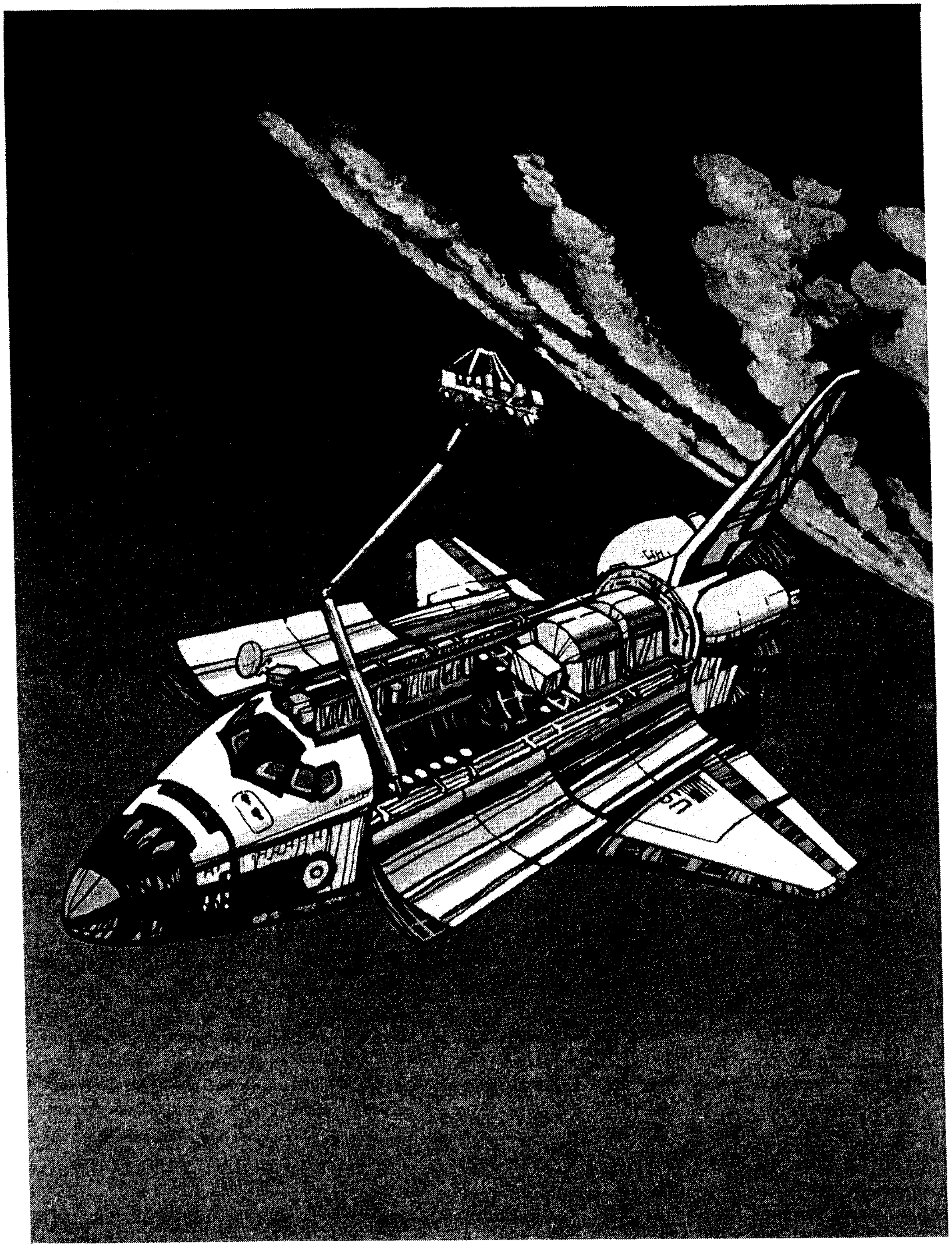

STS-7
PRESS INFORMATION

June 1983

Rockwell International

Space Transportation &
Systems Group

Office of Public Relations

CONTENTS

NEWS About Space Flight

...it comes from Rockwell International

MAKING HISTORY . . . ALL IN A DAY'S FLIGHT

The STS-7 flight of the spaceship *Challenger*. . . its second mission into Earth orbit. . . will chalk up a number of historical marks — firsts in space achievement.

The use of a remote manipulator arm to deploy and release a free flying space platform is a first. Then, the rendezvous, capture, retrieval and reberthing of that platform, each is a first.

And, the person operating these first-time achievements, is a first. . . herself. "She," is astronaut Mission Specialist Sally Ride who will operate the Canadian-built Remote Manipulator System (RMS) arm, the deployment and retrieval element "exercising" the German-built Shuttle Pallet Satellite (SPAS) -01, a platform carrying material processing experiments.

Another first—a cosmetic one—is the fact that the platform also has a black/white/color television camera, a 16mm camera and a 70mm camera aboard which remotely will film the Rockwell International-built *Challenger* for the first time in orbit as the spacecraft flies around the platform some 1,000 feet away. During this same period, cameras aboard *Challenger* will also be filming the SPAS-01.

The platform is one of four major payloads located in *Challenger's* 60-foot-long cargo bay. Two of the payloads are communications satellites, each with PAM (Payload Assist Module) -D boosters.

One is the Canadian Telesat-F or ANIK satellite and the other is the Indonesian government's PALAPA-B satellite. The fourth payload is the OSTA-2 pallet with a number of materials processing experiments. The OSTA gets its name from its NASA manager which is the Office of Space and Terrestrial Applications.

The OSTA-2 pallet remains in the cargo bay for the entire mission and is the first in a series of planned orbital investigations of materials processing in the micro-gravity of space.

The five-day, 23-hour mission of STS-7 will be a busy one for the five astronaut-member crew. In addition to the major payloads in the cargo bay, there will be seven Getaway Special (GAS) experiments.

Included in GAS experiments is the observation of crystal growth; an observance of emissions from the *Challenger's* payload bay by an ultraviolet spectrometer; a study of movement and growth of seedlings; an investigation of micro gravity on soldering, and measurement of emissions with ultraviolet sensitive film.

In the pressurized crew compartment of *Challenger* — the mid deck — the CFES (Continuous Flow Electrophoresis System) and the MLR (Monodisperse Latex Reactor) experiments will be flown again.

In the STS-6 mission, the CFES processed over 700 times more biological materials in the weightlessness of space than can be achieved in similar operations on Earth — and the purity levels were about four times higher.

A Ku-band antenna has also been added to *Challenger's* cargo bay and will be extended after opening of the spacecraft's payload bay doors. The Ku-band antenna, along with the S-band system, will be used to test performance, navigation and proficiency of the communications system and also the Tracking and Data Relay System satellite (TDRS). The Ku-band antenna also will be tested for rendezvous radar system performance with the SPAS free flying platform.

NEWS About Space Flight

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STS-7 MISSION STATISTICS

Launch: Saturday, June 18, 1983
7:33 A.M. E.D.T.
6:33 A.M. C.D.T.
4:33 A.M. P.D.T.

Mission Duration: 120 hours (5 days) 23 hours, 20 minutes

Landing: Friday, June 24, 1983
6:53 A.M. E.D.T.
5:53 A.M. C.D.T.
3:53 A.M. P.D.T.

Inclination: 28.45 degrees

SSME Throttling: 104 to 75 to 104 to 3 "g" limit to 65 percent

Spacecraft Altitudes in Orbit: 1) 160 nautical miles (184 statute miles); 2) 160 x 165 nautical miles (184 x 189 statute miles); 3) 160 x 170 nautical miles (184 x 195 statute miles); 4) to 157 x 170 nautical miles (180 x 195 statute miles) and 5) 157 nautical miles (180 statute miles)

Payload weight "up": Approximately 14,553 kilograms (32,085 pounds)

Payload weight "down": Approximately 7,774 kilograms (17,139 pounds)

Payloads: PALAPA (Indonesian Communications Satellite) B-1, PAM (Payload Assist Module) -D, TELESAT (Canadian Communications Satellite) -F/PAM-D, SPAS (German Shuttle Pallet Satellite) -01, OSTA (Office of Space and Terrestrial Applications Pallet) -2; seven GAS (Getaway Specials), Continuous Flow Electrophoresis System (CFES) experiment, Monodisperse Latex Reactor (MLR) experiment

Entry Angle of Attack: 40 degrees

Maximum Q (aerodynamic pressure): 700 pounds per square foot

Crew Members:
- Commander (CDR) Robert L. Crippen
- Pilot (PLT) Frederick H. Hauck
- Mission Specialist (MS) Sally K. Ride
- Mission Specialist (MS) John M. Fabian
- Mission Specialist (MS) Norman E. Thagard

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

Crossrange: 232 nautical miles (266 statute miles)

Runway: Kennedy Space Center concrete runway 15. The automatic flight control system mode is planned to be used down to 9,144 meters (30,000 feet) altitude, then control stick steering (CSS) is planned to be used from Mach 0.9 down to 3,657 meters (12,000 feet) altitude, then back to automatic to 1,524 meters (5,000 feet) altitude, then to CSS for landing and rollout

FLIGHT TEST AND MISSION OBJECTIVES

FLIGHT TEST

- Ascent aerodynamic verification
- External tank and solid rocket booster ascent performance
- External tank thermal protection system performance
- Solid rocket booster recovery
- Payload deployment retrieval system performance
- Reaction control system plume impingement
- Cabin atmosphere verification
- 10.2 psia cabin pressure control demonstration
- S-band/Tracking Data Relay Satellite (TDRS) communication link performance test No. 1 accomplished with normal S-band to TDRS
- Ku-band communication link performance test No. 1 accomplished with normal Ku-band to TDRS communication
- Orbiter S-band and Ku-band TDRS operation proficiency test No. 1 accomplished with normal S-band and Ku-band communication
- Orbiter/detached NASA payload communication test No. 2
- Orbiter-remote manipulator system dynamic interaction test with attached SPAS-01
- Vernier reaction control system plume impingement effects
- Rendezvous radar sensors performance proximity operations (914 meters — 3,000 feet)
- Proximity operations
- TDRS navigation test accomplished with normal Ku-band and S-band TDRS communication
- Entry aerodynamic test
- Entry with lateral offset
- Thermal protection system heating evaluation
- Kennedy Space Center landing
- Post landing power/unpowered bus tie
- Validation of predictive tests and countermeasures for space motion sickness
- Cardiovascular deconditioning countermeasure assessment
- Head and eye motion monitoring during ascent and entry

- Ambulatory monitoring with/without skeletal loading and other maneuvers
- Inflight countermeasures for space adaptation syndrome with objective measures
- Eye hand coordination
- Acceleration detection sensitivity
- Kinesthetic ability
- Leg volume stocking-plethysmography
- On orbit head and eye tracking tasks
- Audiometry (with cabin noise)
- Near vision acuity
- Ophthalmoscopy
- Microbiology screening test
- Tissue pressure-tonemeter

MISSION OBJECTIVES

- OSTA (Office of Space and Terrestrial Applications) -2 experiments
- Deployment of PALAPA B1/PAM-D
- Deployment of Telesat-F/PAM-D
- First payload deployment and retrieval SPAS-01
- First rendezvous operations
- Seven GAS experiments
- Monodisperse latex reactor experiment
- Continuous flow electrophoresis system experiment
- First Kennedy Space Center landing

- **Heavyweight External Tank**

  Weighs approximately 4,536 kilograms (10,000 pounds) heavier than STS-6 lightweight external tank. This is the last heavyweight eternal tank which weighs approximately 34,927 kilograms (77,000 pounds)

- Installation of remote manipulator system (RMS)

- Installation of Ku-band antenna in payload bay at forward starboard location

- Re-waterproofing of thermal protection system tiles internally except for aft heat shield and upper surface of body flap

- Removed approximately 44 eroded advanced flexible reusable surface insulation blankets (22 per orbital maneuvering system/reaction control system [OMS/RCS] pod) at forward outboard leading edge and replaced with approximately 284 (142 per OMS/RCS pod) low temperature reusable surface insulation (LRSI) tiles. This still leaves approximately 94 AFRSI blankets (47 per OMS/RCS pod)

- Removed ablators from outboard end of each inboard elevon and inboard end of each outboard elevon and replaced with high temperature reusable surface insulation (HRSI) tiles

- Install personal hygiene curtain in crew compartment mid-deck

LINE REPLACEABLE UNITS

- Removed and replaced left orbital maneuvering system secondary engine gimbal actuator controller
- Removed and replaced left aft reaction control system engine L2D
- Removed and replaced teleprinter
- Removed and replaced hydraulic system 2 accumulator
- Removed and replaced operations recorder 1
- Removed and replaced multiplexer/demultiplexer OF2
- Removed and replaced general purpose computer No. 2
- Removed and replaced pilots horizontal situation indicator
- Removed and replaced SSME No. 1 gaseous hydrogen flow control valve
- Removed and replaced main landing gear brakes
- Removed and replaced main landing gear wheels and tires
- Removed and replaced switch for television camera D zoom
- Removed and replaced remote manipulator system end effector
- Removed and replaced fuel cell powerplant No. 1 coolant delta pressure transducer switch
- Removed, repaired and reinstalled three inertial measurement units
- Removed and reinstalled waste management system
- Removed and replaced high pressure fuel turbopump SSME No. 1 due to second stage turbine blade life
- Removed and replaced environmental control and life support system oxygen/nitrogen panel
- Removed and replaced avionics bay No. 1 fan
- Removed and replaced approximately 72 tiles due to in-flight or ground damage
- Removed and replaced SSME No. 2 gaseous hydrogen pressurization outlet temperature sensor
- Rebond bracket for closed circuit television monitor

PAYLOAD ASSIST MODULE (PAM)

The Payload Assist Module (formerly called the Spinning Solid Upper Stage — SSUS) is designed as a higher altitude booster of satellites deployed in near Earth orbit but operationally destined for higher altitudes.

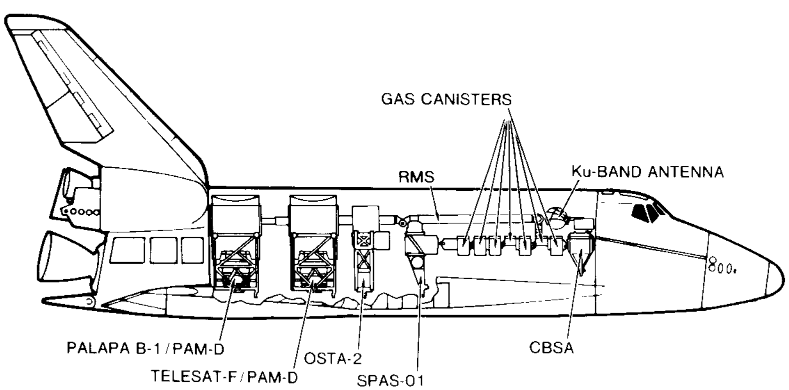
Both payloads carried in STS-7 — the TELESAT-F and PALAPA B1 — will be boosted to geosynchronous orbits (35,887 kilometers — 22,300 miles) by PAM-D's.

There are two verisions of the PAM — the "D" which is utilized to launch lighter weight satellites and the "A" which is capable of launching satellites weighing up to 1,995 kilograms (4,400 pounds) into a 27-degree geosynchronous transfer orbit after being deployed from the Shuttle spacecraft's cargo bay.

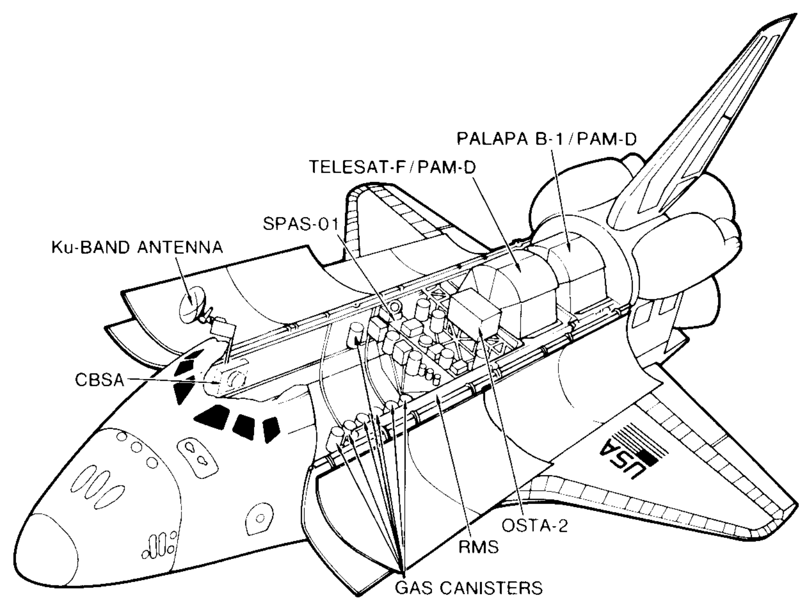
The PAM-D is capable of launching satellite weights up to 1,247 kilograms (2,750 pounds) into a 27 degree geosynchronous orbit following deployment. A requirement for a 1,361 kilogram (3,000 pound) transfer orbit capability requires about a 10-percent increase in the PAM-D motor performance, which can be accomplished by adding more length to the motor case, but reducing the nozzle length the same amount to retain the overall stage length. The motor case extension is about 137 milimeters (5.4 inches). This uprating will require other changes, namely the strengthening and addition of cradle members so that the system structural dynamic frequency will avoid the Space Shuttle forcing frequencies.

The PAM-A and PAM-D have deployable (expendable) stage consisting of a spin stabilized solid rocket fueled motor (SRM), a payload attach fitting (PAF) to mate with the unmanned spacecraft, and the necessary timing, sequencing, power and control assemblies.

The reusable airborne support equipment (ASE) consists of the cradle structure for mounting the deployable system in the Space Shuttle orbiter payload bay, a spin system to provide the stabilizing rotation, a separation system to release and deploy the stage and unmanned spacecraft, and the necessary avionics to control, monitor, and power the system.



STS-Payload Configuration (Side View)

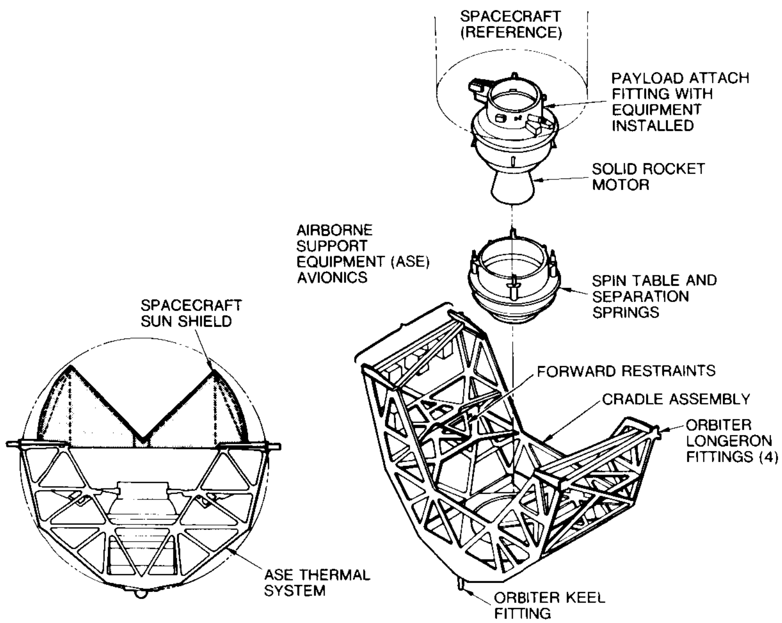


STS-Payload Configuration (Top View)

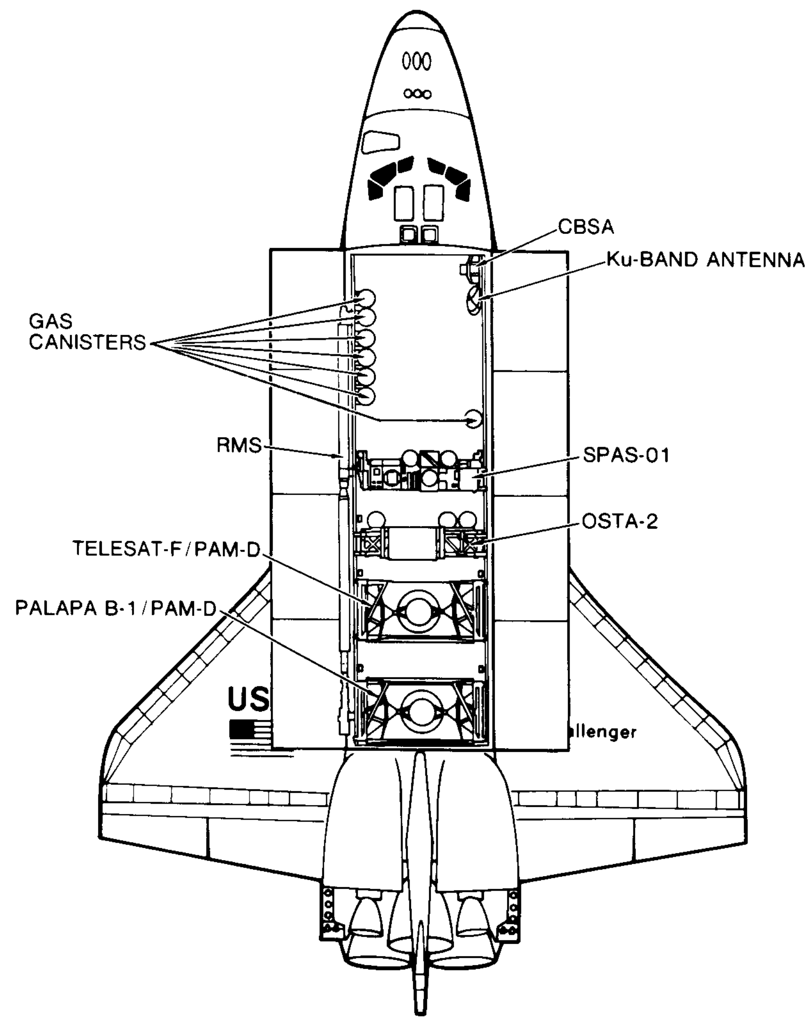
The PAM-A and PAM-D stages are supported through the spin table at the base of the motor and through restraints at the PAF. The forward restraints are retracted before deployment.

The PAM-D also provides a sunshield for thermal protection of the satellite when the Space Shuttle orbiter payload bay doors are open.

PAM-D Airborne Support Equipment and Orbiter Installation. The PAM-D Airborne Support Equipment (ASE) consists of all the reusable hardware elements that are required to mount, support, control, monitor, protect, and operate the PAM-D expendable hardware and unmanned spacecraft from liftoff to deploymenmt from the Space Shuttle. It will also provide the same functions for the safing and return of the stage and spacecraft in case of an aborted mission. The ASE is designed to be as self-contained as possible, thereby minimizing dependence on orbiter or flight crew functions for its operation. The major ASE elements include the cradle for structural mounting and support, the spin table and drive system, the avionics system to control and monitor the ASE and the PAM-D vehicle and the thermal control system.

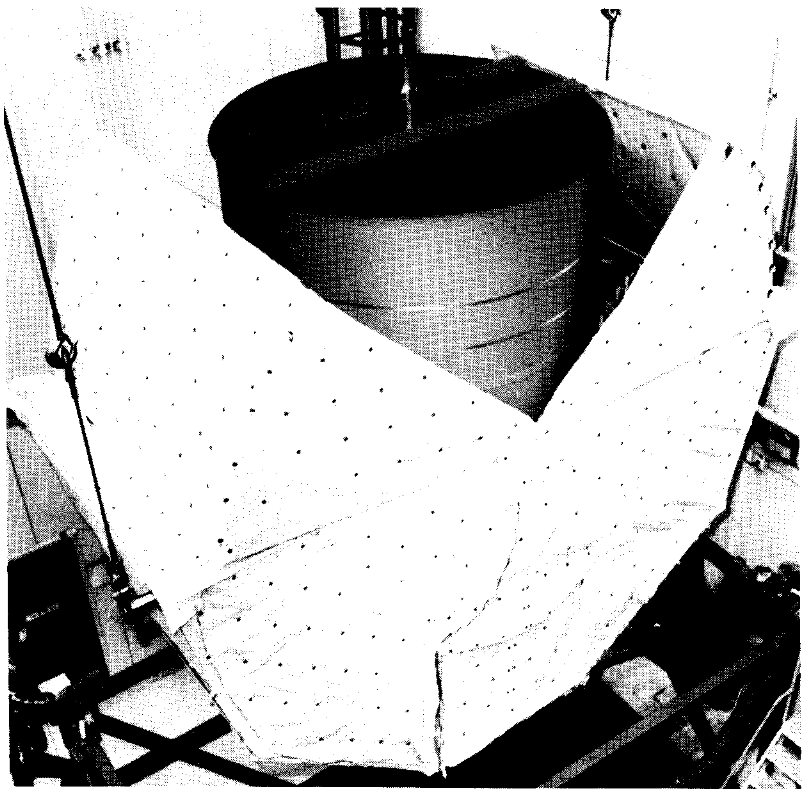


PAM-D System



STS-Payload Configuration (Top View)

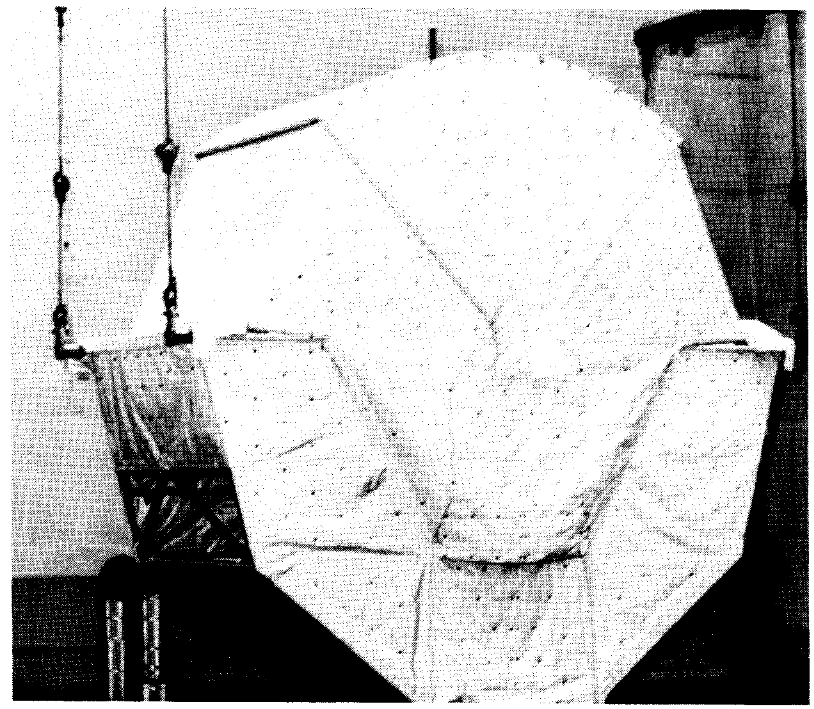
The cradle assembly provides a vertical structural mounting support for the PAM-D/unmanned spacecraft assembly in the orbiter payload bay. The nominal envelope for the PAM-D vertical installation provides a cylindrical volume 2,562 millimeters (100.88 inches) in height on the centerline and a diameter of 2,184 millimeters (86 inches). The diameter limitation applies to all early unmanned spacecraft that require the capability to use the Delta launch vehicle as a backup to the Space Shuttle. After full transition to the Space Shuttle is complete, the unmanned spacecraft configuration may use the extra volume available within the Space Shuttle payload bay, a maximum diameter of 2,743 millimeters (108 inches) inside the cradle, 3,048 millimeters (120 inches) above the cradle. The cradle is 4.5 meters (15 feet) wide. The length of the cradle is 2,362 millimeters (93 inches) static and 2,438 millimeters (96 inches) dynamic. The open truss structure cradle is constructed of machined aluminum frame sections and chrome plated steel longeron and keel trunnions.



PAM-D/Telesat-F Sunshield Open

The spacecraft-to-cradle lateral loads are reacted by forward retractable retraction fittings between the payload attach fitting and cradle, which are driven by redundant dc electrical motors. After the reaction fittings are retracted, the spin table is free to spin the PAM unmanned spacecraft when commanded.

The spin table consists of three subsystems, spin, separation, and electrical interface. The spin subsystem consists of the



Pam-D/Telesat-F Sunshield Closed

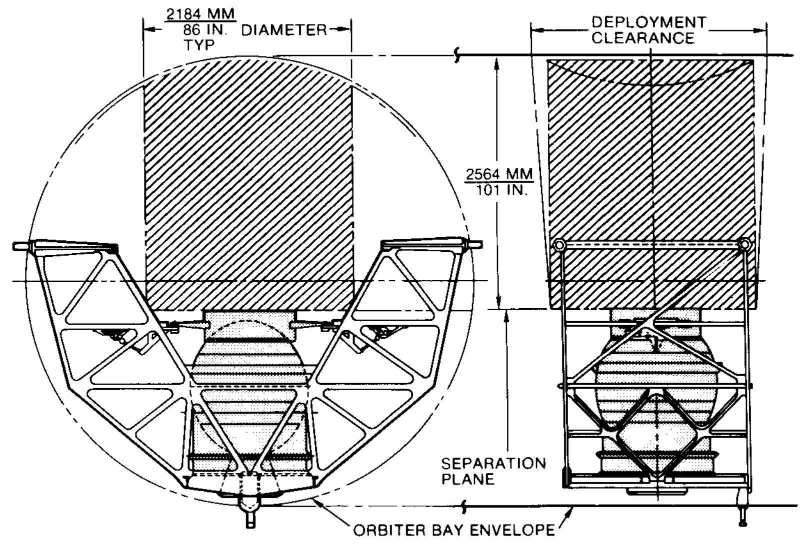
spin table, the spin bearing, the rotating portion of the spin table, a gear and gear support ring, two redundant drive motors, a despin braking device, and a rotational index and locking mechanism. The separation subsystem includes four compression springs mounted on the outside of the rotating spin table, each with an installed preload of 635 kilograms (1,400 pounds) and a Marman-type clamp band assembly.

The electrical interface subsystem is composed of a slip-ring assembly to carry electrical circuits for PAM-D and spacecraft across the rotating spin bearing. The electrical wiring from the slip ring terminates at electrical disconnects at the spin-cable separation point. The slip-ring assembly is used to carry safety-critical command and monitor functions and those commands required before separation from the spin table.

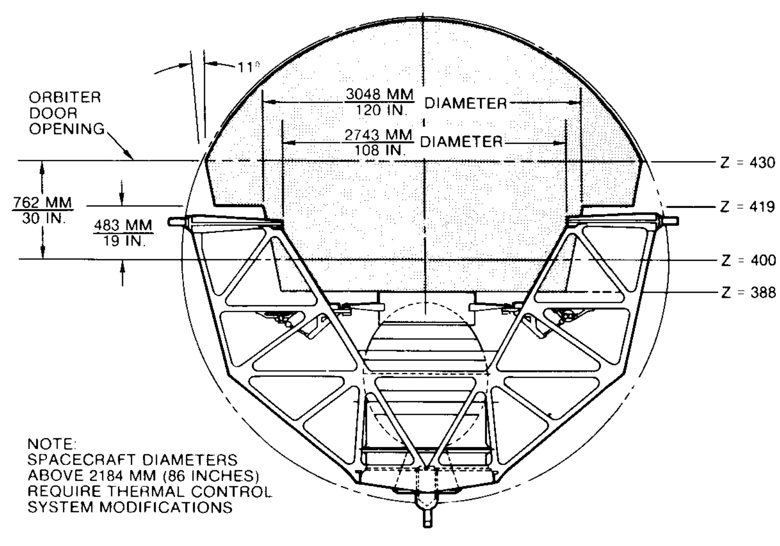
The system provides a capability for spin rates between 45 and 100 rpm. In this flight, the spin rate is approximately 50 rpm. Upon command, the spin table will be spun up to the nominal rpm by two electric motors, either of which can produce the required torque. When the spin table rpm has been verified and the proper point is reached in the parking orbit, redundant debris-free explosive bolt cutters are fired upon command from the electrical ASE to separate the band clamp (which is mechanically retained on the spin table) and the springs provide the thrust to attain a separation velocity of approximately 0.9 meters per second (3 feet per second).

In case of an abort mode after spinup, the multiple-disc-stack friction-type braking device will despin the PAM-D unmanned spacecraft assembly and the spin drive motor will slowly rotate the assembly until the solenoid-operated indexing and locking device is engaged. Upon confirmation by the ASE that the spin table is properly aligned and locked, the restraint pins will be re-engaged.

PAM-D Mounted Thermal Control System. The PAM-D thermal control system is provided to alleviate severe thermal stresses on both the unmanned spacecraft and the PAM-D system.



PAM-D Orbiter Vertical Installation

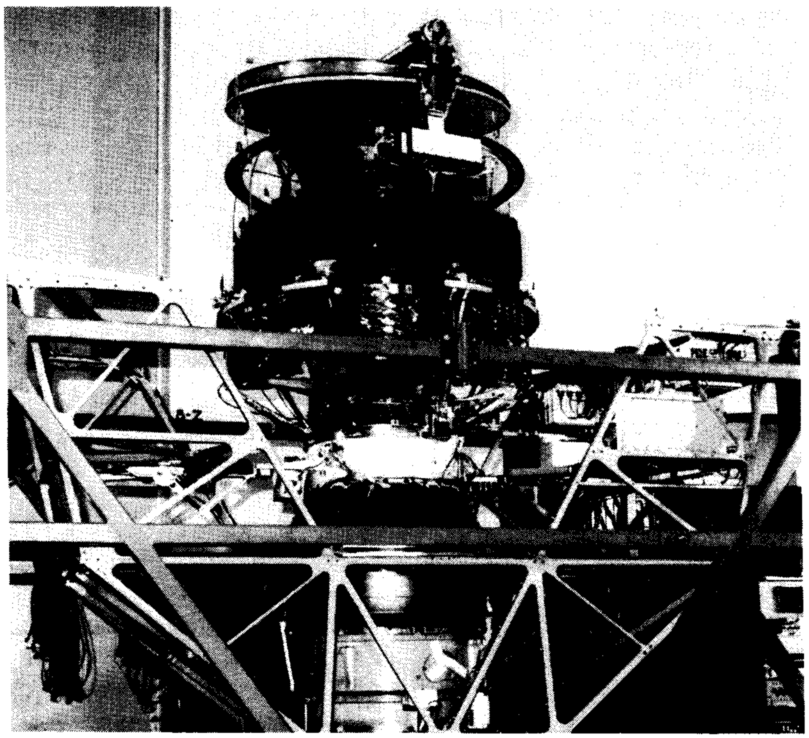


Maximum Spacecraft Envelope With STS PAM-D

The system consists of thermal blankets mounted on the cradle to provide thermal protection for the PAM-D system, and a passive sunshield mounted on the cradle to control the solar input to and heat loss from the payload when the orbiter payload bay doors are open.

Thermal blankets consisting of multilayered insulation mounted to the forward and aft sides of the cradle protect the PAM-D from thermal extremes. On the sides and the bottom, the orbiter payload bay liner protects the PAM-D from the environmental extremes.

A sunshield, consisting of multilayered, Mylar lightweight insulation supported on a tubular frame, mounts to the cradle



PAM-D/Telesat-F

and protects the unmanned spacecraft from environmental extremes. The sunshield panels on the sides are fixed and stationary. The portion of the shield covering the top of the unmanned spacecraft is a clamshell structure that remains closed to protect against thermal extremes when the orbiter payload bay doors are open. The sunshield resembles a two-piece baby buggy canopy. The clamshell is opened by redundant electric rotary actuators operating a control-cable system.

The sunshield required for the PAM-D growth will have a width adjustment capability to accommodate spacecraft up to 2,901 millimeters (115 inches) in diameter.

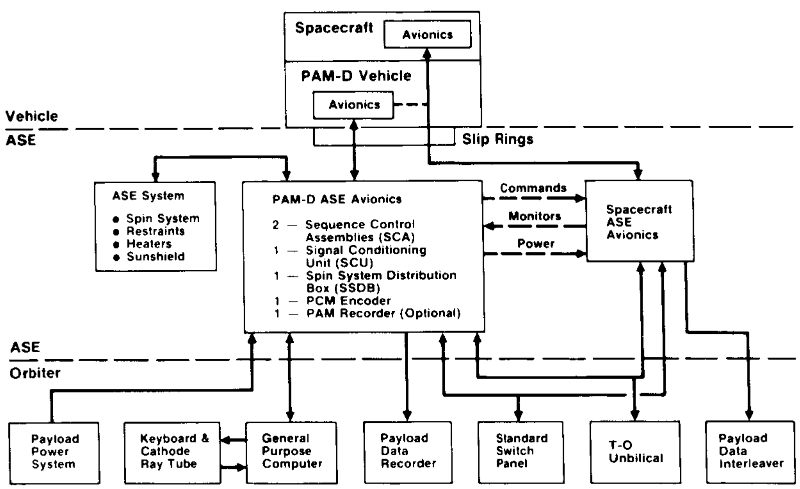
PAM-D Vehicle Configuration. The PAM-D expendable vehicle hardware consists of a Thiokol Star-48 solid-fueled rocket motor, the payload attach fitting and its functional system. The Star-48 motor features a titanium case, an 89-percent solid propellant, a carbon-carbon throat insert, and a carbon-carbon exit cone. Maximum loading of propellant is 1,998 kilograms (4,405 pounds) with a nominal of 1,738 kilograms (3,833 pounds). The motor is 1,239 millimeters (48.8 inches) in diameter and is 1,828 millimeters (72 inches) long.

The payload attach fitting (PAF) structure is a machined forging and provides the subsystem mounting installations and mounts on the forward ring of the motor case. The two cradle reaction fittings provide structural support to the forward end of the PAM-D stage and unmanned spacecraft, and transmit loads to the ASE cradle structure. The forward interface of the PAF provides the spacecraft mounting and separation system. One steel band is preloaded to approximately 2,585 kilograms (5,700 pounds) and separation is achieved by redundant bolt cutters. Four separation springs, mounted inside the PAF provide the impetus for clear separation. The installed preload for each spring is approximately 90 kilograms (200 pounds) with a spring stroke of 133 millimeters (5.25 inches), providing a spacecraft separation velocity of about 0.9 meters per second (3 feet per second). The electrical interface connectors between the PAM-D and the spacecraft are mounted on brackets on opposite sides of the PAF. Other subsystems mounted on the PAF include the redundant safe-and-arm device for motor ignition, and telemetry components (if desired) and the S-band transmitter.

PAM-D Avionics. The electrical ASE minimizes the number of operations to be performed by the flight crew so that greater attention can be paid to monitoring functions that are critical to safety and reliability.

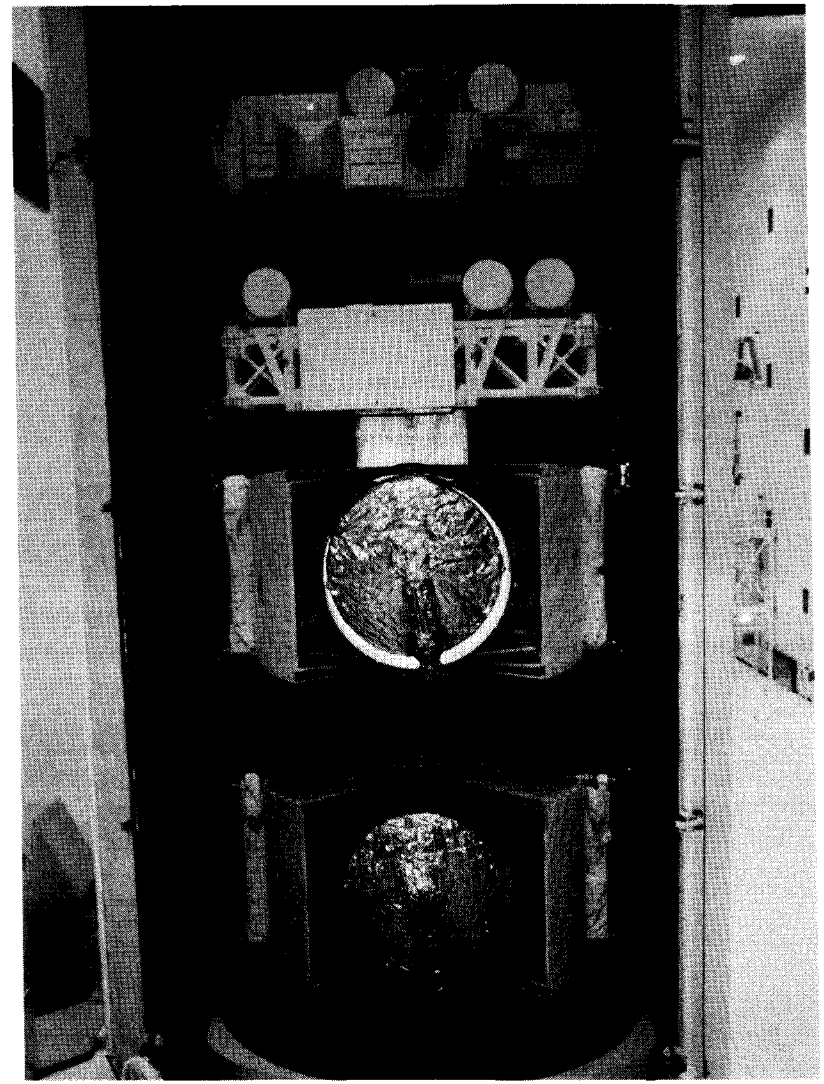
Flight crew control functions include system power on, SRM arming, deployment ordnance arming, emergency deployment and sequence control assembly (SCA) control.

The electrical ASE performs control and monitoring of restraint withdrawal, spin-table spin and deployment functions; arms (and disarms, if necessary) the SRM; controls and monitors the PAM-D vehicle electrical sequencing system (and telemetry system, when used); generates system status information for display to the flight crew (cathode ray tube) via the data lens and from the orbiter keyboard panel; and provides wiring to carry required spacecraft functions. And, as a mission option, it provides control and monitoring of spacecraft systems.



PAM-D Interfaces

The Payload Assist Modules are designed and built by McDonnell Douglas Astronautics, Co., Huntington Beach, California.



STS-7 — SPAS-01, OSTA-2, TELESAT-F and PALAPA-B1

TELESAT-F (ANIK) — C2

Telesat Canada is a federally regulated shareholder-owned commercial Canadian telecommunications common carrier engaged in the transmission and distribution of all forms of telecommunications in Canada by satellite.

Telesat is neither a Crown Corporation nor an agent of Her Majesty. Although the government of Canada is a major but not a majority shareholder, Telesat Canada does not have access to government grants or other funding. It is dependent for its financing on the revenues it generates through its operations and from banks and other commercial sources of debt financing.

It was the intention of the Government of Canada in establishing the company in 1969 that its services would be complementary to and not competitive with the telecommunications services offered by other Canadian carriers.

The company has the statutory mandate to establish satellite communications systems providing, on a commercial basis, telecommunications services between locations in Canada and subject to the appropriate intergovernmental arrangements, to and between other locations.

