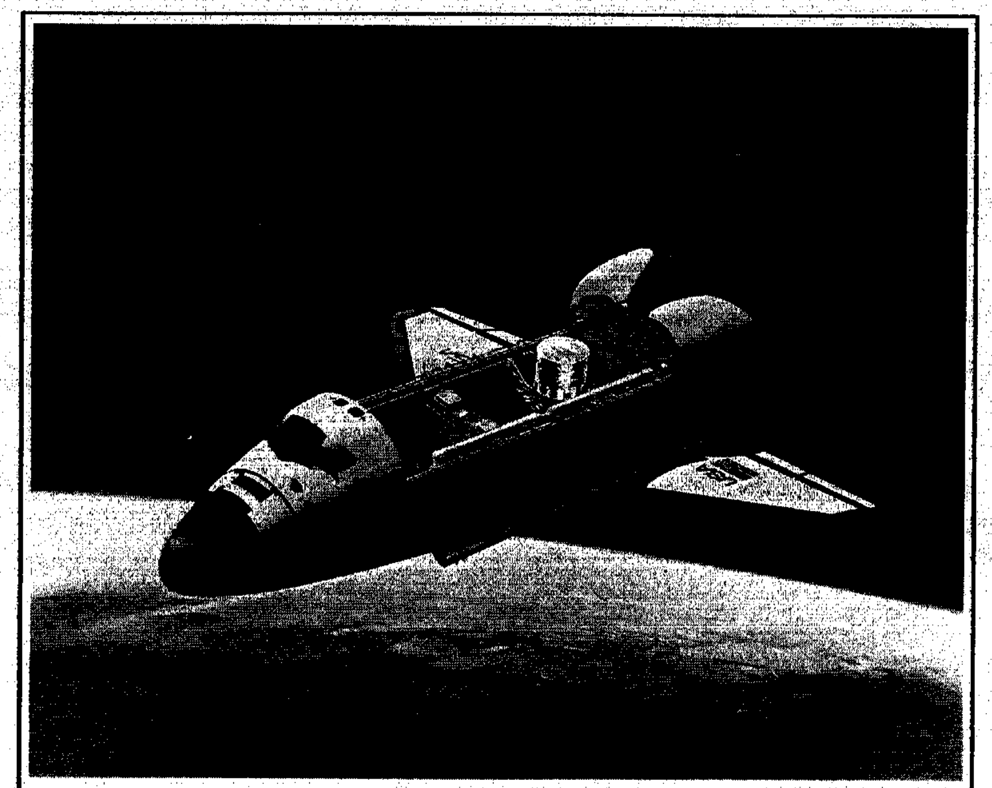

STS-49

PRESS INFORMATION

May 1992

Rockwell International
Space Systems Division

Office of Media Relations

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MISSION OVERVIEW

This is the 1st flight of Endeavour and the 47th for the space shuttle.

The flight crew for the STS-49 mission is commander Daniel (Dan) C. Brandenstein; pilot Kevin P. (Chili) Chilton; and mission specialists Pierre J. Thuot, Kathryn (Kathy) C. Thornton, Richard (Rick) J. Hieb, Thomas (Tom) D. Akers and Bruce E. Melnick.

In addition to testing and evaluating all of Endeavour's basic systems, Endeavour's seven-day maiden voyage will be highlighted by the retrieval, on-orbit repair and reboosting of the International Telecommunications Satellite Organization (INTELSAT) VI (F-3) satellite, one of five INTELSAT commercial communications satellites that form a network designed to provide voice, video and data services to Earth stations in 180 countries. INTELSAT VI was launched March 14,1990, but a malfunction in its Titan booster left it stranded in an unusable low orbit.

The STS-49 INTELSAT VI mission will be the most complex satellite retrieval mission to date. Endeavour and her crew will engage in the first ever active dual rendezvous of two orbiting spacecraft and the first in-orbit attachment of a solid rocket motor. Following a complex set of maneuvers to rendezvous Endeavour and the satellite, mission specialists Thuot and Hieb will perform a space walk on flight day 4 to capture the satellite using a special capture bar. The orbiter's remote manipulator system arm will then be used to berth the satellite atop a new perigee kick motor mounted in the orbiter's payload bay. INTELSAT VI will then be released and maneuvered by INTELSAT ground controllers for reboost into geosynchronous orbit.

Another highlight of the flight will be the Assembly of Station by EVA Methods experiment, which will feature STS-49's second and record-breaking third space walks. Mission specialists Thornton and Akers (flight day 5) and Thuot and Hieb (flight day 6) will perform space walks to demonstrate and verify maintenance and assembly capabilities for Space Station Freedom. The astronauts will construct a space station truss pyramid structure, gathering data on techniques and handling aids for manipulating and berthing large items and examining the handling, transport and assembly techniques for a truss structure and attached hardware. They will also evaluate crew self-rescue devices and techniques and RMS and manual berthing operations of a multiple-purpose experiment support structure pallet onto the space station truss, using both cameras for guidance and oral directions from space walkers.

Other secondary objectives for STS-49 include the Commercial Protein Crystal Growth experiment, Air Force Maui Optical Site, and the Ultraviolet Plume Instrument.

The primary objective of the CPCG experiment is to gather data on the methods and commercial potential for growing high-quality protein crystals in microgravity. CPCG is sponsored by NASA's Office of Commercial Programs and is managed by the Center for Macromolecular Crystallography, University of Alabama at Birmingham, a NASA-sponsored Center for the Commercial Development of Space.

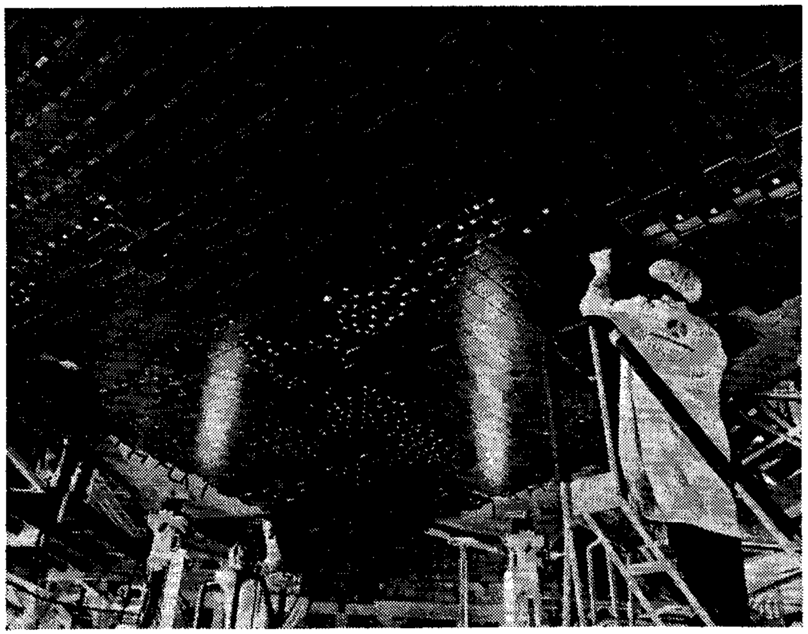
The AMOS and UVPI experiments are both payloads of opportunity that will be conducted if time permits. Neither requires any on-board hardware. The primary objective of AMOS, sponsored by the U.S. Air Force Space Systems Division, is to use the orbiter during cooperative overflights of Maui, Hawaii, to obtain imagery and/or signature data to support the calibration of AMOS ground-based sensors and to observe plume phenomenology. Crew and orbiter participation may be required to establish the controlled conditions for the Maui cooperative overflight. UVPI is a Department of Defense payload located on the Low-Power Atmospheric Compensation Experiment satellite, a Strategic Defense Initiative

Organization satellite in low Earth orbit. UVPI's sensors will be trained on the orbiter to obtain imagery and/or signature data to calibrate the sensors and to observe orbiter jet firings during cooperative encounters of the orbiter with the LACE satellite.

