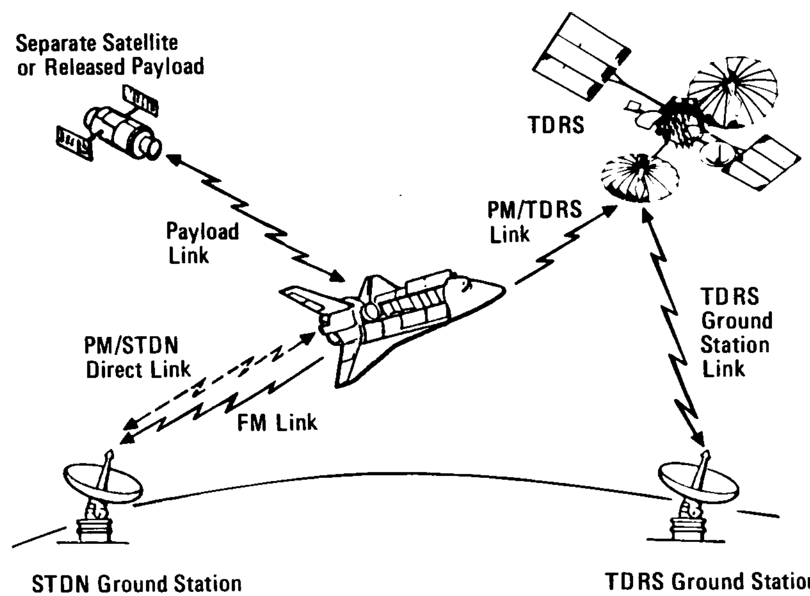
The orbiter Ku-band system operates in the Ku-band portion of the RF spectrum, which is 15,250 MHz to 17,250 MHz. The Ku-band provides a much higher gain signal with a smaller antenna than the S-band system. On the STS-8 mission, high data rate was obtained on S-band and it could be used during the STS-9 mission. Normally in STS-9 mission, the Ku-band system will be used for high data rates. With Ku-band system, the higher data rates can be used.

One drawback of the Ku-band system is its narrow pencil beam, which makes it difficult for the antennas on the TDRS to lock on to the signal. The S-band will be used to lock the antenna into position first because it has a larger beam width. Once the S-band signal has locked the antenna into position, the Ku-band signal will be turned on.

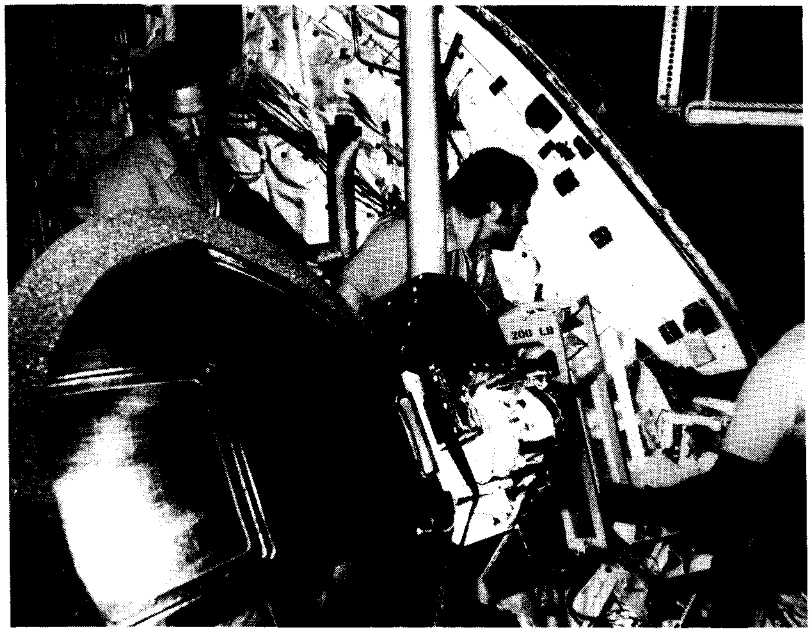
The Ku-band antenna is gimbaled, which permits it to acquire the TDRS for communications acquisition or radar search for other space hardware. The Ku-band system is first given the general location of the space hardware from the orbiter computers. The antenna then makes a spiral scan of the area to pinpoint the target.

With communications acquisition, if the TDRS is not detected within the first eight degrees of spiral conical scan, the search is automatically expanded to 20 degrees. The entire TDRS search requires approximately three minutes. The scanning stops when an increase in the received signal is sensed.

TDRS-A is positioned over the equator at 41 degrees West longitude over the Atlantic Ocean northeast corner of Brazil and is referred to as TDRS-East. Next year, TDRS-B will be carried into earth orbit aboard the Space Shuttle and launched from the spacecraft and positioned over the Pacific Ocean at the equator southwest of Hawaii at 171 degrees West longitude and will be referred to as TDRS-West. TDRS-C is scheduled to be positioned at the central station as a backup just west of South America over the Pacific Ocean at 79 degrees West longitude. The TDRS satellites are positioned at geosynchronous orbit above the equator at an altitude of 35,880 kilometers (22,300 statute miles). At this altitude, because the speed of the satellite is the same as the rotational speed of earth, they remain "fixed" in orbit over one location. The eventual positioning of two



S-Band/TDRS Communications



Ku-Band Antenna Installation in Challenger

TDRS satellites will be 130 degrees apart at geosynchronous orbit — instead of the usual 180 degrees spacing. This 130 degree spacing reduces the ground station to one instead of two if the satellites were spaced at 180 degrees.

When the TDRSS is fully operational (including the in-orbit spare), ground stations of the worldwide Spaceflight Tracking and Data Network (STDN) will be closed or consolidated in savings in personnel, operating and maintenance costs with the exception of Merritt Island, Fla., Ponce de Leon, Fla., and Bermuda which will remain open to support the launch of the Space Transportation System, in addition, any landing when landing at the Kennedy Space Center. Moreover, much of the equipment at the ground stations is almost 20 years old and inadequate to meet the demands of the Space Shuttle and today's advanced spacecraft.

Instead of the existing worldwide network of ground stations which can provide coverage up to only 20 percent of a satellite's or a spacecraft's orbit, limited to the brief periods when the satellite or spacecraft are within the sight of the tracking station. Each tracking station in the network can handle at most two satellites or spacecraft at one time and most stations can handle but one.

The TDRSS operational system can provide continuous global coverage of earth orbiting satellites above 1,200 kilometers (750 miles) up to an altitude of about 5,000 kilometers (3,100 miles). At lower altitudes there will be brief periods when satellites or spacecraft over the Indian Ocean near the equator will be out of view. The TDRSS operational system will be able to provide almost full-time coverage not only for the Space Shuttle but up to 26 other near earth-orbiting satellites or spacecraft simultaneously.

Deep space probes and earth orbiting satellites above approximately 5,000 kilometers (3,100 miles) will use the three ground stations of the Deep Space Network (DSN) operated for NASA by the Jet Propulsion Laboratory, Pasadena, CA. The STDN stations that were co-located with the three DSN stations, Goldstone, CA, Madrid, Spain, and Orroral, Australia will be consolidated with the DSN.

In the STS-9 mission, the liftoff and ascent phase of the mission will use *Columbia's* S-band system through Merritt Island (MILA), Florida and Ponce de Leon (PDL), Florida ground stations, transmitting/receiving in the high data rate mode. After loss of signal at PDL, *Columbia's* S-band system will transmit/receive through the Bermuda (BDA) ground station in the high data rate mode. Prior to loss of signal at BDA, *Columbia's* S-band system will transmit/receive through TDRS-A until loss of signal, thus the White Sands, New Mexico ground terminal in the low data rate mode until out of view of TDRS-A. When *Columbia* is not in view of TDRS-A, *Columbia's* S-band system will transmit/receive through the applicable ground station in view in the high data rate mode.

When *Columbia* is on orbit and the payload bay doors are open, *Columbia's* Ku-band antenna is deployed. When *Columbia* is in view of TDRS-A, *Columbia's* Ku-band antenna will transmit/receive through the TDRS-A in the high data rate mode, thus the TDRS ground terminal at White Sands, New Mexico. When *Columbia* is not in view of TDRS-A, *Columbia's* S-band system will be used to transmit/receive through the applicable ground station in the high data rate mode.

There are times when in view of TDRS-A, that transmission/receiving will be interrupted due to *Columbia* blocking the Ku-band antenna view to TDRS-A because of an *Columbia* attitude requirement or when certain payloads cannot allow Ku-band radiation to be hit by the main beam of the Ku-band antenna. The main beam of *Columbia's* Ku-band antenna produces 340 volts per meter at the antenna but decreases in distance, such as to 200 volts per meter 20 meters (65 feet) away from the antenna. Dependent upon the payload, a program, can be instituted into the Ku-band control system which would limit the azimuth and elevation angle which would inhibit the Ku-band antenna from directing its beam into the area of that payload. This is referred to as an obscuration zone. This program would be instituted from Mission Control Houston. S-band TDRS low data rate mode is used when in the obscuration zone. Ku-band coverage estimate for *Columbia's* present attitude timeline is 32 percent.

In preparation for entry, the Ku-band antenna is stowed and the payload bay doors are closed. When *Columbia* is not in view of TDRS-A, *Columbia's* S-band system will transmit/receive in the high data rate mode through the applicable ground station in view. When *Columbia* is in view of TDRS-A, *Columbia's* S-band system will transmit/receive through TDRS-A in the low data rate mode and during the blackout period of entry, transmission/reception is at present a question mark. After blackout, *Columbia* will continue to operate with TDRS-A to as low a view as possible until reaching the Dryden Flight Research Facility (DFRF), California ground station, at which time *Columbia's* S-band system would transmit through DFRF in the high data rate mode. When the Goldstone (GDS), California, tracking station comes in view, *Columbia's* S-band system will transmit/receive through GDS until GDS goes out of view, then will go back to DFRF through landing, rollout, and safing at Edwards Air Force Base, California landing site.

It is noted that the S-band system forward link (previously referred to as uplink), consists of a high data rate of 72 kbps (kilo-bits-per-second) and a low data rate of 32 kbps through TDRS-A. The high data rate, 72 kbps, consists of two air to ground voice channels at 32 kbps, each and one command channel at eight kbps. The low data rate 32 kbps consists of one air to ground voice channel at 24 kbps and one command channel at eight kbps. The return link (previously referred to as downlink), consists of a high data rate of 192 kbps and a low data rate of 96 kbps. The high data rate, 192 kbps consists of two air to ground voice channels at 32 kbps, each and one telemetry link at 128 kbps. The low data rate, 96 kbps consists of one air to ground voice channel at 32 kbps and one telemetry link at 64 kbps.

The Ku-band system forward link, consists of a mode one and mode two through TDRS-A. Mode one consists of 72 kbps data (two air to ground voice, 32 kbps, each and 8 kbps command) and 128 kbps text and graphics (used in place of teleprinter) and 16 kbps synchronization. Mode two consists of 72 kbps operational data (two air to ground voice, 32 kbps, each and 8 kbps command).

The Ku-band system return link, consists of channel one mode one and two, plus one channel one mode one and two, and one of channel three through TDRS-A. Channel one mode one and two consists of 192 kbps operational data (128 kbps operational data telemetry/Spacelab data plus two air to ground voice at 32 kbps) plus one of channel two mode one and two selection of four; payload digital data from 16 kbps to 2 mbps (mega): or payload digital data from 16 kbps to 2 mbps; or operations recorder playback from 60 kbps to 1,024 kbps: or payload recorder playback from 25.5 kbps to 1,024 kbps; plus one of the following from channel three; mode one attached payload digital data (real-time or playback) from 2 mbps to 50 mbps; or mode two television (color or black/white) composite video; or mode a real time attached payload analog data or payload analog data.

The data acquired by the TDRS satellites is relayed to a single centrally located ground terminal at NASA's White Sands Test Facility in New Mexico. From New Mexico, the raw data will be sent directly by domestic communications satellite (DOMSAT) to NASA control centers at Johnson Space Center, Houston, TX, for Space Shuttle operations and the Goddard Space Flight Center, Greenbelt, MD, which schedules TDRSS operations and controls a large number of unmanned satellites. To increase system reliability and availability, there will be no signal processing done onboard the TDRS satellites, they will act as repeaters, relaying signals to and from the ground stations or to and from user satellites or spacecraft. No user signal processing is done onboard the TDRS satellites.

The TDRSS will serve as a radio data relay, carrying voice, television, analog, and digital data signals. It will be the first telecommunications satellite to simultaneously offer three frequency band service: S-band, C-band, and high capacity Ku-band. The C-band transponders operate at 4-6 gigahertz and the Ku-band TDRS transponders operate at 12-14 gigahertz.

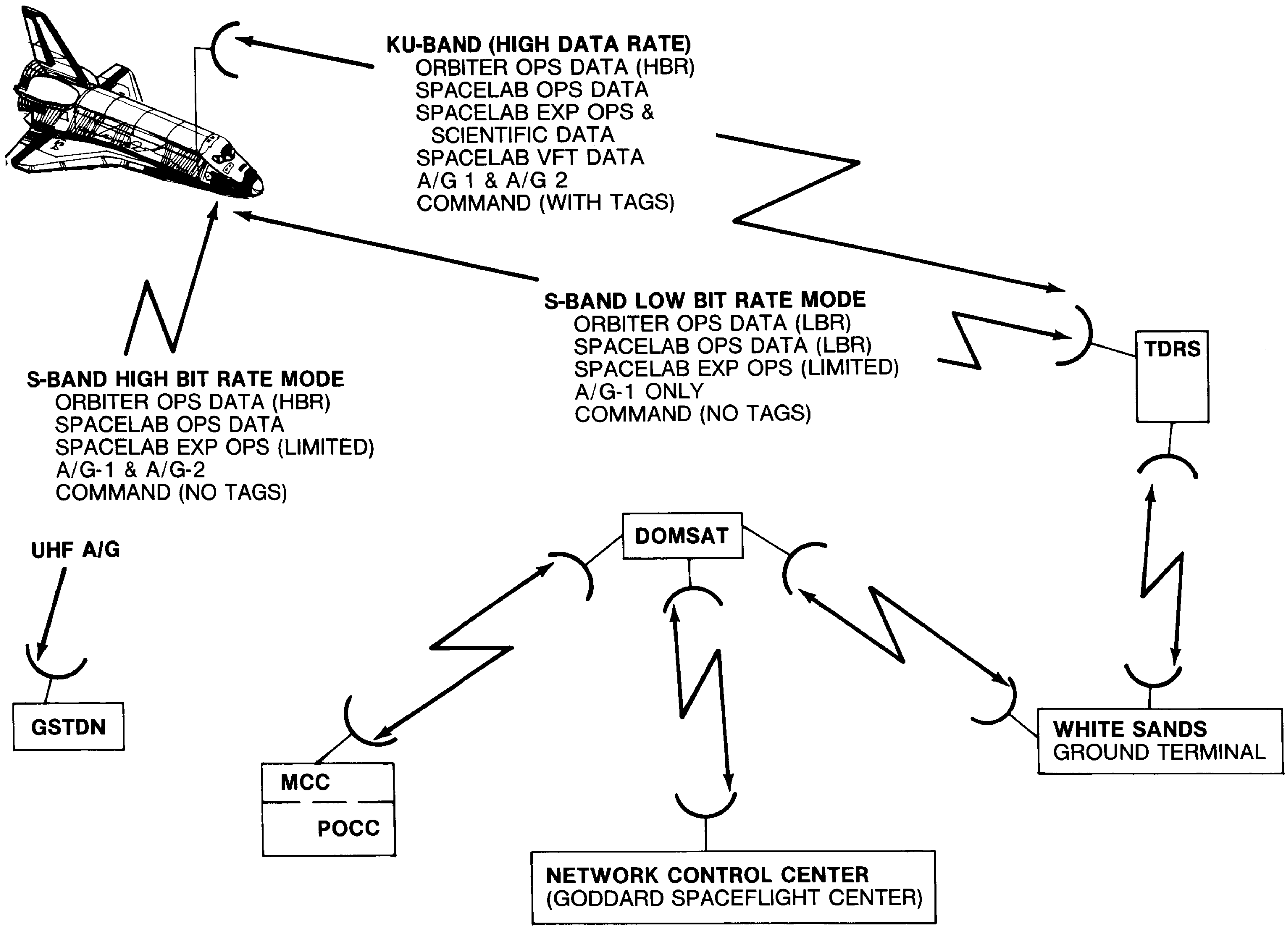
The highly automated ground station is located at NASA's White Sands Test Facility, New Mexico, and is owned and managed by Spacecom, which NASA also leases. The ground station provides a location at a longitude with a clear line-of-sight to the TDRS satellites and a location where rain conditions are very remote, as rain can interfere with the K-band uplink and downlink channels. It is one of the largest and most complex communication terminals ever built. All satellite or spacecraft transmissions are relayed by the TDRS satellites and funneled through the White Sands ground station. The most prominent features of the ground station are three 18 meter (59 feet) Ku-band antennas used to transmit and receive user traffic. Several other smaller antennas are used for S-band and Ku-band communications. NASA is developing a sophisticated operational control system to schedule the use of the system. These control facilities located at Goddard Space Flight Center and adjacent to the ground terminal at White Sands, will enable NASA to schedule the TDRSS support of each user and to distribute the user's data directly from White Sands to the user.

Automatic data processing equipment at the White Sands Ground Terminal aids in making user satellite tracking measurements, controls and communications, equipment in the TDRS and in the ground station, and collects system status data for transmission along with user satellite or spacecraft data to NASA.

Initially the TDRSS will be used to support the Space Shuttle missions, Spacelab missions and the Landsat 4 earth resources satellite program. The TDRSS operational system will provide data from Landsat 4 in near real time, thus eliminating the need to rely upon onboard tape recorders. DOMSAT satellites will be used to transmit Landsat 4 data from White Sands to the data processing facility at the Goddard Space Flight Center and subsequently to the Landsat data distribution center at the Earth Resources Observation System (EROS) Data Center at Sioux Falls, South Dakota.

The orbiter Ku-band system includes a rendezvous radar which will be used to skin-track satellites or payloads that are in orbit. This makes it easier for the orbiter to rendezvous with any satellite or payload in orbit. For large payloads that will be carried into orbit, one section at a time, the orbiter will rendezvous with the payload that is already in orbit to add on the next section.

Radar search for space hardware may use a wider spiral can, up to 60 degrees. Objects may be detected by reflecting the radar beam off the surface of target (passive mode) or by using the radar to trigger a transponder beam on the target (active mode).



STS-9 S-Band—Ku-Band Communications System

RADAR RENDEZVOUS RANGE

PASSIVE SKIN TRACK

RANGE 30 meters (100 feet) to 12 nautical miles (13 statute miles)

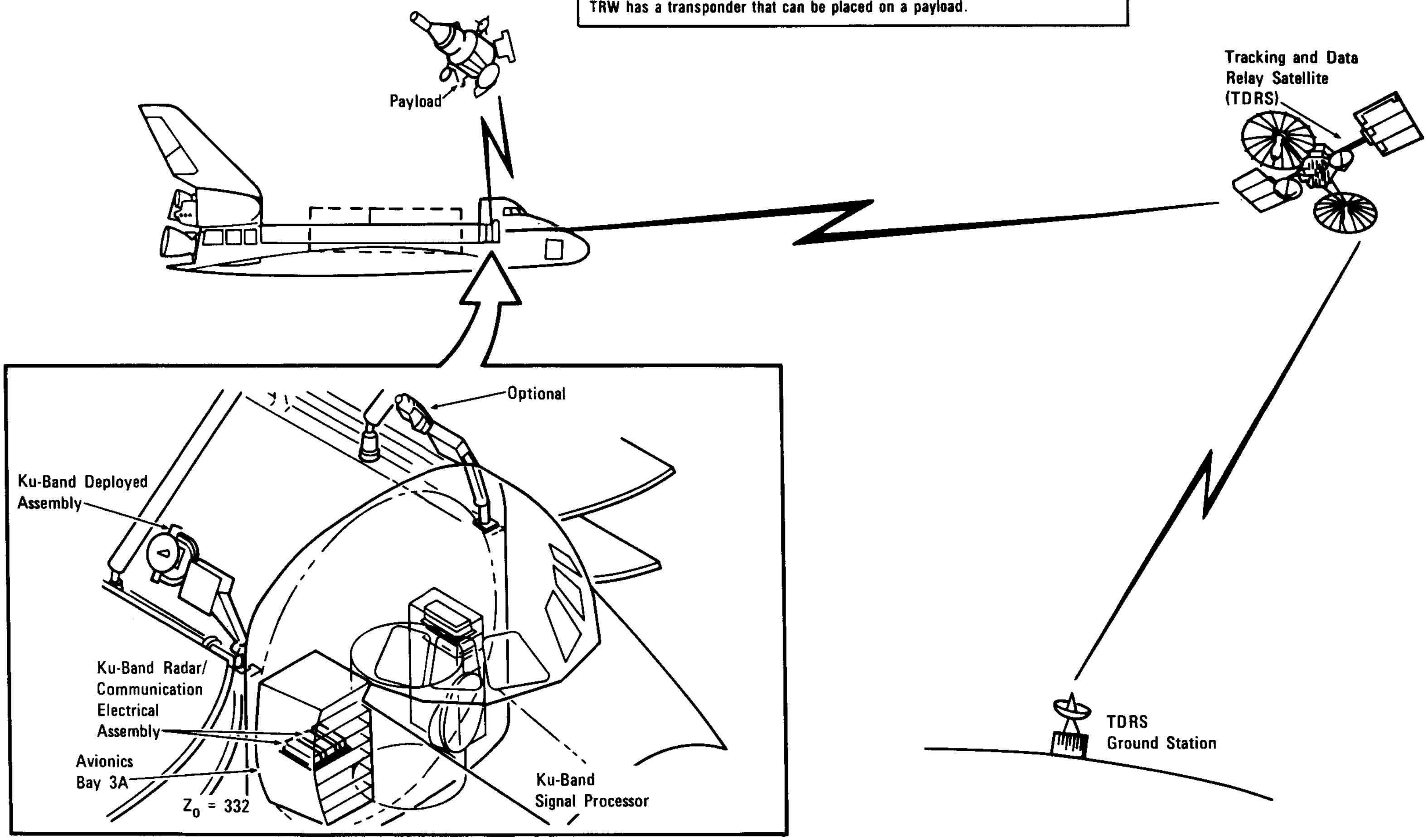
RANGE rate is 45 meters (148 ft) per second opening maximum to 22 meters (75 ft) per second closing maximum

ACTIVE (TRANSPONDER ON THE VEHICLE BEING TRACKED)

RANGE 30 meters (100 ft) to 300 nautical miles (345 statute miles)

RANGE rate is 457 meters (1,500 ft) per second opening maximum to 91 meters (300 ft) per second closing maximum

It is noted that the Shuttle program has not baselined a transponder, however TRW has a transponder that can be placed on a payload.



Ku-Band Radar Communication System

SPACELAB

Spacelab is the manned laboratory built by a group of European nations. This laboratory, which normally will take up the majority of the payload bay. The Spacelab is not deployed free of the orbiter. The Spacelab is scheduled to make a number of flights aboard the Shuttle.

NASA, with the Marshall Space Flight Center as lead center and the European Space Agency (ESA), formerly known as ESRO (European Space Research Organization), signed a memorandum of understanding on September 24, 1973, in which ESA would design, develop, and test a space laboratory to be flown in the cargo bay of the orbiter. ESA has 11 member nations: Belgium, Denmark, France, Ireland, Italy, Netherlands, Spain, Sweden, Switzerland, United Kingdom, and West Germany. A twelfth, Austria, is an observer rather than a full member. All except Sweden are participating in the Spacelab program.

The development of Spacelab construction, and delivery to NASA from ESA of one Spacelab flight unit, one engineering model and ground support equipment cost is about $800 million.

Spacelab is designed to have a lifetime of 50 missions or five years. Nominal mission duration of the Spacelab is seven days, but is designed so that missions up to 30 days can be completed by trading payload capability for consumables and a power extension package.

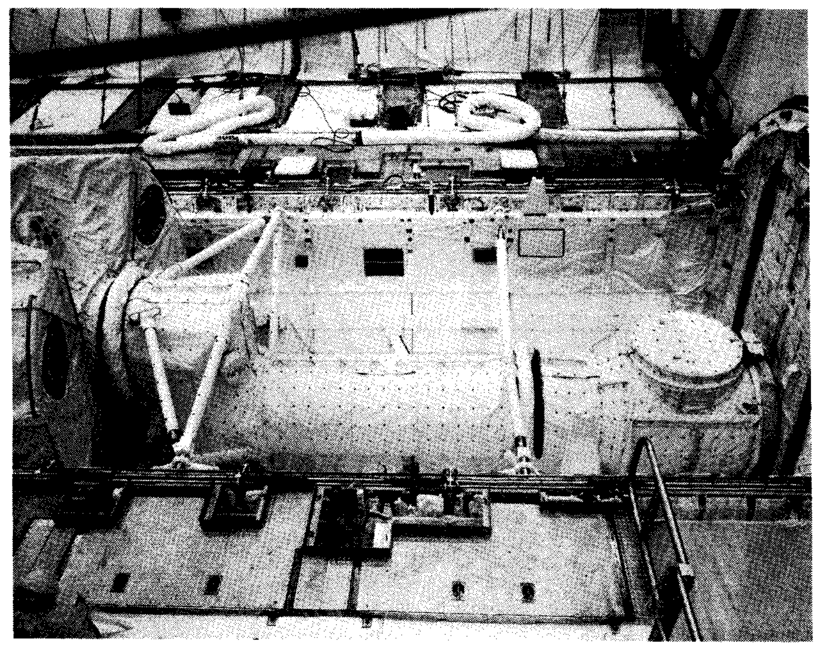
An industrial consortium headed by ERNO-VFW Fokker was named by ESA in June 1974 to build the Spacelab.

Spacelab is developed on a modular basis and can be varied to meet specific mission requirements. Its two principal components are the pressurized module, which provides a laboratory with a shirtsleeve working environment, and the open pallet that exposes materials and equipment to space. Each module is segmented, permitting additional flexibility.

The pressurized module or laboratory comes in two segments. One, called the core segment, contains supporting systems such as data processing equipment and utilities for both the pressurized modules and the pallets. It also has laboratory fixtures such as floor-mounted racks and work benches.

The second, called the experiment segment, is used to provide more working laboratory space. It contains only floor-mounted racks and benches. When only one segment is needed, the core segment is used.

Each pressurized segment is a cylinder 4.1 meters (13-1/2 feet) in diameter and 2.7 meters (9 feet) long. When both segments are assembled with end cones, their maximum outside length is 7 meters (23 feet). Both segments are covered



Tunnel Adapter, Tunnel and Spacelab

with insulation. The segments are structurally attached to the *Columbia* by attach fittings.

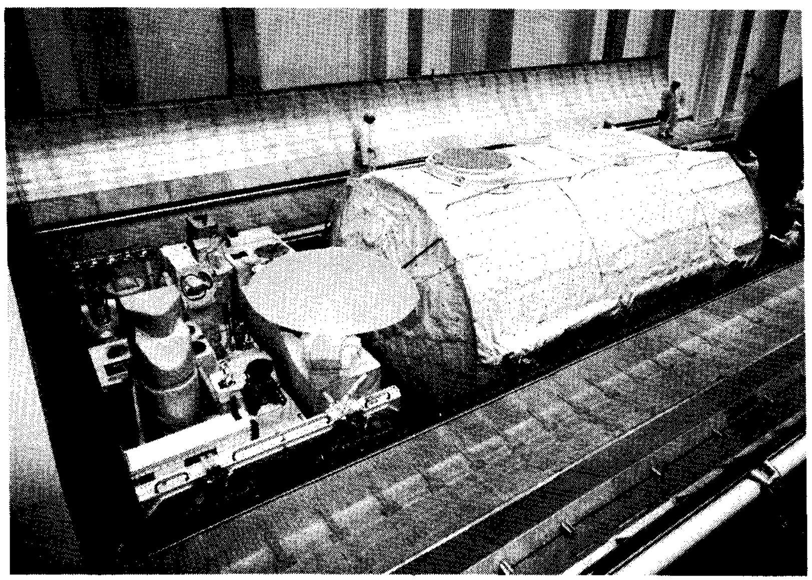
Due to the orbiter center-of-gravity constraints, the Spacelab module cannot lie at the very forward end of the orbiter payload bay. A tunnel is provided for crew equipment and transfer between the orbiter and the Spacelab module. The transfer tunnel is a flexible mounted cylindrical structure with an internal unobstructed diameter of 1,016 millimeters (40 inches) assembled in sections to allow length adjustment as required by different Spacelab configurations. In STS-9 the tunnel length is 5.75 meters (18.88 feet) long.

The airlock, tunnel adapter, hatches tunnel extension and tunnel permits the flight crew members to transfer from *Columbia's* pressurized mid deck crew compartment into Spacelab in a pressurized shirt sleeve environment.

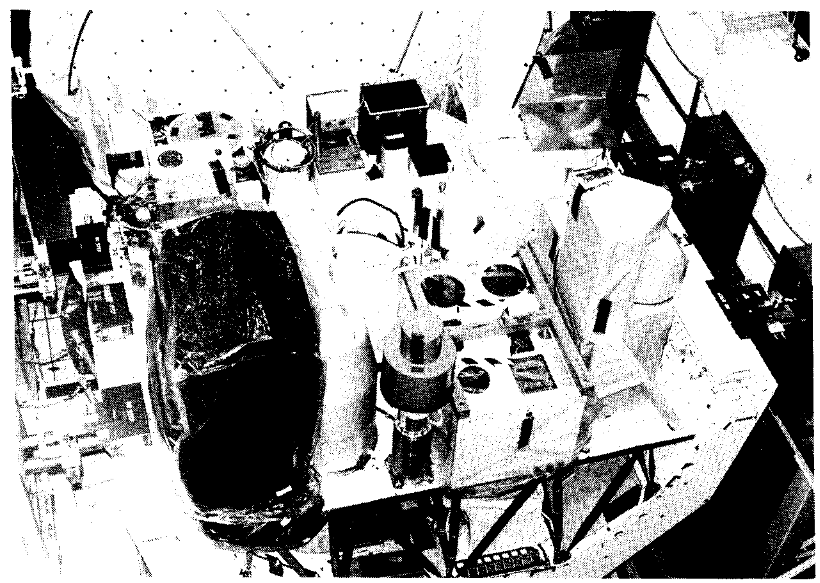
In addition, the airlock, tunnel adapter and hatches permit the EVA flight crew members to transfer from the airlock/tunnel adapter in the space suit assembly into the payload bay without depressurizing *Columbia's* crew cabin and Spacelab.

It is noted, that if an EVA is required, no crew members will be in Spacelab.

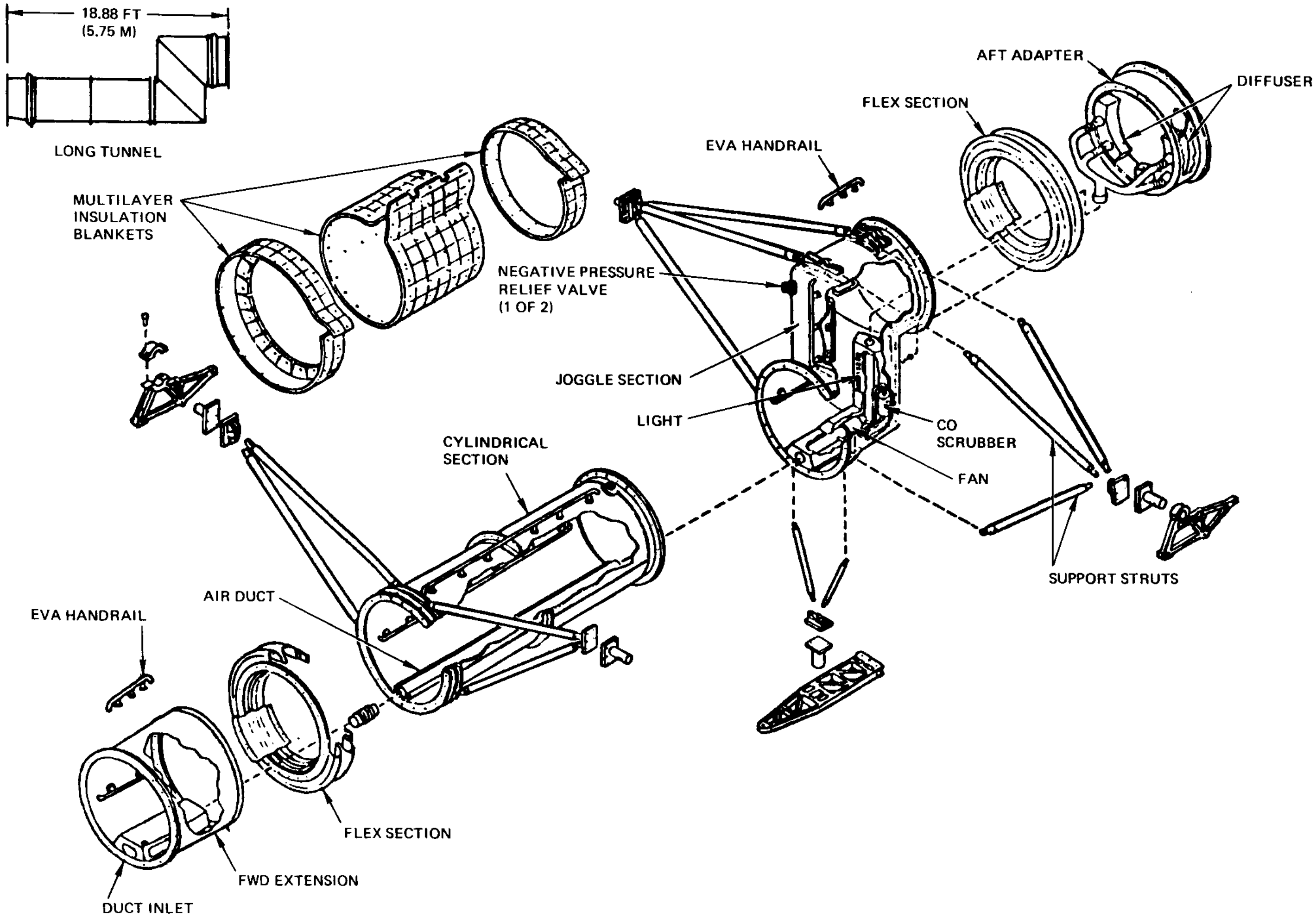
Five unpressurized pallet segments are available. Each U-shaped pallet is 3 meters (10 feet) long, built by the British Aerospace Corp. under contract to ERNO (Zentralgesellschaft VFW-Fokker mbh) and the ESA (European Space Agency). Each pallet is not only a platform for mounting instrumentation but also can cool equipment, provide electrical power, and furnish connections for commanding and acquiring data from the experiments. When pallets only are used, Spacelab portions of the essential systems for supporting experiments (power, experiment control, data handling, and communication, etc.) are protected in a small pressurized and temperature-controlled housing called an igloo. Communications normally is an orbiter function on Spacelab pallet flights. The pallets are designed for large instruments, experiment requiring direct exposure to



Spacelab and Pallet



Pallet



Spacelab Transfer Tunnel

space, or those needing unobstructed or broad fields of view. Such equipment includes telescopes, antennas, and sensors such as radiometers and radars.

In the STS-9 mission, only one pallet is used. The U-shaped pallets are covered with aluminum honeycomb panels. A series of hard points attached to the main pallet structure are provided for mounting of heavy payload equipment. The pallet segments are mounted to the orbiter attach fittings.

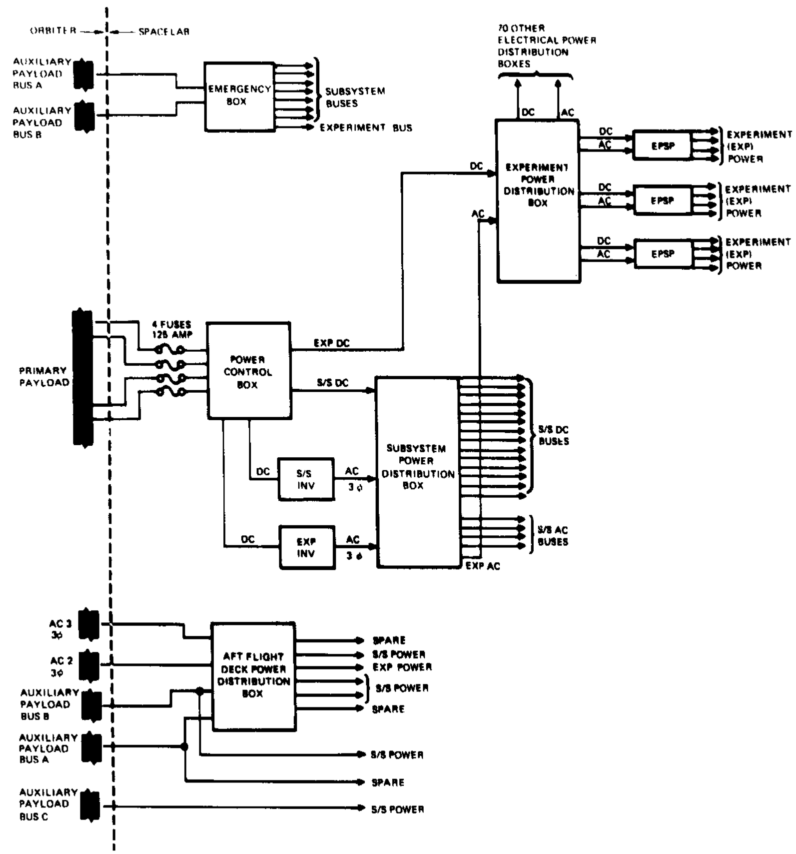
Unlike *Columbia*, the activation of the Spacelab systems does not take place until on-orbit. This necessitates that the Spacelab system be powered up before ingress of the flight crew into Spacelab, which is accomplished via *Columbia's* cathode ray tube (CRT) displays. The orbiter on-orbit GPC configuration will be, one GPC in GNC, one GPC in SM and the other three off. Spacelab activation and deactivation will be accomplished under control of the orbiter SMGPC. Once the Spacelab systems are activated, the software functions of the Spacelab are then handled by the Spacelab displays.