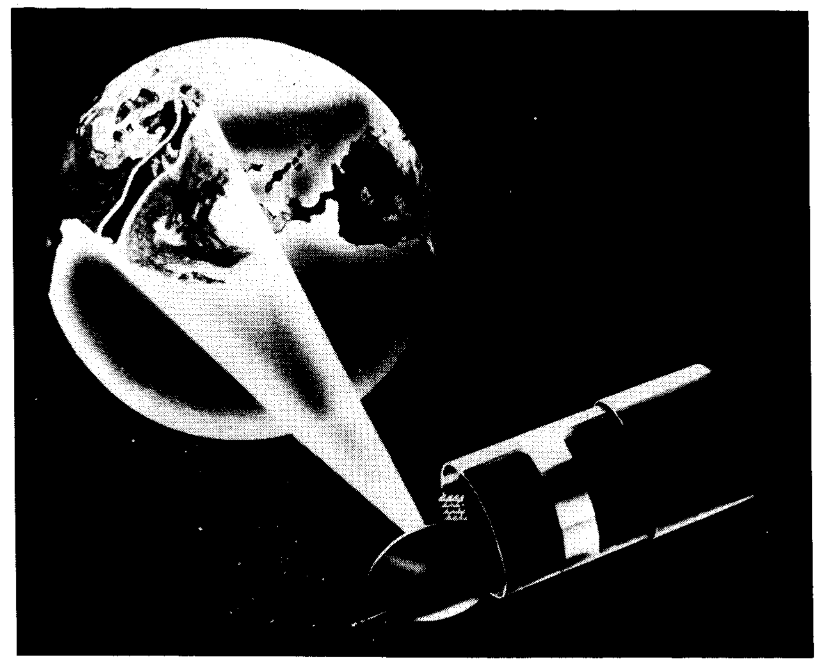
The Telesat-F, also called Anik-C2 (Eskimo for "brother") when on orbit, series satellites will be the most powerful domestic satellites in commercial service until the latter half of the decade.

In addition to the satellites which make up the space segment of the system, several hundred earth stations, more than 100 of which are owned and operated by Telesat, compose the earth segment.

Telesat employs more than 400 people, most of whom work in the company's Ottawa, Ontario headquarters. The majority of the remaining employees staff the company's main heavy route earth station at Allan Park, north of Toronto.

The satellite will be worth close to $160 million (Canadian dollars) and will cost in the vicinity of $9 to $10 million (U.S. dollars) to launch on the Space Shuttle. The satellite weighs 1,140 kilograms (2,513 pounds) in the transfer orbit. Its solar cells are capable of producing 800 watts of electricity to power the satellite.

Anik-C communication satellites are cylindrical in shape and will operate exclusively in the high frequency 14 and 12 gigahertz radio bands, with 16 radio frequency channels (transponders). Each of these 16 channels will be capable of carrying two full color television signals, together with their associated audio and cue and control circuits, for a total television signal capacity of 32 programs or 1,344 one way telephone circuits.



Telesat-F

The combination of higher transmit power from 15-watt output tubes with use of the 14 and 12 gigahertz bands means that the satellite will be able to work with much smaller earth stations than those in use today.

Because of the smaller size, and the fact the higher frequencies in use won't interfere (or be interfered with by) existing terrestrial microwave communications that share the lower frequencies used by other satellites, the earth terminals can be located easily in relatively crowded spaces. They can be placed in city centers or mounted on rooftops of individual homes. Anik-C's will be able to deliver a high quality television picture to a private earth terminal equipped with a dish antenna as small as 1.2 meters (3.93 feet) in diameter, making it ideal for direct broadcast satellite services.

Five of Anik-C2's channels will be leased to the GTE Satellite Corporation of Stamford, Conn, until December, 1984 for pay TV services. A Canada-U.S. agreement allows Telesat to sell temporarily surplus satellite capacity on an interim basis to American companies experiencing a shortage of satellite channels.

Anik-C2 will be the primary in-orbit backup for its identical predecessor, Anik-C3, launched on November 11, 1982 from *Columbia*. Anik-C3 was on station 19 November 1982, at 117.5 degrees west longitude (south of the Canadian Rockies). Anik-C3 service currently carries Canadian pay TV, educational television and general long distance telecommunications traffic. Anik-C2 will be available to carry east-west telecommunications in southern Canada. Anik-C2 is planned to be stationed at 112.5 degrees west over the equator (south of central Alberta).

The remaining Anik-C that will eventually join Anik-C2 and C3 is planned to be stationed at 109 degrees West Longitude over the equator.

Designed to last 10 years, the satellites are expected to have minimum mission lives of around eight years.

The three Anik-C satellites are built for Telesat Canada by Hughes Aircraft Company, Space and Communications Group, El Segundo, Calif. with considerable work performed by Spar Aerospace Limited and other Canadian companies.

For launch the Telesat-F spacecraft is compressed to a height of about 2.7 meters (9 feet) and positioned in its cradle in the orbiter cargo bay. With the PAM, the payload is 4.2 meters (14 feet) tall.

The payload ejected from the bay weights about 3,270 kilograms (7,211 pounds). This includes the payload assist module (PAM-D) which weights 190 kilograms (421 pounds) with 1,963 kilograms (4,328 pounds) of solid propellant for thrusting the satellite from parking orbit to transfer orbit; an apogee motor with 493 kilograms (1,089 pounds) gross weight of solid propellant for injecting the satellite into synchronous orbit; and the satellite itself—622 kilograms (1,373 pounds) including about 148 kilograms (327 pounds) of hydrazine fuel for 8 to 9 years of stationkeeping operation.

Before ejection, the deployable payload is supported by its cradle and electronics system.

TELESAT-F/PAM-D EJECTION

To prepare for cargo ejection, the orbiter flight crew verifies the spacecraft through a series of checks and configures the payload for deployment. The orbiter is at approximately 160 nautical miles (184 statute miles) altitude for spacecraft deployment. The satellite is spun up (to 50 rpm) on the cradle's spin table, communications and other subsystems are checked by means of an electrical and communications harness to the flight crew cabin, and the payload ordnance items are armed. All the checks are performed remotely from the flight crew cabin, and payload data are transmitted from the orbiter to the Mission Control Center in Houston (MCC-H) for analysis.

During a final pre-ejection sequence lasting approximately 30 minutes, the orbiter is maneuvered into a deployment attitude with the open cargo bay facing the direction desired for firing the PAM motor.

Ejection will occur, nominally, about nine and one-half hours after liftoff when the orbiter is over the Pacific Ocean on the seventh descending node (heading south from the Equator on its seventh orbit). A Marman clamp is released by explosive bolts, and the spinning payload pops out of the cradle and cargo bay at 0.9 meters per second (3 feet per second).

At ejection from the orbiter cargo bay, the Telesat-F spacecraft has completed only the first of several critical launch events. At this point it is in an orbit similar to the orbiter's with an altitude of about 160 nautical miles (185 statute miles), a velocity of about 27,835 kilometers (17,300 mph), an inclination to the equator of 28.5 degrees, and a period of 90 minutes.

To perform its intended communications service, the spacecraft must be raised to an altitude of about 36,851 kilometers (22,898 statute miles), with a velocity of about 10,941 kilometers per hour (6,800 mph), at a zero-degree inclination to the equator and a period of 24 hours.

The first in a series of major in-orbit events is the firing of the solid-propellant motor aboard the payload's PAM. At ejection, this motor is armed to automatically fire in 45 minutes. Spacecraft sensors and thrusters automatically maintain the payload's correct attitude (longitudinal axis included 9 degrees to the Equator) for firing. At the time of firing, the spacecraft is over Africa.

The PAM motor firing raises the apogee (high point) of the orbit to about 36,851 kilometers (22,898 statute miles). Now the spacecraft is in a highly elliptical transfer orbit with a perigee of about 158 nautical miles (182 statute miles), an orbital period of 11 hours, and an inclination to the Equator of 23.8 degrees. The PAM motor casing is jettisoned after firing.

Nominally, on the third apogee of the transfer orbit, an on-board solid-fuel motor (or apogee motor) is fired to raise the perigee of the orbit. This puts the spacecraft into a near-circular orbit at near-geosynchronous altitude. The apogee motor will be fired on command by Telesat controllers at Telesat Satellite Control Center in Ottawa, Ontario.

Next comes a series of spacecraft thruster firings by Telesat controllers to refine the orbit and adjust spacecraft velocity so that a controlled drift will bring it to its final destination in two to three weeks.

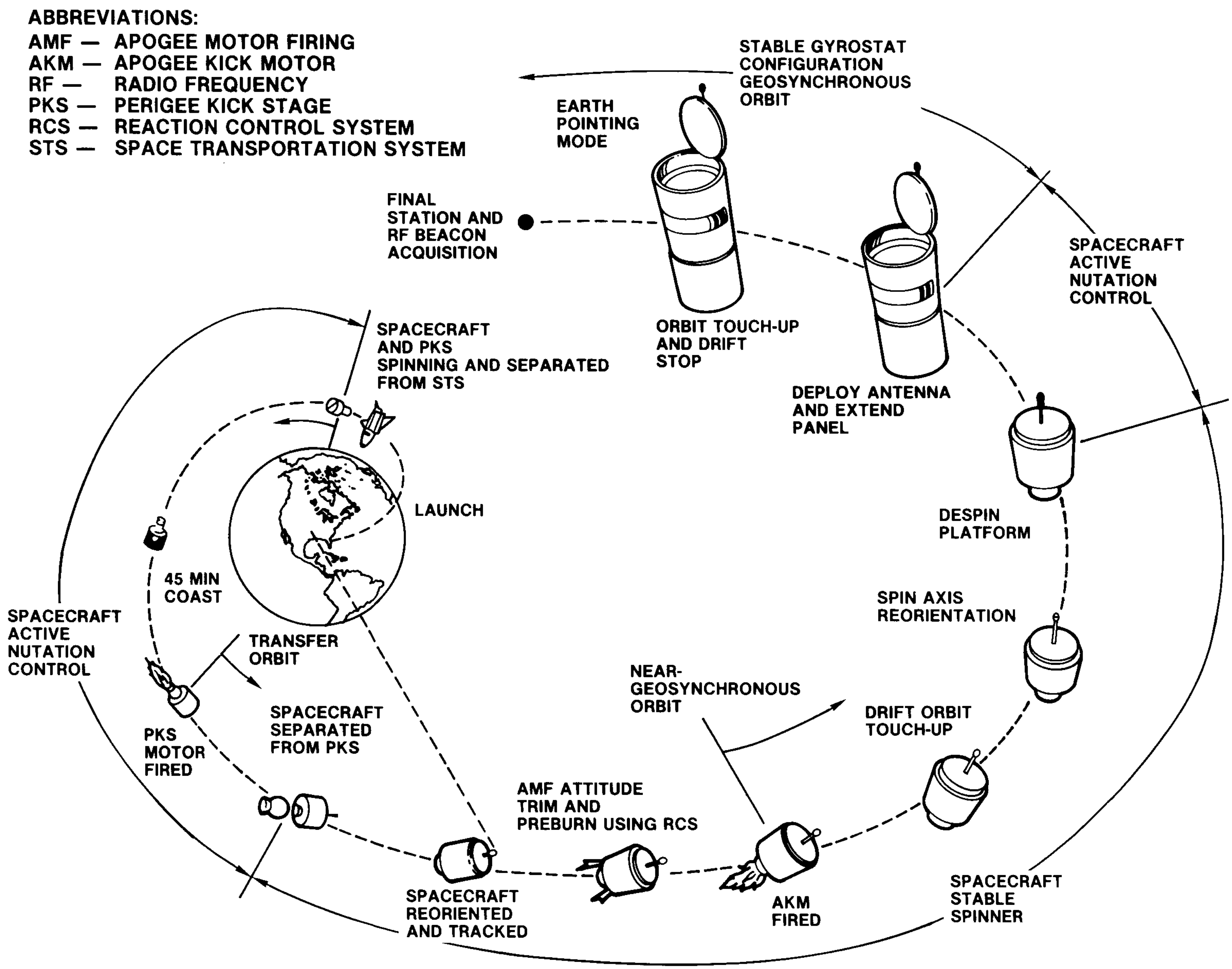
Three other critical maneuvers, in sequence, are the despin of the communications platform, the raising of the spacecraft's antenna reflector, and the lowering of its solar-panel skirt, all by means of on-board electric motors activated on command.

When the maneuvers are completed, Telesat conducts a series of in-orbit tests and verifications of all spacecraft sub-systems, lasting several weeks, before commercial service is begun.

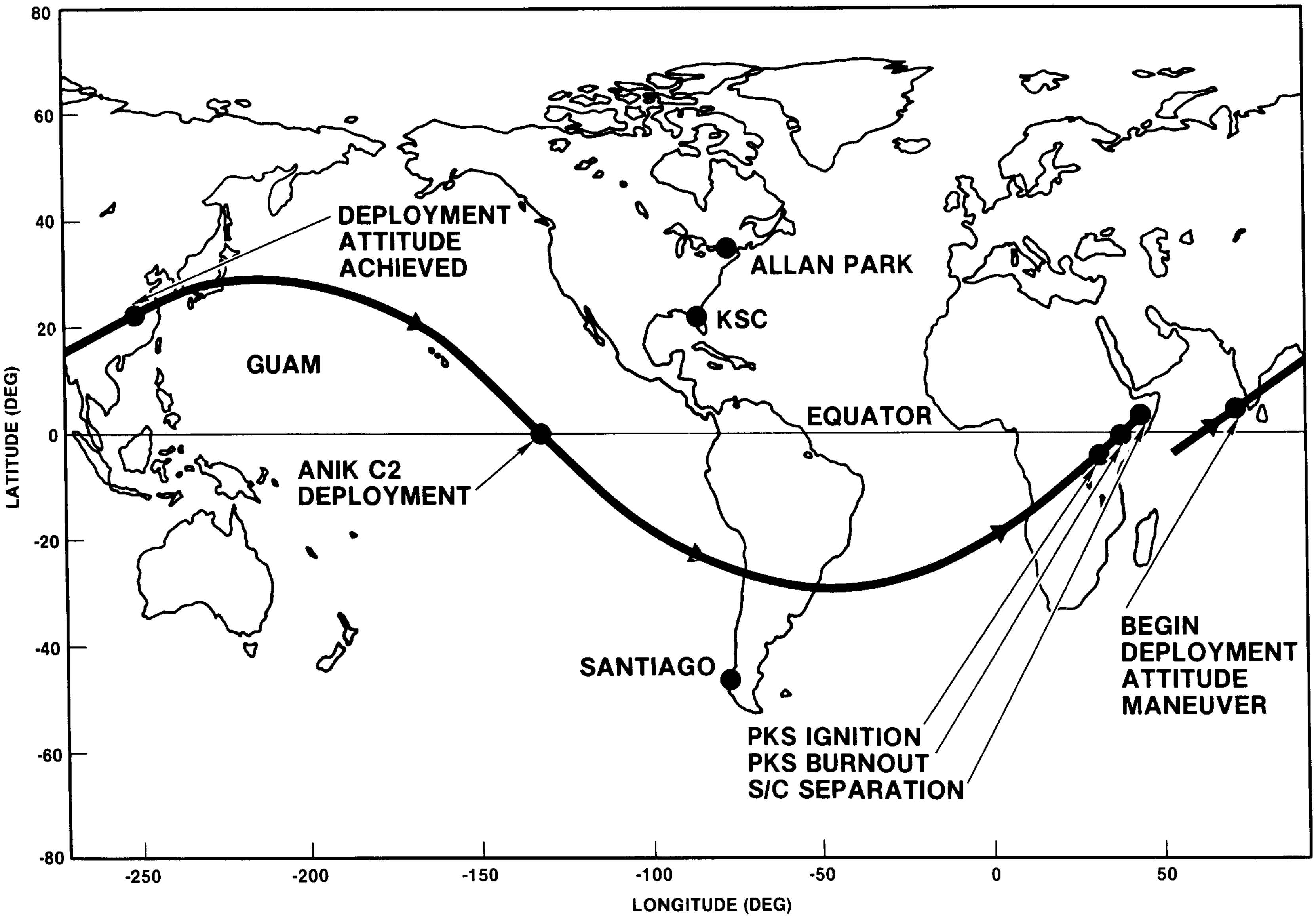
The Telesat Satellite Control Center, Analysis Center and Computer Center are located at Telesat Headquarters in Ottawa, Ontario.

Each Anik-C satellite measures more than 6.4 meters (21 feet) tall with concentric solar skirts and antennas fully deployed.

NASA's responsibility for the launch mission is completed upon the satellite's ejection from the orbiter, except for tracking of the payload until the PAM is fired.



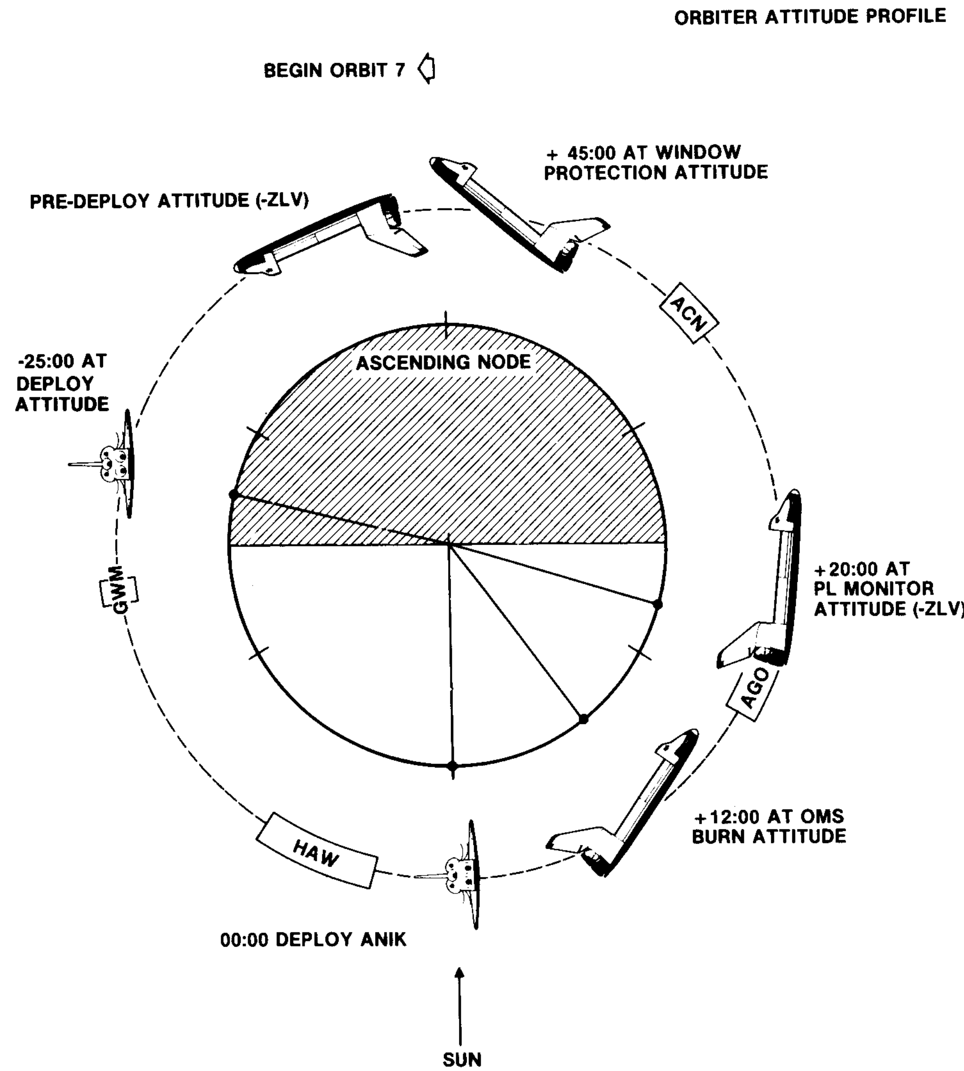
Anik-C2 Mission Scenario



Anik-C2 Deployment and PKS Firing

ORBIT 7 EVENTS

−45:00	BEGIN ORBIT 7
−40:00	INITIATE MANEUVER TO DEPLOY ATTITUDE
−28:00	SUNRISE
−25:00	AT DEPLOY ATTITUDE
−21:00	TO −20:00 GUAM CONTACT
−15:00	MECHANICAL SEQUENCE START
−11:00	TO −04:00 HAWAII CONTACT
−03:00	TERMINAL SEQUENCE START
00:00	DEPLOY ANIK
+03:00	INITIATE MANEUVER TO OMS BURN ATTITUDE
+15:00	OMS SEP BURN
+15:00	TO +21:00 SANTIAGO, CHILE CONTACT
+18:00	INITIATE MANEUVER TO PAYLOAD MONITORING ATTITUDE
+25:00	SUNSET
+29:00	INITIATE MANEUVER TO WINDOW PROTECTION ATTITUDE
+32:00	TO +34:00 ASCENSION CONTACT
+45:00	PAM PERIGEE MOTOR FIRING INITIATE INERTIAL ATTITUDE HOLD



Telesat-F Deployment

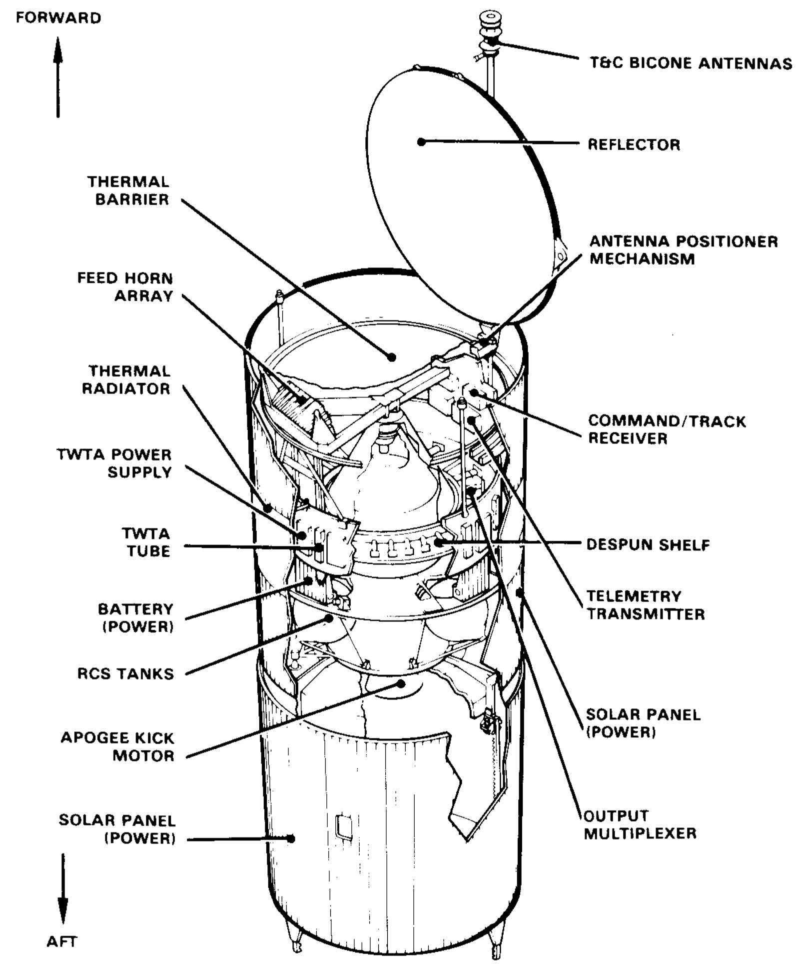
PALAPA-B1

PALAPA-B1 is a second generation communications satellite for Indonesia. PALAPA satellites have electronically linked Indonesia's 13,677 islands that curve along the equator for 5,100 kilometers (3,400 miles) and brought advanced telecommunications to the nations 150 million inhabitants which speak over 250 languages besides the national language Bahasia Indonesia and encompasses a variety of cultures. The expression "PALAPA" denotes Indonesian national unity. The name derives from the historic amuktl palapa oath. Amuktl palapa in ancient Javanese means to relax after exertion.

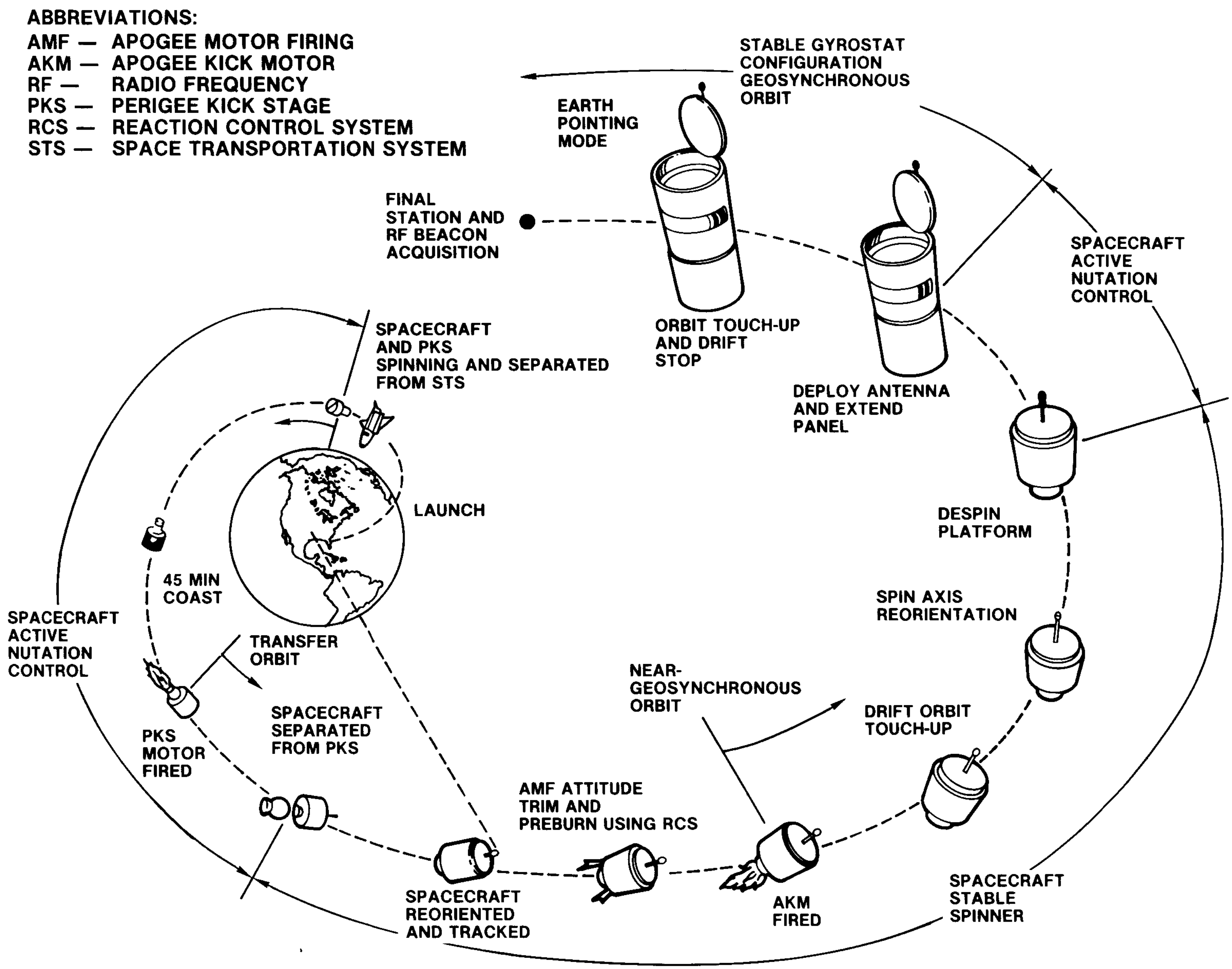
The Indonesian government demonstrated foresight in recognizing early that communication satellites were the most economical and efficient way to handle geographic barriers and electronically link the people of Indonesia and other members of the Association of Southeast Asian Nations (ASEAN).

PALAPA-B satellites are built by Indonesia by Hughes Aircraft Company Space and Communications Group of El Segundo, Calif. The $74.5 million fixed price contract calls for delivery of two spacecraft and their associated perigee stage vehicles under contract to PERUMTEL, Indonesia's state owned telecommunications company. Approximately six percent of the total price is paid on an incentive basis, and is dependent on satisfactory communications performance over a full eight year mission life.

PERUMTEL records as an example, show that between 1976 and 1981, long-distance telephone traffic increased from 1.3 million to 4.2 billion pulses with PALAPA-A. The seven-year service of PALAPA-A is now drawing to a close and the launch of the second generation PALAPA-B satellites assure continuity of communication services and supply expanded capacity to accommodate future growth. The PALAPA system has contributed to government goals for national betterment. Television and radio broadcasts disseminate government policies and information, educational programs, and entertainment. Instantaneous communications and satellite-related job opportunities, direct and indirect, stimulate regional, national, and international economic activity. In addition, PALAPA system assists on the vigilant defense of Indonesia's national security.



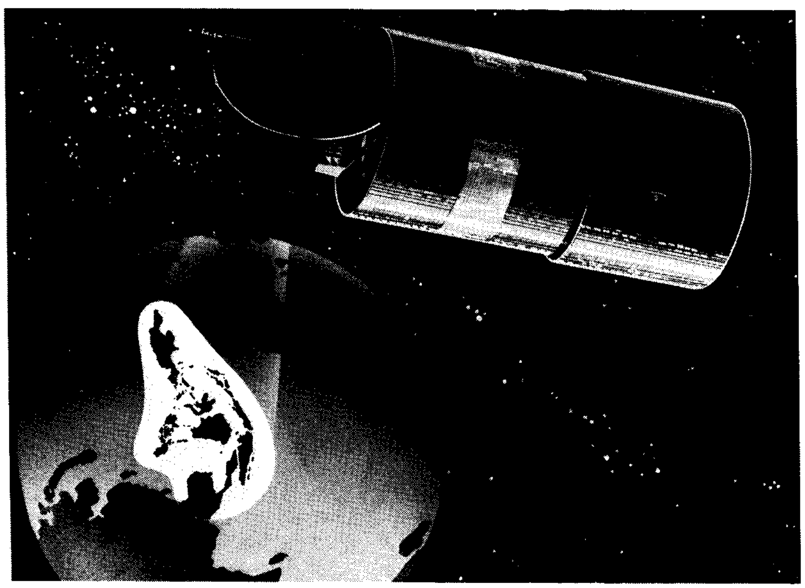
PALAPA-B1 Deployed



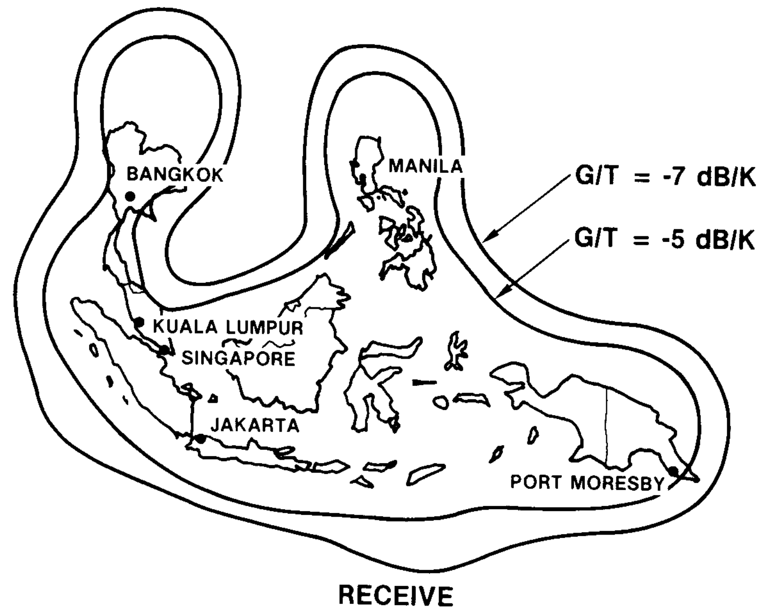
PALAPA-B1 Mission Scenario

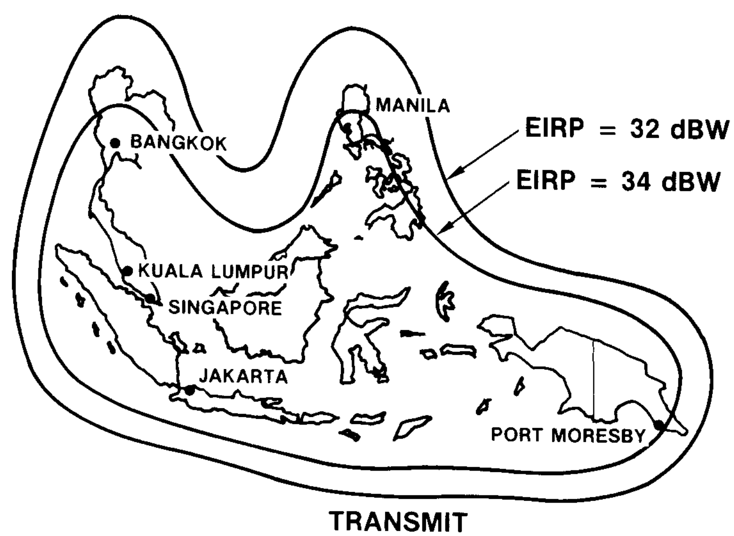
A separate $5.4 million contract between PERUMTEL and Hughes Aircraft Systems International provides for ground equipment, services, and training. The master control station in Cibinong near Jakarta, functions as the center of the system and will be expanded and necessary modifications will also be made at Banduring and Cilacap ground stations. The master control station tracks and sends commands to the satellites and controls the telephone and television networks. New radio, control, and computer equipment has been added to the master control station for the expansion to the second generation PALAPA-B satellites. PERUMTEL staff will continue to be entirely responsible for operation and maintenance of the PALAPA system.

PALAPA-A was inaugurated with 40 ground stations to meet the expanding requirements of PERUMTEL and other users, a network of 125 earth stations are now in operation. The increased power of PALAPA-B makes it possible to utilize stations with antennas 3 to 4.5 meters (9 to 14 feet) in diameter, as opposed to the 10 meter (32 feet) antennas at the original stations.



PALAPA-B1 On Station at Geosynchronous Orbit

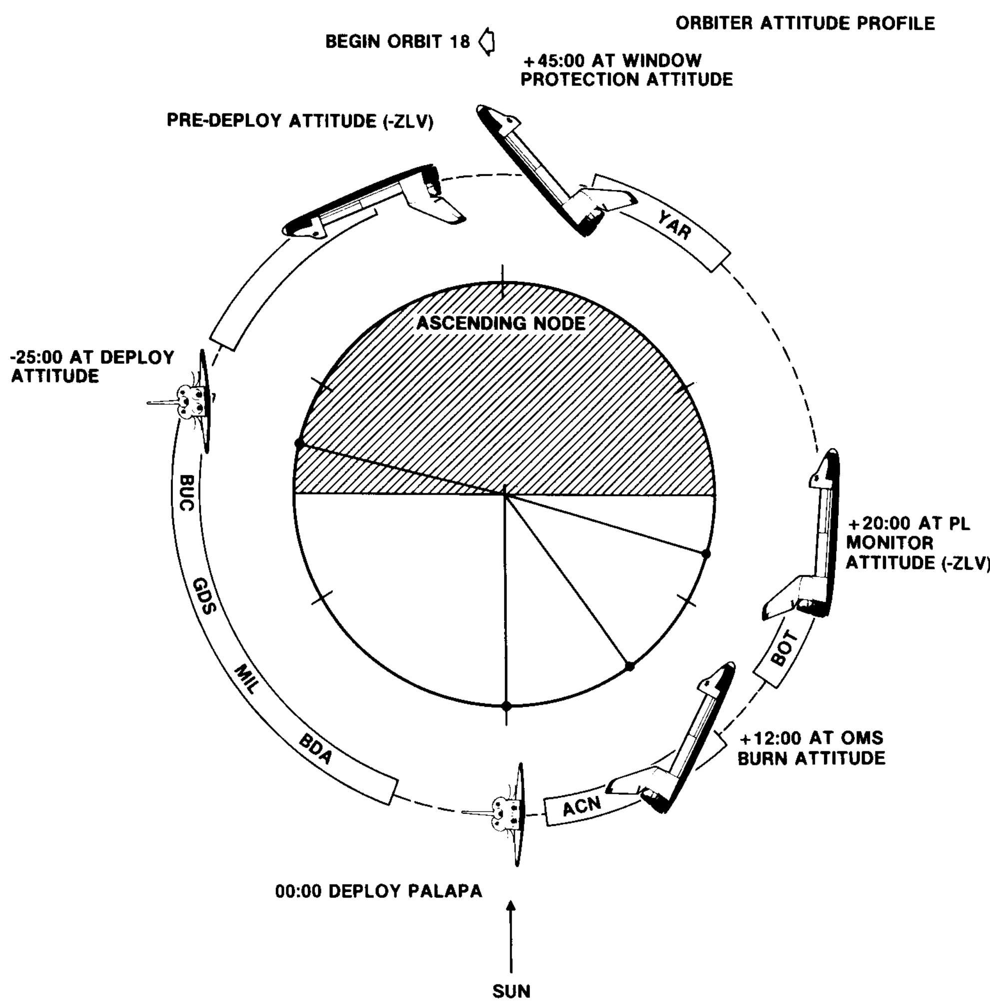




PALAPA-B Coverage

ORBIT 18 EVENTS

−45:00	BEGIN ORBIT 18
−40:00	INITIATE MANEUVER TO DEPLOY ATTITUDE
−28:00	SUNRISE
−37:00	TO −28:00 HAWAII CONTACT
−26:00	TO −18:00 BUCKHORN CONTACT
−25:00	TO −16:00 GOLDSTONE CONTACT
−25:00	AT DEPLOY ATTITUDE
−15:00	MECHANICAL SEQUENCE START
−18:00	TO −09:00 MILA CONTACT
−14:00	TO −07:00 BERMUDA CONTACT
−03:00	TERMINAL SEQUENCE START
00:00	DEPLOY PALAPA-B1
+02:00	TO +10:00 ASCENSION CONTACT
+03:00	INITIATE MANEUVER TO OMS BURN ATTITUDE
+13:00	TO +21:00 BOTSWANA CONTACT
+15:00	OMS SEP BURN
+18:00	INITIATE MANEUVER TO PAYLOAD MONITORING ATTITUDE
+25:00	SUNSET
+29:00	INITIATE MANEUVER TO WINDOW PROTECTION ATTITUDE
+34:00	TO +40:00 YARRAGADEE CONTACT
+45:00	PAM PERIGEE MOTOR FIRING INITIATE INERTIAL ATTITUDE HOLD



PALAPA-B1 Deployment

The two new PALAPA satellites are twice as big and have twice the capacity and four times the electrical power of the earlier built PALAPA-A satellites built by Hughes: The new satellites provide 24 transponders, twice the number of PALAPA-A. The 24 transponders provide 12,000 two-way telephone calls or 24 color television programs or combinations thereof. A conservative estimate as the transponder capacity required up through 1990 is 12 for Indonesia and nine for other ASEAN members. Thailand, Malaysia, the Philippines, and Singapore, a total of 21. The PALAPA-B satellites will bring improved quality and efficiency to the systems television, telephone, telegraph/telex, and data transmission services to Indonesia and the ASEAN members in addition to expanded coverage in remote and rural areas and to Papu, New Guinea either of the two PALAPA-B satellites could satisfy these requirements with three transponders to spare for evolving needs; two satellites in orbit afford the safeguard of a complete backup or redundancy of the space system.

The satellites will be placed in geosynchronous orbit, PALAPA-B1 at 108 degrees east longitude and PALAPA-B2 at 113 degrees east longitude.

The PALAPA-B satellites are similar to the Telesat satellites.

The PALAPA-B1 satellite in the STS-7 mission will nominally be deployed on the descending node of orbit 18 over the Atlantic ocean, mission elapsed time of day one at approximately two hours and three minutes. The predeploy, ejection and sequence of events for placement at geosynchronous orbit are similar to the Telesat-F sequences. PALAPA-B2 satellite is at present scheduled for the STS-11 mission.

Financing for the PALAPA-B satellites is provided by Eximbank in cooperation with major U.S. commercial banks.

SPAS (SHUTTLE PALLET SATELLITE) -01

SPAS-01 is the first reusable satellite to be taken into earth orbit and back. From *Challenger's* payload bay it will be deployed in space using the remote manipulator system then released allowing the SPAS-01 to fly as a free flyer. Several hours later it will be retrieved by the remote manipulator arm and berthed in *Challenger's* payload bay. SPAS-01 is also the first satellite from a private company in Europe that demonstrates how space flights can be used for private enterprise purposes.

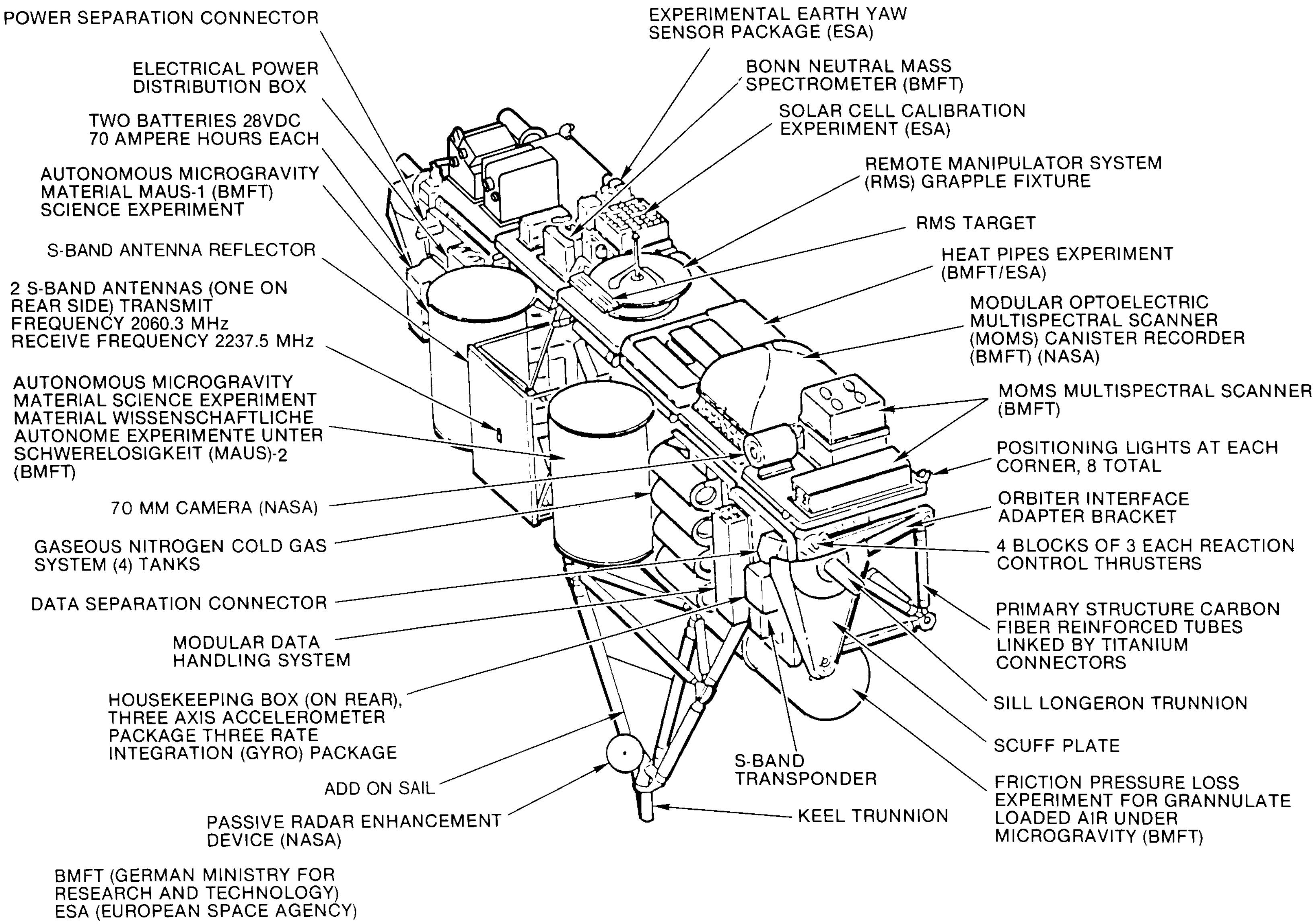
SPAS-01 was developed by the West German firm Messerschmitt-Boelkow-Blohm GmbH (MBB). NASA and MBB signed an agreement in June 1981 at MBB Space Division Headquarters in Bremen; Federal Republic of Germany for launch services to be provided by NASA. In addition to the use of the remote manipulator system. The German Federal Ministry of Research and Technology (BMFT) has promoted the SPAS-01 pilot project and contributed substantially to the funding.