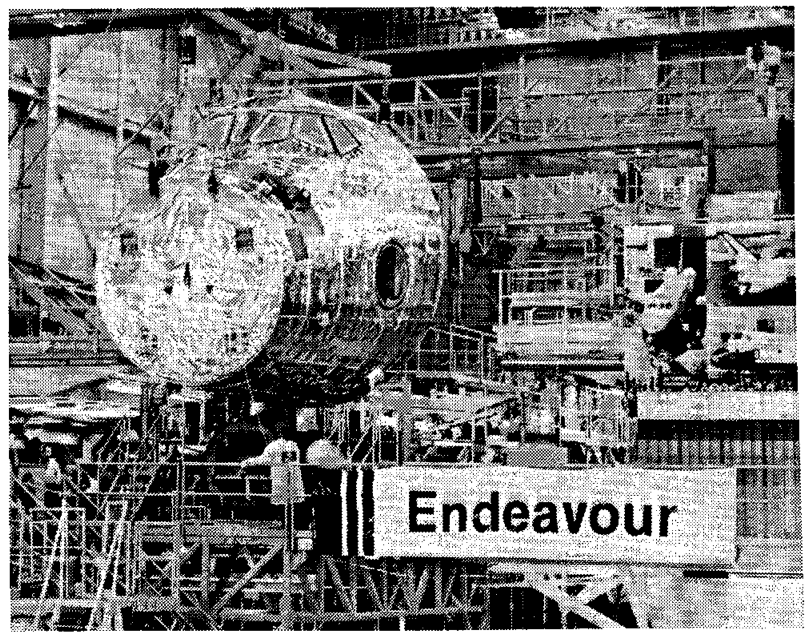
Endeavour is the fifth operational orbiter built by Rockwell International Corporation's Space Systems Division, Downey, Calif. Authority to proceed with construction of Endeavour was received on August 1,1987, and Endeavour rolled out on schedule from SSD's orbiter assembly and modification facility in Palmdale, Calif., on April 25,1991.

The new orbiter incorporates numerous design changes and upgrades made as part of NASA's orbiter continuous improvement program. New features include improved or redesigned avionics systems and updated mechanical systems, including the first shuttle program use of a drag chute that will be deployed after landing at Edwards Air Force Base to assist in slowing the orbiter during rollout. Endeavour is also partially outfitted for extended-duration missions of up to 28 days in length in the future.

Nineteen detailed test objectives and 13 detailed supplementary objectives are scheduled to be flown on STS-49.



Endeavour Thermal Protection System Installation



Mating of Crew Compartment With Orbiter Vehicle Endeavour

MISSION STATISTICS

Vehicle: Endeavour (OV-105), 1st flight

Launch Date/Time:

5/7/92	7:06 p.m., EDT
	6:06 p.m., CDT
	4:06 p.m., PDT

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

Launch Window (planar):

7:06 p.m.-7:52 p.m., EDT; 7:53 p.m.-7:55 p.m., EDT (48 minutes total window duration)

Mission Duration: 6 days, 23 hours, 55 minutes

Landing: Nominal end-of-mission landing on orbit 111

5/14/92	7:01 p.m., EDT
	6:01 p.m., CDT
	4:01 p.m., PDT

Runway: Nominal end-of-mission landing on concrete runway 22, Edwards Air Force Base (EAFB), Calif. Weather alternates are Kennedy Space Center, Fla., and Northrup Strip (NOR), White Sands, New Mexico.

Transatlantic Abort Landing: Banjul, Gambia; alternates: Ben Guerir, Morocco; Rota, Spain

Return to Launch Site: KSC

Abort-Once-Around: EAFB

Inclination: 28.35 degrees

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

The OMS-1 thrusting maneuver after main engine cutoff plus approximately 2 minutes is eliminated in this direct-insertion ascent profile. The OMS-1 thrusting maneuver is replaced by a 5-foot-per-second reaction control system maneuver to facilitate the main propulsion system propellant dump.

Altitude: 183 by 95 nautical miles (211 by 109 statute miles) minimum orbit

Space Shuttle Main Engine Thrust Level During Ascent: 104 percent

Space Shuttle Main Engine Locations:

No. 1 position: Engine 2030
No. 2 position: Engine 2015
No. 3 position: Engine 2017

Editor's Note: The following weight data are current as of April 21,1992

Total Lift-off Weight: Approximately 4,519,238 pounds

Orbiter Weight, Including Cargo, at Lift-off: Approximately 256,597 pounds

Orbiter (Endeavour) Empty, and 3 SSMEs: Approximately 172,796 pounds

Payload Weight Up: Approximately 32,598 pounds

Payload Weight Down: Approximately 8,558 pounds

Orbiter Weight at Landing: Approximately 201,649 pounds

Payloads—Payload Bay (* denotes primary payload): INTELSAT-VI reboost mission hardware,* Assembly of Station by EVA Methods

Payloads—Middeck: Commercial Protein Crystal Growth (CPCG)

Other Mission Objectives—No Flight Hardware: Air Force Maui Optical Site (AMOS), Ultraviolet Plume Instrument (UVPI)

Flight Crew Members:

Commander: Daniel (Dan) C. Brandenstein, fourth space shuttle flight
Pilot: Kevin P. (Chili) Chilton, first space shuttle flight
Mission Specialist 1: Richard (Rick) J. Hieb, second space shuttle flight
Mission Specialist 2: Bruce E. Melnick, second space shuttle flight
Mission Specialist 3: Pierre J. Thuot, second space shuttle flight
Mission Specialist 4: Kathryn (Kathy) C. Thornton, second space shuttle flight
Mission Specialist 5: Thomas (Tom) D. Akers, second space shuttle flight

Ascent Seating:

Flight deck, front left seat, commander Daniel (Dan) C. Brandenstein
Flight deck, front right seat, pilot Kevin P. (Chili) Chilton
Flight deck, aft center seat, mission specialist Bruce E. Melnick
Flight deck, aft right seat, mission specialist Richard (Rick) J. Hieb
Middeck, mission specialist Kathryn (Kathy) C. Thornton
Middeck, mission specialist Pierre J. Thuot
Middeck, mission specialist Thomas (Tom) D. Akers

Entry Seating:

Flight deck, front left seat, commander Daniel (Dan) C. Brandenstein
Flight deck, front right seat, pilot Kevin P. (Chili) Chilton
Flight deck, aft center seat, mission specialist Bruce E. Melnick
Flight deck, aft right seat, mission specialist Thomas (Tom) D. Akers
Middeck, mission specialist Richard (Rick) J. Hieb
Middeck, mission specialist Pierre J. Thuot
Middeck, mission specialist Kathryn (Kathy) C. Thornton

Extravehicular Activity Crew Members, If Required:

Extravehicular (EV) astronaut 1: Pierre J. Thuot
EV-2: Richard (Rick) J. Hieb
EV-3: Kathryn (Kathy) C. Thornton
EV-4: Thomas (Tom) D. Akers

Intravehicular Astronauts: Daniel (Dan) C. Brandenstein, Kevin P. (Chili) Chilton, and Thomas (Tom) D. Akers

STS-49 Flight Directors:

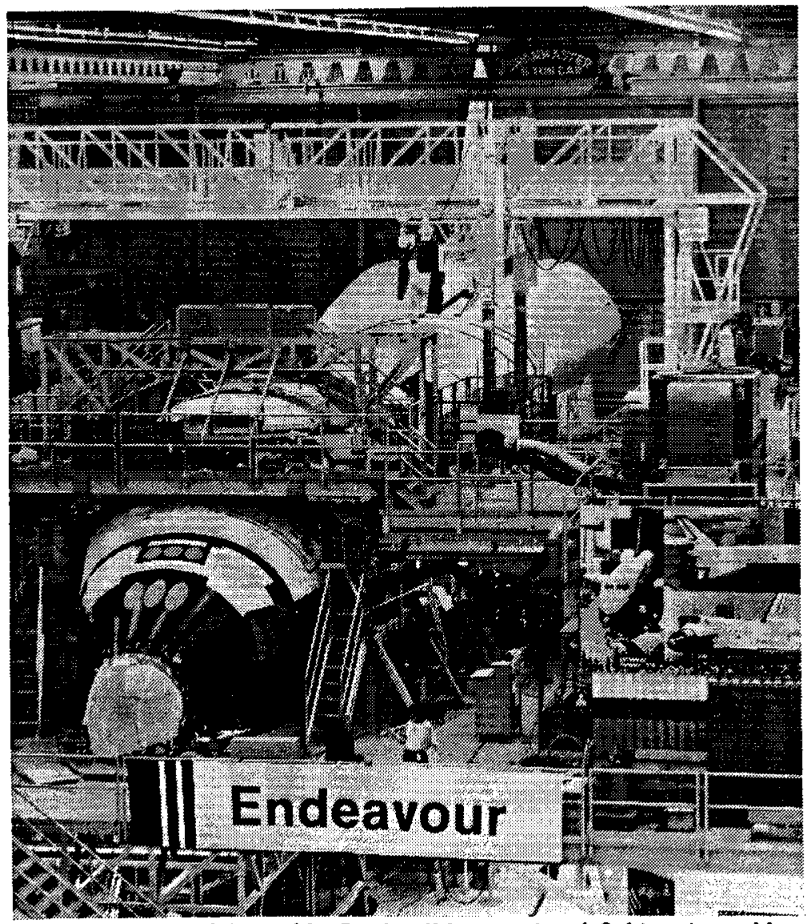
Ascent/Entry: N. W. (Wayne) Hale
Orbit 1 (Rendezvous/EVA) Team (lead): G. A. (Al) Pennington
Orbit 2 (Deploy/EVA) Team (lead): P. L. (Phil) Engelauf

Planning Team: J. M. (Milt) Heflin

Entry: Automatic mode until subsonic, then control stick steering

Notes:

- The remote manipulator system is installed in Endeavour's payload bay for this mission
- The galley is installed in Endeavour's middeck



Endeavour Final Assembly, Rockwell International Orbiter Assembly Facility, Palmdale, Calif.

MISSION OBJECTIVES

- Primary Objective
  - — INTELSAT-VI retrieval, repair, and reboost
- Secondary Objectives
  - — Payload Bay
    - Assembly of Station by EVA Methods (ASEM)
- Middeck
    - Commercial Protein Crystal Growth (CPCG)
  - — Payloads of Opportunity (No Flight Hardware)
    - Air Force Maui Optical Site (AMOS)
    - Ultraviolet Plume Instrument (UVPI)
- Development Test Objectives/Detailed Supplementary Objectives

STS-49 Mission Insignia

FLIGHT ACTIVITIES OVERVIEW

Flight Day 1

Launch
OMS-2
Unstow cabin
Payload activation
First orbit raising burn

Flight Day 2

10.2 psi cabin depressurization
EMU checkout
RMS checkout
Second orbit raising burn

Flight Day 3

DTOs
DSOs
Orbit circularization plane corrections

Flight Day 4

INTELSAT rendezvous
EVA/PKM attachment
INTELSAT deploy

Flight Day 5

ASEM EVA 1

Flight Day 6

ASEM EVA 2

Flight Day 7

Crew press conference
RCS hot-fire test
FCS checkout
Cabin stow
DTOs
DSOs

Flight Day 8

Payload deactivation
Deorbit preparation
Deorbit burn
Landing

Notes:

Each flight day includes a number of scheduled housekeeping activities. These include inertial measurement unit alignment, supply water dumps (as required), waste water dumps (as required), fuel cell purge, Ku-band antenna cable repositioning, and a daily private medical conference.

STS-49 CREW ASSIGNMENTS

Commander (Daniel C. Brandenstein):

Overall mission decisions
Orbiter—caution and warning,* APU/hydraulics, communications/instrumentation,* crew equipment,* DPS,* ECLSS,* EPS, GN&C,* habitability,* MPS, OMS/RCS, training,* flight rules,* IFM
Payload—INTELSAT, AMOS
DTOs/DSOs—DTOs 249 and 648*; DSOs 613 (subject 1), 614 (subject 1), 802, 901, 902 and 903
Other—intravehicular astronaut

Pilot (Kevin P. Chilton):

Orbiter—APU/hydraulics,* caution and warning, communications/instrumentation, crew equipment, DPS, ECLSS, EPS,* GN&C, habitability, IFM, MPS,* OMS/RCS,* PDRS (ASEM), PGSC, flight rules
Payload—ASEM, AMOS
DTOs/DSOs—DTOs 249,* 651 (subject 2), and 700-2*; DSOs 613 (subject 2), 614 (subject 2), 617 (subject 1), 621 (subject 1), 802, 901, 902, and 903
Other—intravehicular astronaut*

Mission Specialist 1 (Richard J. Hieb):

Orbiter—IFM, medical,* photo/TV,* payload bay doors (mechanical—open 1), PGSC,* training
Payload—EV2 (INTELSAT)
DTOs/DSOs—DTOs 648 and 700-2; DSOs 482 (subject 1), 603B (subject 1), 617 (subject 1), 621 (subject 1), 802, 901, 902 and 903
Other—Earth observations*

*Denotes primary responsibility

Mission Specialist 2 (Bruce E. Melnick):

Orbiter—IFM, PDRS (INTELSAT, ASEM), payload bay doors (mechanical—closed 2)
Payload—INTELSAT, ASEM
DTOs/DSOs—DTOs 325 and 651 (subject 1); DSOs 469 (subject 1), 614 (subject 3), 621 (subject 3), 802, 901, 902 and 903

Mission Specialist 3 (Pierre J. Thuot):