It is noted that the airlock, tunnel adapter, tunnel and Spacelab are pressurized prior to liftoff with an ambient atmosphere.

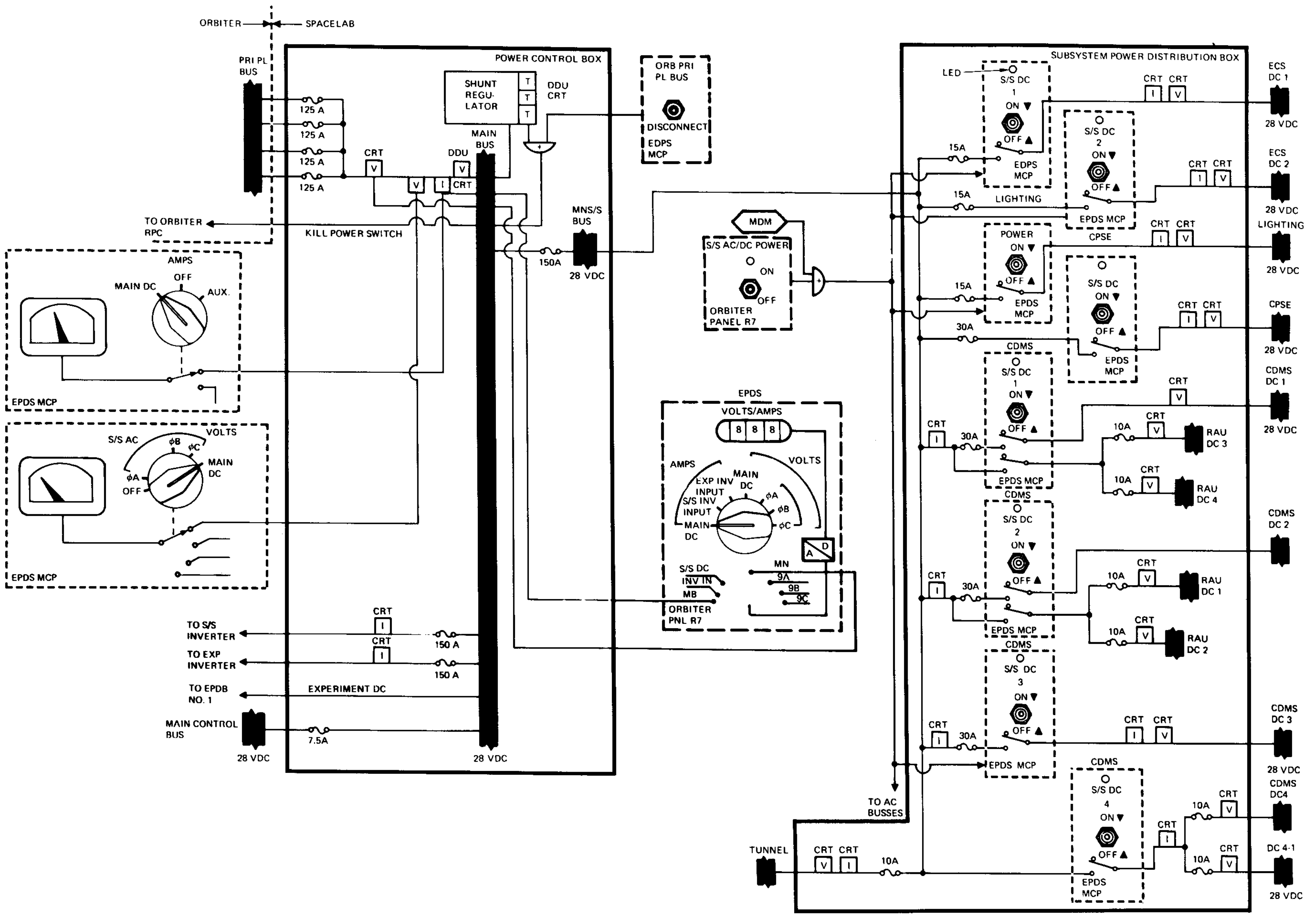
Electrical Power. The electrical power distribution system of *Columbia* provides primary dc, ac, emergency and essential power to the Spacelab subsystems and experiment subsystems.

Columbia's fuel cells No. 2 and No. 3 provide dc power to orbiter MN BUS B and C respectively. In addition, orbiter fuel cells No. 2 and No. 3 through the orbiter main bus tie system, managed and controlled from orbiter display and control Panel R1 and F9, provide dc power from orbiter MN BUS C to the orbiter primary payload (PRI PL) bus to Spacelab Power Control Box (PCB) via four (redundant) main dc power feeders. The orbiter electrical power distribution systems is capable of distributing 7 kilowatts (kw) maximum continuous (12 kw peak) power to Spacelab subsystems and experiments during on-orbit phases. This is equivalent to supplying 14 average homes with electrical power. The ascent and entry power level is less than 1.5 kw. For a fuel cell failure on-orbit, the power level will be 5 kw continuous and 8 kw peak.

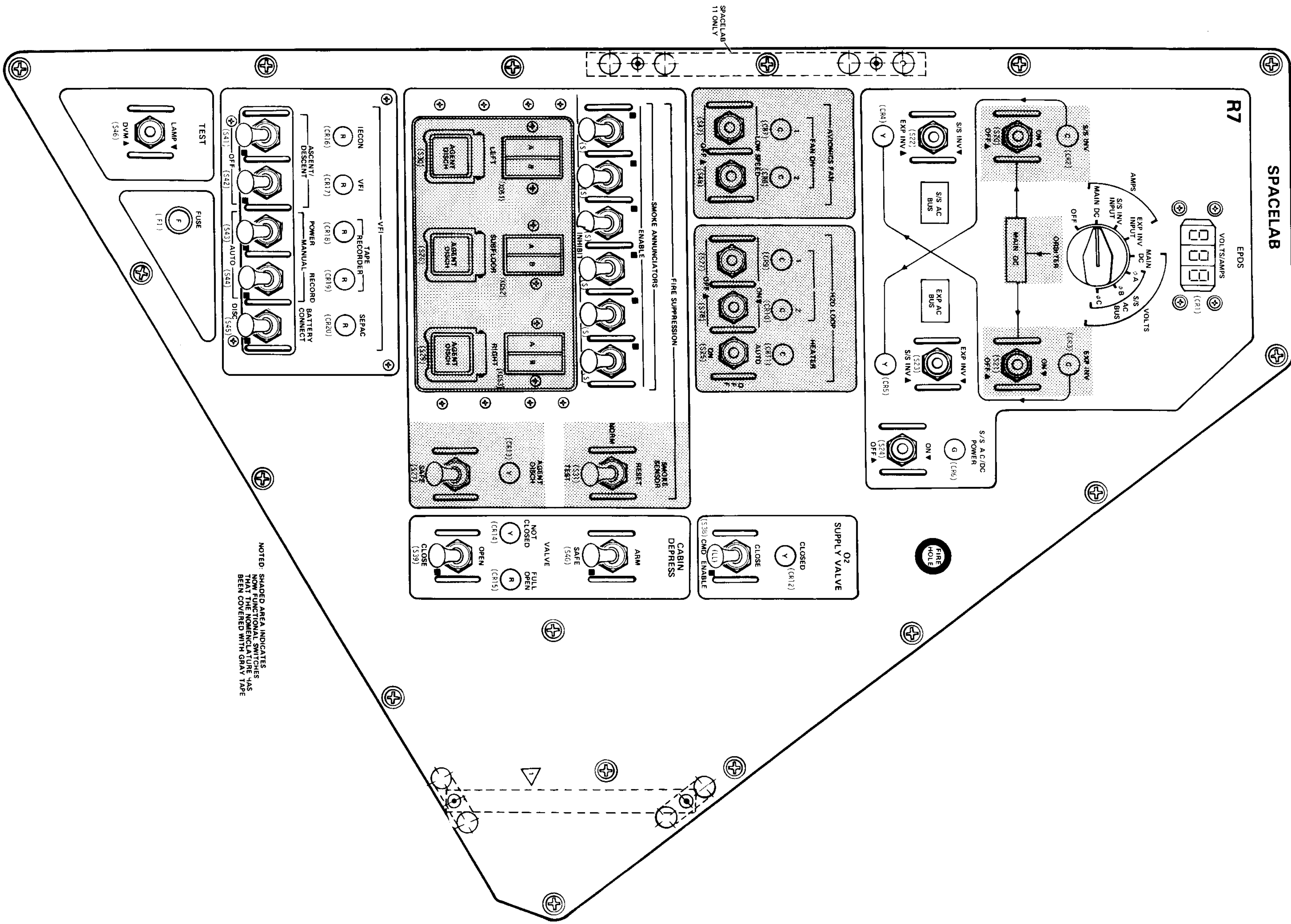
The primary dc power received in the Spacelab from the orbiter PRI P/L bus has a nominal voltage of 28, a maximum voltage of 32, and worst case minimum of 23. The four redundant power feeders from the orbiter feed Spacelab PCB, where they pass through 125 amp fuses. Main bus voltage and current



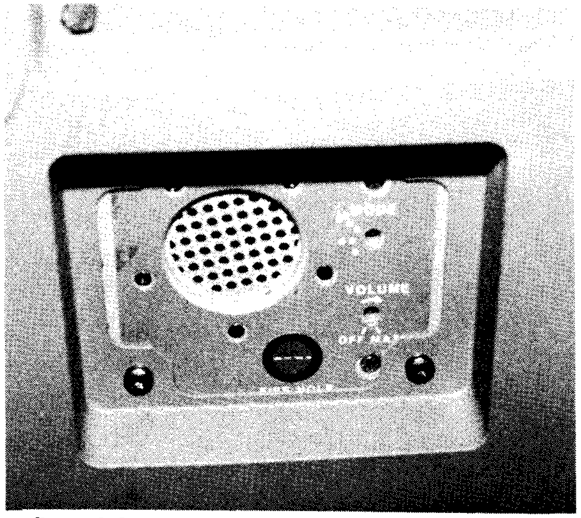
Orbiter Spacelab Electrical Power Distribution



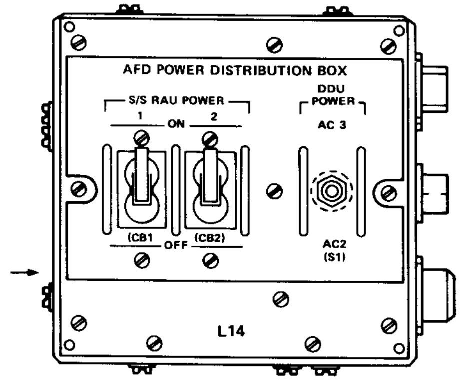
Orbiter to Spacelab Electrical Power Distribution Subsystem DC Power Distribution



NOTED: SHADED AREA INDICATES NOW FUNCTIONAL SWITCHES THAT THE NOMENCLATURE HAS BEEN COVERED WITH GRAY TAPE



Spacelab Aurol Annunciator Located Below Panel L14

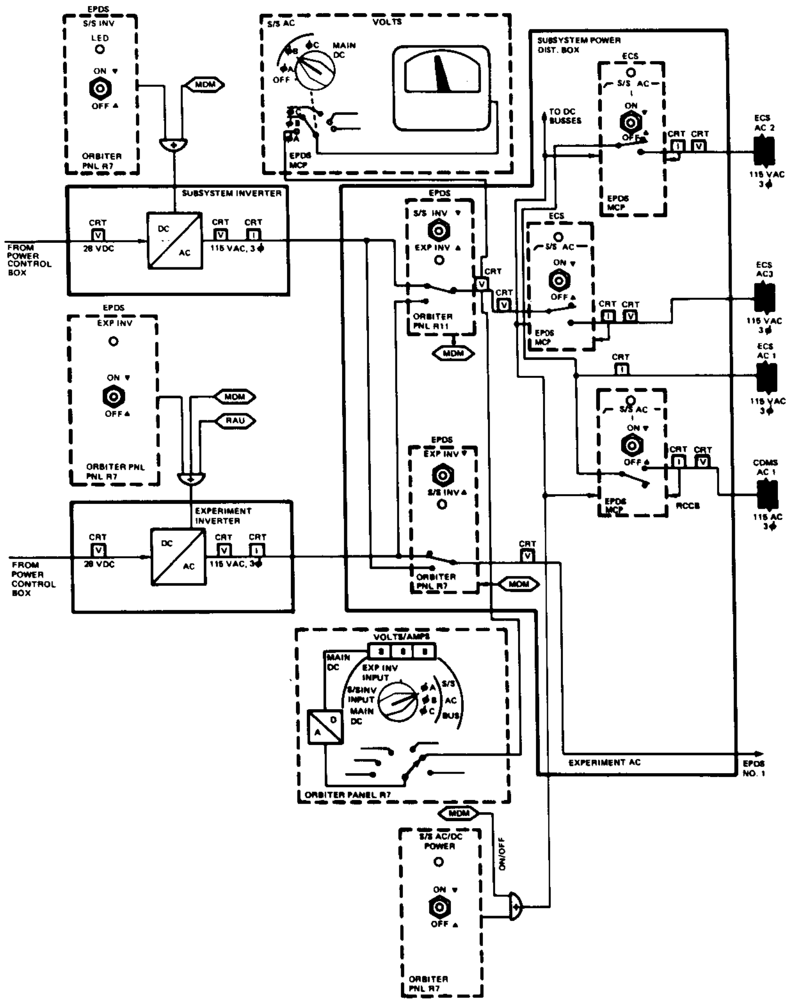


Panel R14

Panel R11

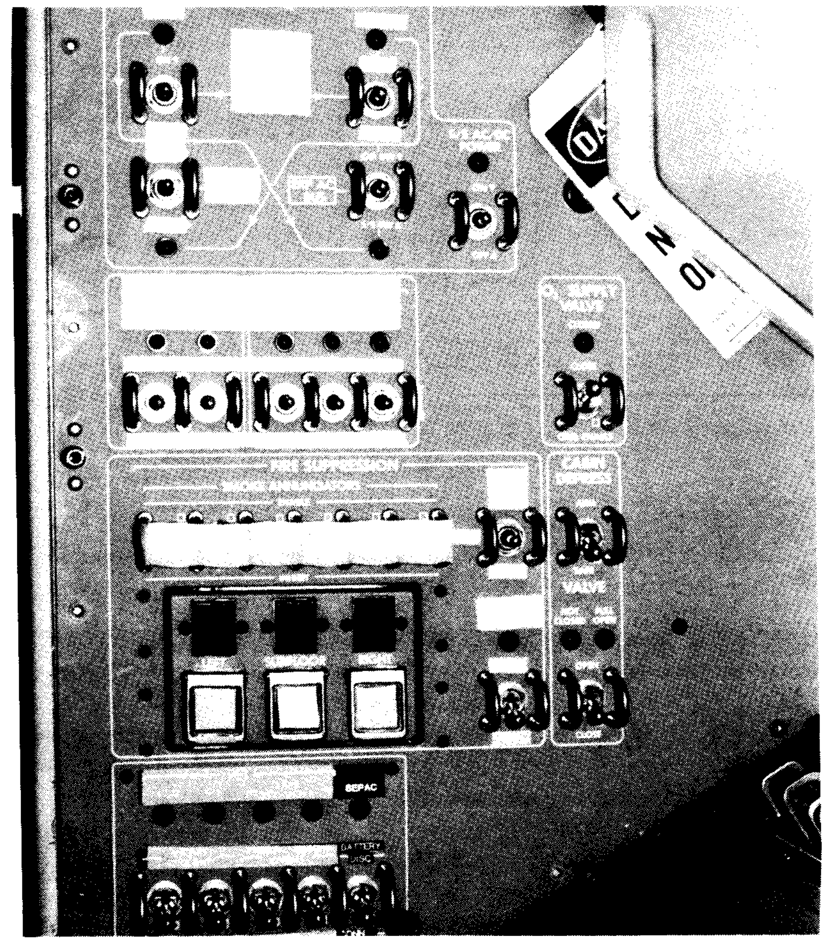
Located behind pilot seat for ascent/entry and located on Panel 11 during orbit.

readings are available on orbiter Cathode Ray Tube (CRT) Spacelab displays, and main bus voltage is available on the Spacelab Data Display Unit (DDU) avionics power/cooling display. The main dc voltage and amperage are available to the flight crew via the electrical power distribution system (EPDS) VOLTS/AMPS digital meter and rotary switch on orbit Aft Flight Deck (AFD) panel R7.



Spacelab Electrical Power Distribution—Subsystem AC Power Distribution

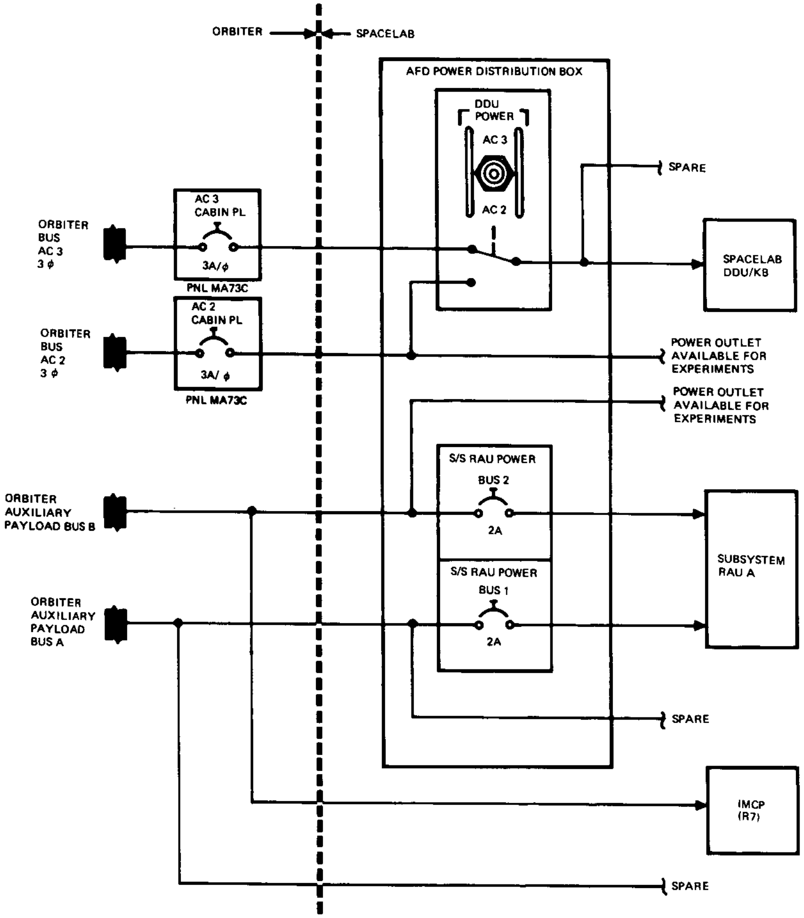
A shunt regulator is provided in the Spacelab PCB to protect the Spacelab from orbiter fuel cell overvoltage. This shunt regulator is activated by the main dc bus voltage at 32v and limits the voltage to 32v by loading the main dc bus with up to 2 kw. A current sensor is used to indicate to the flight crew via or-



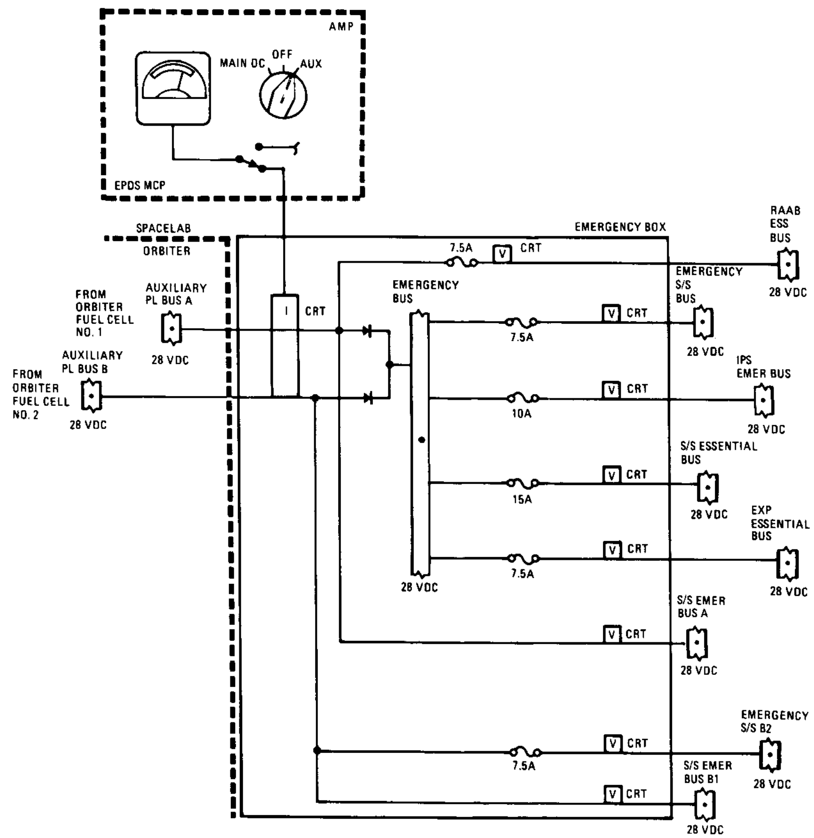
Panel R7

biter CRT Spacelab displays and the Spacelab DDU Avionics Power Cooling display that the shunt regulator is operating. The shunt regulator is provided with five temperature sensors. Two of the sensors provide the shunt temperature reachings to the flight crew via orbiter CRT Spacelab displays. The other three temperature sensors are used on a voting network to trigger a power kill switch in the Orbiter Remote Power Controller (RPC). This automatically disconnects the main orbiter power feeder from Spacelab at a shunt temperature of 60 degrees Celsius (140°F). The power kill switch may also be triggered manually from Spacelab by means of the orbiter (ORB) PRI PL BUS switch on the Spacelab EPDS Monitoring and Control Panel (MCP). The main dc bus must be reset in the orbiter. The shunt temperature reading is still available to the flight crew via orbiter CRT Spacelab display after the power kill.

In the Spacelab PDB, the dc power line feeds several Spacelab subsystem power buses, controlled by switches on the EPDS MCP. All functions on the Spacelab EPDS MCP can be initiated simultaneously by the Subsystem (S/S) AC/DC Power ON/OFF switch on orbiter Panel R7 or by an item command on several orbiter CRT Spacelab displays. The status of this switch



AFI Flight Deck-Orbiter Power Distribution



Emergency and Essential Power Distribution on Panel R7 is available via orbiter CRT and by a GREEN LED (lighting-emitting diode) above the manual switch on Panel R7.

The voltages and currents of the various Spacelab subsystem buses are also available to the flight crew via the orbiter CRT Spacelab S/S Power display.

The dc power in the Spacelab PCB is directed to, two 150 parallel amp fuses, one fuse is to the Spacelab subsystem dc/ac inverter and the other to a Spacelab dc/ac experiment inverter.

Normally, the Spacelab subsystem inverter is used for all Spacelab ac power (Spacelab subsystem and experiment). The Spacelab experiment inverter is available as a backup. It is possible to connect the ac experiment bus to the subsystem inverter and conversely, the subsystem ac bus to the experiment inverter.

Panel R11 is located behind the pilot seat for control of various Spacelab systems during ascent/entry due to the fact Panel R7 cannot be reached during ascent/entry and various Spacelab systems during on orbit operations are controlled from panel R11 or Panel R7 and in some cases from either panel.

The Spacelab Subsystem Inverter is activated via the S/S INV ON/OFF switch on Panel R11 or by orbiter Spacelab CRT command. A GREEN LED light on Panel R11 illuminates to indicate the inverter is activated. The S/S INV switch on Panel R11 is positioned to S/S INV position to supply the Spacelab subsystem inverter bus and a YELLOW LED light above the switch illuminates to indicate the subsystem inverter is supplying power to the S/S AC BUS. The EXP INV/S/S INV switch on Panel R7 is positioned to S/S INV to supply ac power to the Spacelab EXP AC BUS and a YELLOW LED light below the switch illuminates to indicate the Spacelab subsystem inverter is supplying ac power to Spacelab EXP AC BUS. Readings are available via the orbiter CRT display and include inverter ON/OFF status, inverter output voltage, inverter input voltage, inverter input voltage and inverter output current. The subsystem input current and the voltage for phase is available via the digital readout through the use of the rotary switch on Panel R7. The Spacelab EPDS MCP (Monitoring Control Panel) provides a color readout of each subsystem inverter phase voltage.

The Spacelab Subsystem Inverter is protected against overvoltage and overcurrent. It will shut down automatically if the voltage exceeds 130v root mean square (rms) per phase; short circuits are limited to 12a rms per phase; and will shut down all three phases of one phase draws a current of 10A rms for 120 seconds.

The Spacelab Experiment Inverter is activated via the EXP INV ON/OFF switch on panel R11 or by orbiter Spacelab CRT command. A GREEN LED light above the swtich on Panel R11 illuminates to indicate the experiment inverter activation. The experiment inverter can supply the Spacelab subsystem AC BUS by positioning the EXP INV switch on Panel R11 to the EXP INV position and the YELLOW-LED light above the switch on Panel R11 indicates the Spacelab subsystem AC bus is powered by the EXP AC BUS. The positioning of the EXP INV switch on Panel R7 to the EXP INV position would supply Spacelab experiment inverter power to the EXP AC BUS and a YELLOW LED light on Panel R7 across from the switch would illuminate to indicate the experiment inverter is supplying the subsystem ac bus. The switching of Spacelab inverters between two power buses may also be commanded and monitored via the orbiter CRT SL S/S AC power display.

In the Spacelab Subsystem PDB, the subsystem ac bus feeds several Spacelab subsystems power buses controlled by switches on the Spacelab EPDS MCP. All functions on the Spacelab EPDS MCP can be initiated simultaneously by the S/S AC/DC POWER ON/OFF switch on orbiter Panel R7 or by item commands on several orbiter CRT Spacelab displays. The status of the commanded relays are available via orbiter CRT Spacelab displays and by the GREEN LED light above the respective switch on Panel R7 and R11.

Emergency and essential dc power for Spacelab is provided by the orbiter auxiliary (AUX) PL BUSES A and B. The Orbiter AUX PL BUS A and B provide the dc power to the Spacelab Emergency Box. The Spacelab Emergency Box provides emergency and essential power for Spacelab critical Environmental Control System (ECS) sensors and valve, Spacelab fire and smoke suppression equipment, ECS water line heaters, Spacelab module emergency lighting, tunnel emergency lighting, Spacelab intercom system, Spacelab Caution and Warning panel and control circuits.

This power is available during all flight phases and when degraded power is delivered to Spacelab.

The orbiter CRT Spacelab displays include emergency plus essential bus current, voltages for AUX buses A and B, output voltages for Spacelab Subsystem Emergency Buses, output voltage for Spacelab Subsystem essential live and output voltage for Spacelab Remote Amplification and Advisory Box (RAAB) essential bus. The orbiter CRT SL ACT/DEACT, SL S/S dc power and SL System Summary displays will indicate an undervoltage condition for AUX bus A and B. The AUX bus amperage from the orbiter can be monitored on the Spacelab EPDS MCP.

The Aft Flight Deck Power Distribution Box (AFDPDB) located on Panel L14 at the orbiter Aft Flight Deck (AFD) payload station makes orbiter dc and ac power available to a Spacelab Subsystem Remote Acquisition Unit (RAU) and a Spacelab Data Display Unit and Keyboard (DDU-KB).

The dc power is supplied to the Spacelab RAU from orbiter fuel cell 1 MNA bus AUX PL bus A and from orbiter fuel cell 2 MNB bus to AUX PL bus B via the Payload Station Patch Panel. It is noted this power is not affected by the kill switch on the Primary Payload shunt regulator power on L14. The AFD 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.

The ac power is supplied to the Spacelab DDU-KB and is available from orbiter ac buses 2 and 3 by positioning of the panel L14 DDU power switch to AC2 or AC3 position. This power 115 vac, three phase 400 H_2 is available only during on-orbit flight phases. Panel L14 provides no fuse protection for the DDU-KB.

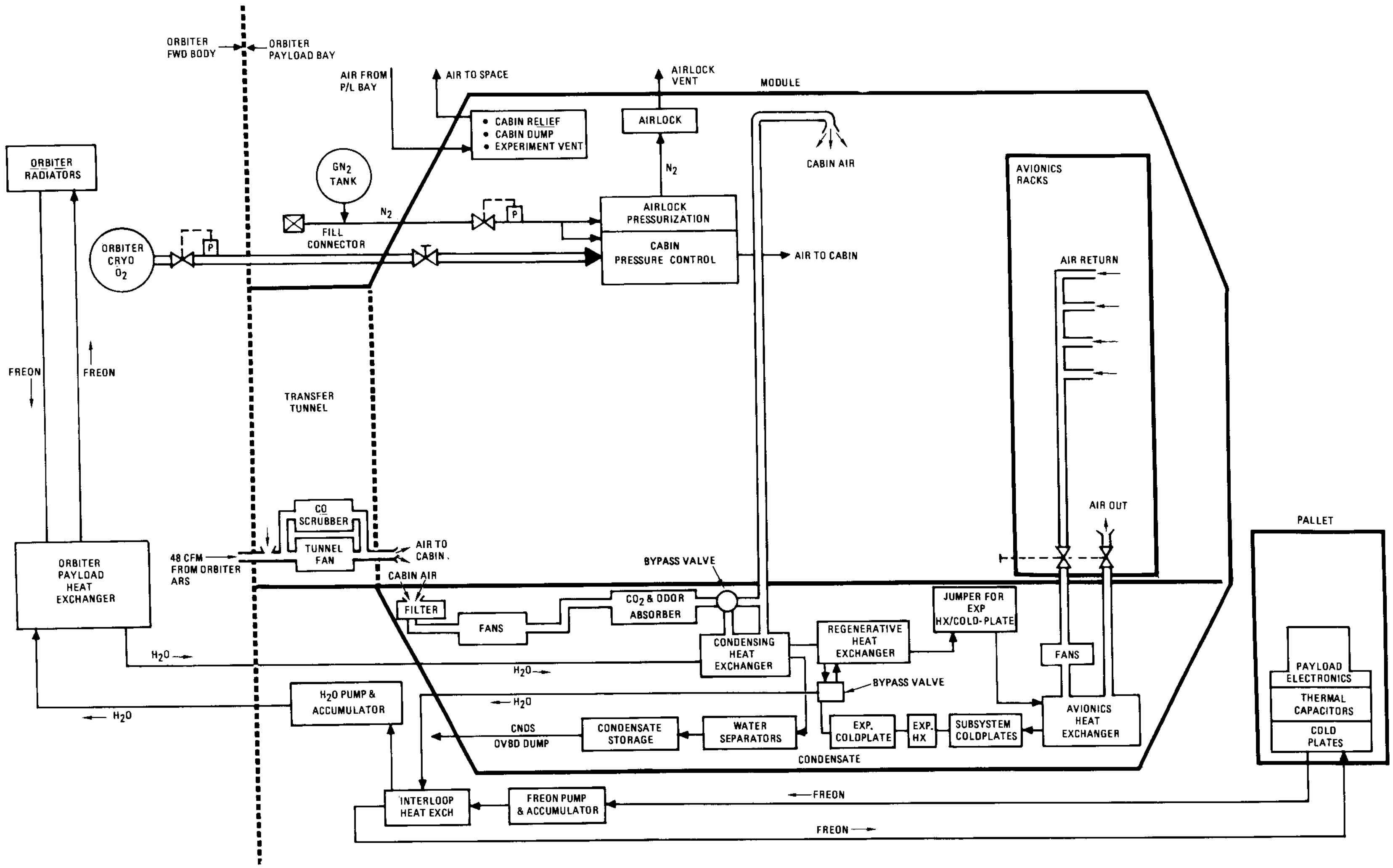
Environmental Control and Life Support Subsystem (ECLS). The Spacelab ECLS consists of two subsystems, the Atmosphere Storage and Control Subsystem (ASCS) and the Atmosphere Revitalization System (ARS).

The Spacelab ASCS receives gaseous oxygen from the orbiter Power Reactant Storage Distribution System (PRSD) and gaseous nitrogen from a gaseous nitrogen tank located on the Spacelab module exterior. The Spacelab ASCS regulates the gaseous oxygen and nitrogen pressure and flow rates to provide a shirtsleeve 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 5,175 mmhg (100 PSI) and at a maximum flow rate of 6.35 kilograms (14.0 pounds) per hour.

A motor controlled valve in the Spacelab module is used to control the flow of gaseous oxygen. This valve is controlled by Spacelab RAU commands when the 0_2 SUPPLY VALVE switch on Panel R7 is in the CMD ENABLE position, but may be closed by positioning the 0_2 SUPPLY VALVE to CLOSE on Panel R7, for such situations as contingency cabin atmosphere dump. A YELLOW LED above the switch on Panel R7 illuminates to indicate the valve is closed. This gaseous oxygen supply valve receives 28 vdc from the Spacelab Emergency bus.

The Spacelab cabin depressurization assembly is provided primarily for contingency dump of Spacelab cabin atmosphere in case of a fire which can't be handled by the Spacelab 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 ECS emergency bus

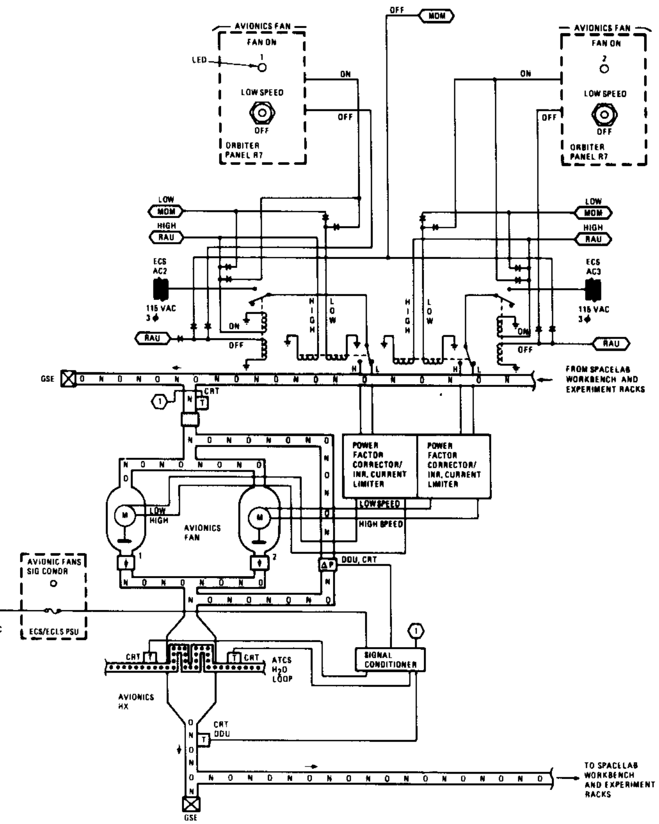


Spacelab/Orbiter Environmental Control System and Life Support System Interface and controlled by the CABIN DEPRESS VALVE OPEN/CLOSE switch and a CABIN DEPRESS ARM/SAFE switch and valve status LED's on orbiter Panel R7. The CABIN DEPRESS ARM switch on Panel R7 arms Spacelab cabin depressurization motor driven valve and when the CABIN DEPRESS VALVE is positioned to OPEN, the Spacelab cabin depressurization assembly located in the Spacelab forward end cone opens and permits depressurization of the Spacelab module at 0.18 kilograms (0.40 pounds) per second. The RED LED light above the switch on Panel R7 illuminates to indicate the Spacelab cabin depressurization motor operated valve is full open. The YELLOW LED light above the switch on Panel R7 illuminates to indicate the Spacelab cabin depressurization motor operated valve is not closed when the CABIN DEPRESS switch is in ARM and CABIN DEPRESS valve is in CLOSED.

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 in orbit, the avionics fans operate when only a few experiments may be operating and require cooling, and are designed for switching from four pole to eight pole operation. The airflow through one fan is reduced from 372 kilograms (1,923 pounds) per hour to 290 kilograms (639 pounds) per hour, and the power is reduced from 643 watts to 110 watts. The two fans are powered by separate 115 vac buses. The fans are activated/deactivated at low speed (eight pole) by the AVIONICS FAN 1/2 LOW SPEED/OFF switches on orbiter Panel R11. Each switch has a YELLOW LED light that illuminates above the respective switch to indicate the respective fan is activated. The fan on/off status is also available via orbiter CRT displays and 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 while the Spacelab RAU deactivation command turns off each fan separately. The high speed status of the Spacelab avionics fans is available via orbiter CRT display and Spacelab DDU display.

Tunnel Airloop. A fan is located in the transfer tunnel and the switch for this fan is located in the transfer tunnel and cannot be accessed until the tunnel/Spacelab hatch is opened and the flight crew member makes the initial transfer to the Spacelab from the orbiter.

When the airlock hatch and the tunnel adapter/Spacelab hatches are open, the orbiter ARS system provides a 13 cubic meters per second (48 cubic feet per minute) duct that branches



Spacelab Avionics Airloop

off of the orbiter cabin air loop downstream of the orbiter cabin heat exchanger and enters the tunnel adapter. In the tunnel adapter, the duct can be controlled by a manual shutoff valve before it passes into the transfer tunnel itself. To enter the transfer tunnel, 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.