Six scientific experiments from BMFT, the main customer and two from the European Space Agency (ESA), are the first European "passengers" on SPAS-01.

The third user of SPAS-01 is NASA. NASA is assuming a major part of the launch costs of SPAS-01. NASA will use SPAS-01 in testing the remote manipulator system deployment and retrieval operation and assess *Challenger's* operating behavior when deploying and recovering SPAS-01. NASA has equipped SPAS-01 with a 70 millimeter Hasselblad photo camera, a 16 millimeter film camera and an color/black/white television camera. These cameras will record *Challenger's* entire operational behavior for the first time from a platform outside the spacecraft. In addition NASA can record SPAS-01's flight behavior from cameras aboard the *Challenger*. SPAS-01 is controlled by its onboard stabilization and control system during the free flyer operation.

Total development and production costs for the basic SPAS is about $13 million including cost of the first launch. Another $8 to $10 million has been spent for the experiment packages on SPAS-01. MBB expects BMFT and ESA to pay about $7 million for the first flight. NASA is providing about $2.5 million in launch services. All but $4 million of the total MBB development costs will be returned in the first flight and SPAS-01 will be available for a second flight after minor refurbishing. MBB believes that its recoverable and reusable satellite will verify in this flight its capability to support both commercial and scientific research packages and lower costs sufficiently to open space to a new group of users. MBB designed the basic SPAS to be reused in space for at least five separate missions.

SPAS-01 structure is 4.2 meters (13.7 feet) long and 0.7 meters (2.2 feet) wide. Fully equipped SPAS-01 weighs 1,500 kilograms (3,307 pounds) and is 1.5 meters (5 feet). SPAS-01 payload is 900 kilograms (1,984 pounds). The structure is constructed of carbon fiber tubes 60 millimeters (2.3 inches) in diameter and 0.7 meter (2.2 feet) in length linked by titanium connectors. The tubes form a grid structure composed of segments each measuring 0.7 x 0.7 x 0.7 meter (2.2 x 2.2 x 2.2 feet). The basic measurement can be used in any way required. The SPAS-01 structure is statically attached by three trunions in *Challenger's* payload bay. Two trunions are attached to *Challenger's* payload bay port and starboard longeron sill and one trunion to *Challenger's* keel fitting at orbiter station X_O 895.93. Other subsystems are also modular, such as, power supply, data processing and attitude stabilization. The data handling system is a multiredundant modular digital system (MODUS). This "brain" of the system covers telemetry, encoding and decoding as well as attitude control logic tasks. SPAS-01 also has radio and radar facilities, 28 Vdc battery power and can provide a gravity gradient or gas nozzle attitude control system. The reaction control thrusters are made up of four blocks of three each for a total of 12 thrusters.



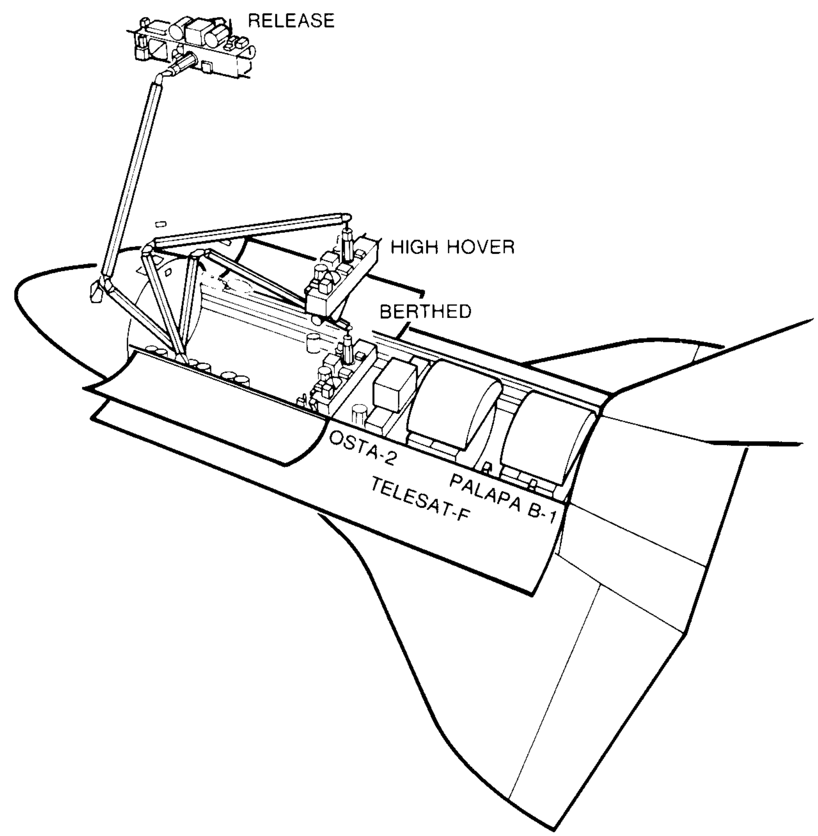
Shuttle Pallet Satellite (SPAS) -01 Configuration

Two mission phases are planned for SPAS-01. In the first phase, some of SPAS-01 experiments will be used for scientfic research while attached to *Challenger's* payload bay. The second phase is the free flyer phase in which SPAS-01 will be used as a test article and also some of SPAS-01 experiments will be operated during free flight.

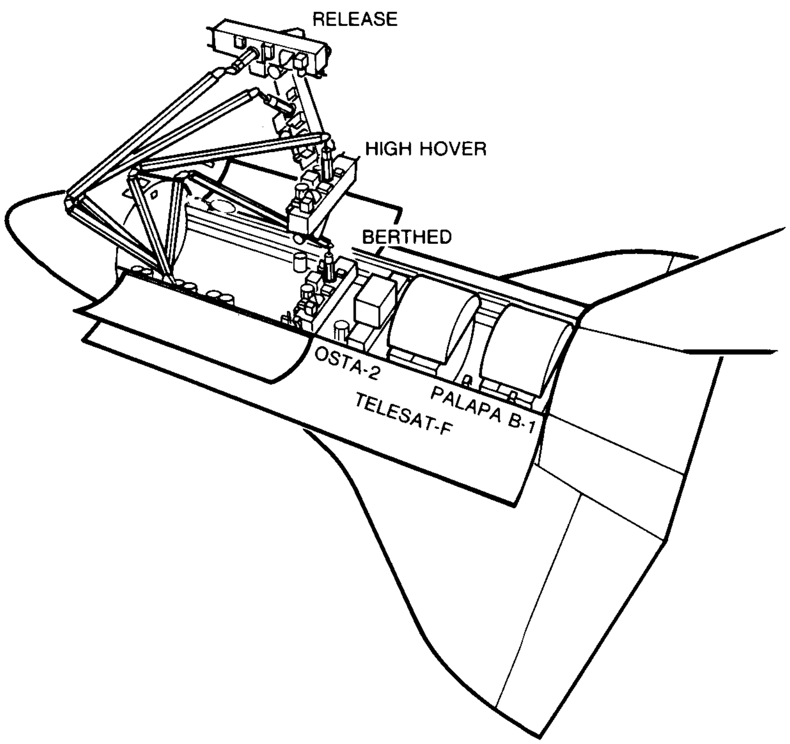
SPAS-01 will be grappled by the remote manipulator system (RMS) in *Challenger's* payload bay then released from the payload bay longeron sill and keel fitting retention mechanisms by electrical motors. The RMS will unberth SPAS-01 and will maneuver SPAS-01 over *Challenger's* payload bay. SPAS-01 will be automatically released from the RMS then captured. Then SPAS-01 will be released manually from the RMS arm allowing it to be in a "free flyer mode." In "free flyer" proximity operations, SPAS-01 is supported by its own subsystem power, attitude control (cold gas-compressed nitrogen) thrusters, data handling and telemetry/command, position lights, and markings to facilitate *Challenger* proximity test operations.

In the first free flyer proximity mode, *Challenger* will drift down and forward of SPAS-01 approximately 304 meters (1,000 feet). During this sequence long range skin tracking and radar tests are accomplished between *Challenger and SPAS-01*. *Challenger* will then approach SPAS-01 and the RMS will automatically capture SPAS-01 over the payload bay. SPAS-01 is then released and rotated, followed by capture. Mission specialist John Fabian is controlling the RMS in this first free flying proximity mode operation.

Approximately one hour later, SPAS-01 will again be released from the RMS in a free flyer mode. SPAS-01 is released from the RMS in a simulated back-up mode over the crewman optical alignment sight (COAS). *Challenger* will fly forward, up and down to a distance of approximately 60 meters (200 feet) from SPAS-01. During this inertial fly around, *Challenger's* reaction control system (RCS) upward engines will be fired at nine different locations to determine *Challenger's* RCS engine (plume survey) effects on SPAS-01 at a distance of approximately 10 to 30 meters (35 to 100 feet) (it is noted that SPAS-01 will be held in attitude control by its own system). During this sequence, short range skin and radar tests are accomplished. *Challenger* will then appraoch and capture SPAS-01 with the RMS over the COAS automatically. This will be followed by a release of SPAS-01 automatically, followed by a single RMS joint track and capture of SPAS-01 by the RMS over COAS. SPAS-01 will then be deactivated and berthed in the payload bay, latched at the orbiter longeron sill and keel fitting by elec-



Release Over payload Bay



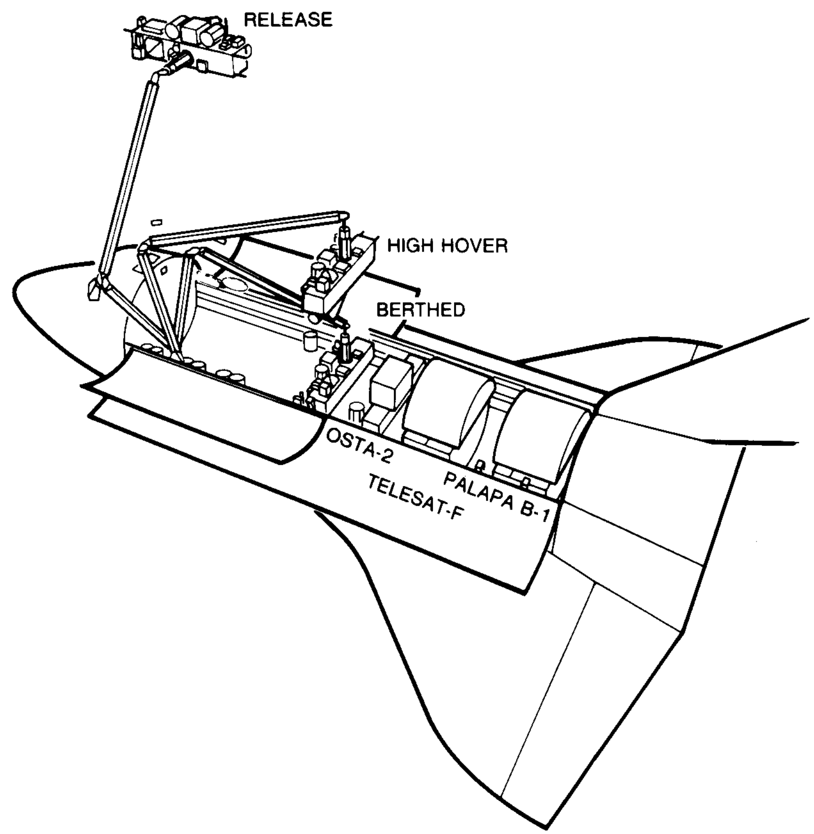
Release Over Crewman Optical Alignment Sight (COAS)

trically operated retention mechanisms. SPAS-01 will be released then by the RMS and the RMS will be berthed and powered down ending the proximity operations. Mission Specialist Sally Ride is controlling the RMS in this second free flying proximity mode operation.

The two free flyer proximity operations with SPAS-01 will be evaluated in preparation for the Solar Maximum Mission repair in the STS-13 flight.

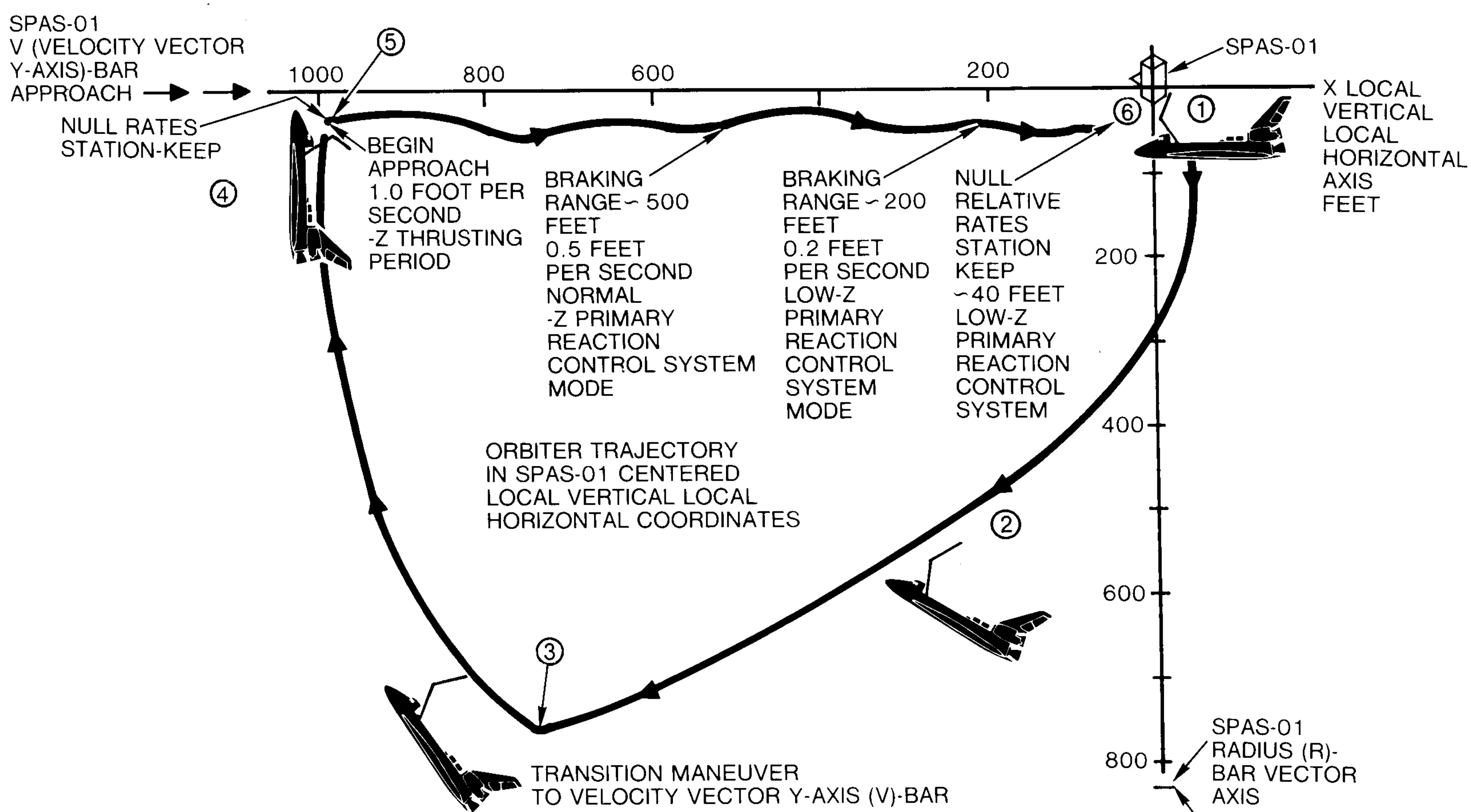
SPAS-01 EXPERIMENTS

The Materialwissenschaftleche Autonome Experiments unter Schwerelosigkist (MAUS) 1 and 2 sponsored by the



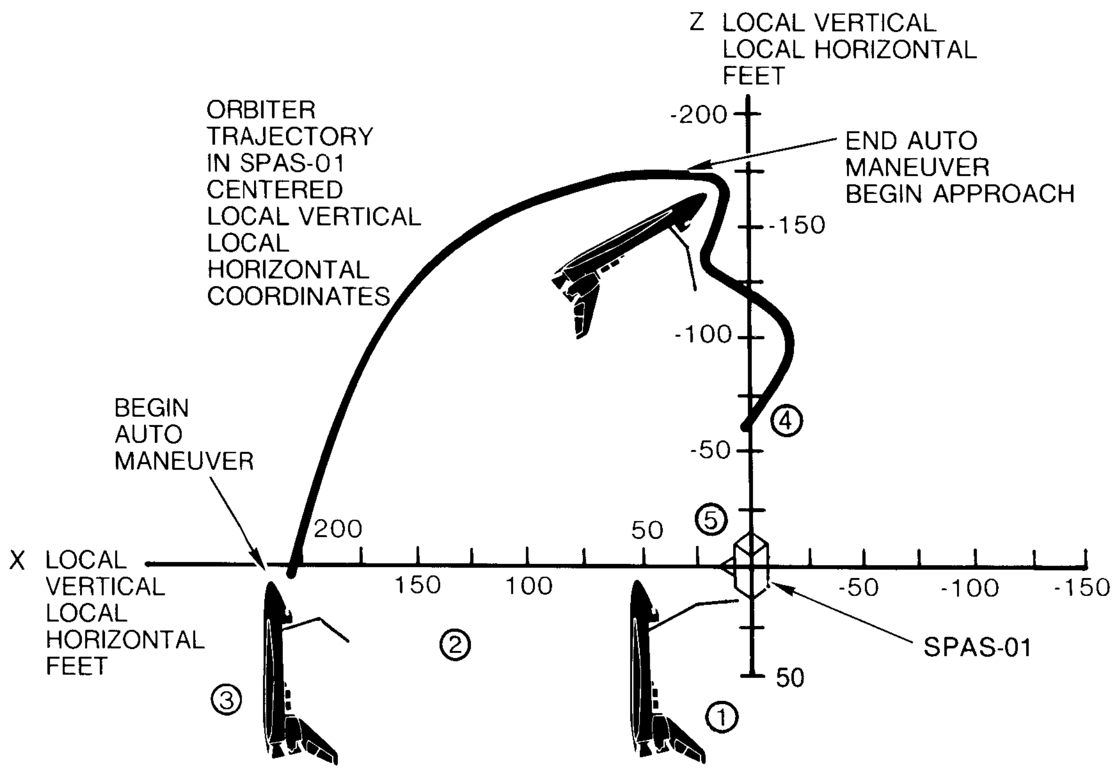
Release and Capture in Single Joint Over Crewman Optical Alignment Sight (COAS)

German Federal Ministry for Research and Technology (BMFT) utilize Getaway Special (GAS) type systems with their own internal batteries and microprocessors. MAUS 1 will test microgravity processing of a new permanent magnet alloy using the properties of two metals (bismuth and maganese) that are difficult to mix on earth. MAUS 2 will measure oscillatory maragoni convection in fusion processes under micro-gravity conditions, a basic experiment concerned with crystal growing in space. These two experiments will be conducted when SPAS-01 is deployed from *Challenger* due to *Challenger's* mass



EVENT		DAY/HR:MIN
①	SPAS CHECKOUT	3/18:49
	RMS ACTIVATION	3/19:07
	GRAPPLE	3/20:10
	SPAS FINAL RELEASE	3/21:02
②	DRIFT TO 1,000 FEET	3/21:25
③	TRANSITION TO V-BAR	3/21:35
④	LONG RANGE SKIN AND RADAR TESTS	3/22:02
⑤	V-BAR APPROACH	4/00:02
⑥	GRAPPLE	4/00:40

SPAS-01 Proximity Operations



EVENT		DAY/HR:MIN
①	SPAS RELEASE	4/01:47
②	ORBITER REACTION CONTROL SYSTEM PLUME DATA TAKE BY SPAS	4/01:56
③	SHORT RANGE SKIN AND RADAR TESTS	4/02:52
④	INERTIAL APPROACH	4/03:57
⑤	BERTH SPAS	4/04:16
	PROXIMITY OPERATIONS COMPLETE	4/04:37

SPAS-01 Proximity Operations
Inertial Fly Around Approach

and stabilization movements will provide gravity that will affect the findings.

The friction loss experiment sponsored by BMFT is an autonomous experiment designed to determine effects of gravity on ground-based pneumatic conveyor systems by studying such systems in a nongravity environment. This experiment must also be conducted when SPAS-01 is deployed from the *Challenger* due to *Challenger's* mass and stabilization movements will provide gravity that will effect the findings.

Modular Optoelectronic Multispectral Scanner (MOMS) sponsored by BMFT is an electronic remote sensing camera. It will provide pictures of *Challenger* in orbit taken from SPAS-01 when in free flyer mode, so that contaminates inside *Challenger's* payload bay can be compared with those in free space. In addition, MOMS will be used to scan the greatest land mass and since the camera operating time is limited and the imaging will not penetrate cloud cover, scientists will use images from the Meteosat as a real-time indicator to determine when the SPAS-01 based camera should operate. MOMS was developed by MBB as a candidate for European remote sensing program.

The Bonn Neutral Mass Spectrometer experiment is a double-focusing magnetic mass spectrometer designed to measure the intensity and composition of gaseous contaminates in the *Challenger* payload bay and vicinity. The experiment is prepared by University of Bonn with support from BMFT.

Heat pipe experiment sponsored by BMFT tests heat pipes with capillary feed under microgravity conditions to improve design basis for such systems for terrestrial and space applications.

Yaw earth sensor package sponsored by ESA is a demonstration model of a sensor capable of measuring the yaw angle of a spacecraft that is stabilized in two axis for later use in operational systems. The system would allow reductions in the complexity of attitude control systems.

Solar cell calibration experiment sponsored by ESA is to measure various solar cells in the sun's direct, undisturbed rays as calibration standards for solar simulation systems on earth.

PAYLOAD RETENTION MECHANISMS

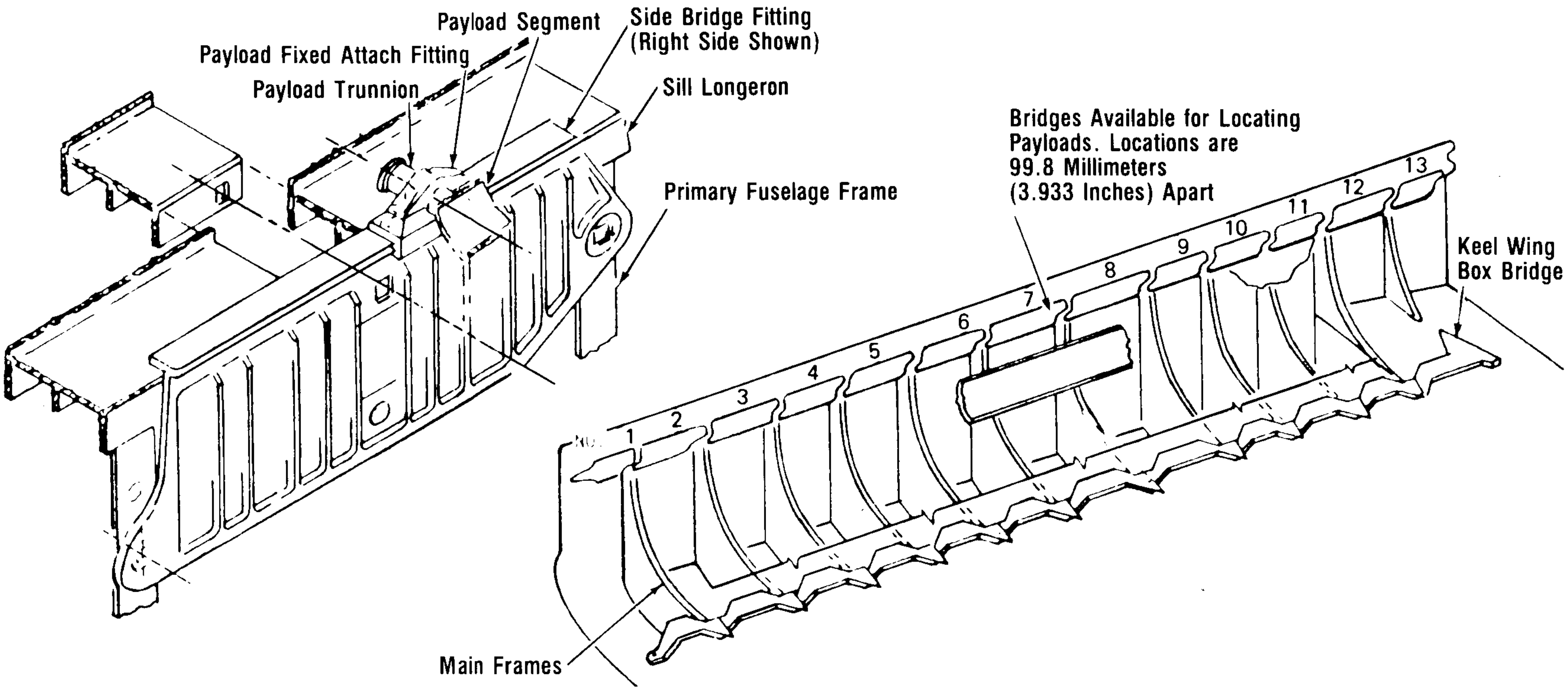
Nondeployable payloads are retained by passive retention devices, whereas, deployable payloads such as SPAS-01 are secured by motor-driven, active retention devices.

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

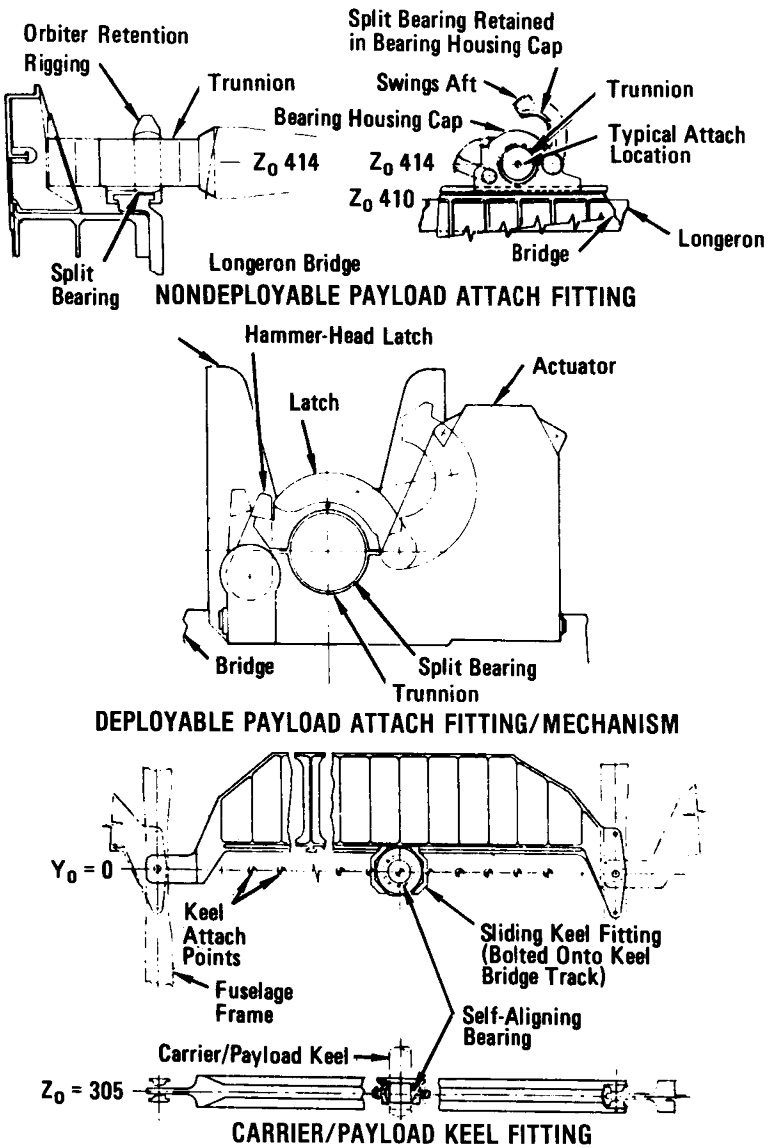
The orbiter payload retention system provides three-axis support for up to five payloads per flight.

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

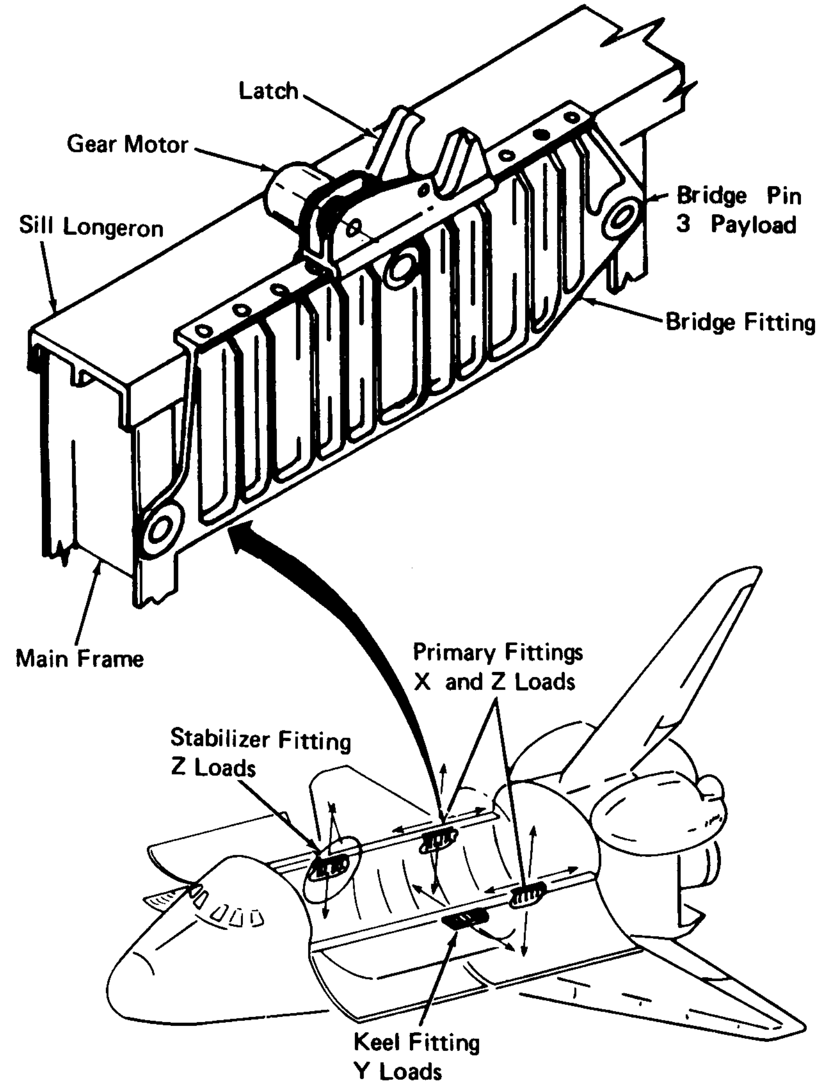
Attachment points in the payload bay are in 99-millimeter (3.933-inch) increments along the left- and right-side longerons and along the bottom centerline of the bay. Of the potential 172 attach points on the longerons, 48 are unavailable because of the proximity of spacecraft hardware. The remaining 124 may be used for carrier/payload attachment: of these, 16 may be used for deployable payloads. Along the centerline keel, 89 attach points are available, 75 of which may be used for deployable payloads. There are 13 longeron bridges per side and 12 keel bridges available per flight. Only the bridges required for a par-



Payload Retention



Standard Attach Fittings for Payloads



Active Payload Retention System

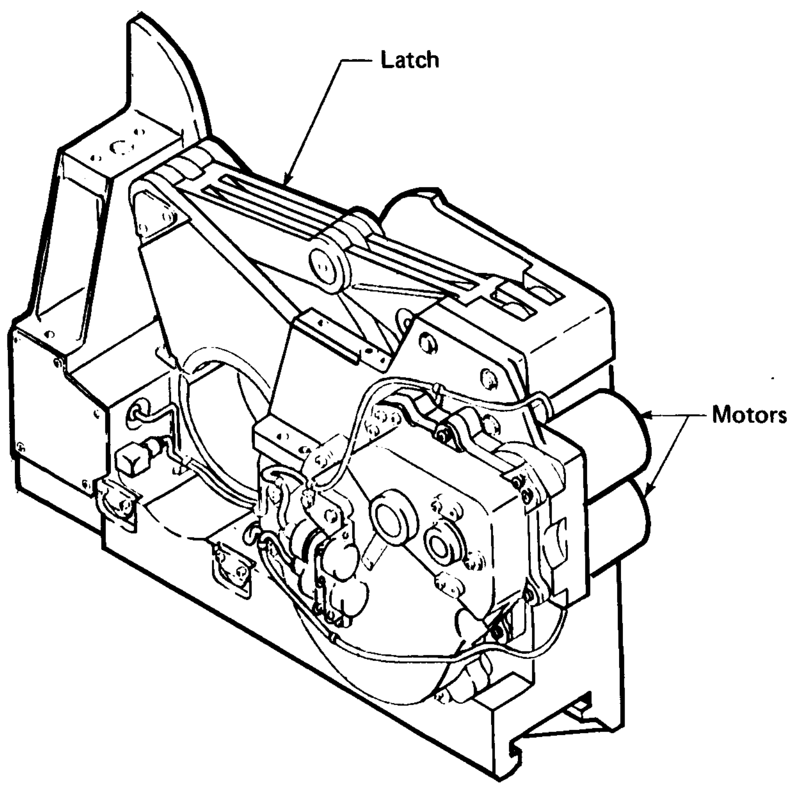
ticular flight are flown. The bridges are not interchangeable because of main frame spacing, varying load capability, and subframe attachments.

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

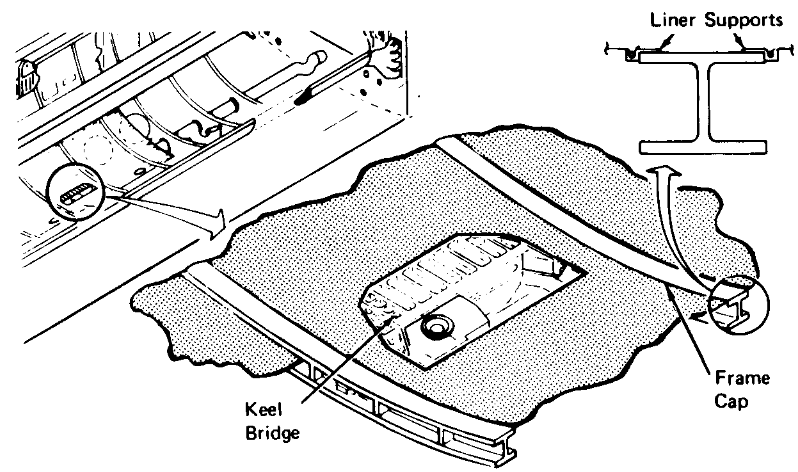
The payload trunnions are the interfacing portion of the payload with the orbiter retention system. The trunnions that interface with the longeron are 82 millimeters (3.25 inches) in diameter and 177.8 or 222.2 millimeters (7 or 8.75 inches) long, depending upon where they are positioned along the payload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

The orbiter/payload attachments are the trunnion/bearing/journal type. The longeron and keel attach fitting have a split, self-aligning bearing for nonrelease-type payloads in which the hinged half is bolted closed. For on-orbit deployment and retrieval of SPAS-01, the hinged half fitting releases or secures the payload by latches that are driven by dual redundant electric motors.

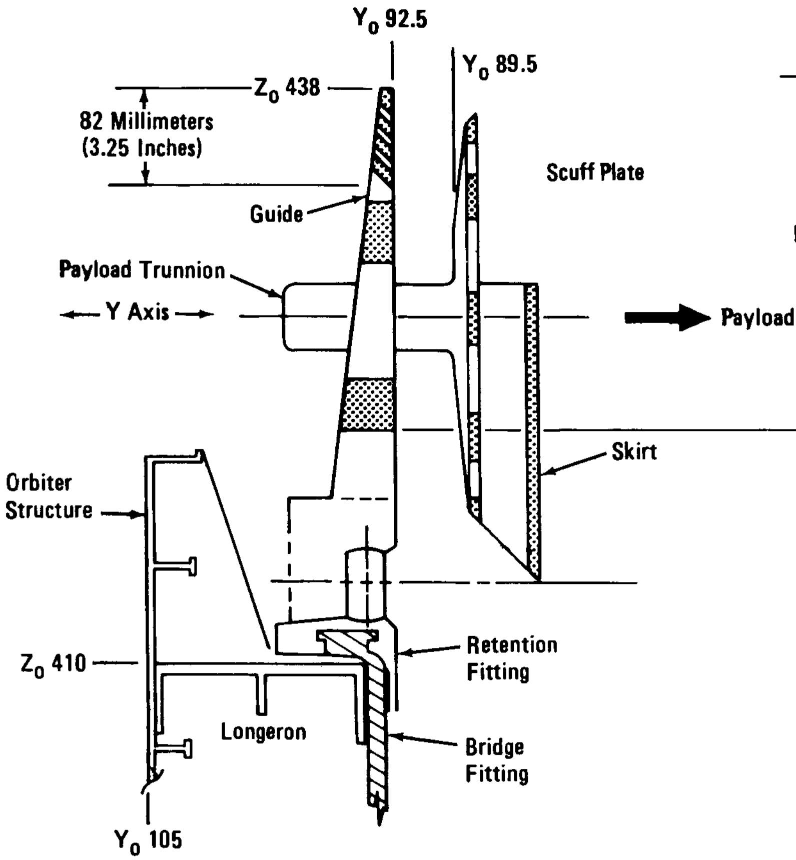
Payload guides and scuff plates are used to assist in deploying and berthing SPAS-01 in the payload bay. The payload is constrained in the X direction by guides and in the Y direction by scuff plates and guides. The guides are mounted to the inboard side of the payload latches and interface with SPAS-01 trunnions and scuff plates. The scuff plates are attached to the SPAS-01 trunnions and interface with the SPAS-01 guides.



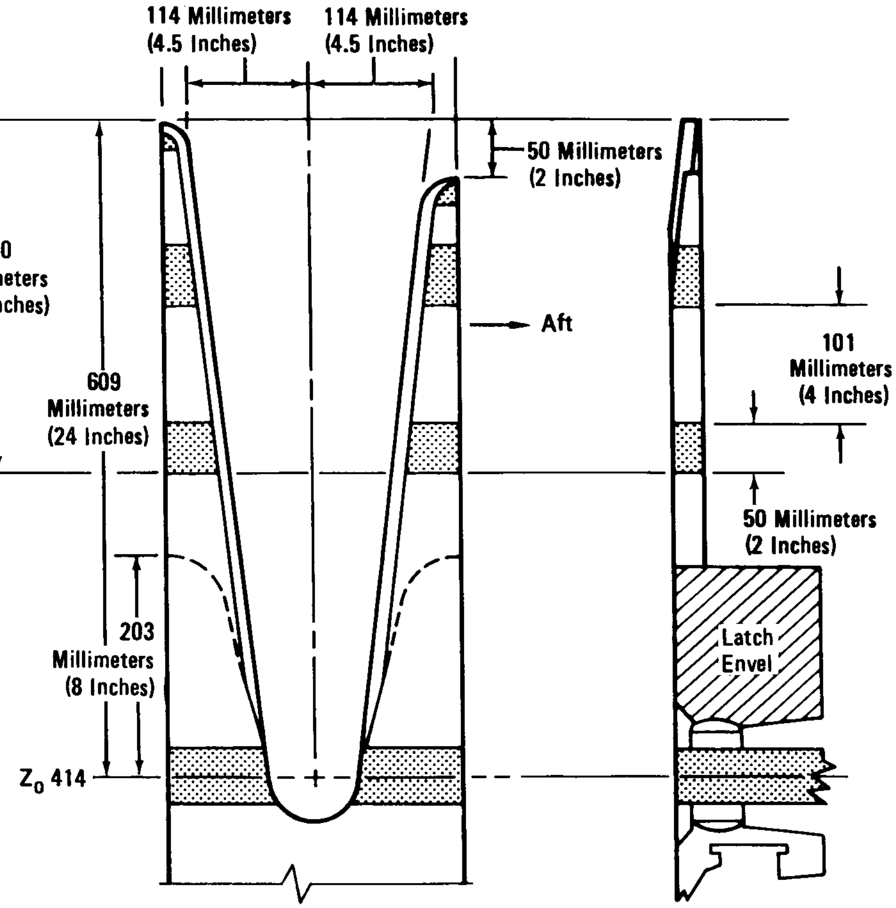
Payload Retention Latch



Active Keel Fitting



Orbiter Payload Guide and Trunnion/Scuff Plate (Nominal)



Orbiter Active Latch Guide

The guides are V shaped with one part of the V being 50.8 millimeters (2 inches) taller than the other part. Parts are available to make either the forward or aft guide, the tallest. This difference enables the operator monitoring the berthing or deployment operations through the aft bulkhead TV cameras to better determine when the SPAS-01 trunnion has entered the guide. The top of the tallest portion of the guide is 609.6 millimeters (24 inches) above the centerline of the payload trunnion when it is all the way down in the guide. The top of the guide has a 228.6-millimeter (9-inch) opening. These guides are mounted to the 203.2-millimeter (8-inch) guides that are a part of the longeron payload retention latches.

