51-B

PRESS INFORMATION

April 1985

Rockwell International

Space Transportation
Systems Division

Office of Public Relations

NEWS About Space Flight

...it comes from Rockwell International

STS 51-Bee—the Spacelab-3 mission—is an operational flight of "pure science."

It's NASA's first dedicated manned mission with acquisition of science data as its primary objective.

This will be the seventh flight of the spacecraft *Challenger,* and the 17th in the Space Transportation System (Space Shuttle) program. Even with the Spacelab-3 and its tunnel occupying most of the cargo bay area, there is still room for a "mission peculiar equipment support structure (MPESS) which will house two experiments and two Get-away Special (GAS) canisters are in the cargo bay as mission payloads. The GAS experiments, for the first time, are experiments which will be deployed into space.

Mission STS 51-Bee will conduct scientific applications and technology experimentation which require a low gravitation environment. The flight attitude of *Challenger* will be rigidly maintained to provide that environment during most of the mission. The spacecraft's vertical stabilizer will be pointed toward the Earth and the spacecraft's long duration stability will be achieved through precise controls of Reaction Control System (vernier engines) firing.

However, in the first 17 hours of the mission, the spacecraft will be controlled to provide various maneuvers for operation of a very wide-lens field camera.

Twelve primary investigations have been selected to fly aboard the Spacelab-3 mission. Of these, ten were originated by the United States, one from India and one from France. The experiments represent a total of five different disciplines, including materials processing in space, environmental observations, life sciences, astrophysics and technology research. Nine of the experiments are located in the Spacelab pressurized module, two are located in the MPESS pallet and the other experiment is located in the *Challenger's* mid-deck.

The 51-Bee flight crew of seven are divided into two "working teams" for on-orbit operations during daily 12 hour shifts. The shifts are designated Silver and Gold. Mission commander Robert Overmyer heads the Gold team with mission specialists Don Lind and William Thornton; the payload specialist (fluids expert) is Lodewijk van den Berg. The Silver shift is comprised of pilot Frederick Gregory, mission specialist Norman Thagard and payload specialist (materials processing expert) Taylor Wang.

Since all crew members must be on duty during launch and deorbit (landing), they will each establish a personal "circadian rhythm" pattern several days before liftoff in an effort to approximate the early and late mission activities sandwiching the 'on-orbit' schedule of 12 hours on duty, eight for sleep and four for eating and miscellaneous. The Silver team will start its six hour sleep period five hours after launch. The Gold shift picks up their eight hour sleep period approximately thirteen hours into the mission.

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NEWS About Space Flight

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51-B MISSION STATISTICS

Launch: Monday April 29, 1985   12:00 P.M. E.D.T.
11:00 A.M. C.D.T.
9:00 A.M. P.D.T.

(Launch window is one hour and launch time remains the same each day.)

Mission Duration: 144 hours (6 days), 20 hours, 58 minutes.

Landing: Monday, May 6, 1985, on orbit 109   8:58 A.M. E.D.T.
7:58 A.M. C.D.T
5:58 A.M. P.D.T

Inclination: 57 degrees

Altitude: 190 nautical miles (nmi) (281 statute miles [sm]) circular orbit.

Total Liftoff Weight: Approximately 2,042,232 kilograms (4,502,276 pounds)

Payload Weight Up: Approximately 13,802 kilograms (30,428 pounds)

Payload Weight Down: Approximately 13,686 kilograms (30,173 pounds)

Payloads: Spacelab-3 (long pressurized module) plus an Mission Peculiar Experiment Support Structure (MPESS) and two Getaway Special (GAS) canisters.

Crew Members:
Commander (CDR): Robert P. Overmyer
Pilot (PLT): Frederick D. Gregory
Mission Specialist (MS)-1: Don Leslie Lind
Mission Specialist (MS)-2: Norman E. Thagard
Mission Specialist (MS)-3: William E. Thornton
Payload Specialist Materials Processing Expert (PSM): Taylor G. Wang
Payload Specialist Fluids Expert (PSF): Lodewijk van den Berg

Ascent and Entry Seating:
Flight deck front left seat—CDR Robert Overmyer
Flight deck front right seat—PLT Frederick Gregory
Flight deck aft center seat—MS-2 Norman Thagard
Flight deck aft right seat—MS-1 Don Lind
Mid-deck—MS-3 William Thornton (next to the mid-deck side hatch), PSM Taylor Wang (in front of mid-deck airlock) and PSF Lodewijk van den Berg (right of Wang).

Extravehicular Activity Flight Crew Members, if required:
Frederick Gregory and Norman Thagard

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Crossrange: Approximately 502 nmi (577 statute miles)   Runway: Runway 15, Kennedy Space Center, Florida

Entry: Will use the automatic mode until subsonic, then to control
stick steering (CSS)

FLIGHT TEST AND MISSION OBJECTIVES

FLIGHT TEST OBJECTIVES

- Cabin air monitoring

- Microbial monitoring and solid sorbent sample of Spacelab-3
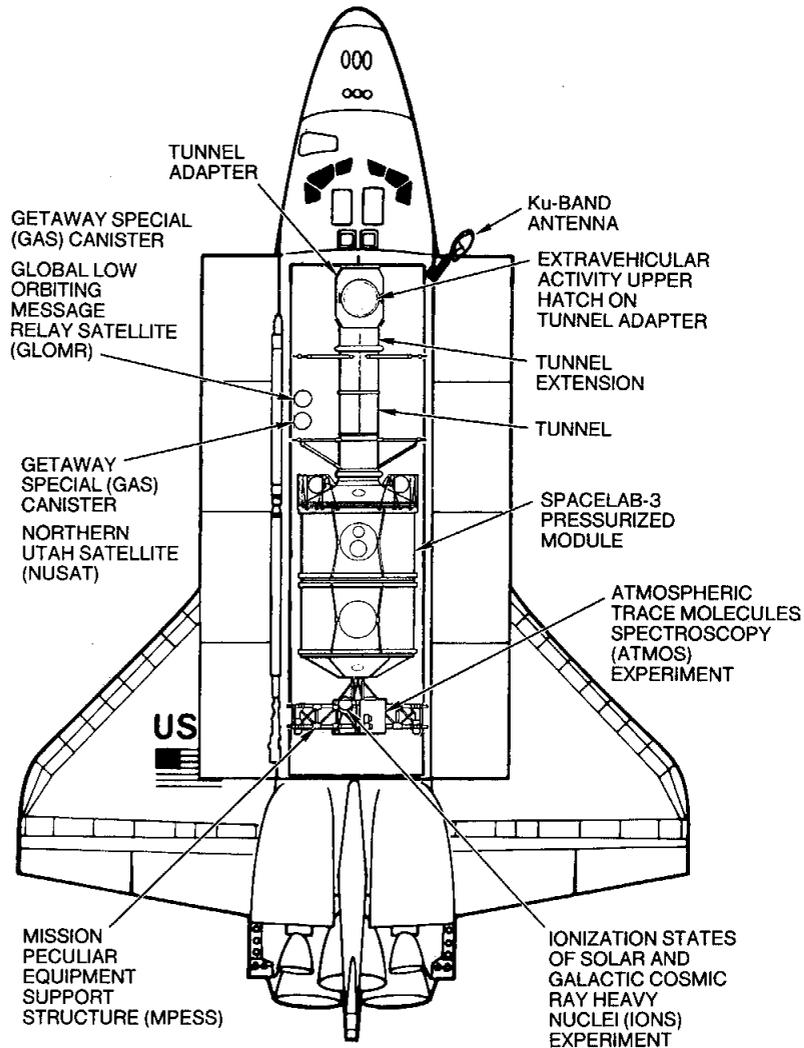
- Elevon entry aerodynamic test maneuvers

MISSION OBJECTIVES

- Spacelab-3 experiments

- Mission Peculiar Experiment Support Structure experiments

- Mid-deck experiment

- Two Getaway Special canisters—satellite deployment

- Tasks performed by flight crew members during 51-B mission

- Commander Robert Overmyer—Atmospheric Trace Molecules Spectroscopy (ATMOS) experiment, photography and auroral photography

- Pilot Frederick Gregory—ATMOS experiment photography, NUSAT (Northern Utah Satellite), and GLOMR
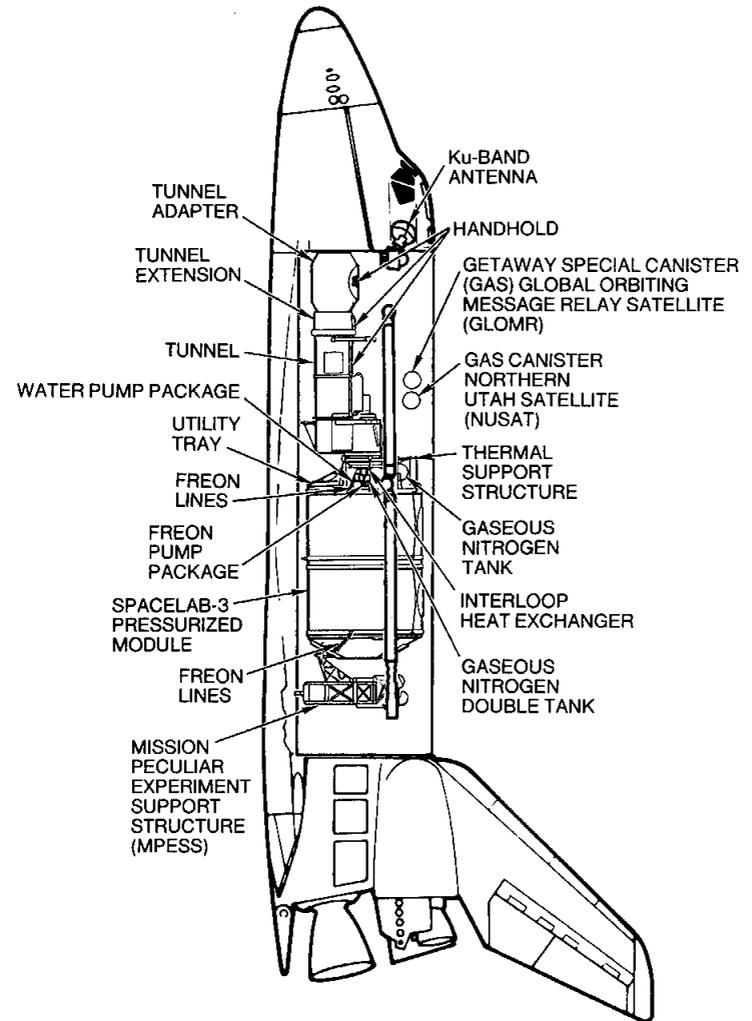
(Global low-orbiting message relay satellite), deploy photography and television

- Mission Specialist (MS)-1 Don Lind—Spacelab-3 activation/deactivation, Fluid Experiment System (FES), Vapor Crystal Growth System (VCGS), Very Wide Field Camera (VWFC), auroral observations and medical objectives

- Mission Specialist (MS)-2 Norman Thagard—Spacelab-3 activation/deactivation, Very Wide Field Camera (VWFC), NUSAT (Northern Utah Satellite), and Global Low Orbiting Message Relay Satellite (GLOMR) deployment, medical objectives, and research animal holding facility - verification test (RAHF-VT)

- Mission Specialist (MS)-3 William Thornton—Research Animal Holding Facility-Verification Test (RAHF-VT), Urine Monitoring Investigation (UMI) activation/deactivation, and medical objectives

- All Payload Crew—Geophysical Fluid Flow Cell (GFFC), Mercuric Iodide Crystal Growth (MICG), ATMOS, Ionization States of Solar and Galactic Cosmic Ray Heavy Nuclei (IONS), and UMI

- For the Autogenic Feedback Training (AFT), Payload Specialists Taylor Wang and Lodewijk are the test subjects and mission specialists Don Lind and William Thornton are the controls

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51B PAYLOAD CONFIGURATION

GETAWAY SPECIAL (GAS) CANISTER

GLOBAL LOW ORBITING MESSAGE RELAY SATELLITE (GLOMR)

TUNNEL ADAPTER

Ku-BAND ANTENNA

EXTRAVEHICULAR ACTIVITY UPPER HATCH ON TUNNEL ADAPTER

TUNNEL EXTENSION

TUNNEL

GETAWAY SPECIAL (GAS) CANISTER

NORTHERN UTAH SATELLITE (NUSAT)

SPACELAB-3 PRESSURIZED MODULE

ATMOSPHERIC TRACE MOLECULES SPECTROSCOPY (ATMOS) EXPERIMENT

US

MISSION PECULIAR EQUIPMENT SUPPORT STRUCTURE (MPESS)

IONIZATION STATES OF SOLAR AND GALACTIC COSMIC RAY HEAVY NUCLEI (IONS) EXPERIMENT

Top View

TUNNEL ADAPTER

TUNNEL EXTENSION

TUNNEL

WATER PUMP PACKAGE

UTILITY TRAY

FREON LINES

FREON PUMP PACKAGE

SPACELAB-3 PRESSURIZED MODULE

FREON LINES

MISSION PECULIAR EXPERIMENT SUPPORT STRUCTURE (MPESS)

Ku-BAND ANTENNA

HANDHOLD

GETAWAY SPECIAL CANISTER (GAS) GLOBAL ORBITING MESSAGE RELAY SATELLITE (GLOMR)

GAS CANISTER NORTHERN UTAH SATELLITE (NUSAT)

THERMAL SUPPORT STRUCTURE

GASEOUS NITROGEN TANK

INTERLOOP HEAT EXCHANGER

GASEOUS NITROGEN DOUBLE TANK

Side View

THE SPACELAB PROGRAM

Spacelab is a manned laboratory built by a group of European nations. The European Space Agency (ESA) formerly known as ESRO (European Space Research Organization) consist of 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 participated in the Spacelab program.

On September 24, 1973, ESA signed a memorandum of understanding with NASA and, with NASA's Marshall Space Flight Center, Huntsville, Alabama as lead center, to design, develop, and test a space laboratory aboard a Shuttle spacecraft which was culminated with the flight of Spacelab-1 aboard *Columbia* in the STS-9 mission, Nov. 28 to Dec. 8, 1983. This agreement included the one Spacelab flight unit, one engineering model and ground support equipment. An industrial consortium headed by ERNO-VFW Fokker was named by ESA in June 1974 to build Spacelab.

Mission 51-B will be the second flight of the Spacelab, redesignated as Spacelab-3.

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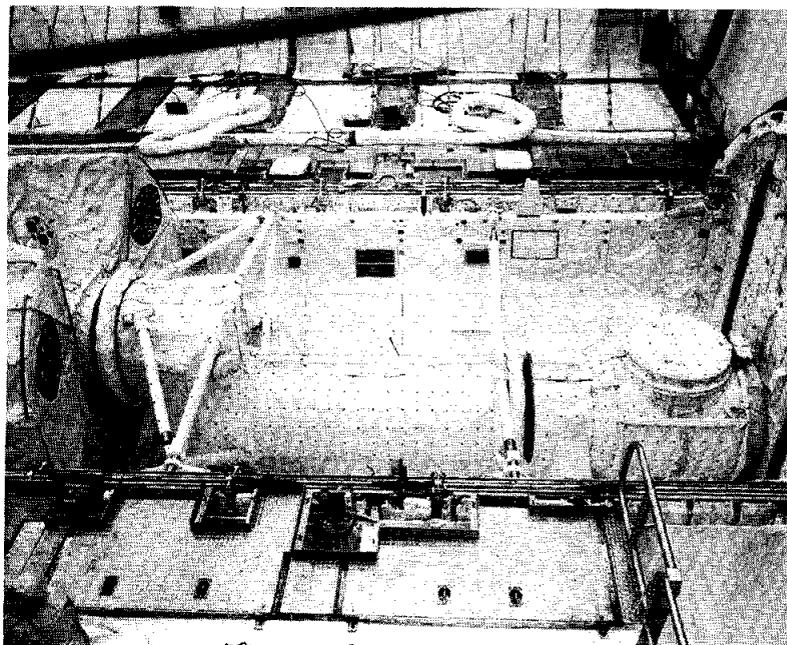
Spacelab is developed on a modular basis and can be varied to meet specific mission requirements. Its two principal components are the pressurized module, which provides a laboratory with a shirtsleeve working environment, and an open pallet or an mission peculiar experiment support structure (MPESS)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

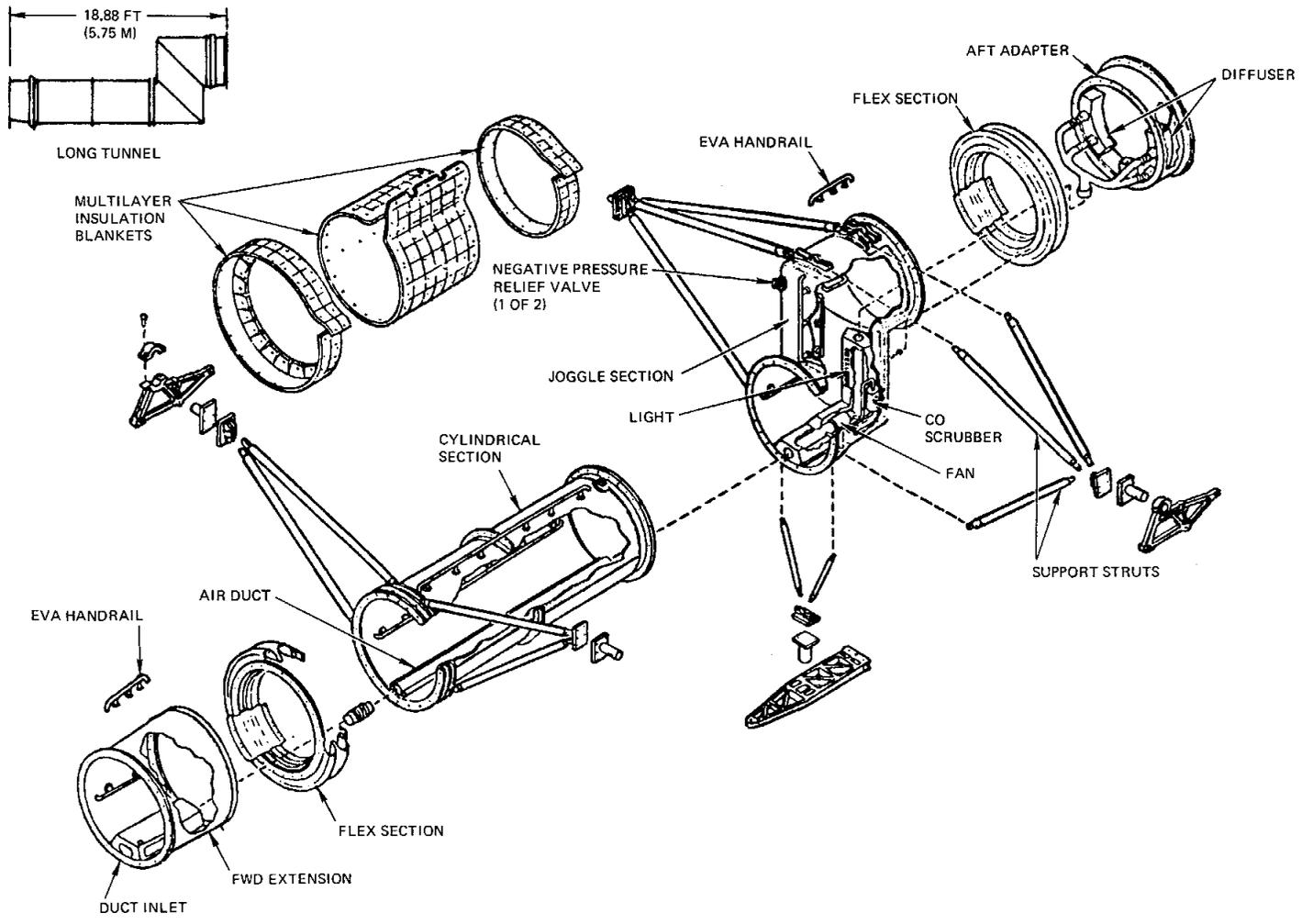The pressurized module or laboratory comes in two segments. One, called the core segment, contains supporting systems such as data processing equipment and utilities for both the pressurized modules and the pallets. It also has laboratory fixtures such as floor-mounted racks and work benches.