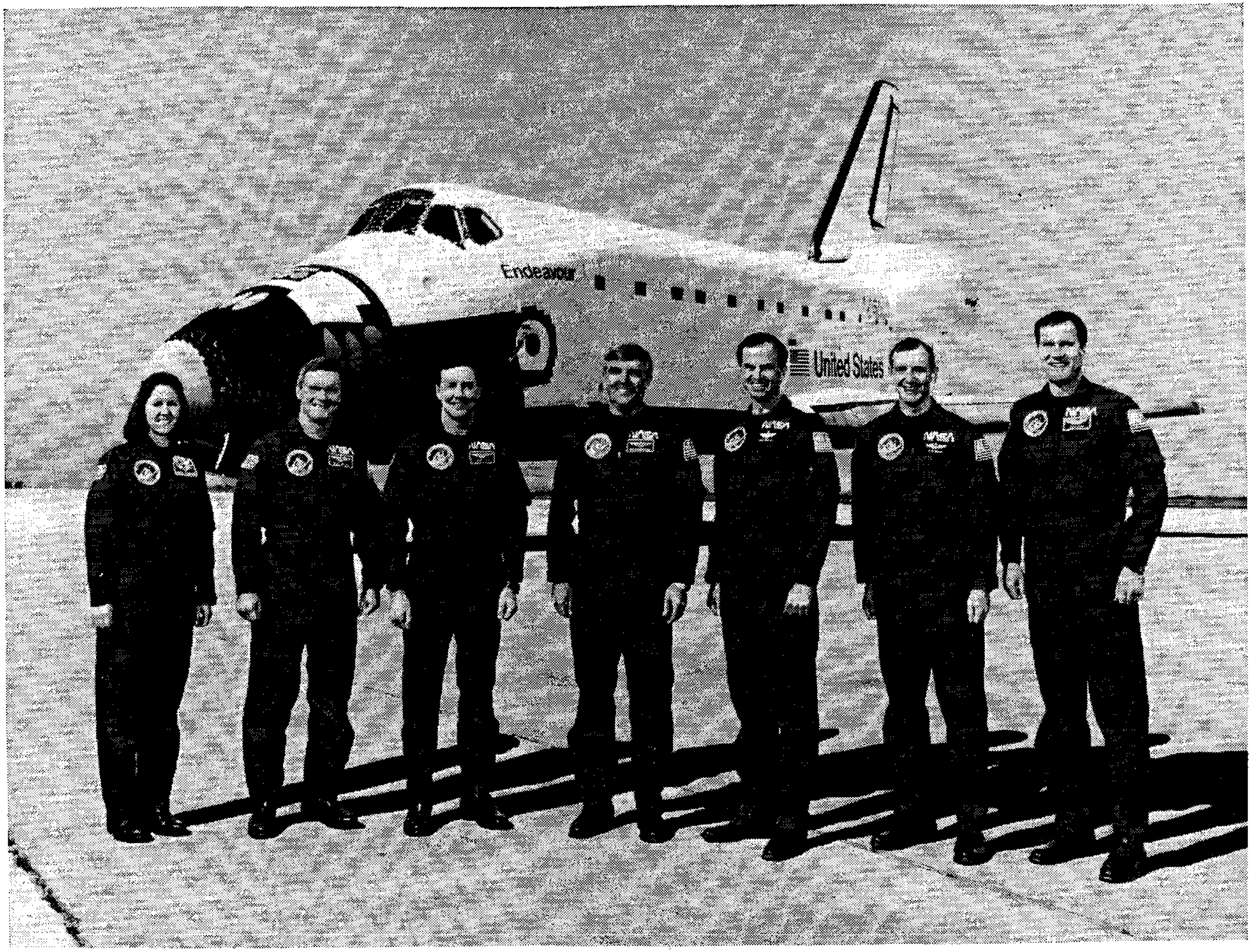
Orbiter—IFM
Payload—EV1 (INTELSAT)
DTOs/DSOs—DTO 640; DSOs 482 (subject 2), 603B (subject 2), 613 (subject 3), 617 (subject 3), 802, 901, 902 and 903
Other—intravehicular astronaut

Mission Specialist 4 (Kathryn C. Thornton):

Orbiter—IFM, medical, PDRS (INTELSAT)
Payload—INTELSAT, EV3 (ASEM)*, crew self rescue, CPCG*
DTOs/DSOs—DSOs 482 (subject 3), 604 (subject 1), 613 (subject 4), 621, 802, 901, 902 and 903

Mission Specialist 5 (Thomas D. Akers):

Orbiter—IFM, photo/TV, payload bay door (mechanical—open 2, close 1)
Payload—EV4 (ASEM), crew self rescue*, CPCG
DTOs/DSOs—DTOs 325,* 640,* and 728*; DSOs 482 (subject 4), 603B (subject 3), 613 (subject 5), 617 (subject 4), 802, 901, 902 and 903
Other—intravehicular astronaut*



STS-49 Crew (Left to Right): Mission Specialists Kathryn C. Thornton, Bruce E. Melnick, and Pierre J. Thuot; Commander Daniel C. Brandenstein; Pilot Kevin P. Chilton, and Mission Specialists Thomas D. Akers and Richard J. Hieb

DEVELOPMENT TEST OBJECTIVES/DETAILED SUPPLEMENTARY OBJECTIVES

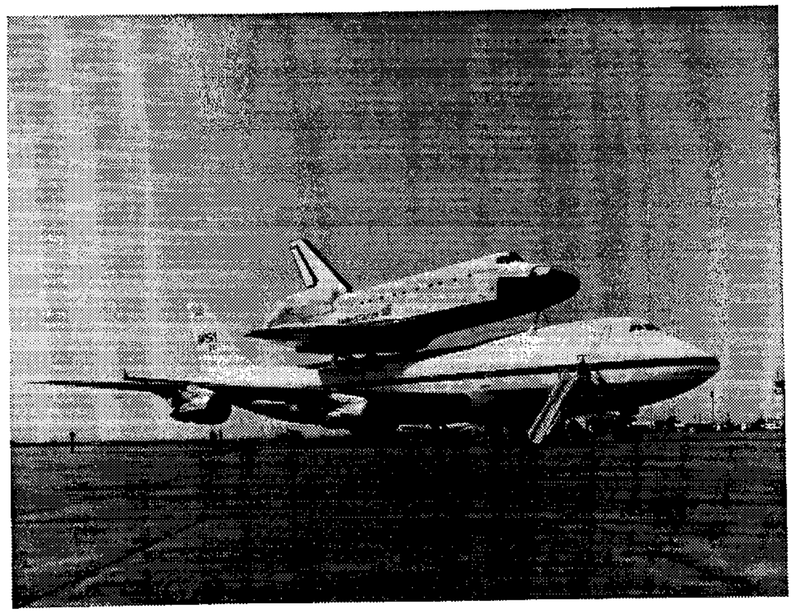
DTOs

- Forward RCS flight test 12-second pulse (DTO 249)
- Ascent structural capability evaluation (DTO 301D)
- Ascent compartment venting evaluation (DTO 305D)
- Descent compartment venting evaluation (DTO 306D)
- Entry structural capability evaluation (DTO 307D)
- ET TPS performance (DTO 312)
- Waste/supply water dumps (DTO 325)
- Carbon brake system test (DTO 519)
- Edwards lake bed runway bearing strength assessment (DTO 520)
- Orbiter drag chute system (DTO 521)
- Cabin air monitoring (DTO 623)
- Hydrazine monitor (DTO 640)
- Electronic still photography test (with downlink) (DTO 648)
- Cycle ergometer hardware evaluation (DTO 651)
- Remote manipulator system unwanted motion evaluation (DTO 659)
- Acoustical dosimeter (DTO 663)
- Laser range and range rate device (DTO 700-2)
- Ku-band antenna friction (DTO 728)
- Crosswind landing performance (DTO 805)