The payload scuff plates are mounted to the SPAS-01 structure. There are two longeron latches and a keel latch for on-orbit deployment and retrieval of SPAS-01. These latches are controlled by dual redundant electric motors with either or both motors releasing or latching the mechanism. The operating time of the latch is 30 seconds with both motors operating or 60 seconds with one motor operating. The latch/release switches on the aft flight deck display and control panel station control the latches. Each longeron latch has two microswitches sensing the ready-to-latch condition. Only one is required to control the ready-to-latch talkback indicator on the aft flight deck display and control panel station. Each longeron latch also has two microswitches to indicate latch and two to indicate release. Only one of each is required to control the latch or release talkback indicator on the aft flight deck display and control panel station. The keel latch also has two microswitches that sense when the keel latch is closed with the trunnion in it. Only one of the switches is required to operate the talkback indicator on the aft flight deck display and control panel station. The keel latch also has two microswitches that verify if the latch is closed or open, with only one required to control the talkback indicator on the aft flight station display and control panel station.

It is noted that the keel latch centers the SPAS-01 in the yaw direction in the payload bay; therefore the keel latch must be closed before the longeron latch is closed. The keel latch can float plus or minus 69 millimeters (plus or minus 2.75 inches) in the X direction.

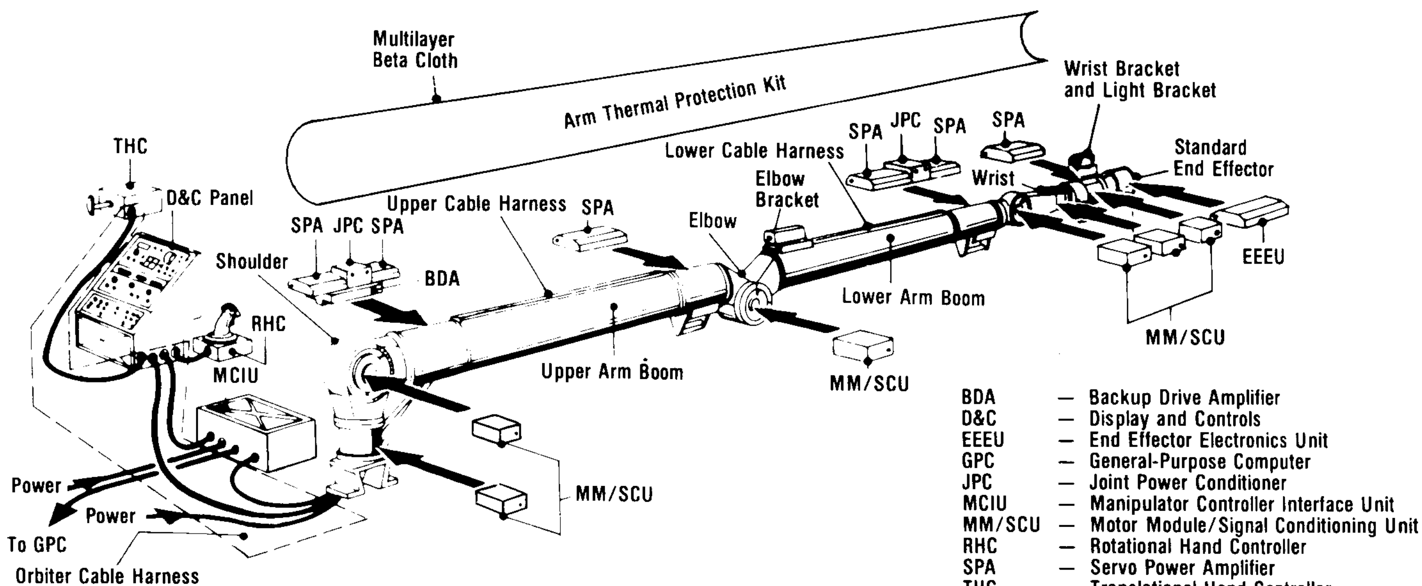
The remote manipulator system (RMS) is the mechanical arm portion of the payload deployment and retrieval system (PDRS) that maneuvers a SPAS-01 from the payload bay to its deployment position and then releases it. It can also grapple SPAS-01 in a free-flying payload, maneuver it to the payload bay, and berth it.

The basic RMS configuration consists of a manipulator arm, an RMS display and control panel (including rotation and translation hand controls), and a manipulator controller interface unit which interfaces with the orbiter computer. The manipulator arm is installed on the port (left) side longeron of the orbiter payload bay.

The fifth onboard computer controls the RMS. The RMS takes up 32 percent of the CPU (computer processor unit) in the one computer for RMS operation and 30 percent for manual augmented operation. The RMS is a simple software package (computer programs) and a simple set of display and control panel hardware at the flight deck aft station.

The manipulator arm is 15 meters, 76.2 millimeters (50 feet, 3 inches) in length, 381 millimeters (15 inches) in diameter, and has six degrees of freedom. In conjunction with handling aids, it can remove and install a 4.5-meter (15-foot diameter), 18-meter (60-foot) long, 29,484-kilogram (65,000-pound) payload. The arm weight is 410 kilograms (905 pounds) and the total system weight is 450 kilograms (994 pounds). The RMS will rotate 31.36 degrees towards the payload bay doors when opened and rotates 31.36 degrees towards the payload bay so the payload bay doors can be closed.

The RMS arm consists of joint housing, electronics housing, arm booms, and shoulder brace. There are two booms: the upper, which connects the shoulder and elbow joints, and the



RMS Components

lower, which connects the elbow and wrist joints. The booms are made of graphite/epoxy, 330 millimeters (13 inches) in diameter, by 5 meters (17 feet) and 6 meters (20 feet) respectively, attached by metallic joints. The composite weight in one arm is 42 kilograms (93 pounds). The joint and electronic housings are made of aluminum alloy. A shoulder brace, used only during launch, minimizes high pitch axis moment loading on the shoulder pitch gear train. The shoulder brace is unlatched by a switch located on the aft flight deck display and control panel.

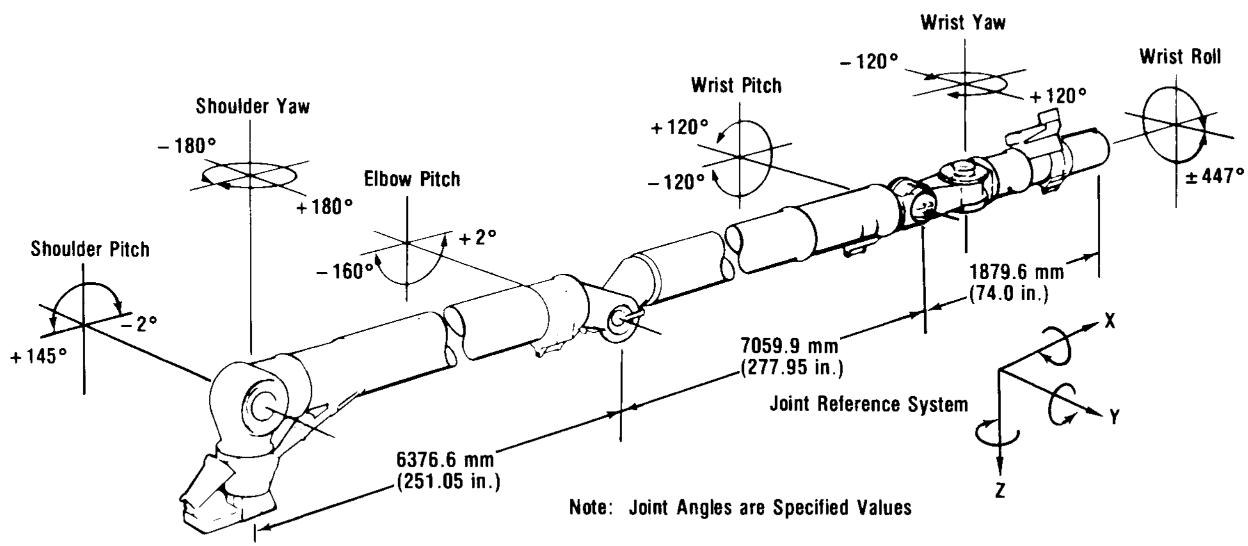
The RMS operates with a standard SPAS-01 end effector. The standard end effector can grapple SPAS-01, keep it rigidly attached as long as required, and then release it.

The standard end effector has two functions: capture/release and rigidize/derigidize. Capture/release is accomplished by rotating an inner cage assembly containing three wire snares to open and close around the SPAS-01 mounted standard grapple fixture. A switch on the back of the RMS rotation hand controller (RHC) commands capture or release. Rigidize/derigidize is accomplished by drawing the snare assembly into the rear of the end effector or moving the snares forward toward the open end of the effector. In the automatic mode, rigidization is automatic; when manually operated, a switch on the aft flight deck station display and control panel is used to rigidize or derigidize the effector.

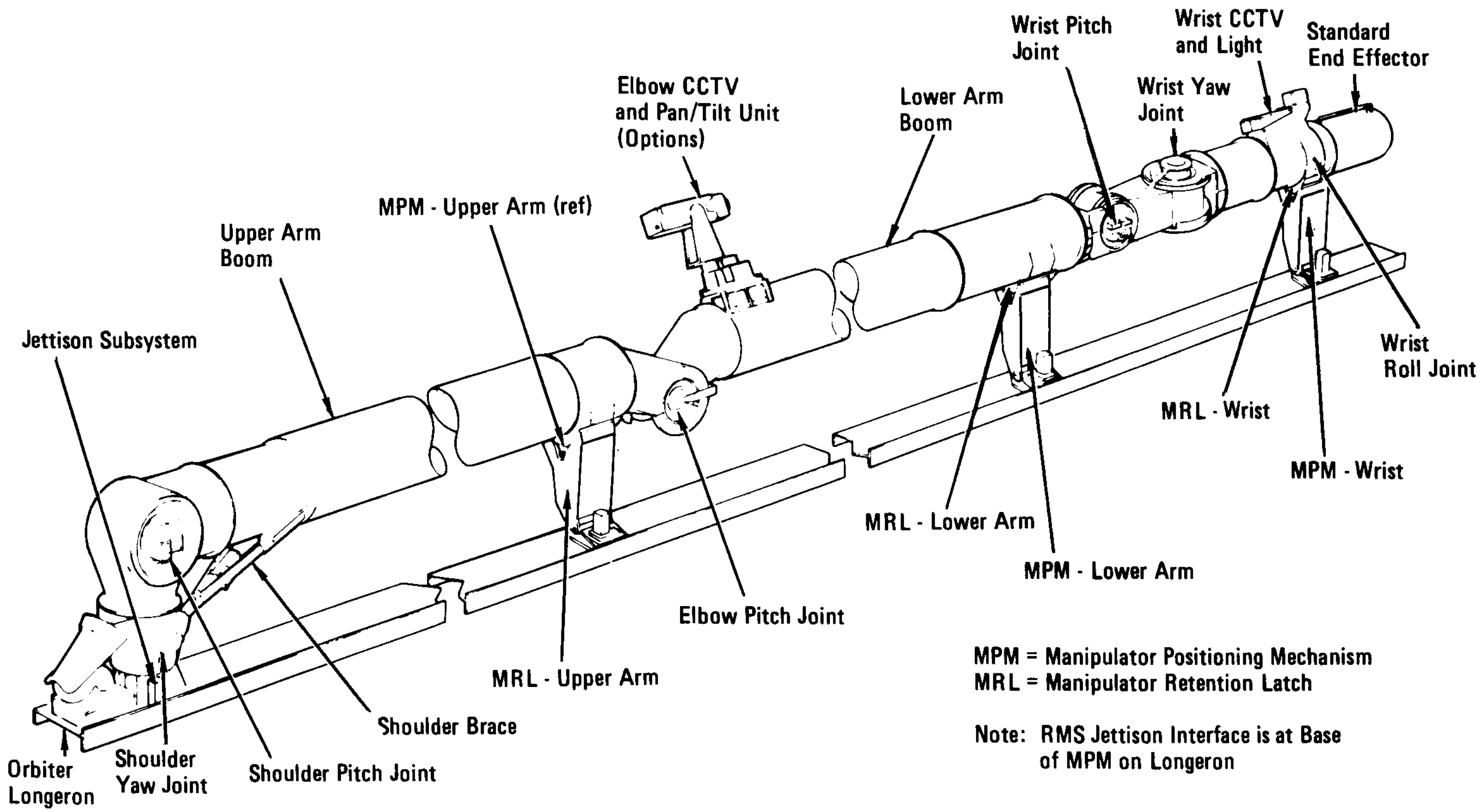
The end effector generates six data signals corresponding to the following indications: snares fully open, snares full closed, payload present, carriage fully extended, maximum tension level crossed, and zero tension crossed.

The arm has a closed-circuit TV camera and a viewing light on the wrist section, as well as closed-circuit TV camera and a pan and a tilt unit at the elbow lower arm transition.

The RMS operator controls arm position and attitude by viewing it through the aft or overhead windows at the aft flight deck station, as well as by using closed-circuit TV from both the arm and payload-bay-mounted cameras. Two closed-circuit TV monitors at the aft flight deck station have split-screen capability.



Mechanical Arm—Stowed Position and Movement Configuration



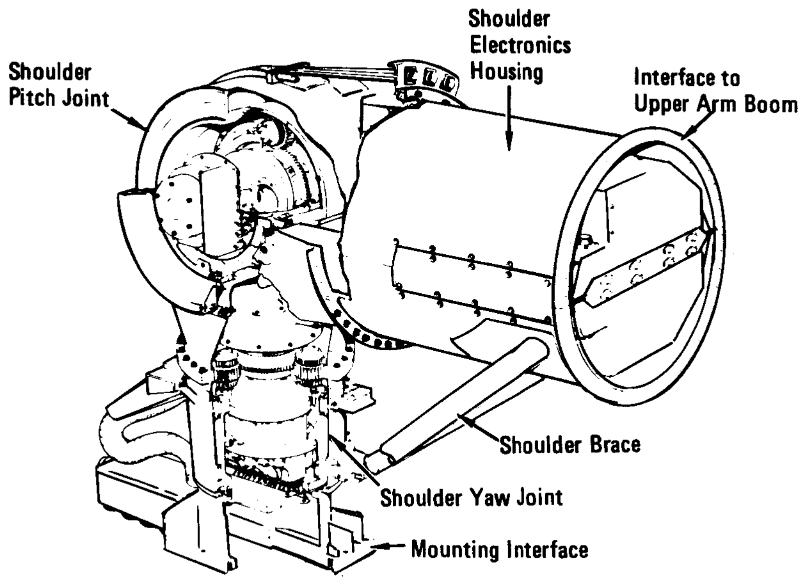
Mechanical Arm—Stowed Position and General Arrangement

The RMS has both passive and active thermal control systems. The passive system consists of multilayer insulation blankets and thermal coatings. The active system consists of 26 heaters on each arm that supply 520 watts of power at 28 Vdc. The heater system uses redundant buses on each arm, so if a failure occurs on one, the other is capable of supplying full heater power. The heaters operate automatically to maintain the temperature within the joints above -25 °C (-14 °F). Heater circuits are individually switched off as the corrsponding temperature reaches 0 °C (32 °F). Twelve temperature thermisters per arm monitor the temperatures, which can be displayed at the aft flight deck station.

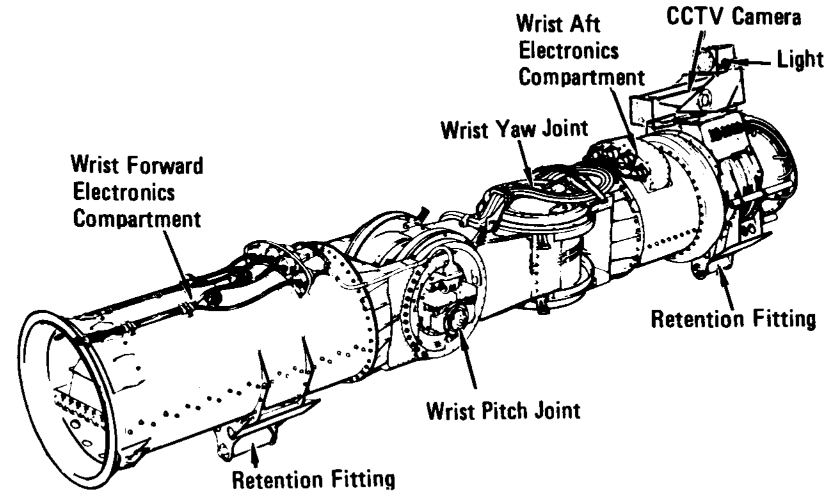
Every joint of the arm is driven electromechanically. The joint drive train consists of a dc drive motor providing joint actuation, an output gear train that controls output speeds from the motor input, an optical encoder on the gearbox output shaft, and a mechanical brake on the motor output shaft.

The end effector drive train consists of a dc drive motor, a brake and clutch associated with the snare system, brake and clutch associated with the rigidization carriage and a differential unit. A spring mechanism is used for backup release.

The joint motor tachometers are the prime means of motion sensing, augmented by optical encoders. Tachometer



Overall Configuration of the Shoulder Joint



Overall Configuration of Wrist Joint

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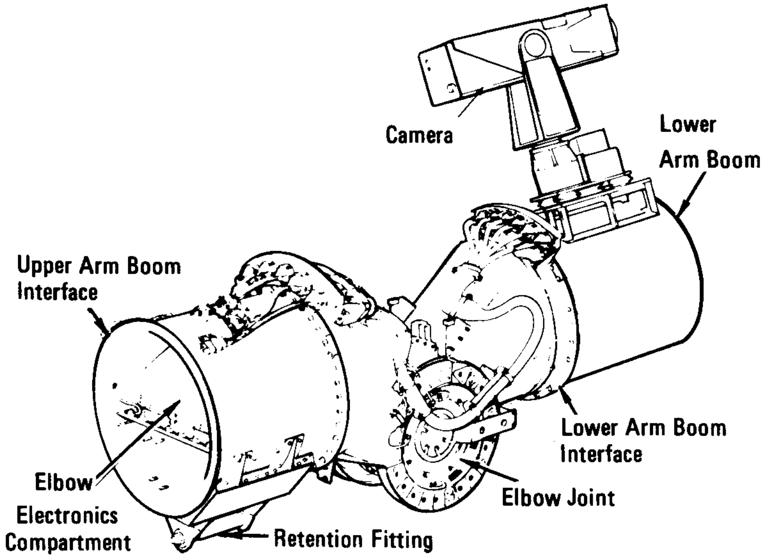
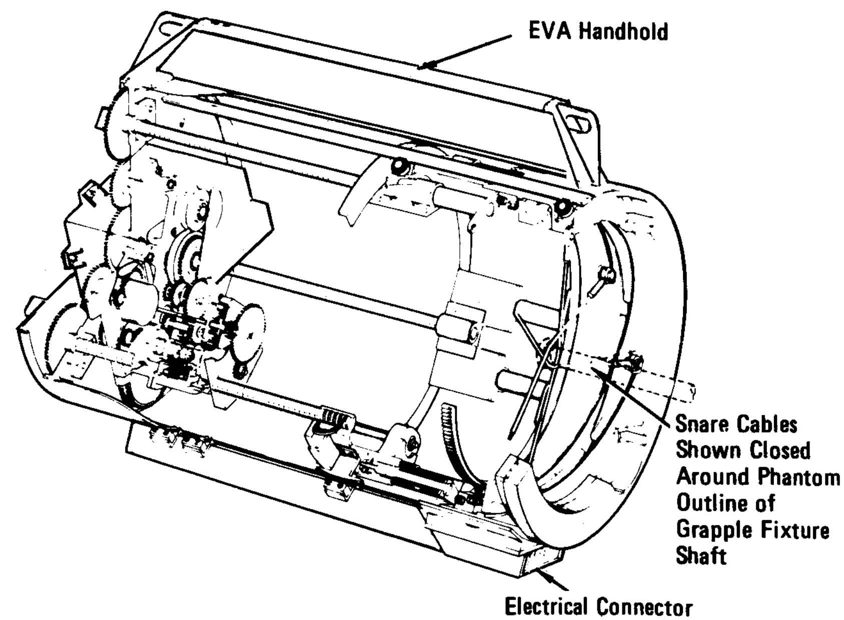
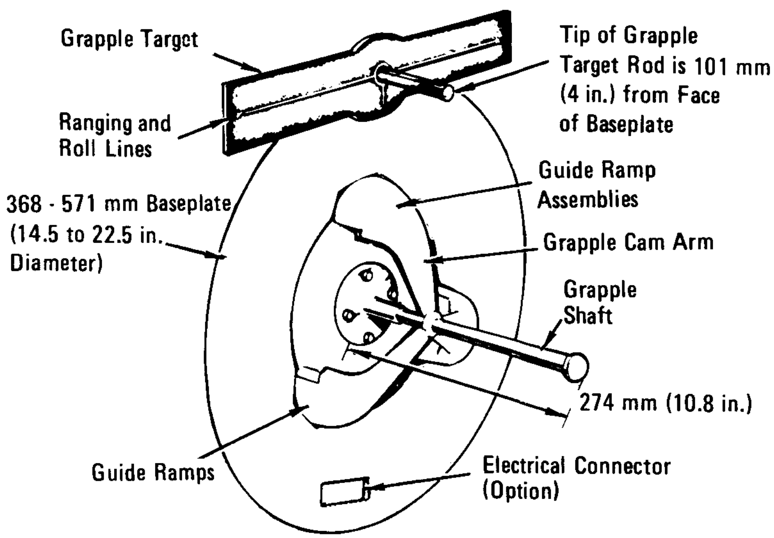


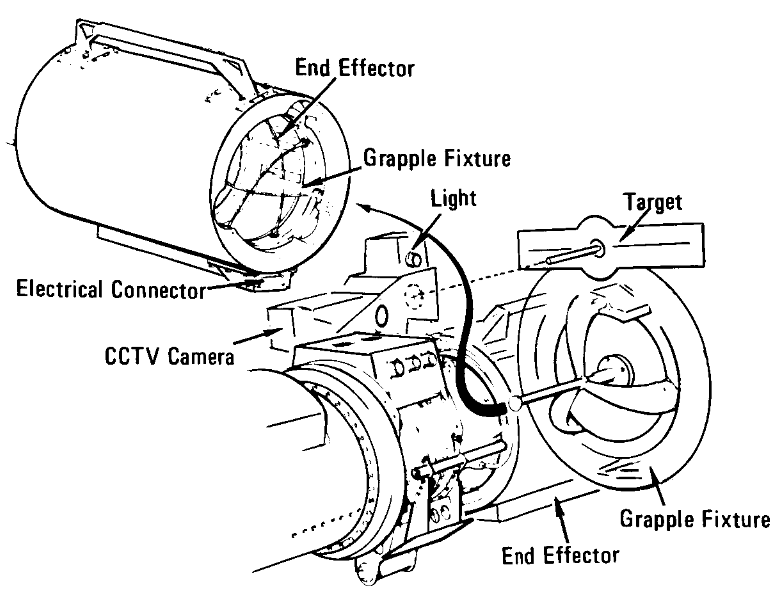
Overall Configuration of the Elbow Joint



Standard Snare Type End Effector



Grapple Fixture/Target Assembly on SPAS-01



End Effector/Grapple Fixture Interface

data is supplied to control algorithms, which convert input drive commands to an output rate demand resolved for each joint of the arm. The algorithms output this rate demand within limits defined according to arm and individual joint loading conditions present at the time of computation. The algorithms supply the rate demand to control either end effector speed or position. The maximum attainable commanded velocity for the end effector and individual joints is limited by arm loading conditions, as is the maximum torque that can be applied to an individual joint under certain conditions. The aspect of arm control is provided by end effector velocity, joint rate, and motor current limiting within the software system under normal operating conditions. Joint velocity is limited during software-supported control modes by specifying a rate limit for each joint by the software system. Current limiting by the computer occurs during capture/rigidization operations. When the capture command is detected, the software commands zero current to all joint servos, except for the wrist roll joint servo; thus, for a short period, there is a "limp" arm, except for the wrist roll joint. This is to allow for constrained motion adjustment during deployment.

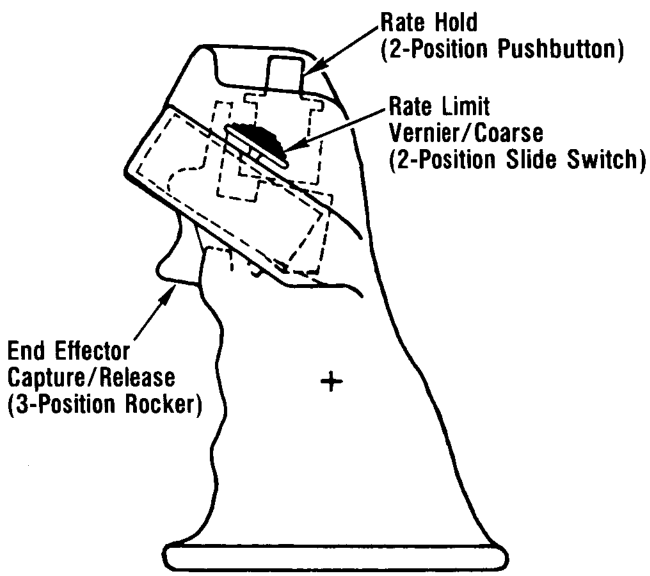
Normal braking is accomplished by motor deceleration, while the joint brakes are used for emergency or driving contingency operations only. Backdriving occurs when the payload or moving arm transmits kinetic energy into the drive train.

The RMS can be operated in any one of five different modes: automatic, manual augmented, manual single-joint drive, direct drive, and manual backup drive.

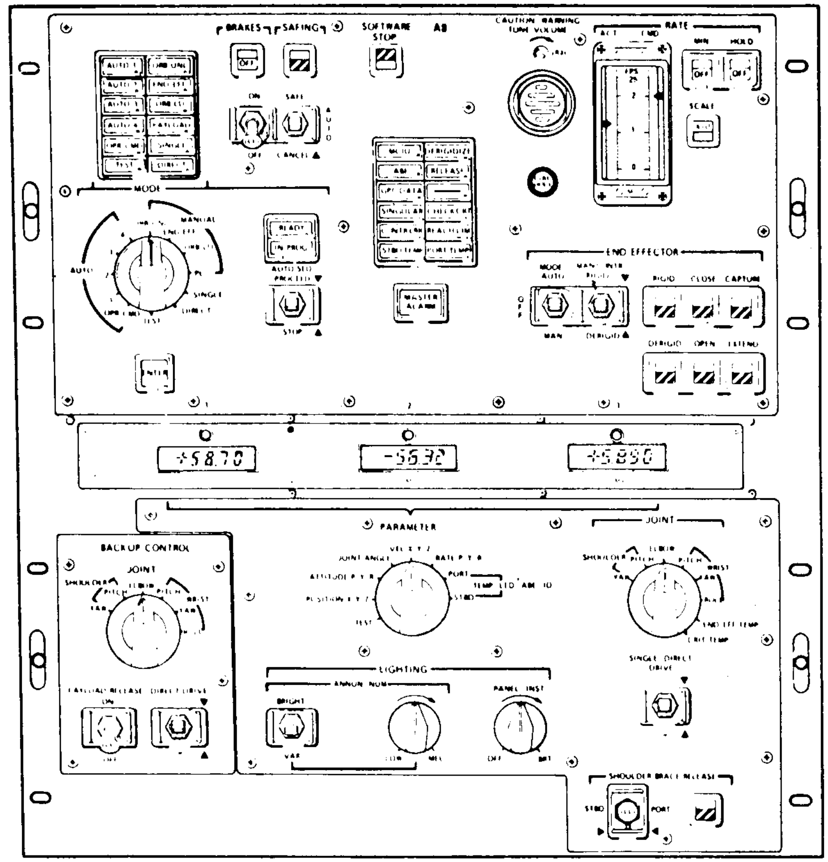
The normal loaded arm movement rate is up to 0.06 meters per second (0.2 feet per second) and the unloaded arm movement rate is up to 0.60 meters per second (2 feet per second), no payload for the latter. Rate of movement can be controlled within 0.009 meters per second (0.03 feet per second) and 0.09 degrees per second.

The manual augmented mode can be used to grapple SPAS-01, maneuver it into or out of the payload retention fittings or handling aids, and grapple or stow it in orbit. The manual augmented mode enables the operator to direct the endpoint of the arm using two 3-degree-of-freedom hand controllers to control end effector translation and rotation rate. The control algorithms process the hand controller signals into a rate demand to each joint of the arm. The operator can carry out manual augmented control of the arm using any four coordinate systems: orbiter, end effector, payload, or orbiter loaded.

When the manual orbiter mode is selected, rate commands through the aft flight deck station RMS translation hand control (THC) result in motions at the tip of the end effector which are parallel to the orbiter-referenced coordinate frame and compatible with the up/down, left/right, in/out direction of the THC. Commands from the aft flight deck station RHC result in rotation at the tip of the end effector, which are also about the orbiter-referenced coordinate frame.

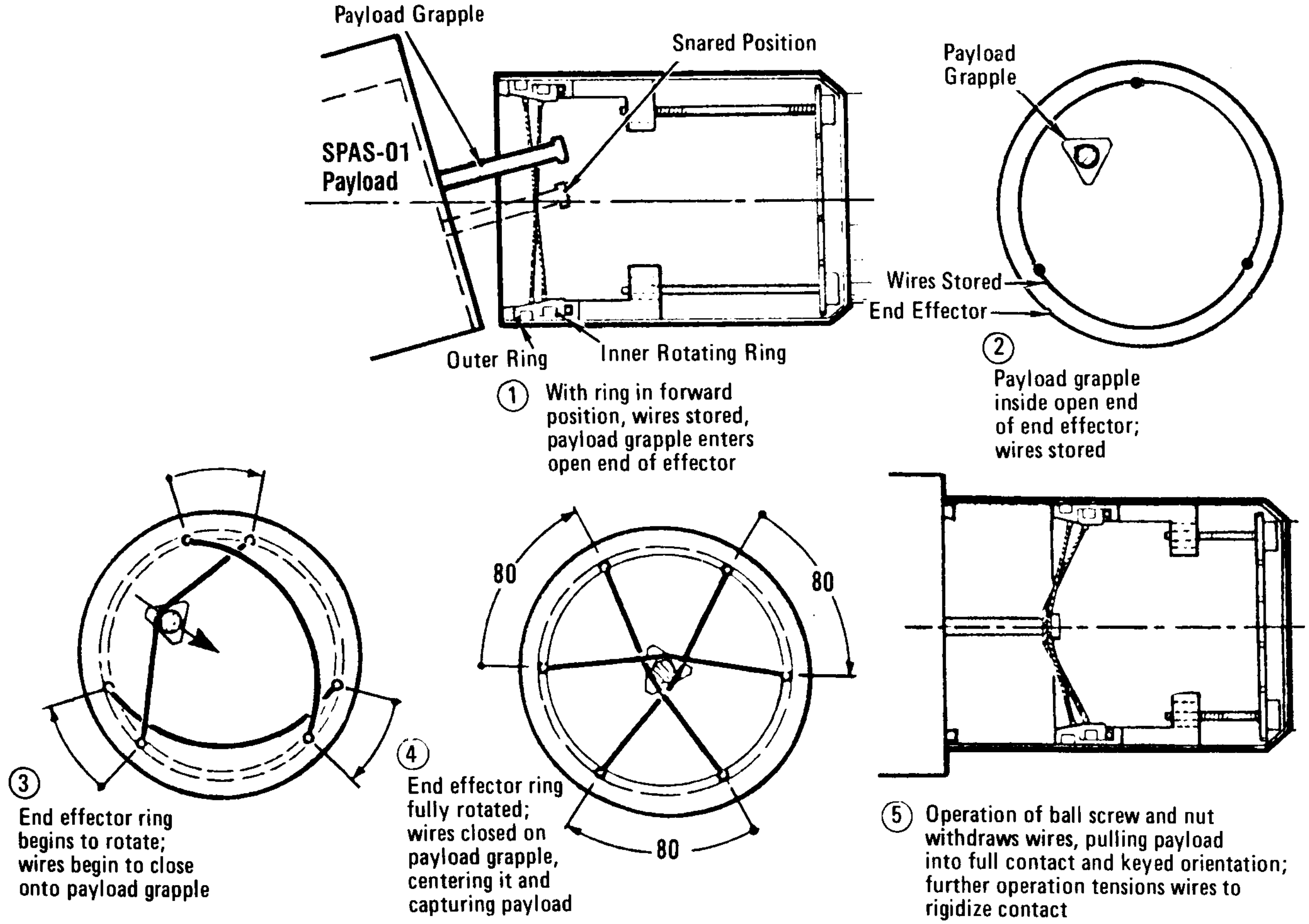


RMS Rotation Hand Control Switches



Display and Control Panel A8A1

The manual end effector mode is to maintain compatibility at all times between rate commands at the THC and RHC and the instantaneous orientation of the end effector. The end effector mode is used primarily for grappling operations in conjunction with a wrist-mounted CCTV camera which is oriented with the end effector coordinates and rolls with the end effector. The CCTV scene presented on the television monitor has viewing axes which are oriented with the end effector coordinate frame. This results in compatible motion between the rate commands applied at the hand controllers and movement of the background image presented on the television monitor.



Snare Capture and Rigidization Sequence

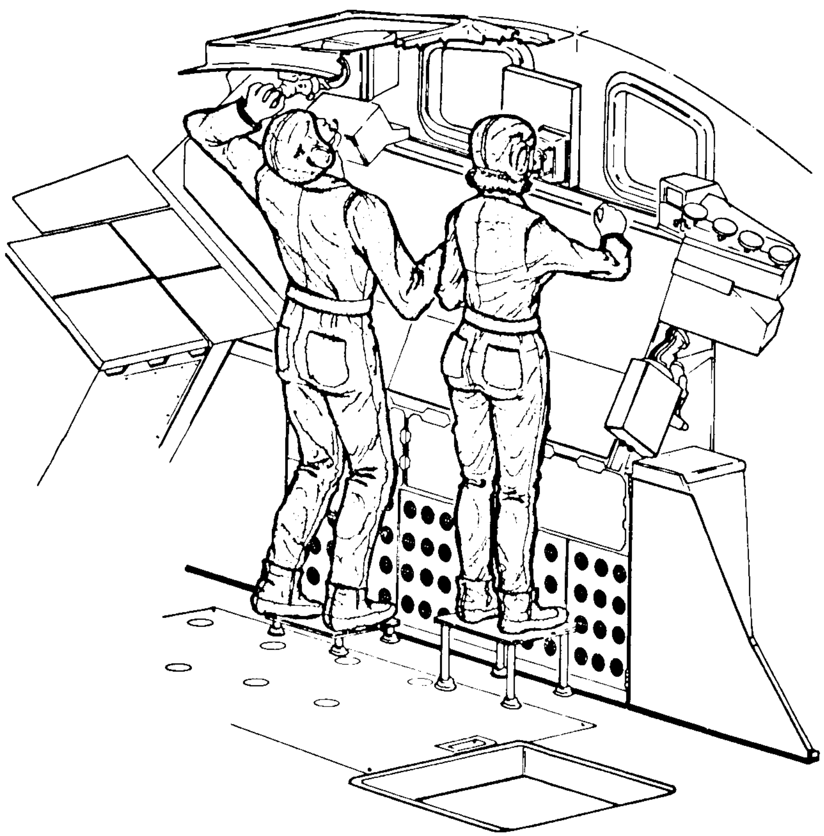
Up/down, left/right, in/out motions of the THC results in the same direction of motion of the end effector as seen on the television monitor, except that the background in the scene will move in the opposite direction. Therefore, the operator must remember to use a "fly to" control strategy and apply commands to the THC and RHC that are toward the target area in the television scene.

The manual orbiter loaded mode is to enable the operator to translate and rotate a payload about the orbiter axis with the point of resolution of the resolved rate algorithm being at a predetermined point within the payload, normally the center of geometry. This allows for pure rotations of the payload, which is useful for berthing operations.

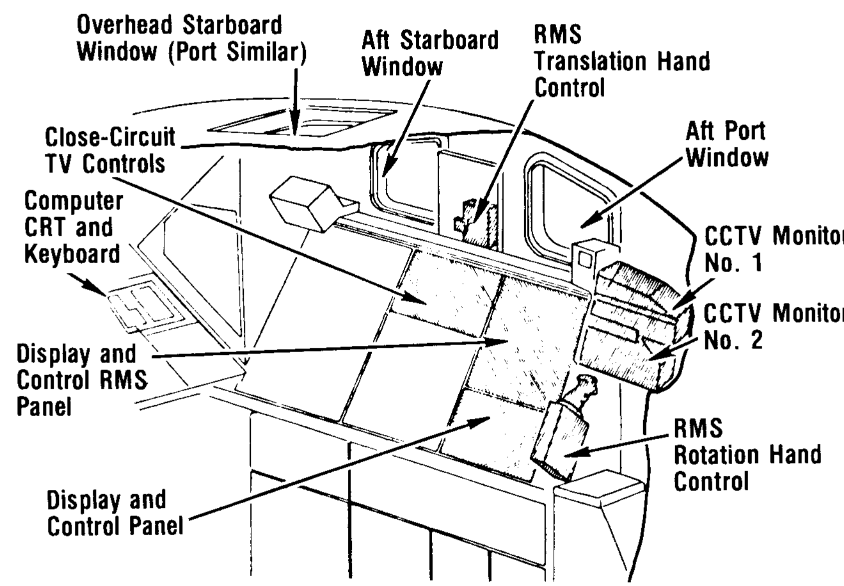
There are two types of automatic modes, preprogrammed and operator commanded. The preprogrammed auto mode can store up to 20 automatic sequences in the computer, four of which can be assigned for selection at the aft flight deck station.

In the automatic modes, the payload is maneuvered to different locations for data taking according to a preprogrammed sequence.

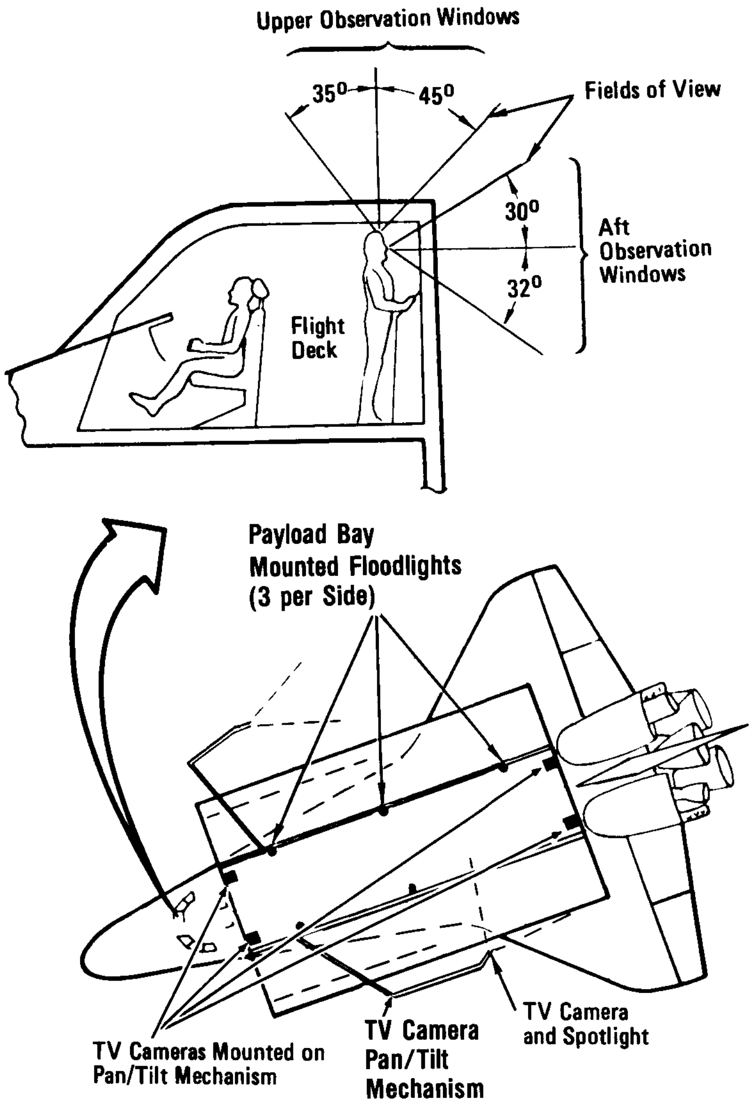
Each automatic sequence is made up of a series of positions and attitudes of the end effector which define a trajectory of motion. The series may have from one to 199 points to define the trajectories. Pauses may be preprogrammed into the trajectory at any point. These will automatically cause the arm to come to rest, from which it may be able to proceed with the automatic sequence through the auto sequence



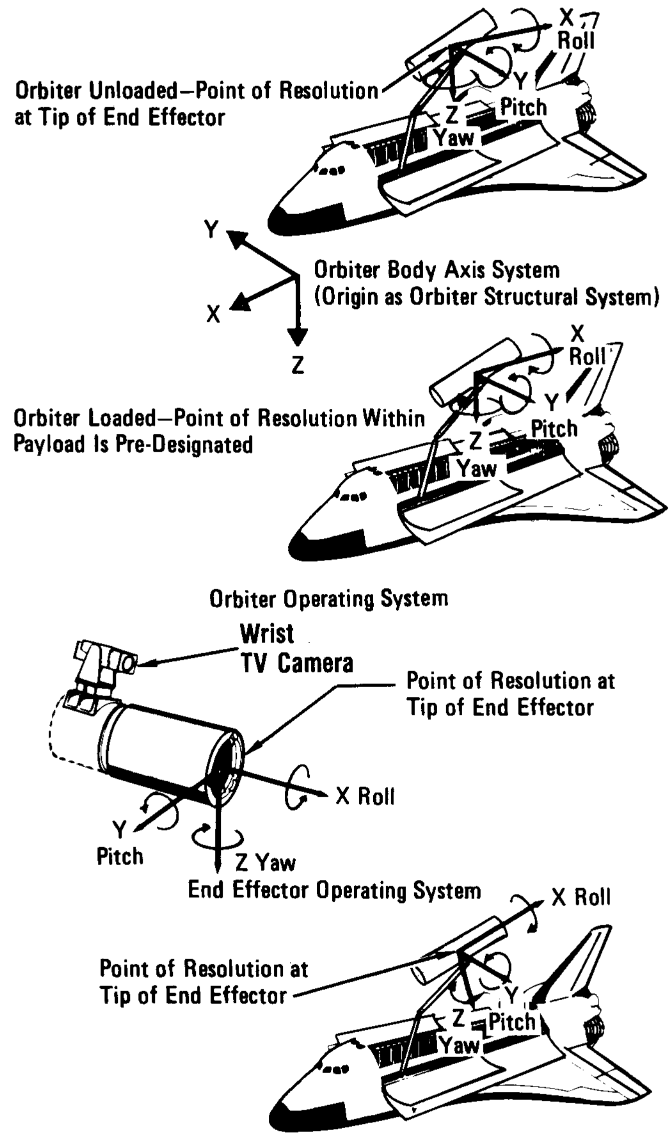
Aft Flight Deck RMS Crew Station/Crew Interface



RMS Controls and Displays



Payload Bay Television Cameras and Floodlights



Control Coordinate Operating Systems

"Proceed/Stop" switch on the aft flight deck station display and control panel. The operator can use the "Stop" position to halt the automatic sequence. This will bring the arm to rest, the switch is positioned to "Proceed" to resume the automatic sequence. When the last point in the sequence is reached, the computer will terminate the movement of the arm and enter a position hold mode. The speed of the end effector between points in a sequence is governed by the individual joint rate limits set in the RMS software.