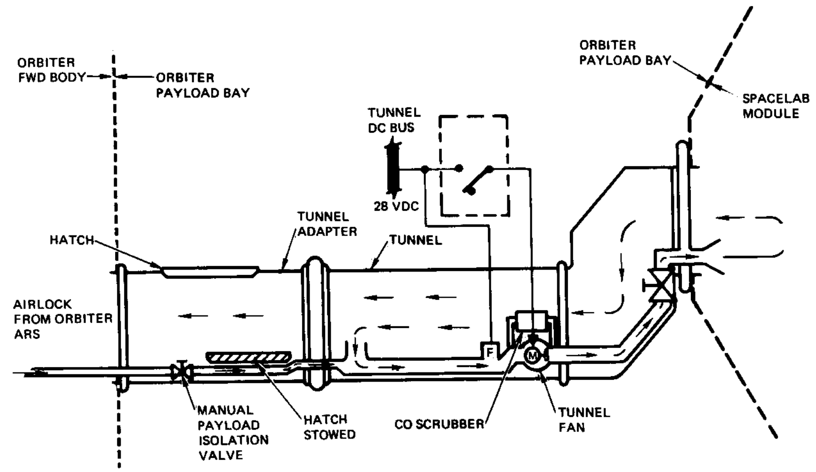
The fan draws in an additional 21 cubic meters per second (77 cubic feet per minute) for a total duct flow of 35 cubic meters per second (125 cubic feet per minute) nominal. This flow rate is delivered to the Spacelab cabin. The return air passes through the transfer tunnel itself, initially at 35 cubic meters per second (125 cubic feet per minute). However, 21 cubic meters per second (77 cubic feet per minute) are sucked into the duct inlet at the Spacelab side of the tunnel/adapter hatch and 13 cubic meters per second (48 cubic feet per minute) enters the orbiter cabin through the tunnel adapter and airlock hatch (open). The tunnel duct provides a scrubber for removal of carbon monoxide. The scrubber is located in parallel with the tunnel fan and flows 0.4 to 1.1 cubic meters per second (1.5 to 4.0 cubic feet per minute) of air.

The tunnel fan receives dc power from the Spacelab EPDS. A flow sensor located in the tunnel indicates a low flow condition by means of an indicator light.

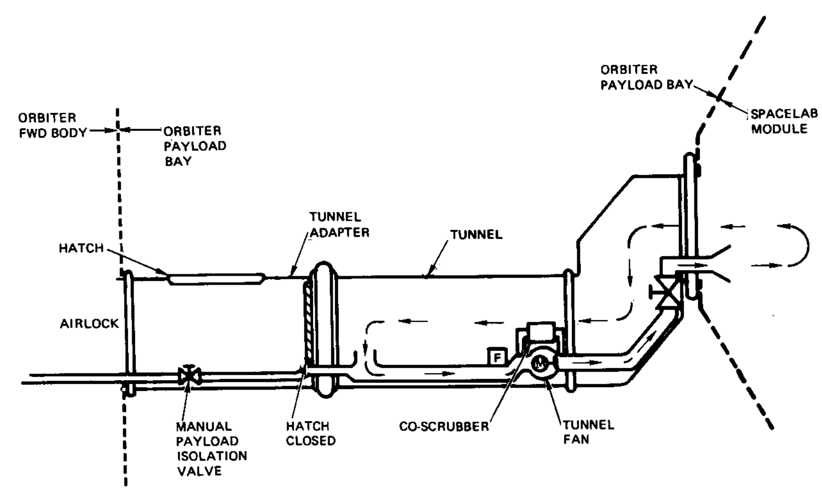
If the Spacelab module is operating with the tunnel adapter hatch closed, the air exchange is not possible. In this case the tunnel fan can be used to circulate 35 cubic meters per second (125 cubic feet per minute) in the tunnel.

Active Thermal Control Subsystem. The Spacelab Active Thermal Control Subsystem (ATCS) consist of a water (H_20) loop to remove heat from the Spacelab module and a Freon loop used to remove heat from equipment on the pallet. The water loop is normally active only during on-orbit flight phases, but requirements for provision of limited cooling to experiments during ascent and descent require that the water loop be operable during ascent and descent in a degraded performance mode.

The Spacelab water loop is circulated by a water pump package consisting of dual-redundant pumps (primary and



Tunnel Adapter Hatch Open—48 CFM Duct Operating



Tunnel Adapter Hatch Closed—48 CFM Duct Not Operating 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 forward end cone. The nominal flow rate through one pump is 227 kilograms (500 pounds) per hour.

The Spacelab water pumps are powered by separate 115 vac buses. They are activated/deactivated by the H_20 LOOP PUMP 1/2 ON/OFF switches on orbiter Panel R11 or by commands from the orbiter CRT keyboards. The GREEN LED above each switch on orbiter Panel R7 illuminates to indicate that pump is in operation. The on/off status of the Spacelab water pumps is also provided in the orbiter CRT displays.

The Spacelab Freon coolant loop removes heat from the pallet and transfers its heat to the interloop heat exchanger to the Spacelab water loop system. The flow rate is approximately 1,368 kilograms (3,010 pounds) per hour. From Spacelab's water loop system, the water passes through the orbiter payload heat exchanger where it transfers all the heat it has collected to the orbiter Freon coolant loops.

Spacelab Command and Data Management System Interfaces With the Orbiter. The Spacelab command and data management system (CDMS) provides a variety of services to Spacelab experiments and subsystems. Most of the CDMS are performed through the use of the computerized system aboard Spacelab, called the Data Processing Assembly (DPA). The DPA is divided into two subsystems, the subsystem DPA and the experiment DPA.

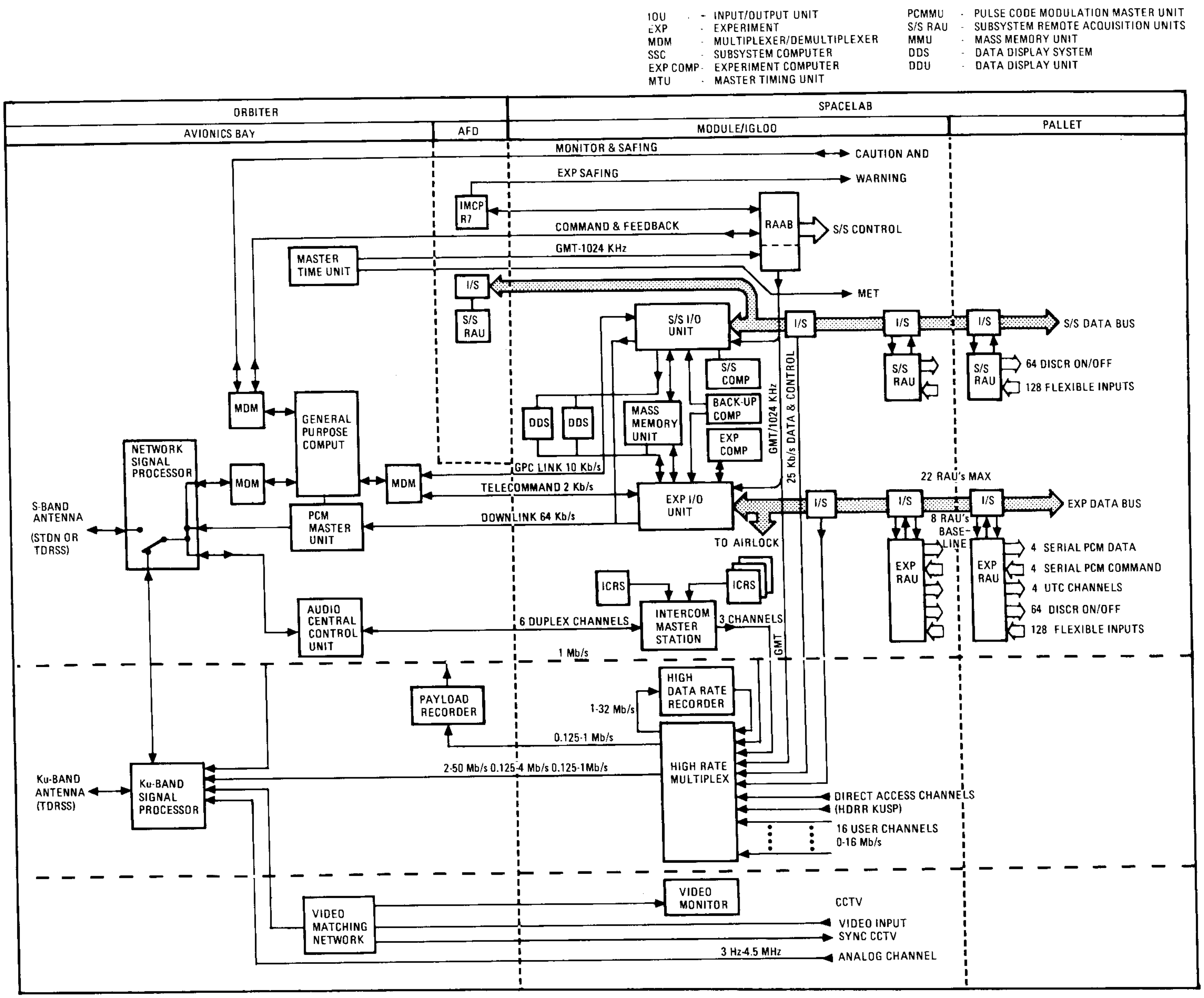
The DPA performs, telemetry data formatting and transfers it to the orbiter for transmission, command data reception from the orbiter and distribution to Spacelab subsystems, data transfer from the orbiter to experiments and distribution of timing signals from the orbiter to experiments.

Two orbiter Payload (PL) multiplexers/demultiplexers (MDM's), PF1 and PF2, are used for data communications between the orbiter GPC's and the CDMS computers. The PL MDM's are under orbiter GPC control.

The orbiter Pulse Code Modulation Master Unit's (PCMMU's) under control of the orbiter GPC's can access Spacelab data for performance monitoring and limit sensing. The PCMMU's contain a fetch command sequence and a random access memory (RAM) for storing fetched data. The data from the PCMMU RAM is combined with orbiter PCM data and is sent to the orbiter network signal processors (NSP's) for transmission on the return link (previously referred to as downlink) via S-band or Ku-band. The 192 kbps data stream consists of a nominal 64 kbps of Spacelab experiment and subsystem data.

The Spacelab experiments computer (EC) interfaces with two telemetry systems, the orbiter PCMMU for low data rate that allows the orbiter to acquire data for onboard systems monitoring and provide Mission Control Center-Houston (MCC-H) with system performance data for real time display and recording via the orbiter NSP and S-band or Ku-band. The other telemetry system is the Spacelab high rate multiplexer (HRM) that provides a high rate link to the Ku-band signal processors that provides scientific data to the Payload Operations Control Center (POCC) for real time display and to Goddard Space Flight Center (GSFC) for recording.

The Spacelab high rate data acquisition (HRDA) consists of a high rate multiplexer (HRM), a high data rate recorder (HDRR) and an orbiter payload 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, subsystem data from Spacelab subsystem computer, experiment data from Spacelab experiment computer, and up to three analog voice channels from Spacelab intercom master station (ICMS). The three digitized channels are pre-multiplexed onto a single 128 kbps channel for interleaving in the format along with GMT signals from the orbiter master timing unit (MTU). This composite output data stream is routed to the Ku-



Spacelab Command and Data Management System Interfaces with the Orbiter band signal processor for transmission on Ku-band or is routed to one of the two recorders.

The Spacelab high data rate recorder (HDRR) records real time multiplexed data or data from the two direct access channels and stores the data at rates of 2, 4, 8, 16, and 32 mbps during mission periods with no downlink capability or degraded downlink capability for playback when the capability is available.

The orbiter payload recorder serves as a backup for the Spacelab HDRR for data rates from 0.125 to 1 mbps and can only record real time multiplexed data.

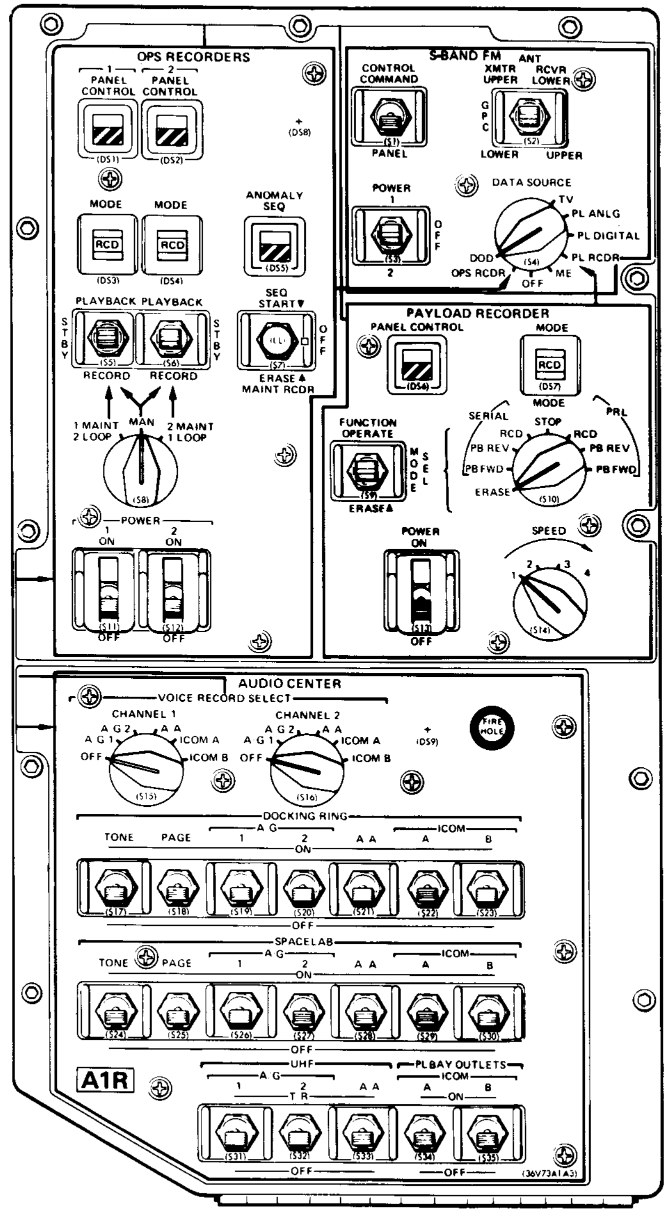
The orbiter master timing unit (MTU) provides MET, GMT and a 1024 khz timing signal to the Spacelab DPA.

Activation of the Spacelab DPA is controlled and monitored via the orbiter CRT Spacelab deploys.

Closed Circuit Television. The Spacelab video system interface with the orbiter closed circuit television (CCTV) 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 them to telemetry. In order to synchronize and remotely control cameras within Spacelab, a sync/command signal is also provided by the orbiter. The orbiter also provides one video output for a Spacelab TV monitor. The Spacelab accommodates a video switching unit which provides Spacelab video recorder capability.

Spacelab analog channel for experiments is directed to the orbiter Ku-band signal processor at 3 to 4.5 mhz.

Columbia's closed circuit television (CCTV) utilizes four cameras and a video tape recorder in the STS-9 mission. The TV camera positions are, one on the orbiter flight deck, one on the orbiter mid deck and two in the payload bay (one on the forward bulkhead and one on the starboard remote manipulator system port). Television data will be downlinked on Ku-band



Panel A1A3

channel three and this channel is time shared between *Columbia's* CCTV system and Spacelab TV/analog output (as well as Spacelab high rate multiplexer high rate data).

INTERCOM. Spacelab intercom master station (ICMS) interfaces with the orbiter audio central control unit (ACCU) and the orbiter EVA/ATC transceiver for communications via orbiter duplex (simultaneous talk and listen) audio channels.

The audio channels are; channel 1 air to ground (A/G)-2 channel 2 ICOM (Intercom)-B and channel 3, A/G-1.

Each of the orbiter channels with the exception of PAGE may be selected on each of the three Spacelab fuel duplex channels A/G-1 for POCC (Payload Operations Control Center)-S/L Spacelab and A/G-2 for orbiter/MCC by rotary switches on Spacelab ICMS. The PAGE channel is used for general address and calling purposes. PAGE signals can originate in either the orbiter or the Spacelab or in both locations.

Access to the orbiter channels are controlled within the orbiter. Normal voice recordings are performed 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.

Caution and Warning. The orbiter receives caution and warning inputs from Spacelab via the orbiter payload MDM's.

There are four channels dedicated in the Spacelab systems to provide payload warning signals to the orbiter and four channels dedicated in the Spacelab systems to provide payload caution to the orbiter. Nineteen remaining caution and warning input channels to the orbiter payload MDM's are available for Spacelab experiment limit sensing in the orbiter GPC's. 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 and all safing commands are initiated at the orbiter CRT-keyboard.

Four manually-switched hardware commands are located on panel R11 for STS-9 which are involved with verification flight instrumentation and functions during ascent/entry. The four GREEN LED lights illuminate to indicate an operating condition.

One manually-switched display hardware command is located on Panel R7, which is involved with an experiment battery CONNECT/DISCONNECT function on the Spacelab pallet.

The lamp test switch on Panel R7 performs a lamp test of the lights on Panel R7.

Panel R14 is involved with verification flight instrumentation on Spacelab and the Induced Environment Contamination (IECM) experiment on Spacelab pallet.

The orbiter GPC can obtain data from Spacelab CDMS via the orbiter PCMMU as an alternate source for caution and warning.

Spacelab Emergency Conditions. Spacelab emergency conditions consists of two categories; fire/smoke in the Spacelab module and rapid Spacelab cabin depressurization. The orbiter and Spacelab provide annunciation of these conditions and safing commands to be used if they occur. These signals are available during all flight phases.

The Spacelab fire/smoke inputs are provided by two ionization chamber type smoke sensors at three locations in the Spacelab to provide redundant fire/smoke signal sources. The six fire/smoke discrete signals are hardwired to six annunciator indicators located on Panel R7. These annunciator indicators are divided into three pairs labeled, LEFT A&B, SUBFLOOR A&B, RIGHT A&B. The six SMOKE ANNUNCIATORS ENABLE/INHIBIT switches on Panel R7, and/or Panel R11 can be used to individually inhibit each fire/smoke sensor output. The SMOKE SENSOR RESET/NORM/TEST switch on panel R11 is used to reset or test all six sensors simultaneously.

Three signals, each from a different sensor location are "ORED" together and connected to the orbiter Panel L1 which provides 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) is generated by the orbiter caution and warning and is transmitted via the orbiter ACCU and provided in the Spacelab module by the loudspeaker in addition to illuminating the Spacelab MASTER ALARM light.

The six fire/smoke signals are also connected to six orbiter MDM inputs for display as emergency alert parameters on orbiter CRT and for telemetry.

Two methods are provided for extinguishing a fire in the Spacelab module; discharge of a fire suppressant into the affected area or dumping of the Spacelab cabin atmosphere when appropriate.

The fire suppressant discharge consists of 15 orbiter-common fire suppression modules, each filled with Freon 1301 suppressant agent.

The AGENT DISCHARGE ARM/SAFE switch on orbiter panel R11 or the panel in the Spacelab module are used to safe or arm the discharge function. Each panel provides a YELLOW indicator light which illuminates 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 concentration. The agent may be discharged from either orbiter Panel R11 or the panel in the Spacelab module by identical sets of three AGENT DISCH switches, one each for the LEFT, SUBFLOOR, and RIGHT areas. The switches are protected by individual switch guards. Positioning one of these switches will completely discharge the contents of all suppression bottles in the indicated area of the Spacelab module.

In addition the Spacelab module 0_2 SUPPLY VALVE CLOSE/CMD ENABLE switch on orbiter Panel R7 can be used to close off the oxygen suppy from the orbiter oxygen system depriving 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 status is indicated via the YELLOW NOT CLOSED and the RED FULL OPEN indicator lights on orbiter panel R7 as well as the orbiter CRT.

SPACELAB-1 EXPERIMENTS

The Spacelab-1 payload is a joint NASA/European Space Agency (ESA) venture. ESA provides roughly one half the experiments and NASA the other half.

Spacelab-1 has a multidisciplinary payload of 73 experiments. Thirty eight of these are various materials science sample types that are processed in one of five different processing devices. The other thirty-five fit into one of seven science descriptions: atmospheric physics, space plasma physics, astronomy, solar physics, earth observations, technology, and life sciences.

The experiments flown on the STS-9 mission come from Austria, Belgium, Denmark, France, Germany, Italy, the Netherlands, Spain, Switzerland, Sweden and United Kingdom. The investigators total more than 100, of whom about 30 are involved in material sciences.

The first letter of the experiment number indicates whether it is a NASA or a ESA experiment; (N)—NASA sponsored, (E)—ESA sponsored. The second letter of the experiment indicates whether it is a scientific (S), technological (T), or applications (A). The last three numbers of the experiment are assigned arbitrarely. Sometimes there is a number (1) before the letter, five character experiment number which indicates it is the first spacelab mission, example INS001.

ATMOSPHERE PHYSICS

INS001 AN IMAGING SPECTROMETRIC OBSERVATORY

Purpose: To measure the airglow spectrum in wavelengths ranging from extreme ultraviolet to infrared.

Importance: Ultraviolet, visible light, and infrared emissions are associated with many processes that occur in the Earth's environment. These emissions constitute the atmospheric airglow, which contains a wealth of information about the composition and state of the atmosphere and ionosphere. These data are largely inaccessible from the ground, but the *Columbia's* orbital altitude is ideal for the acquisition of complete spectral measurements of the airglow. This investigation will give new insight into the varied reactions and energy transfer processes that occur in the Earth's environment.

Method: The Imaging Spectrometric Observatory, located on the pallet, consists of five spectrometers for imaging the optical signatures of processes in the magnetosphere, ionosphere, and atmosphere. The instrument can be used to study the effects of the Space Plasma Physics active experiments near Spacelab or the features of remoter regions. It can look high above orbital altitude to regions of incoming solar and magnetospheric energy, and it can look down into the atmosphere toward auroras and the feet of magnetic field lines. The instrument is a high-speed, broadrange sensor of natural and artificial optical effects, which can be used as an observatory for studies not only of the terrestrial environment but also of various astronomical sources of emissions.

M.R. Torr,
Utah State University,
United States

IES013 GRILLE SPECTROMETER

Purpose: To study, on a global scale, the atmosphere between 15 and 150 km (9 and 93 miles) altitude.

Importance: Atmospheric data from balloon, aircraft, and rocket studies are very localized. High-altitude satellite observations cover a larger viewing area but produce low-resolution spectral data. From Spacelab, it is possible to make high-resolution observations over wide areas and to obtain a more detailed, more comprehensive picture of the Earth's atmosphere. Of special interest are trace gases (carbon dioxide, water vapor, ozone, and a host of other minor constituents) that are involved in atmospheric photochemical processes. We do not currently have accurate measurements of their density at these altitudes.

Method: The technique of infrared spectroscopy will be used to examine the atmosphere along the Earth's horizon or limb. Light coming from the sun through the limb or from the atmosphere itself will be received by a telescope and transmitted into the spectrometer, where the characteristics spectral signature of each atmospheric constituent will be produced. The instrument is located on the pallet and is programmed through a microprocessor that allows interaction between the scientists onboard and the ground-based investigators. This investigation is expected to collect more high-quality data, in a much shorter time, than can be collected by 20 high-altitude balloon flights.

M. Ackerman,
Institut D' Aeronomie
Spatiale de Belgique, Belgium

A. Girard,
Office National d'Etudes et de
Recherches Aerospatiales, France

1ES014 WAVES IN THE OXYGEN HYDROGEN (OH) EMISSIVE LAYER

Purpose: To photograph a layer of high atmosphere in order to examine cloud-like structures that have been observed there.

Importance: Near-infrared photographs of the night sky show large cloud-like structures at the 85-km (53-mile) level. The origin of these forms and the dynamics of this region are not yet understood; they may be related to gravity waves or winds in the upper atmosphere. The only atmospheric constituent at this altitude that emits light in the near-infrared wavelengths is an oxygen-hydrogen compound (OH). Study of OH emissions may reveal the size, movement, evolution, and other features of these mysterious structures. From Spacelab, it is possible to view larger areas of the OH layer for longer times and with greater clarity than by rocket or ground-based methods.

Method: The simplest way to gather data here is to take pictures and return the film to Earth for processing. A modified 16 millimeter movie camera on the pallet will take approximately 2,000 photographs. From these images, the structures, and possible changes in them, can be measured and mapped. Data also will be compared with information obtained in other experiments for a better understanding of mixing and moving processes in the atmosphere.

M. Herse,
Service d'Aeronomie du Centre
National del la Recherche
Scientifique, France

1ES017 INVESTIGATION ON ATMOSPHERIC HYDROGEN (H) AND DEUTERIUM (D) THROUGH MEASUREMENT OF THEIR LYMAN—ALPHA (α) EMISSION

Purpose: To study various sources of Lyman-α emission in the atmosphere, in interplanetary space, and possibly in the galactic medium.

Importance: "Lyman α" designates radiation of a particular wavelength (in the ultraviolet range) that is emitted during a specific transition state of a hydrogen atom. Lyman-α radiation is a characteristic product of the interaction of sunlight and hydrogen (H) in the upper atmosphere. This radiation masks Lyman-α emissions from other sources in the atmosphere, in interplanetary space, and in the galaxy.

Method: The instrument is a spectrophotometer with two absorption cells, one filled with hydrogen, the other with the isotope deuterium (D), "heavy" or enriched hydrogen. All equipment is located on the pallet. Since emissions from atmospheric hydrogen have already been studied well, this background "noise" will be absorbed by the instrument so other sources of Lyman-α radiation, chiefly deuterium, can be observed. Deuterium is an interesting indicator of atmospheric turbulence. The distribution of deuterium between 90 and 250 km (56-155 miles) will be measured and mapped, and other atmospheric and astronomical sources will also be observed. The anticipated result is a better understanding of isotope enrichment processes in planetary atmospheres, which play an important part in theories of the origin of the solar system.

J.L. Bertaux,
Service d'Aeronomie du Centre
National de la Recherche
Scientifique, France

SPACE PLASMA PHYSICS

1NS002 SPACE EXPERIMENTS WITH PARTICLE ACCELERATORS (SEPAC)

Purpose: To perform active and interactive perturbation experiments in the Earth's ionosphere and magnetosphere.

Importance: The Earth's envelope of magnetic fields and charged particles acts as a gigantic electrical generator, producing and depositing energy in the atmosphere, where it is released in the auroras. To understand these complex physical processes, it is necessary to disturb the space environment artificially and watch the resultant effects and interactions. It is possible to use space itself as a vast laboratory for active experiments on magnetospheric processes and solar-terrestrial linkage. These experiments also give insight into similar physical processes occurring in other magnetic environments elsewhere in the universe (pulsars, X-ray stars, radio galaxies, planetary environments, and solar flares).

Method: High-intensity electron and ion beams and neutral gas clouds will be fired from accelerators into the space environment to illuminate the invisible structure and dynamics of the Earth's envelope of magnetized plasma. Particle beam injections create small-scale artificial auroras for studies of the natural auroral process. These beams also trace magnetic field lines along which energy travels into the atmosphere. A variety of detecting and measuring instruments from SEPAC and other complementary investigations will monitor the beam injection experiments. Most of the SEPAC equipment is located on the pallet and controlled by scientists in the laboratory module.

T. Obayashi,
Institute of Space and
Astronautical Sciences, Japan

1NS003 ATMOSPHERIC EMISSIONS PHOTOMETRIC IMAGING

Purpose: To observe faint optical emissions associated with natural and artifically induced phenomena in the upper atmosphere.

Importance: Many atmospheric processes and constituents produce faint optical emissions that can be used as "tracers" for electric fields, high-altitude winds, and other dynamic phenomena. Viewed from above, the atmosphere is nature's television screen; patterns of light emitted there carry information about natural and artificially induced activity in the environment.

Method: A low-light-level television and photometer mounted on the pallet will be used to produce images of faint atmospheric emissions. The shape and size of the images can be analyzed to "diagnose" the effects of active experiments (to identify beam interactions with the ionosphere, for example). These instruments also will be used to investigate natural phenomena, such as ion motion in the ionosphere. This investigation is largely controlled by the onboard computer.

S.B. Mende,
Lockheed Palo Alto Research
Laboratories, United States

1NS019A STUDY OF LOW-ENERGY ELECTRON FLUX AND ITS REACTION TO ACTIVE EXPERIMENTATION ON SPACELAB

Purpose: To use artificially accelerated electrons as tracer particles for electric fields parallel to the Earth's magnetic field.

Importance: Auroras occur when particles (chiefly electrons), guided along magnetic field lines, collide with the upper atmosphere. These particles may be influenced by electric fields parallel to the magnetic field. Improved understanding of the structure and electrical features of the Earth's environment is essential for a better understanding of the complex processes that occur there.

Method: In conjunction with the electron beam experiments, this investigation will detect the presence of electron "echoes" produced when electrons fired upward along a field line are reflected by a parallel electric field. Measurements of the energy and transit time of the echoes give information about the field strength and location of the electric potential barrier. The pallet-mounted detector also will be used to monitor spacecraft charging related to operation of the electron accelerators. The crew will activate the investigation and make adjustments as required.

K. Wilheim,
Max Planck Institut für Aeronomie,
Federal Republic of Germany

1ES020 PHENOMENA INCLUDED BY CHARGED PARTICLE BEAMS

Purpose: To study the effects of charged particle beam injections into the Earth's upper atmosphere.

Importance: When a beam of fast, electrically charged particles passes through an ionized gas (plasma), several physical processes are triggered in the gas. Natural beam-plasma interactions occur in the auroral zone of the ionosphere, in the magnetosphere, and elsewhere in the universe. Beam-plasma interactions also can be created artificially by experiments that use the Earth's plasma environment itself as a laboratory. These active experiments may lead to a better understanding of the Earth's environment and basic plasma physics.

Method: Moderate-intensity particle beams will be fired into the space plasma around the Orbiter. The "active package" of instruments on the pallet contains electron and ion accelerators and some diagnostic instruments. The "passive package" will be deployed in the scientific airlock by the crew for measurements of the surrounding plasma. Coordination of this experiment and several other investigations is planned in order to evaluate various beam injection instruments and techniques for continued use of Spacelab missions. The crew assists in the operation of this investigation.

C. Beghin,
Centre National de la
Recherche Scientifique, France

This experiment will alternate with 1ES022 in the Spacelab Scientific Air Lock (SAL). The SAL is located in the ceiling of the experiment section of the Spacelab module. The MS and PS jointly operate the experiment. There is a provision for an EVA to clear the SAL for payload bay door closure in the event of a jam.

1ES019B DC MAGNETIC FIELD VECTOR MEASUREMENT

Purpose: To determine the magnetic field around the Orbiter during the Spacelab 1 mission.

Importance: In the Earth's magnetic field, the motion of electrically charged particles, such as those fired out by beam accelerators, has three components: gyration around the magnetic field line, bounce between north and south mirror points, and drift around the Earth. Several Spacelab 1 investigations of particles require accurate measurements of the strength and direction of the local magnetic field.

Method: The instrument is a magnetic field sensor on the pallet; it includes three magnetometers, each measuring one component of particle motion in the magnetic field. The experiment will function throughout the mission for long duration, large area mapping of magnetic field strength. Calculated magnetic field data will be available for other experiments.

R. Schmidt,
Space Research Institute of the
Austrian Academy of Sciences, Austria

1ES024 ISOTOPE STACK-MEASUREMENT OF HEAVY COSMIC RAY ISOTOPES

Purpose: To measure heavy cosmic ray nuclei with a nuclear charge of 3 or more.

Importance: There is much to learn about the acceleration, energy, and chemical composition of cosmic rays that penetrate the Earth's magnetosphere from solar and galactic sources. Of special interest for understanding particle movement in the solar system are heavy (partially ionized) nuclei. These low energy particles can be detected only outside the atmosphere. They may carry significant information about their origins and their transportation through space.

Method: The detector, a stack of plastic sheets behind a thin shield, will be exposed on the pallet. Heavy ions stopping in or passing through the sheets leave latent tracks that can be revealed by chemical processing on the ground after the mission. Analysis of the tracks will yield information about the nuclear charge and mass of the ions, and thus about their chemical composition, energy spectrum, source, and acceleration. The detectors will remain sensitive throughout the mission.

R. Beaujean,
Institut fur Reine und Angewandte
Kernphysic für Universitat Kiel,
Federal Republic of Germany

ASTRONOMY

1NS005 FAR ULTRAVIOLET ASTRONOMY USING THE FAR ULTRAVIOLET SPACE TELESCOPE (FAUST)

Purpose: To observe, with higher sensitivity than previously possible, faint ultraviolet emissions from various astronomical sources.

Importance: Much remains to be learned about the stages in the life of a star. It is thought that aging stars reach very high temperatures and emit intense far-ultraviolet radiation. These emissions cannot be detected by ground-based astronomers, but they can be detected by an ultraviolet sensor placed outside the Earth's atmosphere. Better knowledge of ultraviolet sources will lead to improved understanding of the life cycle of stars and galaxies throughout the universe.

Method: The Far Ultraviolet Space Telescope (FAUST) is a compact, wide field-of-view instrument that has already been used on rockets for brief astronomical observations. FAUST will be mounted on the pallet and operated by the crew from the module. It is sensitive enough to detect very faint ultraviolet emissions that are predicted to exist just prior to the death of a star. Observations of galaxies and quasars and joint observations with other Spacelab 1 experiments will also be conducted. This investigation will demonstrate the effective use on Spacelab of existing hardware at low cost and the suitability of Spacelab as a platform for astronomical studies. It will also provide a wealth of photographic data unavailable before this mission.

C.S. Bowyer,
University of California
at Berkeley, United States

1ES022 VERY WIDE FIELD GALACTIC CAMERA

Purpose: To make a general ultraviolet survey of the celestial sphere in a study of large-scale phenomena.

Importance: Astronomical observation with wide field-of-view instruments is relatively new. This technique is faster and easier to interpret than scanning of many points over a large area, and it allows constant comparison with the sky background and reference stars. Wide-angle photography is well-suited for studies of large-scale ultraviolet radiation in zodiacal light, diffuse galactic light, interstellar clouds, and other sources. Ultraviolet radiation is a signature of high-temperature stars—both very young, massive stars and aging stars near the end of their evolution.

Method: A camera-telescope mounted in the Spacelab scientific airlock by the crew will take wide-angle pictures of the sky in ultraviolet wavelengths. The instrument will be used to study the large-scale structure of the Milky Way and the remnants of large explosions that occurred eons ago near the sun. These features should be especially noticeable through wide-angle photography.

G. Courtes,
Laboratoire d'Astronomie
Spatiale, France

This experiment will alternate with 1ES020 in the Spacelab Scientific Air Lock (SAL). The SAL is located in the ceiling of the experiment section of the Spacelab module. The MS and PS jointly operate the experiment. There is a provision for an EVA to clear the SAL for payload bay door closure in the event of a jam.

1ES023 SPECTROSCOPY IN X-RAY ASTRONOMY

Purpose: To study detailed features of cosmic X-ray sources and their variations in time.

Importance: Rockets, balloons, and satellites have opened new "windows" for observing the universe. Observations from above the atmosphere, which absorbs most wavelengths and limits our view of the cosmos, have caused a revolution in astronomy in the last few years. We can now see that violent, high-energy processes are the norm rather than the exception in the life cycle of stars and galaxies. These explosive events emit X-rays. In order to understand the processes that dominate stellar evolution, we must learn to observe and interpret these X-ray emissions. Cosmic X-ray spectroscopy is a promising new field of astronomical research.

Method: The detector system for this experiment is a gas scintillation proportional counter. X-rays from an astrophysical target (e.g., a pulsar, supernova remnant, or cluster of galaxies) are received and their characteristics recorded by the way they excite Xenon gas within the instrument. These data can be analyzed to determine the energy of each X-ray event. Results are expected to provide new insights into very high energy events in our galaxy and elsewhere in the universe. Instrumentation is located on the pallet, and data are stored on magnetic tape after transmission to the ground. The crew starts, stops, and checks operations.

R. Andresen,
ESA/European Space Research
and Technology Centre,
The Netherlands

INA008 ACTIVE CAVITY RADIOMETER

Purpose: To measure the total solar irradiance ("solar constant") and its variation through time with state-of-the-art accuracy and precision.

Importance: The sun's optical radiation is the primary driving force for the circulation of the Earth's atmosphere and the formation of weather systems. Small variations in the sun's total radiant output would have significant effects on the weather and climate of the Earth. It is therefore important to determine the magnitude of possible variations in the sun's total output of energy.

Method: The total solar irradiance from far ultraviolet through far infrared wavelengths will be measured with three heat detectors (pyrheliometers) mounted on the pallet and controlled automatically. The heating effect of solar irradiance will be determined by comparison to a known heating value to obtain an accurate measurement of the solar constant.

R.C. Willson,
Jet Propulsion Laboratory,
United States

IES016 SOLAR SPECTRUM FROM 170-3200 NANOMETERS (1,700-32,000 ANGSTROMS)

Purpose: To measure the energy output in the ultraviolet to infrared range of the solar spectrum.

Importance: It is important to know which wavelength ranges of the solar spectrum are involved in the variability of the solar constant. Variability below 300 nm (3000Å) influences the ozone layer and equilibrium of the Earth's upper atmosphere, while variability above 700 nm (7000 Å) affects water vapor and carbon dioxide absorption at lower altitudes. Accurate measurements of the spectral distribution and variation of the solar constant are important to the study of solar physics, planetary atmospheres, and climatology.