DSOs

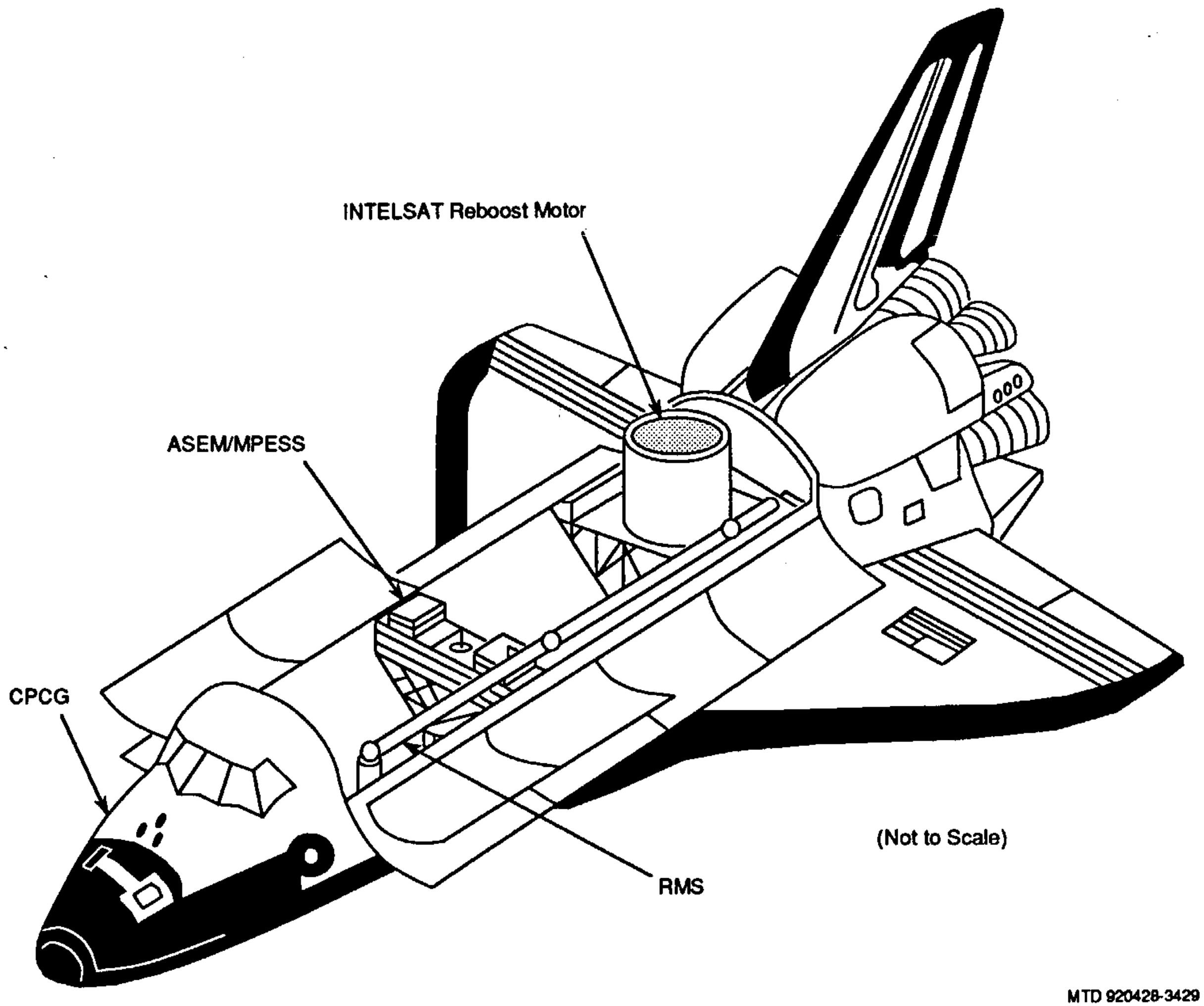
- Inflight radiation dose-distribution (TEPC) (DSO 469C)
- Cardiac rhythm disturbances during extravehicular activity (DSO 482)
- Orthostatic function during entry, landing, and egress (DSO 603)
- Visual-vestibular integration as a function of adaptation (0I-1) (DSO 604A)
- Postural equilibrium control during landing/egress (DSO 605)
- Changes in the endocrine regulation of orthostatic tolerance during space flight (DSO 613)
- Head and gaze stability during locomotion (DSO 614)
- Evaluation of functional skeletal muscle performance following space flight (DSO 617)

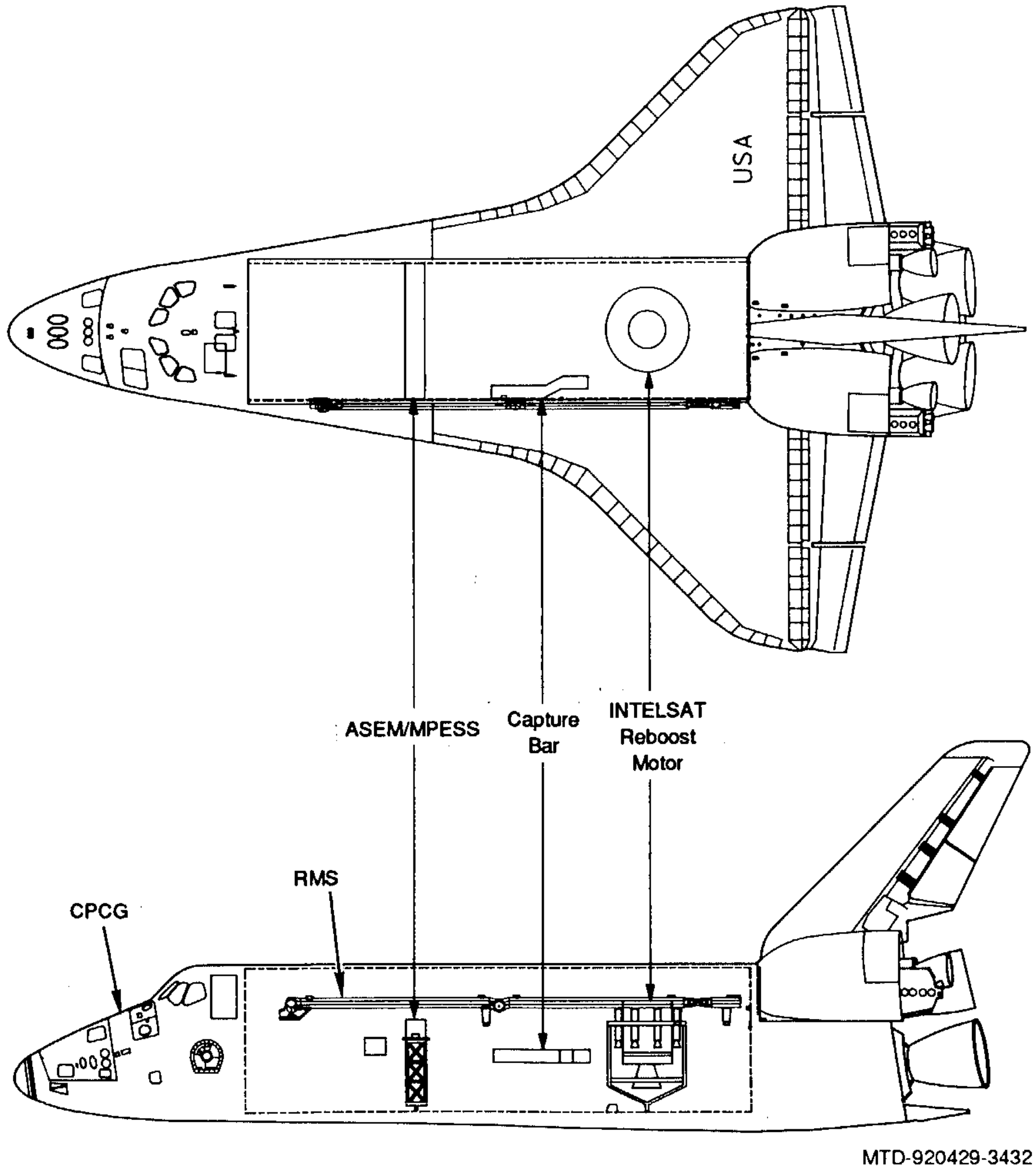
- Inflight use of florinef to improve orthostatic intolerance post-flight (DSO 621)
- Educational activities (DSO 802)
- Documentary television (DSO 901)
- Documentary motion picture photography (DSO 902)
- Documentary still photography (DSO 903)



Endeavour Atop NASA 747 Shuttle Carrier Aircraft

STS-49 PAYLOAD CONFIGURATION





STS-49 Payload Locations

INTELSAT VI REPAIR AND REBOOST

INTELSAT VI (F–3) is one of a series of five commercial communication satellites that provides voice, video, and data services to Earth stations in 180 countries. Launched March 14, 1990, to join its four sister satellites in geosynchronous orbit (approximately 22,300 miles above Earth), INTELSAT VI and its perigee kick motor failed to separate from the second stage of the Titan launch vehicle. Since then, ground commands have stabilized the stranded satellite's thermal and power systems, separated it from its PKM, and raised its orbit to 299 x 309 nautical miles, where it maintains a parking mode in a stowed configuration. When fully deployed, the spacecraft is 38 feet high, 11.7 feet in diameter, and weighs 8,960 pounds.

STS–49 will be the most complex satellite retrieval mission to date: Endeavour and its crew will perform the first active rendezvous of two orbiting spacecraft and the first installation of a solid rocket motor in orbit.