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. The module houses nine experiments in the 51-B mission.

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

Tunnel Adapter, Tunnel and Spacelab

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18.88 FT
(5.75 M)

LONG TUNNEL

MULTILAYER
INSULATION
BLANKETS

AFT ADAPTER

DIFFUSER

FLEX SECTION

EVA HANDRAIL

NEGATIVE PRESSURE
RELIEF VALVE
(1 OF 2)

JOGGLE SECTION

LIGHT

CO
SCRUBBER

CYLINDRICAL
SECTION

FAN

SUPPORT STRUTS

EVA HANDRAIL

AIR DUCT

FLEX SECTION

FWD EXTENSION

DUCT INLET

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Spacelab Transfer Tunnel

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 51-B 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 *Challenger'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 *Challenger's* crew cabin and Spacelab.

It is noted, that if an EVA is required, no crew members will be in Spacelab.
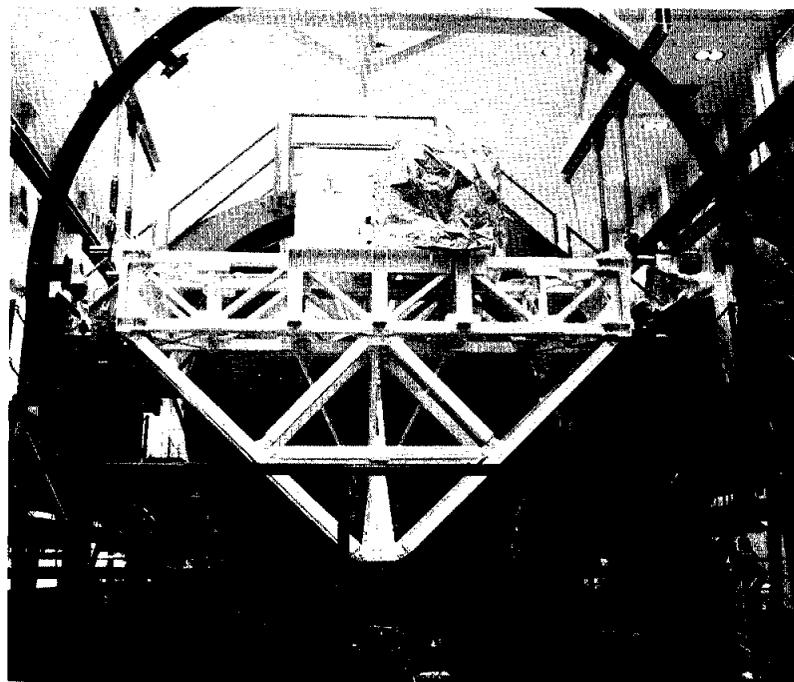
The mission peculiar equipment support structure (MPESS) houses two experiments in the 51-B mission.

Unlike *Challenger*, 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 *Challenger'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 *Challenger* provides primary dc, ac, emergency and essential power to the Spacelab subsystems and experiment subsystems.

Challenger'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.

*Mission Peculiar Equipment Support Structure (MPESS)
With Two Experiments*

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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 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.

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 orbiter 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 simul-
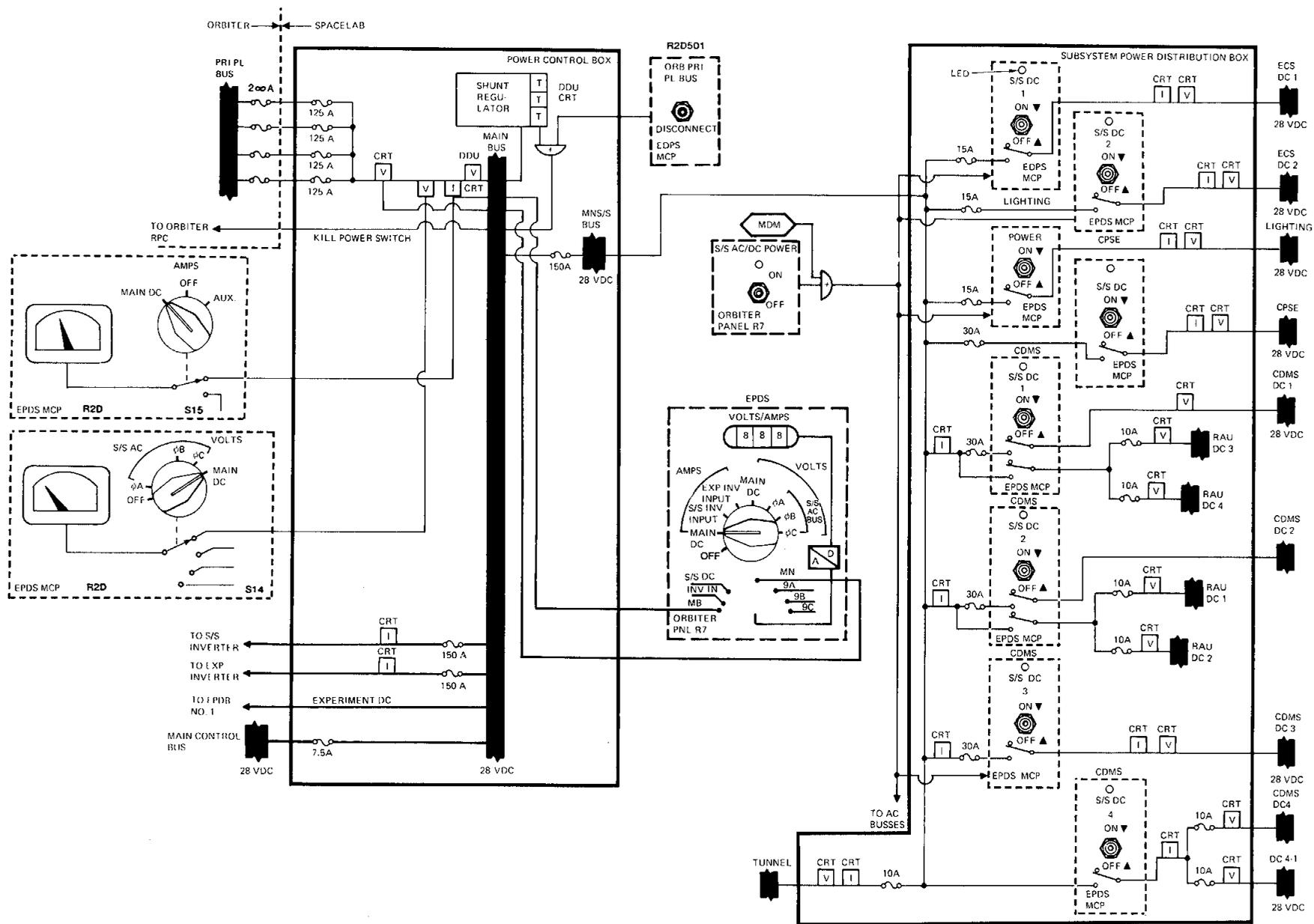
taneously by the Subsystem (S/S) AC/DC Power ON/OFF switch on orbiter Panel R7 or by an item command on several orbiter CRT Spacelab displays. The status of this switch on Panel R7 is available via orbiter CRT and by a GREEN LED (lighting-emitting diode) above the manual switch on Panel R7.

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.
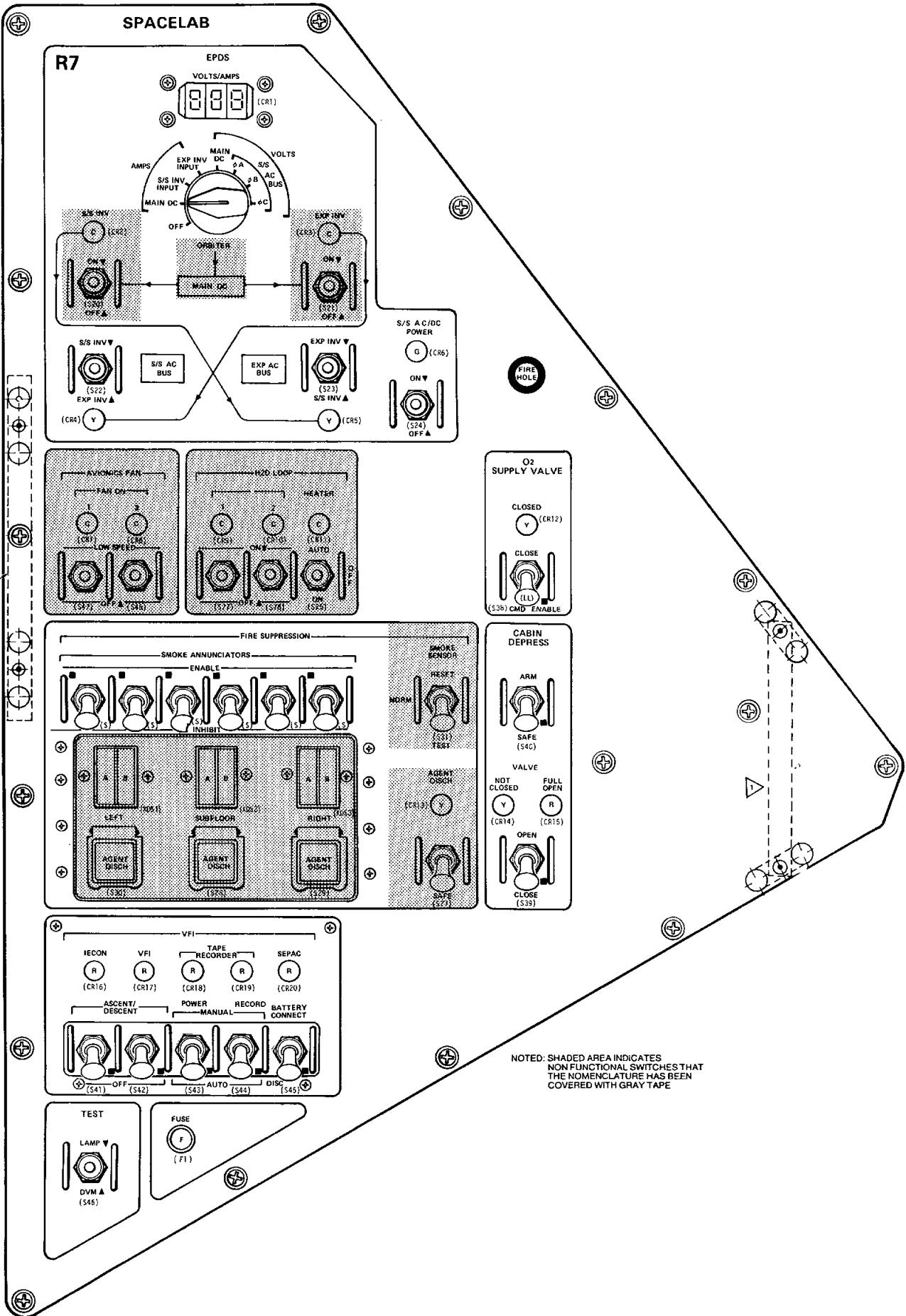
The dc power in the Spacelab PCB is directed to, two 150 par-

7
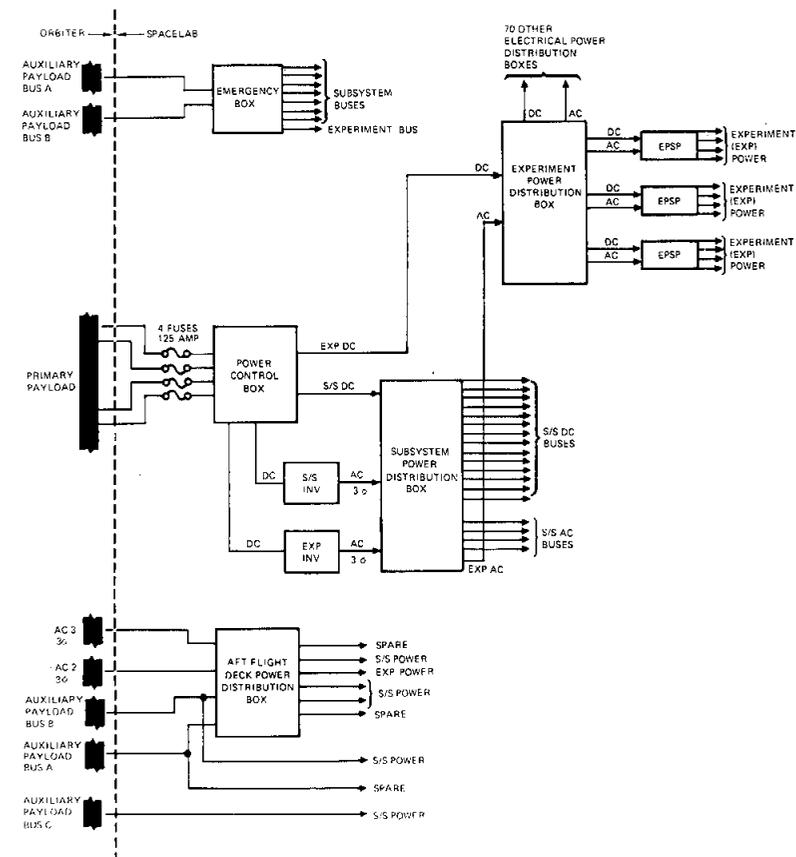
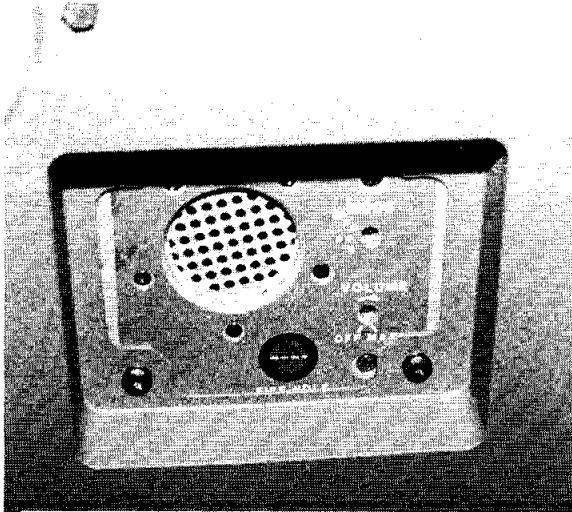*Orbiter Spacelab Electrical Power Distribution*

Orbiter to Spacelab Electrical Power Distribution Subsystem DC Power Distribution

SPACELAB

R7

EPDS

VOLTS/AMPS

(CR1)

AMPS
EXP INV INPUT
MAIN DC
VOLTS
S/S INV INPUT
φA
φB
S/S AC BUS
MAIN DC
φC
OFF

ORBITER

MAIN DC

S/S INV
(CR2)
ON
(S20)
OFF

EXP INV
(CR3)
ON
(S21)
OFF

S/S A C/DC POWER
G (CR6)
ON
(S24)
OFF

S/S INV
(S22)
EXP INV

S/S AC BUS

EXP AC BUS

EXP INV
(S23)
S/S INV

(CR4) Y

Y (CR5)

FIRE HOLE

AVIONICS FAN
FAN ON
(CR7) (CR8)
LOW SPEED
(S37) OFF (S38)

H2O LOOP
HEATER
(CR9) (CR10) (CR11)
ON AUTO
(S27) OFF (S26) ON (S25)

O2 SUPPLY VALVE

CLOSED
Y (CR12)

CLOSE
(LL)
(S36) CMD ENABLE

FIRE SUPPRESSION
SMOKE ANNUNCIATORS
ENABLE
(S) (S) (S) (S) (S) (S)
INHIBIT

A B   A B   A B
LEFT (S51) SUBFLOOR (S52) RIGHT (S53)

AGENT DISCH   AGENT DISCH   AGENT DISCH
(S30)   (S28)   (S29)

SMOKE SENSOR
RESET
NORM
(S31)
TEST

AGENT DISCH
(S13) Y

SAFE
(S2)

CABIN DEPRESS

ARM
(S40)
SAFE

VALVE
NOT CLOSED
Y (CR14)
FULL OPEN
R (CR15)

OPEN
(S39)
CLOSE

VFI
IECON   VFI   TAPE RECORDER   SEPAC
R   R   R   R   R
(CR16) (CR17) (CR18) (CR19)   (CR20)

ASCENT/DESCENT   POWER   RECORD   BATTERY CONNECT
MANUAL
(S41) OFF (S42) (S43) AUTO (S44) DISC (S45)
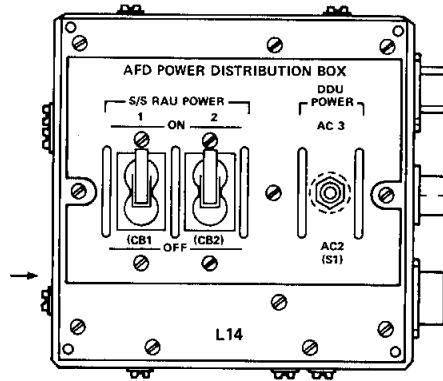
TEST
LAMP
(S46)
DVM