Method: Three pallet-mounted double monochromators (for ultraviolet, visible, and infrared spectral ranges) will be used as a detecting and counting system. Inflight calibration by the crew will contribute to the accuracy and precision of the measurements. Periodic reflights will permit measurements over a longer time scale than a single mission and will be essential for detection of long-term variations. Spacelab 1 marks the first time that spectral and total irradiance have been measured simultaneously from the same spacecraft.

G. Thuillier,
Service d'Aeronomie du Centre
National de la Recherche
Scientifique, France

IES021 MEASUREMENT OF THE SOLAR CONSTANT

Purpose: To measure the absolute value of the solar constant with improved accuracy and to detect and measure short-term variations.

Importance: The solar constant is the total radiant energy of the sun received at the Earth. The absolute value of the solar constant is a critical term in determinations of the Earth's absorption and reflection of radiation (our "radiation budget") and in the energy balance equation governing atmospheric circulation (thus, weather and climate). More accurate measurements of the value of the solar constant, which can be made only from outside the atmosphere, are needed.

Method: A high-resolution absolute pyrheliometer (radiance sensor) will measure the solar constant directly from the pallet. Data will be compared with measurements from the other two Spacelab 1 solar experiments as well as with data gathered since 1960 to resolve discrepancies. Reflights of the instrument are proposed to detect and measure long-term variations. This investigation is largely controlled by the onboard computer.

D. Crommelynck,
Institut Royal Météorologique
de Belgique, Belgium

EARTH OBSERVATIONS

IEA033 METRIC CAMERA EXPERIMENT

Purpose: To test the mapping capabilities of high-resolution photography from space.

Importance: In the past 100 years, only 35% of the land area of the world has been mapped adequately by conventional procedures. Current techniques for compiling and revising maps are too slow to provide up-to-date topographic and thematic maps needed for global natural resource planning. A possible remedy is the use of an aerial survey camera system at orbital altitude. Mapping from space may allow complete mapping of the remaining 65% of the globe in the near future.

Method: A large-film mapping camera will be mounted at the optical window in the Spacelab module. The metric camera system includes the camera body with optics and exposure meter, film magazines (24 cm wide aerial film), filters, and a remote control unit. The experiment will be monitored and controlled on a day-to-day basis from the payload control center via an onboard microprocessor. The crew will install the camera at the window and will change film magazines and filters as necessary.

Spacelab 1 provides the first opportunity to take photos up to 58° north and south latitude and return them to Earth. The resolution of these photographs is expected to be an order of magnitude higher than images now available from Earth-observation satellites.

M. Reynolds,
ESA Headquarters, France,
for Federal Republic of Germany

IEA034 MICROWAVE REMOTE SENSING EXPERIMENT

Purpose: To develop an all-weather microwave remote sensing system.

Importance: Uninterrupted remote sensing and imaging of the Earth's land and ocean surfaces can be performed with microwave radar, regardless of cloud cover or rain. Agricultural, fishing, and shipping concerns can benefit from continuous monitoring of crops, natural resources, sea waves, sea temperatures, icebergs, and ice floes.

Method: The microwave radar facility operates in both active and passive modes to transmit microwave energy to targets on Earth, to detect back-scattered radar signals, and to detect the microwave brightness (temperature) of the targets. Operation is largely automatic, but the experiment can be controlled by a Payload Specialist or an investigator on the ground. An antenna and related equipment are located on the pallet; the associated computer and subsystems are inside the Spacelab module. Data are processed onboard and transmitted to the ground for storage and analysis. This experiment is an important precursor to a planned European space platform for microwave remote sensing of the Earth.

G. Dieterie,
ESA Headquarters, France,
for Federal Republic of Germany

INS006 RADIATION ENVIRONMENT MAPPING

Purpose: To measure the cosmic radiation inside Spacelab.

Importance: Some radiation from the space environment penetrates the protective shielding on spacecraft. Information about the nature of cosmic radiation inside Spacelab is vital to the protection of people working there. Such data are also necessary for protecting experiments that may be affected by exposure to radiation.

Method: Dosimeters (radiation detectors) and stacks of plastic detector film will be mounted in various places inside Spacelab. The sampling sites will represent a wide range of spacecraft shielding. Penetrating neutrons, protons, and particles with high charge and energy leave tracks in the detector materials that can be developed by processing after the flight. These tracks carry information about the nature of radiation inside the Spacelab module; the measurements will be used to determine the potential radiation risk to humans and experiments. The crew will have no duties in this investigation.

E.V. Benton,
University of San Francisco,
United States

IES027 ADVANCED BIOSTACK EXPERIMENT

Purpose: To determine the radiobiological importance of cosmic radiation particles of high charge and high energy.

Importance: Further information is needed to assess the hazard of cosmic radiation to humans and experiments in space and to establish guidelines for their protection. We also need to understand the effects of single particles on biological matter.

Method: The experimental packages are biostacks, layers of different biological matter sandwiched between different types of detectors. Biostacks will be exposed to cosmic radiation at several locations inside the module and on the pallet. Characteristic tracks of particles in the detector material will be correlated with injury of the biological matter. Improved methods of localization and biological evaluation will be used to interpret these data.

H. Bücker,
Institut für Flugmedizin/Abteilung
für Biophysik,
Federal Republic of Germany

IES029 MICROORGANISMS AND BIOMOLECULAS IN HARD SPACE ENVIRONMENT

Purpose: To measure the influence of the space environment on various biological specimens.

Importance: Exposure to the vacuum and high-energy radiation in space may influence living matter at the cellular, subcellular, and molecular levels. Growth disturbances, membrane damage, and structural changes in enzymes and proteins are possible consequences of prolonged exposure in space. Precise information about the effects of space on living matter is expected to hasten the solution of several problems in space biology and basic research.

Method: More than 300 samples of test materials (microorganisms and biomolecules, packed in four containers) located on the pallet will be exposed to the space vacuum and to various wavelengths and intensities of solar ultraviolet radiation. The specimens will be evaluated after the flight and compared with findings from simulation experiments on the ground.

G.Horneck,
Institut fur Flugmedizin/Abteilung
für Biophysik,
Federal Republic of Germany

INS102 VESTIBULAR EXPERIMENTS

Purpose: To study the causes of space motion sickness and to study sensory-motor adaptation to weightlessness.

Importance: The gravity-sensitive vestibular organ in the inner ear is responsible for our ability to sense changes in the speed and direction of bodily movement, even when our eyes are closed. We use information from the vestibular apparatus to walk, maintain an upright posture, and see as we move. The vestibular system also causes the symptoms of motion sickness. In space, this organ will not give the usual information to the brain about the body's orientation and movement. The brain must adapt to weightlessness by greater reliance on other sensory cues.

Method: Several experiments will investigate the effects of weightlessness on the vestibular apparatus, man's sensitivity to movement, vestibular control of eye movements, and man's susceptibility to motion sickness. Equipment includes a body restraint system, cameras, tape recorders, and other devices for visual stimulation and recording. The crew will serve as subjects in several tests of eye movements and bodily sensations. Expected results are improved understanding of vestibular function, motion sickness, and adaptation to the loss of a major channel of sensory information.

L.R. Young,
Massachusetts Institute of
Technology, United States

INS104 VESTIBULO-SPINAL REFLEX MECHANISMS

Purpose: To observe changes in spinal reflexes and posture during sustained weightlessness.

Importance: The vestibular and otolith organs of the inner ear are associated with nerves and muscles that govern the body's posture. Changes in postural reflexes that suggest adaptation to weightlessness have been observed during and after spaceflight. Observations of these responses through longer periods of weightlessness are necessary for assessing the ability of a crew to function effectively in space.

Method: The crew will participate in several experiments to record neuromuscular reflexes associated with the vestibular-otolith system. In the virtual absence of gravity, acceleration forces (which stimulate the vestibular-otolith organs) will be simulated with elastic cords in a "hop and drop" technique. The subject's physiological responses to this stimulation will be monitored, recorded, and analyzed.

M.F. Reschke,
NASA/Johnson Space Center,
United States

IES201 EFFECTS OF RECTILINEAR ACCELERATIONS, OPTOKINETIC, AND CALORIC STIMULATIONS IN SPACE

Purpose: To investigate the vestibular functions of the inner ear, particularly the otolith organs which normally help to maintain upright posture.

Importance: Many astronauts have experienced motion sickness during their first few days in space. Recent studies suggest that space sickness may be caused by a malfunction of the inner ear's gravity-sensitive otolith organs in the absence of gravity. Improved understanding of the vestibular functions would benefit both medical science and the space program.

Method: The vestibular system will be stimulated by very weak linear accelerations applied to a "floating" crew-member. A special body restraint system will prevent him from touching the walls of Spacelab. For optical stimulation, the subject will wear a helmet containing visual stimulation and recording devices. All eye movements and postures will be transmitted to the payload control center.

R. von Baumgarten,
Johannes Gutenberg Universität,
Federal Republic of Germany

INS105 EFFECTS OF PROLONGED WEIGHTLESSNESS ON THE HUMORAL IMMUNE RESPONSE OF HUMANS

Purpose: To determine the effect of weightlessness on the body's immune response or ability to resist disease.

Importance: Practically, it is important to establish the immunological capability of humans in space to protect their health and productivity during a mission. For basic science, it is desirable to understand the interrelationships of various components in the immune response. Under the stress of weightlessness, these components may not respond equally.

Method: Blood samples will be obtained from crewmembers at designated times before, during, and after flight. These specimens will be analyzed for changes in antibody levels. Several tests have been developed to analyze the total antibody content of the samples, as well as specific antibody activities, to reveal whether weightlessness is a stress factor on the immune response.

E.W. Voss, Jr.
University of Illinois, United States

INS103 THE INFLUENCE OF SPACE FLIGHT ON ERYTHROKINETICS

Purpose: To measure changes in the circulating red blood cell mass (erythrokinetics) of people exposed to weightlessness.

Importance: A consistent finding from recent space flights is a reduction in the circulating red blood cell mass that begins early in a mission. The exact mechanism and progress of this change in blood count is not yet understood. Further information is necessary for assessments of human capability for short and long space missions.

Method: Blood samples will be collected from crewmembers before, during, and after flight. Samples will be analyzed to determine whether there is a significant change in red blood cell mass and plasma volume during initial exposure to weightlessness and whether red blood cell production is inhibited in space. These data will aid the search for the mechanism that causes temporary "spaceflight anemia."

C.Leach,
NASA/Johnson Space Center,
United States

IES026 AND IES032 MEASUREMENT OF CENTRAL VENOUS PRESSURE AND DETERMINATION OF HORMONES IN BLOOD SERUM DURING WEIGHTLESSNESS

Purpose: To collect data on changes in the distribution of body fluids and in the balance of water and minerals.

Importance: Astronauts on previous missions have experienced a shift of body fluids from the legs into the chest and head. They have also undergone some changes in fluid and mineral metabolism. The causes and physiological mechanisms of these changes are not well understood. Data on central venous pressure and hormones in the blood serum should be useful for understanding fluid circulation and metabolism in weightlessness, and perhaps also in health and disease on Earth.

Method: The Payload Specialists will take turns measuring central venous pressure in an arm vein, using sterile needle-strain gauge assemblies. They will also draw blood samples for hormone analysis on the ground. These procedures will be performed on each man near the beginning, middle, and end of the mission.

K. Kirsch,
Physiologisches Institut der
Freien Universität,
Federal Republic of Germany

IES025 MASS DISCRIMINATION DURING WEIGHTLESSNESS

Purpose: To compare the perception of mass in space with the perception of weight on Earth.

Importance: This experiment concerns the nature of information (both physical and sensory cues) that we use to judge mass and weight. It also concerns the rate of human adaptation to changes in gravity.

Method: The apparatus for a mass discrimination test includes 24 small steel balls (of equal size but variable mass) and some test cards. Each Specialist will follow a set procedure of selecting pairs of balls, judging which ball in the pair feels heavier, and recording his answer. The 20-minute test will be conducted before and after the flight (when all objects have their normal weight) as well as during the flight. Performance in weightlessness and on the ground will be compared to determine the difference in mass that can be discriminated correctly and to measure the rates of adaptation to weightlessness and readaptation to gravity.

H. Ross,
University of Stirling,
United Kingdom

IES028 THREE-DIMENSIONAL BALLISTOCARDIOGRAPHY IN WEIGHTLESSNESS

Purpose: To record a three-dimensional ballistocardiogram under a unique condition (the test subject is floating in weightlessness) and to compare it with tracings recorded on the same subject on the ground.

Importance: Just as a pistol recoils when it fires, the human body reacts to each heartbeat with little movements. Ballistocardiography is a method of recording these periodic motions as a series of waves. Ballistocardiograms are useful indicators of cardiovascular performance, which is of interest in cardiac surgery, sports medicine, and aerospace medicine. Three-dimensional recordings are very difficult under the influence of gravity on Earth.

Method: For the experiment, a crewmember will wear a backpack fitted with mini-accelerometers and an EKG (electrocardiogram) lead connected to a miniature tape recorder. He will perform a series of breathing and physical exercises while the instruments record bodily accelerations and vibrations associated with heart activity, respiratory movements, and voluntary motions of his limbs. Comparison of these data with tests of the same subject on the ground may be useful for assessing cardiovascular adaptation to weightlessness.

A. Scano,
University of Rome, Italy

IES030 PERSONAL MINIATURE ELECTROPHYSIOLOGICAL TAPE RECORDER

Purpose: To collect physiological data on normal man in an abnormal environment as a basis for future studies.

Importance: In the past, personnel exposed to prolonged weightlessness were a select group of astronauts. Now the people who will go into space in Spacelab are more representative of the general population in age, physical fitness, and previous stress exposure. Nothing is known yet about the physiological reaction of this "normal" population to the stress of space flight. Such information might influence crew selection and activities planned for a mission.

Method: A standard battery-powered medical recorder will be worn on the Specialist's belt and connected to electrodes attached to other parts of his body. Brain electroencephalogram (EEG), heart electrocardiogram (EKG), and eye electrooculogram (EOG) functions will be recorded continuously. Of special interest is physiological activity during sleep and during ascent into and descent from orbit. Important information about physiological changes and adaptation to weightlessness will be gleaned from the tapes.

H. Green,
Clinical Research Centre,
United Kingdom

IES031 EFFECT OF WEIGHTLESSNESS ON LYMPHOCYTE PROLIFERATION

Purpose: To study the effect of weightlessness on lymphocyte activation.

Importance: Lymphocytes constitute about 30% of the white cells in human blood and are important in maintaining immunity against infection. Lymphocytes react to foreign substances (antigens) by multiplying and producing antibodies. Spaceflight apparently affects this cellular reactivity, but the details are not yet understood. Changes in the body's immune response would be important on a long mission in space.

Method: Human lymphocytes in a culture medium will be stored in an incubator in the lab module. Crew-members will add various substances by syringes to some of the cultures and then will stow the samples in a freezer. Postflight analysis will determine the response of each culture to the added substance and will evaluate the effect of weightlessness on lymphocyte stimulation. The transition from resting status to stimulated lymphocyte is a good indicator or immune response and cell differentiation.

A. Cogoli,
Eidgenössische Technische
Hochschule, Switzerland

INS007 PRELIMINARY CHARACTERIZATION OF PERSISTING CIRCADIUN RHYTHMS DURING SPACEFLIGHT: NEUROSPORA AS A MODEL SYSTEM

Purpose: To compare the growth of plants cultured in Spacelab and on the ground to test whether circadian rhythms persist in space.

Importance: Many physiological functions are not constant during a 24-hour day but vary in regular cycles (circadian rhythms) as if timed by a biological clock. This timekeeping mechanism may be internal and unaffected by changes in the environment, or it may respond to subtle environmental cues, such as changes in atmospheric pressure or electromagnetic radiation. Spacelab 1 offers an excellent opportunity for a pilot study to test the latter hypothesis and determine whether circadian rhythms persist outside the Earth's environment.

Method: A fungus with a characteristic circadian rhythm of growth will be grown in cultures in Spacelab and on the ground. The crew will inject the fungus into a nutrient-filled growth tube to start the experiment. Both samples will be kept in constant darkness, and their growth patterns will be compared after the mission. This experiment is a precursor of circadian rhythm studies planned for future Spacelab missions, and it will contribute to our understanding of the mysterious biological clock that governs living things on Earth.

F.M. Sulzman,
State University of New York
at Binghamton, United States

INS001 NUTATION OF HELIATHIES ANNUS IN A MICROGRAVITY ENVIRONMENT

Purpose: To observe the growth movements of plants in very low gravity.

Importance: On Earth, growing plant parts move in tiny spiral patterns (nutations) that can be influenced by gravity. The nature and cause of these growth movements are not yet understood fully, but they may be a key to the puzzling question, "How do plants know which way is up?" That is, how do plants sense gravity and acceleration force, process the information, and translate it into a growth response? Research in the absence of gravity is necessary for a better understanding of plant growth and physiology.

Method: The nutation of dwarf sunflower seedlings in different stages of development will be measured through time lapse videotape recordings. To avoid complications caused by the plants response to light, infrared illumination and an infrared sensitive camera will be used. The crew will tend the plants and select the seedlings for each photo session. After the mission, the tapes will be analyzed to identify and measure nutation. Results will help to explain whether nutation is gravity-driven movement or an independent behavioral property.

A.H. Brown,
University of Pennsylvania,
United States

MATERIALS SCIENCE

1ES300 DOUBLE RACK FACILITY

Purpose: To perform in extremely low gravity a wide variety of pilot materials processing experiments in crystal growth, fluid physics, and metallurgy.

Importance: Materials processing is both an art and a science. Progress in many fields depends upon the availability of better materials. Improved materials are required to meet new needs such as miniaturization or use under extreme temperatures and pressures. Three environmental conditions—temperature, pressure, and gravity—control materials processing on Earth; only gravity, which is often a disturbance, cannot be reduced. Spacelab offers an excellent opportunity to investigate the advantages of a microgravity environment for materials processing.

Method: The Spacelab 1 science crew will perform more than 30 different experiments for 29 investigators from 8 European countries. Most of these experiments will be performed in shared facilities called the "Materials Science Double Rack." A few experiments require special equipment that will not be integrated into the multiuser facility. The Materials Science Double Rack includes several furnaces and process chambers to be used in a variety of studies.

Isothermal Heating Facility: Solidification studies, diffusion, casting of metals and composites, and preparation of new or improved glasses and ceramics.

Gradient Heating Facility: Crystal growth, unidirectional solidification of alloys.

Mirror Heating Facility: Crystal growth using the melt zone or traveling solvent methods.

Fluid Phyics Module: Fluid phenomena and fluid physics.

V. Huth
ESA Headquarters, France

Y. Malmëjac,
Centre d'Energie Atomique, France

L. Napolitano,
University of Naples, Italy

A diverse program of materials processing is scheduled for the Spacelab 1 mission. These experiments will test equipment and techniques for reuse on future missions.

EXPERIMENTS USING THE ISOTHERMAL HEATING FURNACE

SOLIDIFICATION OF IMMISCIBLE ALLOYS 1ES301

H. Ahlborn,
Universität Hamburg, Germany

SOLIDIFICATION OF TECHNICAL ALLOYS 1ES302

D. Poetschke,
F. Krupp GmbH,
Germany

SKIN TECHNOLOGY 1ES303

H. Sprenger,
Maschinenfabrik
Augsburg-Nürnberg AG, Germany

VACUUM BRAZING 1ES304

W. Schönherr,
Bundesanstalt für Materialprüfung, Germany

VACUUM BRAZING 1ES305

R. Stickler,
University of Vienna, Austria

EMULSIONS AND DISPERSION ALLOYS 1ES306

H. Ahlborn
for Battelle-Institut e.V., Germany

REACTION KINETICS IN GLASS 1ES307

H.G. Frischat,
Technische Hockschule, Germany

METALLIC EMULSIONS AlPb 1ES309

P.D. Caton,
Fulmer Research Institute Ltd., United Kingdom

BUBBLE REINFORCED MATERIALS 1ES311

P. Gondi,
Instituto de Fisica della Universita, Italy

NUCLEAR BEHAVIOR OF Ag-Ge 1ES312

Y. Maimejac,
Centre d'Energie Atomique Centre d'Etudes Nucleaires, France

SOLIDIFICATION OF NEAR MONOTECTIC ZnPb ALLOYS 1ES313

H. Fischmeister,
Montanuniversität Leoben, Austria

DENDRITE GROWTH AND MICROSEGREGATION 1ES314

H. Fredriksson,
The Royal Institute of Technology, Sweden

COMPOSITES WITH SHORT FIBERS AND PARTICLES 1ES315

A. Deruyttetrs,
Universite Catholique de Leuven, Belgium

UNIDIRECTIONAL SOLIDIFICATION OF CAST IRON 1ES325

T. Luyendijk,
Laboratorium voor Metaalkunde, The Netherlands

EXPERIMENTS USING THE LOW TEMPERATURE GRADIENT FURNACE

UNIDIRECTIONAL SOLIDIFICATION OF Al-Zn EMULSIONS 1ES316

C. Potard
Centre d'Energie Atomique Centre d'Etudes Nucleaires, France

UNIDIRECTIONAL SOLIDIFICATION OF Al-Al_2Cu, Ag-Ge EUTECTICS 1ES317

Y. Malmejac
Centre d'Energie Atomique Centre d'Etudes Nucleaires, France

GROWTH OF LEAD TELLURIDE 1ES318

H. Rodot,
CNRS Laboratoire d'aerothermique, France

UNIDIRECTIONAL SOLIDIFICATION OF EUTECTICS (InSb-NiSb) 1ES319

K.L. Müller,
Universität Eriangen, Germany

THERMODIFFUSION IN TIN ALLOYS 1ES320

Y. Malmëjac;
Centre d'Energie Atomique Centre d'Etudes Nucleaires, France

EXPERIMENTS USING THE MIRROR FURNACE

ZONE CRYSTALLIZATION OF SILICON 1ES321

R. Nitsche,
Kristallographisches Institut der Universität Freiburg, Germany

TRAVELLING SOLVENT GROWTH OF CdTe 1ES322

H. Jäger,
Battelle Institut e.V., Germany

TRAVELLING HEATER METHOD OF III—V COMPOUNDS (InSb) 1ES323

K.W. Benz,
Universität Stuttgart, Germany

CRYSTALLIZATION OF SILICON SPHERES 1ES324

Dr. Köiker,
Consortium für Elektrochemische Industrie GmbH, Germany

EXPERIMENTS USING THE FLUID PHYSICS MODULE

OSCILLATION DAMPING OF A LIQUID IN NATURAL LEVITATION 1ES326

H. Rodot,
CNRS Laboratoire d'aerothermique, France

KINETICS OF SPREADING OF LIQUIDS ON SOLIDS 1ES327

J.M. Haynes,
University of Bristol, United Kingdom

FREE CONVECTION IN LOW GRAVITY 1ES328

L.G. Napolitano,
Universita degli Studi, Italy

CAPILLARY SURFACES IN LOW GRAVITY 1ES329

J.F. Padday,
Kodak Limited, United Kingdom

COUPLED MOTION OF LIQUID-SOLID SYSTEMS IN NEAR ZERO GRAVITY 1ES330

J.P.B. Vreeburg,
National Aerospace Laboratory NLR, The Netherlands

FLOATING ZONE STABILITY IN ZERO GRAVITY 1ES331

I. Da Riva,
Ciudad Universitaria, Spain

INTERFACIAL INSTABILITY AND CAPILLARY HYSTERESIS 1ES339

J.M. Haynes,
University of Bristol, United Kingdom

SINGLE EXPERIMENTS USING SPECIAL EQUIPMENT

CRYSTAL GROWTH OF PROTEINS 1ES334

W. Littke,
Chemisches Laboratorium der Universität Freiburg, Germany

SELF-DIFFUSION AND INTERDIFFUSION IN LIQUID METALS 1ES335

Dr. Kraatz,
Technische Universität, Germany

ADHESION OF METALS UHV CHAMBER 1ES340

G. Ghersini,
Centro Informazioni Studi Esperienze, Italy

TECHNOLOGY

INTO11 TRIBIOLOGICAL EXPERIMENTS IN ZERO-GRAVITY

Purpose: To observe wetting and spreading phenomena and fluid distribution patterns without the interference of gravity.

Importance: Tribology, the study of interacting surfaces in motion, concerns friction, wear, and their control by lubrication. Spreading and wetting of an oil over surfaces occur in all lubrication systems. Often the long-term distribution and movement of the lubricant determine the useful life of a machine. Lubrication phenomena cannot be observed accurately on Earth because gravity overwhelms the other forces involved. Data collected in space will have both scientific and engineering significance, advancing our knowledge of fluid behavior and, perhaps, leading to new designs for fluid handling hardware and bearings.

Method: Two types of experiments will be conducted by the crew and their progress will be photographed: wetting and spreading of lubricants on stationary surfaces, and movement of fluid films in a bearing mechanism. All equipment will be located in a drawer inside the Spacelab module.

C.H.T. Pan,
Columbia University, United States

A.F. Whitaker and R.L. Gause,
NASA/Marshall Space Flight Center, United States

1ES322/333 CRYSTAL GROWTH FROM SOLUTION UNDER MICROGRAVITY CONDITIONS

Purpose: To grow crystals by several procedures and to analyze the effects of weightlessness on crystal growth.

Importance: There are many technical applications, particularly in electronics, for improved crystals. Crystal formation on Earth is adversely affected by gravity-induced convection in the chemical solutions or melts, resultant crystals are often flawed in structure and composition. It is expected that crystals of high perfection can be grown in the virtually gravity-free environment of Spacelab, where convection is minimized.

Method: Crystals of various chemical compounds will be grown in the Spacelab module. Several crystal growth processes will be tried. Distortion of crystalline structure by convection is expected to be negligible.

K.F. Nielsen,
Technical University of Denmark,
Denmark

A. Authier,
Université Pierre et Marie Curie,
France

1ES338 CRYSTAL GROWTH OF MERCURY IODIDE BY PHYSICAL VAPOR TRANSPORT

Purpose: To grow crystals by several procedures and to analyze the effects of weightlessness on crystal growth.

Importance: There are many technical applications, particularly in electronics, for improved crystals. Crystal formation on Earth is adversely affected by gravity-induced convection in the chemical solutions or melts: resultant crystals are often flawed in structure and composition. It is expected that crystals of higher perfection can be grown in the virtually gravity-free environment of Spacelab, where convection is minimized.

Method: Crystals of various chemical compounds will be grown in the Spacelab module. Several crystal growth processes will be tried. Distortion of crystalline structure by convection is expected to be negligible.

C. Belouet,
Laboratoire d'Electronique et de
Physique Appliquée, France

AMATEUR RADIO TO FLY ON STS-9

Mission Specialist Owen Garriott will use a hand-held radio during part of his off duty time in the STS-9 mission to communicate with some of the thousands of Amateur Radio operators around the world.

While only licensed Amateur Radio operators will be allowed to transmit signals, anyone with one of the popular programmable "scanner" radios can listen to these conversations.

Dr. Garriott's transceiver is a battery powered unit capable of five watts of output. The printed circuit antenna is placed on *Columbia's* upper aft flight deck crew compartment overhead window. Garriott will wear the standard in-flight headset when operating the radio.

All radio operation for the STS-9 will be in the Amateur Radio 2-meter band, 144 to 148 MHz. The primary frequency Dr. Garriott will be using when transmitting over the U.S. is 145.55 MHz. All that will be needed to listen is a receiver (such as a scanner) capable of tuning to 145.55 MHz. The backup frequencies are 145.53 and 145.57 MHz.

When *Columbia* approaches the portion of the ground track where Amateur Radio operations are planned, Garriott will call and transmit continuously for one minute on the even minutes and will receive continuously for one minute on the odd minutes.

During a typical even minute transmission period, Dr. Garriott will identify a geographical area that he will listen for. He will also, as time permits, describe the flight crew activity or views of Earth.

During the odd-minute receive period, Garriott will scan the announced receive frequencies for call signs from the designated area only. To establish contact, an Amateur Radio operator will send his full call sign only, repeating it several times during the scanning period.

During the next transmission, Garriott will acknowledge all call signs he has heard during the listening period. No other report will be needed: call-sign identification constitutes a two-way contact. This procedure will give more operators a chance to make contact. If time permits, some stations may be called on for short transmissions to fill the time period.

Dr. Garriott's call sign is W5LFL. Use of the transceiver will be limited to one hour a day.

EXTRAVEHICULAR ACTIVITY (EVA) AND EXTRAVEHICULAR MOBILITY UNITS (EMU'S)

Two extravehicular mobility unit's (EMU's) are stowed in the airlock of *Columbia* for the STS-9 mission in the event a contingency EVA is required in the STS-9 mission. If an EVA is required, Commander John Young and mission specialist Owen Garriott will perform the EVA.

The airlock, tunnel adapter, hatches, tunnel extension and tunnel permits the flight crew members to transfer from *Columbia's* pressurized mid deck crew compartment into Spacelab in a pressurized shirt sleeve environment.

In addition, the airlock, tunnel adapter and hatches permit the EVA flight crew members to transfer from the airlock/tunnel adapter in the space suit assembly into the payload bay without depressurizing *Columbia's* crew cabin and Spacelab.

The EMU's are an integrated space suit assembly and life support system which provides the capability for the flight crew members to leave the airlock/tunnel adapter and work outside the pressurized areas in space.

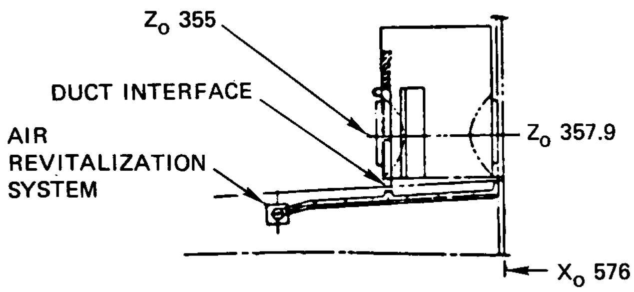
The airlock is located inside the mid-deck of the spacecraft's pressurized crew cabin. It has an inside diameter of 1,600 millimeters (63 inches), is 2,108 millimeters (83 inches) long, and has two 1,016 millimeter (40 inch) diameter D-shaped openings, 914 millimeters (36 inches) across, plus one pressure sealing hatch on the mid-deck side of the airlock and a complement of airlock support systems. The airlock volume is 4.24 cubic meters (150 cubic feet).

The airlock is sized to accommodate two fully suited flight crew members simultaneously. The airlock support provides airlock/tunnel adapter depressurization and repressurization, EVA equipment recharge, liquid cooled garment water cooling, EVA equipment checkout, donning, doffing, and communications. All EVA gear, checkout panel and recharge stations are located against the internal walls of the airlock.

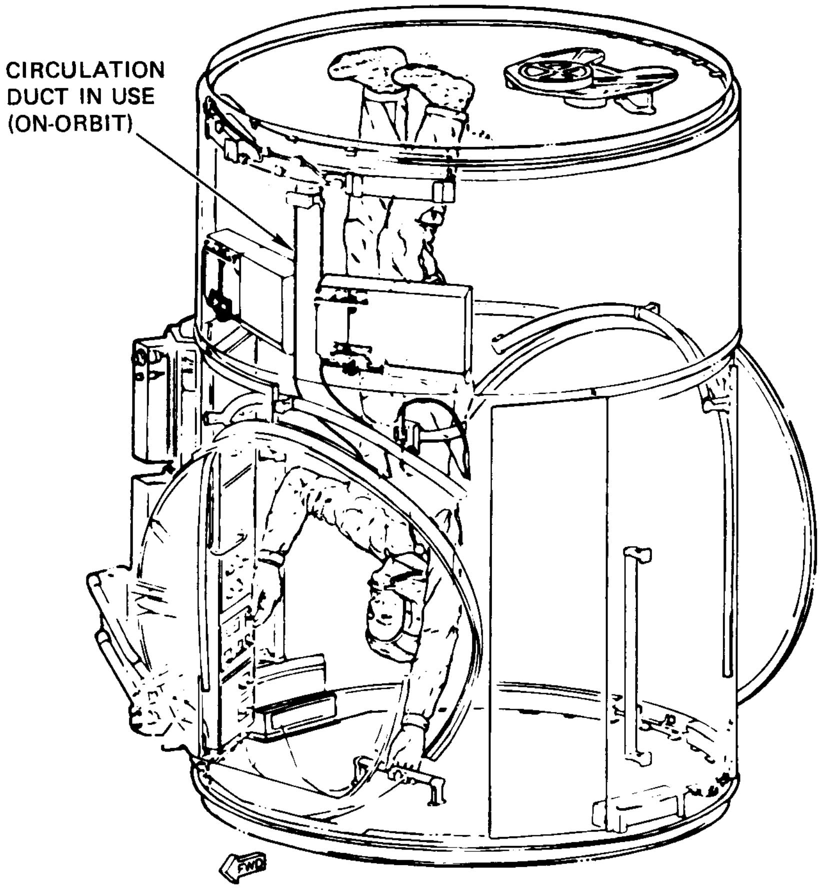
The tunnel adapter is located in the payload bay and is attached to the airlock at orbiter station X_O 576 and attached to the tunnel extension at X_O 660, thus the Spacelab tunnel and Spacelab. The tunnel adapter has an inside diameter of 1,600 millimeters (63 inches) at the widest section and tapers in the cone area at each end, to two 1,016 millimeter (40 inch) diameter D-shaped openings, 914 millimeters (36 inches) across. A 1,016 millimeter (40 inch) diameter D-shaped opening, 914 millimeters (36 inches) across is located at the top of the tunnel adapter. Two pressure sealing hatches are located in the tunnel adapter, one at the upper area of the tunnel adapter and one at the aft end of the tunnel adapter. The tunnel adapter is constructed of 2,219 aluminum and is a welded structure with 60 by 60 millimeter (2.4 by 2.4 inch) exposed structural ribs on surface and an external waffle skin stiffening.

The hatch located on the mid-deck side of the airlock is mounted on the exterior of the airlock and opens into the mid-deck. This hatch isolates the airlock from the spacecraft crew cabin. The hatch located in the tunnel adapter aft end isolates the tunnel adapter/airlock from the tunnel extension tunnel and Spacelab. This hatch opens into the tunnel adapter. The hatch located in the tunnel adapter at the upper D-shaped opening isolates the airlock/tunnel adapter from the unpressurized payload bay when closed and permits the EVA crew members to exit from the airlock/tunnel adapter to the payload bay when open. This hatch opens into the tunnel adapter.

Airlock repressurization is controllable from inside the orbiter crew cabin mid-deck and from inside the airlock. It is performed by equalizing the airlock and cabin pressure with airlock hatch-mounted equalization valves mounted on the inner hatch. Depressurization of the airlock is controlled from inside the airlock. The airlock is depressurized by venting the airlock pressure overboard. The airlock hatch is installed to open toward the primary pressure source, the orbiter crew cabin, to achieve pressure assist sealing when closed. The two



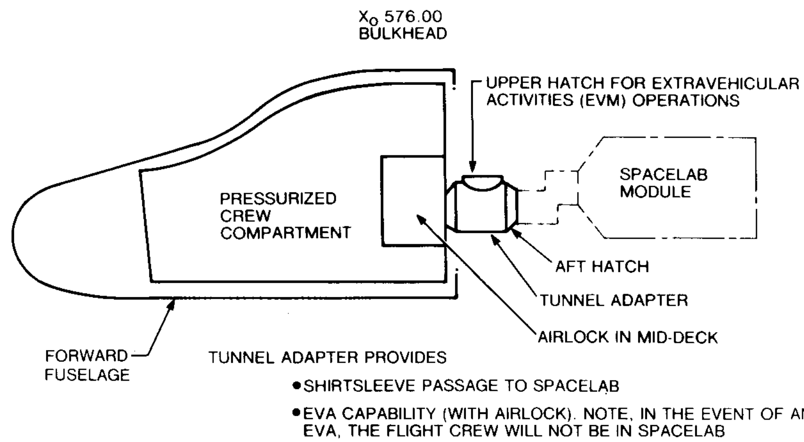
AIRLOCK – IN CABIN



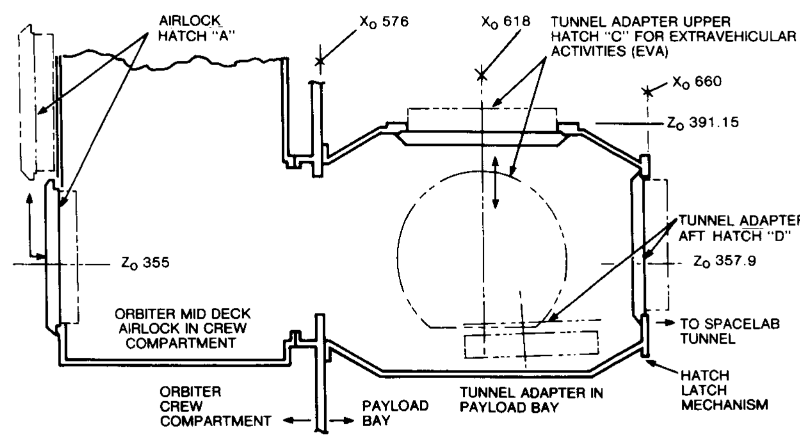
Airlock

hatches in the tunnel adapter are also installed to open toward the primary pressure source, the orbiter crew cabin, to achieve pressure assist sealing when closed.