EQUIPMENT

Endeavour will carry a new 23,000–pound PKM built by United Technologies Corp. The PKM will be secured in the payload bay during launch and ascent by a specially designed cradle built by Hughes Aircraft Co. A special adapter incorporating Superzip technology (devised by Lockheed Missile and Space Co.) facilitates separation of the PKM from the cradle. A forward spacecraft adapter and docking adapter are used to connect the new PKM to the satellite.

Other special equipment includes a spacecraft capture bar with a releasable grapple fixture, EVA power tools, and a portable foot restraint (called a PAD) that can be attached to the remote manipulator system to maneuver EVA crew members.

INTELSAT ACTIVITIES

There are three main steps to the INTELSAT operations: retrieval, repair, and reboost.

Retrieval

Endeavour's flight begins with launch to direct orbit insertion and firing of the orbital maneuvering system to reach the satellite rendezvous orbit of 173 x 199 nautical miles. The crew will then check out the orbiter's remote manipulator system, depressurize the cabin to 10.2 psi in preparation for EVA, check out the four EVA spacesuits, and fire Endeavour's reaction control system to reach an orbit of 175 x 204 nmi. Final OMS and RCS burns will bring the shuttle to an orbit of 201 x 205 nmi.

Meanwhile, ground controllers will begin maneuvering the INTELSAT spacecraft to a predetermined area within 6 degrees of arc of a 200 x 210 nmi, 28.35 degree inclination orbit. About 46 hours into the mission and about 6 hours before Endeavour approaches the satellite, INTELSAT will be spun down to about 0.65 rpm. The orbiter will then approach and keep the satellite within range of its RMS grapple mechanism.

When Endeavour reaches an orbit of 208 x 212 nmi, mission specialists Pierre Thuot and Rick Hieb will enter the payload bay to prepare for PKM attachment. Thuot will be situated on the RMS PAD foot restraint.

From inside the cabin, mission specialist Bruce Melnick will maneuver the RMS and Thuot within reach of the satellite. Thuot will attach the capture bar to the satellite's aft separation ring and, using the steering wheel located in the center of the capture bar, stop any remaining satellite rotation and nutation. While Thuot is capturing the INTELSAT, Hieb will be preparing clamps and electrical connections in Endeavour's payload bay for the satellite.

Once the satellite is stationary, Thuot will attach the RMS to the grapple fixture on the end of the satellite's capture bar. The RMS will then move Thuot and the satellite back into the payload bay in preparation for repair, and the PAD will be removed.

Repair

During the repair phase, Thuot and Hieb will position themselves in the payload bay on opposite sides of the PKM cradle and Hieb will install the starboard capture bar alignment extension. Next, the PKM thermal blanket will be removed and the RMS will move the satellite into position over the docking adapter.

When the alignment guides on the spacecraft adapter ring and the capture bar are in place over the cradle, Thuot and Hieb will secure the satellite docking latches to join the satellite to the docking adapter. They will then mate the two electrical umbilicals, release the restraining pins from the push–off springs, and release the RMS grapple fixture and capture bar alignment extensions. The capture bar will then be removed from the satellite, repositioned, and secured to the docking adapter.

The astronauts will then activate the staging and boost unit 6–hour timers, which inhibit ground commands to the spacecraft perigee stage. With the satellite ready for reboost, the astronauts will return to the airlock.

Reboost

At a time, location, and orbiter orientation to be determined by the INTELSAT team, a crew member on the aft flight deck will throw a switch to initiate the satellite's deployment. Upon deployment, the Superzip separation system will detach the satellite/PKM assembly from the cradle and canted push–off springs will thrust the satellite from the payload bay at approximately 0.65 fps and 0.67 rpm.

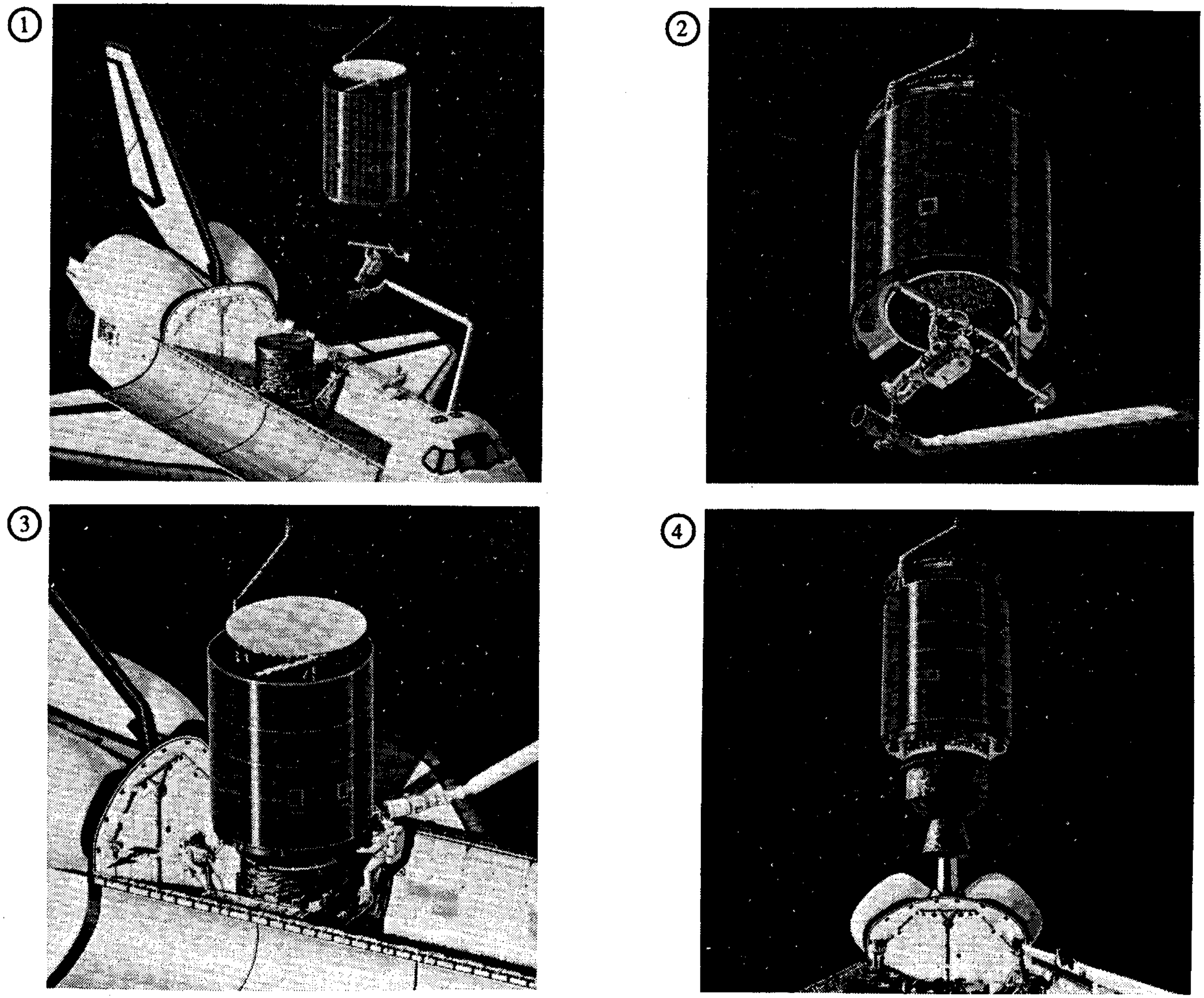
About 35 minutes after deployment, the INTELSAT Launch Control Center will increase the satellite's spin rate to 10 rpm in preparation for PKM firing. The PKM cannot be fired until the satellite drifts into either the ascending or descending node of the orbit, which could happen at any time from a few hours to up to 12 days after deployment. The length of time necessary for the satellite to fall into the proper orbit will depend on the time of the Shuttle's launch and the length of the rescue mission. The wait is expected to be about 2 days.