FUSE
F
(F1)

SPACELAB 11 ONLY

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

Spacelab Aurol Annunciator Located Below Panel L14

AFD POWER DISTRIBUTION BOX

S/S RAU POWER
1   ON   2

DDU
POWER
AC 3

(CB1)   OFF   (CB2)

AC2
(S1)

L14

Panel R14

Panel R11

Located behind pilot seat for ascent/entry and located on Panel R11 during orbit

allel amp fuses, one fuse is to the Spacelab subsystem dc/ac inverter and the other to a Spacelab dc/ac experiment inverter.
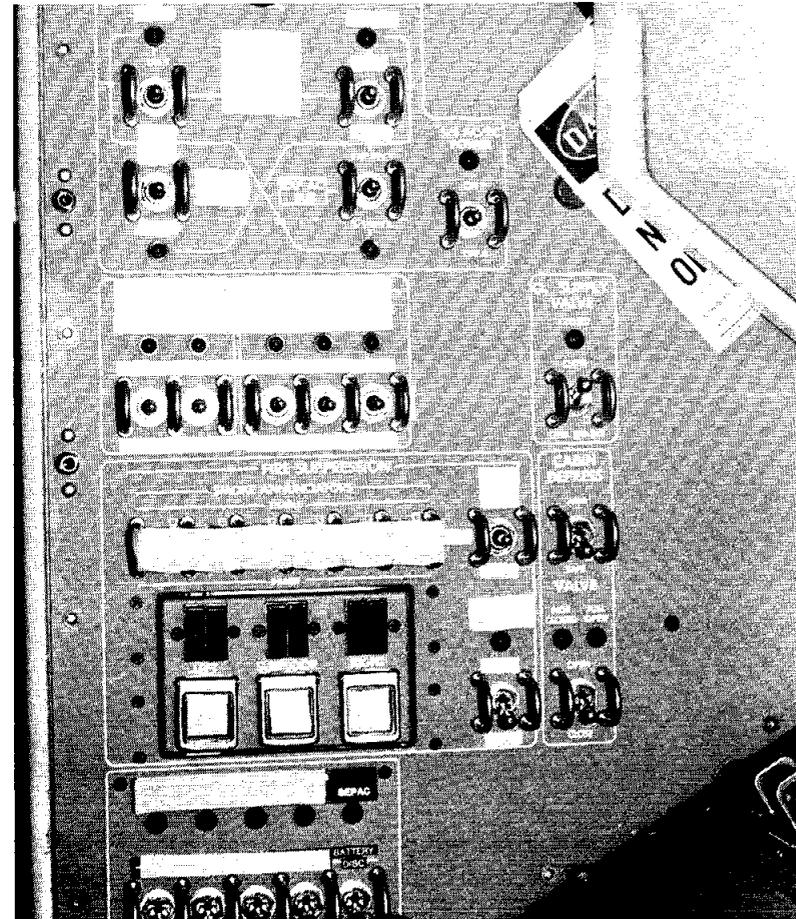
Normally, the Spacelab subsystem inverter is used for all Spacelab ac power (Spacelab subsystem and experiment). The Spacelab experiment inverter is available as a backup. It is possible to connect the ac experiment bus to the subsystem inverter and conversely, the subsystem ac bus to the experiment 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.
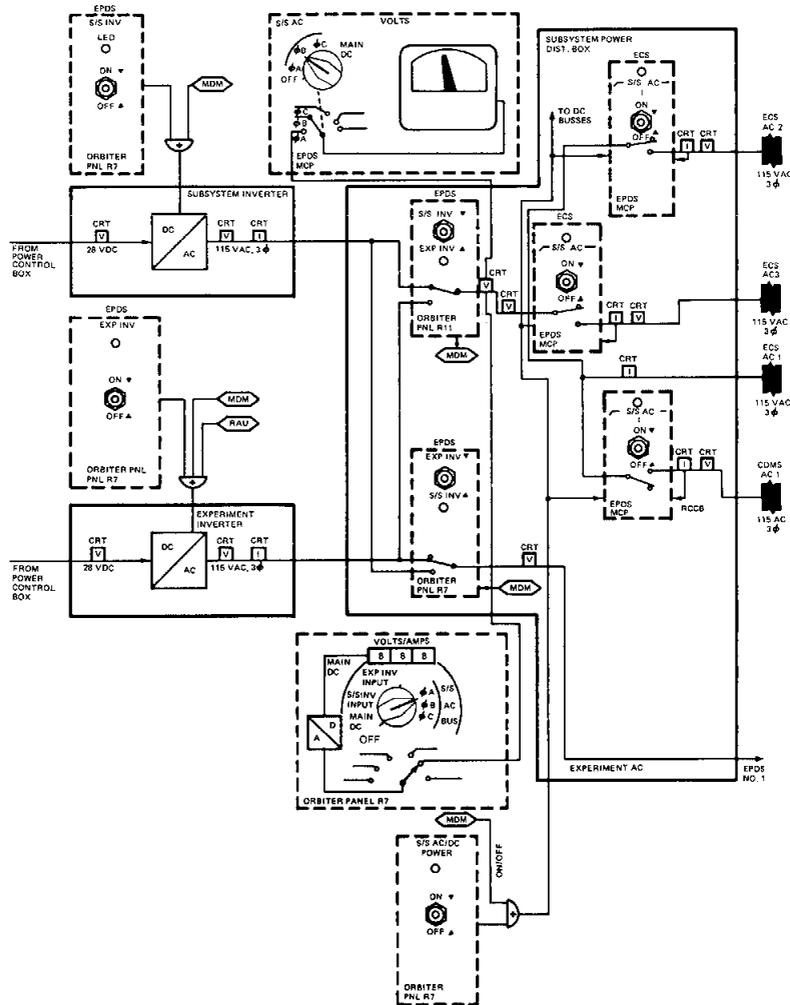
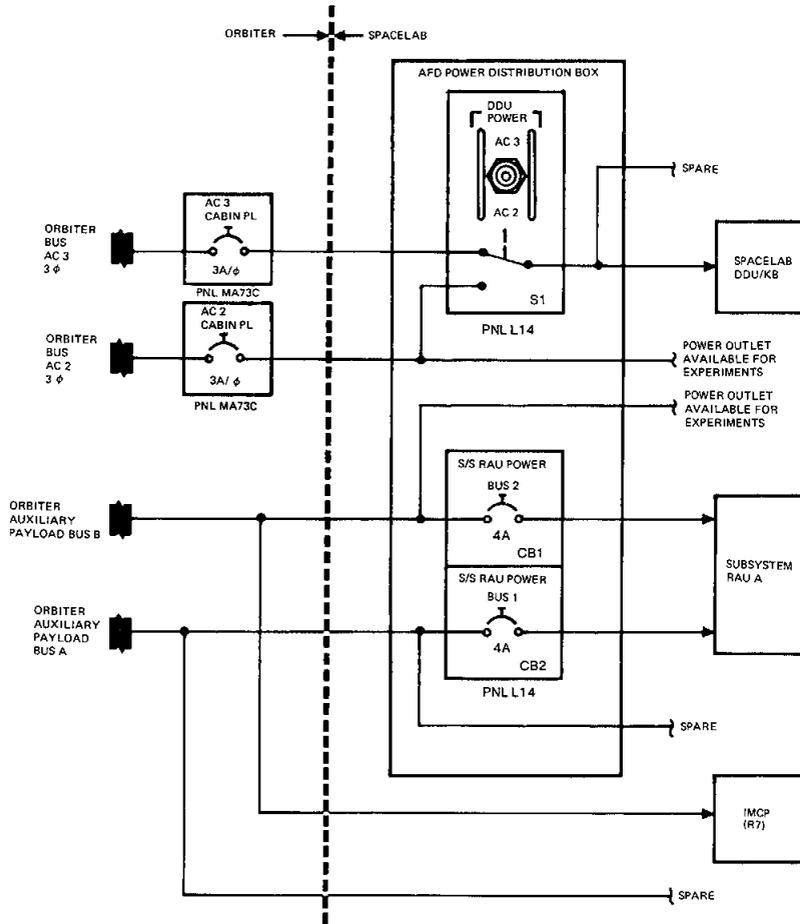*Spacelab Electric   Power Distribution—Subsystem AC Power Distribution*
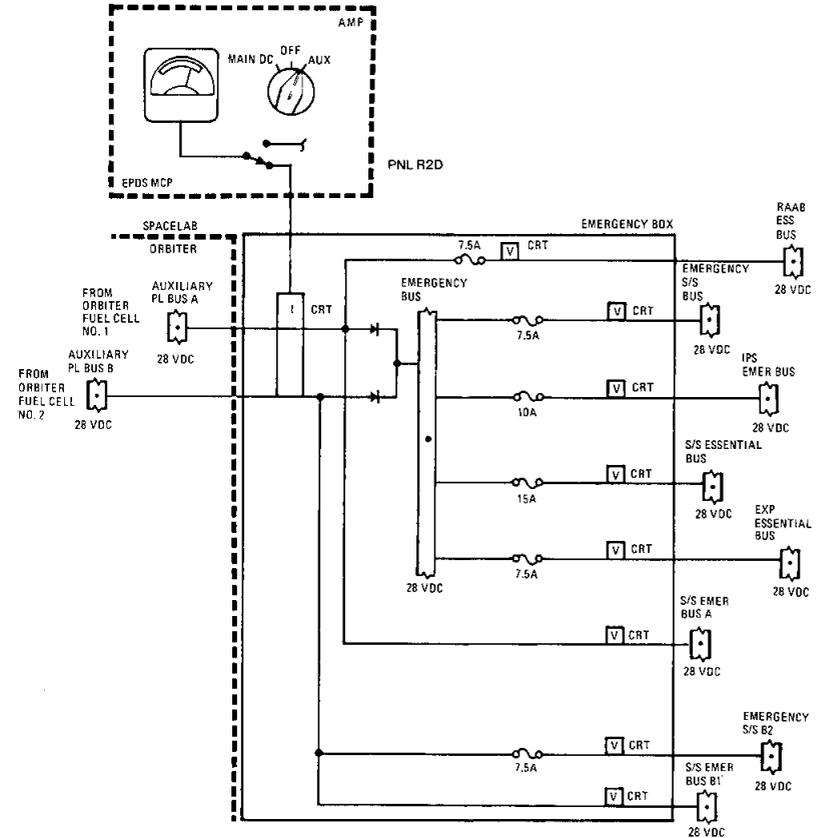

Panel R7

11

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

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AFI Flight Deck-Orbiter Power Distribution

Emergency and Essential Power Distribution

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
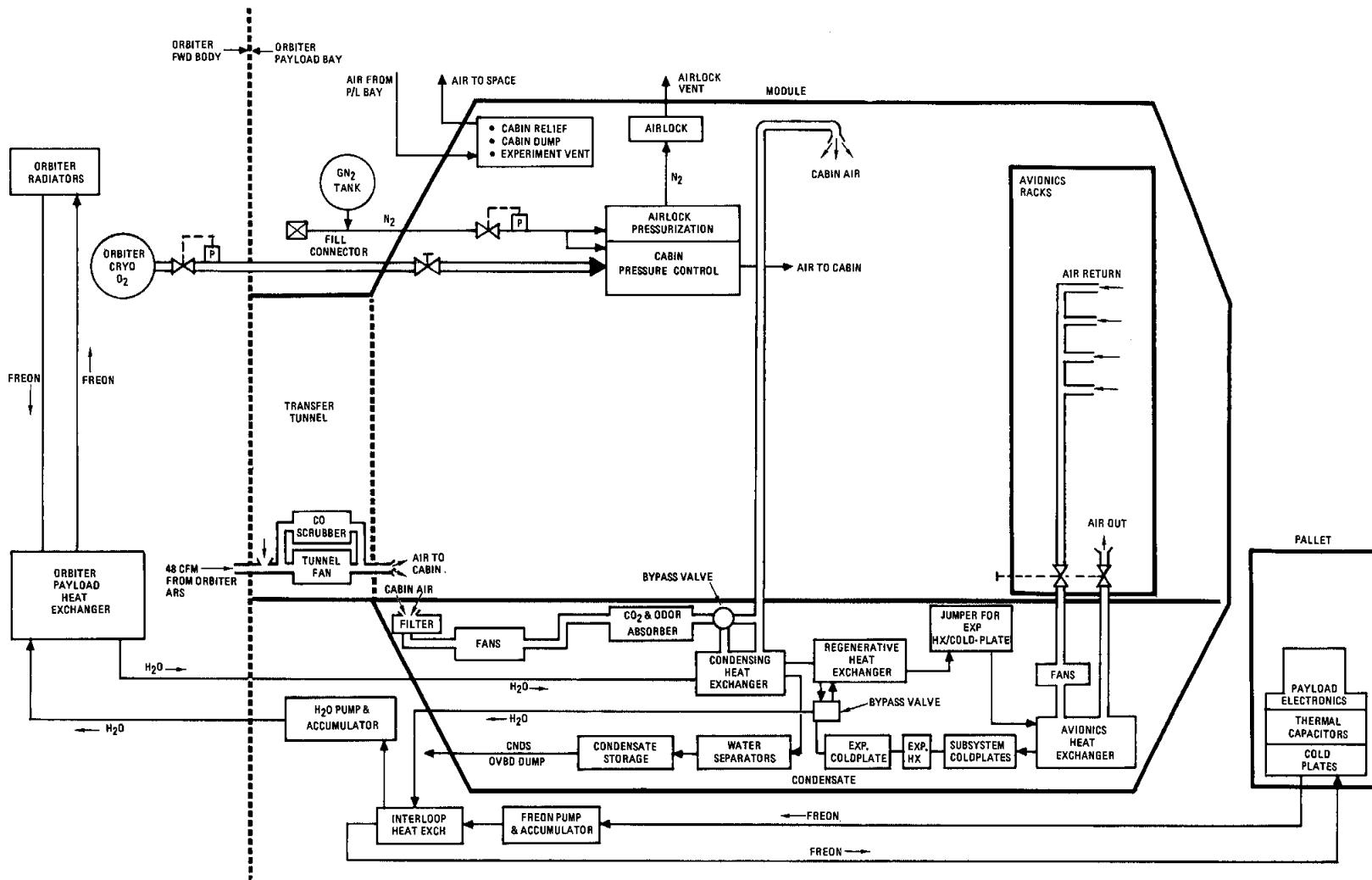
Spacelab/Orbiter Environmental Control System and Life Support System Interface

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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 O_2 SUPPLY VALVE switch on Panel R7 is in the CMD ENABLE position, but may be closed by positioning the O_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 motordriven shutoff valve is powered by Spacelab ECS emergency bus 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 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_2O) 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 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_2O LOOP PUMP

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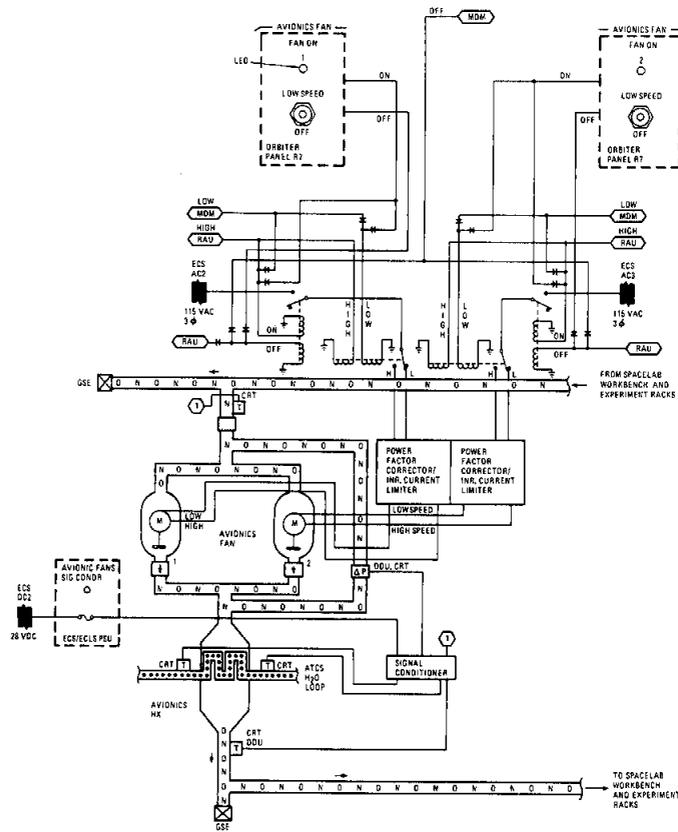
Spacelab Avionics Airloop

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.
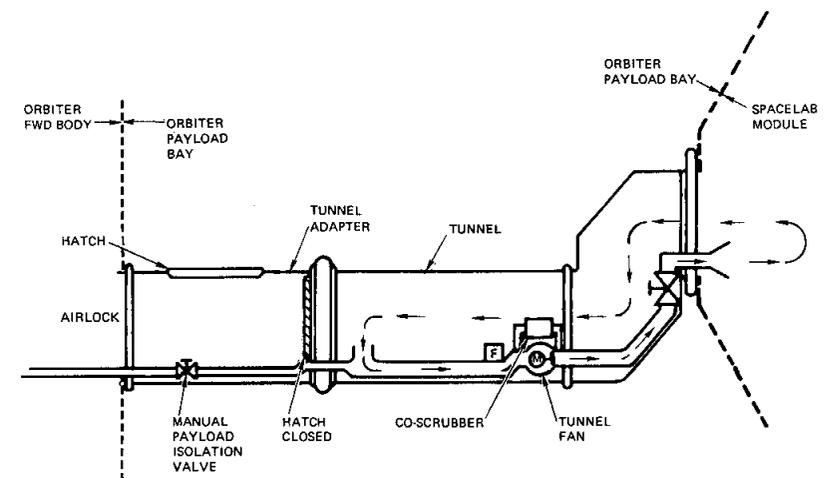
The orbiter Pulse Code Modulation Master Unit's (PCMMU's) under control of the orbiter GPC's can access Spacelab data for performance monitoring and limit sensing. The PCMMU's contain a fetch command sequence and a random access memory (RAM) for storing fetched data. The data from the PCMMU RAM is combined 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 (EXC) interfaces with two telemetry systems, the orbiter PCMMU for low data rate that allows the orbiter to acquire data for onboard systems monitoring
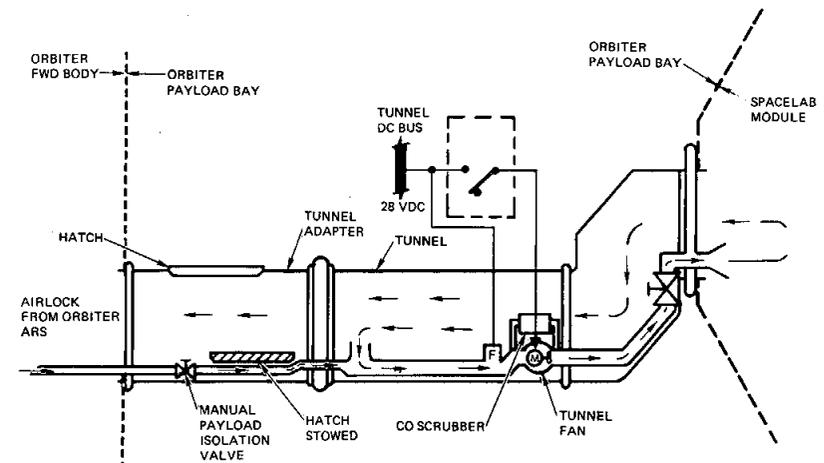