The operator-commanded automatic mode moves the end effector from its present position and orientation to a new one defined by the operator to the computer via the keyboard and RMS cathode ray tube (CRT) display. After the data is keyed in, the RMS software verifies that the acquired position and orientation are "legal" with respect to arm configuration and reach envelope. The outcome of this check is displayed on the CRT. After the check, a "Ready" light will be displayed and the operator can execute the automatic sequence by placing the automatic sequence switch to "Proceed." The end effector will move in a straight line to the required position and orientation and then enter the hold mode. The operator can stop and start the sequence through the automatic sequence switch.

The single-joint drive control mode enables the operator to move the arm on a joint-by-joint basis with full computer support, thereby enabling full use of joint drive characteristics on a joint-by-joint basis. The operator supplies a fixed drive signal to the control algorithms via a toggle switch at the aft flight deck station. The algorithms supply joint rate demands to the selected joint while holding position on the other joints. The single-joint drive mode is used to stow and unstow the arm and drive it out of joint travel limits.

Direct-drive control is a contingency mode. It bypasses the manipulator control interface unit (MCIU), computer, and data buses to send a direct command to the motor drive amplifier (MDA) via hardwires. The direct-drive mode is used when the MCIU or computer has a problem that necessitates arm control by the direct drive mode to maneuver the loaded arm to a safe payload release position or to maneuver the unloaded arm to the storage position. The operator must place the brake on and select direct drive on the mode select switch. Since this is a contingency mode, full joint performance characteristics are not available. Computer-supported displays may or may not be available, depending on the fault that necessitated use of direct drive.

Back drive control is a contingency mode used when the prime channel drive modes are not available. The backup is a degraded joint-by-joint drive system. It meets the fail-safe requirement of the RMS by using only the drive train of the prime channel.

Safing and braking are the two methods available for bringing the arm to rest. Safing can be accomplished by the operator from the aft flight deck station or by the MCIU in receipt of certain failure indications. Operator-initiated safing is sent on hardwires to the input latches, setting them to zero and thus resulting in zero current to each joint independent of computer commands.

The RMS has a built-in test capability to detect and display critical failures. It monitors the arm based electronics (ABE), display and controls, and the MCIU software checks in the computer monitor computations. Failures are displayed on the aft flight deck station panel and on the CRT and also are available for downlinking through orbiter telemetry.

All of the major systems of the ABE are monitored by built-in test equipment. The MCIU checks the integrity of the communications link between itself and the ABE, display and control, and the orbiter computer. It also monitors end effector functions, thermistor circuit operation, and its own internal consistency. The computer checks cover an overall check of each joint's behavior through the consistency check, encoder data validity, and end effector behavior, as well as the proximity of the arm to reach limits, soft stops, and singularities.

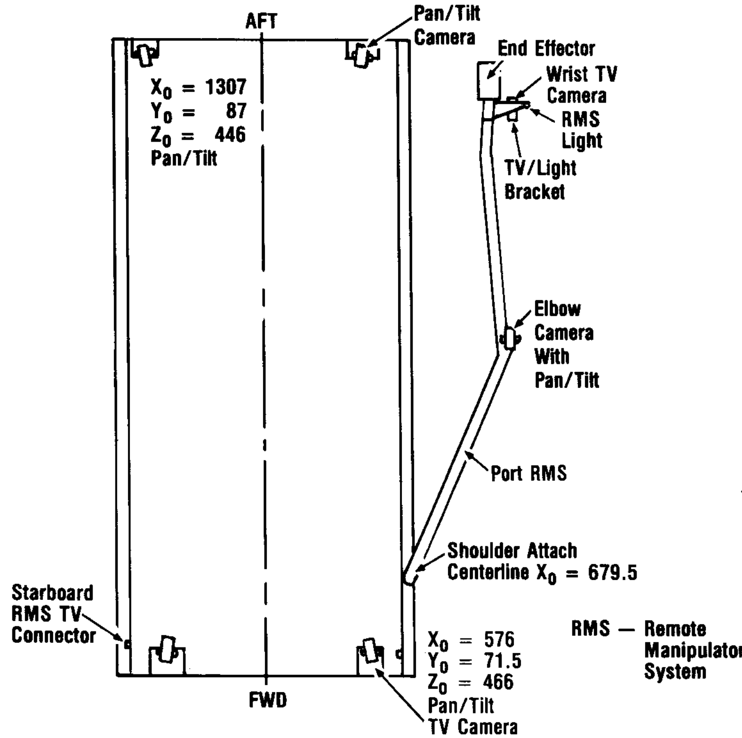
The caution/warning annunciators are located on the aft flight deck station display panel. There are six caution annunciators (port temperature, starboard temperature, reach limit, singularity, control error, and check CRT) and five warning annunciators (release, derigidize, ABE, GPC data, and MCIU). A "Master Alarm" light and an audio signal attract the flight crew member's attention whenever a fault condition is detected.

A jettisoning system is installed within the Rockwell-provided manipulator positioning mechanism in the event the RMS cannot be stowed. Three floodlights are installed on each side of the payload bay. A portion of the orbiter closed circuit television (CCTV) system supports the payload deployment retrieval operations. The payload deployment retrieval operator uses the four payload bay TV cameras, the remote manipulator arm cameras, the TV monitors, and the TV controls and displays to assist in all phases of the payload deployment retrieval system operations. There are six TV cameras on STS-7 positioned in the following locations, arm wrist, arm elbow, forward port bulkhead, forward starboard bulkhead, aft port bulkhead and aft starboard bulkhead.

The wrist TV camera is mounted on the roll joint of the arm; the elbow TV camera is mounted on the lower arm boom next to the elbow joint. The payload bay bulkhead TV camera brackets are attached to the aft and forward bulkheads. The TV monitors and the displays and controls are mounted on the aft flight deck display and control panel station.

The TV cameras used for payload deployment and retrieval operations are identical and, therefore, interchangeable. They are black and white cameras. The cameras have a pan/tilt unit, which provides plus or minus 170° in pan and tilt, except when used on the arm's wrist or in the payload keel.

There are two black and white monitors. The monitors' electronic crosshairs have both vertical and horizontal components at the electrical center of the image. They are used to align the cameras with targets and sighting aids. The crosshairs are also used to align overlays with the monitor image. Alphanumerics are available on the monitors. The pan and tilt



Remote Manipulator System

angles are displayed in degrees and tenths of degrees when the monitors display full scene images. The alphanumerics can be turned off. Each monitor can display two images simultaneously. The right or left half of the monitor will display the center half of the selected camera scene when the split screen mode is used.

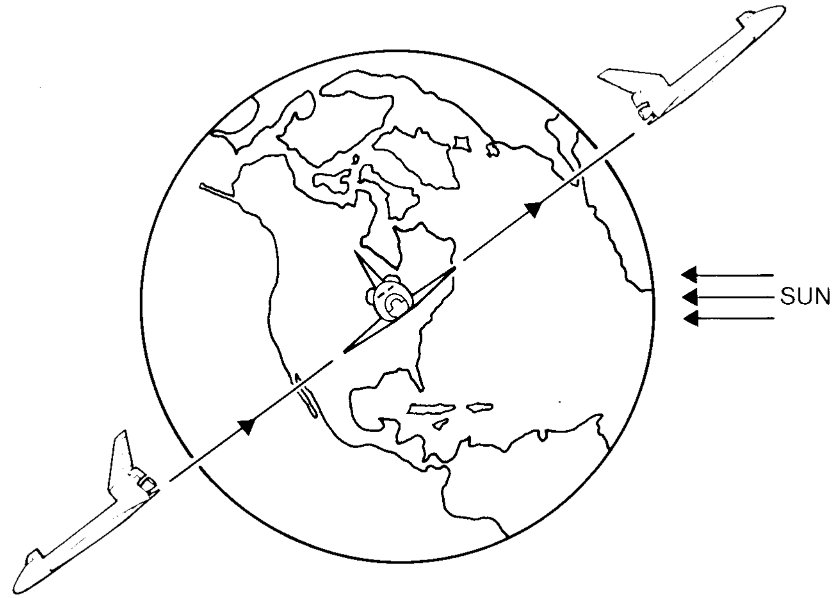
Spar Aerospace Limited, Toronto, Canada, is the prime contractor to the National Research Council for development of the RMS for NASA. CAE Electronics Ltd, Montreal is responsible for the displays and controls in the orbiter. RCA Ltd, Montreal is responsible for the electronic interfaces, provides servo amplifiers and power conditioners. Dilworth, Secord, Meagher and Assoc. Ltd (DSMA), Toronto is responsible for the end effector.

This payload is the first in a series of planned orbital investigations of materials processing in space. OSTA-2 is a cooperative materials processing mission developed by the United States and the Federal Republic of Germany. The payload consists of two experiment facilities that operate automatically: the Materials Experiment Assembly (MEA) sponsored by NASA and the Materialwissenschaftliche Autonome Experimente unter Schwerelosigkeit (MAUS) sponsored by the German Ministry for Research and Technology (BMFT). The NASA facility was developed by Marshall Space Flight Center in Huntsville, Ala., and the German facility was developed under the management of the German Aerospace Research Establishment (DFVLR).

The OSTA-2 is one of the first cooperative international research projects to be conducted on the Space Shuttle. Besides providing apparatus for this joint investigation of materials processing, scientists from each country will share experiment data and exchange analytical information about crystal growth, containerless production of glass, and metallurigical processes in space.

On Earth, gravity influences the processing of materials in ways that produce undesirable effects. For example, gravity causes sedimentation or "settling" in melts of composite materials whose constituents have different densities. Other results of gravity are hydrostatic pressure and convection currents which cause objectionable stirring in fluids. Even the containers in which materials are solidified under gravity cause stresses and imperfections in the confined crystals.

The resultant materials processed on Earth are often flawed in structure or composition and are less suitable for advanced technology uses than a more homogenous product would be. To date we have not been able to achieve the theoretical properties of these materials because freedom from the constraints of gravity can be attained on Earth only for a few seconds.

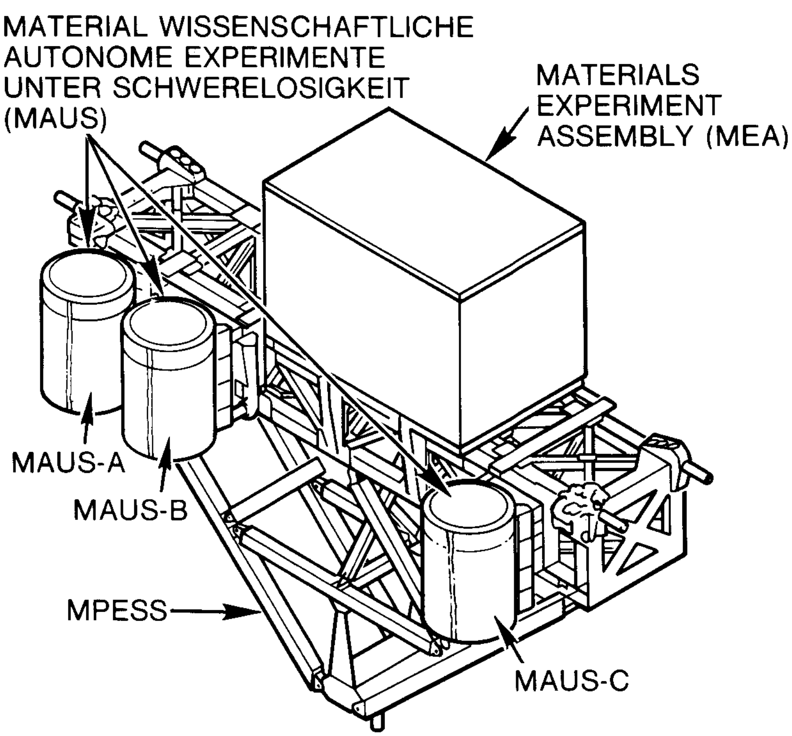


Gravity Gradient Attitude

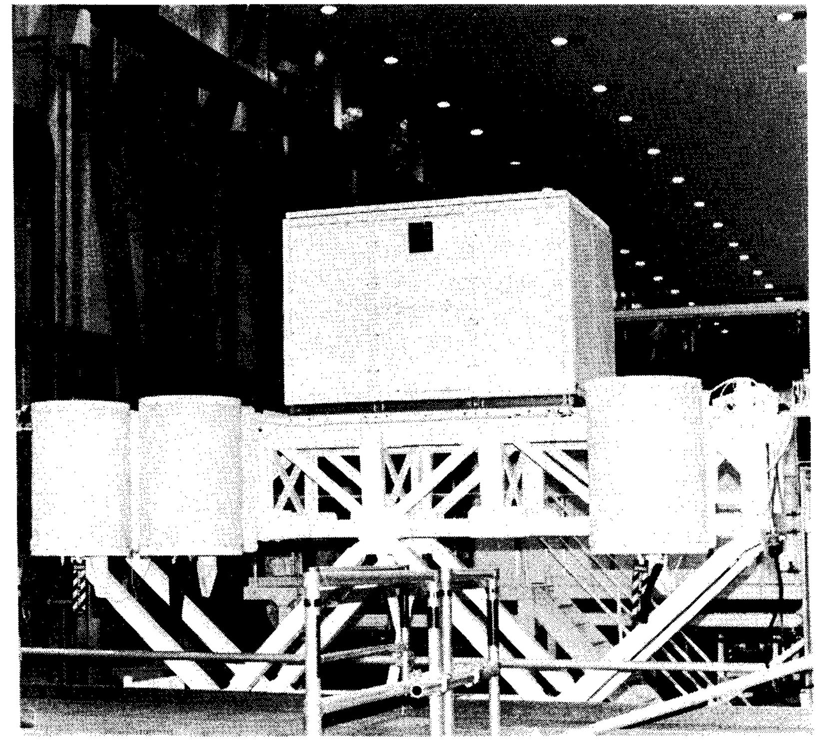
In the very low gravity environment of space, such negative influences can be minimized or eliminated. Analysis of more than 50 experiments on Skylab and other spacecraft suggests the attractiveness of this environment for materials processing. Materials processing in space holds promise for products whose quality is dependent on the nature of the crystalline state, such as semiconductors, super conductors, and specialized composites, and for those separation processes that are hampered by gravity-induced convection on Earth. An exciting process is containerless processing in space, where the shape of a liquid or melt is controlled largely by surface tension and only small forces such as electromagnetic, electrostatic, or acoustic fields are required to manipulate and confine the material.

During the operation of OSTA-2 payload, the *Challenger* will be oriented to attitudes that maintain the g-level requirements of the materials processing investigations. An example of this orientation referred to as "gravity gradient" attitude with the tail of *Challenger* pointing toward the center of Earth. These experiments require periods of minimum vehicle-induced "g" forces with acceptable vernier reaction control system attitude control.

The elements of the OSTA-2 payload are located in *Challenger's* payload bay on a Mission Peculiar Equipment Support Structure (MPESS). In addition to mechanical support, the MPESS will provide near hemispherical space-view for the MEA payload thermal radiator. Payload on/off command switches to be activated by the flight crew are located in the *Challenger* aft flight deck display and control panel.



OSTA-2 Payload Mounted on Mission Peculiar Equipment Support Section (MPESS)

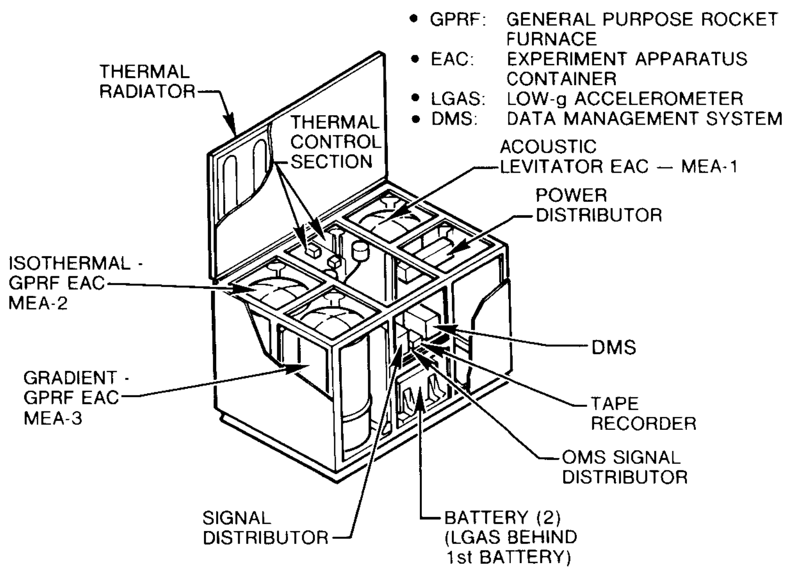


Office of Space and Terrestrial Applications (OSTA-2)

MEA is a self contained facility consisting of a support structure for attachment to the MPESS and thermal, electrical, data, and structural subsystems necessary to support experiment apparatus located inside experiment apparatus containers (EAC's). The three MEA experiment apparatus are an Isothermal General Purpose Rocket Furnace (IGPRF), a Gradient-General Purpose Rocket Furnace (G-GPRF), and a Single Axis Acoustic Levitator (SAAL). These experiment apparatus were developed for the Space Processing Applications Rocket (SPAR) project and modified to support MEA OSTA-2 experiments.

The MEA subsystems include a low gravity accelerometer, a data recorder, a battery powered electrical system and storage bottles for gases and liquids. The top of the rectangular MEA package is a passive thermal radiator that is hinged to allow access to the experiments and subsystems. The advantage of the self contained automated facility is its ability to accommodate a large variety of space processing experiments while maintaining a minimum integration interface with *Challenger*. MEA on its first flight, STS-7, OSTA-2 will carry three experiments in the disciplines of crystal growth, transport phenomena, metallurgy, and containerless glass technology. The three experiments located in the three EAC's are: vapor growth of alloy-type semiconductor crystals; liquid phase miscibility gap materials; and containerless processing of glass forming melts.

Vapor growth of alloy-type semiconductor crystals MEA-3. This experiment is to grow single crystals of alloy semiconductors by the chemical vapor transport technique in the microgravity environment of space. Germanium selenide is placed in a sealed glass tube. Both ends of the tube are heated at different temperatures. In a process similar to fog condensing to form ice crystals on a cold day, the substance turns to vapor

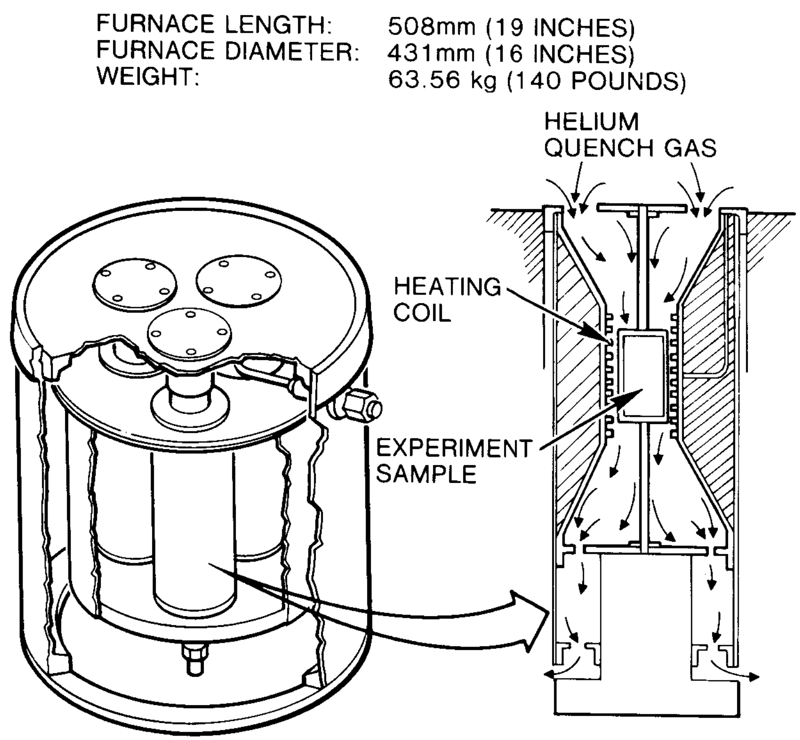


Materials Experiment Assembly (MEA)

when heated and moves to the cooler end of the tube where it crystalizes — thus vapor transport. It is concerned with the continued investigation of basic vapor transport and crystal growth properties of electronic materials. Practical benefits and applications that could result from this type of research include improved semiconductor technology for the electronics industry. The experiment will use two of the three available cavities of the G-GPRF. These cavities are thermally independent of each other and support independent melting and resolidification experiments. The temperature gradient in each cavity will be maintained by programmed control of three heating elements and a controllable water-cooled heat exchanger within the heating cavity. Temperature measurements of the furnace cavity and the samples will be made and recorded during processing to verify that the sample has been subjected to the desired preselected temperature history. This experiment will need 35 hours of processing time.

The principle investigator for the experiment is Dr. Heribert Wiedemeier of Rensselaer Polytechnic Institute, with Dr. E.A. Irene of IBM and Dr. C.C. Wang of RCA as co-investigators. After the mission, the principal investigator will analyze the experiment samples and data recorded during processing in space to determine the characteristics of space-grown crystals as compared with control specimens grown on Earth under similar time and thermal conditions. Marshall Space Flight Center Science Laboratory and Test Laboratory developed the experiment hardware.

Liquid phase miscibility gap materials MEA-2. Some alloys have a temperature region within their cooling curve where the two molten metallic components of different densities do not mix and tend to separate on Earth, like oil and water. Even though the liquids mix initially, over a period of time they separate due to gravity, convection, and other influences. In space, however, two liquid metals can be heated, mixed, and cooled down to produce a new solid metal alloy containing the qualities of both materials. This temperature region is known as the miscibility gap, and the alloys formed out of these miscibility gap systems generally show large-scale inhomogeneities. This experiment investigates the physics of the alloy forming process, using miscibility gap systems to determine if the reduction of component separation will significantly change the structure. Among the potential benefits of this experimentation are understanding the structural, electrical, and magnetic properties of materials. This experiment will use the remaining G-GPRF and all three cavities of the I-GPRF. The I-GPRF provides three mutually independent cavities for melting and resolidification of experiments. The isothermal temperature environment is maintained by the MEA computer programmed control of a single heating element in the cavity and a gaseous helium cooling medium. Specimen temperatures will be measured with thermocouples installed in each experiment cartridge during pro-



General Purpose Rocket Furnace (GPRF) — Isothermal Type — MEA-2

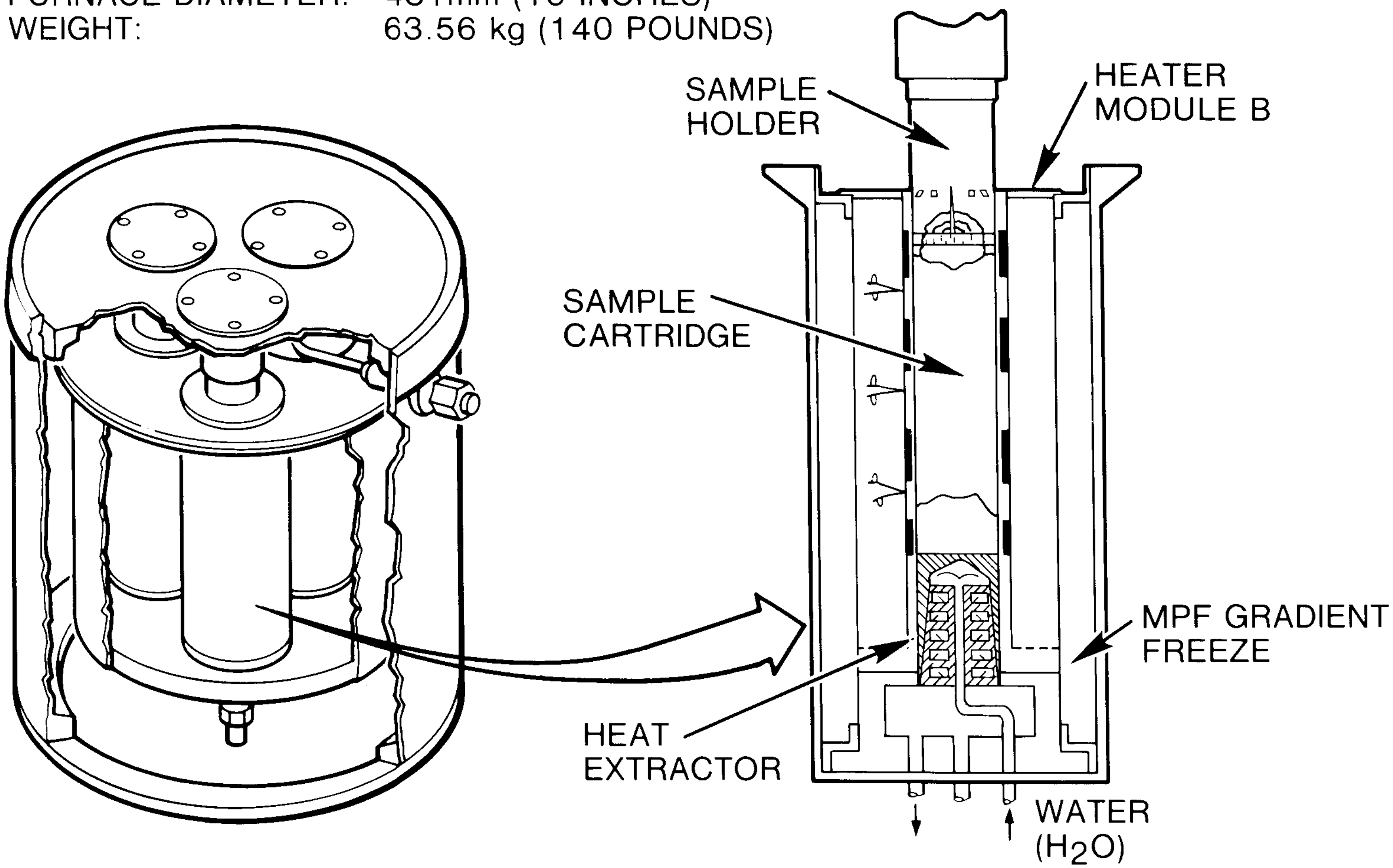
cessing and will be recorded by the Data Management System (DMS) for postflight use. This experiment will use 25 hours of processing time.

The principal investigator is Dr. S.H. Gelles of S.H. Gelles Associates with Dr. A.J. Markworth of Battelle Columbus Laboratory as the co-investigator. The principal investigator will analyze the alloys produced in space and the associated recorded data for comparison with alloys processed under similar time and temperature conditions in a laboratory on Earth. Marshall Space Flight Center Space Science Laboratory developed the experiment hardware.

Containerless processing of glass forming melts MEA-3. The primary purpose of this experiment is an evaluation of the SAAL furnace. The secondary purpose includes a determination of the raw materials preparation and melting procedures required to achieve chemically homogenous viscous melts and a comparative property analysis of glasses processed on Earth and in space. Possible applications of this experiment include improvements in glass technology. The experiment will use the one dimensional levitator furnace with automatic sample exchange for eight samples. Sound wave pressure is used to suspend sample materials free of any container that could contaminate the sample, allow the sample to melt, then cooled and collected. The high-temperature furnace cavity is heated by a silicon carbide heating element. Cooling is accomplished by positioning a metal cooling shroud around the sample. The sound beam is projected through a port in one wall of the furnace and the specimen is injected through a port in the opposite wall. A quartz window allows primary data recording of melting and cooling behavior of the glass samples via a 16 millimeter motion picture camera.

Upon activation during the flight, the system will operate automatically by the preprogrammed levitator microprocessor control, which is activated by the MEA Data Management System (DMS). The principal investigator is Dr. Delbert E. Day of the University of Missouri-Rolla. The principal investigator will analyze the samples postflight to determine their physical

FURNACE LENGTH: 508mm (19 INCHES)
FURNACE DIAMETER: 431mm (16 INCHES)
WEIGHT: 63.56 kg (140 POUNDS)

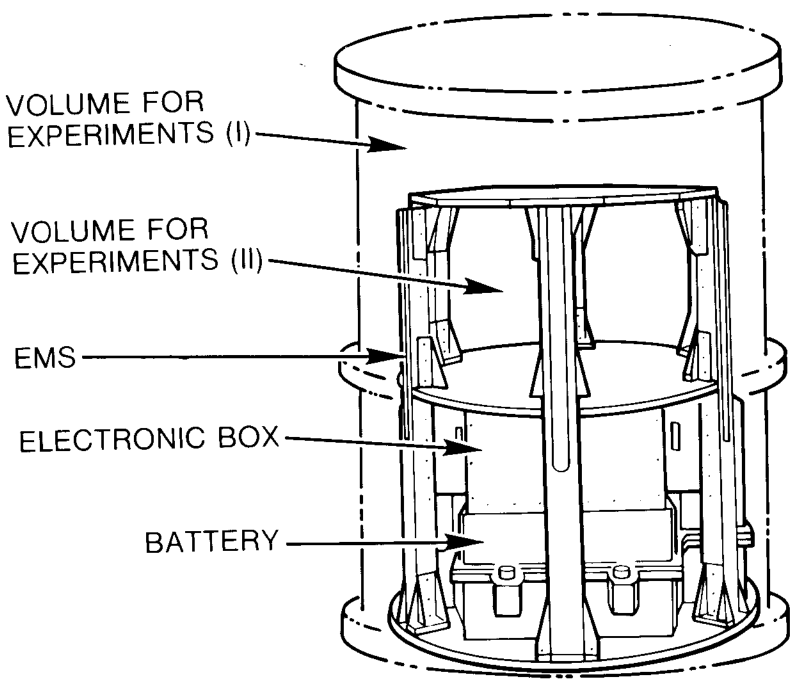


General Purpose Rocket Furnace (GRPF) —
Gradient Type — MEA-3

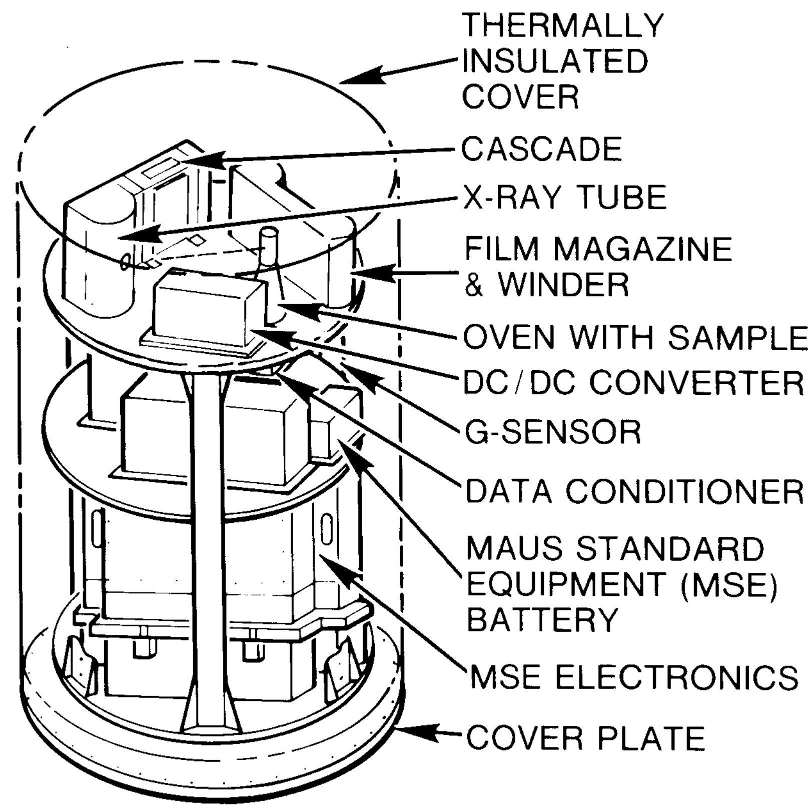
and optical charcteristics. The acoustic levitator for the experiment was developed by Intersonics Incorporated, Northbrook, Ill.

The MAUS experiments are contained in three ''Getaway Special'' (GAS) containers with autonomous support systems. The GAS containers are thermally insulated cylindrical pressure enclosures. Each container will have its own service module containing experiment hardware, electrical power, experiment control, data acquisition, and storage, as well as housekeeping sensors. Thermal control of the MAUS experiment is passive. The experiments are housed in three individual GAS containers and are directed to the study of fluid dynamics, transport phenemona, and metallurgy. The three MAUS experiments operate independently in an automatic mode through on/off commands by the flight crew from the *Challenger* aft flight deck display and control panel. The MAUS experiments are: stability of metallic dispersions and solidification front.

Stability of metallic dispersions. The experiment occupies two of the GAS cannisters and are identical in each cannister, except for different heating and cooling cycles and are identified as MAUS-A and B. This experiment investigates in low gravity the behavior of metallic dispersions during the heat-up, temperature soak, and repeated cooling into a temperature region where the two liquids do not mix in Earth gravity, known as miscibility gap phase. The engineering objective is the



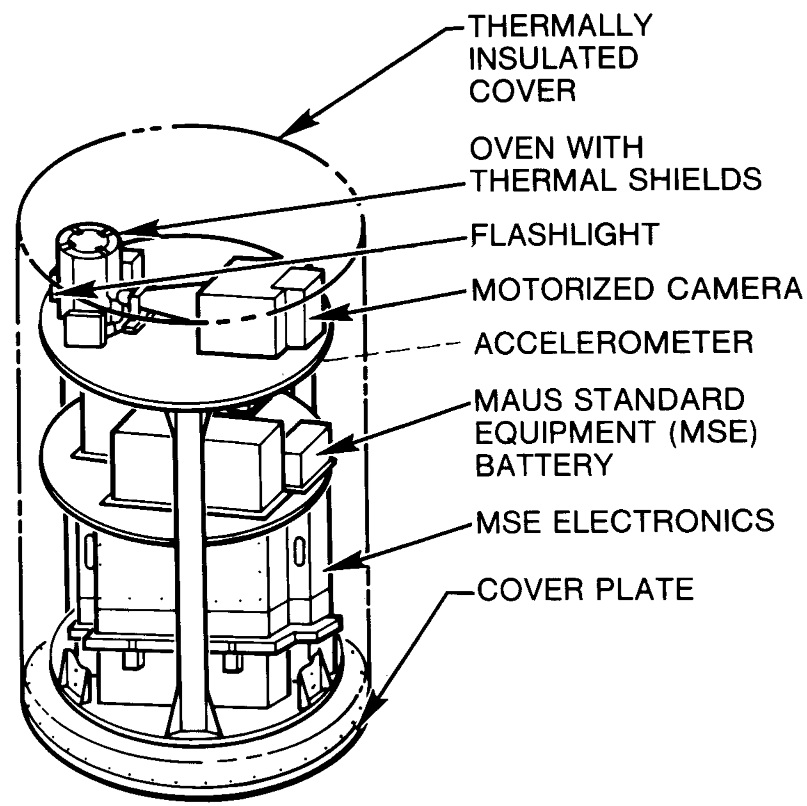
MAUS Service Module



Metallic Dispersion Experiment in the GAS Container — MAUS A and B development of an automated X-ray unit and "X-ray transparent" oven for dispersion studies. Potential results of this experiment include materials with improved physical, chemical or electrical characteristics for beneficial applications on Earth. The experiment consists of an X-ray unit working at 80 kv supplied through a cascade system, an X-ray transparent Teflon oven, and a motorized advance mechanism for double lagered continuous X-ray film. The sample consisting of gallium with 20 atom percent of mercury, is sealed within the oven. The experimental procedure will consist of three or four temperature cycles (a total operation time of 48 hours), which will differ only in the cooling rate of the sample. The four phases of each experiment cycle are: heating to the soak temperature; soaking for the prescribed time; cooling of the sample at different rates; and low temperature hold. X-ray transmission photography of the sample will be made at predetermined times during the four phases of each experiment cycle.

Experiment operation and temperature control of the oven will be preprogrammed MAUS Standard Equipment (MSE). Process temperature, X-ray tube current and voltage, and camera operation will be recorded by the MSE recorder. All the components of the experiment are housed in each GAS container and electrical power to the experiment and its control are provided by the MSE. The investigator is Dr. Guenther H. Otto of DFVLR Institut fur Raumsimulation. The data gathered by the MSE including accelerometer data and the X-ray film data, will be analyzed on the ground to study diffusion, convection (including Marangoni), sedimentation, and particle growth (Ostwald ripening).

Solidification front. The GAS cannister is identified as MAUS-C. The solidification front experiment will determine particle movement during the melting and solidification of metal alloys. This knowledge is of value in the fabrication of composite materials beneficial to mankind. The behavior of the second-phase particles at solidification fronts and fluid particle motion driven by means of interfacial tension gradient at the particle/melt interface. The experiment equipment consists of a gradient furnace fabricated by the experimenters, an observa-



Solidification—Front Experiment in the GAS Container—MAUS C

tion system consisting of a flashlight, a motor camera with film magazine for 200 photographs, and a Zeiss-Lumina objective, as well as associated electronics. All components of the experiment facility are mounted on the two experiment platforms inside the GAS container. Experiment operation and control and electrical power to the experiment will be powered by the MSE.

During the flight, the experiment will be turned on by a flight crew member. Each step of the subsequent operation will be carried out by a MAUS preprogrammed microprocessor. The experiment will be operational for 1.75 hours and consists of two phases: heating up the gradient furnace; and solidification program. The motor camera will record the motion of the fluid and solid particles at the solidification front of the transparent cesium chloride melt by taking one picture every 20 seconds. In addition, data output from the three thermocouples on the gradient furnace will be recorded by the MSE recorder. The data recorded by the motor-camera and MSE recorder, including MSE accelerometer data, will be analyzed after the flight. The principal investigator is Dr. Hermann Klein of DFVLR Institut fur Raumsimulation. Co-investigators are Dr. Axel Bewersdorff, DFVLR Institut fur Raumsimulation, Dr. Ing Jurgen Postchke of Krupp Forschungsinstitut, Essen, and Dr. Hans C. Walter of DFVLR Institut fur Werkstoff-Forschung.

The OSTA-2 payload will remain with the *Challenger* and return aboard the *Challenger* to the Kennedy Space Center where it will be removed from *Challenger* in the Orbiter Processing Facility and transported to the Operations and Checkout Building. When the payload is disassembled, data and apparatus will be provided to the respective experiment developers and investigators for reflight refurbishment and scientific analyzers, as appropriate. The MEA and MAUS experiment facilities will be removed for refurbishment and planned reflight. Under terms of the cooperative agreement between the United States and the Federal Republic of Germany, scientific data will be shared by the two sponsoring organizations.

KU-BAND ANTENNA, *CHALLENGER* AND TRACKING DATA RELAY SATELLITE (TDRS) -A

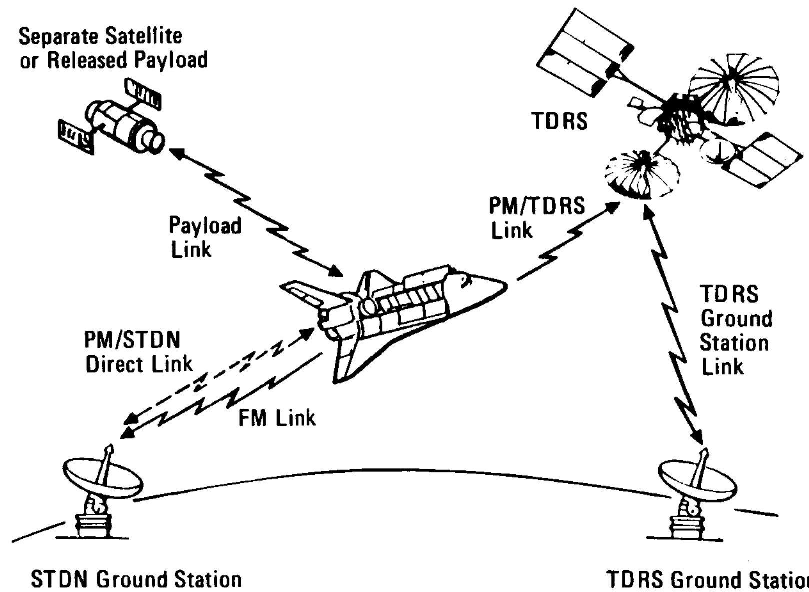
In the STS-7 flight of *Challenger*, a 914 millimeter (36 inch) diameter Ku-band antenna is mounted on the starboard forward portion of *Challenger's* payload bay. The Ku-band antenna is stowed in this area and after payload bay door opening, the Ku-band antenna is deployed. If the Ku-band antenna cannot be stowed, provisions are incorporated to jettison the assembly so the payload bay doors can be closed for entry.

In the STS-7 mission of *Challenger*, performance, navigation and proficiency tests of *Challenger's* S-band system will be accomplished with TDRS-A in addition to *Challenger's* Ku-band system with TDRS-A.

The orbiter Ku-band system operates in the Ku-band portion of the RF spectrum, which is 15,250 MHz to 17,250 MHz. The Ku-band provides a much higher gain signal with a smaller antenna than the S-band system. The S-band system can be used to communicate via the TDRS, but the low-data-rate mode must be used because of limited power since the S-band does not have a high enough signal gain to handle the high data rate. With Ku-band system, the higher data rates can be used.