Once the satellite has reached its proper position, its rotation will be increased to 35 rpm and the PKM will be fired. The satellite will be boosted into a supersynchronous transfer orbit with a perigee at low Earth orbit and an apogee of 48,000 nmi, an orbit that saves the satellite's on–board propellant. A series of ground commands will then lower the satellite into geosynchronous orbit, where its solar array and appendages will be deployed, gving INTELSAT its final on–orbit configuration.

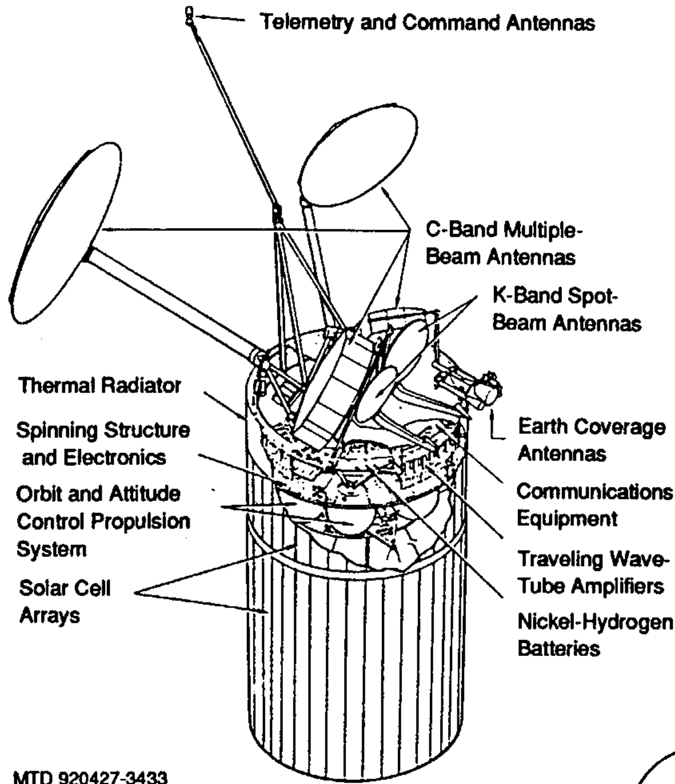
The satellite is expected to be in full service in the Atlantic Ocean region in mid–1992, after completion of on–orbit testing.

SPONSOR

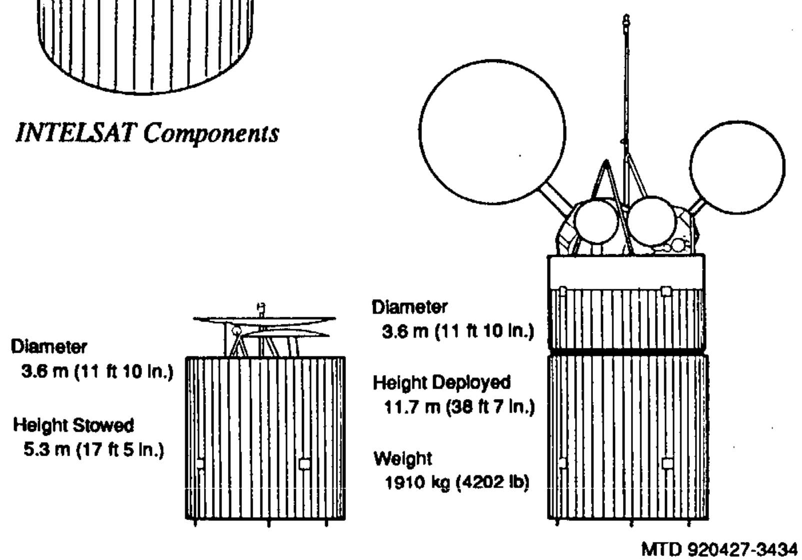
INTELSAT (the International Telecommunications Satellite Organization), which comprises 119 shareholding nations, enables 160 countries to send and receive telephone calls, telegrams, and television programs. Its system of satellites in geosynchronous orbit carries two thirds of the world's overseas telephone traffic and almost all international television.



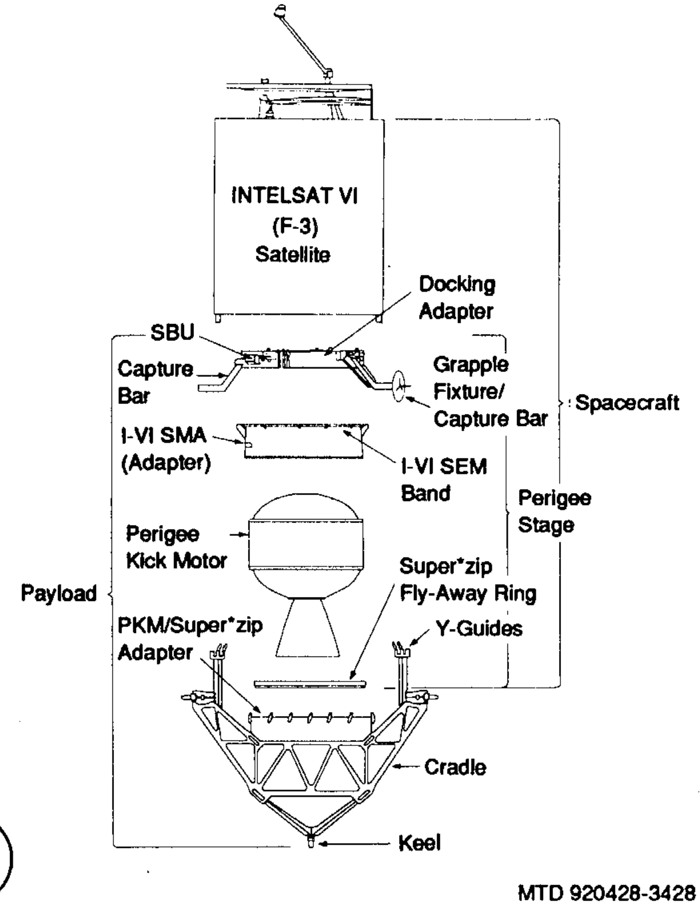
(1) Astronaut Approaches Satellite With Capture Bar (2) Astronaut Attaches Capture Bar and Brings Satellite Back to Payload Bay
(3) Inside Payload Bay, Astronauts Attach New Hardware and Boost Motor (4) Spacecraft With New Motor Is Released From Shuttle