Tunnel Adapter Hatch Open—48 CFM Duct Operating

Tunnel Adapter Hatch Closed—48 CFM Duct Not Operating

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| IOU | - INPUT/OUTPUT UNIT | PCMMU | - PULSE CODE MODULATION MASTER UNIT |
EXP	- EXPERIMENT	S/S RAU	- SUBSYSTEM REMOTE ACQUISITION UNITS
MDM	- MULTIPLEXER/DEMULTIPLEXER	MMU	- MASS MEMORY UNIT
SSC	- SUBSYSTEM COMPUTER	DDS	- DATA DISPLAY SYSTEM
EXP COMP	- EXPERIMENT COMPUTER	DDU	- DATA DISPLAY UNIT
MTU	- MASTER TIMING UNIT		

18
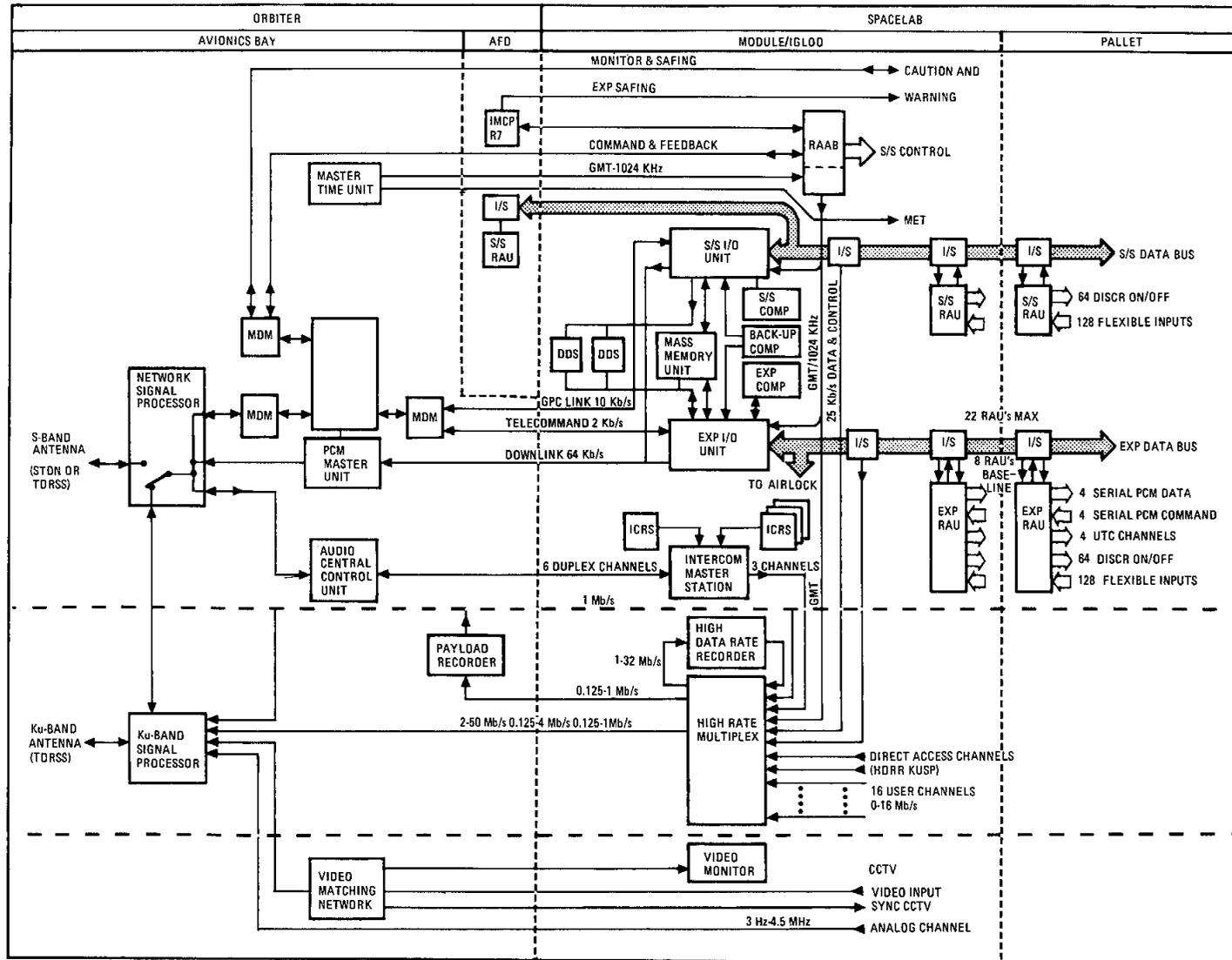
Spacelab Command and Data Management System Interfaces with the Orbiter

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-band signal processor for transmission on Ku-band or is routed to one of the two recorders.

The high data rate recorder (HDRR) is located in the Control Center rack of Spacelab. It records real time multiplexed data or data from two direct access channels and stores the data at rates from one to 32 mbps during mission periods with no downlink capability or degraded downlink capability for playback when the capability is available. The HDRR dumps in reverse order at 2, 4, 8, 12, 16, 24 or 32 mbps. At a rate of 32 mbps, a tape runs for 20 minutes. The HDRR can be changed manually by the flight crew, however, the time required to change tapes is very long and it is much more efficient to dump the tape rather than reload. Thus, no tape changes are planned.

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.

Panel A1A3

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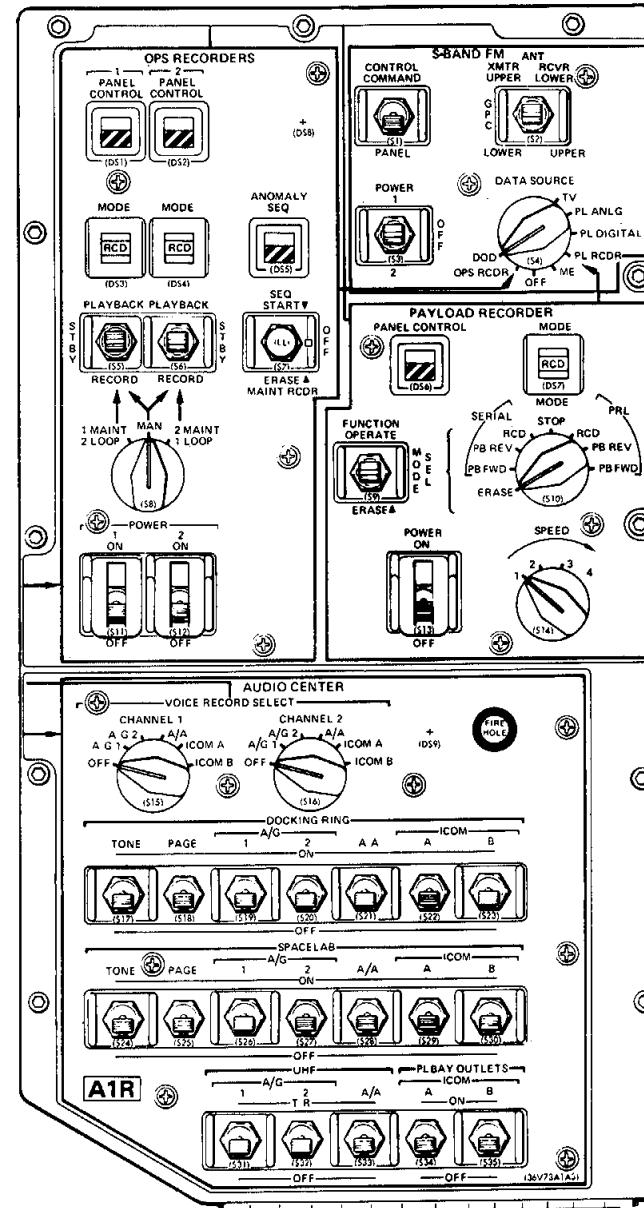
The orbiter master timing unit (MTU) provides MET, GMT and a 1024 khz timing signal to the Spacelab DPA.

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

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.

Challenger's closed circuit television (CCTV) utilizes four cameras and a video tape recorder. 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 channel three and this channel is time shared between *Challenger'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 full 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 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.

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 O_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.

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THE MISSION OF SPACELAB-3

Twelve investigations have been selected to fly aboard the Spacelab-3 mission. Of these, ten originate from the United States, one from India, and one from France. Nine of the experiments are located in the pressurized module, two are located on the mission peculiar equipment support structure (MPESS) and one is located in *Challenger's* crew compartment mid-deck. The experiments represent a total of five different disciplines, including materials processing in space, environmental observations, life sciences, astrophysics, and technology research.

The pressurized module experiments on Spacelab-3 require the planned low-gravity environment that requires a minimum number of vernier reaction control system (VRCS) thruster firings and use a gravity-gradient stabilized orientation with *Challenger's* tail pointing towards earth. The experiments requiring the low gravity environment are clustered in Spacelab-3 around the center of gravity of the *Challenger* in this mission.

The materials processing experiments in the pressurized module that require the planned low gravity environment are the mercuric iodide crystals to be grown in the Vapor Crystal Growth System (VCGS), mercury iodide crystal growth (MICG) in a two-zone furnace and the fluid experiment system (FES) which will be used to grow triglycine sulfate crystals from seed crystals.

Two experiments in the pressurized module that require a low-gravity environment as well as an extended duration of stable vehicle attitude are fluid mechanics. One experiment is the dynamics of rotating and oscillating free drops (DROP) using the drop dynamics module (DDM). The second experiment is the geophysical fluid flow cell (GFFC).

The life sciences experiments conducted by NASA's Ames Research Center (ARC) and Johnson Space Center (JSC) will evaluate the performance of specifically designed equipment and facilities for use in a low gravity environment. Both human and animal objects will be used in a variety of measurement and observation activities for life sciences research in future Spacelab missions.

The two experiments located on the mission peculiar equipment support structure (MPESS) are the atmospheric trace molecule spectroscopy (ATMOS) and the ionization states of solar and galactic cosmic ray heavy nuclei (IONS).

MATERIALS PROCESSING IN SPACE

Solution Growth of Crystals in Zero Gravity. A series of experiments will be performed in which triglycine sulfate (TGS) crystals will be grown by a low temperature solution growth technique in the microgravity environment of the orbital Spacelab-3.

Triglycine sulfate (TGS) crystals will be grown in the fluid experiment system (FES) identified as item 10 in Spacelab-3 by slowly extracting heat at a controlled rate through a seed crystal of TGS suspended on an insulated sting in a saturated solution of TGS. Variations in liquid density, solution concentration, and temperature around the growing crystal will be studied using a variety of techniques. Growth in earth's gravity will also be studied by the same techniques, and in both cases, the resulting crystalline features will be compared and correlated with the growth conditions.

In a microgravity environment, it should be possible to significantly reduce convective flows and establish a diffusion-controlled transport of the solute to the interface. By extracting heat from the crystal in a controlled manner, it should be possible to maintain saturation at the growth interface. This should allow a slow but very uniform growth, resulting in a higher degree of crystal perfection.

TGS crystals have practical applications as infrared detectors whose performance might be improved by increased perfection.

The principle investigator is Dr. R. Lal, Alabama A&M University. Experiment developer is NASA's Marshall Space Flight Center (MSFC), Huntsville, Alabama.

Mercuric Iodide Crystal Growth. This experiment is to grow a more perfect mercuric iodide crystals in a low gravity environment

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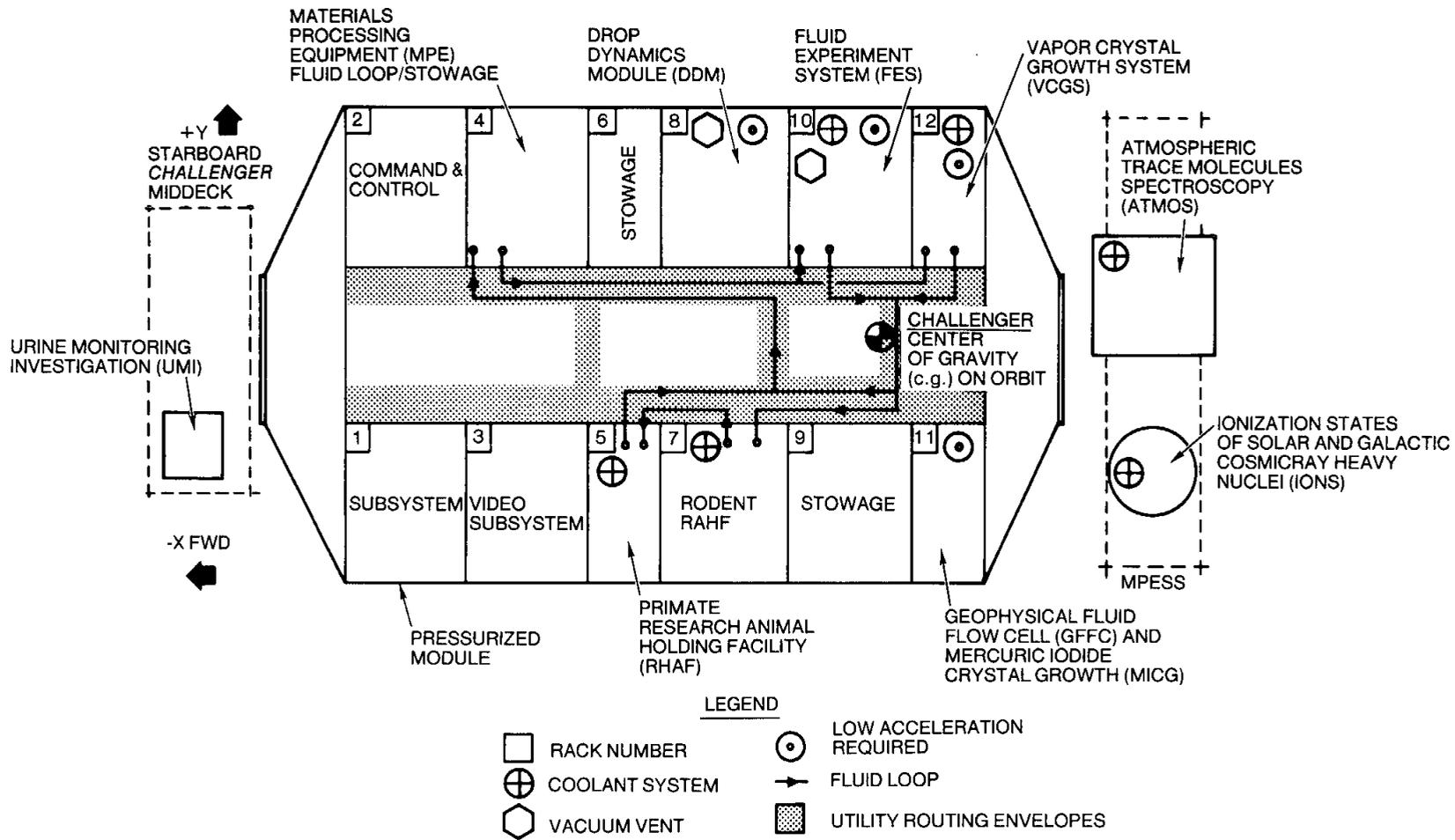
Spacelab-3 Pressurized Module Layout and Mission Peculiar Equipment Support Structure (MPESS) Layout

in the vapor crystal growth system (VCGS), identified as item 2 in Spacelab-3, by taking advantage of diffusion-controlled growth conditions and by avoiding the problem of strain dislocations produced by the crystals weight.

The performance of mercuric iodide crystals rarely approach the expected performance, presumably because some of the free electrical charges produced within the crystal are not collected at the electrodes but instead remain trapped or immobilized at crystal defects.

These crystals will be grown by vaporization and recondensation at approximately 120 degrees Celsius in a specially designed furnace located in the vapor crystal growth system (VCGS). Provisions will be made to reverse the growth procedure if polycrystalline growth begins, which is a common problem in growing this crystal on earth.

The low level of gravity-driven convection reduces fluctuations in vapor density and temperature in the vicinity of the seed crystal. This better-controlled environment is conducive to uniform growth with far fewer defects as demonstrated on Skylab. The crystal structure is a layer type with weak bonding between slip planes and it is suggested that the high dislocation densities and strain fields observed in earth grown crystals probably originate from the weight of the crystal as it is supported during growth.

It is anticipated that the mercuric iodide crystals grown in space will have lower defect densities and will exhibit better performance than the best mercuric iodide grown on earth. This crystal has considerable practical importance as a sensitive gamma-ray detector and energy spectrometer that can operate at ambient temperature, as compared to presently available detector that must be cooled to near liquid nitrogen temperatures. This experiment would help establish the inherent performance of this crystal and may possibly lead to production of a limited number of these crystals in space for use as experimental nuclear radiation detectors.

The principle investigator is Mr. W. Schnepple of EG&G Incorporated, Santa Barbara Operations, Goleta, California. Experiment developer is MSFC.

Mercury Iodide Crystal Growth (MICG). This experiment is to grow near-perfect single crystals of mercury iodide in a microgravity environment which will decrease the convection effects on crystal growth. Evaporation and condensation are the only transformations involved in this experiment. A two-zone furnace will be used to accomplish this MICG identified as item 11 in Spacelab-3 and two sensors collect the temperature data, one in each zone.