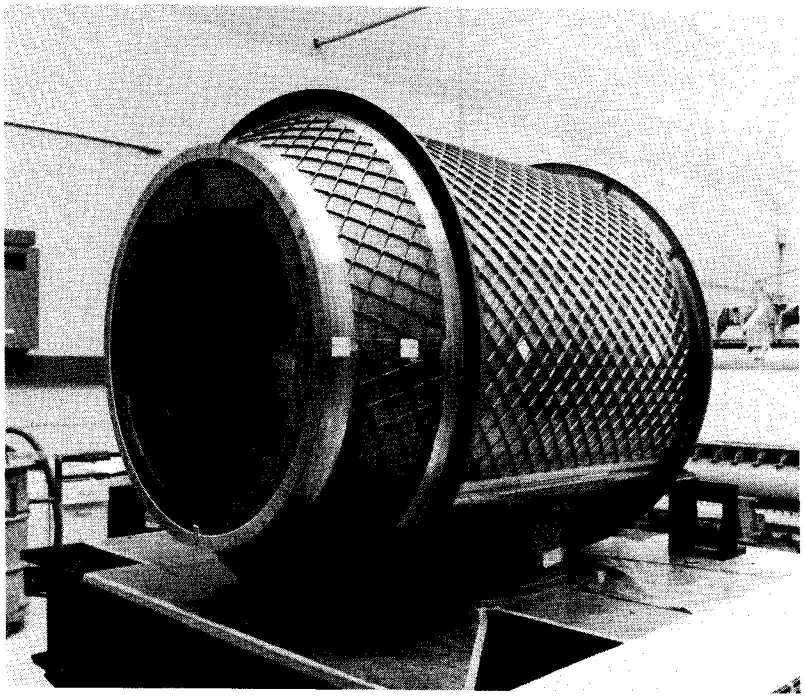
Each hatch has six interconnected latches (with the exception of the aft hatch which has 17) with a gearbox/ actuator, a window, a hinge mechanism and hold-open device, a differential pressure gage on each side, and two equalization valves.



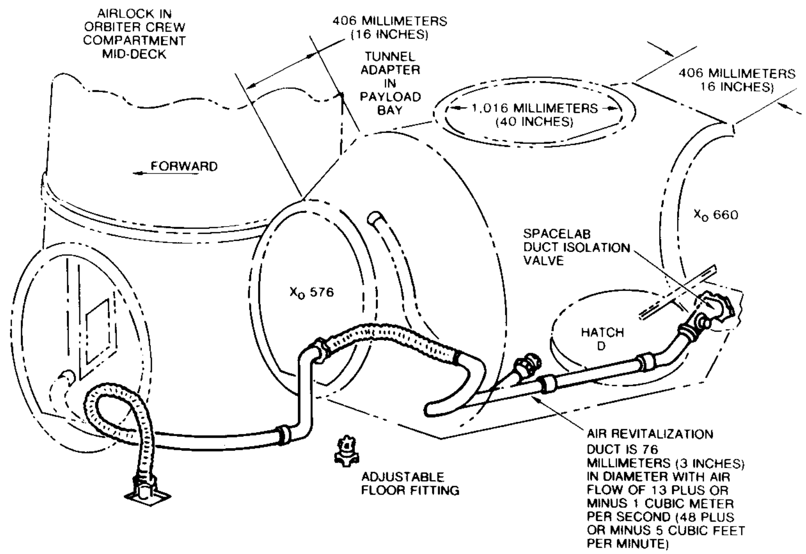
Airlock/Tunnel Adapter 61



Airlock and Tunnel Adapter Hatch Mechanical Systems



Tunnel Adapter



Environmental Control Life Support System (ECLSS) Air Circulation Duct Routing

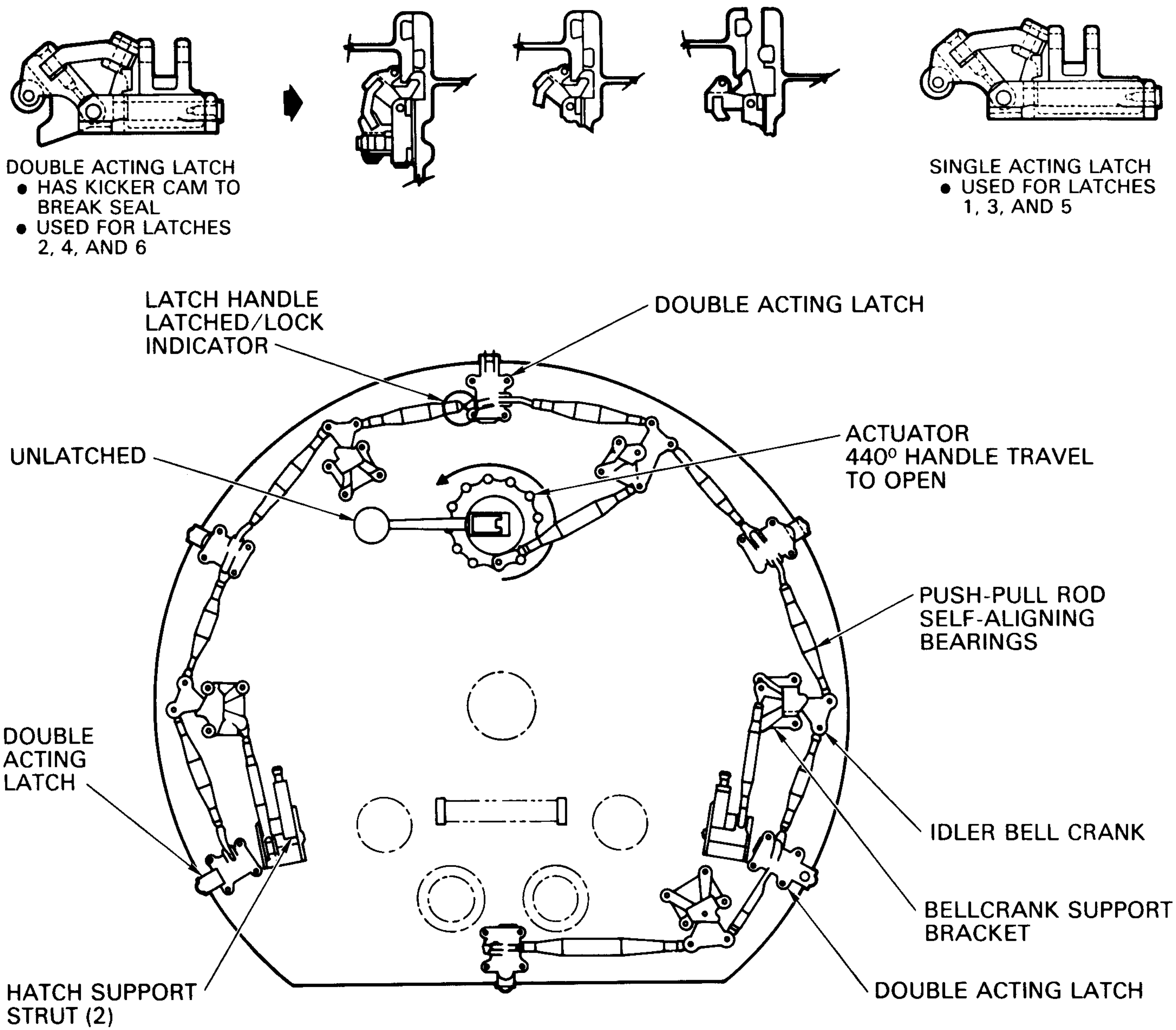
The window in each hatch is 101 millimeters (4 inches) in diameter. The window is used for crew observation from the cabin/airlock, tunnel adapter to tunnel, and tunnel adapter to payload bay. The dual window panes are made of polycarbonate plastic and mounted directly to the hatch using bolts fastened through the panes. Each hatch window has dual pressure seals with seal grooves located in the hatch.

Each hatch has dual pressure seals to maintain pressure integrity. One seal is mounted on the hatch and the other on the structure. A leak check quick disconnect is installed between the hatch and the pressure seals to verify hatch pressure integrity prior to flight.

The gearbox with latch mechanisms on each hatch allows the flight crew to open and/or close the hatch during transfers and EVA operation. The gearbox and the latches are mounted on the low pressure side of each hatch, with a gearbox handle installed on both sides to permit operation from either side of the hatch.

Three of the six latches on each hatch are double acting (with the exception of the aft hatch which has two). They have cam surfaces which force the sealing surfaces apart when the latches are opened, thereby acting as crew assist devices. The latches are interconnected with "push-pull" rods and an idler bellcrank installed between the rods for pivoting the rods. Self-aligning dual rotating bearings are used on the rods for attachment to the bellcranks and the latches. The gearbox is connected to the latching system, using the same rod/bellcrank and bearing system. To latch or unlatch the hatch, a rotation of 440 degrees on the gearbox handle is required.

The hatch actuator/gearbox is used to provide the mechanical advantage to open/close the latches. The hatch ac-



Airlock Hatch Latches

tuator lock lever requires a force of 35 to 44 Newtons (8 to 10 pounds) through an angle of 180 degrees to unlatch the actuator. A rotation of 440 degrees minimum with a force of 133 Newtons (30 pounds) maximum applied to the actuator handle is required to operate the latches to their fully unlatched positions.

The hinge mechanism for each hatch permits a minimum opening sweep into the tunnel adapter or the spacecraft crew cabin mid deck. The airlock crew cabin hatch in the mid deck is pulled/pushed forward to the mid-deck approximately 152 millimeters (6 inches). The hatch pivots up and to the starboard (right) side. Positive locks are provided to hold the latch in both an intermediate and a full open position. To release the lock, a spring-loaded handle is provided on the latch hold-open bracket. Friction is also provided in the linkage to prevent the hatch from moving if released during any part of the swing.

The aft hatch is hinged to be first pulled into the tunnel adapter and then pulled forward at the bottom. The top of the hatch is rotated towards Spacelab and downward until the hatch rests with the Spacelab side facing the tunnel adapter floor. The linkage mechanism guides the hatch from the closed/open, open/closed position with friction restraint throughout the stroke. The hatch is held in the open position by straps and velcro.

The upper (EVA) hatch in the tunnel adapter opens and closes to the port (left) wall of the tunnel adapter. The hatch is hinged to be first pulled into the tunnel adapter and then pulled forward at the hinge area and rotated down until it rests against the port wall of the tunnel adapter. The linkage mechanism guides the hatch from the closed/open, open/closed position with function restraint throughout the stroke. The hatch is held in the open position by straps and velcro.

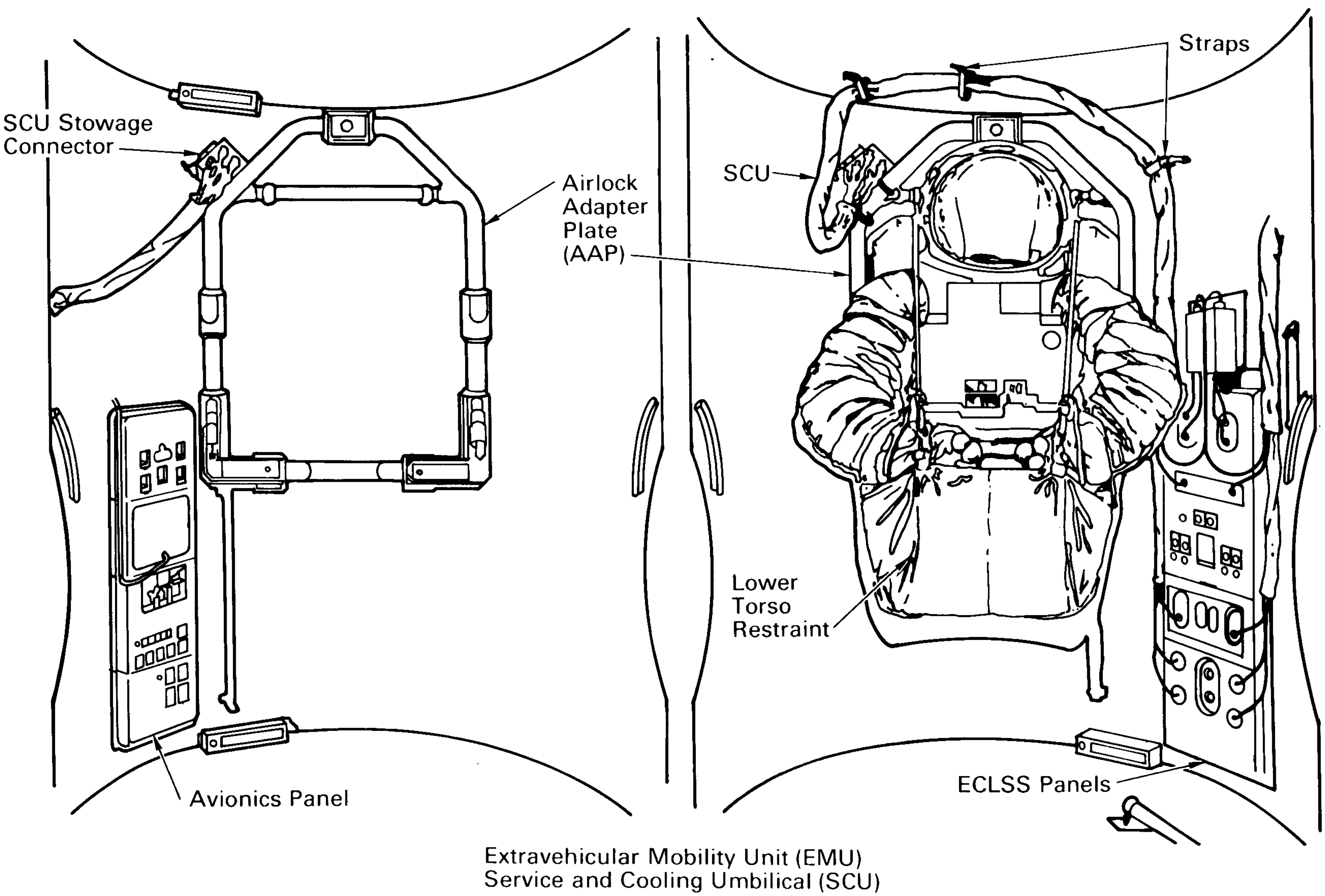
The hatches can be removed in-flight from the hinge mechanism via up pins, if required.

The spacecraft environmental control life support system (ECLSS) provides conditioned air to the airlock, tunnel adapter, and tunnel during non-EVA operation periods. Upon airlock hatch opening in-flight, the duct is attached to the spacecraft ECLSS. The duct must be disconnected from the spacecraft ECLSS prior to closing the airlock hatch.

To assist the crew member in pre- and post-EVA operations, the airlock incorporates handrails and foot restraints. Handrails are located alongside the avionics and ECLSS panels. A handhold is mounted on each side of the hatches. They are aluminum alloy and oval configurations 19.05 by 33.52 millimeters (0.75 by 1.32 inches) and are painted yellow. The handrails are bonded to the airlock walls with an epoxy-phenolic adhesive. Each handrail provides a handgrip clearance of 57 millimeters (2.25 inches) from the airlock wall to the handrail to allow gripping operations in a pressurized glove. Foot restraints are installed on the airlock floor nearer the payload bay side and the ceiling handhold installed nearer the cabin side of the airlock. The foot restraints can be rotated 360 degrees by releasing a spring-loaded latch and will lock in every 90 degrees. A rotation release knob on the foot restraint is designed for shirt sleeve operation, and therefore must be positioned before the suit is donned. The foot restraint is bolted to the floor and cannot be removed in flight and is sized for the EMU boot. The crew member ingresses by first inserting the foot under the toe bar and then the heel is pressed down by rotating the heel from inboard to outboard until the heel of the boot is captured.

There are four floodlights in the airlock. The lights are controlled by switches in the airlock on panel AWI8A; light 2 can also be controlled by a switch on mid-deck panel M013Q, allowing illumination of the airlock prior to entry. Lights 1, 3, and 4 are powered by buses MNA, B, and C respectively and light 2 is powered by ESS1BC. The circuit breakers are on panel ML86B.

In preparation for an EVA, the mission specialists will first don a liquid cooled and ventilation garment (LCVG). It is similar to "long-john" underwear into which have been woven many feet of flexible tubing that circulates cooling water. The



Airlock Stowage Provisions

liquid cooled and ventilation garment is worn under the pressure and gas garment to maintain desired body temperature.

A urine collection device (UCD) is worn for collection of urine in the suit. It stores approximately 0.9 liter (approximately one quart) of urine. It consists of adapter tubing, storage bag and disconnect hardware for emptying after an EVA into the orbiter waste water system.

The airlock provides stowage for two Extravehicular Mobility Units (EMU's) and two service and cooling umbilicals (SCU's) and various miscellaneous support equipment.

Both EMU's are mounted on the airlock walls by means of an airlock adapter plate (AAP).

The prime contractor to NASA for the space suit/life support system is United Technologies' Hamilton Standard Division in Windsor Locks, Conn. Hamilton Standard is program systems manager for the space suit/life support system in addition to designer and builder. Hamilton Standard's major subcontractor is ILC Dover of Frederica, Del., which fabricates the space suit.

The EMU's provide the necessities for life support, such as oxygen, carbon dioxide removal, a pressurized enclosure, temperature control and meteoroid protection during EVA.

The EMU space suit comes in various sizes so that prior to launch, flight crew members can pick their suits "off the rack." Components are designed to fit male and female from the 5th to the 95th percentiles of body size.

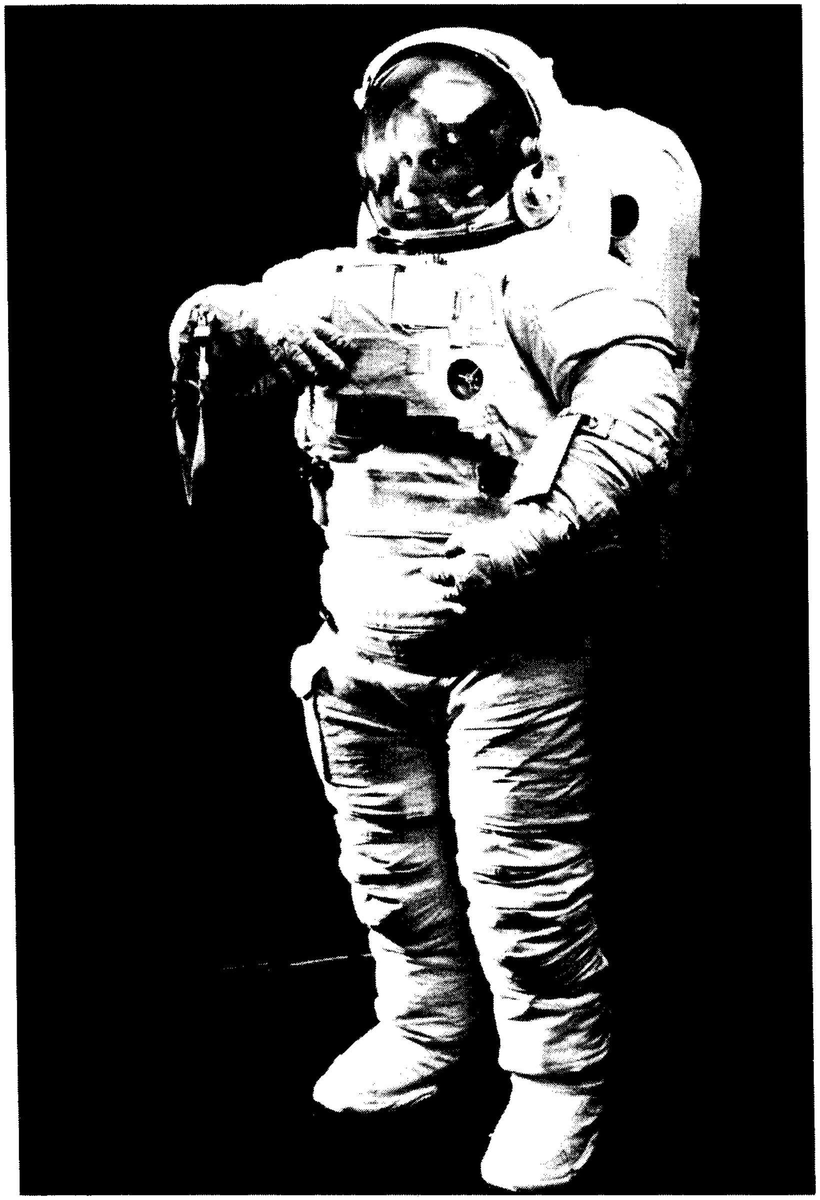
The life support system is self contained and contains seven hours of expendables such as oxygen, battery power for electrical power, water for cooling, and lithium hydroxide for carbon dioxide removal and a 30 minute emergency life support system during an EVA.

The airlock adapter plate in the airlock also provides a

Extravehicular Mobility Unit (EMU)

fixed position for the EMU's to assist the crew member during donning, doffing, checkout and servicing. Each EMU weighs approximately 102 kilograms (225 pounds) and the overall storage envelope is 660 by 711 by 1,016 millimeters (26 by 28 by 40 inches). For launch and entry, the lower torso restraint, a cloth bag attached to the airlock adapter plate (AAP) with straps, is used to hold the lower torso and arms securely in place.

To don the EMU, the crew member enters the airlock and dons the lower torso assembly which has boots attached. The lower torso consists of the pants, boots and the hip, knee and ankle joints. The hard, upper torso assembly includes the life support backpack and provides the structural mounting interface for most of the EMU including helmet, arms, lower torso, portable life support system, display and control module and electrical harness. The arm assembly contains the shoulder joint and upper arm bearings that permit shoulder mobility as well as


Extravehicular Mobility Unit (EMU)

the elbow joint and wrist bearing. The gloves contain the wrist disconnect, wrist joint and insulation padding for palms and fingers. The helmet consists of a clear polycarbonate bubble neck disconnect and ventilation pad. An EVA visor assembly is attached externally to the helmet which contains visors which are manually adjusted to shield the crew member's eyes. The upper and lower torsos are connected with a waist ring.

In addition, the portable life support system consists of an EMU electrical harness that provides bioinstrumentation and communications connections; a display and control module that is chest mounted which contains all external fluid and electrical interfaces and controls and displays; the portable life support subsystem referred to as the "backpack" which contains the life support subsystem expendables and machinery; a secondary oxygen pack mounted on the base of the portable life support subsystem which contains a 30 minute emergency oxygen supply and a valve and a regulator assembly, and an in-suit drink bag that stores liquid in the hard upper torso which has a tube projecting up into the helmet to permit the crew member to drink while suited.

The orbiter provides electrical power, oxygen, liquid cooled ventilation garment cooling and water to the EMU's in the airlock via the SCU for EVA prep and post-EVA operations.

The service and cooling umbilical (SCU) is launched with the orbiter end fittings permanently connected to the appropriate ECLSS panels and the EMU connected to the airlock adapter plate stowage connector. The SCU contains communication lines, electrical power, water and oxygen, recharge lines and drain lines. It allows all supplies (oxygen, water, electrical, and communication) to be transported from the airlock control panels to the EMU before and after EVA without using the EMU expendable supplies of water, oxygen and battery power that are scheduled for use in the EVA. The SCU also provides EMU recharge. The SCU umbilical is disconnected just before the crew member leaves the airlock on an EVA and upon return to the airlock after an EVA. Each SCU is 3,657 millimeters (144 inches) long and 88 millimeters (3.5 inches) in diameter and weighs 9.1 kilograms (20 pounds). Actual usable length after attachment to the control panel is approximately 2 meters (7 feet).

The airlock has two display and control panels. The airlock control panels are basically split to provide either ECLSS or avionics operations. The ECLSS panel provides the interface for the SCU waste and potable water, liquid cooled ventilation garment cooling water, EMU hardline communication, EMU power and oxygen supply. The avionics panel includes the airlock lighting, the airlock audio system, and the EMU power and battery recharge controls. The avionics panel is located on the starboard (right) side of the cabin airlock hatch and the ECLSS panel on the port (left) side. The airlock panels are designated AW18H, AW18D, and AW18A on the port side and AW82H, AW82D, and AW82B on the starboard side. The ECLSS panel is divided into EMU1 functions on the starboard side and EMU2 functions on the port side.

Airlock communications are provided with the orbiter audio system at airlock panel AW82D where connectors for the headset interface units (HIU's) and the EMU's are located at airlock panel AW18D which is the airlock audio terminal (ATU). The HIU's are inserted in the crew-member communications carrier unit (CCU1 and CCU2) connectors on airlock panel AW82D. The CCU's are also known as the "Snoopy Cap" which fits over the crew member's head and snaps into place with a chin guard. It contains a microphone and headphones for two-way communications and receiving caution and warning tone. The adjacent two-position switches labeled CCU1 and CCU2 POWER enable transmit functions only, as reception is normal as soon as the HIU's are plugged in. The EMU1 and EMU2 connectors on the same panel to which the service and cooling umbilical (SCU) is connected include contacts for EMU hard-line communications with the orbiter prior to EVA. Panel AW18D contains displays and controls used to select access to and control volume of various audio signals. Control of the airlock audio functions can be transferred to the mid-deck ATU's panel M042F, by placing the CONTROL knob to MIDDECK position.

During EVA, the Extravehicular Communicator (EVC) is part of the same UHF system which is used for air-to-air and air-to-ground voice communications between the orbiter and landing site control tower and the orbiter and chase aircraft. The EVC provides full duplex (simultaneous transmission and reception) communications between the orbiter and the two EVA crew members and continuous data reception of electrocardiogram signals from each crew member by the orbiter and orbiter processing and relay of electrocardiogram signals to the ground. The UHF airlock antenna in the forward portion of the payload bay provides the UHF-EVA capability.

Panel AW18H in the airlock provides 17 plus or minus 0.5 vdc at five amperes at both EMU electrical connector panels, panel AW82D, in EVA prep. Bus MNA or B can be selected on the BUS SELECT switch and then the MODE switch is positioned to POWER. The BUS SELECT switch provides a signal to a remote power controller (RPC) which applies 28 vdc from the selected bus to the power/battery recharger. The MODE switch in the POWER position makes the power available at the SCU connector and also closes a circuit that provides a battery feedback voltage charger control which inhibits EMU power when any discontinuity is sensed in the SCU/EMU circuitry. The MODE switch in the POWER position also applies power through the SCU for the EMU microphone amplifiers for hardline communication. When the SCU umbilical is disconnected for EVA, the EMU operates on its self contained battery power. For post-EVA, when the SCU is reconnected to the EMU, selecting a bus and the CHARGE position on the MODE switch charges the portable life support system battery at 1.55 plus or minus 0.05 amps. When the battery reaches 21.8 plus or minus 0.1 vdc and/or the charging circuit exceeds 1.55 plus or minus 0.05 amps, a solenoid controlled switch internal to the battery charger removes power to the charging circuitry. The EMU silver zinc battery provides all electrical power used by the portable life support system during EVA and is filled with electrolyte and charged prior to flight.

Cooling for the flight crew members before and after the EVA is provided by the liquid cooled garment circulation system via the SCU and LCG (liquid cooled garment) SUPPLY

AND RETURN connections on panel AW82B. These connections are routed to the orbiter liquid cooled garment heat exchanger which transfers the collected heat to the orbiter Freon-21 coolant loops. The nominal loop flow of 113 kilograms per hour (250 pounds per hour) is provided by the EMU/portable life support system water loop pump. The system circulates chilled water at 10 degrees Celsius (50 °F) maximum to the liquid cooled ventilation garment inlet and provides a heat removal capability of 2,000 Btu (British Thermal Units) per hour per crew member. When the SCU is disconnected the portable life support system provides the cooling. Upon return from the EVA, the portable life support system is reconnected to the SCU and the crew member cooling is provided as it was in the EVA prep.

With the suit connected to the SCU, oxygen at 15,525 to 46,575 mmhg (300 to 900 psia) is supplied through airlock panel AW82B from the orbiter oxygen system when the OXYGEN valve is in the OPEN position on the airlock panel. This provides the suited crew member with breathing oxygen, preventing depletion of the portable life support system oxygen tanks prior to the EVA. Prior to the crew member sealing the helmet, an oxygen purge adapter hose is connected to the airlock panel to flush nitrogen out of the suit.

The crew member will prebreathe pure oxygen in the EMU for approximately 3 and one-half hours prior to the EVA. This is necessary to remove nitrogen from their blood before working in the pure oxygen environment of the EMU due to the orbiter pressurized crew cabin mixed gas atmosphere of 20 percent oxygen and 80 percent nitrogen at a pressure of 760 plus or minus 10 mmhg (14.7 plus or minus 0.2 psia). Without prebreathing, bends occur when an individual fails to reduce nitrogen levels in the blood prior to working in a pressure condition that can result in nitrogen coming out of solution in the form of bubbles in the bloodstream. This condition results in pain in the body joints, possibly because of restricted blood flow to connective tissues or the extra pressure caused by bubbles in the blood at joint area. During prebreathe, the suit is at 77 mmhg (1-1/2 psig).

When the SCU is disconnected, the portable life support system provides oxygen for the suit. When the EVA is completed and the SCU is reconnected, the orbiter oxygen supply begins recharging the portable life support system, providing the OXYGEN valve on panel AW82B is OPEN. Full oxygen recharge takes approximately one hour (allowing for thermal expansion during recharge) and the tank pressure is monitored on the EMU display and control panel as well as on the airlock oxygen pressure readout.

Each EMU is pressurized to 207 mmhg (4.0 psid) differential. They are designed for a 15 year life with cleaning and drying between flights.

The EMU WATER SUPPLY and WASTE valves are opened during the EVA prep by switches on panel AW82D. This provides the EMU, via the SCU, access to both the orbiter potable water and waste water systems. The support provided to the EMU portable life support system is further controlled by the EMU display and control panel. Potable water—supplied from the orbiter at 828 plus or minus 25 mmhg (16 plus or minus 0.5 psi), 45 to 58 kilograms per hour (100 to 300 pounds per hour), and 4 to 37 degrees C (40 to 100 °F)—allowed to flow to the feedwater reservoir in the EMU which provides pressure which would "top-off" any tank not completely filled. Waste water, condensate, developed in the portable life support system is allowed to flow to the orbiter waste water system via the SCU whenever the regulator connected at the bacteria filters (airlock end of the SCU) detects upstream pressure in excess of 828 plus or minus 25 mmhg (16 plus or minus 0.5 psi).

When the SCU is disconnected from the EMU, the portable life support system assumes this function. When the SCU is reconnected to the EMU upon completion of the EVA, the same functions as in pre-EVA are performed except that the water supply is allowed to continue until the portable life support system water tanks are filled, which takes approximately 30 minutes.

In preparation for the EVA from the airlock, all hatches are closed and depressurization of the airlock begins.

Airlock/tunnel adapter depressurization is accomplished by a three position valve located on the ECLSS (Environmental Contol Life Support System) panel AW82A in the airlock. The airlock depressurization valve is covered with a pressure/dust cap. Prior to removing the cap from the valve, it is necessary to vent the area between the cap and valve by pushing the vent valve on the cap. In-flight storage of the pressure/dust cap is adjacent to the valve. The airlock depressurization valve is connected to a 50 millimeter (2 inch) inside diameter stainless steel overboard vacuum line. The AIRLOCK DEPRESS valve controls the rate of depressurization by varying the valve diameter size. Depressurization is accomplished in two stages. The CLOSED position prevents any airflow from escaping to the overboard vent system.

When the crew members have completed the prebreathe in the EMU's for 3.5 hours, the airlock/tunnel adapter is depressurized from 760 mmhg (14.7 psia) to 258 mmhg (5 psia) by position labeled "5" on the AIRLOCK DEPRESS valve which opens the depressurization valve and allows the pressure in the airlock to decrease until the flight crew closes the valve at 258 mmhg (5 psia). Pressure during depressurization can be monitored by the delta pressure gage on the airlock hatch. A delta pressure gage is installed on each side of the hatches.

At this time the flight crew performs an EMU suit leak check, electrical power is transferred from the umbilicals to the EMU batteries, the umbilicals are disconnected and the suit oxygen packs are brought on line.

The second stage of airlock depressurization is accomplished by positioning the AIRLOCK DEPRESS valve closed to "0" which increases the valve diameter and allows the pressure in the airlock to decrease from 258 mmhg (5 psia) to 0 mmhg (0 psia). The depressurization of airlock/tunnel adapter is accomplished within 18 minutes at rates no more than 5.1 mmhg (0.1 psia) per second during normal operations. The suit sublimators are activated for cooling, EMU system checks are performed and the airlock/payload bay hatch can be opened. The hatch is capable of opening against a 10 mmhg (0.2 psia) differential maximum.

Hardware provisions are installed in the orbiter payload bay, on the tunnel adapter, tunnel and Spacelab for use by the crew member during the EVA.

Handrails and tether points are located on the payload bulkheads, forward bulkhead station X_O 576 and aft bulkhead station X_O 1307, and along the sill longeron on both sides of the bay to provide translation and stabilization capability for the EVA crew member. The handrails are designed to withstand a load of 90.72 kilograms (200 pounds), 127.01 kilograms (280 pounds) maximum in any direction. Tether attach points are designed to sustain a load of 260.37 kilograms (574 pounds), 364.69 kilograms (804 pounds) maximum, in any direction.

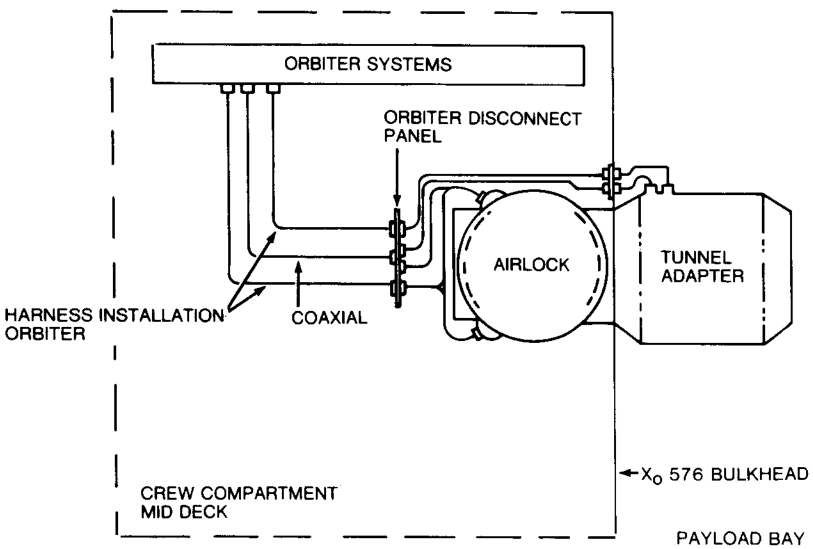
The handrails have a cross section of 33 by 19 millimeters (1.32 by 0.75 inches). They are made of aluminum alloy tubing and are painted yellow. The end braces and side struts of the handrails are constructed of titanium. An aluminum alloy end support standoff functions as the terminal of the handrail. Each end support standoff incorporates a 25.4 millimeter (one inch) diameter tether point.

A 7.62 meter (25 foot) crew member safety tether is attached to each crew member at all times during an EVA.

The tether consists of a reel case with an integral "D" ring, a reel with a light takeup spring, a cable and a locking hook. The safety tether hook is locked onto the slidewire before launch and the cable is routed and clipped along the port (left) and starboard (right) handrails to a position just above the airlock/payload bay hatch. After opening the airlock hatch and before egress, the crew member attaches a waist tether to the "D" ring of the safety tether to be used. The other end of the waist tether is hooked to a ring on the EMU waist bearing. The crew member may select either the port or the starboard safety tether. With the selector on the tether in the locked position, the cable will not retract or reel out. Moving the selector to the unlocked position allows the cable to reel out and the retract feature to take up slack. The cable is designed for a maximum load of 398 kilograms (878 pounds). The routing of the tethers follows the handrails, allowing the crew member to deploy and restow his tether during translation.

The two slidewires, approximately 14.11 meters (46.3 feet) long, are located in the longeron sill area on each side of the payload bay. They start approximately 2.83 meters (9.3 feet) aft of the forward bulkhead and extend approximately 14.11 meters (46.3 feet) down the payload bay. The slidewires withstand a tether load of 260.37 kilograms (574 pounds) with a safety factor of 1.4 or 364.49 kilograms (804 pounds) maximum.

The airlock/cabin hatch has two pressure equalization valves which can be operated from both sides of the hatch for repressurizing the airlock volume. Each valve has three positions, CLOSED, NORM (Normal), and EMERG (Emergency) and is protected by a debris pressure cap on the intake (high-pressure) side of the valve, which on the other two hatches must be vented for removal. The caps are tethered to the valves and also have small Velcro spots which allow temporary stowage on the hatch. The exit side of the valve contains an air diffuser to provide uniform flow out of the valve.



Airlock/Tunnel Adapter Harness Installation and Coaxial Antenna

Through the use of the equalization valve/valves in the various positions, the airlock can be repressurized in a normal mode to 760 mmhg (14.7 psia) within 13 minutes at rates no more than 5.1 mmhg (0.1 psia) per second during normal operations. If both equalization valves are positioned to EMERG, the airlock/tunnel adapter can be repressurized to 760 mmhg (14.7 psia) in 65 plus or minus 5 seconds at rates no more than 51.75 mmhg (1.0 psi) per second. The hatch is capable of opening against a 10 mmhg (0.2 psia) differential maximum.