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

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



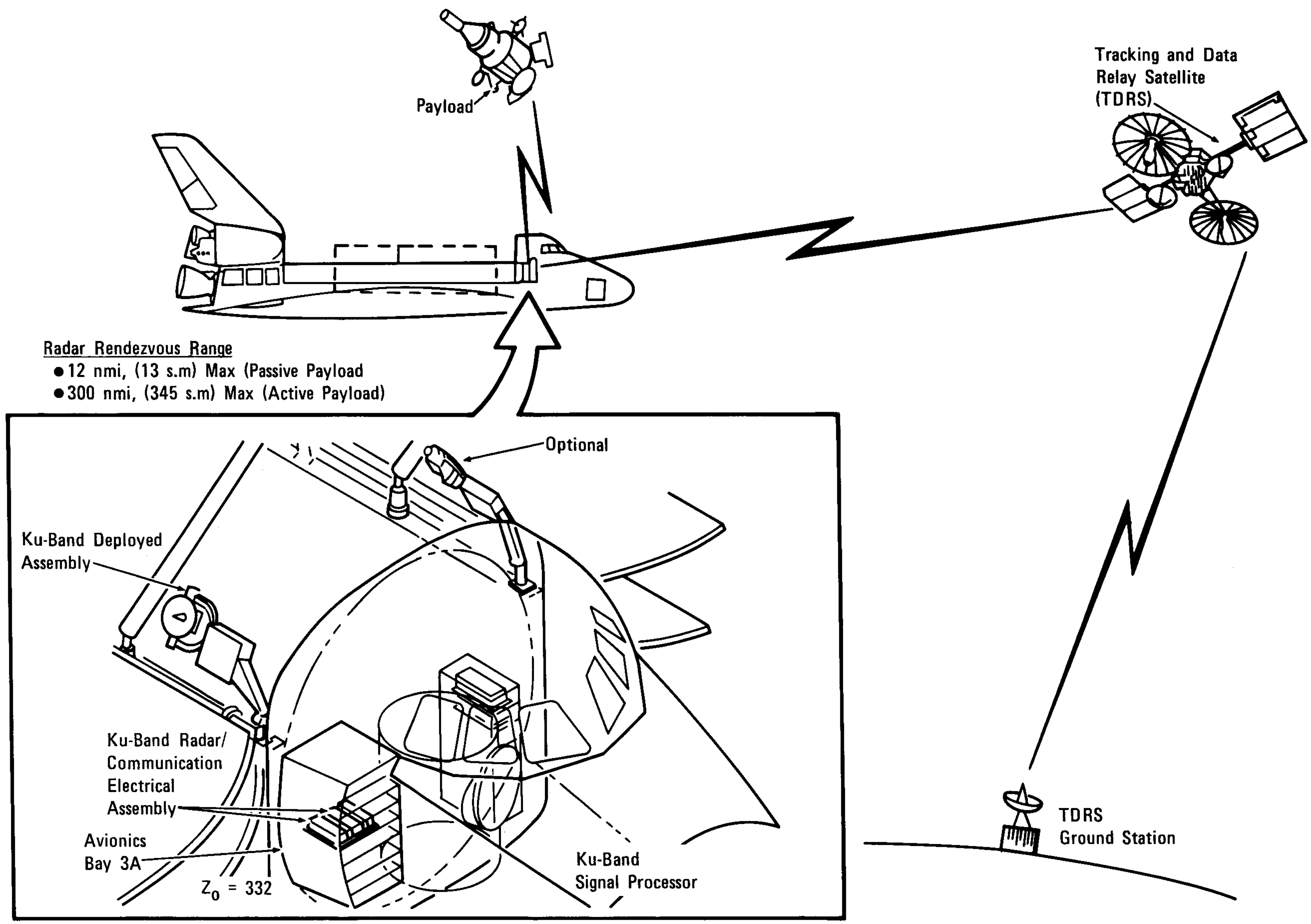
S-Band/TDRS Communications

In the STS-7 flight, *Challenger* will test orbiter/detached NASA payload communications and rendezvous radar sensor performance with SPAS-01 during proximity operations.

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

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

Ku-Band Antenna Installation in Challenger



Ku-Band Radar Communication System

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

TDRS-A was positioned at the equator over the northeast corner of Brazil at 41 degrees west longitude after launch from *Challenger* in the STS-6 mission and is referred to as TDRSS-East. Next year, TDRS-B will be carried into earth orbit and launched from the spacecraft and positioned over the Pacific ocean at the equator southwest of Hawaii at 171 degrees longitude and will be referred to as TDRSS-West. TDRS-C is scheduled to be positioned at the central station as a backup at 79 degrees longitude west. An approximate three month checkout is scheduled for each satellite when it is on station and the fully operational three satellites are scheduled for operational status in 1984.

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

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

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

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

The TDRS-A satellite is at geosynchronous orbit above the equator at an altitude of 35,880 kilometers (22,300 statute miles). At this altitude, because the speed of the satellite is the same as the rotational speed of earth, they remain "fixed" in orbit over one location.

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

The TDRSS communications capability extends across a wide spectrum that includes voice, television, analog and digital signals.

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

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

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

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

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

MONODISPERSE LATEX REACTOR (MLR) EXPERIMENT

The monodisperse latex reactor experiment flown on *Columbia* in STS-3 produced tiny plastic spheres successfully as planned. The experiment was designed to study the feasibility of making monodisperse (identical size) polystyrene latex microspheres which may have major medical and industrial research applications.

In STS-3, the purpose of the experiment was to see whether near weightlessness in orbit would allow the polymerization reaction to continue without creaming, that is, to produce larger latex spheres without large, irregular masses of latex forming.

The examination of the product from the experiment in the STS-3 flight of *Columbia* showed that the theory was indeed correct and was 95 to 98 percent successful. Latex microspheres were made larger than scientists can produce on earth.

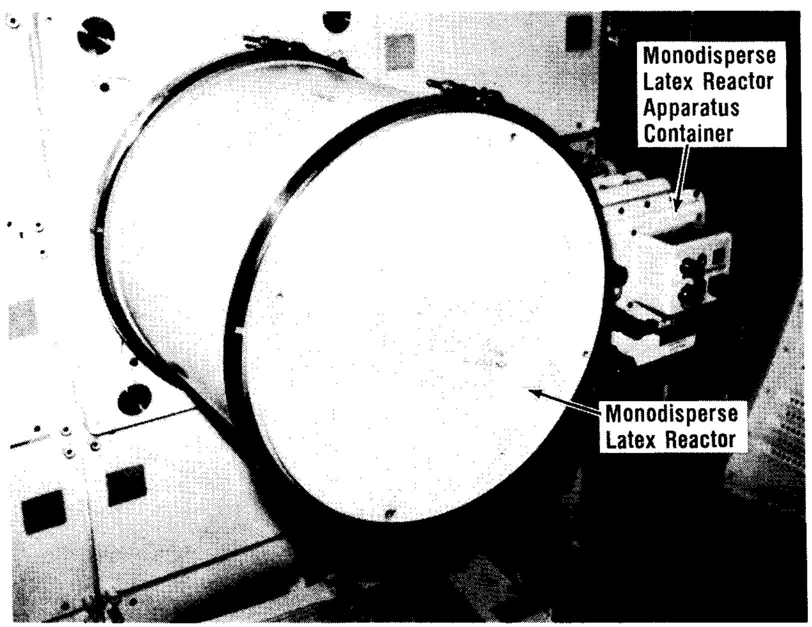
Some of the material produced in the STS-3 flight of *Columbia* were used as a seed in the STS-4 flight of *Columbia* to produce larger spheres.

Each of the four reactor chambers in the STS-3 mission experiment produced about 20 percent usable solids in the 100 cubic centimeters (almost a half-cup) of raw material, each had at the start. One chamber produced spheres that were 0.2-0.3 microns wide as a control to be compared with ground-based spheres. The others produced spheres about 3.5-4.5 and 5.5-6.0 microns wide. Even at the largest size, it would take more than 4,200 spheres to span an inch. The largest that can be produced on the ground are 2-3 microns wide "using nonheroic measures."

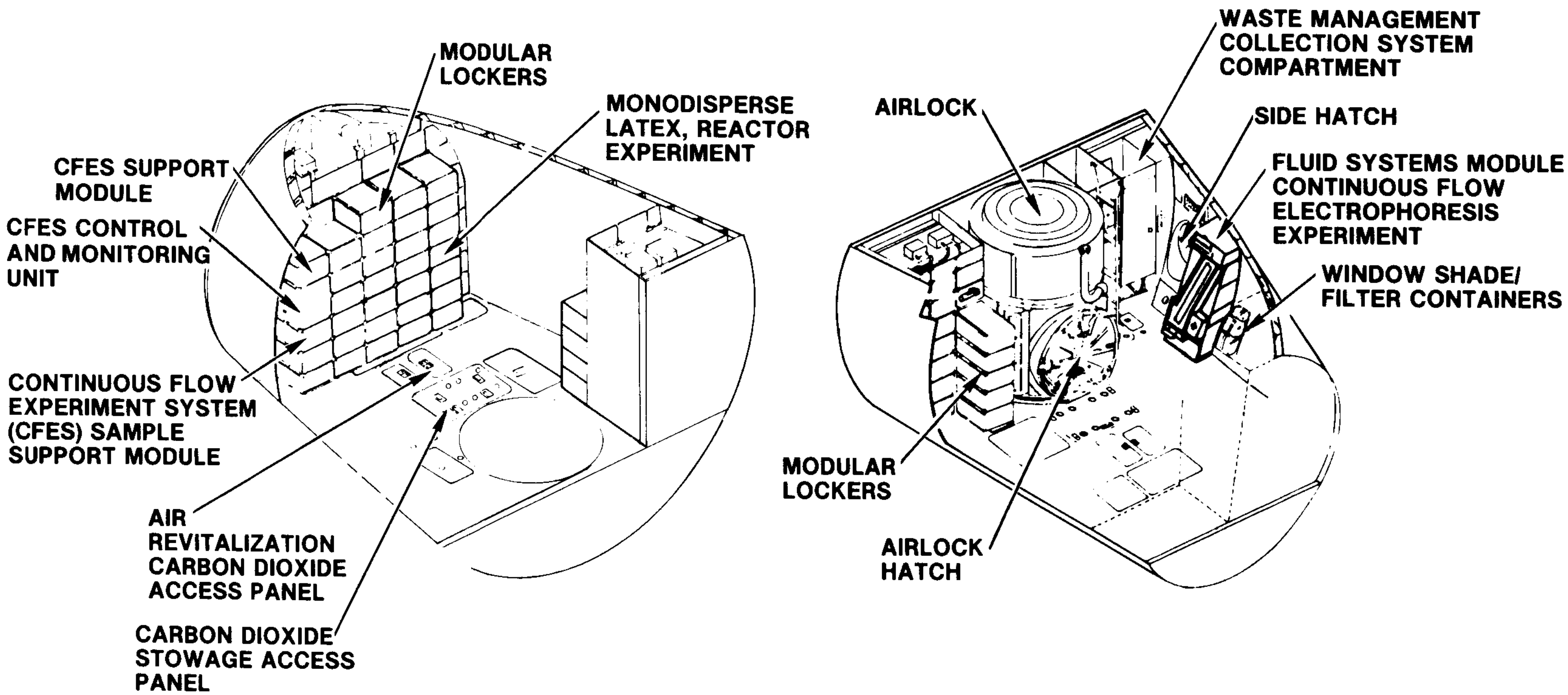
The monodisperse latex reactor (MLR) experiment on the STS-4 prevented the chemical process from taking place as planned due to a malfunction in the dc-dc converter during the mission. Four batches of latex "seed" particles from the STS-3 flight were expected to grow in a range of sizes up to 10 microns. Due to the malfunction, the chemical process was only 55 percent completed.

In the STS-6 mission, latex particles in the 10 micron diameter range were produced. In the STS-7 mission, latex particles, 20 micron size are expected to be produced.

This process was discovered more than 30 years ago when Dr. J.W. Vanderhoff of Lehigh University was with Dow Chemical Company. However, since Vanderhoff discovered the process, they have been limited to a maximum size of about five microns in size and still be monodisperse because gravity causes convection and other effects that limit the reaction to very small yields at great expense and effort. The experiment will help



MLR Experiment in Mid-Deck



Mid-Deck Configuration for STS-7

determine if much larger (perhaps as large as 40 microns) monodisperse beads can be produced practically and economically in space. One micron is a millionth of a meter. One inch is 25,400 microns long.

Possible applications for the spheres include measuring the size of pores in the wall of the human intestines in cancer research and measuring the size of pores in the human eye in glaucoma research as a carrier of drugs and radioactive isotopes for treatment of cancerous tumors and measuring blood flow in humans in heart research.

If there is a major difference in pores within healthy and tumor cells, then the latex microspheres could become missiles that would stick inside tumors but not healthy tissues, thus carrying a higher drug dose in malignant tissue.

The National Bureau of Standards has also indicated its interest in routine use of the beads as calibration standards in medical and scientific equipment.

The experiment series was designed to help determine whether much larger (perhaps as large as 40 microns) monodisperse beads can be produced practically and economically in space.

The experiment consists of four, 304 millimeter (12 inch) tall reactors, each containing a chemical latex forming recipe, housed in a 609 millimeter (24 inch) tall metal cylinder. The recipe is a suspension of very tiny (micron size) latex beads in water or another liquid which cause the beads to "grow" larger when the experiment is activated in space. In space, the latex mixture is heated to a constant 70 degrees Celsius (158 °F) which initiates a chemical reaction to form the larger plastic beads.

Prior to launch, each side of the reactors are loaded with 100-cubic centimeters (6.102 cubic inches) of the chemical latex-forming recipe. A small onboard computer will control the experiment after the flight crew turns it on in orbit. A recorder will store all data produced during operation of the experiment. After 20 hours, the experiment turns itself off.

The reactor is removed from the *Challenger* spacecraft at the landing site and returned to the experimenters for sample and data analysis. After a cleanup and refurbishment of the experiment hardware, it will be ready for another flight.

The MLR experiment is located in the crew compartment mid-deck. It occupies the space of three mid-deck stowage lockers. It requires electrical power from the spacecraft to maintain timing and provide intermittent stowing operations in orbit.

The principal investigator on the experiment is Dr. John W. Vanderhoff of Lehigh University. The three co-investigators are Drs. Fortunato J. Micale and Mohamed S. El-Aasser, of Lehigh University, and Dale M. Kornfield of the Marshall Space Flight Center, Huntsville, AL.

Marshall Space Flight Center Payload Project Office, supported by the Center's Space Sciences Laboratory is responsible for producing and testing the experiment. The Spacelab Payload Project Office is also responsible for experiment safety and interfacing requirements for Space Shuttle flights.

Design support and integration of the experiment was provided by Rockwell International's Space Transportation and Systems Group, Downey, CA. General Electric Company, Valley Forge, PA, built the reactors.

CONTINUOUS FLOW ELECTROPHORESIS SYSTEM (CFES) EXPERIMENT

The continuous flow electrophoresis experiment (CFES) in the STS-6 flight achieved four times better purification of biological materials and also demonstrated that it can separate over 700 times the quantity obtainable in similar ground-based units here on earth. In order to achieve the greater purity in the STS-6 flight, two changes were made. The voltage applied across the chamber was increased from 140 to 400 volts and the amount of time the materials remained in the chamber was increased by 60 percent. Three samples were run on each of two days in the flight. The samples separated were a laboratory standard mixture of rat and egg albumins, a cell culture fluid containing many types of proteins and two samples of hemoglobin. The hemoglobins were tested for NASA's Marshall Space Flight Center. One sample contained only hemoglobin and a second sample containing a mixture of hemoglobin and polysaccharide (a complex sugar). The hemoglobin sample, at 10 times the concentration that can be processed in an earth-based laboratory was designed to explore the concentration limits of electrophoresis in space. The results are still being analyzed, although scientists did note some unexpected broadening of the sample flow. The sample of a mixture of hemoglobin and a polysaccharide was separated to determine the quality of separations in a space-based electrophoresis device. The sample with a lower concentration of hemoglobin, provided data showing a good separation of the biological materials.

In the STS-7 flight, CFES will be used by McDonnell Douglas for separation tests to identify other materials that might be candidates for commercial development.

In the STS-7 flight, NASA's Marshall Space Flight Center Space Sciences Laboratory will also use the CFES for these research. NASA's use of CFES is part of the consideration provided to the space agency under terms of the NASA/McDonnell Douglas joint Endeavor Agreement. This agreement provides a vehicle for private enterprise and NASA to work together to promote the utilization of space where a technological advancement is needed and there is a potential commercial application. The Commercial Materials Processing in Low Gravity Office at Marshall manages NASA's effort under the joint endeavor agreement. In the STS-7 flight CFES will be used to run samples of dyed polystyrene latex particles to further investigate the concentration limitations of CFES in space and to calibrate the experiment hardware.

NASA's experiments are being carried out by Dr. Robert Snyder, chief of the Separation Processes Branch at Marshall. He is assisted in the study by Dr. John Sloyer, a member of Snyder's staff. The joint endeavor agreement provides that general equipment performance data and the results from NASA's experiments using CFES will be made public.

The 249 kilogram (550 pound), 1.8 meter (6 feet) high electrophoresis operations in space (EOS) device is scheduled to be flown three more times in the mid-deck of the spacecraft to identify materials that might be candidates for commercial development. After the completion of these flights, McDonnell Douglas plans to install a 2,268 kilogram (5,000 pound), 4.2 meter (14 feet) long prototype production unit to be carried in the spacecraft's payload bay on two future Space Shuttle flights. The fully automated system will have 24 separation chambers, compared with one that is flown in the mid-deck. The next step would be to install a production EOS in an earth-orbiting satellite to be serviced by the Space Shuttle spacecraft on a six-month schedule by the late 198O's. Proposed satellites under consideration include the Space Platform, the Space Operations Center, and the Multimission Modular Spacecraft.

The continuous flow electrophoresis system experiment is a pharmaceutical producing device designed to demonstrate that pharmaceuticals of marketable purity can be produced in quantity in the zero gravity of space. This is the first of many steps leading to possible commercial operation in space of "space factories." It provides a processing system which can segregate biological samples using a separation process based on the relative motion of charged particles through an electric field (electrophoresis).

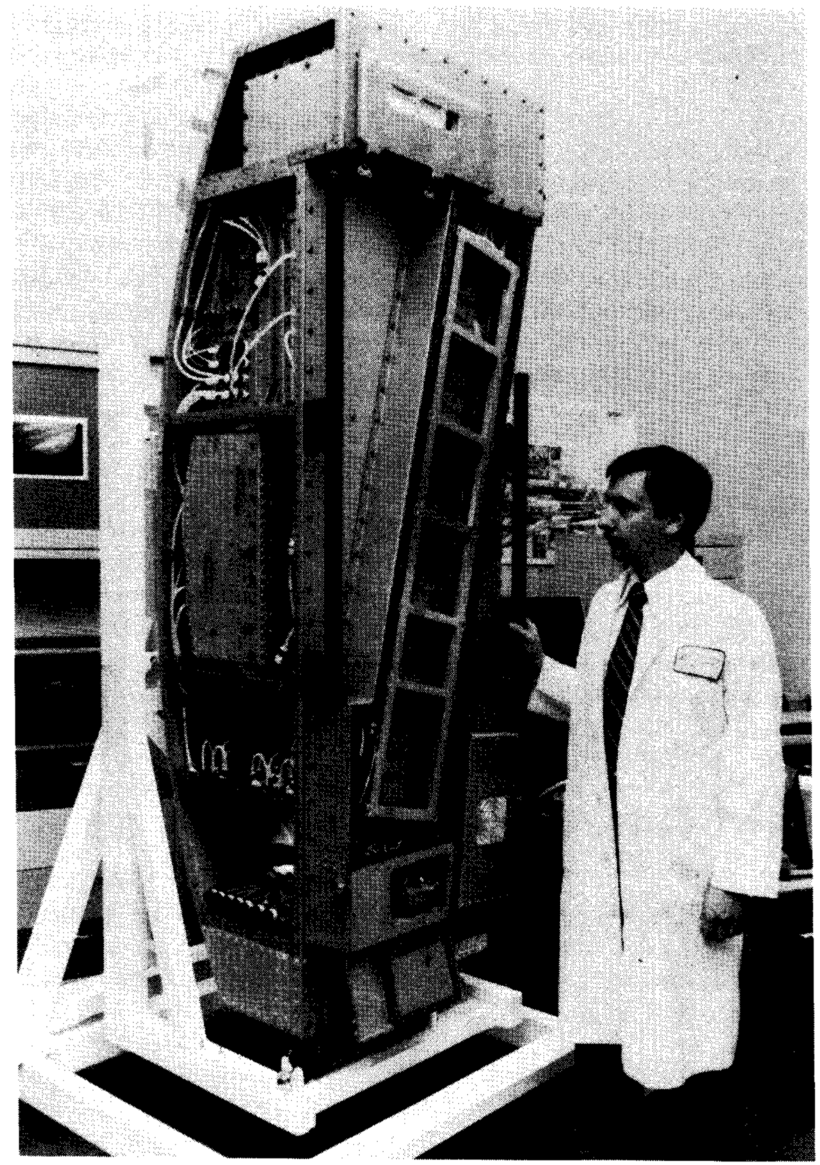
The U.S. materials processing in space (MPS) program is designed to accommodate applied research payloads on economically viable materials, technology, and industrial processes in space and is part of a space processing applications program. It is hoped that this technology will develop products that cannot be produced on earth, or that can be improved greatly by being processed in space. NASA is confident that these payloads will advance new product technology and make significant contributions to American industry for many years.

On earth, people accept the pull of gravity and the atmosphere as essential elements in their existence. Weight is the balance between the earth's gravitational attraction and the centrifugal force caused by the earth's constant high-speed rotation. It is commonly thought of as a force pulling the body or object downward; we refer to it as a force of one-g at sea level. In space (earth orbit), the gravitational attraction of earth to an object is reduced as the object moves away from earth, while centrifugal force increases as it moves faster. In a stable orbit, the two forces equal and cancel each other. This is referred to as zero-g or weightlessness.

Until orbital space flights became possible, a zero-gravity environment could be produced only for very short periods in free fall. Drop towers, aircraft nose-overs, and sounding rocket coast periods could provide periods of zero or reduced gravity lasting from a few seconds to six minutes.

Gravity and the atmosphere often pose serious problems in the manufacturing of certain very important products. The space environment, with its zero gravity and almost perfect vacuum, offers interesting possibilities for large-scale manufacturing of products.

Space processing can provide advantages by lowering costs through the more efficient processing available in space. More frequently, it provides the capability for producing substances or devices that cannot be produced in the presence of gravity and an atmosphere.



Continuous Flow Electrophoresis System

Examples of the difference between earth and space environments are the effects of gravity on the processes of sedimentation and convection. An example of sedimentation is fruit gelatin dessert; the gelatin must be allowed to thicken to a certain extent before adding fruit or the fruit will settle to the bottom. Sedimentation is caused by the effect of gravity on mixtures of solid particles in liquids.

Convection is either the upward movement of part of a gas or liquid that is heated, or the downward movement of a gas or liquid that is cooled. It is caused by the difference in gravity force-weight or buoyancy which occurs at different temperatures. Wind is an example of natural convection of the air; the currents observed in a heated glass pot of water is another example.

In space, sedimentation and convection are virtually absent. A liquid mixture containing materials of greatly differing densities can be solidified without the materials separating. Without convection, some parts of the liquid mixture will get much hotter or colder than on earth. This enables control of the way liquids solidify and thereby control of the product produced. The lack of gravitational forces in space also allows liquids to levitate, or float freely, so that processes can be conducted in space that are impossible on earth because the liquids to be processed would react with their containers.

In earth's one-g environment, it is almost impossible to process useful quantities of some pure biological (such as vaccines). Pharmaceutical companies are presently spending millions of dollars a year on research to improve biological processing. A method called electrophoresis may be used in zero-g to obtain quantities of highly superior, purer biological substances than those that can be produced on earth.

The electrophoresis method separates biological materials, such as human cells, by means of an electrical field (electrical voltage force). In zero-g, the cells will separate because each cell reacts in a different degree to the electrical field. Electrophoresis is not a new process. It has been widely used in blood and urine analysis. However, sedimentation becomes a serious problem in electrophoresis on earth if the particles to be separated are large and heavy, since the gravitational forces on the particles become large relative to the electrophoresis forces. Convection also causes currents that tend to remix the separate factions.

In recent years, scientists have determined that cures or greatly improved treatments for a number of diseases might be possible using certain cells, enzymes, hormones or proteins. One problem has been that these substances are not available in the quantity or purity needed.

In the electrophoresis process, gravity limits the concentration of starting material to be used and thus the output of the process itself. On earth the starting must be diluted to only about 0.1 percent by weight in order for its density to equal that of the carrier fluid a condition necessary for proper suspension and successful separation. In space, these concentrations can be increased to at least 10 percent and as high as 40 percent, and still remain suspended in the carrier fluid. This increased concentration means that an electrophoretic chamber in space could turn out 100 to 400 times as much as a chamber on the ground in the same length of time, thereby providing the premise that marketable quantities of the product can be obtained.

Processing in space offers the additional benefit of improved product purity. On earth, as the starting material separates into individual streams, gravity acts on the density differences between them and the carrier fluid. This phenomenon causes the streams to widen and overlap, which in turn limits the purity of the output product. Because this overlapping phenomenon does not occur as extensively in the microgravity of space, product purity will increase. Analysis indicate that product purity will increase by a factor of about five.

Extensive analytical and experimental work has been accomplished by a skilled team of engineers and scientists representing such disciplines as fluid dynamics, thermodynamics, microbiology, and biochemistry. They continued to develop improved laboratory electrophoresis units so that, by optimizing earth performance, they could understand the limitations of the process. When gravity effects are removed, they predict a significant improvement of the process and thus larger quantity and greater purity.

Thus, the start of space testing is the next step. In addition, the conceptual design of a precommercial space flight pilot plant has been initiated. Present plans call for pilot plant demonstration in 1985 or 1986. Maintaining this schedule could result in commercial operation in 1986 or 1987.

The electrophoresis program is the result of a unique joint endeavor agreement between McDonnell Douglas Corporation and NASA. In addition, McDonnell Douglas Corporation has an agreement with the Ortho Pharmaceutical Division of Johnson & Johnson to collaborate in studying the commercial feasibility of production in space.

McDonnell Douglas anticipates that following successful experimental work, approximately six more years would be necessary before commercial operations can begin; five years would encompass product research and development, space flights to verify technology and to demonstrate a scale-up pilot plant. The additional year is to obtain final Food and Drug Administration approvals.

In this flight, experiment runs will develop data related to electrophoresis separation of six (6) biological samples, each sample running for about ten minutes.

The CFES is comprised of three equipment modules in the orbiter crew compartment mid-deck.

The fluid systems module is installed in lieu of the galley location in the mid deck of the orbiter crew compartment. The fluid systems module contains all fluid systems associated with control of the electrophoretic process. The flow control/conditioning subsystem of the fluid systems module provides functional control of buffer and sample flow rates and system pressures, and is comprised of buffer pumps, flow thermal electronic cooling unit and internal cooling blower.

The buffer reservoir subsystem of the fluid system module provides a depletable supply of process buffer liquid, 35 liters (9.2 gallons) and also serves as a return loop waste tank and the other reservoir provides a fixed volume supply of process buffer 10 liters (2.6 gallons).

The separation column of the fluid system module provides the equipment item within which a sample stream of biological material is separated and contains the carrier buffer/sample separation flow chamber, electrode chambers, fluid supply manifold, sample fraction collection tubing bundle and instrumentation for sensing system parameters of temperature, pressure, differential pressures, and separation chamber voltage gradients.

The degassing subsystem of the fluid system module provides the removal of the hydrogen product of electrolysis generated within the cathode chamber of the separation column and is comprised of three membrane deaeration/ degassing columns, vacuum systems, solenoid isolation valves, liquid sensors and a catalytic converter.

The fraction collecting subsystem of the fluid system module provides valving control of all effluent fractions from the separation column and the positioning control for sample cartridge collectors. The cartridge positioning mechanism is contained in a housing that isolates its interior from the interior of the fluid system module. A latched door on the front of the housing enclosure provides access for installing and removing sample collection cartridges for each separation run collection cycle.

The fluid system module structure is equipped with gasketing to contain liquids within the fluid systems module interior in the event of system leakage. The fluid system module interior tracks cabin pressurization profiles via air exchange through hydrophobic breather panels installed in the fluid systems module enclosure panels.

The sample storage module is a separate insulated enclosure mounted in the module locker area of the mid-deck equipped with a thermal electric cooling unit and shelving for stowing sample supply syringes and sample collection cartridges. The experiment command and monitoring module is a separate module from the fluid systems module located above the sample storage module, which provides autonomous control of the electrophoresis system and is comprised of dedicated experiment processor, power supplies computer peripherals, fusing, displays and electrophoresis to orbiter power interface connectors.

The flight crew will be required to operate the experiment twice during the early portion of the flight. Each operating time lasts approximately seven hours.

The total weight of all three modules and cables is 299 kilograms (660 pounds). The fluid system module is 1.8 meters (6 feet) in height and is 457 millimeters (18 inches) in width.

GETAWAY SPECIAL

The getaway special (GAS), officially titled small self contained payloads (SSCP's), is offered by NASA to provide anyone who wishes the opportunity to fly a small experiment aboard the Space Shuttle.

Since the offer was first announced in the fall of 1976, more than 326 GAS reservations have been made by over 197 individuals and groups. Payload spares have been reserved by several foreign governments and individuals: United States industrialists, foundations, high schools, colleges and universities, professional societies, service clubs and many others. Although many reservations have been obtained by persons and groups having an obvious interest in space research, a large number of spaces have been reserved by persons and organizations entirely outside the space community.

There are no stringent requirements to qualify for space flight, but the payload must meet safety criteria and must have a scientific or technological objective. A person who wishes to fly items of a commemorative nature, such as medallions for later resale as "objects that have flown in space," would be refused.

GAS requests must first be approved at NASA Headquarters, Washington, DC, by the Director, Space Transportation Systems Utilization Office, Code OT6. It is at this point that requests for Space Shuttle space are screened for propriety, and scientific or technical aim. These requests must be accompanied or preceded by the payment of $500 earnest money.

Requests approved by the Space Transportation Systems Utilization Office are given a payload identification number and referred to the GAS Team at the Goddard Space Flight Center, Greenbelt, MD. The center has been designated the lead center or direct manager for the project.

The GAS Team screens the proposal for safety and provides advice and consultation for payload design. The GAS Team certifies that the proposed payload is safe, that it will not harm or interfere with the operations of the Space Shuttle, its crew, or other experiments on the flight. If any physical testing must be done on the payload to answer safety questions prior to the launch, the expense of these tests must be borne by the customer.

In flight, the flight crew will turn on and off up to three payload switches, but there will be no opportunity for flight crew monitoring of GAS experiments or any form of in-flight servicing.

The cost of this unique service will depend on the size and weight of the experiment; Getaway Specials of 90 kilograms (200 pounds) and 0.14 cubic meter (5 cubic feet) may be flown at a cost of $10,000; 45 kilograms (100 pounds) and 0.07 cubic meter (2.5 cubic feet) for $5,000, and 27 kilograms (60 pounds) and 0.07 cubic meter (2.5 cubic feet) at $3,000. These prices remain fixed for the first three years of Space Shuttle operations.

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

The weight of the GAS container, experiment mounting plate and its attachment screws, and all hardware regularly supplied by NASA is not charged to the experimenter's weight allowance.

The GAS container is made of aluminum and the circular end plates are 15 millimeters (5/8 inch) thick aluminum. The bottom 76 millimeters (3 inches) of the container are reserved for NASA interface equipment such as command decoders and pressure regulating systems. The container is a pressure vessel capable of evacuation prior to launch, or evacuation during launch and repressurization during reentry, or maintaining about one atmosphere pressure at all times, evacuation and repressurization during orbit as provided by the experimenter. The experimenters' payload envelopes in the 0.14 cubic meter (5 cubic feet) container are 501 millimeters (19.95 inches) in diameter and 717 millimeters (28.25 inches) in length. The payload envelope in the 0.07 cubic meter (2.5 cubic feet) container is 501 millimeters (19.95 inches) in diameter and 358 millimeters (14.13 inches) in length.

The GAS program is managed by the Goddard Space Flight Center. Project manager is James S. Barrowman. Clarke Prouty, also of Goddard, is technical liaison officer, and queries can be addressed to him at Code 741, Goddard Space Flight Center, Greenbelt, MD, 20771. Program manager at NASA Headquarters, Washington, DC, is Donna S. Miller.

Beginning with the STS-7 mission, the GAS team has inaugurated a new facility dedicated to the preparation of GAS payloads. The facility is located in the old Delta third-stage facility on the Cape Canaveral Air Force, Fla., station.

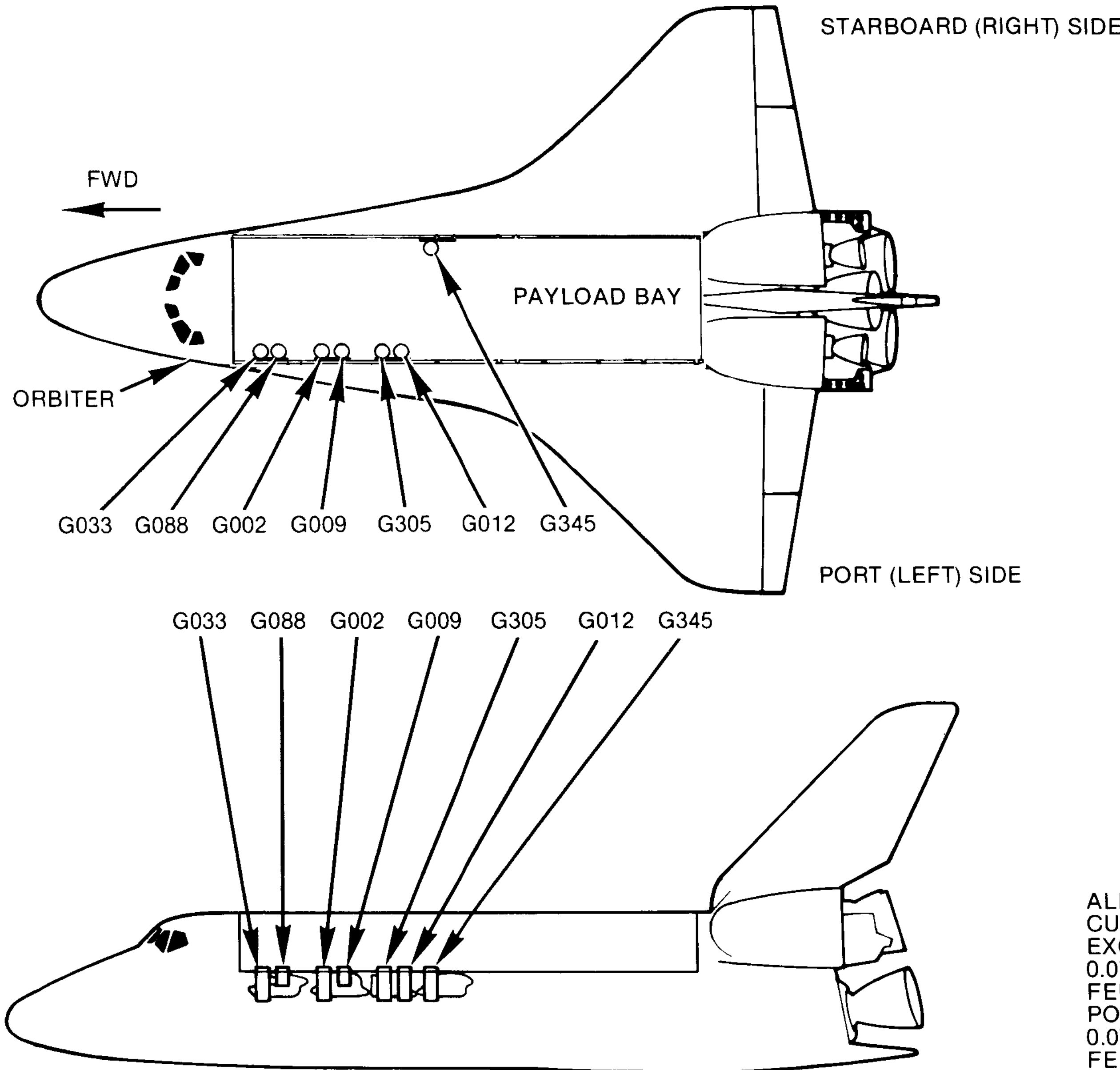
Seven GAS containers are aboard the *Challenger* for the STS-7 mission. These seven GAS experiments have been conceived, designed and built by people who range from high school students to college students, and teachers as well as engineers and technicians from small businesses and large corporations.

Six of the GAS containers require active participation by the flight crew while one GAS container will be turned on by a barometer switch. Six GAS cannisters are attached to the port (left) side of *Challenger's* payload bay and one to the starboard (right) side of *Challenger's* payload bay. One GAS cannister by the U.S. Air Force Space Division will be the first to use a motorized door assembly.

Prior to the STS-7 mission, five GAS cannisters have been flown, one on STS-4, one on STS-5, three on STS-6 and with the inclusion of STS-7, a total of 12 GAS cannisters will have been flown.

GAS cannister G-002 will carry five experiments selected in a nationwide competition between high school students in West Germany. Kayser-Threde, a small West German aerospace company sponsored the experiment. Jugend Forscht, a non-profit organization that organizes an annual nationwide competition among high school students covers all areas of science and technology and selected the five experiments to be flown. The five experiments are contained in one 0.14 cubic meter (5 cubic foot) cannister with a 90 kilogram (200 pounds) capacity. The total mission time for these five experiments range from 72 hours up to 84 hours. These experiments desire two Vernier Reaction Control System (VRCS) attitude control periods of 8 to 10 hours each.

The crystal growth experiment by Michael Pascherat will observe the growth of a crystal in a liquid salt solution under the microgravity environment. Density structures of the solution



ALL GAS CANISTERS ARE 0.14 CUBIC METER (5 CUBIC FEET), EXCEPT FOR G009, WHICH IS A 0.07 CUBIC METER (2.5 CUBIC FEET) 45 KILOGRAMS (100 POUNDS) AND G088, WHICH IS A 0.07 CUBIC METER (2.5 CUBIC FEET) 27 KILOGRAM (60 POUND) CANISTER

Getaway Special (GAS) Canister Locations around the growing crystal will be detected by a laser interferometer and registered by a photographic camera.

The nickel catalysts experiment by Herbert Riepl will manufacture nickel catalysts by thermal processing of four specimen cartridges inside a furnace. Each cartridge contains a mixture of raw material and dry nitrogen.

The plant contamination experiment by Heinz Katzenmeier will determine the transport mechanisms of heavy metals in plants using watercress shoots. Three growth compartments contain seeds, liquids for initiation and fixation as well as air at atmospheric pressure. Temperature will be closely controlled. Three 12 hours day/night cycles are simulated by LED arrays.

The biostack experiment by Marcus Buchwald is designed to determine the influence of cosmic radiation on plant seeds. Different specimen are embedded in containers and exposed to radion. Detector foils are used to determine radiation density.

The microprocessor sequencer by Gunnar Possekel uses a new approach for payload control and sequencing at a low power consumption.

GAS cannister G305 by the U.S. Air Force Space Division's Space Test Program/Naval Research Laboratory is a 0.14 cubic meter (5 cubic foot) cannister with 90 kilograms (200 pounds) capacity. This GAS cannister makes use of an optional GAS cannister opening cover. The first experiment to be carried in the GAS cannister with an opening lid is the Space Ultraviolet Radiation Environment (SURE) instrument developed in the Space Science Division at the Naval Research Laboratory. SURE is a self-contained payload designed to measure the natural radiation field in the upper atmosphere at extreme ultraviolet (EUV) wavelengths between 50 and 100 nanometers. The hardware consists of a spectrometer which separates the wavelength band into two intervals of 128 discrete wavelengths. The radiation intensity at each wavelength is measured and stored on a tape recorder within the SURE payload.

The radiation field in the EUV bank is produced through the action of sunlight on the outer atmosphere above 100 kilometers (62 statute miles) and photochemical process during the day and night. By observing the radiation at discrete wavelengths, signatures of atmospheric and ionospheric atoms, molecules and ions, and the electron density can be obtained. Thus, measurements of the upper atmosphere radiation field in the EUV provides a means of remotely sensing the ionsphere and upper atmosphere. The SURE experiment is the first of a series to be developed at Naval Research Laboratory which ultimately will have the capability of observing "inospheric weather." It is envisioned that in the future, satellites will be stationed at high altitudes to provide global pictures of ionspheric weather conditions. Ionspheric storms or the effects of unusual events, such as solar flares or eruptions, could be monitored and their evolution accurately followed. Effects on communication systems could be observed immediately at any place on the globe.

The SURE experiment is being integrated under the auspices of the DOD (Department of Defense) Space Test program, managed by the USAF Space Division, Space Test Program Office, Los Angeles, Calif. On-site Navy management and technical support is provided by the Navy Space Systems Activity colocated with the USAF Space Division.

The spectrometer will observe emissions out of the *Challenger's* payload bay along the negative Z-axis. One attitude maneuver is desired for this experiment.

GAS cannister GOO9 was donated by DR. Harold Ritchey, an alumnus of Purdue University for use by Purdue University. A program was established within the School of Science which, provided undergraduate and graduate with the opportunity to acquire experience with real problems in science and engineering beyond the traditional "paper" analysis or design projects. In the spring of 1978, experiment proposals were solicited from students by a faculty committee headed by Professor John T. Snow of the Department of Geosciences at Purdue University.

Three experiments were eventually selected and developed. The three experiments are housed in one 0.07 cubic meter (2.5 cubic feet) cannister with a 45 kilogram (100 pounds) capacity. The actual development of the flight hardware was supported by the School of Science, the Schools of Engineering, the School of Technology, and the School of Agriculture of Purdue University. Numerous gifts of materials and supplies have been received from private industry. The U.S. Navy gave access to test facilities. The National Science Foundation provided support for three students to work full time on the project during the summer of 1980. The experiment desires an attitude maneuver after the experiment starts. The experiments includes batteries, temperature control system and an electronic control package. The experiments are entirely self-sufficient except for the three on-off switches through the autonomous payload controller under flight crew control.

The space science experiment, the Nuclear Particle Detection experiment is to detect nuclear particles that may be encountered in the near-earth space environment, and to record their subsequent paths as they penetrate a sensitive stack of sensitive plastic sheets. The information obtained from post-flight, 3-D analysis of the paths will serve to determine their energy and identify the detected particles.

The biological experiment, the Seed Germination experiment will use Sunflower seeds and allow the seeds to germinate in the low gravity environment for a period of 72 hours. In this way, the effect of gravity on the germination and growth of seeds, geotropism (any movement or growth of a living organism in response to the force of gravity-positive geotropism is roots growing downward towards earth—negative geotropism is away from earth) will be studied. The experiment includes a simple life support system and a subsystem for preserving the sprouts for post-flight investigation.

The fluid dynamics experiment will study the motion in very low gravity conditions of a drop of mercury immersed in a clear liquid. This motion will be recorded on film, and measurements of the bulk oscillations of this drop will then be made and compared to theory. The development of this experiment presented real challenges in optics and camera design.

GAS cannister GO33 by the California Institute of Technology. The two experiments are in one 0.14 cubic meter (5 cubic feet) GAS cannister with a 90 kilogram (200 pounds) capacity. One experiment will test how newly-sprouted radish seeds respond to microgravity of space and test the concept that gravity forces dense structures called amyloplasts to settle to the bottom of cells in root tips, which in turn cause the roots to grow downward (geotropism). The second experiment will mix oil and water and see how they separate over a 96 hour period and photographed during this period for interest in space manufacturing, to allow predictions about possibilities of manufacturing materials such as improved metal alloys and semi-conductors in zero "g."

GAS cannister G088 by EDSYN Incorporated an engineering firm in Van Nuys, Calif., is to investigate the process of soldering and desoldering in a space invironment. Nine experiments are contained in one 0.07 cubic meter (2.5 cubic feet) cannister with a 27 kilogram (60 pound) capacity. These experiments will investigate the inevitable soldering/desoldering repair in space of electrical connections and electronic units as well as manufacturing in space. The experiment planning to date has already indicated a number of modifications that will be required of the usual earth-based techniques, particularly for unsoldering and repair (floating solder debris and fumes). One period of VRCS attitude control is desired for the duration of the experiment.

The dynamic flux behavior experiment is designed to determine the best choice of flux to be used in a space enivronment. A comparison will be made between a quadrant soldered on earth and one that has been soldered in space.