Normal operations of this experiment are performed by the Spacelab-3 experiment computer. The sequence of experiment operation and duration is approximately 100 hours over the mission. The computer switches the experiment through programmed instructions. During the operation of the experiment, the computer monitors the power supply status and the temperature difference between the two zones in the oven. A light and an audible
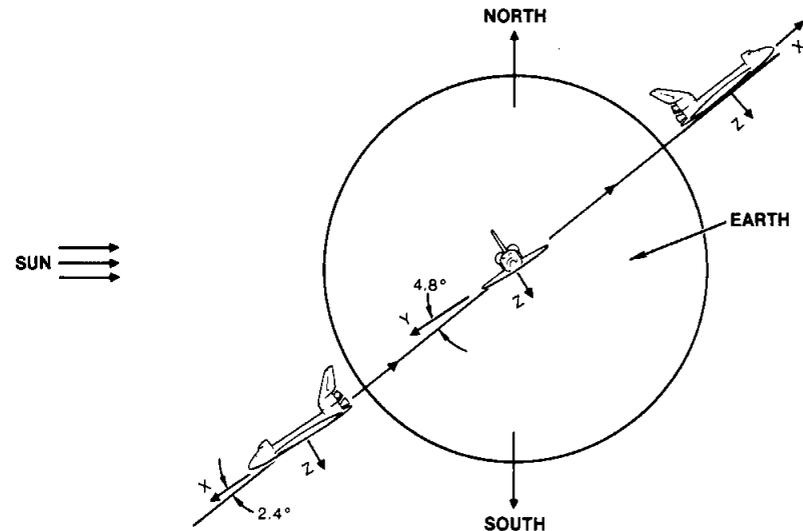
Spacelab-3 Major Attitude During 51-B Mission

tone from the Spacelab-3 command and data management subsystem (CDMS) provides for crew intervention if the power supply and/or temperature parameters are out-of-limits. At the end of normal operations, the Spacelab-3 experiment computer will shut down the experiment.

The principle investigator is Dr. R. Cadoret, CNES, France. This is a reimbursable experiment. Experiment developer is CNES.

TECHNOLOGY

Dynamics of Rotating and Oscillating Free Drops (DROP). This experiment is to be performed using the drop dynamics module (DDM)/identified as item 8 in Spacelab-3. The DROP experiment is to study the equilibrium figures of a rotating drop and the study of the large-amplitude oscillations of a liquid drop. The DROP experiment in relation to the DDM is to establish the advantages of conducting future drops and bubbles experiments in space.

The two component experiments (rotation and oscillation) of the DROP experiment have been chosen as the simplest representative of the entire class of drop dynamics experiments. This experiment provides the most complete and extensive investigation of theories of liquid drops in space. The experiment will observe the large amplitude, nonlinear oscillation of a simple liquid drop. Consequently, the experiment will indicate how the theories must be revised, if they must and will set the stage for all later experiments on liquid drops. This experiment is an important exercise of the module's ability to provide drop oscillation and the requisite science data. In later experiments, more complicated liquids can be used; bubbles can be included, and the non-periodic dynamics of an oscillating drop can be studied.

The principle investigator is Dr. T.G. Wang of the Jet Propulsion Laboratory (JPL), Pasadena, California. Experiment developer is JPL.

ENVIRONMENTAL OBSERVATIONS

Geophysical Fluid Flow Cell Experiment (GFFC). This experiment is to simulate global atmospheric flows which occur naturally in the atmospheres of rotating planets and stars and gain insights and obtain answers to crucial questions concerning the large-scale nonlinear mechanics of the global geophysical flows. In particular, the investigator hopes to identify those external conditions related to fluid viscosity, rotation, gravity, etc., which allow qualitatively different modes of instability or waves in the model. In a geophysical context, the investigator is trying to understand why Jupiter and Saturn have axisymmetric cloud patterns as compared to the Sun, which, as a rotating convecting body like Jupiter, seems to have a preferred orientation of large eddies from pole to pole.

Theoretical models of planetary circulations indicate that the planetary curvature plays a crucial role in the dynamics of rotating atmospheres because the two major constraints on flow - rotation and gravity - vary with latitude relative to each other. Previous laboratory models of planetary atmospheres could not incorporate the curvature effect because, given the uniformity of terrestrial gravity, a rotating tank experiment was always required to have parallel rotation and gravity vectors.

This experiment will be accomplished through the use of a dielectric field confined between two concentric, rotating, electrically conductive spherical sheets identified as item 11 aboard Spacelab-3. The dielectric fluid will have a dielectric constant which is temperature dependent. Upon application of a voltage between the spheres, an electric field will occur; and a radially directed body force will act on the fluid in a manner exactly analogous to the gravitational body force which acts on oceans and stellar and planetary atmospheres. Because of the low-gravity environment of Spacelab-3, this experiment (unlike previous earth bound experiments) will contain the correct vector relationship between the rotation vector and gravitational body force vector of a planet; i.e., maximum value at equator and zero at the poles.

The apparatus includes a convection cell, temperature controllers for maintaining thermal boundary conditions at the inner and outer boundaries of the cell, a servo-controlled rotation drive to set the rotation speed, and a high-voltage supply. A camera is positioned above the cell at an angle to view a quadrant of approximately 90 degrees longitude and from equator to pole in the northern hemisphere. Visualization of the flow pattern is obtained either by injecting dye lines into the working fluid by exciting photochromic molecules and photographing the displacement of the dye or by photographing the distortion of a set of ruled lines on the outer spherical shell caused by refractive index changes in the fluid. In either case, it will be possible to ascertain the state of the fluid-steady no-motion, steady axisymmetric, banded, unsteady, etc. In addition, the principal wavelengths and frequencies of the unstable modes will be measured.

The experiment should be able to verify existing theories of moderately nonlinear fluid systems on spherical surfaces and provide basic data on flows which are more strongly nonlinear than can currently be handled on a computer or by asymptotic methods. Of particular interest is the orientation of flow instabilities at various external conditions.

The principle investigator is Dr. J. Hart, University of Colorado. Experiment developer is MSFC.

Atmospheric Trace Molecule Spectroscopy (ATMOS). This experiment is located on the mission peculiar equipment support structure (MPESS). The experiment is designed to obtain fundamental information related to the chemistry and physics of the earth's upper atmosphere using the techniques of infrared absorption spectroscopy. There are two principle objectives to be met on this experiment.

The first objective is the determination, on a global scale, of the compositional structure of the upper atmosphere and its spatial variability. The establishment of this variability represents the first step toward determining the characteristic residence times for the upper atmospheric constituents; the magnitudes of their sources and sinks; and, ultimately, an understanding of their effects on the stability of the stratosphere.

The second objective to provide the high resolution, calibrated spectral information which is essential for the detailed design of advanced instrumentation for subsequent global monitoring of specific species found to be critical to atmospheric stability. This information will be disseminated in the form of a three-dimensional atlas of solar absorption spectra obtained over a range of latitudes, longitudes, and altitudes.

In addition to the compositional data, a great deal of information related to the physics of the upper atmosphere will be acquired. As an example, the data obtained will also make it possible to describe the three-dimensional temperature structure and to study local departures from thermodynamic equilibrium regimes of dissociation as well as radiative transfer processes.

The choice of remote sensing method for acquiring the data is dictated by the need to obtain simultaneous concentration infor-
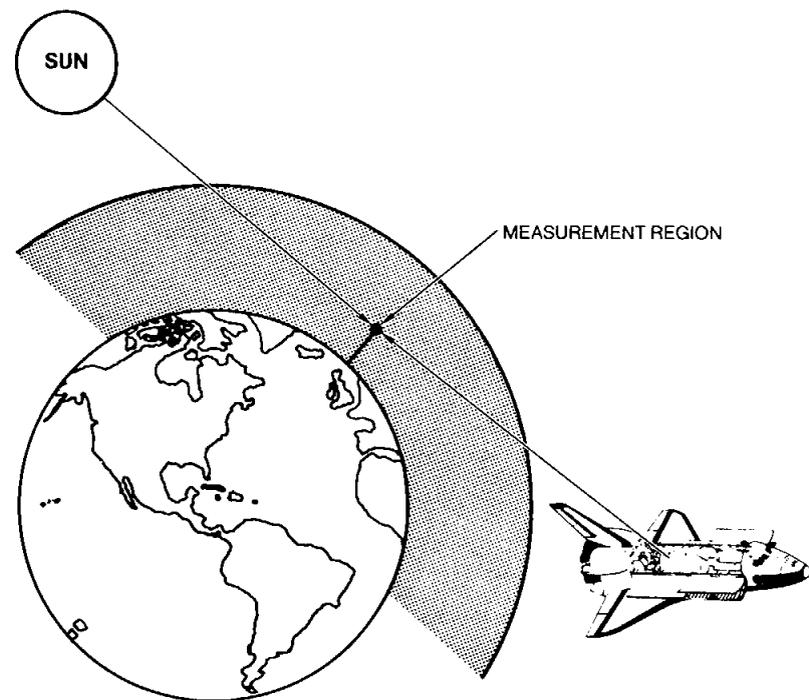
Atmospheric Trace Molecule Spectroscopy (ATMOS)

mation for a large number of stratospheric species in times sufficiently short to provide useful spatial resolution. The one common characteristic possessed by almost all of the species of interest is that their rotational and vibrational transition frequencies lie in the infrared region; and thus, simultaneous measurements can be made using infrared spectroscopic techniques. However, the transition frequencies are widely separated from different constituents, necessitating broad wavelength coverage in each observation. Moreover, in adopting the solar absorption mode as the experimental technique to be used in this mission from the MPESS, each observation must be made in times on the order of one to two seconds if the required vertical resolution is to be obtained. Interferometry, with its high-energy throughput and multiplexing advantage is the only infrared technique capable of satisfying the last two constraints. The ATMOS will be a continuous scanning spectrometer in the two to 16-μm (micrograms per cubic meter) wavelength region and capable of generating one interferogram each second with a spectral resolution of 0.01 centimeters.

To acquire the necessary data, the sun will be viewed with the ATMOS during the periods just prior to entry into, and shortly after emerging from solar occultation; specifically, the viewing periods will be timed to occur when ATMOS view of the sun is being occulted by the upper atmosphere. During these periods, ATMOS will make a set of interferometric measurements of the solar radiation incident upon its function of optical path difference within ATMOS. Each set of measurements, generated for stratospheric layers at different altitudes, will provide the information necessary to establish vertical composition profiles for the species of interest.

Because of data rate and instrument performance considerations, the entire spectral range from two to 16 μm will not be covered in a single scan, but will be divided into narrower wavelength intervals by the use of optical fibers. ATMOS has provisions for six filters.

Seventy-two observations are planned by ATMOS, approximately half of them sunrises and the other half sunsets. During each of the 72 occultations, ATMOS will have a three minute period of operational time in which to acquire a data set. A data set may include as many as 100 interferograms.

The ATMOS data stream is multiplexed into the general data stream from Spacelab-3 and transmitted in real time to NASA's Goddard Space Flight Center at Greenbelt, Maryland, for demultiplexing and preliminary formatting. All other aspects of the data reduction will be accomplished on a dedicated facility at the Jet Propulsion Laboratory, Pasadena, California.

ATMOS is comprised of four major elements; a suntracker, a telescope, an interferometer, and a data handling system. The suntracker contains two single-axis, motor driven mirrors and a silicon diode assembly for sensing and controlling the position of mirrors with respect to the sun. A 16 mm camera records the sun superimposed over the field stop to verify the position of the pointing vector with respect to solar disc during each observation. An f/2 telescope system is used to concentrate the radiation received into a beam suitable for the interferometer. A retroreflecting mirror double passes the radiation through the arms of the interferometer before it is recombined and sent to the detector. The use of the cat's-eye retroreflectors and double passing make ATMOS insensitive to both angular and lateral motion of moving elements. The detector is cooled to cryogenic temperatures. Its output is amplified and digitized by the Spacelab data handling system and multiplexed with the optical path difference information and housekeeping data into a single 15.7 mbps data system. A system controller coordinates all instrument functions and operations, formats the data for proper telemetry inputs and provides a responsive interface to the ATMOS microprocessor. Data-taking sequences are normally initiated by pre-entered command.

The principle investigator is Dr. C.B. Farmer, California Institute of Technology. Experiment developer is JPL.

ASTROPHYSICS

Studies of the Ionization States of Solar and Galactic Cosmic Ray Heavy Nuclei (IONS). This experiment is located on the

MPESS. This experiment is designed to study the recently discovered anomalous component of low energy galactic cosmic ray ions of carbon, nitrogen, oxygen, neon and calcium to iron of energy in the five to 10 million electron volts per atomic mass unit in regard to their ionization states, composition, and intensity, and to study the ionization states of heavy elements from oxygen to iron in energetic solar particles emitted during solar flares from the sun. The same detector system will serve for both studies, with the second objective being given priority if there are any solar particle events during the mission.

Cosmic ray nuclei of galactic origin have been studied during the past 20 years and energetic solar nuclei during the past 15 years in an attempt to understand the characteristics of their sources and the nature of their acceleration processes. Until recently, the chemical composition and energy spectra of these nuclei were determined only for energies equal to or greater than 50-million electron volts per atomic mass unit. Recent studies at lower energies indicate that the charge and energy distribution of low energy cosmic rays are different from that of high-energy cosmic rays. Observations of the flux of medium nuclei (carbon, nitrogen, oxygen) at 10-million electron volts per atomic mass unit appear to indicate the nuclei may be partially ionized in contrast to high-energy nuclei which are completely ionized; i.e., all electrons are stripped from the nucleus. The origin of this new component is unknown.

The direct measurements of the charge state of low-energy heavy ions are crucial to the understanding of new particle phenomena observed by the present investigator in Skylab (1973-1974) and by several investigators on other satellites. Information on the ionization states of solar heavy nuclei which may be provided by this experiment (depending on the occurrence of solar flares) is of immediate interest in the understanding of the acceleration and confinement of energetic nuclei in the sun.

The detector system consists of stacks of thin sheets of special plastics such as cellulose nitrate (CN) and lexan polycarbonate, which are efficient low-noise detectors for heavy nuclei. The stacks are in the shape of a cylindrical module with a diameter of 40 centimeters and a height of approximately 5 centimeters. There are two distinct stacks, a major lower stack (5 centimeters thick) which is slowly rotated at the rate of four degrees per hour with respect to a thin, fixed upper stack (0.5 centimeters) thick, with a separation of 0.05 centimeters.

An energetic particle entering through the top stack and stopping in the bottom stack leaves a damage trail along its path that can be revealed optically by a suitable chemical treatment in the laboratory. The identity and energy of the particle can then be determined from measurements on the geometry of the tracks and the range transversed in the stack. Also, by identifying the segments of the same track in the top and bottom stacks, the arrival time of the particle can be determined from the displacement between the segments. The arrival time can be measured to the nearest 20 seconds and this coupled with the arrival direction, gives the lower bound on the magnetic rigidity (momentum/effective charge) of the particle as determined by the earth's magnetic field configuration. Thus, the combined information permits the determination of the particle's charged state.

The structure housing consists of an approximate cylindrical enclosure of 44 centimeters diameter and 25 centimeters in height with the top of the enclosure being covered by a thin spherical shell of aluminum. Inside the housing, a high resolution stepper motor rotates the lower detector stack with respect to the fixed upper one in steps of approximately 40 arc-seconds once in ten seconds, so that the full 360 degrees rotation is completed in 90 hours. The rotation history of the detector stack is recorded and monitored with a 15-bit optical absolute shaft angle encoder. The instrument enclosure is maintained at one-tenth atmospheric pressure. The experiment is controlled by the on-board Spacelab-3 experiment computer through a Spacelab-3 remote acquisition unit. Thermal control of the experiment is provided by the MPESS cold plate on which the experiment is mounted and by a reflective coating on the outer surface.

Two kinds of information are obtained from the experiment. One is telemetered to ground together with time and *Challenger* attitude vectors which is the output of the angular motion of the

shaft angle encoder. The other is the data obtained from the measurements on particle tracks in the detectors with optical microscopes. Analysis of these data is carried out for identifying nuclear charge and energy using an interactive program package employing graphic displays. Combining this information allows the determination of ionization states of solar and galactic cosmic ray heavy nuclei of five to 10 million electron volts per atomic mass unit energy.

The principle investigator is Dr. S. Biswas, Tata Institute of Fundamental Research, India and the Institute is also the experiment developer.

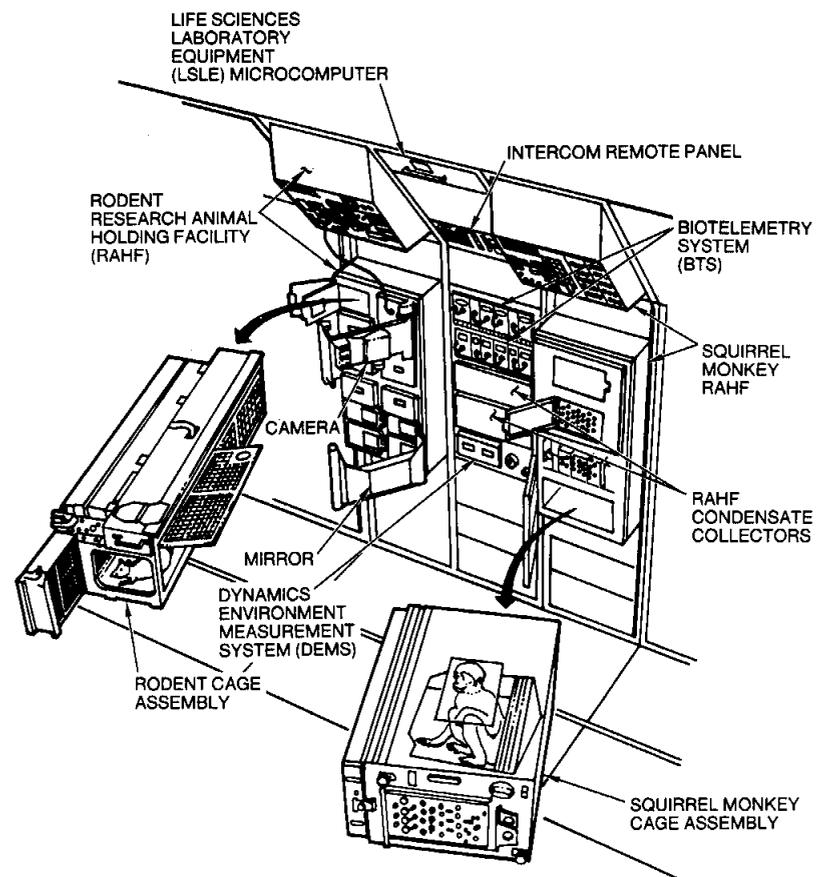## LIFE SCIENCES, NASA AMES RESEARCH FACILITY

In response to a recognized need for an in-flight animal housing facility to support Spacelab life sciences investigators, a rack and system compatible research animal holding facility (RAHF) has been developed. Spacelab-3 provides the opportunity to perform an inflight verification test (VT) of the RAHF. Lessons learned from the RAHF-VT and baseline performance data will be invaluable in preparation for subsequent dedicated life sciences missions.