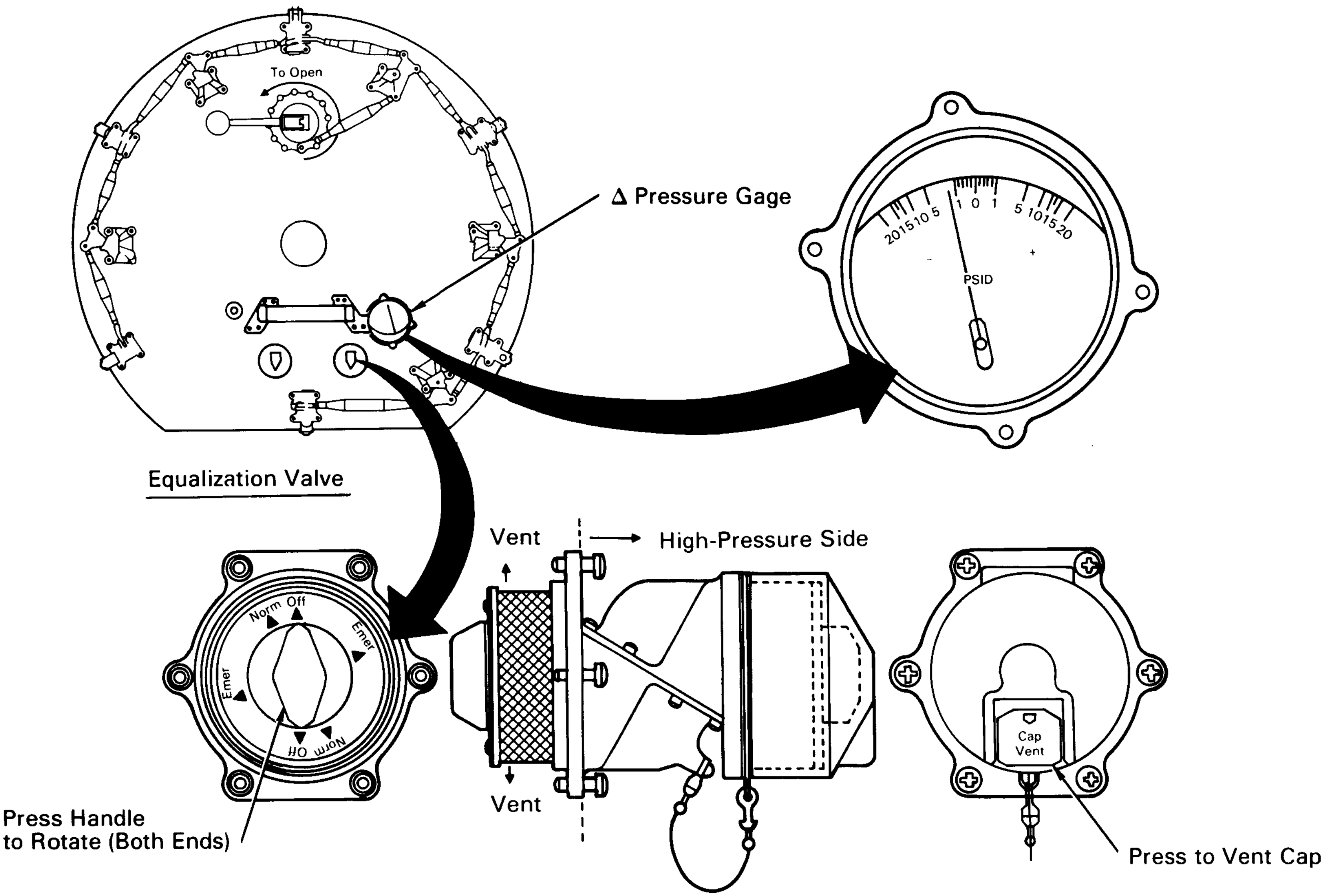
The airlock is initially pressurized to 258 mmhg (5 psia) and the umbilicals are connected and electrical power is transferred back to umbilical power. The airlock is then pressurized to equalize with the cabin pressure, followed by EMU doffing and the crew members' recharge of the EMU's.

The orbiter provides accommodations for three two-flight-crew member EVA's of six-hour duration per flight at no weight or volume cost to the payload. Two of the EVA's are for payload support and the third is reserved for orbiter contingency. Additional EVA's can be considered with consumables charged to payloads.

CARGO BAY STOWAGE ASSEMBLY (CBSA)

The Cargo Bay Stowage Assembly contains miscellaneous tools for use in the payload bay. It is located on the starboard (right) side of the payload bay forward, between Orbiter Station X_O = 589 and X_O = 636.

The CBSA is approximately 1,066 millimeters (42 inches) wide, 609 millimeters (24 inches) in depth and 914 millimeters (36 inches) in height. The CBSA weight is approximately 259 kilograms (573 pounds).



Airlock Repressurization

PAYLOAD RETENTION MECHANISMS

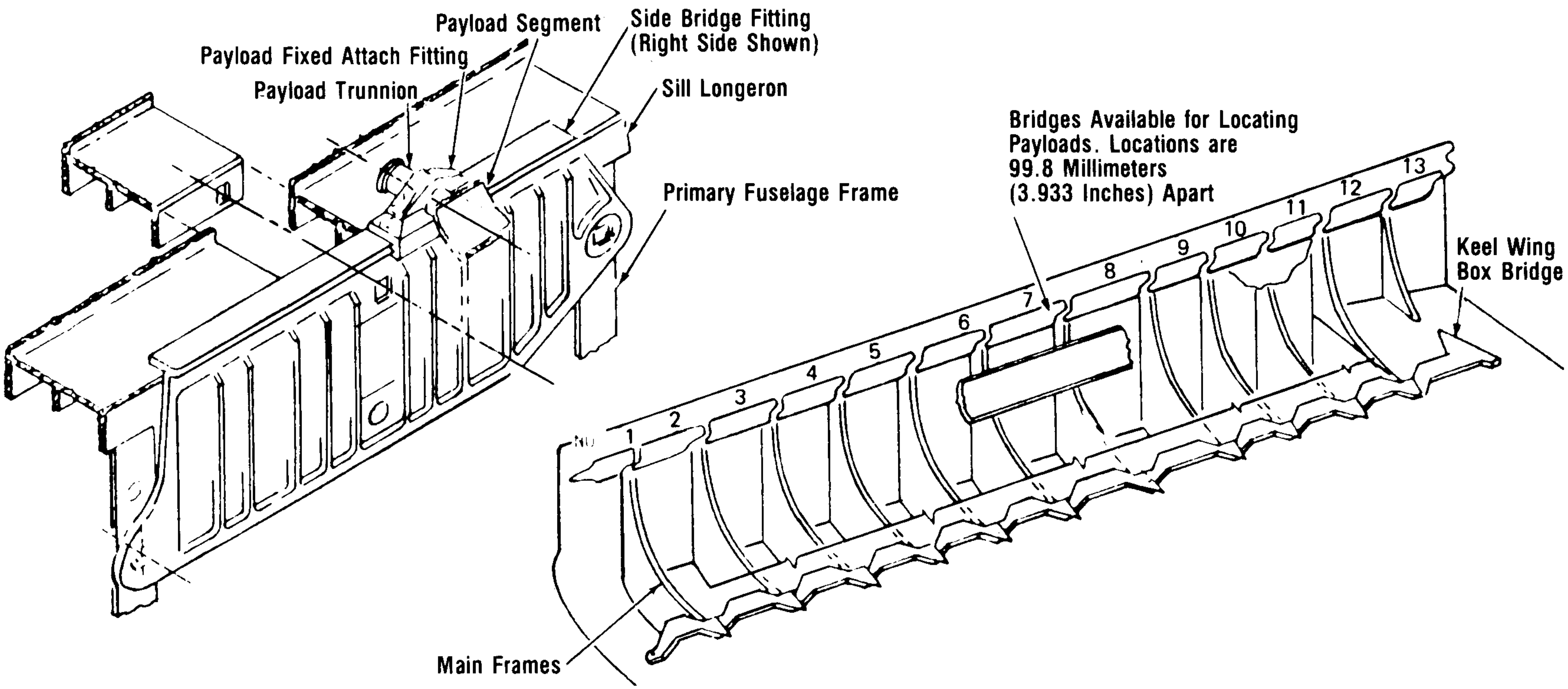
Nondeployable payloads are retained by passive retention devices, whereas, unberthing and berthing of the deployable payloads are secured by motor-driven, active retention devices.

Payloads are secured in the orbiter payload bay by means of the payload retention system or are equipped with their own unique retention systems.

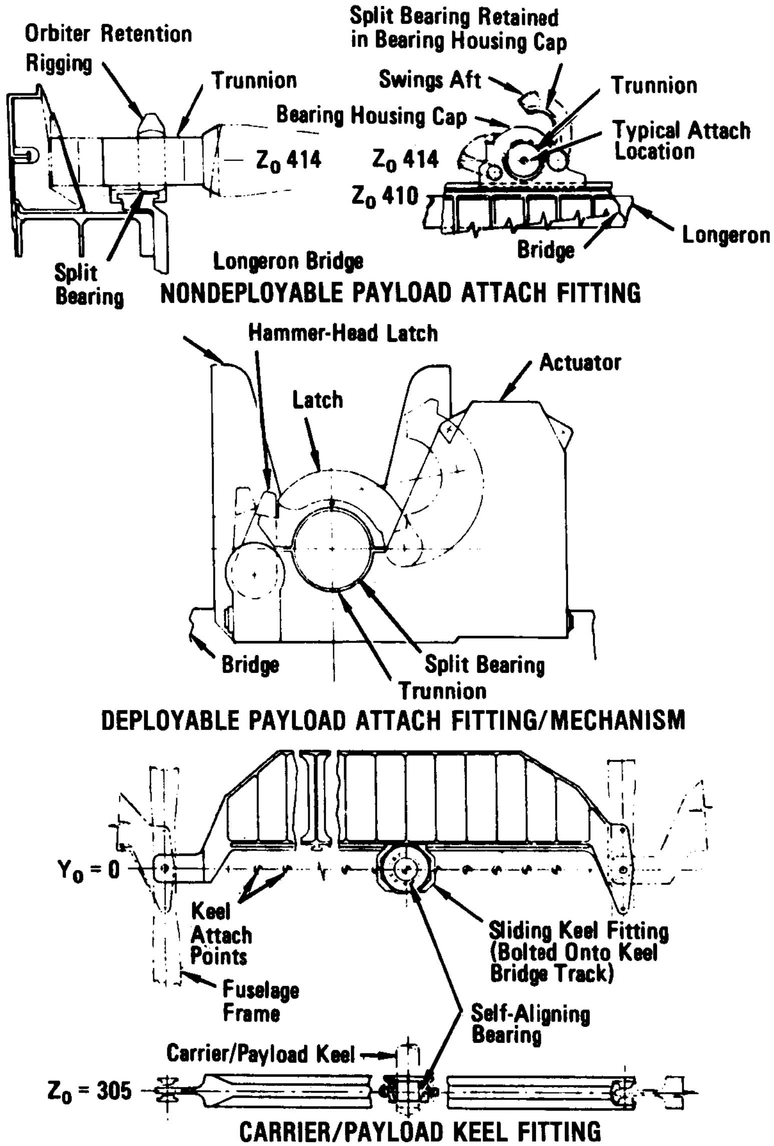
The orbiter payload retention system provides three-axis support for up to five payloads per flight.

The payload retention mechanisms secure the payloads during all mission phases and provides for installation and removal of the payloads when the orbiter is either horizontal or vertical.

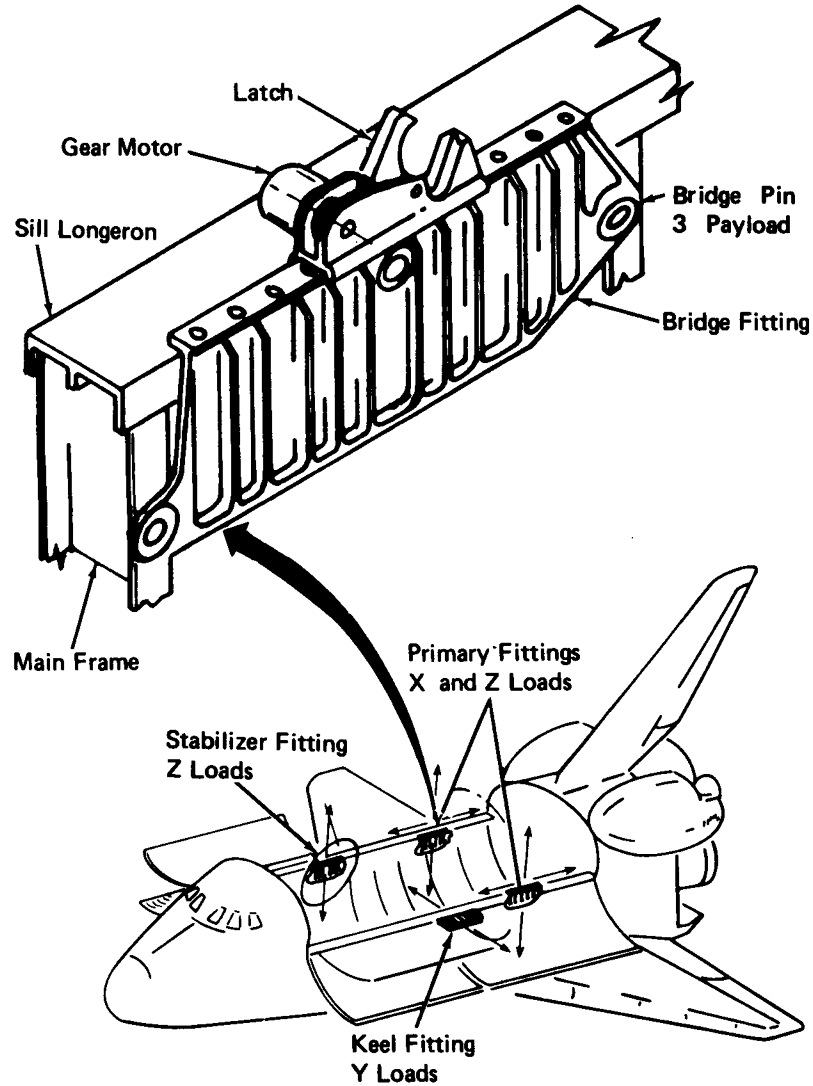
Attachment points in the payload bay are in 99-millimeter (3.933-inch) increments along the left- and right-side longerons and along the bottom centerline of the bay. Of the potential 172 attach points on the longerons, 48 are unavailable because of the proximity of spacecraft hardware. The remaining 124 may be used for carrier/payload attachment: of these, 16 may be used for deployable payloads. Along the centerline keel, 89 attach points are available, 75 of which may be used for



Payload Retention



Standard Attach Fittings for Payloads

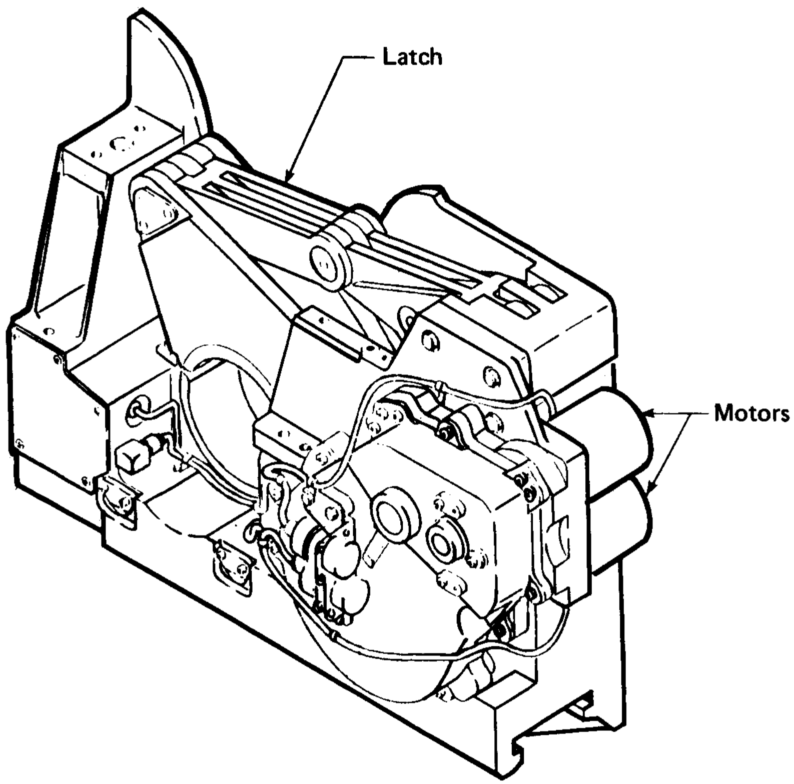


Active Payload Retention System

deployable payloads. There are 13 longeron bridges per side and 12 keel bridges available per flight. Only the bridges required for a particular flight are flown. The bridges are not interchangeable because of main frame spacing, varying load capability, and subframe attachments.

The longeron bridge fittings are attached to the payload bay frame at the longeron level and at the side of the bay. Keel bridge fittings are attached to the payload bay frame at the bottom of the payload bay.

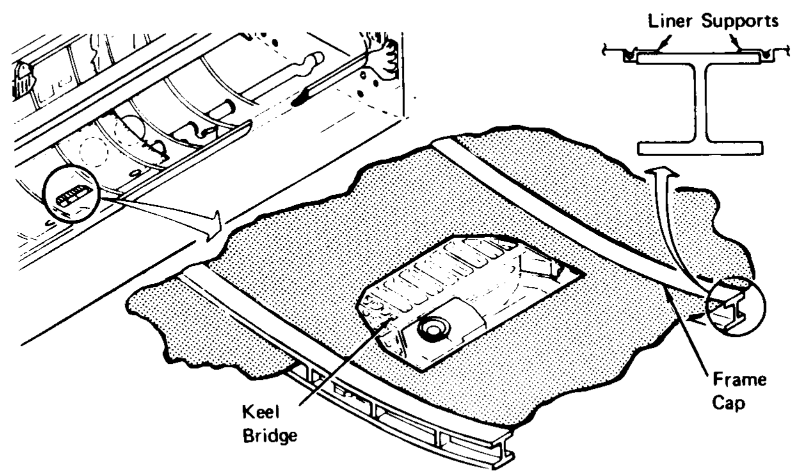
The payload trunnions are the interfacing portion of the payload with the orbiter retention system. The trunnions that interface with the longeron are 82 millimeters (3.25 inches) in diameter and 177.8 or 222.2 millimeters (7 or 8.75 inches) long, depending upon where they are positioned along the payload bay. The keel trunnions are 76.2 millimeters (3 inches) in diameter and vary in length from 101.6 to 292.1 millimeters (4 to 11.5 inches), depending upon where they fit in the payload bay.



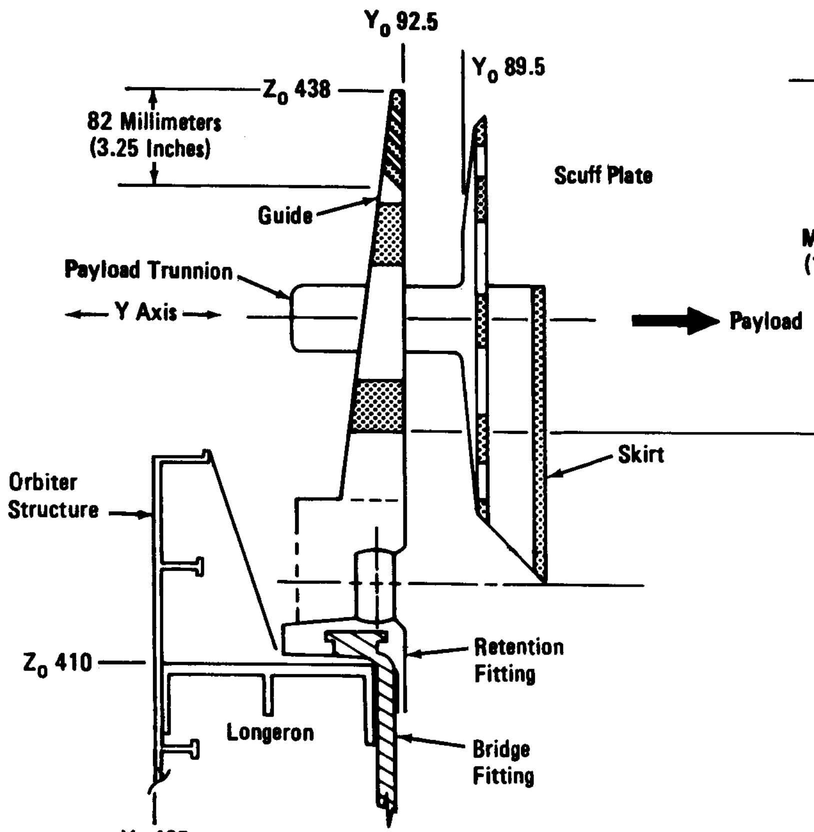
Payload Retention Latch

The orbiter/payload attachments are the trunnion/bearing/ journal type. The longeron and keel attach fitting have a split, self-aligning bearing for nonrelease-type payloads in which the hinged half is bolted closed. For on-orbit unberth and berthing of the deployable payloads, the hinged half fitting releases or secures the payload by latches that are driven by dual redundant electric motors.

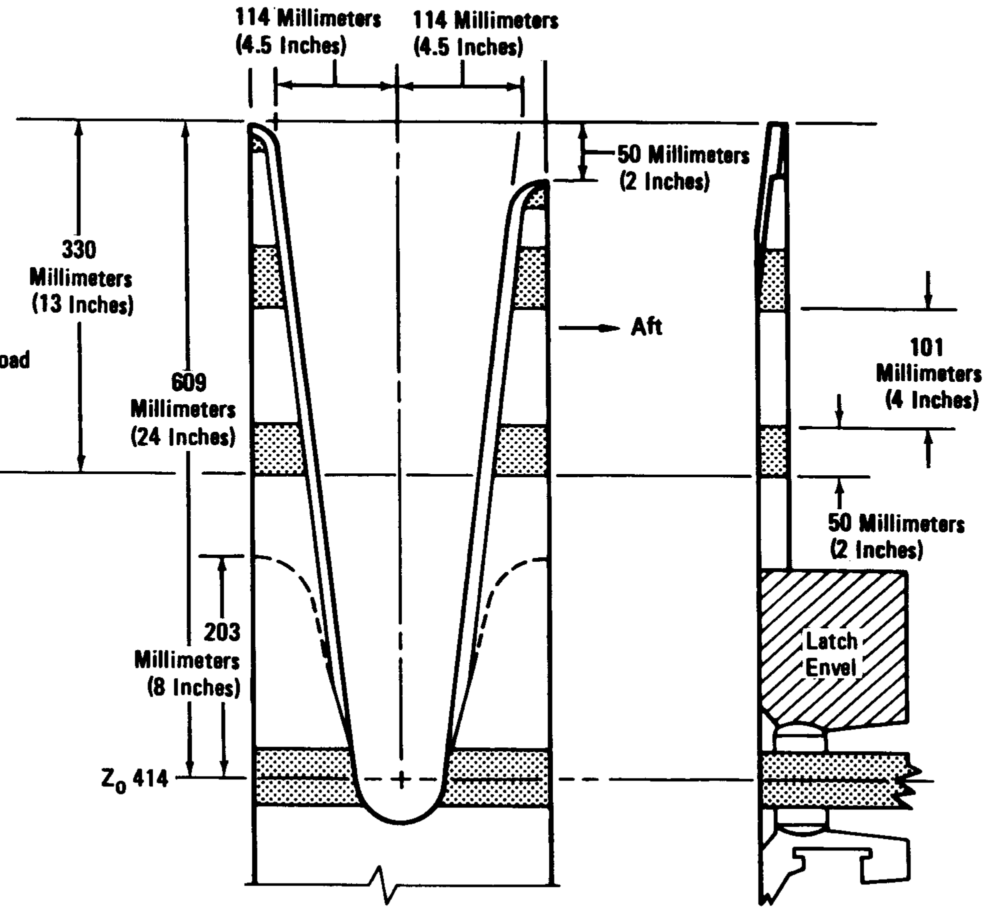
Payload guides and scuff plates are used to assist in unberthing and berthing deployable payloads in the payload bay. The payload is constrained in the X direction by guides and in the Y direction by scuff plates and guides. The guides are mounted to the inboard side of the payload latches and interface with the deployable payload trunnions and scuff plates. The scuff plates are attached to the deployable payload trunnions and interface with the deployable payload guides.



Active Keel Fitting



Orbiter Payload Guide and Trunnion/Scuff Plate (Nominal)



Orbiter Active Latch Guide

The guides are V shaped with one part of the V being 50.8 millimeters (2 inches) taller than the other part. Parts are available to make either the forward or aft guide, the tallest. This difference enables the operator monitoring the unberthing or berthing operations through the aft bulkhead TV cameras to better determine when the deployable payload trunnion has entered the guide. The top of the tallest portion of the guide is 609.6 millimeters (24 inches) above the centerline of the payload trunnion when it is all the way down in the guide. The top of the guide has a 228.6-millimeter (9-inch) opening. These guides are mounted to the 203.2-millimeter (8-inch) guides that are a part of the longeron payload retention latches.

The payload scuff plates are mounted to the deployable payload structure. There are two longeron latches and a keel latch for on-orbit unberthing and berthing of deployable payloads. These latches are controlled by dual redundant electric motors with either or both motors releasing or latching the mechanism. The operating time of the latch is 30 seconds with both motors operating or 60 seconds with one motor operating. The latch/release switches on the aft flight deck display and control panel station control the latches. Each longeron latch has two microswitches sensing the ready-to-latch condition. Only one is required to control the ready-to-latch talkback indicator on the aft flight deck display and control panel station. Each longeron latch also has two microswitches to indicate latch and two to indicate release. Only one of each is required to control the latch or release talkback indicator on the aft flight deck display and control panel station. The keel latch also has two microswitches that sense when the keel latch is closed with the trunnion in it. Only one of the switches is required to operate the talkback indicator on the aft flight deck display and control panel station. The keel latch also has two microswitches that verify if the latch is closed or open, with only one required to control the talkback indicator on the aft flight station display and control panel station.

It is noted that the keel latch centers the deployable payload in the yaw direction in the payload bay; therefore the keel latch must be closed before the longeron latch is closed. The keel latch can float plus or minus 69 millimeters (plus or minus 2.75 inches) in the X direction.

AERODYNAMIC COEFFICIENT IDENTIFICATION PACKAGE (ACIP)/ HIGH RESOLUTION ACCELEROMETER PACKAGE (HIRAP)

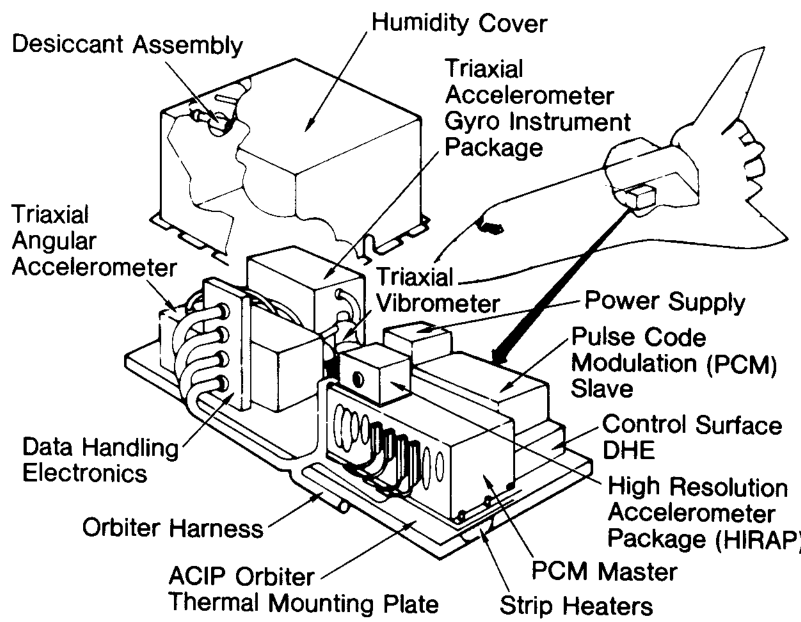
The ACIP/HIRAP is a sensor package installed below the payload bay area in the aft area of the mid-fuselage at station X_O 1069. It contains a rate gyro package, a linear accelerometer package, an angular accelerometer package, and associated electronics.

The ACIP/HIRAP will collect aerodynamic data in the hypersonic, supersonic, and transonic flight regimes, regions in which there has been little opportunity for gathering and accumulating practical data, to establish an extensive aerodynamic data base for verification of and correlation with ground-based test data including assessments of the uncertainties in such data. In addition, it will provide flight dynamics state and variable data in support of other technology areas, such as aerothermal and structural dynamics. HIRAP is mounted on the present ACIP. HIRAP will use existing ACIP output channels and will provide accurate determination of aerodynamic coefficients at near orbital attitudes (up to 213,360 meters [70,000 feet]) which were heretofore unobtainable.

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

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

The ACIP/HIRAP incorporates four triads of instruments: A HIRAP of micro-g accelerometers, one triad of linear accelerometers, one triad of angular accelerometers, and one triad of rate gyros. Also included are the power conditioner for the system, the power control system, and the housekeeping components for the instruments. The ACIP/HIRAP is aligned to the orbiter axes to a very high order of accuracy. Mounted on the ACIP/HIRAP base is a triaxial vibrometer which will pro-



Aerodynamic Coefficient Identification Package (ACIP)/High Resolution Accelerometer Package (HIRAP) vide the structural vibration characteristics of the orbiter affecting the ACIP/HIRAP experiment necessary for baseline filtration of accelerometer data. The output signals of the instruments are recorded on the orbiter operational recorders. The ACIP/HIRAP operates through launch and through the entry and descent phases. The internal instruments continuously sense the dynamic X, Y, and Z attitude changes to determine performance characteristics of the orbiter through these critical flight phases. In addition, the ACIP/HIRAP receives indications of position of the control surfaces and converts them into high resolution digital data before recording them with the attitude data. Power is supplied from the mid-power control assembly 3 main bus C. Heaters are employed on the package and controlled by a switch on panel R11.

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

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STS-1 MISSION FACTS
(COLUMBIA)
APRIL 12-14, 1981

Commander: John W. Young

Pilot: Robert L. Crippen

Mission Duration—54 hours, 21 minutes, 57 seconds

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

Orbits of Earth—36

Orbital Attitude—145 nautical miles (166 statute miles)

Landing Touchdown—853 meters (2,800 feet) beyond planned touchdown point

Landing Rollout—274 meters (8,993 feet) from main gear touchdown

Orbiter Weight at Landing—Approximately 89,014 kilograms (196,500 pounds)

Landing Speed at Main Gear Touchdown—180 to 185 knots (207 to 212 mph)

STS-1 Liftoff Weight—Approximately 2,020,052 kilograms (4,453,379 pounds)

Landed—Runway 23 dry lake bed at Edwards Air Force Base, Calif.

STS-2 MISSION FACTS
(COLUMBIA)
NOV. 12-14, 1981

Commander: Joe Engle

Pilot: Richard Truly

Mission Duration—54 hour, 24 minutes, 4 seconds

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

Orbits of Earth—36

Orbital Altitude—137 nautical miles (157 statute miles)

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

Landing Rollout—Approximately 2,133 meters (7,000 feet) from main gear touchdown

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

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

STS-2 Liftoff Weight—Approximately 2,030,287 kilograms (4,475,943 pounds)

STS-2 Cargo Weight—Approximately 8,771 kilograms (19,388 pounds)

Landed—Runway 23 dry lake bed at Edwards Air Force Base, Calif.

STS-3 MISSION FACTS
(COLUMBIA)
MARCH 22-30, 1982

Commander: Jack Lousma

Pilot: Gordon Fullerton

Mission Duration—192 hours (8 days), 6 minutes, 9 seconds

Miles Traveled—Approximately 3.9 million nautical miles (4.4 million miles)

Orbits of Earth—130

Orbital Altitude—128 nautical miles (147 statute miles)

Landing Touchdown—Approximately 359 meters (1,180 feet) from threshold

Landing Rollout—Approximately 4,185 meters (13,732 feet) from main gear touchdown

Orbiter Weight at Landing—Approximately 94,122 kilograms (207,500 pounds)

Landing Speed at Main Gear Touchdown—Approximately 220 knots (253 miles per hour)

STS-3 Liftoff Weight—Approximately 2,031,653 kilograms (4,478,954 pounds)

STS-3 Cargo Weight—Approximately 9,658 kilograms (21,293 pounds)

Landed—Runway 17 lake bed at White Sands Missile Range, New Mexico

STS-4 MISSION FACTS
(COLUMBIA)
JUNE 27 — JULY 4, 1982

Commander: Ken Mattingly

Pilot: Henry Hartsfield

Mission Duration—168 hours (7 days), 1 hour, 10 minutes, seconds

Miles Traveled—Approximately 2.9 million nautical miles (3.3 million statute miles)

Orbits of Earth—112 orbits

Orbital Altitude—160 nautical miles (184 statute miles), then to 172 nautical miles (197 statute miles)

Landing Touchdown—Approximately 288 meters (948 feet) from threshold

Landing Rollout—Approximately 2,924 meters (9,595 feet) from main gear touchdown

Orbiter Weight at Landing—Approximately 95,029 kilograms (209,500 pounds)

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

STS-4 Liftoff Weight—Approximately 2,033,437 kilograms (4,482,888 pounds)

Landed—Runway 22 concrete at Edwards Air Force Base, Calif.

STS-5 MISSION FACTS
(COLUMBIA)
NOV. 11-16, 1982

Commander: Vance D. Brand

Pilot: Robert F. Overmyer

Mission Specialist: Joseph P. Allen

Mission Specialist: William B. Lenoir

Mission Duration—120 hours (5 days), 2 hours, 15 minutes, 29 seconds

Miles Traveled—1.5 million nautical miles (1.8 million statute miles)

Orbits of Earth—81

Orbital Altitude—160 nautical miles (184 statute miles)

Landing Touchdown—Approximately 498 meters (1,637 feet) from threshold

Landing Rollout—Approximately 2,911 meters (9,553 feet) from main gear touchdown

Orbiter Weight at Landing—Approximately 92,581 kilograms (204,103 pounds)

Landing Speed at Main Gear Touchdown—Approximately 198 knots (227 miles per hour)

STS-5 Liftoff Weight—Approximately 2,036,010 kilograms (4,488,559 pounds)

STS-5 Cargo Weight Up—Approximately 14,974 kilograms (33,013 pounds)

Landed—Runway 22 concrete at Edwards Air Force Base, Calif.

STS-6 MISSION FACTS
(CHALLENGER)
APRIL 4-9, 1983

Commander: Paul Weitz

Pilot: Karol Bobko

Mission Specialist: Donald Peterson

Mission Specialist: Story Musgrave

Mission Duration—120 hours (5 days), 24 minutes, 31 seconds

Miles Traveled—1,819,859 nautical miles (2,092,838 statute miles)

Orbits of Earth—80

Orbital Altitude—153.5 nautical miles (176.6 statute miles)

Landing Touchdown—Approximately 548 meters (1,800 feet) beyond threshold

Landing Rollout—Approximately 2,225 meters (7,300 feet) from main gear touchdown

Orbiter Weight at Landing—Approximately 89,177 kilograms (196,600 pounds)

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

STS-6 Liftoff Weight—Approximately 2,036,889 kilograms (4,490,498 pounds)

Cargo Weight Up—Approximately 20,658 kilograms (45,544 pounds)

Landed—Runway 22 concrete at Edwards Air Force Base, Calif.

STS-7 MISSION FACTS
(CHALLENGER)
JUNE 18-24, 1983

Commander: Robert L. Crippen
Pilot: Frederick H. Hauck
Mission Specialist: Sally K. Ride
Mission Specialist: John M. Fabian
Mission Specialist: Norman E. Thagard
Mission Duration—144 hours (6 days), 2 hours, 25 minutes, 41 seconds
Miles Traveled—2,198,964 nautical miles (2,530,567 statute miles)
Orbits of Earth—97
Orbital Altitude—160 nautical miles (184 statute miles) to 160 x 165 nautical miles (184 x 189 statute miles) to 160 x 170 nautical miles (184 x 195 statute miles) to 157 x 170 nautical miles (180 x 195 statute miles) to 157 nautical miles (180 statute miles)
Landing Touchdown—Approximately 831 meters (2,727 feet) beyond threshold
Landing Rollout—Approximately 3,185 meters (10,450 feet) from main gear touchdown
Orbiter Weight at Landing—Approximately 92,069 kilograms (202,976 pounds)
Landing Speed at Main Gear Touchdown—Approximately 205 knots (235 miles per hour)
STS-7 Liftoff Weight—Approximately 2,034,666 kilograms (4,485,579 pounds)
Cargo Weight Up—Approximately 14,553 kilograms (32,085 pounds)
Landed—Runway 15 lake bed at Edwards Air Force Base, Calif.

STS-8 MISSION FACTS
(CHALLENGER)
AUGUST 30 — SEPTEMBER 5, 1983

Commander: Richard H. Truly
Pilot: Daniel C. Brandenstein
Mission Specialist: Guion S. Bluford, Jr.
Mission Specialist: Dale A. Gardner
Mission Specialist: William E. Thornton
Mission Duration—144 hours (6 days), 1 hour, 9 minutes, 33 seconds
Miles Traveled—2,184,983 nautical miles (2,514,478 statute miles)
Orbits of Earth—97
Orbital Altitude—160 nautical miles (184 statute miles) to 166 x 160 nautical miles (191 x 184 statute miles) to 166 x 121 nautical miles (191 x 139 statute miles) to 121 nautical miles (139 statute miles)
Landing Touchdown—Approximately 853 meters (2,800 feet) beyond threshold
Landing Rollout—Approximately 2,804 meters (9,200 feet) from main gear touchdown
Orbiter Weight at Landing—Approximately 92,657 kilograms (204,272 pounds)
Landing Speed at Main Gear Touchdown—Approximately 195 knots (224 miles per hour)
STS-8 Liftoff Weight—Approximately 2,038,027 kilograms (4,493,007 pounds)
Cargo Weight Up—Approximately 10,255 kilograms (26,609 pounds)
Landed—Runway 22 concrete at Edwards Air Force Base, Calif.
Third night launch and night landing

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STS-8 SUMMARY

The STS-8 flight crew completed fifty-four out of fifty-four test objectives. In addition the flight crew performed two additional shopping list tests. One involved two star tracker sunlit earth horizon limit tests which were accomplished successfully and the other test successfully conducted concerned the ability of the star tracker to acquire a rendezvous target.