Dynamic wetting and surface tension I experiment is designed to measure wetting and surface tension. This test consists of four wires connected to a heating element and bent in such a manner that the wires form a gap for the solder to flow across. The results will be compared with samples prepared on the ground.

Dynamic wetting and surface tension II wire braid wick experiment is designed to determine the solder wetting and surface tension characteristics that relate to the ability of solder to bridge gaps. They will be compared with samples on the ground.

Dynamic metallurgical properties experiment is designed to remelt solder in eyelet and twisted pairs for later cross sectioning and analysis plus determining whether significant contaminants (vapors) are produced during rework operations in space.

Dynamic desoldering I experiment is designed to determine if contamination resulted from the use of conventional solder and desoldering tools can be controlled by surface tension/wicking. The amount of solder that has been removed to the tip will be compared with samples prepared on the ground.

Dynamic desoldering space experiment is designed to determine if solder can be removed from a printed circuit board by use of a hollow tube soldering tube with a hole through the tip and back up through the heater. This test will determine if solder can be removed using air/pressure.

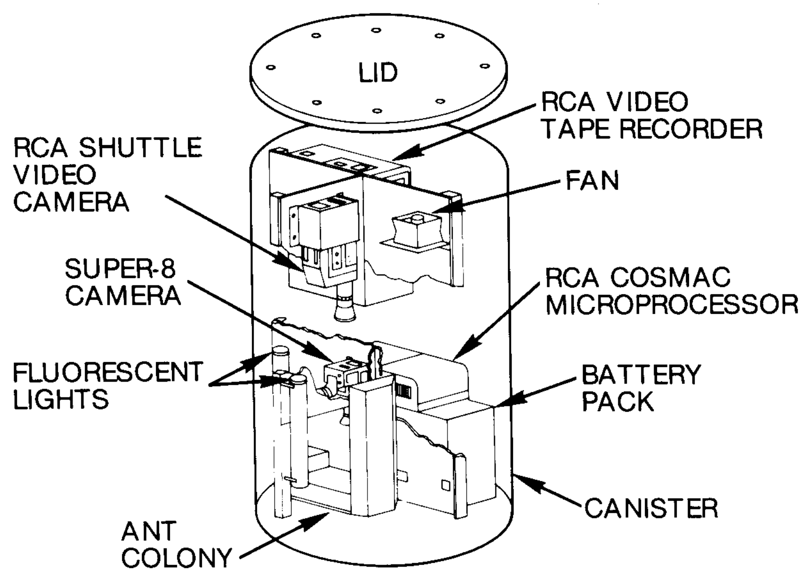
Dynamic general contamination experiment is designed to determine if the basic operation of a soldering tool in space will produce any significant contamination to space environment.

Dynamic solder removal experiment is designed to determine if an integrated circuit can be removed with a multiple head desoldering tool that applies heat then absorbs solder into a braid mesh and for each solder hole in a circuit board.

Static experiment is designed to determine if basic solder tools can be used in space without the requirement of remaining pressurized as they are transported from one spacecraft to another or if personnel must repair a satellite in space, when the repair must be made outside a repair shop environment.

GAS cannister G012 sponsored by RCA Corporation who also supplied technical guidance to students from Camden and Wilson High Schools in Camden, New Jersey, will observe a live ant colony. The ant colony experiment is in one 0.14 cubic meter (5 cubic feet) GAS cannister with a 90 kilogram (200 pound) capacity. The ants will be housed in a special farm and placed in the GAS cannister, along with television and movie cameras, to see whether weightlessness affect the colony's social structure. The ants are Carpenter Ants supplied by Temple University and wood chips are supplied within the cannister for food. The experiment is designed to provide information useful to humans who may colonize space someday.

GAS cannister G345 experiment is conducted by Dr. Werner Neupert of NASA's Goddard Space Flight Center, Bethseda, Md. The experiment is in one 0.14 cubic meter (5 cubic feet) GAS cannister with a 90 kilogram (200 pound) capacity. The experiment is designed to measure the effect of *Challenger's* payload bay environment on extreme ultraviolet sensitive film. Twelve stainless steel cannisters each containing



Ant Colony Experiment

unexposed strips of flown will be placed inside the one GAS cannister. Seven of the cannisters are located inside a large stainless steel cylinder which is initially sealed off from the outside environment by means of a motor driven valve located between the central purge port of the GAS cover and the large stainless steel cylinder. Initially, each of the seven cylinders are open to the interior of the large container. After the experiment timer opens the large container valve, the valves of the individual film cannister are closed at various intervals so film strips are exposed to the *Challenger's* payload bay environment for varying periods of time. One cannister within the large container remains sealed throughout the flight as a control unit. Five cannisters mounted on the outside of the large container will be used for a variety of film tests.

Two extravehicular mobility units (EMU's) are stowed in the airlock of *Challenger* for the STS-7 mission in the event a contingency extravehicular activity (EVA) is required in STS-7. If an EVA is required, mission specialists John Fabian and Norman Thagard will perform the EVA.

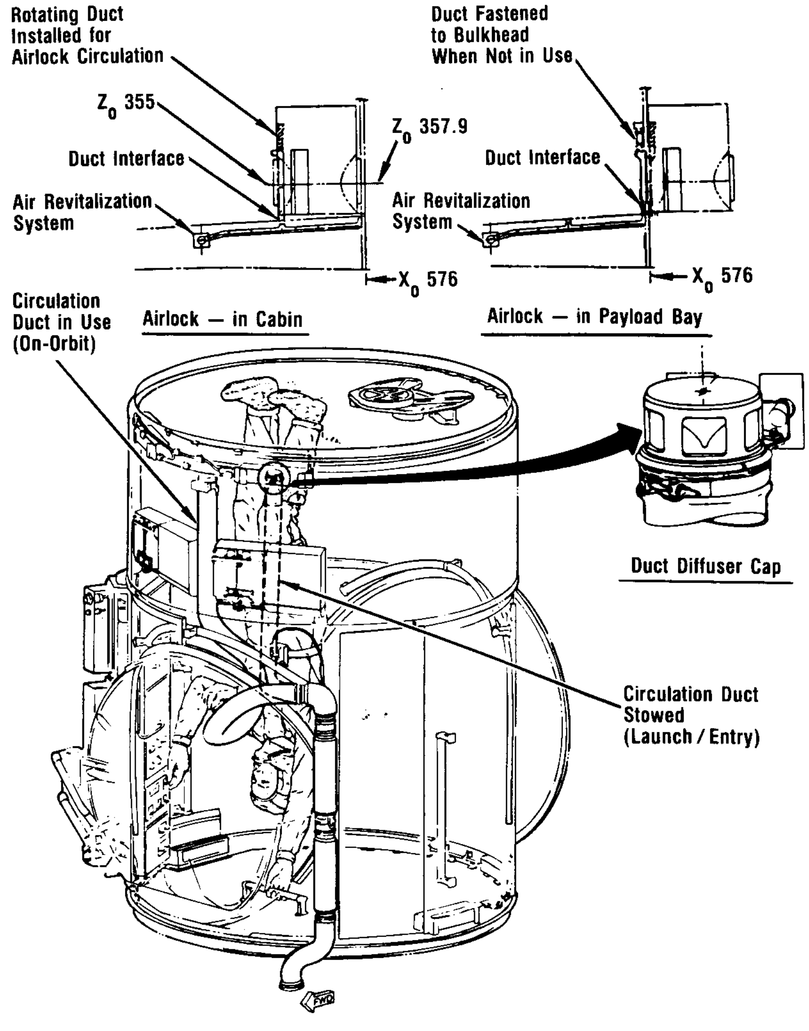
The airlock and airlock hatches permit the EVA flight crew members to transfer from the mid-deck crew compartment into the payload bay without depressurizing the orbiter crew cabin.

The EMU's are an integrated space suit assembly and life support system which provides the capability for the flight crew to leave the orbiter pressurized crew cabin and work outside the cabin in space.

The airlock in this flight 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 two pressure sealing hatches 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 depressurization and repressurization, EVA equipment recharge, liquid cooled garment water cooling, EVA equipment checkout, donning and communications. All EVA gear, checkout panel, and recharge stations are located against the internal walls of the airlock.

The airlock hatches are mounted on the airlock. The inner hatch is mounted on the exterior of the airlock (orbiter crew cabin mid-deck side) and opens in the mid-deck. The inner hatch isolates the airlock from the orbiter crew cabin. The outer hatch is mounted in the interior of the airlock and opens in the airlock. The outer hatch isolates the airlock from the unpressurized payload bay when closed and permits the EVA crew members to exit from the airlock to the payload bay when open.



Airlock

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 two D-shaped airlock hatches are installed to open toward the primary pressure source, the orbiter crew cabin, to achieve pressure assist sealing when closed.

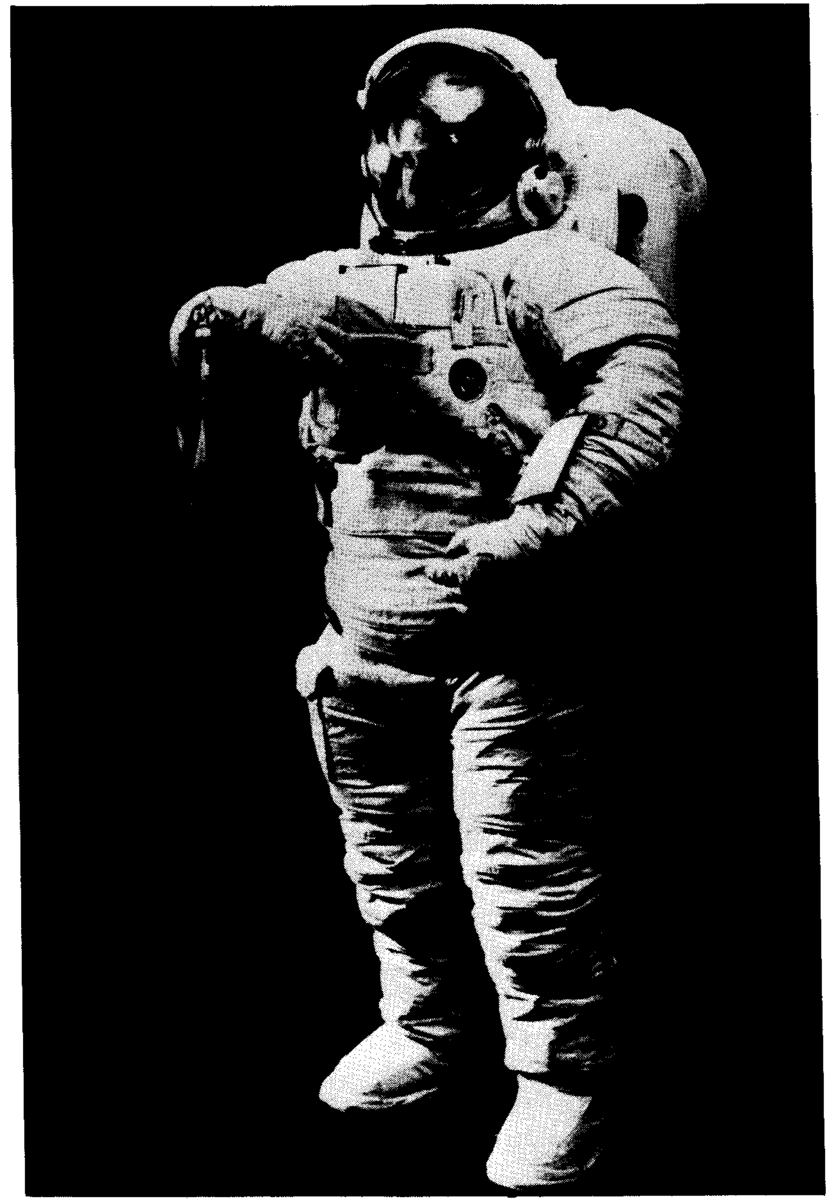
Each hatch has six interconnected latches with a gearbox/actuator, a window, a hinge mechanism and hold-open device, a differential pressure gage on each side, and two equalization valves.

The window in each airlock hatch is 101 millimeters (4 inches) in diameter. The window is used for crew observation from the cabin/airlock and the airlock/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.

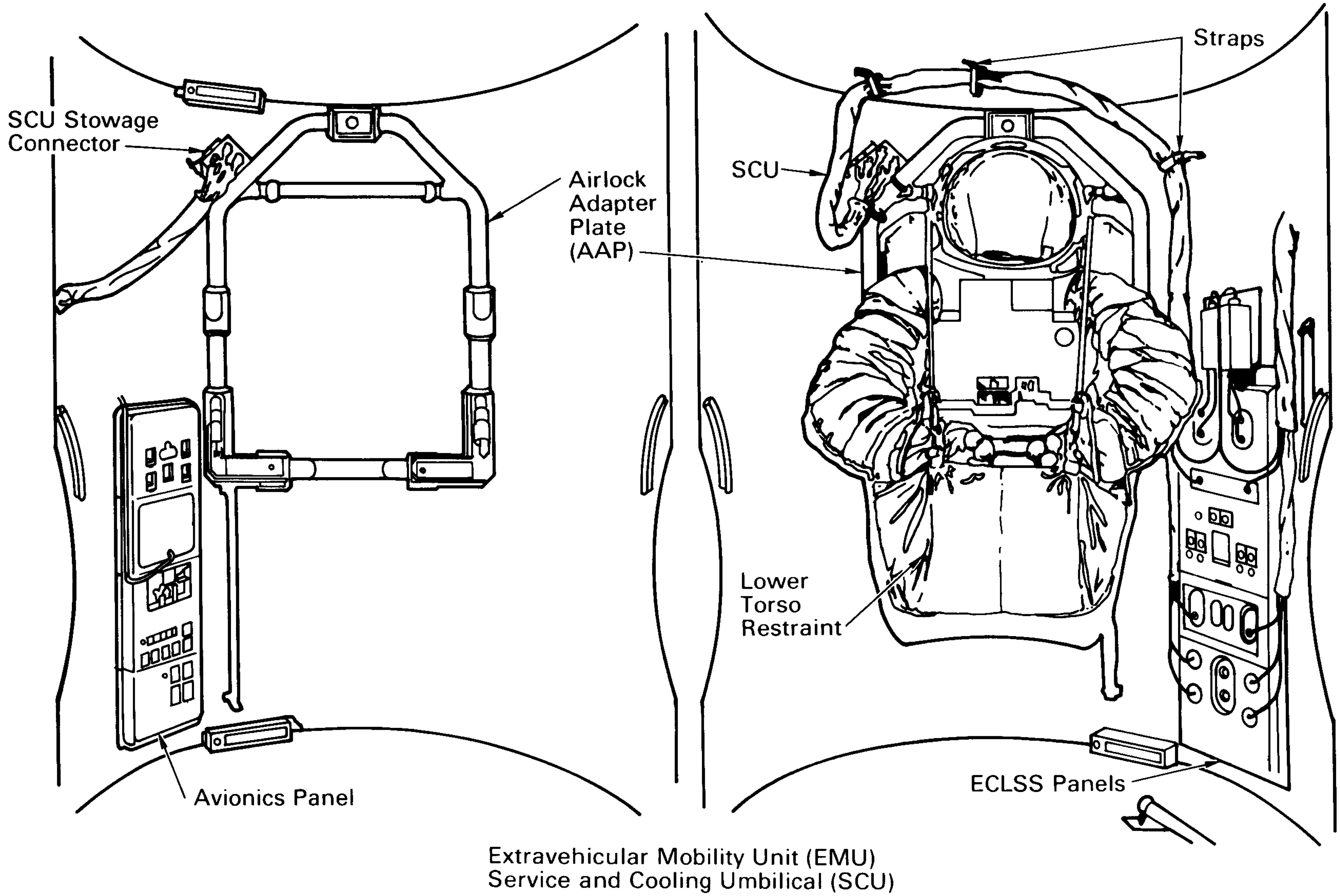
Each airlock hatch has dual pressure seals to maintain pressure integrity for the airlock. One seal is mounted on the airlock hatch and the other on the airlock structure. A leak check quick disconnect is installed between the hatch and the airlock pressure seals to verify hatch pressure integrity prior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

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

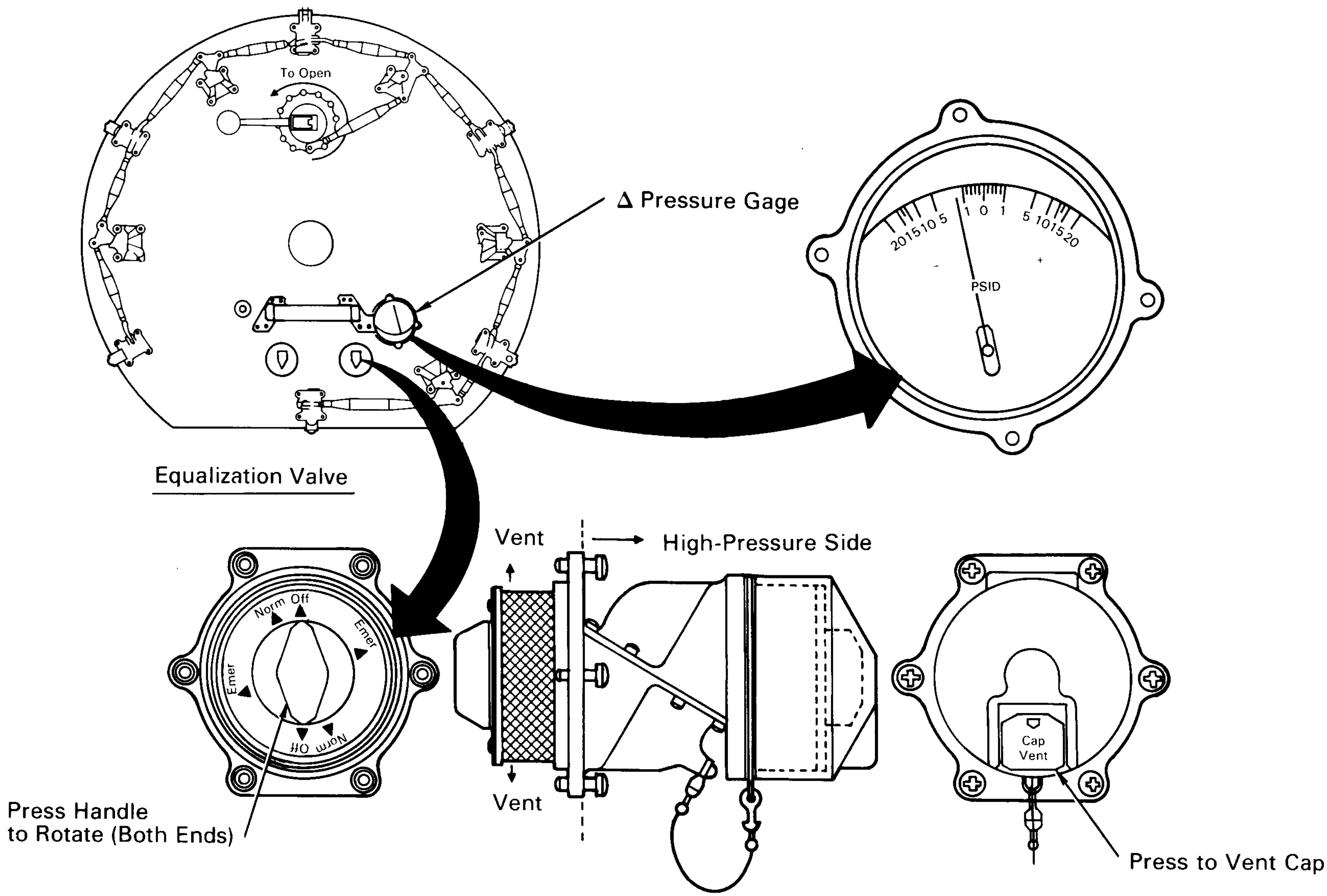
Three of the six latches on each hatch are double acting. They have cam surfaces which force the sealing surfaces apart



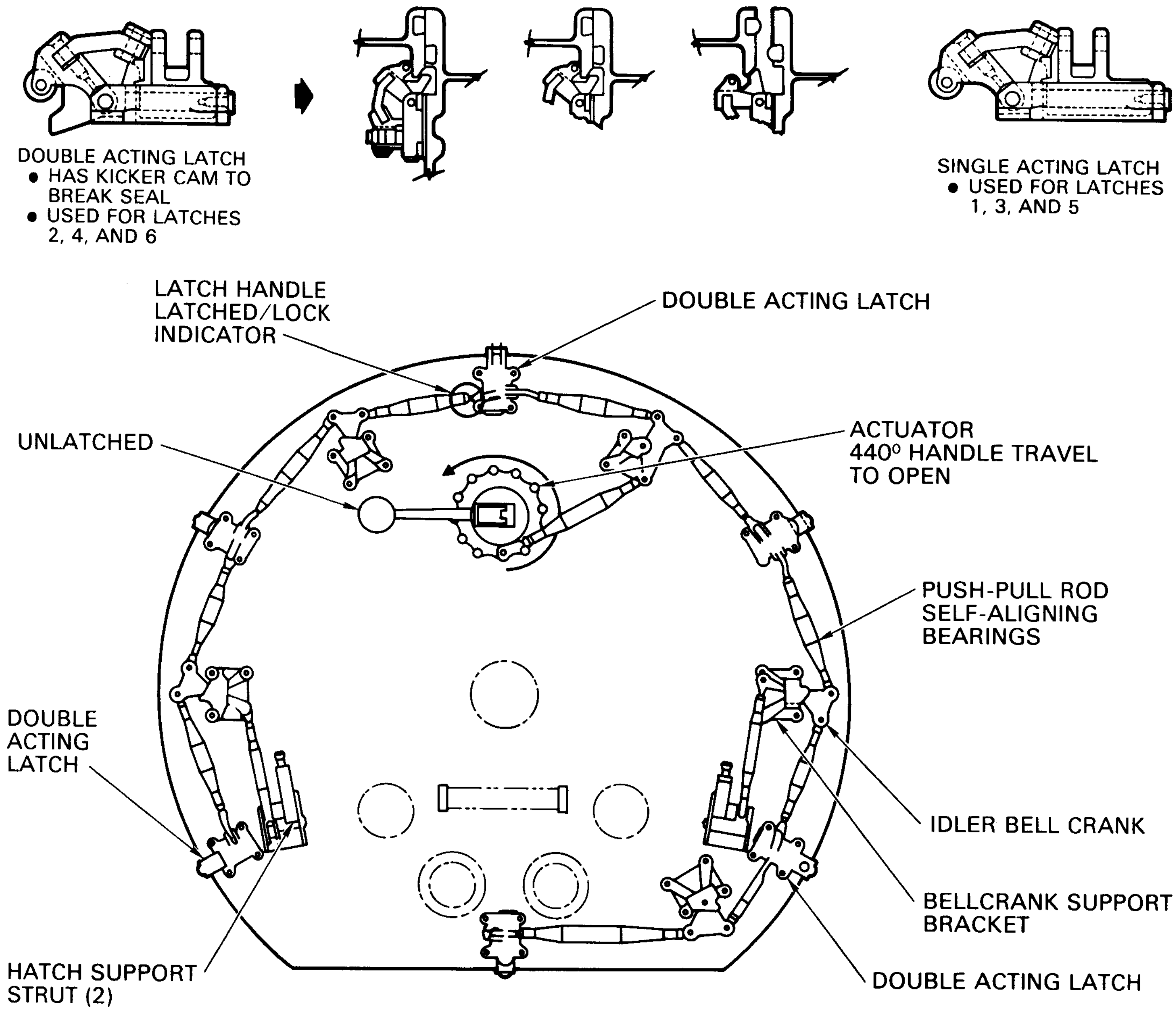
Extravehicular Mobility Unit (EMU)



Airlock Stowage Provisions



Airlock Repressurization



Airlock Hatch Latches

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 and hatch open support struts are also 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) maximum applied to the actuator handle is required to operate the latches to their fully unlatched positions.

The hinge mechanism for each hatch permits a minimum opening sweep into the airlock or the crew cabin mid-deck. The inner hatch (airlock to crew cabin) is pulled/pushed forward to the crew cabin approximately 152 millimeters (6 inches). The hatch pivots up and to the starboard (right) side. Positive locks are provided to hold the hatch 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 outer hatch (in airlock to payload bay) opens and closes to the contour of the airlock wall. The hatch is hinged to be first pulled into the airlock and then pulled forward at the bottom and rotated down until it rests with the low pressure (outer) side facing the airlock ceiling (mid-deck floor). The linkage mechanism guides the hatch from the closed/open, open/closed position with friction restraint throughout the stroke. The hatch has a hold-open hook which snaps into place over a flange when the hatch is fully open. The hook is released by depressing the spring-loaded hook handle and by pushing the hatch toward the closed position. To support and protect the hatch against the airlock ceiling, the hatch incorporates two deployable struts. The struts are connected to the hatch linkage mechanism and are deployed when the hatch linkage mechanism and are deployed when the hatch linkage is rotated open. When the hatch latches are rotated closed, the struts are retracted against the hatch.

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

Airlock air circulation system provides conditioned air to the airlock during non-EVA operation periods. The airlock revitalization system duct is attached to the outside airlock wall at launch. Upon airlock hatch opening in-flight, the duct is rotated by the flight crew through the cabin/airlock hatch and installed into the airlock and held in place by a strap holder. The duct has a removable air diffuser cap installed on the end of the flexible duct which can adjust the airflow from 0 to 97 kilograms per hour (216 pounds per hour). The duct must be rotated out of the airlock prior to closing the cabin/airlock hatch for airlock depressurization. During the EVA preparation period, the duct is rotated out of the airlock and can be used as supplemental air circulation in the mid-deck.

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 was removed for stowage of the third EMU. The foot restraints can be rotated 360 degrees by releasing a spring-loaded latch and will lock in every 90 degrees. A rotation release knob on the foot restraint is designed for shirt sleeve operation, and therefore must be positioned before the suit is donned. The foot restraint is bolted to the floor and cannot be removed in flight and is sized for the EMU boot. The crew member ingresses by first inserting the foot under the toe bar and then the heel is pressed down by rotating the heel from inboard to outboard until the heel of the boot is captured.

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

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

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

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

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

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

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

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

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

The airlock adapter plate in the airlock also provides a 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.

Extravehicular Mobility Unit (EMU)

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

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

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

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

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

Panel AW18H in the airlock provides 17 plus or minus 0.5 Vdc at five amperes at both EMU electrical connector panels, panel AW82D, in EVA prep. Bus MNA or B can be selected on the BUS SELECT switch and then the MODE switch is positioned to POWER. The BUS SELECT switch provides a signal to a remote power controller (RPC) which applies 28 Vdc from the selected bus to the power/battery recharger. The MODE switch in the POWER psoition 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 46,575 mmhg (900 psia) plus or minus 2,587 mmhg (500 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 750 plus or minus 10 mmhg (14.5 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 2.5 mmhg (1/2 psia).

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, the airlock hatch to the orbiter crew cabin is closed and depressurization of the airlock begins.

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

When the crew members have completed the prebreathe in the EMU's for 3.5 hours, the airlock is depressurized from 750 mmhg (14.5 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. Pressure during depressurization can be monitored by the delta pressure gage on either airlock hatch. A delta pressure gage is installed on each side of both airlock hatches. The depressurization from 750 mmhg (14.5 psia) to 258 mmhg (5 psia) takes approximately 200 seconds.

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 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) in approximately 13 seconds. 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 for use by the crew member during the EVA.

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

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

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

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

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

The airlock/cabin hatch has two pressure equalization valves which can be operated from both sides of the hatch for repressurizing the airlock volume. Each valve has three positions, CLOSED, NORM (Normal), and EMERG (Emergency) and is protected by a debris pressure cap on the intake (high-

MODULAR AUXILIARY DATA SYSTEM (MADS)

The Modular Auxiliary Data System (MADS) for OV-099, the *Challenger* is an onboard instrumentation system that measures and records selected pressure, temperature, strain, vibration, and event data to support payloads and experiments and to determine orbiter environments during the flights of the *Challenger*. MADS supplements the operational instrumentation (OI) that exists in the *Challenger*. The MADS equipment conditions, digitizes, and stores data from selected sensors and experiments.

MADS collects detailed data during ascent, orbit, and entry to define the vehicle response to the flight environment, permit correlation of data from one flight to another, and enable comparison of the *Challenger* flight data to the flight data of the *Columbia*.

All of the MADS equipment installed on the *Challenger* are structurally mounted and environmentally compatible with the orbiter and mission requirements. Due to its location, the MADS will not intrude into the payload envelope.

The MADS for *Challenger* consists of a pulse code modulation (PCM) multiplexer, a frequency division multiplexer (FDM), a power distribution assembly (PDA), and appropriate signal conditioners mounted on shelf 8 beneath the payload bay liner of the mid-fuselage. The MADS also consists of a MADS control module (MCM) and a MADS recorder that are mounted below the mid deck floor.

MADS will record approximately 246 measurements throughout the orbiter. These measurements are from the orbiter airframe and skin and the orbital maneuvering system/reaction control system (OMS/RCS) left hand pod only. Measurements of MADS components are connected to existing operational instrumentation for real time monitoring of MADS status.

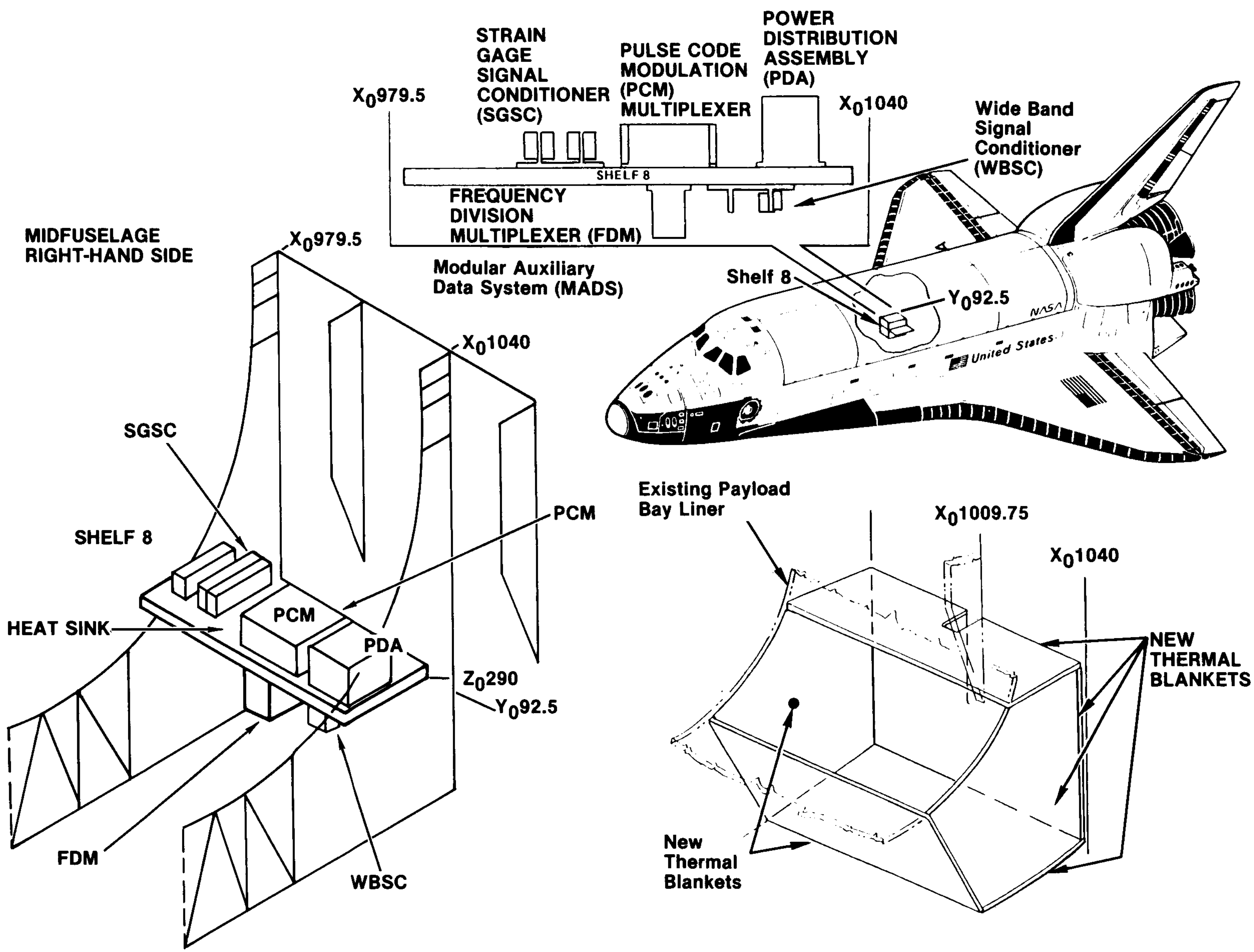
The MADS interfaces with the orbiter through the orbiter electrical distribution system and the inputs to the operational instrumentation for MADS status monitoring. Coaxial cables and wire harnesses from the sensors are routed through the orbiter payload bay harness bundles to the signal conditioners, PCM, and FDM, attached to mid-fuselage shelf 8. After the signal conditioners and the multiplexers have processed the data, four outputs of the FDM and one output of the PCM is routed forward to the MCM, which will then record them on five tracks of the MADS recorder. The same five channels will be routed back through the X-1307 bulkhead to the T-0 umbilical.

Eight tracks of the MADS recorder will be used during ascent to record additional Space Shuttle data. Two tracks will be used to record solid rocket booster (SRB) wideband (WB) data, five tracks to record heavyweight external tank (ET) data, and one track to record aerodynamic coefficient package (ACIP) data.

The MADS is not considered mandatory for launch nor will the loss of MADS during flight be a cause for a mission abort.

MADS will measure and record data for predetermined events. These events are determined by test and mission requirements.

During a typical mission at approximately five hours prior to launch, the MADS will be powered on from the preset switch configuration to supply a prelaunch manual calibration. After completion of the calibration, all switches will be returned to the preset configuration. This leaves the MADS in the standby position, with only the MCM receiving power. This mode will continue until five minutes 30 seconds prior to launch, at which time the MADS will be put into the full system mode through uplink commands and all the MADS components are powered on. In this mode, the MADS will be recording at a continuous (CONT) tape speed of 381 millimeters (15 inches) per second. It



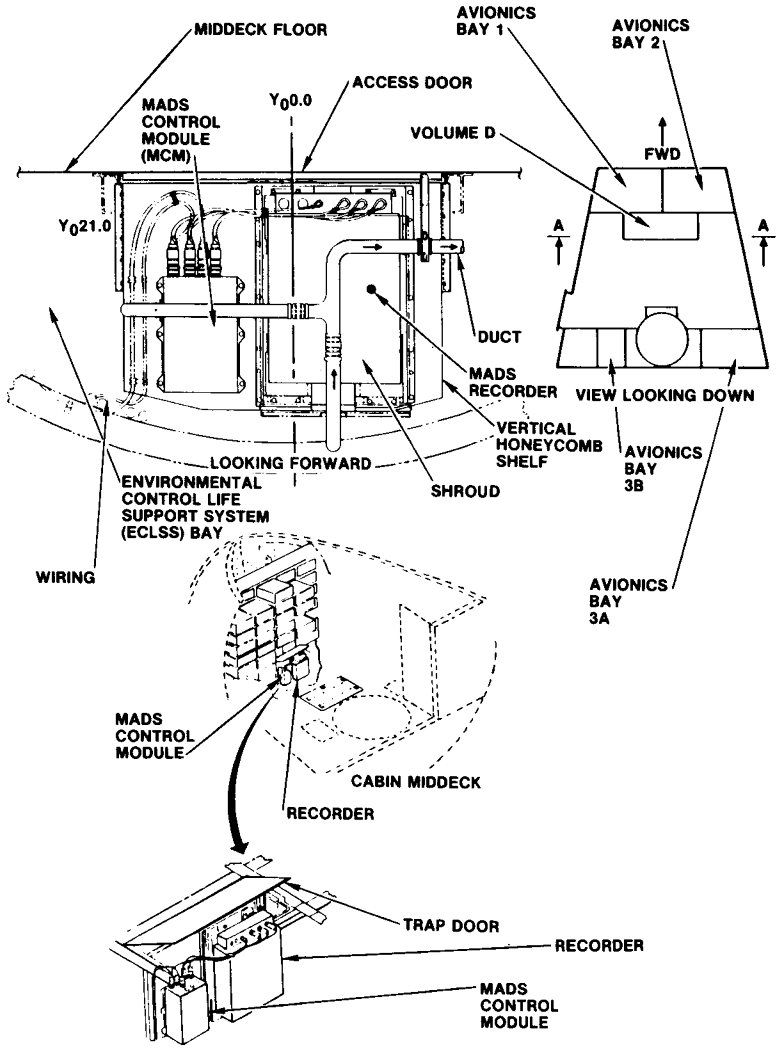
Modular Auxiliary Data System (MADS) Mid-Fuselage will be recording ACIP flight acceleration safety cutoff (FASCO), ET, SRB, WB, and PCM data. The MADS PCM will have a bit rate of 64 kilo-bits-per second (kbps).

The wideband (WB) only mode will be used only during the prelaunch automatic (AUTO) and manual (MAN) calibrations. In this mode, the recorder will be recording the AC and DC current calibration levels provided by the FDM. Each manual calibration level will be recorded for 10 seconds at a tape speed of 381 millimeters (15 inches) per second in the continuous mode.

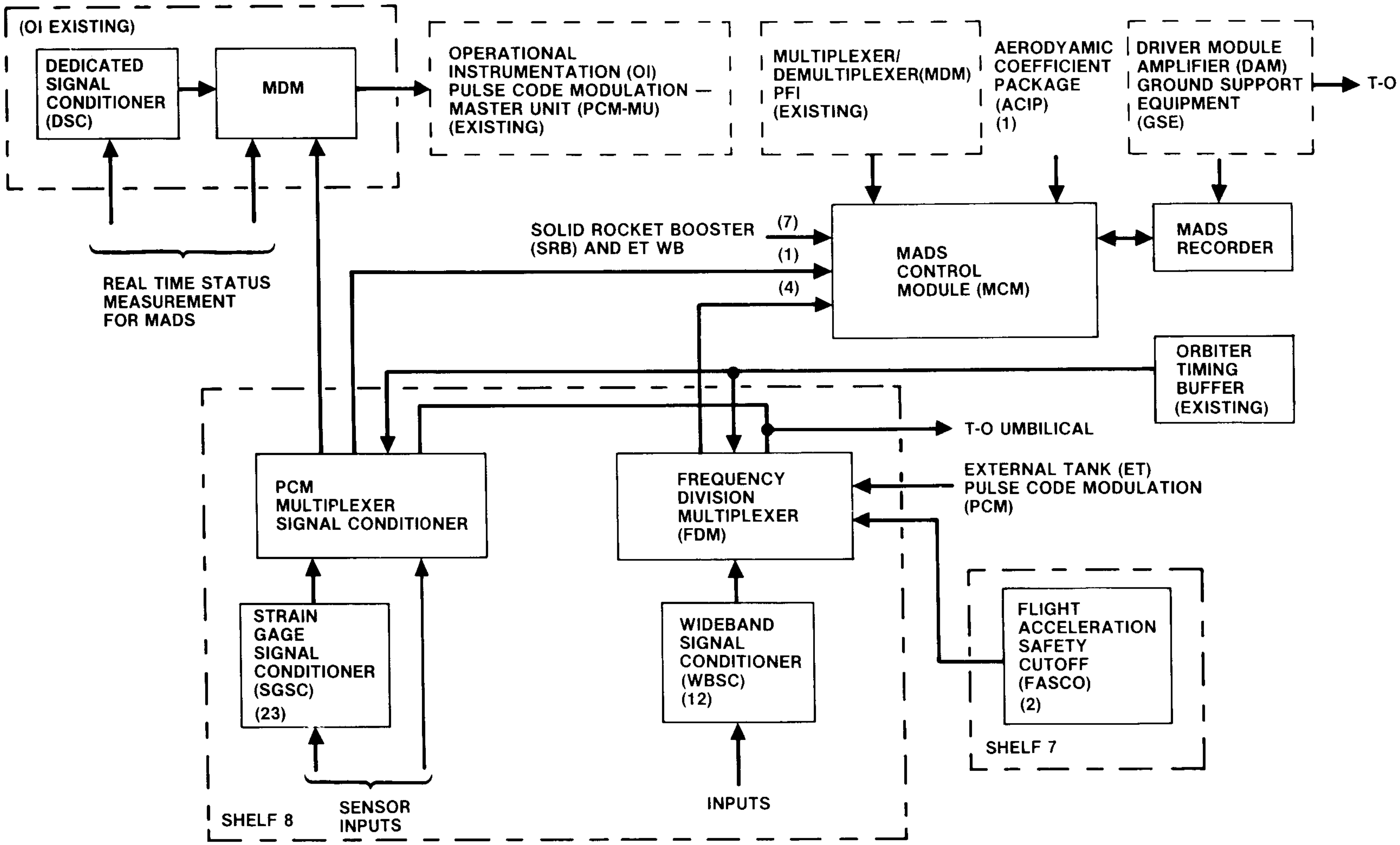
At 12 minutes after launch MADS will be commanded into the PCM snapshot (S/S) with strain gage signal conditioner (SGSC) mode. In this mode, the recorder will be in the sample mode and conserves power and recorder tape. In this S/S mode, data will be recorded every 10 seconds every 10 minutes at a PCM bit rate of 32 kbps and a tape speed of 95 millimeters (3-3/4 inches) per second.

At two minutes prior to the OMS-2 thrusting period, commands will be given to put the MADS back into the full system mode until the thrusting period is completed. At this time, commands will be given to put the MADS into the PCM only mode, which will continue during the orbit until a quiescent period is achieved. During the quiescent period, one minute of ACIP calibration will be required, after which the MADS will continue in the PCM only mode. The system will be switched to the full system mode for the OMS separation thrusting periods and then be returned to the PCM only mode for the majority of the on-orbit mission.

The PCM with strain gage signal conditioners (SGSC) mode is similar to the PCM only mode, but strain measurements will also be recorded during this period. The SGSC's will be cycled along with the other MADS components to signal conditioners to warm up. This mode will occur between two full system modes to minimize flight crew participation and conserve power and recorder tape. This mode can be initiated from the full system mode or returned to the full system mode by one uplink command. This mode can be put into the PCM only mode by commanding the SGSC off, which is done manually by positioning switch 4 on panel A7A2 in the OFF position. This mode is used on orbit.



Modular Auxiliary Data System (MADS) Crew Compartment



Modular Auxiliary Data System (MADS) Block Diagram

At two minutes before the deorbit thrusting period, the MADS will be put into the full system mode for one hour to record descent (entry) data. At the conclusion of the one hour period, the MADS will be powered down for the entire post-landing period.