The RAHF is configured to support animals ranging in size from rodents to small primates by cage module interchange. The RAHF for Spacelab-3 comprises two major units; an Ames single rack (ASR) that can contain four squirrel monkeys and an Ames double rack (ADR) containing 24 rats and ancillary equipment. Over the seven day mission, food and water is dispensed and is automatically monitored. There are four compartments, one for each squirrel monkey and 12 compartments for the rats, two rats per compartment. An infrared detector monitors the activity of the animals. All of the animals are of the male gender.

The RAHF-VT will be evaluated for performance of the cage and cage modules; environmental control; food delivery; water delivery; lighting; activity monitors; waste management; data controls and displays; and the interface with the Spacelab-3 flight crew. After the flight, the data will be analyzed and the hardware will be refurbished and corrections made where necessary in operating procedures and hardware systems.

A biotelemetry system (BTS) measures the deep body temperature and heart rate and electrocardiogram (ECG) pattern for four rats. Sensors and transmitter packages are implanted in the animals in preflight. Sensor data are telemetered to an antenna within the RAHF cages and routed to the BTS through antenna lead in cables from both RAHF's. RAHF-VT biocompatibility will be assessed after the flight by measurements of weight, growth, appearance, pathology, and behavior. Rodent histology,

Life Sciences Research Animal Holding Facility in Spacelab-3

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body composition, hormone and mineral levels and vestibular morphology will also be determined. Housekeeping data includes RAHF temperatures and relative humidity.

The four rats will intermittently photographed during the mission by a movie camera programmed at given frame rates to assess behavioral response to launch, weightlessness, entry and return to earth. Television will also be used to view rat and monkey activities.

A dynamics environment measurement system (DEMS) accompanies the RAHF and will monitor acceleration, vibration, and noise data through launch and entry.

The flight crew activities with these experiments include activation, monitoring and periodic adjustment of instrumentation operation. The DEMS and BTS are powered by Spacelab-3. The BTS uses a dedicated life sciences laboratory equipment (LSLE) microcomputer to telemeter data to the ground during its continuous operation throughout the on-orbit phase of the mission.
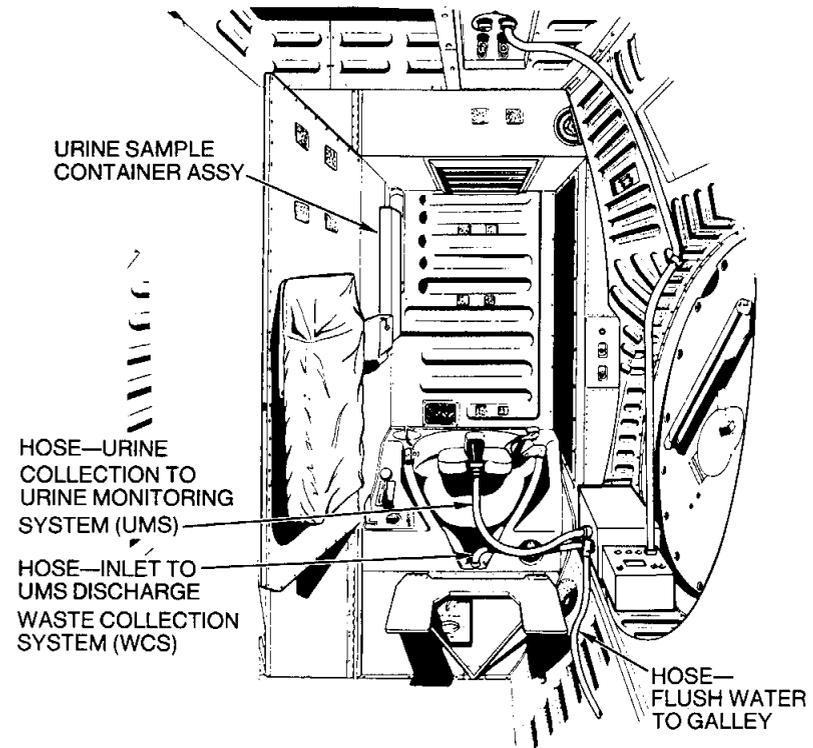
During ascent and descent, the DEMS stores data on a tape recorder. The DEMS and data recorder are flight crew activated just prior to launch and data are recorded automatically until Spacelab-3 activation.

Upon Spacelab activation, the crewmember switches the DEMS off and the BTS to Spacelab power/data transmission mode. Power to the BTS is verified by front panel displays. The LSLE microcomputer is reset by a front panel switch. The signal strengths for the BTS are then adjusted using front panel controls/displays. This latter operation is performed periodically, and may be requested by ground operations at other times. The data and signal strengths are monitored and verified at the science monitoring area (SMA) concurrently with inflight operations. Prior to Spacelab deactivation, the BTS is deactivated; the tape cassette in the data recorder is changed out; and the DEMS is switched to the descent mode through front panel controls. DEMS data are automatically recorded during the Spacelab re-entry phase.

The project scientist for this experiment is Dr. C. Schatte, Facility Science Manager, NASA Ames Research Center, (ARC), California and ARC is also the experiment developer.

LIFE SCIENCES JOHNSON SPACE CENTER

The Johnson Space Center life sciences payload for the Spacelab-3 mission is the urine monitoring investigation (UMI) experiment. The hardware for this experiment is located in *Challenger's* mid deck and the experiment will be conducted *Challenger's* mid deck. Several hardware items are stowed in the mid deck lockers and will be removed from the lockers for mounting of the equipment in the mid deck for on-orbit operation of this experiment.

URINE SAMPLE CONTAINER ASSY

HOSE—URINE COLLECTION TO URINE MONITORING SYSTEM (UMS)

HOSE—INLET TO UMS DISCHARGE

WASTE COLLECTION SYSTEM (WCS)

HOSE—FLUSH WATER TO GALLEY

Urine Monitoring System On-Orbit Configuration

The urine monitoring investigation (UMI) objectives are to evaluate and verify the operation of the urine monitoring system (UMS) in the collection and sampling of urine, perform inflight calibration of the UMS, develop and utilize a feasible procedure for monitoring flight crew water intake using the existing galley water supply and food system and verify the system for preparing urine samples for postflight analysis.

Subsequent dedicated life sciences missions are anticipated to incorporate the UMS in support of a number of experiments which will be directed at studying the body volume disturbances which result from low-gravity exposure. The data from the urine volume measurements and particularly, from the analysis of samples collected during this mission and the inflight operational performance of the UMS will help extend the present understanding of the adaptive changes which alter the fluid, electrolyte, renal, and circulatory status of humans exposed to the weightlessness environment of space flight.

The proposed measurements on the collected urine samples include indices of renal function and electrolyte, protein, and hormone levels. The results will provide insight into the fluid redistribution hypothesis which has been proposed to account for circulatory-endocrine-renal involvement in the loss of fluids and electrolytes during the immediate inflight period and extends the Skylab observations (1973-1974) in the adapting phase of flight by examining specific urine biochemical parameters related to the development of new homeostatic levels. Limitations of previous space flight studies will be overcome by ensuring that the flight crew subjects are adequately hydrated, by performing urine collection on a void-by-void basis, by collecting data early in the flight and by monitoring flight crew water intake throughout the mission.

The UMS consists of the UMS assembly and sample container assembly. It is designed as a carry-on unit capable of accommodating eight flight crew members. It is stowed in *Challenger's* mid deck lockers near *Challenger's* waste collection system (WCS). The UMS assembly and sample container assembly are removed from the mid-deck lockers and installed near the WCS. The UMS

flush water inlet is connected to the galley water supply, and the UMS power connection is made to an orbiter service outlet. The sample container assembly is maintained in the WCS compartment near the UMS. In this configuration, the UMS assembly is in a standby mode and remains in this configuration throughout the flight. Urine collection will be performed automatically in each urine void. Urine sampling will be accomplished by the UMS in the sampling mode. Sample containers are removed from the UMS and stored in the sample container assembly.

The water intake monitoring portion of the investigation requires that each crew person record the daily drinking water consumption; non-menu beverage or food consumption; menu items not consumed; pantry items substituted for menu items; and an estimate of amount consumed, in the event of partial consumption. The urine collection and sampling portion requires urine volume measurement on a void-by-void basis on all flight crew members and urine sampling on two flight crew members.

The measurement calibration portion of this investigation will be accomplished by comparing the UMS volume measurements to premeasured aliquots of water containing salt (specific gravity 1.021). The premeasured aliquots will be launched in 32 modified, veterinary dose, 300-ml syringes and injected into the urinal during flight. The syringes will be utilized in different groups to provide a range of calibration volumes resulting in 20 data points. Following injection, the UMS dump cycle wil be activated, as during normal micturition. The syringes will be recapped and returned to Earth to allow measurement of and correction for the residual fluid.

Deactivation activities for this investigation consist of deactivating the UMS assembly upon completion of the urine collection and sampling operation as late in the mission as possible. The UMS assembly and other associated hardware are then stowed in the orbiter middeck lockers for return.

The principle investigator for the experiment is Dr. C. Leach Huntoon, NASA Johnson Space Center, Houston, Texas.

VERY WIDE FIELD GALACTIC CAMERA

The very wide field galactic camera (VWFC) is a reflight of the camera flown on Spacelab-1 (STS-9). It is used in this mission to make a general survey of ultraviolet radiation (UV) of a large part of the celestial sphere. It is removed by the flight crew from its stowage position on the floor in Spacelab-3 and mounted in Spacelab's pressurized module scientific airlock (SAL) for use on-orbit. Its use will be on Mission Elapsed Time (MET) day zero, from about six hours to 18 hours after launch and is removed from the SAL and stowed. This is due to the low gravity environment experiments having the priority of this mission from this MET on throughout the mission. The SAL is located in the ceiling of the pressurized module. It is noted, there is a provision for an extravehicular activity (EVA) to clear the SAL for payload bay door closure in the event of a jam.

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, intersteller 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.

The principle investigator is Dr. G. Courtes and experiment developer is Labortoire D'Astronomic Spatiale, France.

AUTOGENIC FEEDBACK TRAINING

Autogenic feedback training (AFT) is designed to help flight crew members overcome the effects of zero-gravity motion sickness. AFT is not to get at the cause of space motion sickness but to counteract-space motion sickness via a non drug technique. Autogenic, is for the flight crew member to think about what is going on in the body such as cool moist hands, tell himself that his hands are warm and dry in suggestive exercises. Feedback, are measurements made on the individual such as skin temperature and heart rate which are displayed on a wrist display for counteraction. Taylor Wang and Lodewijk van den Berg are the test subjects and Don Lind and William Thornton are the controls.

The principle investigator is Dr. P. Cowings of the Johnson Space Center.

AURORA OBSERVATION

Aurora observations of the high latitude aurora will be made during the mission by eye, television and photography. This observation is to study the magnetic activity of the magnetosphere (magnetic tail of earth) and obtain an three dimensional structure of the aurora with the television cameras aboard *Challenger*.

The principle investigator is Dr. T. Hallenan and experiment developer is Geophysical Institute, Fairbanks, Alaska.

GETAWAY SPECIALS

Each of the two Getaway Special (GAS) canisters in the payload bay of *Challenger* contain a small experimental satellite that will be deployed from each GAS canister for the first time. The GAS canisters have been upgraded with ejection systems for this mission. A motorized door for the GAS canister similar to the one flown on the STS-7 mission is used to allow the GAS payload to be exposed to space. The new design is called the full diameter motorized door assembly (FDMA). The FDMA enables the GAS canister to be insulated before and after the satellite is deployed and provides a means for retaining the satellite in the container in case of a malfunction. The satellites are scheduled for deployment on the sixth day of the seven day mission.

Northern Utah Satellite (NUSAT) GAS. NUSAT is a 482 millimeter (19 inch) diameter, 52 kilogram (115 pound) satellite in a 0.14 cubic meter (5 cubic foot) GAS canister. The satellite will calibrate antenna patterns of L-band radars involved in the world-wide air traffic control networks operated by the Federal Aviation Administration (FAA), U.S. military and foreign governments. NUSAT is the second satellite to be deployed from its GAS canister at a MET of six days, 9 hours, and 135 minutes.

NUSAT is retained in its GAS canister by means of a V-band clamp and pedestal. At the time for deployment, the lid of the GAS canister is opened upon command from the flight crew, followed by the firing of two guillotine cutters which sever bolts that was securing the V-band clamp and a compression spring pushes the satellite out of the canister away from *Challenger* at approximately one meter per second (3.5 feet per second).

NUSAT will then orbit the earth between 57 degrees north and 57 degrees south latitude (above and below the equator) and is expected to remain functional for approximately eight months.
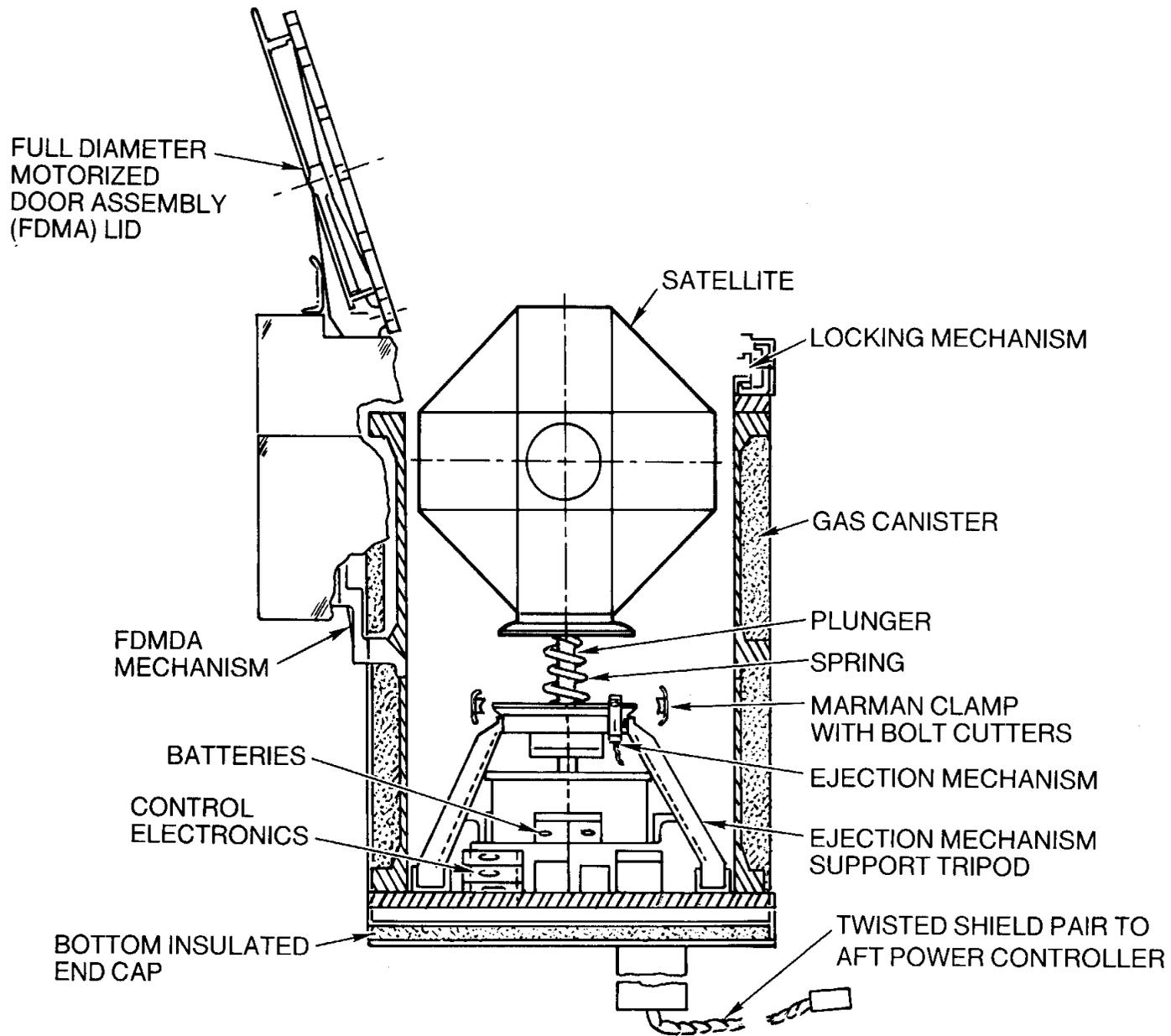
NUSAT communications consists of six antennas, a transmitter receiver and telemetry/tracking/command. It also contains photodiodes for attitude, a probe for potential and electron temperature and strobe lights.

A separation switch will then connect the satellite's electrical power to its UHF (450 MHz) command receiver, and, when the satellite passes within line of sight of Ogden, Utah, later that same day, a command will be sent from a UHF transmitter located in a master control station on the campus of Weber State College to power up the on-board processor and to report via a VHF (137.9 MHz) transmitter on the status of the satellite's health. One battery and twelve solar cells provide system power throughout the satellite's lifetime.

Following the execution of a series of test routines during the next few days, the system will be put into the following operational mode: approximately once per day, a VHF command will be sent to the satellite to insert a code into the onboard processor capable of discriminating against all illuminating radars except the one selected for calibration. A clock will be started in the processor to command six L-band (1,030 MHz) receivers to turn on at the time the satellite is about to come over the horizon of the selected radar set (for example, Johannesburg, South Africa). The radar will transmit a unique pulse-position code during the calibration interval, which will permit the satellite to distinguish that signal from all others. This code is a standard test code that does not interfere with the radar's ability to trigger aircraft beacons and to perform its normal air traffic control function.

As the satellite makes its pass from horizon to horizon, the pulses from the selected tracking radar will be received by one or more of the on-board L-band receivers. Each receiver is connected to its own antenna. The antennas are mounted in pairs at opposite ends of the satellite's three major axes. The on-board processor will serially scan and store the outputs of the six receivers in solid state memory on a pulse-by-pulse basis.