The major objectives of this flight were to deploy the INSAT-1B satellite, perform the Continuous Flow Electrophoresis operations and exercise the Remote Manipulator System with heavy loads and perform *Challenger* Ku-band tests with the Tracking and Data Relay Satellite System.

The STS-8 flight was launched on August 30, 1983, at 06:32:00.009 GMT (2:32:00.009 a.m., E.D.T) at Kennedy Space Center, Florida, and landed at Edwards AFB, CA. STS-8 provided the first night launch and landing of the National Space Transportation System Program with the launch being delayed 17 minutes because of adverse weather (thunderstorms) in the launch area. The crew for this fourth operational flight was Capt. R. H. Truly, Commander; Cdr. D. C. Brandenstein, Pilot; Lt. Col. G. S. Bluford, and Lt. Cdr. D. A. Gardner, Mission Specialists; and W. E. Thornton, M.D., Medical Specialist.

The ascent phase was normal in all respects as was the ET (external tank) separation, and the two OMS (orbital maneuvering system) maneuvers that placed the vehicle in the planned 160 nautical-mile circular orbit. The SRB's (solid rocket boosters) were recovered along with their parachutes and the ET impacted within the planned footprint.

Experiment activities during this first day included running the first two samples on the CFES (Continuous Flow Electrophoresis System), activation of the first two samples in the incubator, and activation of the ISAL (Investigation of STS Atmopheric Luminosities) experiment.

The most significant failure of the flight occurred this first day when the no. 2 hydraulic circulation pump failed to start and exhibited an elevated temperature and an excessive current draw during start-up attempts. Adequate workarounds, as well as the higher temperatures maintained within the hydraulic systems, enabled the rest of the flight to be conducted without the no. 2 pump; consequently, its loss had no adverse effect on the mission.

Operations progressed satisfactorily during the second day with the most significant event being the on-time deployment of the INSAT-1/PAM-D satellite followed 45 minutes later by the planned OMS separation maneuver. The PAM-D and INSAT maneuvers required to place the satellite in the desired geosynchronous orbit were satisfactorily completed and satellite activation has been accomplished.

Experiment activities were as planned during the second day; however, one problem arose that required the crew to be awakened to correct. The telemetry link through the TDRS (Tracking and Data Relay Satellite) was lost for about 3 hours, resulting in the total loss of onboard telemetry data for this period. Crew voice communications were still available through other links, so one crew member was awakened to switch the data over to the S-band link.

During the third day, the crew began RMS (remote manipulator system) activities with the PFTA (payload flight test article). For the most part, all planned activities except for some of the communication link tests through the TDRS were completed. The TAGS (text and graphics system) was tested and failed after receiving five good pages during four separate transmissions. The RMS tests with the PFTA included unberthing, grappling, RMS/primary RCS (reaction control subsystem) interaction, control system evaluation, and direct drive unberthing and berthing.

The fourth day's activities were centered around the RMS and PFTA, and the TDRS S-band and Ku-band tests. The RMS/PFTA activities went well with all planned items completed, but the S-band and Ku-band/TDRS tests were not as successful. The primary problem appeared to be with the White Sands ground station software. The TDRS link was lost at least twice during the flight for extended periods of time because of White Sands ground station problems.

A cabin pressure leak was noted during this day's activities and was isolated to the waste collection system. The crew was able to manually control the cabin pressure at the desired level; consequently, this leak did not impact the overall flight accomplishments.

During the fifth day, three RMS shopping list items were completed. The RMS operated very satisfactorily again during all of its tests. Additional tests were conducted with the TDRS with acceptable results. The OPS 8 (flight control system) checkout with APU (auxiliary power unit) 1 was successfully conducted.

The final day of the on-orbit operations was spent making the final runs on some experiments, stowing for entry, and completing the remaining tests with TDRS.

Two potentially significant problems occurred during this final day. The first was the split of GPC (general purpose computer) 1 and 2 into a one-on-one configuration. A review of dumped data indicated that GPC 1 had a failure-to-sync which dropped one bit in CPU (central processing unit) register 1. Although GPC-1 was recovered for use, the computer was interchanged with GPC-4 in the redundant set configuration for entry. This placed GPC-1 in string 4, the least critical position.

The second problem that occurred involved IMU (inertial measurement unit) no. 2 and its failure to standby. The IMU was successfully realigned and incorporated back into the navigation set. The cause of this failure is being investigated.

The crew completed preparations for entry on the morning of the seventh day and performed the 139.5-second deorbit maneuver at 248:06:47:30 GMT. The entry was normal in all respects and all scheduled PTI (programmed test input) maneuvers were successfully performed. The Orbiter was guided to the first night landing of the National Space Transportation System Program at Edwards AFB, CA, at 248:07:40:42 GMT (2:40:42 a.m. CDT). All systems operated properly throughout the entry, and the rollout distance was approximately 2,804 meters (9,200 feet) with touchdown occurring at the 853 meter (2,800 foot) point from the beginning of the runway.

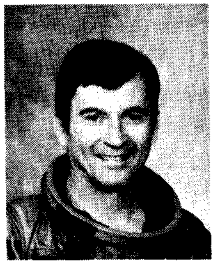
STS-8 TIMELINE

Day of Year	GMT* Hr:Min:Sec	Event
242	06:27:08	APU activation (1)
	06:27:09	APU activation (2)
	06:27:10	APU activation (3)
	06:31:32	SRB HPU activation
	06:31:53	MPS — start (Engine 3)
	06:32:00.009	SRB ignition command from GPC (lift-off)
	06:32:24.6	Initiate throttle down to 69 percent thrust for max g (Engine 3)
	06:32:49.7	Max q
	06:33:01.2	Initiate throttle up to 100 percent thrust (Engine 3)
	06:34:05	SRB separation initiation
	06:39:50.3	Throttle down for 3 "g" acceleration (Engine 3)
	06:40:42	MECO (main engine cutoff) command
	06:41:00	ET physical separation
	06:42:41.9	OMS-1 engine ignition
	06:45:00.7	OMS-1 engine cutoff
	06:46:14	APU deactivation
	07:16:51	OMS-2 engine ignition
	07:18:47.3	OMS-2 engine cutoff
243	07:48:54	INSAT-1B/PAM deploy
	08:03:54.2	OMS-3 engine ignition
	08:04:00.6	OMS-3 engine cutoff

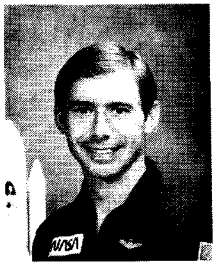
Day of Year	GMT* Hr:Min:Sec	Event
245	04:28:28.2	OMS-4 engine ignition
	04:29:05.6	OMS-4 engine cutoff
	05:13:24.8	OMS-5 engine ignition
	05:14:11.4	OMS-5 engine cutoff
247	04:38:17	FCS OPS-8 checkout APU 3 start
	04:46:17	FCS OPS-8 checkout APU 3 shutdown
248	06:42:30	APU 1 activation
	06:47:30.2	Deorbit OMS engine ignition
	06:50:01.0	Deorbit OMS engine cutoff
	06:57:31	APU activation
	07:10:24	Entry interface
	07:27:00	End blackout
	07:34:23	TAEM
	07:40:43	Main landing gear contact
	07:40:50	Nose landing gear contact
	07:41:33	Wheels stop
	07:54:09	APU deactivation

*GMT—Subtract 4 hours for EDT
5 hours for CDT
6 hours for MDT
7 hours for PDT

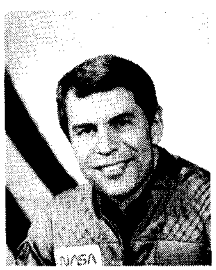
STS-9 FLIGHT CREW



JOHN W. YOUNG, veteran of five space flights, is the commander of the STS-9 flight and was commander for the 54-1/2 hour STS-1 flight. He has logged 642 hours, 30 minutes in space flight on the Gemini 3 and 10 missions, the Apollo 10 and 16 flights to the moon, and the STS-1 flight. A graduate of Georgia Institute of Technology in aeronautical engineering, Young entered U.S. Naval service and after a year of destroyer duty he was accepted and completed flight training. He is a graduate of the Navy's Test Pilot School and was stationed at the Naval Air Test Center for three years prior to entering the Astronaut Corps in 1962. He retired from the Navy in 1976. Young was assigned responsibility for the Space Shuttle Branch of the Astronaut Office in 1973, and in 1975 was named as chief of the Astronaut Office. Young is a Fellow of the American Astronautical Society (AAS), and the Society of Experimental Test Pilots (SETP) and associate fellow of the American Institute of Aeronautics and Astronautics (AIAA). He was awarded the Congressional Medal of Honor, the Department of Defense Distinguished Service Medal, three NASA Distinguished Service Medals, two NASA Exceptional Service Medals, the JSC Certificate of Commendation, two Special Achievement Awards, the Navy Astronaut Wings, two Navy Distinguished Service Medals, three Navy Distinguished Flying Crosses, the Georgia Tech Distinguished Alumni Award (1965) and the Distinguished Service Alumni Award (1972), the SETP Iven C. Kincheloe Award, the AAS Flight Achievement Award, the FAI Yuri Gagarin Gold Medal, and the AIAA Haley Astronautics Award. Young was born in San Francisco, Calif., Sept. 24, 1930, is married and has two children. He is 5'9" in height, weighs 165 pounds, and has green eyes and brown hair.



BREWSTER A. SHAW, is the pilot for the STS-9 flight. Shaw was selected as an astronaut candidate in 1978. He received a bachelor and master of science degrees in Engineering Mechanics from the University of Wisconsin in 1968 and 1969 respectively. Shaw entered the Air Force in 1968 and after completing Officer Training School, attended undergraduate pilot training, receiving his wings in 1970 and was assigned to the F-100 at Luke AFB, Ariz., and was subsequently assigned to the Republic of Vietnam. He returned to the U.S. in 1971 and was assigned to the F-4 and subsequently reported to Thailand, where he flew the F-4. In 1973 he returned to George AFB, Calif., for F-4 instructor duties. In 1976, he attended the USAF Test Pilot School and remained at Edwards AFB, Calif., as an operational test pilot. He then served as an instructor at the USAF Test Pilot School from 1977 until selected as an astronaut candidate. Shaw is married and has three children. He was born in Cass City, Mich., May 16, 1945. He is 5'8" in height and weighs 135 pounds. He has brown hair and blue eyes.



ROBERT ALLAN RIDLEY PARKER, is a mission specialist for the STS-9 flight. Parker was a member of the astronaut support crews for the Apollo 15 and 17 missions and served as program scientist for the Skylab Program Director's Office during the three manned Skylab flights. He received a bachelor of arts degree in Astronomy and Physics from Amherst College in 1958 and a doctorate in Astronomy from the California Institute of Technology in 1962. Parker was an associate professor of astronomy at the University of Wisconsin prior to his selection as an astronaut. Dr. Parker was selected as a scientist-astronaut in 1967. He has logged over 2,225 hours flying time in jet aircraft. He was awarded the NASA Exceptional Scientific Achievement Medal and the NASA Outstanding Leadership Medal. He is married and has two children. He was born in New York City, December 14, 1936, but grew up in Shrewsburg, Mass. Parker is 5'10" in height and weighs 160 pounds. He has brown hair and blue eyes.

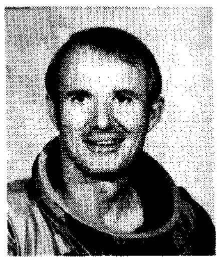
OWEN K. GARRIOTT, is a mission specialist for the STS-9 flight. Dr. Garriott was the science pilot for the Skylab 3, 59-1/2 day mission. He logged 1,427 hours and 9 minutes in space in the Skylab 3 mission and also spent 13 hours and 43 minutes in three separate extravehicular activities outside the Skylab workshop. Since the Skylab 3 flight, Garriott has served as Deputy and then Director of Science and Applications and as the Assistant Director for Space Science at JSC. Dr. Garriott was selected as a scientist astronaut in 1965. Prior to his selection as an astronaut, he taught electronics, electromagnetic theory, and ionospheric physics as an associate professor in the Department of Electrical Engineering at Stanford University. He has performed research in ionospheric physics since obtaining his doctorate. Garriott remains a consulting professor at Stanford University. He has logged over 3,900 flying hours—including over 2,100 hours in jet aircraft and the remainder in spacecraft, light aircraft, and helicopters. In addition he holds FAA commercial pilot and flight instructor certification for instrument and multi-engine aircraft. He has received the NASA Distinguished Service Medal, the City of Chicago Gold Medal, the Robert J. Collier Trophy, the FAI V. M. Komarov Diploma, and was elected to the International Academy of Astronautics. He is a Fellow of the AAS and a member of the IEEE. He is married and has four children. Garriott was born in Enid, Okla., November 22, 1930. He is 5'9" in height and weighs 140 pounds. He has brown hair and blue eyes.

STS-9 FLIGHT CREW

BYRON K. LICHTENBERG, is one of the payload specialists in the STS-9 flight. Payload specialists are normally career scientists selected to go into space aboard a particular Spacelab mission, in this case, Spacelab 1. His profession is biomedical engineer/pilot. Lichtenberg received his science degree in electrical engineering from Brown University, Providence, R.I., in 1969. He did graduate work at the Massachusetts Institute of Technology, Cambridge, Mass., receiving his master's degree in mechanical engineering in 1975 and his SC.D in biomedical engineering in 1979. Dr. Lichtenberg is a member of the research staff at the Massachusetts Institute of Technology. His primary area of research is biomedical engineering. Lichtenberg was selected to train for the Spacelab mission as one of two U.S. payload specialists. Payload specialists training is coordinated by the Marshall Space Flight Center at Huntsville, Ala. Between 1969 and 1973 he served in the U.S. Air Force. He received two Distinguished Flying Crosses during his tour of duty in Vietnam. At present he is a fighter pilot in the Massachusetts Air National Guard, flying the A-10 close air support aircraft. Lichtenberg is a member of the Aerospace Medical Association. He was born in Stroudsburg, Pa., in 1948. He is married and has two children.

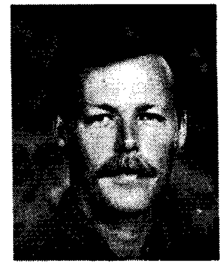
ULF MERBOLD, is one of the payload specialists in the STS-9 flight. His profession is physicist. Merbold received a diploma in physics in 1968 and a doctorate in science from Stuttgart University in 1976. He joined the Max-Planck Gesellschaft at Stuttgart, Germany, first on a scholarship in 1968, and later as a staff member. He worked as a solid-state physicist on a research team of the Max-Planck Institute for metals research. His main fields of research were crystal lattice defects and low-temperature physics. He was involved in the investigation of the irradiation damage on iron and vanadium produced by fast neutrons. In 1978 he was selected by the European Space Agency (ESA) as one of two European payload specialists to train for the Spacelab 1 mission. Dr. Merbold is a member of the German Society for physics. He holds a private pilots license. He is a German citizen and was born in Greiz, Germany in 1941. He is married and has two children. Merbold is presently based at the Marshall Space Flight Center, Huntsville, Ala.

STS-11 FLIGHT CREW

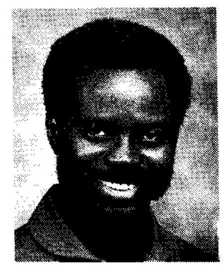


VANCE D. BRAND, is the spacecraft commander for the STS-11 flight. Brand was also the commander on the STS-5 flight. He has logged 339 hours and 43 minutes in space flight as command module pilot of the Apollo-Soyuz Test Project and commander of the STS-5 flight. A graduate of the University of Colorado with a bachelor of science degree in business (1953) and a bachelor of science degree in aeronautical engineering (1960), and a masters degree in business administration from UCLA in 1964, Brand was commissioned a naval aviator and served as a Marine Corps fighter pilot until 1957. He was with the Marine Reserve and Air National Guard until 1964. He joined Lockheed Aircraft as a flight test engineer in 1960, and following completion of the Navy's Test Pilot School was assigned to Palmdale, Calif., as an experimental test pilot on the F-104. He was selected as an astronaut in 1966, and was a crew member of the prototype command module in thermal-vacuum chamber program. He was a support crewman on Apollo 8 and 13, and was backup pilot for Apollo 15 and the Skylab 3 and 4 missions. Brand is a Fellow, American Astronautical Society, Associate Fellow of AIAA, and a member of SETP. He has the NASA Distinguished and Exceptional Service Medals, the JSC Certificate of Commendation, the Richard Gottheil Medal, the Wright Brothers International Manned Space Flight Award, the VFW National Sapce Award, the FAI Yuri Gagarin Gold Medal the AIAA Special Presidential Citation and the Hanley Astronautics Award, the AAS's Flight Achievement Award, and the University of Colorado's Alumnus of the Century award. Brand was born in Longmont, Colo, May 9, 1931, is married and has five children. He is 5'11" in height, and weighs 175 pounds. He has blond hair and gray eyes.

BRUCE McCANDLESS, is a mission specialist for the STS-11 mission. He received a bachelor of science degree in Naval Sciences from the United States Naval Academy in 1958 and a master of science degree in electrical engineering from Stanford University in 1965. McCandless received flight training at Navy bases in Florida and Texas and was designated a naval aviator in March of 1960 and proceeded to Key West, Florida for weapons system and carrier landing training in the F-6A. From December, 1960 to February 1964 he flew the Skyray and F-4B from the USS Forrestal and USS Enterprise. In early 1964, he was an instrument flight instructor at the Naval Air Station, Apollo Soucek Field, Oceana, Virginia and then reported to the Naval Reserve Officer's Training Corps Unit at Stanford University for graduate studies in electrical engineering. McCandless has logged more than 3,650 flying hours, 3,300 hours in jet aircraft. He was selected as an astronaut by NASA in April 1966. He was a member of the astronaut support crew for the Apollo 14 mission and was backup pilot for the Skylab 2 mission. His awards include the National Defense Service Medal, American Expeditionary Service Medal, NASA Exceptional Service Medal (1974) and the American Astronautical Society Victor A. Prather Award (1975). He is a member of the U.S. Naval Institute and Institute of Electrical and Electronic Engineers. McCandless was born in Boston, Massachusetts, June 8, 1937, is married and has two children. He is 5'10" and weighs 155 pounds. He has brown hair and blue eyes.

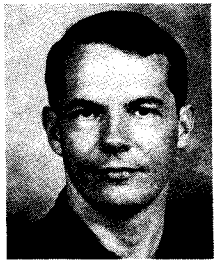


ROBERT L. GIBSON, is the pilot for the STS-11 flight. He received a bachelor of science degree in aeronautical engineering from California Polytechnic State University in 1969. Gibson entered active duty with the Navy in 1969. He received primary and basic flight training at Naval Air Stations in Florida and Mississippi and completed advanced flight training at the Naval Air Station Kingsville, Texas. From April 1970 to September 1975 he saw duty aboard the USS Coral Sea and the USS Enterprise, flying 56 combat missions in Southeast Asia. He returned to the United States and was assigned as an F-14A instructor pilot with Fighter Squadron 124. He graduated from the U.S. Naval Test Pilot School, Patuxent River, Maryland in June 1977 and later became involved in the test and evaluation of F-14A aircraft while assigned to the Naval Air Test Center's Strike Aircraft Test Directorate. His flight experience includes over 2,500 hours in over 35 types of civil and military aircraft. He holds commercial pilot, multi-engine, and instrument ratings, and has held private pilot rating since age 17. He was selected as an astronaut candidate in January 1978 and completed his one year training and evaluation in August, 1979 making him eligible for assignment as a pilot. Gibson was awarded three Air Medals, the Navy Commendation Medal with Combat V, a Navy Unit Commendation, Meritorious Unit Commendation, Armed Forces Expeditionary Medal, Humanitarium Service Medal, an RVN Cross of Gallantry, RVN Meritorious Unit Commendation, and Vietnam Service Medal. Gibson was born in Cooperstown, New York, October 30, 1946 but considers Lakewood, California his hometown. He married Astronaut Margaret Seddon and has two children. Gibson is 5'11" and weighs 165 pounds. He has blond hair and blue eyes.



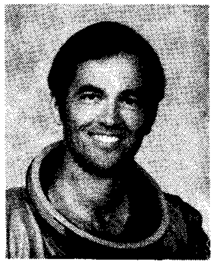
RONALD E. McNAIR, is a mission specialist on the STS-11 flight. He received a bachelor of science degree in physics from North Carolina A&T State University in 1971 and a doctor of philosophy in physics from Massachusetts Institute of Technology in 1976 and presented an honorary doctorate of Laws from North Carolina A&T State University in 1978. Dr. McNair performed some of the earliest development of chemical HF DF and high pressure CO lasers while at Massachusetts Institute of Technology. In 1975 Dr. McNair studied laser physics at E'cole D'ete Theorique de Physique, Les Houches, France with many authorities in the field. Following graduation from MIT in 1976, McNair became a staff physicist with Hughes Research Laboratories in Malibu, California. Dr. McNair was selected as an astronaut candidate by NASA in January 1978 and completed a one year training and evaluation period in August 1979, making him eligible for assignment as a mission specialist. He was named a Presidential Scholar (1967-1971), a Ford Foundation Fellow (1971-1974), a National Fellowship Fund Fellow (1974-1975), a NATO Fellow (1975) and a recipient of the National Society of Black Engineers Distinguished National Scientist Award (1979). He was born in Lake City, South Carolina, October 21, 1950, is married. He is 5'8" and weighs 158 pounds. He has black hair and brown eyes.

STS-11 FLIGHT CREW

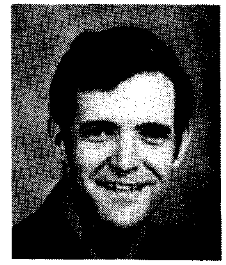


ROBERT L. STEWART, is a mission specialist for the STS-11 mission. He received a bachelor of science degree in mathematics from the University of Southern Mississippi in 1964 and a master of science in Aerospace Engineering from the University of Texas in 1972. Stewart entered active duty with the United States Army in May 1964 and was designated an Army aviator in July 1966 upon completion of rotary wing training. He flew 1,035 hours combat time from August 1966 to 1967. He was an instructor pilot at the U.S. Army Primary Helicopter school. Stewart is a graduate of the U.S. Army's Air Defense School's Air Defense Officers Advanced Course and Guided Missile System Officers Course. From 1972 to 1973 he served in Seoul, Korea. He next attended the U.S. Naval Test Pilot School at Patuxent River, Maryland, completing rotary wing Test Pilot Course in 1974 and then assigned as an experimental test pilot to the U.S. Army Aviation Engineering Flight Activity at Edwards Air Force Base, California. He has military and civilian experience in 38 types of airplanes and helicopters and has logged approximately 4,600 hours of flying time. Stewart was selected as an astronaut candidate by NASA in January 1978 and completed a one year training and evaluation period in August, 1979, making him eligible for assignment as a mission specialist. He was awarded three Distinguished Flying Crosses, a Bronze Star, Meritorious Service Medal, 33 Air Medals, Army Commendation Medal with Oak Leaf Cluster and "V" Device, two Purple Hearts, the National Defense Service Medal, the Armed Forces Expeditionary Medal, and the U.S. and Vietnamese Vietnam Service Medals. He is a member of the Society of Experimental Test Pilots, the National Geographic Society and the Scabbard and Blade (military honor society). He was born August 13, 1942 in Washington, D.C., but considers Arlington, Texas his hometown. He is married and has two children. Stewart is 5'6" and weighs 138 pounds. He has brown hair and brown eyes.

STS-13 FLIGHT CREW

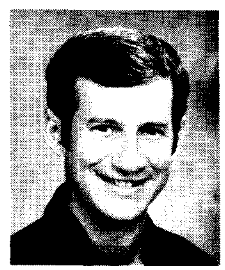


ROBERT L. CRIPPEN, is the commander for the STS-13 flight. He was the pilot in the 54-1/2 hour STS-1 flight and the commander in the 146 hour 25 minute STS-7 flight. He has logged more than 4,980 hours of flying time-most of it in jet-powered aircraft—as a U.S. Navy pilot and astronaut. A graduate of the University of Texas in aerospace engineering, Crippen entered naval service and was a carrier pilot. He completed the U.S. Air Force's Aerospace Research Pilot School at Edwards AFB and remained as an instructor until he was selected for the Manned Orbiting Laboratory program in 1966. He transferred to the NASA Astronaut Office in 1969 and was a crew member of the Skylab Medical Experiments Altitude Test—a 56-day simulation of the Skylab mission. He was a member of the support crew for Skylab 2, 3, and 4, and the ASTP mission. He has been awarded the NASA Distinguished Service Medal and Exceptional Service Medal and the JSC Group Achievement Award. Crippen was born in Beaumont, Tex., September 11, 1937, is married and has three children. He is 5'10" in height, weighs 160 pounds, and has brown hair and eyes.

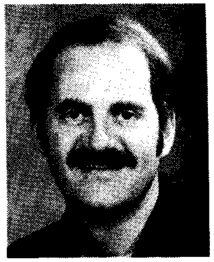


FRANCIS R. (DICK) SCOBEE, is the pilot for the STS-13 flight. Scobee received a bachelor of science degree in aerospace engineering from the University of Arizona in 1965. Scobee enlisted in the United States Air Force in October 1957, trained as an reciprocating engine mechanic and stationed at Kelly AFB, Texas. While there, he attended night school and acquired two years of college credit which led to his selection for the airman's education and commissioning program. Upon graduation from the University of Arizona, he was assigned to officer's training school and pilot training. He received his commission in 1965 and received his wings in 1966. He completed a number of assignments including a combat tour in Vietnam. Scobee returned to the United States and attended the USAF Aerospace Research Pilot School at Edwards Air Force Base, California, graduating in 1972. He has participated in test programs on the C-5, 747, X-24B and F-111. He has logged more than 5,300 hours flying time in 40 types of aircraft. Scobee was selected as an astronaut candidate by NASA in January, 1978 and completed a one year training and evaluation period in August, 1979 making him eligible for assignment as a pilot. He retired from the United States Air Force in January, 1980 after more than 22 years of active service but continues his assignment as a NASA astronaut in a civilian capacity. He has received the Air Force Distinguished Flying Cross and Air Medal. He is a member of the Society of Experimental Test Pilots, the Experimental Aircraft Association, and the Air Force Association. Scobee was born May 19, 1939, in Cle Elum, Washington. Scobee is married and has two children. He is 6'1" and weighs 175 pounds. He has brown hair and blue eyes.

GEORGE D. NELSON, is a mission specialist for the STS-13 flight. Nelson received a bachelor of science degree in physics from Harvey Mudd College in 1972 and a master of science and a doctorate in astronomy from the University of Washington in 1974 and 1978, respectively. Dr. Nelson has performed various astronomical research at the Sacrements Peak Solar Observatory, Sunspot, New Mexico; the Astronomical Institute of Utrecht, the Netherlands; and the University of Gottingen Observatory, Gottingen, West Germany. Prior to reporting for training as an astronaut candidate, he was a postdoctoral research associate at the Joint Institute for Laboratory Astrophysics in Boulder, Colorado. Dr. Nelson was selected as an astronaut candidate in January, 1978 and completed a one year training and evaluation period in August, 1979, making him eligible for assignment as a mission specialist. Dr. Nelson is a member of the American Association for Advancement of Science and the American Astronomical Society. Dr. Nelson was born July 13, 1950, in Charles City, Iowa but considers Willmar, Minnesota to be his hometown. Dr. Nelson is married and has two children. He has blond hair and blue eyes. He is 5'9" and weighs 160 pounds.



TERRY J. HART, is a mission specialist for the STS-13 flight. Hart received a bachelor of science degree in mechanical engineering from Lehigh University in 1968, a master of science in mechanical engineering from the Massachusetts Institute of Technology in 1969, and a master of science in electrical engineering from Rutgers University in 1978. Hart entered active duty with the Air Force Reserve in June, 1969. He completed undergraduate pilot training in Georgia and in December 1970 to 1973, he flew F-106 aircraft at Tyndall Air Force Base, Florida, Loring Air Force Base, Maine, and at Dover Air Force Base, Delaware. He joined the New Jersey Air National Guard and continued flying the F-106 until 1978. From 1968 to 1978, Hart was employed as a member of the technical staff of Bell Telephone Laboratories. He has logged 2,000 hours flying time, 1,400 hours in jets. Mr. Hart was selected as an astronaut candidate by NASA in January, 1978 and completed a one year training and evaluation period in August 1979, making him eligible for assignment as a mission specialist. Hart has received the National Defense Medal. He was born October 27, 1946 in Pittsburg, Pennsylvania. Hart is married and has two children. He has brown hair and brown eyes. He is 5'8" and weighs 145 pounds.

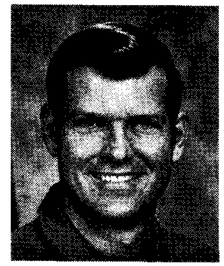


JAMES D. van HOFTEN, is a mission specialist for the STS-13 flight. He received a bachelor of science degree in civil engineering from the University of California, Berkeley, in 1966; and a master of science degree in hydraulic engineering and a doctor of philosophy in fluid mechanics from Colorado State University in 1968 and 1976, respectively. From 1969 to 1974 van Hoften was a pilot in the United States Navy. He received flight training at Pensacola, Florida, and completed jet pilot training at Beeville, Texas, in November 1970. He was assigned to the Naval Air Station, Miramar, California to fly F-4's and subsequently assigned to the carrier USS Ranger in 1972 and participated in two cruises to Southeast Asia where he flew 60 combat missions. He has logged 1,850 hours flying time, 1.750 hours in jet aircraft. He resumed his academic studies in 1974 and in September 1976, he accepted an assistant professorship of civil engineering at the University of Houston teaching fluid mechanics and conducted research on biomedical fluid flows concerning flows in artificial internal organs and valves until his selection as an astronaut candidate. Dr. van Hoften was selected by NASA as an astronaut candidate in January, 1978, and completed a one year training and evaluation period in August, 1979, making him eligible for assignment as a mission specialist. Dr. van Hoften has received two Navy Air Medals, the Vietnam Service Medal, and the National Defense Service Medal. He is a member of the American Society of civil engineers. He was born on June 11, 1944, in Fresno, California, but considers Burlingame, California his hometown. He is married and has two children. He has brown hair and hazel eyes. He is 6'4" and weighs 208 pounds.

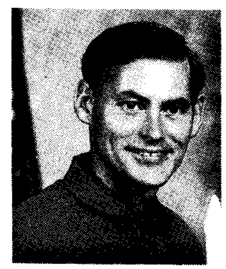
STS-12 FLIGHT CREW

HENRY W. HARTSFIELD, JR., is the commander for the STS-12 flight. He was the pilot on the STS-4 flight. He has logged 169 hours and 10 minutes in space. Hartsfield was a member of the Development Flight Test missions group of the astronaut office and was responsible for supporting the development of the Space Shuttle entry flight control system and its associated interface. In 1977, he retired from the U.S. Air Force with more than 22 years of service, but continues his assignment as a NASA astronaut in a civilian capacity. Hartsfield became a NASA astronaut in 1969. He was a member of the astronaut support crew for Apollo 16 and Skylab 2, 3, and 4 missions. Hartsfield was assigned in 1966 to the USAF Manned Orbiting Laboratory program as an astronaut until the program was canceled in 1969, when he was reassigned to NASA. He has logged over 5,270 flying hours—of which over 4,700 hours are in the F-86, F-100, F-104, F-105, F-106, T-33 and T-38A. Hartsfield received his commission through the Reserve Officers Training program at Auburn University. He entered the Air Force in 1955, and his assignments included a tour with the 53rd Tactical Fighter Squadron in Germany. He is also a graduate of the USAF Test Pilot school at Edwards Air Force Base, California and was an instructor there prior to his assignment as an astronaut in the USAF Manned Orbiting Laboratory program. He was awarded the Air Force Meritorious Service Medal and the General Thomas D. White Space Trophy. Hartsfield was born in Birmingham, Alabama, November 21, 1933, is married and has two children. He is 5'10" in height, weighs 165 pounds, and has green eyes and brown hair.

JUDITH A. RESNICK, is a mission specialist for the STS-12 flight. She received a bachelor of science degree in electrical engineering from Carnegie-Mellon University in 1970 and a doctorate in electrical engineering from the University of Maryland in 1977. Upon graduating from Carnegie-Mellon in 1970, Dr. Resnick was employed by RCA Missile and Surface Radar in Morristown, New Jersey and in 1971, she transferred to the RCA Service Company in Springfield, Virginia. While with RCA, her projects as a design engineer included circuit design and development of custom integrated circuitry for phased array radar control systems. From 1974 to 1977 Dr. Resnick was a biomedical engineer and staff fellow in the Laboratory Neurophysiology at the National Institute of Health in Bethesda, Maryland, where she performed biological research experiments concerning the physiology of visual systems. Immediately preceding her selection by NASA in 1978, she was a senior systems engineer in product development with Xerox Corporation at El Segundo, California. Dr. Resnick was selected as an astronaut candidate by NASA in January 1978 and completed one year training and evaluation period in August 1979, making her eligible for assignment as a mission specialist. She is a member of the Institute of Electrical and Electronic Engineers, American Association for the Advancement of Science, American Institute of Aeronautics and Astronautics and Senior Member of the Society of Women Engineers. Dr. Resnick's special honors include the American Association of University Women Fellow, 1975-1976. Dr. Resnick was born April 5, 1949 in Akron, Ohio. She is single and is 5'4" and weighs 115 pounds. She has black hair and brown eyes.



MICHAEL L. COATS, is the pilot for the STS-12 flight. He received a bachelor of science degree from the United States Naval Academy in 1968, a master of science in administration of science and technology from George Washington University in 1977, and master of science in aeronautical engineering from the U.S. Naval Postgraduate School in 1979. Coats was designated a naval aviator in September 1969. After training as an A-7E pilot, he was assigned from August 1970 to September 1972 aboard the USS Kitty Hawk and flew 315 combat missions in Southeast Asia. He served as a flight instructor with A-71 at Naval Air Station, Lemoore, California from September 1972 to December, 1973, and was then selected to attend the U.S. Naval Test Pilot School, Patuxent River, Maryland. Following test pilot training in 1974, he was project officer and test pilot for A-7 and A-4 aircraft at Strike Aircraft Test Directorate. Coats served as a flight instructor at the U.S. Naval Postgraduate School from April 1976 until May 1977 and then attended U.S. Naval Postgraduate School at Monterey, California. He has logged 2,600 hours of flying time and 400 carrier landings in 22 different types of aircraft. Coats was selected as an astronaut candidate by NASA in January 1978 and completed a one year training and evaluation in August, 1979, making him eligible for assignment as a pilot. Coats was awarded two Navy Distinguished Flying Crosses, 32 Strike Flight Air Medals, three Individual Action Air Medals, and nine Navy Commendation Medals with Combat V. Coats was born in Sacramento, California, January 16, 1946, but considers Riverside, California his hometown. He is married and has two children. He is 6' and weighs 185 pounds. He has brown hair and blue eyes.



RICHARD M. MULLANE, is a mission specialist for the STS-12 flight. He received a bachelor of science degree in military engineering from the United States Military Academy in 1967 and awarded a master of science degree in aeronautical engineering from the Air Force Institute of Technology in 1975. Mullane, an Air Force Major completed 150 combat missions as an RF-4C weapon system operator in Vietnam from January to November 1969 and a subsequent four tour of duty in England. In July 1976, he completed the USAF Test Pilot School's Flight Test Engineer Course at Edwards Air Force Base, California and assigned as a flight test weapon system operator at Eglin Air Force Base, Florida. He was selected as an astronaut by NASA in January 1979, and completed a one year training and evaluation in August 1979 making him eligible for assignment as a mission specialist. Mullane was awarded six Air Medals, the Air Force Distinguished Flying Cross, Meritorious Service Medal, Vietnam Campaign Medal, National Defense Service Medal, Vietnam Service Medal and Air Force Commendation Medal. He is a member of the Air Force Association. He was born September 10, 1945 in Wichita Falls, Texas, but considers Albuquerque, New Mexico his hometown. He is married and has three children and is 5'10" and weighs 146 pounds. He has brown hair and brown eyes.

STEVEN A. HAWLEY, is a mission specialist on the STS-12 flight. He received a bachelor of arts degree in physics and astronomy from the University of Kansas in 1973 and a doctor of philosophy in astronomy and astrophysics from the University of California in 1977. During his tenure as an undergraduate at the University of Kansas he was employed by the Department of Physics and Astronomy as a teaching assistant. In 1971, he was awarded an undergraduate research grant from the College of Liberal Arts and Sciences for an independent studies project on stellar spectroscopy. He spent the summers of 1972, 1973 and 1974 as a research assistant at the U.S. Naval Observatory in Washington, D.C., National Radio Astronomy Observatory in Green Bank, West Virginia. He attended graduate school at Lick Observatory, University of California, Santa Cruz and while there held a research assistantship for three years. Prior to his selection as an astronaut, Dr. Hawley was a postdoctoral research associate at Cerro Tolola Inter-American Observatory in La Serena, Chile. Dr. Hawley was selected by NASA as an astronaut candidate in January 1978 and completed a one year training and evaluation period in August 1979, making him eligible for assignment as a mission specialist. He has received the Evans Foundation Scholarship (1970), Veta B. Lear Award (1970), University of California Regents Fellowship (1974) and is a member of the American Astronomical Society and Astronomical Society of the Pacific. He was born December 12, 1951 in Ottawa, Kansas, but considers Salina, Kansas his hometown. He married Astronaut Sally Ride on July 24, 1982. He is 6' and weighs 150 pounds. He has blond hair and blue eyes.