With the use of the MADS switches located in the flight crew compartment, commands can be initiated by the flight crew. These switches are located on two panels, C3A5 and A7A2. Panel C3A5 is located on the forward flight deck center console and contains the MADS master power switch (S14). This switch will be used to turn power on or off during prelaunch, postlanding and emergencies. Panel A7A2 is located on the aft flight station and contains the component power and functional switches for MADS. From this panel, various control functions can be accomplished. To reduce flight crew participation, all commands should be uplink if possible from Mission Control Center (MCC) Houston (H) and transmitted to the on-board multiplexer/demultiplexer (MDM), Payload Forward (PF)-1. The MDM will then route the commands to the MCM for processing.

Power for the MADS will be supplied from the orbiter's 28 vdc main buses A and B. The ACIP experiment is a separate identity, but its power will be distributed by the MADS power distribution assembly (PDA). The ACIP experiment will consume power when the WB is powered on, using switch 5 on panel A7A5. The 64 kbps of PCM data from the ACIP experiment will be recorded on the MADS recorder during the ascent and entry phases.

The flight acceleration safety cutoff located on shelf 7 in the mid fuselage, directly above the MADS shelf 8, interfaces 12 vibration measurements with the MADS.

The MADS shelf 8 components will be protected from overheating by a passive thermal control system that will be used to constrain maximum temperatures. The MADS installation is thermally isolated from the orbiter structure by 1.2 millimeter (0.049 inches), thin wall titanium struts. The installation is also enclosed from the orbiter environment by a 38 millimeter (1.5 inch) bulk insulation enclosure.

Each measurement uses either a thermocouple, resistance thermometer, radiometers, vibration sensor, strain gage, or pressure transducer.

The MADS recorder is a Bell and Howell 28-track wide-band modular airborne recording system (MARS) similar to the *Columbia* development flight instrumentation (DFI) missions and orbiter experiments (OEX recorders). The recorder is capable of simultaneously recording, and subsequently reproducing, 28 tracks of digital biphase L data or any combination of wideband analog and digital biphase L data equal to 28 tracks.

All 28 tracks can be output simultaneously with adequate levels to drive the input circuitry of the driver amplifier module (DAM) which is part of the MADS equipment that is not installed in the orbiter. It is support equipment that will be carried on and used for dumping the data recorder during the checkout or postlanding.

The total weight of the MADS is 290 kilograms (641 pounds).

The ACIP incorporates three triaxial instruments: one of dual-range linear accelerometers, one of angular accelerometers, and one of rate gyros. Also included are the power conditioner for the gyros, the power control system, and the housekeeping components for the instruments. The ACIP is aligned to the orbiter axes to a very high order of accuracy. Mounted on the ACIP base is a triaxial vibrometer which will provide the structural vibration characteristics of the orbiter affecting the ACIP experiment necessary for baseline filtration of accelerometer data. The output signals of the instruments are recorded on the Modular Auxiliary Data System (MADS) recorder. The ACIP operates through launch and through the entry and descent phases. The internal instruments continuously sense the dynamic and performance characteristics of the orbiter through these critical flight phases. In addition, the ACIP receives indications of position of the control surfaces and converts them into higher orders of precision before recording them with the attitude data. Power is supplied from the mid-power control assembly 3 main bus C. Heaters are employed on the package and controlled by a switch on panel R11.

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

AERODYNAMIC COEFFICIENT IDENTIFICATION PACKAGE (ACIP)

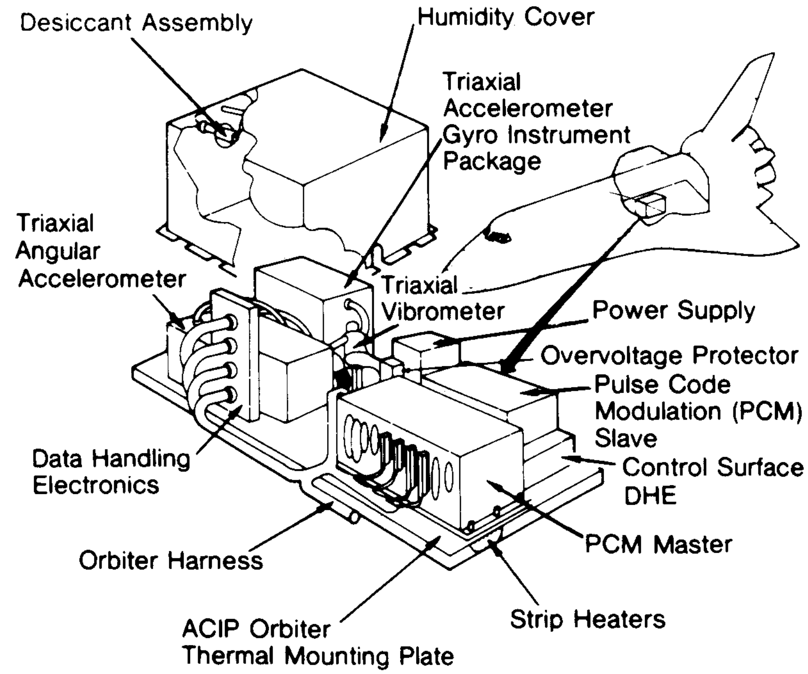
The ACIP is a sensor package installed below the payload bay area in the aft area of the mid-fuselage at station X_O 1069. It contains a rate gyro package, a linear accelerometer package, an angular accelerometer package, and associated electronics.

The ACIP will collect aerodynamic data in the hypersonic, supersonic, and transonic flight regimes, regions in which there has been little opportunity for gathering and accumulating practical data, to establish an extensive aerodynamic data base for verification of and correlation with ground-based test data including assessments of the uncertainties in such data. In addition, it will provide flight dynamics state and variable data in support of other technology areas, such as aerothermal and structural dynamics.

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

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

The ACIP incorporates three triaxial instruments: one of dual-range linear accelerometers, one of angular accelerometers, and one of rate gyros. Also included are the power conditioner for the gyros, the power control system, and the housekeeping components for the instruments. The ACIP is aligned to the orbiter axes to a very high order of accuracy. Mounted on the ACIP base is a triaxial vibrometer which will provide the structural vibration characteristics of the orbiter affecting the ACIP experiment necessary for baseline filtration of accelerometer data. The output signals of the instruments are recorded on the modular auxiliary-data system (MADS) recorder. The ACIP operates through launch and through the entry and descent phases. The internal instruments continuously sense the dynamic and performance characteristics of the orbiter through these critical flight phases. In addition, the ACIP receives indications of position of the control surfaces and converts them into higher orders of precision before recording them with the attitude data. Power is supplied from the mid-



Aerodynamic Coefficient Identification Package (ACIP) Experiment

power control assembly 3 main bus C. Heaters are employed on the package and controlled by a switch on panel R11.

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

KENNEDY SPACE CENTER SHUTTLE LANDING FACILITY

The runway at the Kennedy Space Center, Florida Shuttle landing facility is among the world's most impressive in terms of length and width. The runway is 4,572 meters (15,000 feet) in length plus a 304 meter (1,000 foot) overrun at each end. The width of the runway is 91 meters (300 feet). The concrete runway 22/04 at Edwards Air Force Base, Calif., matches the Kennedy Space Center runway in length and width with an overrun of eight kilometers (five miles) extending into the dry lake bed when landing on 04.

The Kennedy Space Center runway on a northwest-southeast alignment is designated runway 15 from the northwest to southeast and runway 33 from the southeast to the northwest. The runway is located approximately 3 kilometers (2 miles) northwest of the 160 meter (525 feet) tall Vehicle Assembly Building. The runway required approximately 546 hectares (1,350 acres) of land area, most of it high, dry land. Its use before the lands were purchased in the early 1960's was primarily agriculture. The runway is 406 millimeters (16 inches) thick in the center with thickness diminishing to 381 millimeters (15 inches) on the sides. Underlaying the concrete paving completed in late October 1975, is a 152 millimeter (6 inch) thick base of soil cement. The concrete used in paving the landing facility required about 1,000 carloads of cement and 10,000 carloads of crushed limestone and sand aggregate. 192,679 cubic meters (252,000 cubic yards) of concrete was used in paving the runway. The landing facility was built and outfitted at a cost of $27.2 million.

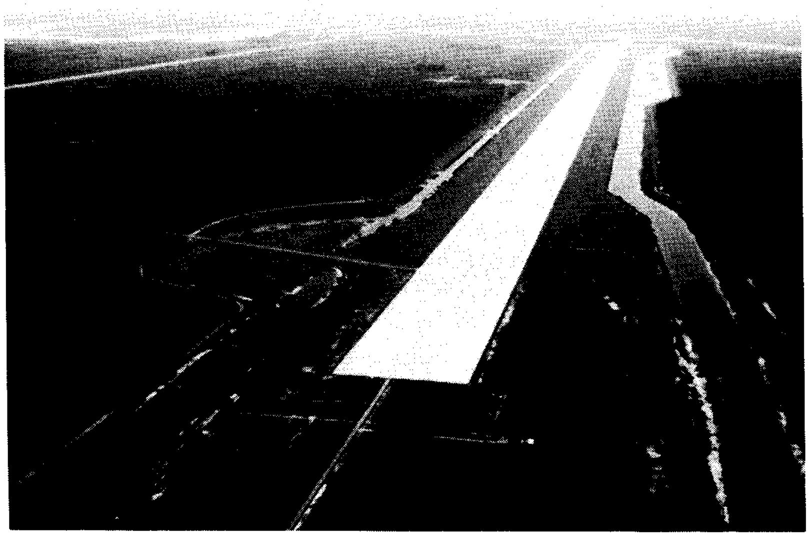
The runway is grooved, together with the slope of the runway, 609 millimeters (24 inches) from centerline to edge, provides rapid drain off of any water from a heavy Florida rain, preventing hydroplaning.

From its inception, the Shuttle landing facility was designed as an ecological model for airfield construction and environmental impact was held to a minimum.

The orbiter navigation system acquires the Microwave Scan Beam Landing System (MSBLS) usually on or near the final leg of the heading alignment cylinder for the TAEM (Terminal Area Energy Management)/Autoland interface. The ground based MSBLS components are located in small shelters off the west side of the runway.

The two MSBLS azimuth/distance measuring equipment shelters at the far end of each runway is approximately 396 meters (1,300 feet) beyond the stop end of each end of the runway and 94 meters (308 feet) to the west of the runway's centerline. The MSBLS azimuth/distance measuring equipment shelter sends signals which sweep 15 degrees on each side of the landing path with directional and distance data.

The two MSBLS elevation stations are approximately



Runway at KSC

1,082 meters (3,500 feet) in from the runway threshold at each end of the runway. Signals from the MSBLS shelter near the spacecraft touchdown point sweep the landing path to provide elevation data up to 30 degrees. The three MSBLS system aboard the spacecraft receives these data and the spacecraft adjusts to the glide path. The two radar altimeters aboard the spacecraft provide altitude information in the spacecraft when it is below 1,524 meters (5,000 feet) altitude.

Approach lights point to the runway centerline and the threshold and edge lights outline the field similar to a commercial runway.

The tow way from the Shuttle Landing Facility to the Orbiter Processing Facility is approximately 3.2 kilometers (2 miles).

It is noted, that during the entry and landing phase planned for runway 15 at the Kennedy Space Center, Fla., C-band tracking stations at San Nicholas Island off the coast of California, Vandenberg Air Force Base, California, White Sands, New Mexico, Stallion Station, Arizona, Scotts Peak, Arizona and Mt. Lemmon, Arizona, will provide highly critical tracking data on the *Challenger* before it comes into view of the Eastern Test Range C-band stations at Merritt Island and Patrick Air Force Base, Florida. The Goddard Space Flight Center (GSFC) Merritt Island S-band station will provide highly critical telemetry, command and air-ground support as well as tracking data to the Johnson and Kennedy Control Centers.

PAYLOAD REVISIONS FOR STS-8 MISSION

On May 27, 1983 NASA announced that the Tracking and Data Relay Satellite (TDRS-B) would not be flown on the STS-8 mission. It was also announced that the Payload Deployment Retrieval System (PDRS)/Payload Flight Test Article (PFTA) originally scheduled to be flown on the STS-11 mission, would now be flown on the STS-8 mission along with the originally manifested INSAT (India Communications Satellite) -1B/PAM (Payload Assist Module) -D. In addition, the present schedule also calls for four Getaway Specials (GAS) to be flown on the STS-8 mission.

Proper placement in geostationary orbit of the INSAT-1B satellite dictates the requirement of the night launch of STS-8 *(Challenger)* from Kennedy Space Center in Florida and the night landing on the dry lakebed runway at Edward Air Force Base, Calif. The STS-8 mission duration will now be five days in duration instead of the original four day mission. The launch inclination remains at the original schedule of 28.5 degrees and 150 nautical mile (172 statute mile) attitude.

INSAT-1B will be relocated in *Challenger's* payload bay from cargo bay station No. X_o 715 — X_o 793 to No. X_o 1202.73 — X_o 1281.4 and the PFTA is installed at station No. X_o 892 — X_o 1072.93.

The PFTA is 6.03 meters (19 feet 9 inches) in length and 4.77 meters (15 feet 8 inches) in width. This payload has a total of four different grapple fixture locations, which the PDRS (Remote Manipulator System [RMS]) will grapple in removing the PFTA from *Challenger's* mid-body for the on orbit test of the RMS and the berthing of the PFTA in the mid-body. The on orbit weight of the PFTA for the testing is 3,383 kilograms (7,460 pounds).

Preliminary discussions are also underway to place the Development Flight Instrumentation (DFI) pallet (minus its DFI instrumentation used in the flights of *Columbia*) in the payload bay of *Challenger* for the STS-8 mission, in front of the PFTA with experiments on it.

MODIFICATIONS TO *COLUMBIA* FOR STS-9 SPACELAB MISSION

1982

Dec. 20	Start Spacelab-1 modifications

1983

May 13	Install Forward Reaction Control System
May 16	Install Right Hand Orbital Maneuvering System/Reaction Control System pod
May 23	Post modification power up
June 8	Install Left Hand Orbital Maneuvering System/Reaction Control System pod
June 25	Install Space Shuttle Main Engine (SSME) No. 1 and No. 2
July 21	Install SSME No. 3
Aug. 3	Install Spacelab-1
Aug. 24	Transfer *Columbia* from Orbiter Processing Facility to Vehicle Assembly Building for mating with External Tank and Solid Rocket Boosters
Sept. 2	Transfer Space Shuttle *(Columbia)* from Vehicle Assembly Building to Launch Complex 39A
Sept. 30	Launch STS-9 Spacelab-1

MODIFICATIONS

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

Thermal Protection System

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

MODIFICATIONS COMPLETED

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

Complete catalytic surface coating experiment removal

Aerosurface servo amplifier removal and replacement update to operational configuration

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

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

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

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

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

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

Removed and replaced ammonia boiler.

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

Water dump valve replaced with updated configuration.

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

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

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

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

Removed and replaced accelerometer assemblies.

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

Removed and replaced Orbital Maneuvering System high pressure helium isolation valves.

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

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

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

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

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

Orbital Maneuvering System Engine gimbal actuator replacement.

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

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

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

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

Modified left hand Orbital Maneuvering System fuel pressure transducer fitting.

Replaced aft Orbital Maneuvering System aft fuel probe in fuel tanks.

Modification of timing buffer power supply.

Incorporation of payload timing signal distribution.

Relocation of treadmill in crew compartment mid-deck.

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

Microwave Scan Beam Landing System (MSBLS) decoder update.

Removal and replacement of main hydraulic pump bolt/washer.

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

Main propulsion system 17 inch external tank disconnect flow liner modification.

Orbital Maneuvering System helium pressure regulators changed out.

Modification of screw in Star Tracker Light shade.

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

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

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

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

Removal and installation of updated operational configuration flash evaporator system.

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

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

Inlet fittings of Freon coolant loop flow proportional valve change.

Removal of atmospheric revitalization system diffusers.

MODIFICATIONS IN WORK

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

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

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

Modification of nose landing gear door thermal barrier.

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

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

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

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

Addition of strut pad for Spacelab unique crew stations.

Avionics bay 6 strut rework.

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

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

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

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

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

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

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

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

Addition of fuel cell instrumentation.

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

Air data transducer assembly removal and replacement.

UHF transceiver removal and replacement.

NEWS About Space Flight

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

Commander: John W. Young

Pilot: Robert L. Crippen

Mission Duration—54 hours, 21 minutes, 57 seconds

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

Orbits of Earth—36

Orbital Attitude—145 nautical miles (166 statute miles)

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

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

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

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

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

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

Commander: Joe Engle

Pilot: Richard Truly

Mission Duration—54 hour, 24 minutes, 4 seconds

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

Orbits of Earth—36

Orbital Altitude—137 nautical miles (157 statute miles)

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

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

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

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

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

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

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

Commander: Jack Lousma

Pilot: Gordon Fullerton

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

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

Orbits of Earth—130

Orbital Altitude—128 nautical miles (147 statute miles)

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

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

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

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

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

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

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

Commander: Ken Mattingly

Pilot: Henry Hartsfield

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

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

Orbits of Earth—112 orbits

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

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

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

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

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

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

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

Commander: Vance D. Brand

Pilot: Robert F. Overmyer

Mission Specialist: Joseph P. Allen

Mission Specialist: William B. Lenoir

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

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

Orbits of Earth—81

Orbital Altitude—160 nautical miles (184 statute miles)

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

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

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

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

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

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

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

Commander: Paul Weitz

Pilot: Karol Bobko

Mission Specialist: Donald Peterson

Mission Specialist: Story Musgrave

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

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

Orbits of Earth—80

Orbital Altitude—153.5 nautical miles (176.6 statute miles)

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

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

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

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

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

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

STS-6 SUMMARY

The maiden flight of *Challenger* STS-6 with its crew of Paul Weitz (commander), Karol Bobko (pilot) and Donald Peterson and Story Musgrave (mission specialists) began the STS-6 mission with a flawless countdown and launch on April 4, 1983 from Kennedy Space Center, Fla. (launch complex 39A) and concluded April 9, 1983 at Edwards Air Force Base (the Dryden Flight Research Center Facility), Calif.

Challenger on its first flight into space carried the Inertial Upper Stage (IUS)/Tracking Data Relay Satellite (TDRS) -A to its respective drop-off point 153.5 nautical miles (176 statute miles) above the earth successfully. An additional objective of an extra-vehicular activity (space walk) was also accomplished.

On April 4, the launch of the IUS/TDRS-A was accomplished on time at 11:30:01 P.M. E.S.T. After ejection of the IUS/TDRS-A, the IUS first stage motor ignition was commanded on time at 12:26 A.M. E.S.T., April 5 for a duration of two minutes and 31 seconds. The first stage was jettisoned on time. Shortly after 6 A.M. E.S.T. on April 5, second stage ignition of the IUS was commanded for a duration of one minute and 43 seconds. Approximately 70 seconds into the IUS second stage thrusting period communications with the IUS/TDRS-A were lost and ground control thought the IUS/TDRS-A was tumbling at a high rate. Shortly after 9 A.M. E.S.T. on April 5, however, it was confirmed that the IUS had separated from TDRS-A and that TDRS-A had extended its solar panels and was back under control. The apparent misfiring of the IUS second stage had placed TDRS-A into a high ellipitical orbit, 24,359 kilometers (21,950 miles) apogee and at 20,908 kilometers (13,450 miles) perigee. However TDRS-A was not in the plane of the earth's equator, but crosses within parameters of an equatorial plane 2.4 degrees. A series of selected thrusting periods by the small attitude control hydrazine thrusters on TDRS-A have and are being conducted to eventually place TDRS-A at geosynchronous orbit of 35,888 kilometers (22,300 miles) at the Equator. Once TDRS-A is on station at the Equator, the TDRS-A payload (communications systems) will begin their checkout period.

On April 7, at 12:38 P.M. E.S.T., mission specialists Story Musgrave and Donald Peterson were in their extravehicular mobility units (EMU's or space suits) and began the three and one-half hours of prebreathing of 100 oxygen in their respective suits in the airlock of *Challenger*. Upon completion of the prebreath, Musgrave and Peterson began the preparations of closing the airlock hatch, depressurization of the airlock, EMU checkout, with opening of the airlock hatch into *Challenger's* payload occurring at 4:05 P.M. E.S.T. Musgrave and Peterson accomplished the preplanned extra-vehicular activity tasks in *Challenger's* payload bay and entered the airlock and closed the airlock hatch on the payload bay side at 8:15 P.M. E.S.T. The airlock was pressurized and Musgrave and Peterson doffed their space suits.

On April 9, the flight crew of *Challenger* completed the STS-6 mission with landing occurring on concrete runway 22 at Edwards Air Force Base, Calif. The automatic flight control system mode was utilized down to 9,144 meters (30,000 feet) altitude, then Control Stick Steering (CSS) was used from Mach 0.9 down to 3,657 meters (12,000 feet) altitude, then back to automatic to 1,524 meters (5,000 feet) altitude, then to CSS for landing and rollout.

It is noted, that in this first flight of *Challenger*, only 22 flight plan anomalies were noted in contrast with 82 on the first flight of *Columbia*.

This summary of STS-6 is not the usual detailed summary provided in flights STS-1 through STS-5. Because of the frequent flights of *Columbia* and *Challenger* we will not publish finite details in future summaries.

STS-6 TIMELINE

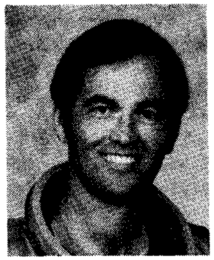
Day of Year	GMT* Hr:Min:Sec	Event
94	18:25:10	Auxiliary Power Unit (APU) No. 1 activation
	18:25:12	APU No. 2 activation
	18:25:14	APU No. 3 activation
	18:29:32	Solid Rocket Booster (SRB) Hydraulic Power Unit (HPU) activation command
	18:29:53	Main propulsion system start command
	18:30:00**	SRB ignition command from General Purpose Computer (GPC) liftoff
	18:30:30.6	Main engine throttle down command to 81 percent thrust
	18:31:02.7	Main engine throttle up command to 104 percent thrust
	18:31:10.96	Maximum dynamic pressure (max Q)
	18:32:09.38	SRB separation command
	18:37:22.758	Main engin throttle down command for 3 "g" acceleration
	18:38:19.6	Main engine cutoff command
	18:38:37.456	External tank separation
	18:40:19.7	Orbital Maneuvering System (OMS) -1 ignition
	18:42:35.3	OMS-1 cutoff
	18:43:43	APU deactivation
	19:13:37.70	OMS-2 ignition
	19:15:34.70	OMS-2 cutoff
	20:04:57.6	Payload bay doors open
95	04:50:53.27	OMS-3 ignition

Day of Year	GMT* Hr:Min:Sec	Event
	04:51:14.27	OMS-3 cutoff
	20:00:47.27	OMS-4 ignition
	20:01:08.87	OMS-4 cutoff
96	04:30:01	Tracking Data Relay Satellite (TDRS) deploy
	19:57:58	APU 2 activation
	20:03:09	APU 2 deactivation
97	21:05:00	Extravehicular activity (EVA) start
98	01:15:00	EVA complete
99	14:36:20	Payload bay doors closed
	17:55:00.06	Deorbit maneuver ignition (OMS-5)
	17:57:25.22	Deorbit maneuver cutoff
	18:10:30	APU 2 and 3 activation
	18:23:27	Entry interface
	18:31:23	End blackout
	18:47:29	Terminal area energy management (TAEM)
	18:53:42	Main landing gear contact
	18:53:54	Nose landing gear contact
	18:54:31	Wheels stop
	19:08:55	APU deactivation

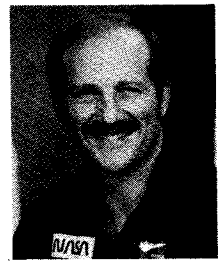
*GMT—Subtract 5 hours for EST
6 hours for CST
7 hours for MST
8 hours for PST

**Liftoff time has been rounded off from day 94:18:30:00.016

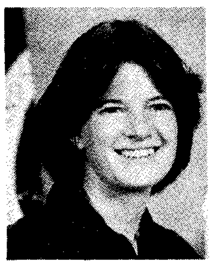
STS-7 FLIGHT CREW



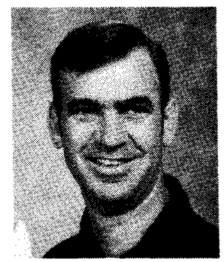
ROBERT L. CRIPPEN is the commander for the STS-7 flight. He was the pilot in the 54-1/2 hour STS-1 flight. He has logged more than 4,980 hours of flying time—most of it in jet-powered aircraft—as a U.S. Navy pilot and astronaut. A graduate of the University of Texas in aerospace engineering, Crippen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



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



SALLY K. RIDE is a mission specialist for the STS-7 flight. She was selected as an astronaut candidate by NASA in 1978. Dr. Ride received a bachelor of arts in English from Stanford University in 1973, a bachelor of science, a master of science, and doctorate degrees in Physics in 1973, 1975, and 1978, respectively from Stanford University. Dr. Ride has held teaching assistant and research assignments while a graduate student in the Physics Department at Stanford University. Her research includes one summer with the low-temperature group working in experimental general relativity and three years in X-ray astrophysics. She was born in Los Angeles, Calif., May 26, 1951 and considers Encino, Calif. her hometown. Dr. Ride is 5'5" in height and weighs 115 pounds. She has brown hair and blue eyes. She married Astronaut Steve Hawley on July 24, 1982.



JOHN M. FABIAN is a mission specialist for the STS-7 flight. He was selected as an astronaut candidate in 1978. He received a bachelor of science degree in Mechanical Engineering from Washington State University in 1962, a master of science in Aerospace Engineering from the Air Force Institute of Technology in 1964 and a doctorate in Aeronautics and Astronautics from the University of Washington in 1974. Fabian was an Air Force ROTC student at Washington State University and was commissioned in 1962. He had various assignments in the Air Force Institute of Technology at Wright-Patterson Air Force Base, Ohio, aeronautical engineer at San Antonio Air Material Area, Kelly AFB, Tex., then attended flight training at Williams AFB, Ariz., and spent five years as a KC-135 pilot at Wurtsmith AFB, Mich., and flew 90 combat missions in Southeast Asia. Following additional graduate work at the University of Washington, he served four years on the faculty of the Aeronautics Department at the USAF Academy in Colo. He has logged 3,400 hours flying time, including 2,900 hours in jet aircraft. He is a member of AIAA. He is married and has two children. He was born in Goosecreek, Tex., January 28, 1939, but considers Pullman, Wash., his hometown. He is 6' 1" in height and weighs 175 pounds. He has brown hair and green eyes.

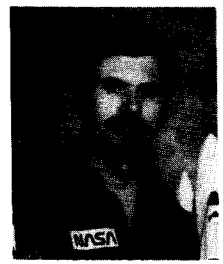
NORMAN E. THAGARD is a mission specialist on the STS-7 mission. He will conduct medical tests to collect additional data on several physiological changes that are associated with space adaptation syndrome. These tests will focus on the neurological system and are a continuation of the new approach to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

STS-8 FLIGHT CREW

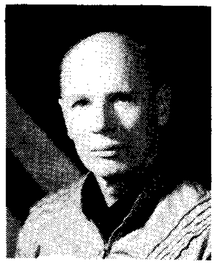
RICHARD H. TRULY is the commander for the STS-8 flight. He was the spacecraft pilot for the 54 hour, 24 minute STS-2 flight. He was an orbiter pilot during the successful Approach and Landing Test program, and as a naval pilot and astronaut has logged nearly 6,000 hours in jet aircraft. He graduated from the Georgia Institute of Technology in aeronautical engineering and entered naval flight training. Following service as a carrier pilot, Truly completed the USAF Aerospace Research Pilot School at Edwards and was subsequently assigned there as an instructor. In 1965 he was assigned to the Manned Orbiting Laboratory program and in 1969 was assigned to the NASA Astronaut Office. Truly was a member of the Skylab support crew and served in a similar capacity for the ASTP flight. He has been awarded two NASA Exceptional Service Medals, the JSC Superior Achievement Award and Special Achievement Award, the SETP Iven C. Kincheloe Award, the AFA's David C. Schilling Award, the American Astronomical Society's Flight Achievement Award, the Navy Distinguished Flying Cross, and the AIAA's Haley Space Flight Award. Truly was born in Fayette, Miss., Nov. 12, 1937, is married and has three children. He is 5'8" in height, weighs 150 pounds, and has brown hair and eyes.

DANIEL C. BRANDENSTEIN is the pilot for the STS-8 flight. Brandenstein was selected as an astronaut candidate in 1978. He was a member of the STS-1 and STS-2 astronaut support crew and served as ascent capcom. He received a bachelor of science degree in Mathematics and Physics from the University of Wisconsin in 1965. He entered the Navy in 1965 and was designated a naval aviator in 1967. He flew 192 combat missions in Southeast Asia from the USS Constellation and Ranger. He graduated from the U.S. Naval Test Pilot School. He then served aboard the USS Ranger in the Western Pacific and Indian Ocean flying A-6 aircraft. He has logged 3,600 hours flying time in 19 different types of aircraft and has 400 carrier landings. Brandenstein is married and has one child. He was born in Watertown, Wisc., January 17, 1943. He is 5'11" in height and weighs 185 pounds. He has brown hair and blue eyes.

GUION S. BLUFORD JR. is a mission specialist for the STS-8 flight. He was selected as an astronaut candidate in 1978. He received a bachelor of science degree in Aerospace Engineering from Pennsylvania State University in 1964, a master of science degree with distinction in Aerospace Engineering from the Air Force Institute of Technology in 1974, and a doctor of philosophy in Aerospace Engineering with a minor in Laser Physics from the Air Force Institute in 1978. Bluford was an Air Force ROTC graduate at Penn State University and attended pilot training at Williams AFB, Ariz., and received his wings in 1965. He was assigned to F-4C combat crew training and subsequently flew 144 combat missions. He was assigned then as a T-38A instructor pilot at Sheppard AFB, Tx., and served as a standardization/evaluation officer and as an assistant flight commander. In 1972 he entered the Air Force Institute of Technology at Wright-Patterson AFB, Ohio, and upon graduating in 1974, he was assigned to the Air Force Flight Dynamics Laboratory at Wright-Patterson AFB as a staff development engineer. He then served as Deputy for Advanced Concepts for the Aeromechanics Division and as Branch Chief of the Aerodynamics and Airframe Branch in the Laboratory. He has logged over 3,000 hours jet flight time in the T-33, T-37, T-38, F-4C, C-135, and F-5A/B, including 1,300 hours as a T-38 instructor pilot. Bluford also has an FAA commercial license. He is married and has two children. He was born in Philadelphia, Pa., November 22, 1942. He is 6' in height and weighs 180 pounds. He has black hair and brown eyes.



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



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

STS-9 FLIGHT CREW

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

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

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

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

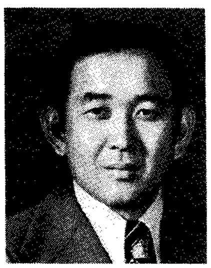
STS-9 FLIGHT CREW

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

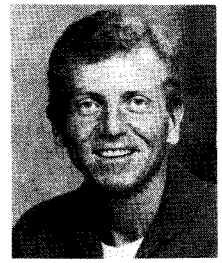
ULF MERBOLD is one of the payload specialists in the STS-9 flight. His profession is physicist. Merbold received a diploma in physics in 1968 and a doctorate in science from Stuttgart University in 1976. He joined the Max-Planck Gesellschaft at Stuttgart, Germany, first on a scholarship in 1968, and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

STS-10 FLIGHT CREW

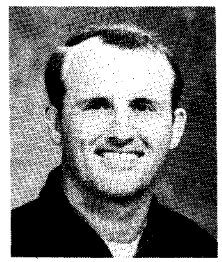
THOMAS K. MATTINGLY, II is the commander for the STS-10 mission. He was also the commander in the STS-4 flight. He was the backup commander for the STS-3 flight and STS-2 flight. From 1979 to 1981 he headed the astronaut ascent/entry group. Mattingly was previously assigned as technical assistant for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



ELLISON S. ONIZUKA is a mission specialist on the STS-10 mission. He received bachelor and master of science degrees in Aerospace Engineering in June and December 1969, respectively, from the University of Colorado. Onizuka entered active duty with the United States Air Force in January 1970 after receiving his commission at the University of Colorado through the four year ROTC program as a distinguished military graduate. As an aerospace flight test engineer with the Sacramento Air Logistics Center at McClellan Air Force Base, California, he participated in flight test programs and systems safety engineering for the F-84, F-100, F-105, F-111, EC-121T, T-33, T-39, T-28 and A-1 aircraft. He attended the USAF Test Pilot School and in July 1975 he was assigned to the Air Force Flight Test Center at Edwards Air Force Base, California, serving on the USAF Test Pilot School staff initially as squadron flight test engineer and later as chief of the engineering support section in the training resources branch. He has logged more than 900 hours flying time. Onizuka was selected as an astronaut candidate in January 1978 and in August 1979, he completed a one year training and evaluation period making him eligible for assignment as a mission specialist. He is a recipient of the Air Force Commendation Medal, Air Force Meritorious Service Medal, Air Force Outstanding Unit Award, Air Force Organizational Excellence Award, and National Defense Service Medal. He is a member of the Society of Flight Test Engineers, the Air Force Association and AIAA. He was born in Kealakekua, Kona, Hawaii, June 24, 1946. He is married and has two children. He is 5'9" in height and weighs 162 pounds. He has black hair and brown eyes.

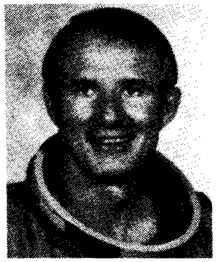


LOREN J. SHRIVER is the pilot for the STS-10 mission. He received a bachelor of science in Aeronautical Engineering from the United States Air Force Academy in 1967 and a master of science degree in Astronautical Engineering from Purdue University in 1968. Shriver was commissioned in 1967 upon graduation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

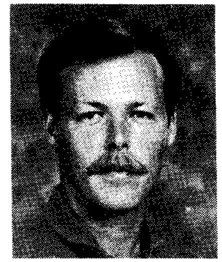


JAMES F. BUCHLI is a mission specialist on the STS-10 mission. He received a bachelor of science degree in Aeronautical Engineering from the United States Naval Academy in 1967 and a master of science degree in Aeronautical Engineering Systems from the University of West Florida in 1975. He received his commission in the United States Marine Corps following graduation from the United States Naval Academy at Annapolis in 1967. He served a one year tour of duty in the Republic of Vietnam and upon his return to the United States in 1969, he reported to naval flight officer training at Pensacola, Florida. Buchli spent the next three years assigned to the Marine Fighter/Attack Squadron at Kaneohe Bay, Hawaii and Iwakuni, Japan and in 1973 he proceeded to duty with Marine Fighter/Attack Squadron at Namphong, Thailand, and Iwakuni, Japan. At completion of this tour of duty he returned to the United States and participated in the Marine Advanced Degree Program at the University of West Florida. He was assigned subsequently to Marine Fighter/Attack Squadron at the Marine Corps Air Station, Beaufort, S. C., and in 1977, to the U.S. Test Pilot School, Patuxent River, Maryland. He was selected as an astronaut candidate by NASA in January 1978 and in August 1979, he completed a one-year training and evaluation period making him eligible for assignment as a mission specialist. He has logged 1,900 hours flying time, 1,780 hours in jet aircraft. Buchli is the recipient of an Air Medal, Navy Commendation Medal, Purple Heart, Combat Action Ribbon, Presidential Unit Citation, Navy Unit Citation, a Meritorious Unit Citation, and a Vietnamese Cross of Gallantry with the Silver Star. He was born in New Rockford, North Dakota, June 20, 1945, but considers Fargo, North Dakota his hometown. He is married and has two children. He has brown hair and hazel eyes. He is 5'7" in height and weighs 160 pounds.

STS-11 FLIGHT CREW

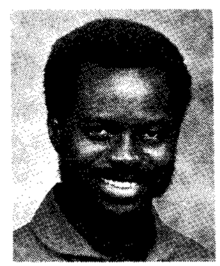


VANCE D. BRAND is the spacecraft commander for the STS-11 flight. Brand was also the commander on the STS-5 flight. He has logged 339 hours and 43 minutes in space flight as command module pilot of the Apollo-Soyuz Test Project and commander of the STS-5 flight. A graduate of the University of Colorado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

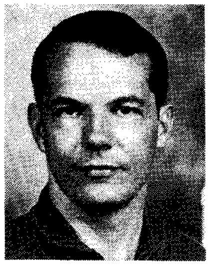


ROBERT L. GIBSON is the pilot for the STS-11 flight. He received a bachelor of science degree in aeronautical engineering from California Polytechnic State University in 1969. Gibson entered active duty with the Navy in 1969. He received primary and basic flight training at Naval Air Stations in Florida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

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



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

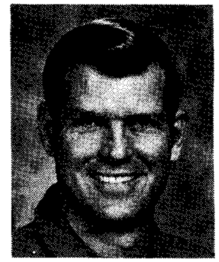


ROBERT L. STEWART is a mission specialist for the STS-11 mission. He received a bachelor of science degree in mathematics from the University of Southern Mississippi in 1964 and a master of science in Aerospace Engineering from the University of Texas in 1972. Stewart entered active duty with the United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

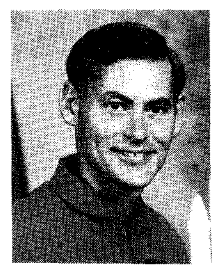
STS-12 FLIGHT CREW

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

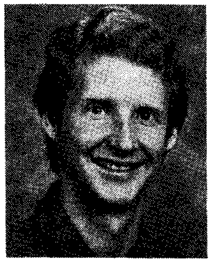
JUDITH A. RESNICK is a mission specialist for the STS-12 flight. She received a bachelor of science degree in electrical engineering from Carnegie-Mellon University in 1970 and a doctorate in electrical engineering from the University of Maryland in 1977. Upon graduating from Carnegie-Mellon in 1970,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



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

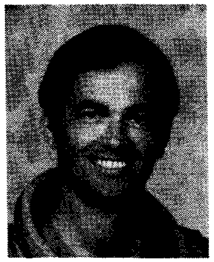


RICHARD M. MULLANE is a mission specialist for the STS-12 flight. He received a bachelor of science degree in military engineering from the United States Military Academy in 1967 and awarded a master of science degree in aeronautical engineering from the Air Force Institute of Technology in 1975. Mullane,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

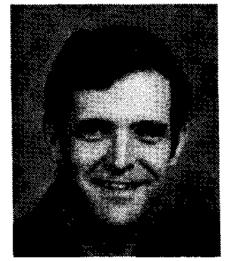


STEVEN A. HAWLEY is a mission specialist on the STS-12 flight. He received a bachelor of arts degree in physics and astronomy from the University of Kansas in 1973 and a doctor of philosophy in astronomy and astrophysics from the University of California in 1977. During his tenure as an undergraduate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

STS-13 FLIGHT CREW

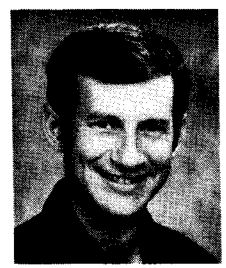


ROBERT L. CRIPPEN is the commander for the STS-13 flight. He was the pilot in the 54-1/2 hour STS-1 flight and is the commander for the STS-7 flight. He has logged more than 4,980 hours of flying time—most of it in jet-powered aircraft—as a U.S. Navy pilot and astronaut. A graduate of the University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



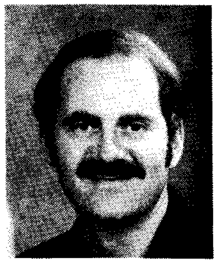
FRANCIS R. (DICK) SCOBEE is the pilot for the STS-13 flight. Scobee received a bachelor of science degree in aerospace engineering from the University of Arizona in 1965. Scobee enlisted in the United States Air Force in October 1957, trained as an reciprocating engine mechanic and stationed at Kelly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

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



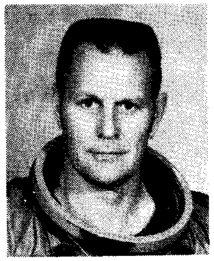
TERRY J. HART is a mission specialist for the STS-13 flight. Hart received a bachelor of science degree in mechanical engineering from Lehigh University in 1968, a master of science in mechanical engineering from the Massachusetts Institute of Technology in 1969, and a master of science in electrical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

STS-13 FLIGHT CREW



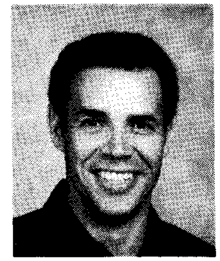
JAMES D. van HOFTEN is a mission specialist for the STS-13 flight. He received a bachelor of science degree in civil engineering from the University of California, Berkeley, in 1966; and a master of science degree in hydraulic engineering and a doctor of philosophy in fluid mechanics from Colorado State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

STS-18 FLIGHT CREW



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

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

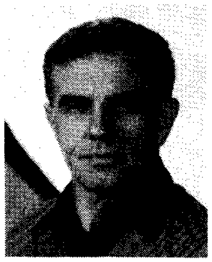


FREDERICK D. GREGORY is the pilot for the STS-18 flight. He received a bachelor of science degree from the United States Air Force Academy in 1964, and a masters degree in information systems from George Washington University in 1977. Gregory entered pilot training after graduation from the United States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

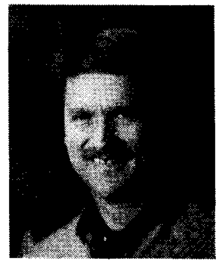
DON LESLIE LIND is a mission specialist for the STS-18 flight. Lind received a bachelor of science with high honors in physics from the University of Utah in 1953 and a doctor of philosophy degree in high energy nuclear physics in 1964 from the University of California, Berkeley and performed post-doctoral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

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

STS-24 FLIGHT CREW



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



ANTHONY W. ENGLAND is a mission specialist on the STS-24 flight. He received bachelor and master of science degrees in Geology and Physics from Massachusetts Institute of Technology in 1956 and a doctor of philosophy from the Department of Earth and Planetary Sciences at MIT in 1970. He was a graduate fellow at MIT for three years immediately preceding his assignment to NASA. He has performed heat flow measurements throughout the southwest, has taken part in a magnetic study in Montana, has performed radar sounding studies of glaciers in Washington state and Alaska, has performed microwave airborne surveys throughout the western United States, and has participated in and led field parties during two seasons in Antarctica. Dr. England was selected as a scientist-astronaut by NASA in August 1967. He completed academic training and a 53 week course in flight training at Laughlin Air Force Base, Texas. He has logged over 2,000 hours in flying time. He served as a support crewman for the Apollo 13 and 16 flights. From August 1972 to June 1979, England was a research geophysicist with the U.S. Geological Survey. He returned to the Johnson Space Center in 1979 as a senior scientist astronaut. England was presented the Johnson Space Center Superior Achievement Award (1970); the NASA Outstanding Achievement Medal (1973); and the U.S. Antarctic Medal (1979). He is a member of the American Geophysical Union, the American Geological Institute, the Society of Exploration Geophysicists, the American Association for the Advancement of Science, and the International Glaciological Society. England was born May 15, 1942 in Indianapolis, Indiana, but considers Fargo, North Dakota his hometown. England is married and has two children. He has brown hair and blue eyes. He is 5'10" and weighs 165 pounds.