After the satellite has passed below the horizon of the radar under test, its L-band receivers will be turned off. The next time the satellite passes within line of sight of the master control station in Ogden, Utah, a UHF command will be sent to power up the VHF transmitter and to dump the information collected during

FULL DIAMETER
MOTORIZED
DOOR ASSEMBLY
(FDMA) LID

SATELLITE

LOCKING MECHANISM

GAS CANISTER

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FDMDA
MECHANISM

PLUNGER

SPRING

MARMAN CLAMP
WITH BOLT CUTTERS

BATTERIES

EJECTION MECHANISM

CONTROL
ELECTRONICS

EJECTION MECHANISM
SUPPORT TRIPOD

TWISTED SHIELD PAIR TO
AFT POWER CONTROLLER

BOTTOM INSULATED
END CAP

Northern Utah Satellite (NUSAT) in Getaway Special (GAS) Canister

the data-taking pass. Several acceptable passes will occur at Ogden per day for a 57 degree orbit. The transmitter will then be turned off, and the clock will be reset for another data-taking pass.

Orbital data for the satellite will be supplied by the North American Air Defense Command (NORAD), using a combination of skin-tracking radars and optical telescopes. A pair of Xenon flashlamps aboard the satellite will be pulsed during selected night passes over NORAD's Ground-based Electro-Optical Deep-space Surveillance System (GEODSS) sites to facilitate spacecraft identification and tracking.

A Langmuir probe on board the satellite will measure ambient electron density during every data pass, and the readings will be telemetered to the master control station during each data dump. A standard rf source in the satellite will also be employed to provide an end-to-end calibration during every data pass.

In addition, battery voltages and component temperatures will be monitored and reported for every data pass.

Satellite orbits calculated from the NORAD data will be employed to derive the specific geometry of a pass by the satellite over the radar under calibration. Signal strength data will then be reduced and corrected for space loss, atmospheric effects, satellite antenna pattern variations, and space-borne component drift. The resultant antenna pattern for the ground-based air traffic control radar will be plotted and communicated to the appropriate operating agency.

The NUSAT project was organized with three principal objectives in mind: demonstrating a new space technique for improving the safety of the traveling public; providing a stimulating educational experience for substantial numbers of under-graduate college students; and extending the spectrum of services provided by the Getaway Special program to include ejection of payloads into independent orbit.

The program was conceived in 1978, in response to a suggestion by the Federal Aviation Administration in Salt Lake City,

Utah, that all three of these objectives could be nicely satisfied by starting a calibration satellite Getaway Special project at one of the local universities. After several years of program definition and review of the resource availability, the project actually got under way on a formal basis in 1982.

It was organized around three educational institutions - Weber State College in Ogden, Utah, Utah State University in Logan, Utah, and New Mexico State University in Las Cruces, New Mexico. Weber State College's School of Technology took the lead responsibility for the overall program. In addition, its students and faculty concentrated on the satellite's mechanical structure, its retention and ejection system, its power supply, UHF and VHF antennas, onboard processor, L-band receivers and all system software. Utah State University's Center for Atmospheric and Space Sciences took on the system integration, safety and NASA interface tasks, together with the Langmuir probe, battery and flashlamp effort. New Mexico State University's Physical Science Laboratory is designed, fabricated and patterned the satellite's L-band antennas.

A substantial contingent of aerospace companies and government installations became involved in supporting these educational institutions in their NUSAT endeavor. This support consisted of the provision of materials, hardware and money, plus engineering and program management counsel on the part of their Utah-based personnel. For instance, TRW donated the satellite's solar arrays from its facilities in Redondo Beach, California, and one of its Ogden area engineering managers donated up to three nights a week, working with Weber State students on the design of system architecture. Similarly, Morton Thiokol supplied stress analysis, safety engineering, mechanical design, NASA soldering certification, mechanical fabrication, materials and overall program direction.

Sperry supplied the L-band satellite receiver design and fabrication supervision. Rockwell provided command and telemetry link design and monetary support. National Semiconductor supplied the satellite microcomputer. Apple Corporation supplied the computers for the master control station. Boeing performed vibra-

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tion tests on the satellite and its support structure, using Hill Air Force Base facilities. Hill Air Force Base civilian engineers were involved in system software design, link calculations and satellite communications hardware modification and testing. The FAA provided design requirements and monetary support.

McDonnell Douglas provided retention and ejection system design and hardware under an agreement with the Goddard Space Flight Center. Goddard, in its role as Getaway Special lead center, provided overall system safety requirements and liaison with NASA Headquarters and the Johnson Space Center.

Martin Marietta provided solar thermal/vacuum testing of the assembled satellite and its support structure. United Technologies supplied monetary support. Williams Research performed precision machining services. Chromalox fabricated the satellite skin support structure. Globesat provided circuit board layout and fabrication services, together with electronic component packaging.

Microtech Research supplied the cross-assembler and simulator for satellite microcomputer software development.

The NUSAT Project is managed by an executive committee. Committee membership consists of local industry and government project representatives, together with the principal Weber State College and Utah State University project faculty members.

Global Low Orbiting Message Relay Satellite (GLOMR) GAS. The GLOMR satellite is a data relay, communication satellite designed and built by Defense Systems Incorporated (DSI), McLean, Virginia. It will be used by the U.S. Navy for readout and command oceanographic sensors and locate ground user equipment. GLOMR is stowed in a 0.14 cubic meter (5 cubic feet canister).

It is the second satellite to be deployed from a GAS canister at a MET of six days nine hours and 55 minutes. Its ejection sequence is identical to that of NUSAT. Once deployed it will orbit the earth between 57 degrees north and 57 degrees south latitude (above and below the equator) and is expected to remain in orbit for approximately one year.

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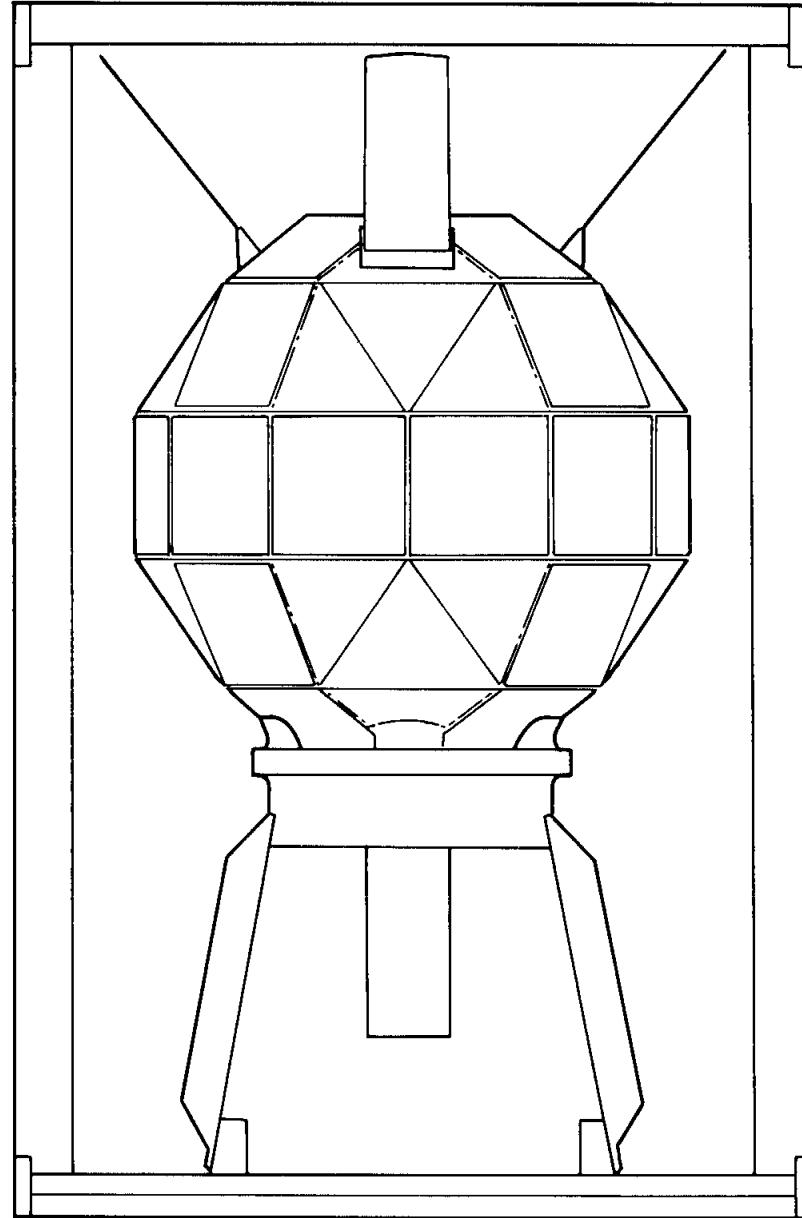
Global Low Orbiting Message Relay Satellite (GLOMR) in in Getaway Special (GAS) Canister

It is 406 millimeters (16 inches) in diameter and weighs 68 kilograms (150 pounds) when deployed. Its communications consists of four antennas, a transmitter/receiver and telemetry/ tracking/command. Electrical power consists of five batteries for the ejection system and twelve solar cells for the satellite.

AIRLOCK AND TUNNEL ADAPTER EXTRAVEHICULAR ACTIVITY, IF REQUIRED

Two extravehicular mobility unit's (EMU's) are stowed in the airlock of *Challenger* for the 51-B mission in the event a contingency EVA is required. If an EVA is required, pilot Frederick Gregory and mission specialist Norman Thagard will perform the EVA.

The airlock, tunnel adapter, hatches, tunnel extension and tunnel permits the flight crew members to transfer from *Challenger'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 *Challenger'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.
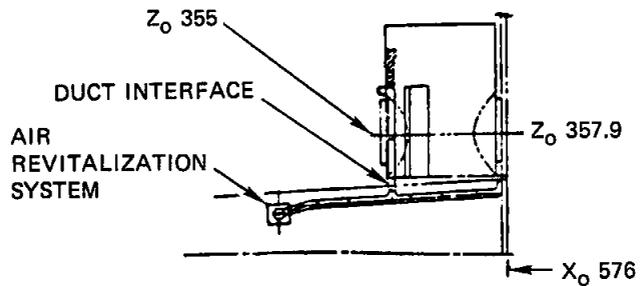
The airlock is located inside the mid-deck of the spacecraft's pressurized crew cabin. It has an inside diameter of 1,600 millimeters (63 inches), is 2,108 millimeters (83 inches) long, and has two 1,016 millimeter (40 inch) diameter D-shaped openings, 914 millimeters (36 inches) across, plus one pressure 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.
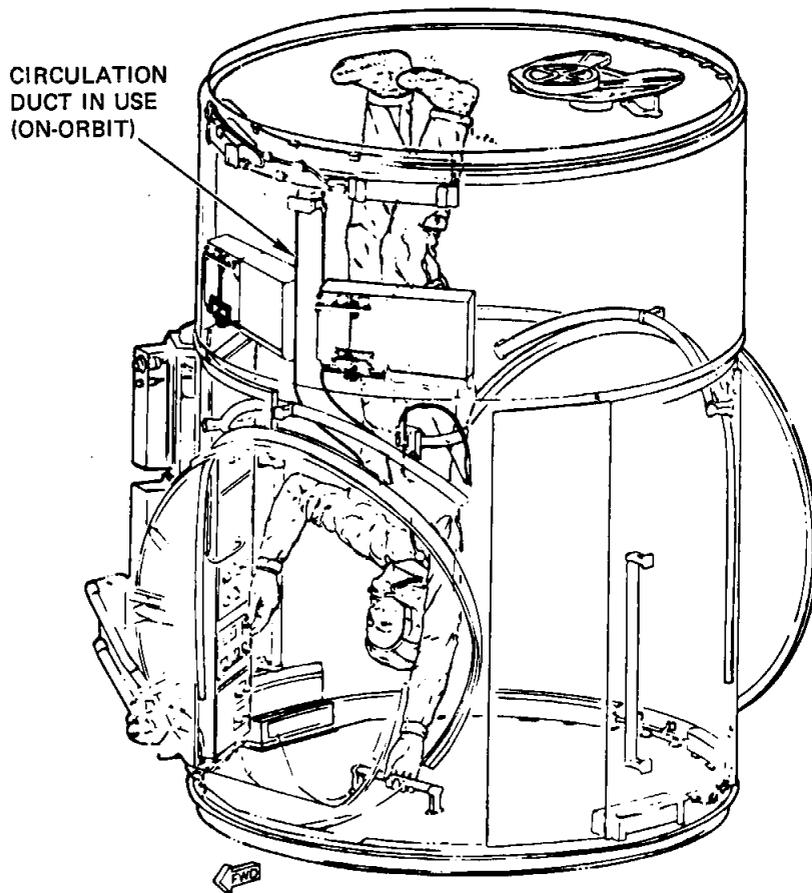
The tunnel adapter is located in the payload bay and is attached to the airlock at orbiter station X_O 576 and attached to the tunnel extension at X_O 660, thus the Spacelab tunnel and Spacelab. The tunnel adapter has an inside diameter of 1,600 millimeters (63 inches) at the widest section and tapers 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
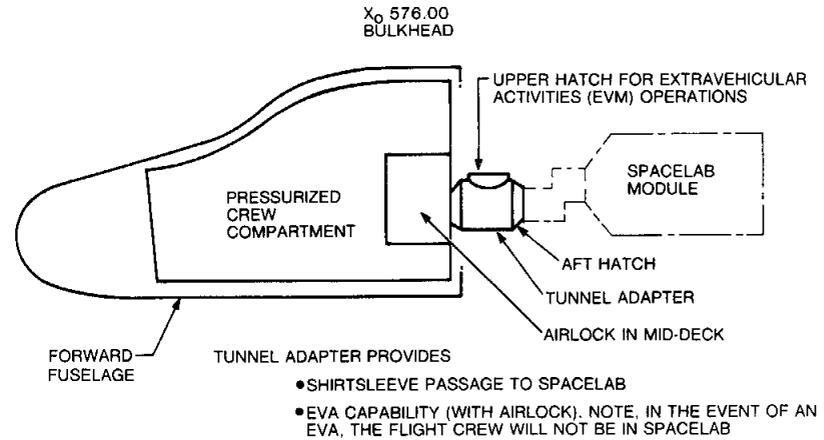
Z_0 355
DUCT INTERFACE
AIR REVITALIZATION SYSTEM
Z_0 357.9
X_0 576

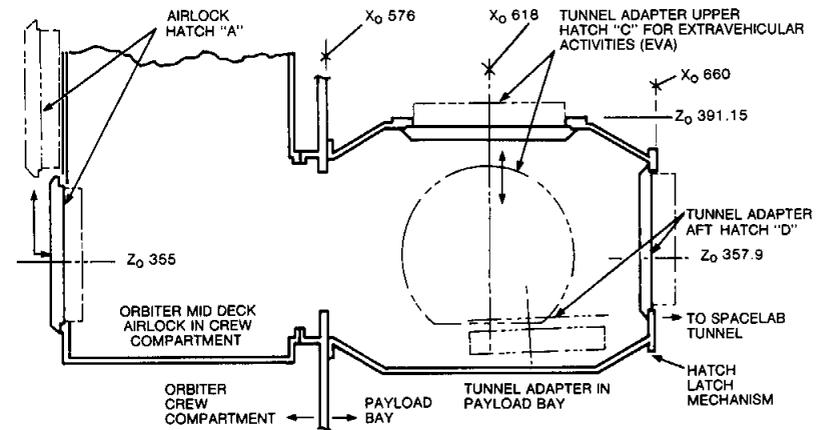**AIRLOCK — IN CABIN**

CIRCULATION DUCT IN USE (ON-ORBIT)

Airlock

when closed. The two 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.

X_0 576.00 BULKHEAD

UPPER HATCH FOR EXTRAVEHICULAR ACTIVITIES (EVM) OPERATIONS

PRESSURIZED CREW COMPARTMENT

SPACELAB MODULE

AFT HATCH

TUNNEL ADAPTER

AIRLOCK IN MID-DECK

FORWARD FUSELAGE

TUNNEL ADAPTER PROVIDES

- SHIRTSLEEVE PASSAGE TO SPACELAB
- EVA CAPABILITY (WITH AIRLOCK). NOTE, IN THE EVENT OF AN EVA, THE FLIGHT CREW WILL NOT BE IN SPACELAB

Airlock/Tunnel Adapter

AIRLOCK HATCH "A"

X_0 576

X_0 618

TUNNEL ADAPTER UPPER HATCH "C" FOR EXTRAVEHICULAR ACTIVITIES (EVA)

X_0 660

Z_0 391.15

TUNNEL ADAPTER AFT HATCH "D"