ASTRONAUT CREWS

Beginning in 1984, astronaut crews will be announced by payload assignment rather than an STS-number. Mission designations consist of a numerical designator for the launch ("1" for a KSC launch and "2" for a Vandenburg AFB launch), and a letter suffix which reflects the originally scheduled order of launch.

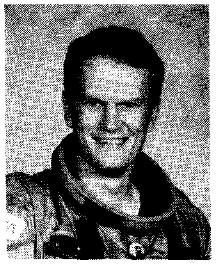
Mission 41-D, for example is a 1984 launch—"4"; to occur at KSC—"1"—and was originally manifested as the fourth mission of that fiscal year.—"D". If the launch moves in sequence, the mission designator will not change.

The 41-E mission payloads are TELESAT-I, SYNCOM IV-I, a Large Format Camera (LFC), and a multipurpose experiment support structure (MPESS) provided by the Office of Aeronautics and Space Technology (OAST). Launch is forecast for June 6, 1984 and is to be the second flight of *Discovery*.

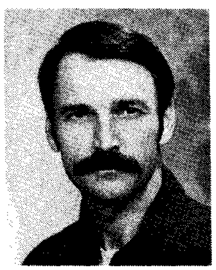
The 41-F mission payload will be a Department of Defense (DOD) payload. The flight crew will be the ones previously assigned to STS-10.

The 41-G mission payloads are TELESTAR, Satellite Business Systems (SBS), Hughes Aerospace and an astronomy experiment named SPARTAN (Shuttle Pointed Autonomous Research Tool for Astronomy)-1. Projected launch date is August 1, 1984 with Discovery.

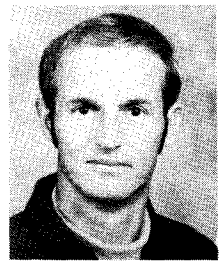
41-E FLIGHT CREW



KAROL J. BOBKO, is the commander for the 41E flight. He was the pilot on the STS-6 mission, logging 120 hours in space. He was a member of the Skylab Medical Experiments Altitude Test (SMEAT)—a 56 day simulation of the Skylab mission—and a member of the astronaut support crew for the ASTP mission and a member of the support crew for the Space Shuttle Approach and Landing Test program. He was then involved with the ground test and checkout of the Columbia. He received a bachelor of science degree from the Air Force Academy in 1959 and a master of science degree in Aerospace Engineering from the University of Southern California in 1970. Bobko received his wings in 1960 and flew F-100 and F-105 aircraft from 1961 to 1965, then attended the Aerospace Research Pilots school and was assigned as an astronaut in the USAF Manned Orbiting Laboratory Program in 1966 and became a NASA astronaut in 1969. He has logged over 4,800 hours of flying time in the F-100, F-104, F-105, T-33 and T-38. Bobko was awarded the NASA Exceptional Service Medal, three JSC Group Achievement Awards and two USAF Meritorious Service Medals. He is married and has two children. He was born in New York, New York December 23, 1937. He is 5'11" in height and weighs 190 pounds. He has blond hair and blue eyes.

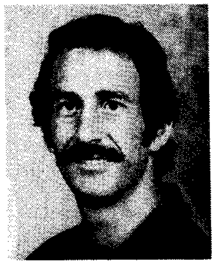


S. DAVID GRIGGS, is a mission specialist for the 41E flight. He received a bachelor of science degree from the United States Naval Academy in 1962 and a master of science in Administration from George Washington University in 1970. Griggs entered pilot training after graduation from Annapolis, receiving his wings in 1964. He was assigned to Attack Squadron 72 flying A-4 aircraft and completed two Southeast Asia Cruises and one Mediterranean Cruise aboard the aircraft carrier USS Independence and Roosevelt. Griggs entered the U.S. Naval Test Pilot School at Patuxent River, Md., in 1967 and upon completion was assigned to the Flying Qualities and Performance Branch, Flight Test Division where he flew various test projects on fighter and attack-type aircraft. In 1970 he resigned his regular United States Navy Commission and affiliated with the naval air reserve. In July, 1970 Griggs was employed at the Johnson Space Center as a research pilot working on various flight test and research projects. In 1974, he was the project pilot for the Shuttle trainer aircraft and participated in the design, development and testing. In 1976 he was appointed chief of the Shuttle training aircraft operations. He has logged 6,200 hours flying time, 5,100 hours in jet aircraft and has flown over 40 different types of aircraft. He holds an airline transport license and is a certified flight instructor. He was awarded the Navy Distinguished Flying Cross and Air Medal, Navy Unit Commendation, NASA Achievement Award, and NASA Sustained Superior Performance Award. He is a member of the Society of Experimental Test Pilots and a Colonel in the Confererate Air Force. He was selected as an astronaut candidate in January 1978, completing a one year training and evaluation period in August 1979, making him eligible for an assignment as a pilot. Griggs was born in Portland, Oregon, September 7, 1939. He is married and has two children. He is 5' 10" and weighs 175 pounds. He has brown hair and eyes.



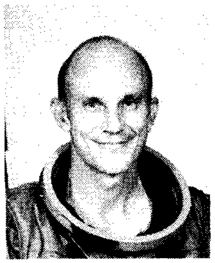
DONALD E. WILLIAMS, is the pilot of the 41E flight. He received a bachelor of science degree in Mechanical Engineering from Purdue University in 1964. Williams received his commission through the NROTC program at Purdue University. He completed flight training at Pensacola, Fla, Meridian, Miss., and Kingsville, Texas, receiving his wings in May 1966. After A-4 training, he made two Vietnam deployments aboard the USS Enterprise with attack squadron 113. He served as a flight instructor in Attack Squadron 125 at Naval Air Station Lemoore, Calif., for two years and transitioned to A-7 aircraft. He made two additional Vietnam deployments aboard the USS Enterprise. Williams completed a total of 330 combat misions. He attended the U.S. Naval Test Pilot School at Patuxent River, Md., in June 1974 and was assigned to Naval Air Test Center's Suitability Branch of Flight Test Division. From August 1976 to June 1977, he became head of the Carrier Systems Branch, Strike Aircraft Test Directorate. He reported next for A-7 refresher training and was assigned to Attack Squadron 94 when selected by NASA. He has logged 3,400 hours of flying time, which includes 3,200 hours in jets and 745 carrier landings. Williams was awarded 31 Air Medals, two Navy Commendation Medals with Combat V, two Navy Unit Commendations, a Meritorious Unit Commendation, the National Defense Medal, an Armed Forces Expeditionary Medal, the Vietnam Service Medal (with four stars), a Vietnamese Gallantry Cross (with gold star), and the Vietnam Campaign Medal. Williams is a member of the Society of Experimental Test Pilots. He was selected as an astronaut candidate in January 1978, completing a one year training and evaluation period in August 1979, making him eligible for assignment as a pilot. Williams was born in Lafayette, Ind., February 13, 1942. He is married and has two children. He is 5' 11" and weighs 155 pounds. He has brown hair and eyes.

MARGARET RHEA SEDDON, is a mission specialist for the 41E flight. She received a bachelor of arts degree in physiology from the University of California, Berkeley, in 1970, and a doctorate of Medicine from the University of Tennessee College of Medicine in 1973. After med school Dr. Seddon completed a surgical internship and three years of a general surgery residency in Memphis, Tennessee, with a particular interest in surgical nutrition. Between the period of her internship and residency, she served as an emergency room physician at a number of emergency rooms in Miss., and Tennessee, hospitals and serves in this capacity in the Houston, Texas area in her spare time. Dr. Seddon has also performed clinical research into the effects of radiation therapy on nutrition in cancer patients. She is a member of the 99's (International Women Pilots Association), the American College of Emergency Physicians, the Harris County, Texas Medical Society, the Texas Medical Association, charter member of the American Society of Parenteral and Enteral Nutrition, and a member of the National Society of the Daughters of the American Revolution. Dr. Seddon was selected as an astronaut candidate in January 1978, completing a one year training and evaluation period in August 1979, making her eligible for assignment as a mission specialist. She is married to astronaut Robert L. Gibson. They have one son. She was born in Murfreesboro, Tennessee, November 8, 1947. She is 5' 3" and weighs 110 pounds. She has blond hair and blue eyes..

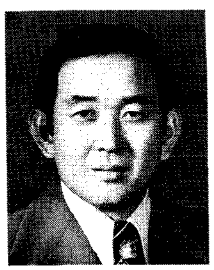


JEFFREY A. HOFFMAN, is a mission specialist on the 41E flight. Hoffman received a bachelor of arts degree in Astronomy from Amherst College in 1966 and a doctor of philosophy in Astrophysics from Harvard University in 1971. Dr. Hoffman's research interests are in high-energy astrophysics, specifically cosmic gamma ray and x-ray astronomy. His doctoral work at Harvard was the design, construction, testing, and flight of a balloon-borne low energy gamma ray telescope. During three years (1972 to 1975) of postdoctoral work at Leicester University, he worked on three rocket payloads — two for the observation of lunar occultations of x-ray sources and one for an observation of the crab nebula with a solid state detector and concentrating x-ray mirror. During his last year at Leicester, he was project scientist for the medium-energy x-ray experiment on the European Space Agency's (ESA) EXOSAT satellite. He worked in the center for Space Research at MIT from 1975 to 1978 as a project scientist in charge of the orbiting HEAO-1 A4 hard x-ray and gamma ray experiment. He was also involved extensively in analysis of x-ray data from the SAS-3 satellite operated by MIT performing research on the study of x-ray bursts. Dr. Hoffman has authored or co-authored more than 20 papers on this subject since bursts were first discovered in 1976. He has received a Woodrow Wilson Foundation Pre-Doctoral Fellowship, 1966-67, a National Science Foundation Pre-Doctoral Fellowship, 1966-71, a National Academy of Sciences Post-Doctoral Vesting Fellowship, 1971-72, a Harvard University Sheldon International Fellowship, 1972-73, and a NATO Post-Doctoral Fellowship, 1973-74. He is a member of the International Astronomical Union and the American Astronomical Society. Dr. Hoffman was selected as an astronaut candidate in January 1978, completing a one year training and evaluation period in August 1979, making him eligible for assignment as a mission specialist. He was born in Brooklyn, N.Y., November 2, 1944 but considers Scarsdale, N.Y., his hometown. He is married and has two children. He is 6' 2" and weighs 160 pounds. He has brown hair and eyes.

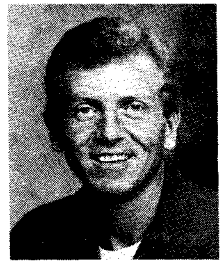
41-F FLIGHT CREW



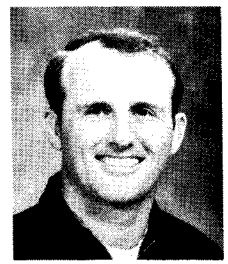
THOMAS K. MATTINGLY, II, is the commander for the 41F mission. He was also the commander in the STS-4 flight. He was the backup commander for the STS-3 flight and STS-2 flight. From 1979 to 1981 he headed the astronaut ascent/entry group. Mattingly was previously assigned as technical assistant for flight test to the manager of the Development Flight Test program. He was the head of the astronaut office support to the STS program from 1973 to 1978. Mattingly was the designated command module pilot for the Apollo 13 flight, but was removed from flight status 72 hours prior to the scheduled launch due to exposure to the German measles. He subsequently served as command module pilot of Apollo 16, April 16 through April 27, 1972. Mattingly has logged 435 hours and 1 minute in space—1 hour and 13 minutes of which were spent in extravehicular activity (EVA). He has logged 6,300 hours of flight time—4,130 hours in jet aircraft. Mattingly is one of the 19 astronauts selected by NASA in April 1966. Prior to reporting for duty as an astronaut, he was a student at the Air Force Aerospace Research Pilot school. Mattingly began his naval career as an ensign in 1958 and received his wings in 1960. He was then assigned to the USS Saratoga from 1960 to 1963 flying AIH aircraft and then served aboard the USS Franklin D. Roosevelt where he flew A3B aircraft for two years. He served as a member of the astronaut support crews for the Apollo 8 and 11 missions. Mattingly is an Associate Fellow, American Institute of Aeronautics and Astronautics; Fellow, American Astronautical Society; and Member, Society of Experimental Test Pilots, and the U.S. Naval Institute. He has the NASA Distinguished Service Medal, the JSC Group Achievement Award, the Navy Distinguished Service Medal and Navy Astronauts Wings, the SETP Ivan C. Kincheloe Award, the Delta Tau Delta Achievement Award, the Auburn Alumni Engineers Council Outstanding Achievement Award, the AAS Flight Achievement Award, the AIAA Haley Astronautics Award, and the Federation Aeronautique Internationale V. M. Komarov Diploma. Mattingly was born in Chicago, Illinois, March 17, 1936, and has one child. He is 5'10" and weighs 140 pounds. He has brown hair and blue eyes.



ELLISON S. ONIZUKA, is a mission specialist on the 41F mission. He received bachelor and master of science degrees in Aerospace Engineering in June and December 1969, respectively, from the University of Colorado. Onizuka entered active duty with the United States Air Force in January 1970 after receiving his commission at the University of Colorado through the four year ROTC program as a distinguished military graduate. As an aerospace flight test engineer with the Sacramento Air Logistics Center at McClellan Air Force Base, California, he participated in flight test programs and systems safety engineering for the F-84, F-100, F-105, F-111, EC-121T, T-33, T-39, T-28 and A-1 aircraft. He attended the USAF Test Pilot School and in July 1975 he was assigned to the Air Force Flight Test Center at Edwards Air Force Base, California, serving on the USAF Test Pilot School staff initially as squadron flight test engineer and later as chief of the engineering support section in the training resources branch. He has logged more than 900 hours flying time. Onizuka was selected as an astronaut candidate in January 1978 and in August 1979, he completed a one year training and evaluation period making him eligible for assignment as a mission specialist. He is a recipient of the Air Force Commendation Medal, Air Force Meritorious Service Medal, Air Force Outstanding Unit Award, Air Force Organizanizational Excellence Award, and National Defense Service Medal. He is a member of the Society of Flight Test Engineers, the Air Force Association and AIAA. He was born in Kealakekua, Kona, Hawaii, June 24, 1946. He is married and has two children. He is 5'9" in height and weighs 162 pounds. He has black hair and brown eyes.

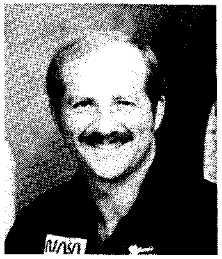


LOREN J. SHRIVER, is the pilot for the 41F mission. He received a bachelor of science in Aeronautical Engineering from the United States Air Force Academy in 1967 and a master of science degree in Astronautical Engineering from Purdue University in 1968. Shriver was commissioned in 1967 upon graduation from the USAF Academy and from 1969 to 1973 he served as a T-38 academic instructor pilot at Vance Air Force Base, Oklahoma. He completed F-4 combat crew training at Homestead Air Force Base, Florida, in 1973, and was assigned to Thailand until 1974. He attended the USAF Test Pilot School in 1975 and was assigned to the 6512th Test Squadron at Edwards Air Force Base. In 1976, Shriver served as a test pilot for the F-15 joint Test Force at Edwards. He was selected as an astronaut candidate in January 1978, and in August 1979, he completed a one year training and evaluation period making him eligible for assignment as a pilot. He has flown in 30 different types of single and multi-engine civilian and military fixed wing and helicopter aircraft and has logged over 2,950 hours in jet aircraft, and holds commercial pilot and glider ratings. He has received the Air Force Meritorious Service Medal, Air Force Commendation Medal, two Air Force Outstanding Unit Awards, and the National Defense Service Medal, Shriver is a member of SETP, Air Force Association and AIAA. He was born in Jefferson, Iowa but considers Paton, Iowa his hometown. He is married and has four children. He is 5'10" in height and weighs 160 pounds. He has blond hair and blue eyes.

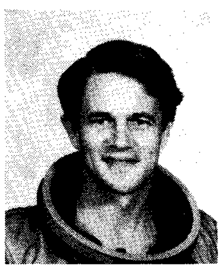


JAMES F. BUCHLI, is a mission specialist on the 41F mission. He received a bachelor of science degree in Aeronautical Engineering from the United States Naval Academy in 1967 and a master of science degree in Aeronautical Engineering Systems from the University of West Florida in 1975. He received his commission in the United States Marine Corps following graduation from the United States Naval Academy at Annapolis in 1967. He served a one year tour of duty in the Republic of Vietnam and upon his return to the United States in 1969, he reported to naval flight officer training at Pensacola, Florida. Buchli spent the next three years assigned to the Marine Fighter/Attack Squadron at Kaneohe Bay, Hawaii and Iwakuni, Japan and in 1973 he proceeded to duty with Marine Fighter/Attack Squadron at Namphong, Thailand, and Iwakuni, Japan. At completion of this tour of duty he returned to the United States and participated in the Marine Advanced Degree Program at the University of West Florida. He was assigned subsequently to Marine Fighter/Attack Squadron at the Marine Corps Air Station, Beaufort, S.C., and in 1977, to the U.S. Test Pilot School, Patuxent River, Maryland. He was selected as an astronaut candidate by NASA in January 1978 and in August 1979, he completed a one-year training and evaluation period making him eligible for assignment as a mission specialist. He has logged 1,900 hours flying time, 1,780 hours in jet aircraft. Buchli is the recipient of an Air Medal, Navy Commendation Medal, Purple Heart, Combat Action Ribbon, Presidential Unit Citation, Navy Unit Citation, a Meritorious Unit Citation, and a Vietnamese Cross of Gallantry with the Silver Star. He was born in New Rockford, North Dakota, June 20, 1945, but considers Fargo, North Dakota his hometown. He is married and has two children. He has brown hair and hazel eyes. He is 5'7" in height and weighs 160 pounds.

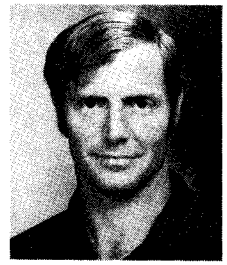
41-G FLIGHT CREW



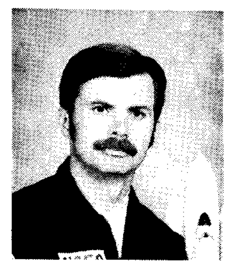
FREDERICK H. HAUCK, is the commander for the 41G flight. He was the pilot on the STS-7 mission, logging 146 hours in space. He was a member of the support crew for STS-1 and capsule communicator during reentry for the STS-2 flight. He was selected as an astronaut candidate by NASA in 1978. Hauck received a bachelor of science degree in Physics from Tufts University in 1962 and a master of science degree in Nuclear Engineering from MIT in 1966. He was a Navy ROTC student at Tufts University and was commissioned upon graduation and served as communications officer and CIC officer on the USS Warrington. In 1964 he attended the U.S. Naval Postgraduate School, Monterey, Calif., in math and physics and studied Russian at the Defense Language Institute in Monterey. He was then selected for the Navy's Advanced Science Program. He received his wings in 1968. He flew 114 combat and combat support missions in the Western Pacific aboard the USS Coral Sea. He graduated from the U.S. Naval Test Pilot School in 1971. Hauck then served as a project test pilot for automatic carrier landing systems in the A-6, A-7, F-4 and F-14 aircraft. In 1974 he was assigned to the USS Enterprise flying A-6, A-7 and F-14 aircraft. He was an executive officer in February 1977 until he was selected as an astronaut. He was born in Long Beach, Calif., April 11, 1941 but considers Winchester, Mass., and Washington, D.C. as his hometown. He is married and has two children. He is 5'9" in height and weighs 175 pounds. He has blond hair and blue eyes.



JOSEPH P. ALLEN, is a mission specialist on the 41G flight. He was a mission specialist on the STS-5 mission, logging 122 hours in space. He received a bachelor of arts degree in math-physics from DePauw University and a master of science degree and doctorate in physics from Yale University. He was a staff physicist at the Nuclear Structure Lab at Yale from 1965 to 1966 and served as a guest research associate at Brookhaven National Laboratory from 1963 to 1967 and was a research associate in the Nuclear Physics Laboratory at the University of Washington from 1967 until he was selected as a scientist astronaut in 1967. He was a mission scientist while a member of the astronaut support crew for Apollo 15 and served as a staff consultant on science and technology for the President's Council on International Economic Policy. From 1975 to 1978, Allen served as NASA Assistant Administrator for Legislative Affairs in Washington, D.C. Allen has received two NASA Group Achievement Awards, the Yale Science and Engineering Association Award, the DePauw University Distinguished Alumnus Award, the NASA Exceptional Scientific Achievement Medal, a NASA Exceptional Service Medal. He is a member of the American Physical Society, the American Astronomical Society, the AIAA, the American Association for the Advancement of Science, and the AAS. He has logged more than 2,800 hours of flying time in jet aircraft. Allen is married and has two children. He was born in Crawfordsville, Ind., June 27, 1937. He is 5'6" and weighs 125 pounds. He has brown hair and blue eyes.



DAVID M. WALKER, is the pilot for the 41G flight. He received a bachelor of science degree from the United States Naval Academy in 1966. Upon graduation from Annapolis, he received his flight training at Naval Air Training Command bases in Fla., Miss., and Texas. He was designated a Naval Aviator in December 1967 and proceeded to Naval Air Station Miramar, Calif., for assignment to Fighter Squadron 92 where he completed two combat cruises in Southeast Asia as a fighter pilot flying F-4 Phantoms aboard carriers USS Enterprise and America. From December 1970 to 1971, he attended the USAF Aerospace Research Pilot School at Edwards AFB, Calif., and was subsequently assigned in January 1972 as an experimental and engineering test pilot in the flight test division at the Naval Air Test Center, Patuxent River, Maryland. He participated in the Navy's preliminary evaluation and Board of Inspection and Survey trails of the F-14 and F-4 Phantom. He then attended the U.S. Navy Safety Officer School at Monterey, Calif., and completed replacement pilot training in the F-14 at Naval Air Station Miramar, Calif. In 1975, Walker was assigned to Fighter Squadron 142 at Naval Air Station Oceana, Va., and was deployed to the Mediterranean aboard the USS America. He has logged more than 3,000 hours flying time, 2,800 hours in jet aircraft. He was awarded six Navy Air Medals, a Battle Efficiency Ribbon, the Armed Forces Expeditionary Medal, the National Defense Service Medal, the Vietnamese Cross of Gallantry, the Vietnam Service Medal, and the Republic of Vietnam Campaign Medal. He is a member of the Society of Experimental Test Pilots. Walker was selected as an astronaut candidate in January 1978, completing a one year training and evaluation period in August 1979, making him eligible for assignment as a pilot. He was born in Columbus, Ga., May 20, 1944, but considers Eustis, Fla. his hometown. He is married and has two children. He is 5' 10" and weighs 165 pounds. He has red hair and blue eyes.



DALE A. GARDNER, is a mission specialist on the 41G flight. He was a mission specialist on the STS-8 mission, logging 145 hours in space. He was selected as an astronaut candidate in 1978. He received a bachelor of science degree in Engineering Physics from the University of Illinois in 1970. Gardner entered the U.S. Navy in 1970 upon graduation from college and was assigned to Aviation Officer Candidate School. In 1970 he attended basic naval officer training and was graduated with the highest academic average ever achieved in the 10-year history of the squadron. He proceeded to the Naval Aviation Technical Training Center for advanced naval flight officer training and received his wings in 1971. From 1971 to 1973 he was assigned to weapons system test division at the Naval Test Center in F-14A development test and evaluation as project officer for testing inertial navigation system. He then flew F-14A aircraft and participated in two WESTEC cruises while deployed aboard the USS Enterprise. From 1976 until reporting to NASA, Gardner was with the Air Test and Evaluation Squadron in the operational test and evaluation of fighter aircraft. Gardner is married and has one child. He was born in Fairmont, Minn., November 8, 1948, but considers Clinton, Iowa, his hometown. He is 6' in height and weighs 160 pounds. He has brown hair and eyes.

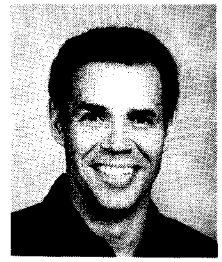
41-G FLIGHT CREW

ANNA L. FISHER, is a mission specialist on the 41G flight. She received a bachelor of science in chemistry and a doctor of medicine from the University of California, Los Angeles, in 1971 and 1976 respectively, completing a one year internship at Harbor General Hospital in Torrance, California, in 1977. After graduating from UCLA in 1971, Dr. Fisher spent a year in graduate school in chemistry at UCLA working in the field of x-ray crystallographic studies of metallocarboranes. She co-authored three publications relating to these studies for the journal of Inorganic Chemistry. She has specialized in emergency medicine and had worked in several hospitals in the Los Angeles area. She was awarded a National Science Foundation Undergraduate Research Fellowship in 1970, and 1971. She is a member of the American College of Emergency Physicians and instructor for the American Heart Association's Advanced Cardiac Life Support. Dr. Fisher was selected as an astronaut candidate in January 1978, completing a one year training and evaluation period in August 1979, making her eligible for assignment as a mission specialist. She is married to astronaut Dr. William F. Fisher. She was born in St. Albans, N.Y., August 24, 1949. She is 5' 4" and weighs 110 pounds. She has brown hair and hazel eyes.

STS-18 FLIGHT CREW

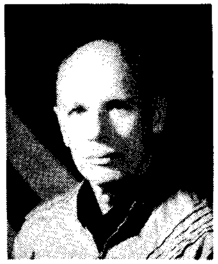
ROBERT F. OVERMYER, is the commander for the STS-18 flight. He was a pilot on the STS-5 flight, logging 122 hours in space. He was previously assigned engineering development duties on the Space Shuttle program and the Development Flight Test missions group of the astronaut office. His first assignment with NASA was engineering development duties on Skylab. Overmyer then served on the support crews for the Apollo 17 and Apollo-Soyuz Test Project. In 1976 he was the prime T-38 chase pilot for the Approach and Landing Test program on orbiter free flights 1 and 3. Overmyer was selected as a NASA astronaut when the U.S. Air Force Manned Orbiting Laboratory program was canceled in 1969. Colonel Overmyer entered active duty with the Marine Corps in January 1958. After flight training, several squadron tours, and graduate school, he attended the Air Force Test Pilots school in 1965. He was selected as an astronaut for the U.S. Air Force Manned Orbiting Laboratory program in 1966. He is a member of the Society of Experimental Test Pilots. He has the USAF Meritorious Service Medal and the USMC Meritorious Award. Overmyer was born in Lorain, Ohio, July 14, 1936, but considers Westlake, Ohio his hometown. He is married and has three children. He is 5'11-3/4" and weighs 180 pounds. He has brown hair and blue eyes.

NORMAN E. THAGARD, is a mission specialist on the STS-18 mission. He was a mission specialist on the STS-7 flight logging 146 hours in space and conducted medical tests to collect additional data on several physiological changes that were associated with space adaptation syndrome. These tests focused on the neurological system and were a continuation of the new approach to making inflight measurements which began on STS-4. These efforts were directed toward initiation of an inflight search for countermeasures and to provide a more complete understanding of the space adaptation syndrome. He received a bachelor and master of science degrees in Engineering Science in 1965 and 1966 and subsequently performed pre-med coursework and received a doctor of Medicine from the University of Texas Southwestern Medical School in 1977. September 1966, he entered on active duty with the United States Marine Corps Reserve. In 1967, he achieved the rank of Captain and was designated a naval aviator in 1968 and was assigned to duty flying F-4s at Marine Corps Air Station, Beaufort, South Carolina. He flew 163 combat missions in Vietnam from January 1969 to 1970. He returned to the United States and was assigned aviation weapons division officer at the Marine Corps Air Station, Beaufort, South Carolina. Thagard resumed his academic studies in 1971, pursuing a degree in medicine. His interning was in the Department of Internal Medicine at the Medical University of South Carolina. Thagard was selected as an astronaut candidate in January 1978 and in August 1979, he completed a one-year training and evaluation period making him eligible for assignment as a mission specialist. He has logged 1,100 hours flying time, 1,000 hours in jet aircraft. He was awarded 11 Air Medals, the Navy Commendation Medal with Combat V, the Marine Corps "E" Award, the Vietnam Service Medal and the Vietnamese Cross of Gallantry with Palm. Thagard is a member of AIAA. He was born in Marianna, Florida, July 3, 1943, but considers Jacksonville, Florida his hometown. He is married and has three children. He has brown hair, blue eyes. He is 5'9" in height and weighs 164 pounds.



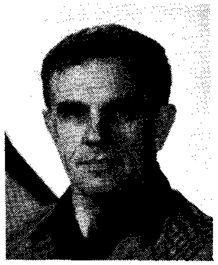
FREDERICK D. GREGORY, is the pilot for the STS-18 flight. He received a bachelor of science degree from the United States Air Force Academy in 1964, and a masters degree in information systems from George Washington University in 1977. Gregory entered pilot training after graduation from the United States Air Force Academy in 1964 and received his wings from undergraduate training in 1965. After three years of helicopter flying, including a Vietnam tour, he was re-trained as a fighter pilot and flew the F-4. He attended the U.S. Naval Test Pilot School in 1970 and was subsequently assigned as a research/engineering test pilot for the Air Force and for NASA from 1971 until 1977. Gregory has flown more than 40 different types of single and multi-engine fixed and rotary wing aircraft including gliders. He has logged over 4,100 hours of flight time and holds an FAA commercial and instrument certificate for single, multi-engine and rotary aircraft. Gregory was selected as an astronaut candidate by NASA in January 1978, and completed a one year training and evaluation period in August 1979, making him eligible for assignment as a pilot. Gregory was awarded the Air Force Distinguished Flying Cross, the Meritorious Service Medal, the Air Medal with 15 Oak Leaf Clusters, the Air Force Commendation Medal and recipient of the National Society of Black Engineers Distinguished National Scientist Award (1979). He is a member of the Society of Experimental Test Pilots, the American Helicopter Society, the Air Force Association and the National Technical Association. He was born January 7, 1941, in Washington, D.C. He is married and has two children. He has brown hair and blue eyes. He is 5'11" and weighs 175 pounds.

DON LESLIE LIND, is a mission specialist for the STS-18 flight. Lind received a bachelor of science with high honors in physics from the University of Utah in 1953 and a doctor of philosophy degree in high energy nuclear physics in 1964 from the University of California, Berkeley and performed post-doctoral study at the Geophysical Institute, University of Alaska, in 1975-1976. Lind served four years on active duty with the Navy at San Diego and later aboard the carrier USS Hancock. He received his wings in 1957. Lind has logged more than 3,800 hours flying time, 3,300 hours in jet aircraft. Before his selection as an astronaut, he worked at the NASA Goddard Space Flight Center as a space physicist. He had been at Goddard since 1964 and was involved in experiments to determine the nature and properties of low energy particles within the earth's magnetosphere and interplanetary space. Previous to this, he worked at the Lawrence Radiation Laboratory, Berkeley, California, doing research in basic high energy particle interaction. Dr. Lind was selected as a NASA astronaut in April 1966. He served as a backup science pilot for Skylab 3 and 4 and as a member of the rescue crew for the Skylab missions. Lind has received the NASA Exceptional Service Medal (1974). Lind is a member of the American Geophysical Union, and the American Association for Advancement of Science. He is married and has seven children. Lind was born May 18, 1930, in Midvale, Utah. He has brown hair and hazel eyes. He is 5'11-3/4" and weighs 180 pounds.

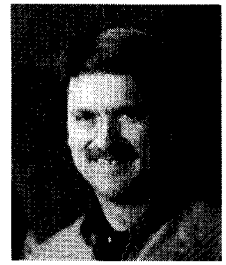


WILLIAM E. THORNTON, is a mission specialist on STS-18 mission. He was a mission specialist on the STS-8 flight, logging 145 hours in space and conducted medical tests to collect additional data on several physiological changes that were associated with the space adaptation syndrome. These tests focused on the neurological system and were a continuation of the new approach to making inflight measurements which began on STS-4. These efforts were directed toward initiation of an inflight search for countermeasures and to provide a more complete understanding of the space adaptation syndrome. He received a bachelor of science degree in Physics and a doctorate in Medicine from the University of North Carolina in 1952 and 1963. Following graduation from the University of North Carolina and having completed Air Force ROTC training, Thornton served as officer-in-charge of the Instrumentation Lab at the Flight Test Air Proving Ground. From 1955 to 1959 he was chief engineer of the electronics division of the Del Mar Engineering labs in Los Angeles, Calif. and directed its Avionics Division. He returned to the University of North Carolina Medical School in 1959 and graduated in 1963. Thornton completed his internship training in 1964 at the Wilford Hall USAF Hospital at Lackland AFB, San Antonio, Texas. He returned to active duty with the USAF and was assigned to the USAF Aerospace Medical Division at Brooks AFB in San Antonio, Texas and became involved in space medicine research during his two year duty. Dr. Thornton was selected as a scientist astronaut in August 1967. He completed flight training at Reese AFB, Texas. He was physician crew member on the 56 day simulation of Skylab Medical Experiments Altitude Test (SMEAT). He was a member of the astronaut support crew for Skylab 2, 3, and 4 missions and principle investigator of Skylab experiments on mass measurement, anthropometric measurements, hemodynamics, and human fluid shifts and physical conditioning. Dr. Thornton holds more than 15 issued patents. He is recipient of the Air Force Legion of Merit, the NASA Exceptional Service Medal in 1972, NASA Exceptional Scientific Achievement Medal in 1974, and presented the American Astronautical Society's Melbourne W. Boynton Award for 1975 and 1977. He has logged over 2,375 hours in jet aircraft. Dr. Thornton was born in Faison, North Carolina, April 14, 1929. He is married and has two children. He has blond hair and blue eyes. He is 6' in height and weighs 200 pounds.

STS-24 FLIGHT CREW



KARL C. HENIZE, is a mission specialist for the STS-24 flight. He received a bachelor of arts degree in Mathematics in 1947 and a master of arts degree in Astronomy in 1948 from the University of Virginia; and awarded a doctor of Philosophy in Astronomy in 1954 by the University of Michigan. Henize was an observer for the University of Michigan Observatory from 1948 to 1951, stationed at the Lamont Hussey Observatory in Bloemfontein, Union of South Africa. In 1954, he became a Carnegie post-doctoral fellow at the Mount Wilson Observatory in Pasadena, California. From 1956 to 1959 he served as a senior astronomer at the Smithsonian Astrophysical Observatory. Dr. Henize was appointed associate professor in Northwestern University's Department of Astronomy in 1959 and was awarded a professorship in 1964. In addition to teaching he conducted research on planetary nebulae, peculiar emission-line stars, S-stars, and T-associations. During 1961 and 1962, he was guest observer at Mt. Stromoto Observatory in Canberra, Australia. He became principal investigator of experiment S-013 which obtained ultraviolet stellar spectra during the Gemini 10, 11, and 12 flights. He also became principal investigator of experiment S-019 used on Skylab to obtain ultraviolet spectra of faint stars. Spectra were obtained of hundreds of stars and these are being studied at the Unversity of Texas where Dr. Henize now holds an adjunct professorship. He is the author and/or co-author of 56 scientific publications dealing with astronomy research. Dr. Henize was selected as a scientist-astronaut by NASA in August 1967. He completed the academic training and the 53-week jet pilot training program at Vance Air Force Base, Oklahoma. He has logged 1,900 hours of flying time in jet aircraft. He was a member of the astronaut support crew for the Apollo 15 mission and for the Skylab 2, 3, and 4 missions. He was presented the Robert Gordon Memorial Award for 1968; recipient of the NASA Group Achievement Award (1971, 1974, 1975, 1978); awarded the NASA Exceptional Scientific Achievement Medal (1974). He is a member of the American Astronomical Society; the Royal Astronomical Society; the Astronomical Society of the Pacific; and the Astronomical Union. He was born October 17, 1926, in Cincinnati, Ohio. He is married and has four children. He has brown hair and brown eyes. He is 5'7" and weighs 170 pounds.



ANTHONY W. ENGLAND, is a mission specialist on the STS-24 flight. He received bachelor and master of science degrees in Geology and Physics from Massachusetts Institute of Technology in 1965 and a doctor of philosophy from the Department of Earth and Planetary Sciences at MIT in 1970. He was a graduate fellow at MIT for three years immediately preceding his assignment to NASA. He has performed heat flow measurements throughout the southwest, has taken part in a magnetic study in Montana, has performed radar sounding studies of glaciers in Washington state and Alaska, has performed microwave airborne surveys throughout the western United States, and has participated in and led field parties during two seasons in Antarctica. Dr. England was selected as a scientist-astronaut by NASA in August 1967. He completed academic training and a 53 week course in flight training at Laughlin Air Force Base, Texas. He has logged over 2,000 hours in flying time. He served as a support crewman for the Apollo 13 and 16 flights. From August 1972 to June 1979, England was a research geophysicist with the U.S. Geological Survey. He returned to the Johnson Space Center in 1979 as a senior scientist astronaut. England was presented the Johnson Space Center Superior Achievement Award (1970); the NASA Outstanding Achievement Medal (1973); and the U.S. Antarctic Medal (1979). He is a member of the American Geophysical Union, the American Geological Institute, the Society of Exploration Geophysicists, the American Association for the Advancement of Science, and the International Glaciological Society. England was born May 15, 1942 in Indianapolis, Indiana, but considers Fargo, North Dakota his hometown. England is married and has two children. He has brown hair and blue eyes. He is 5'10" and weighs 165 pounds.