Z_0 357.9

TO SPACELAB TUNNEL

Z_0 365

ORBITER MID DECK AIRLOCK IN CREW COMPARTMENT

HATCH LATCH MECHANISM

ORBITER CREW COMPARTMENT

PAYLOAD BAY

TUNNEL ADAPTER IN PAYLOAD BAY

Airlock and Tunnel Adapter Hatch Mechanical Systems

39

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
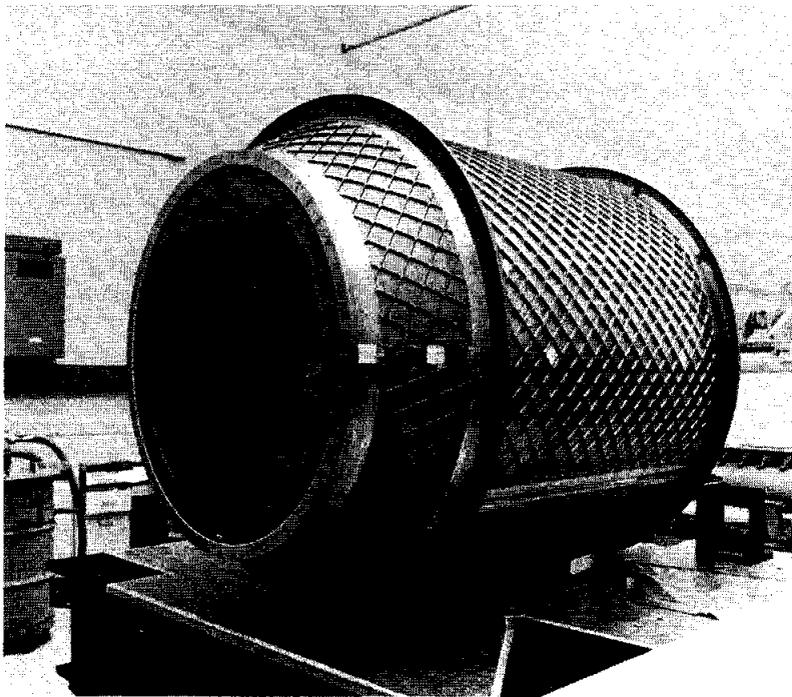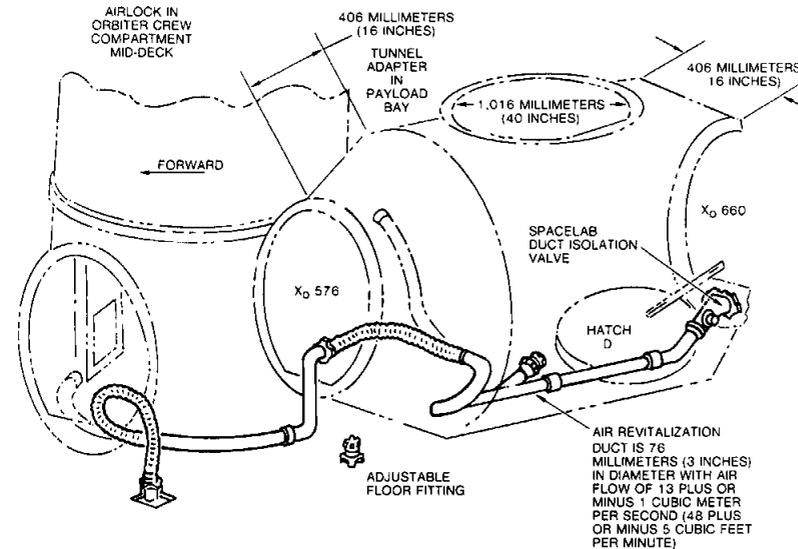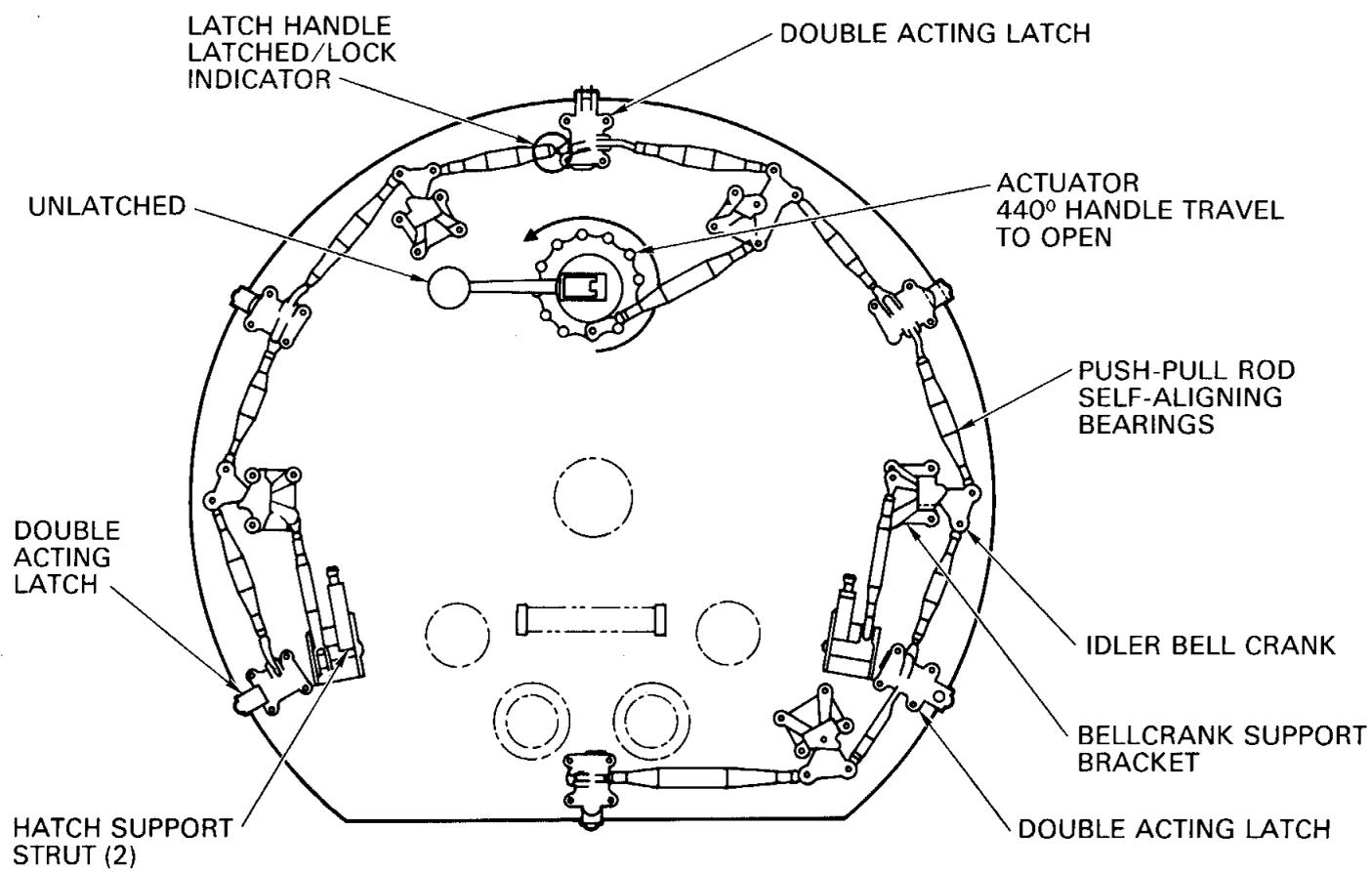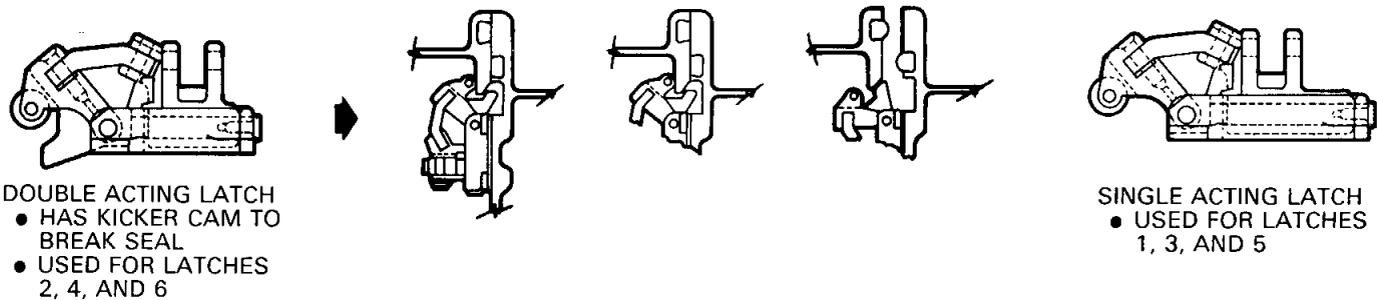

Tunnel Adapter

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 actuator 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) maxi-

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

DOUBLE ACTING LATCH
• HAS KICKER CAM TO BREAK SEAL
• USED FOR LATCHES 2, 4, AND 6

SINGLE ACTING LATCH
• USED FOR LATCHES 1, 3, AND 5

LATCH HANDLE LATCHED/LOCK INDICATOR

DOUBLE ACTING LATCH

UNLATCHED

ACTUATOR 440° HANDLE TRAVEL TO OPEN

PUSH-PULL ROD SELF-ALIGNING BEARINGS

DOUBLE ACTING LATCH

IDLER BELL CRANK

BELLCRANK SUPPORT BRACKET

HATCH SUPPORT STRUT (2)

DOUBLE ACTING LATCH

Airlock Hatch Latches

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mum 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.

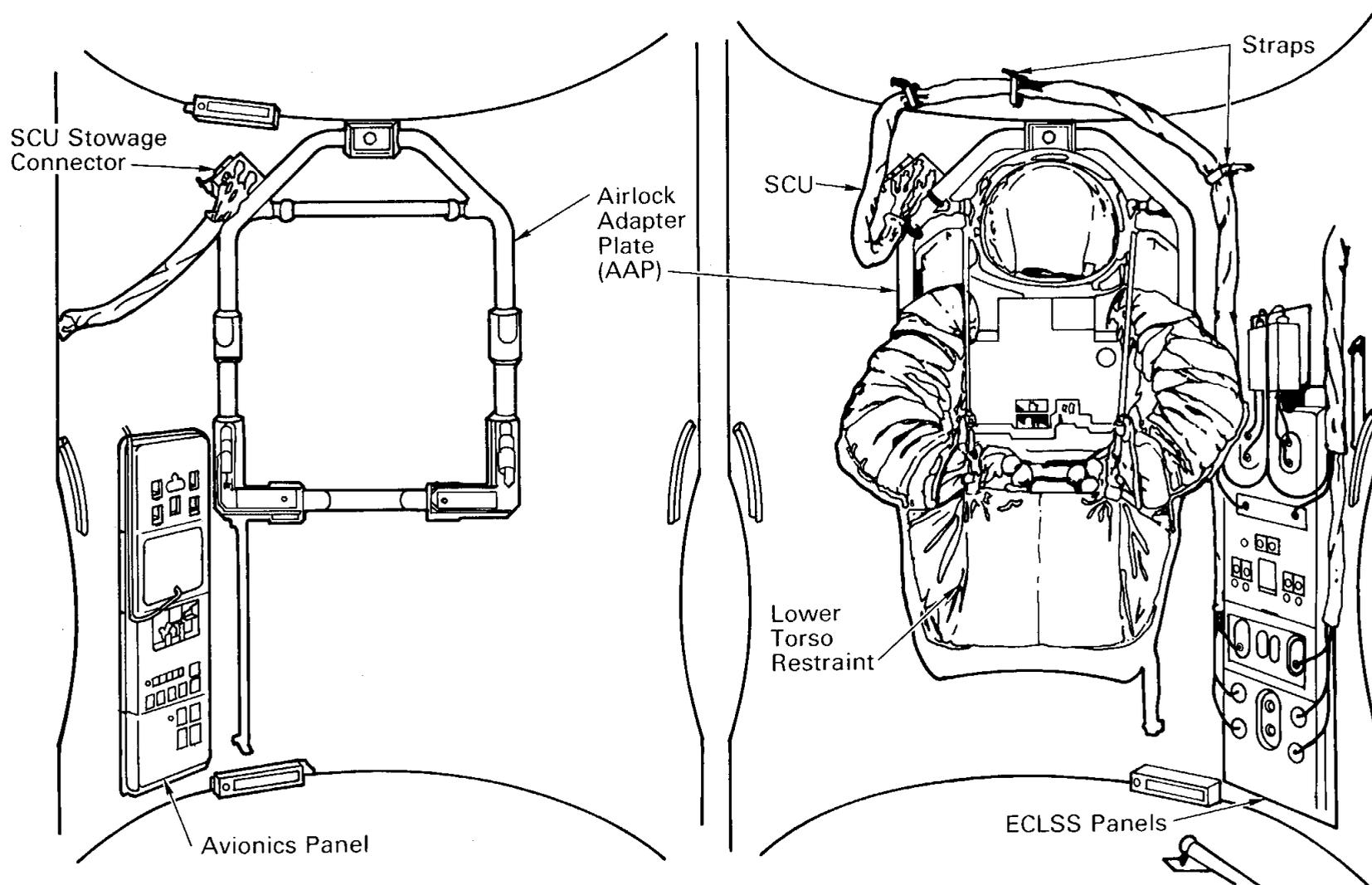The hatches can be removed in-flight from the hinge mechanism via up pins, if required.

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 epoxyphenolic 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 AW18A; 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 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.

SCU Stowage
Connector

Airlock
Adapter
Plate
(AAP)

Avionics Panel

Straps

SCU

Lower
Torso
Restraint

ECLSS Panels

Extravehicular Mobility Unit (EMU)
Service and Cooling Umbilical (SCU)

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Airlock Stowage Provisions

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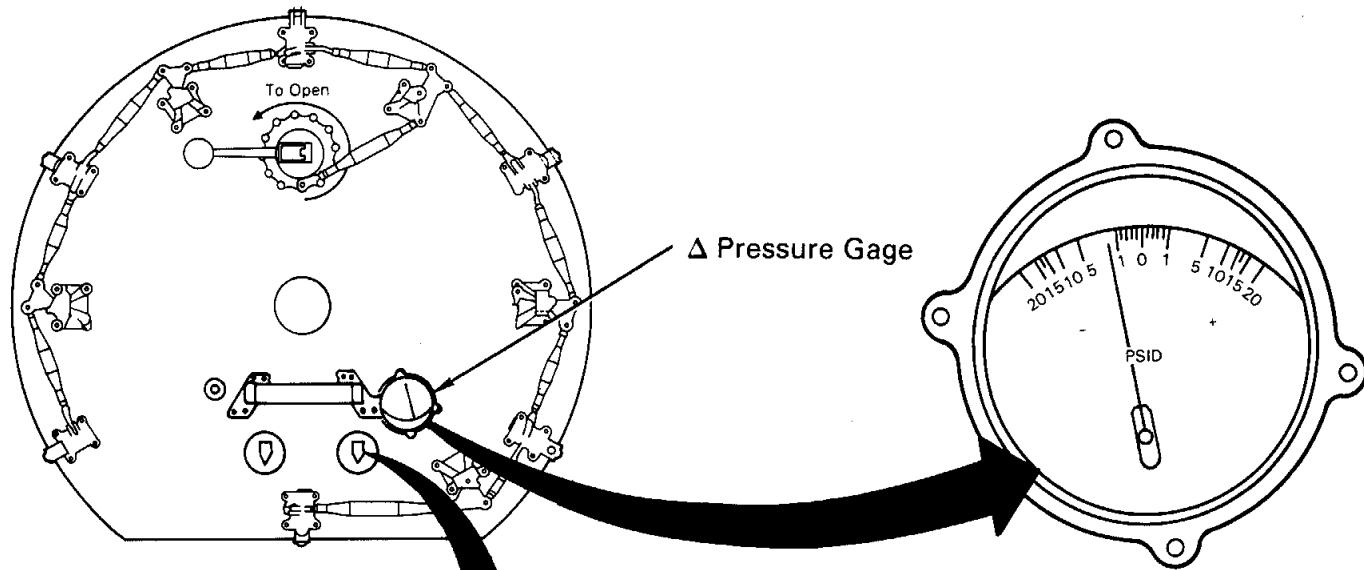
Hardware provisions are installed in the orbiter payload bay, on the tunnel adapter, tunnel and Spacelab for use by the crew member during the EVA.

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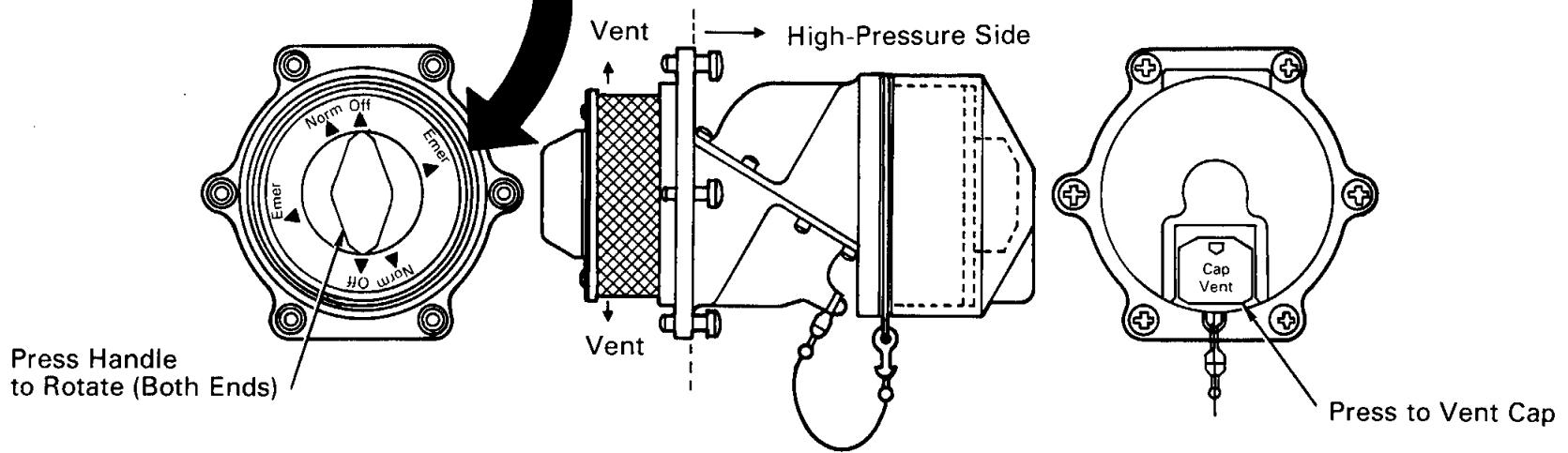
The handrails have a cross section of 33 by 19 millimeters (1.32 by 0.75 inches). They are made of aluminum alloy tubing and are painted yellow. The end braces and side struts of the handrails are constructed of titanium. An aluminum alloy end support standoff functions as the terminal of the handrail.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

To Open

Δ Pressure Gage

2015 10 5 1 0 1 5 10 15 20

PSID

Equalization Valve

Vent → High-Pressure Side

Norm Off
Emer
Emer
Norm Off

Vent

Vent

Press Handle
to Rotate (Both Ends)

Cap Vent

Press to Vent Cap

Airlock Repressurization

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.

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.
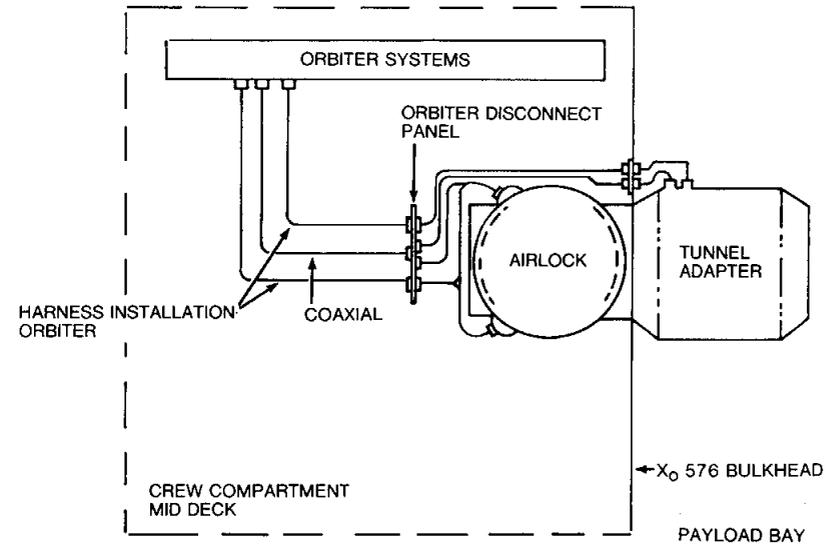
Airlock/Tunnel Adapter Harness Installation and Coaxial Antenna