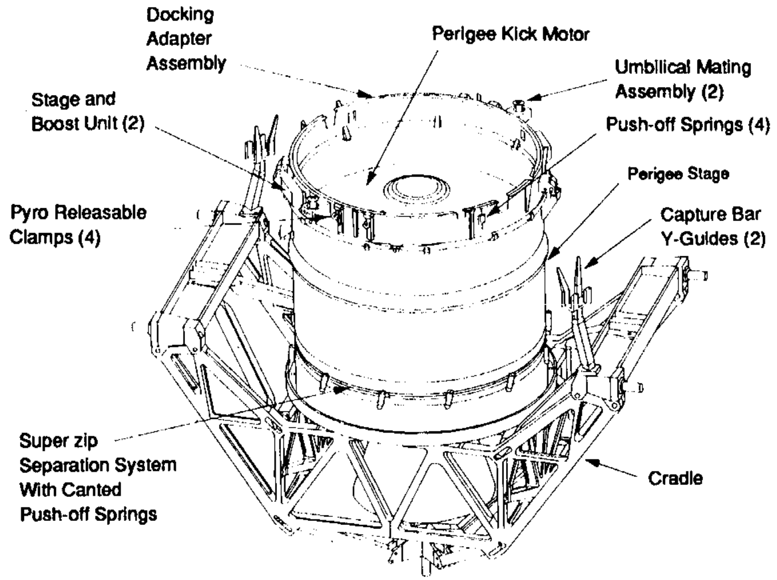
INTELSAT Components



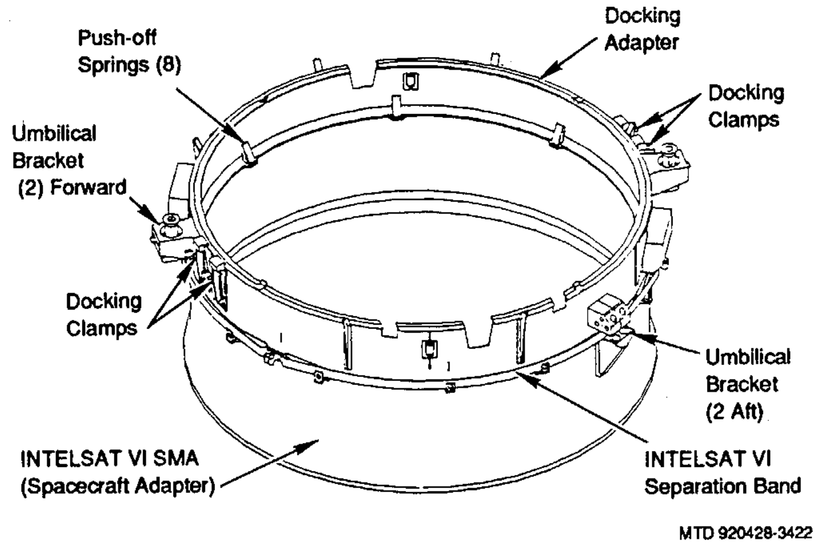
INTELSAT Statistics



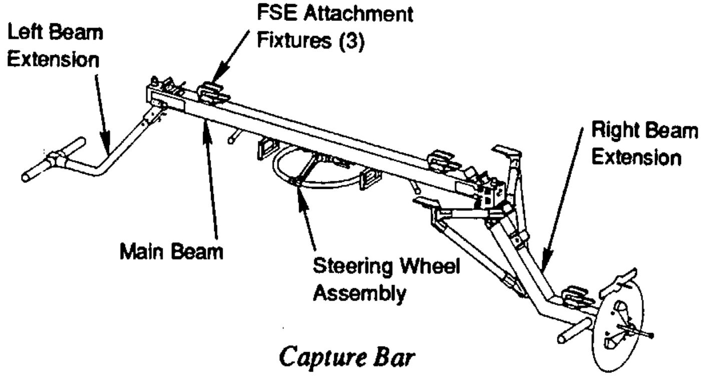
INTELSAT VI F-3 Reboost Payload Layout



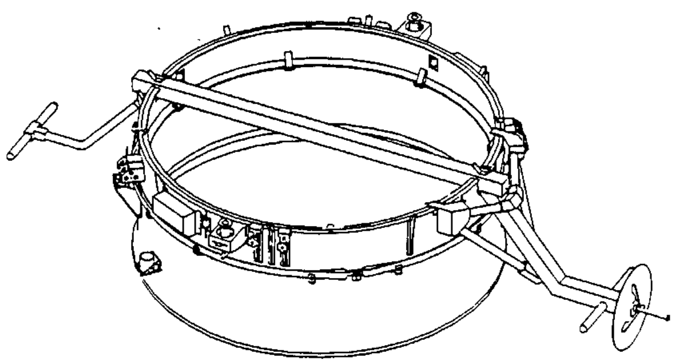
Vertical Perigee Stage



Docking Adapter Assembly and Solid Motor Adapter



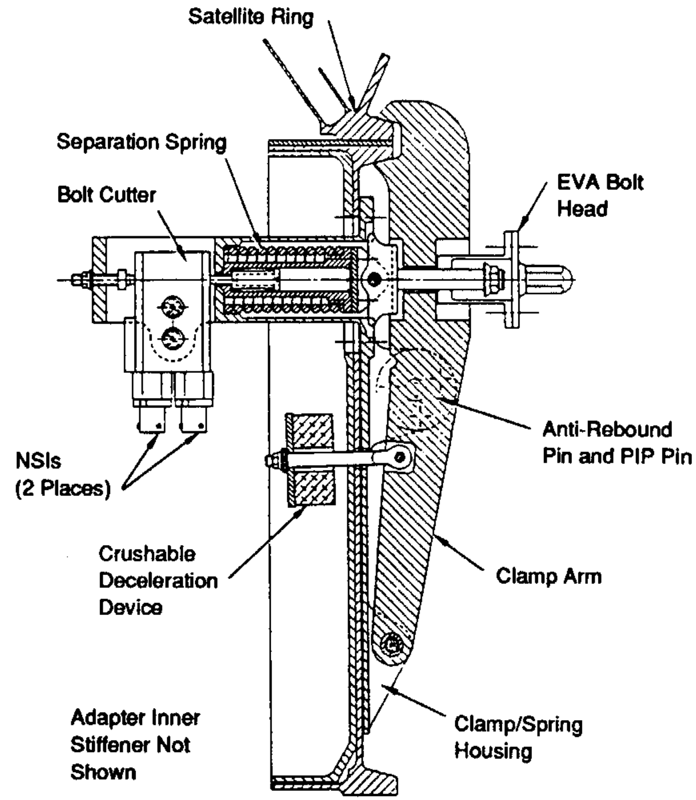
Capture Bar



Docking Adapter

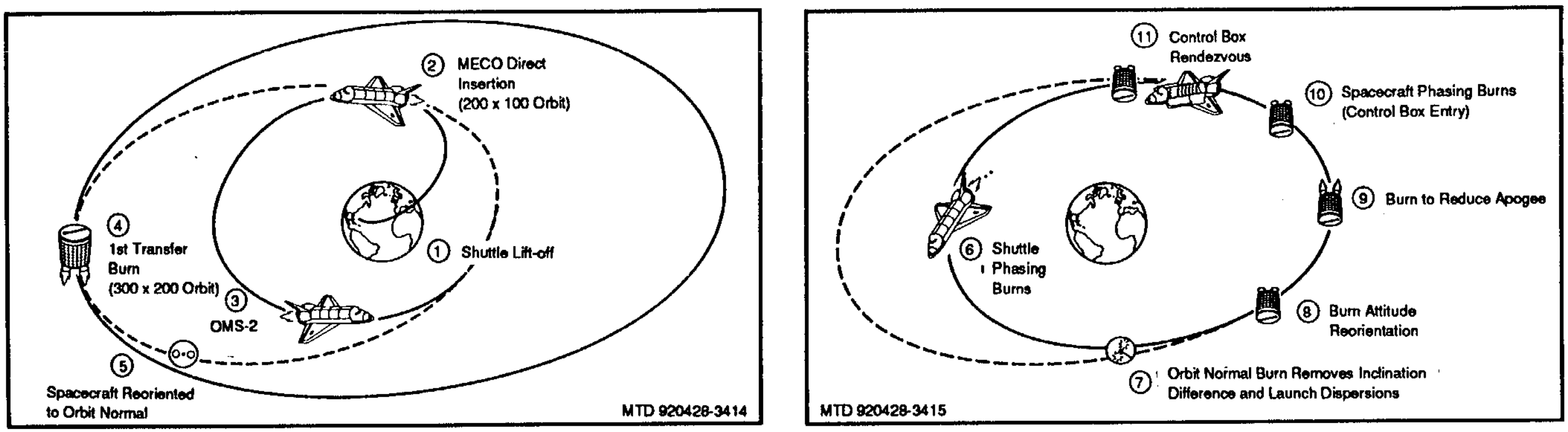
MTD 920428-3423

Capture Bar and Docking Adapter

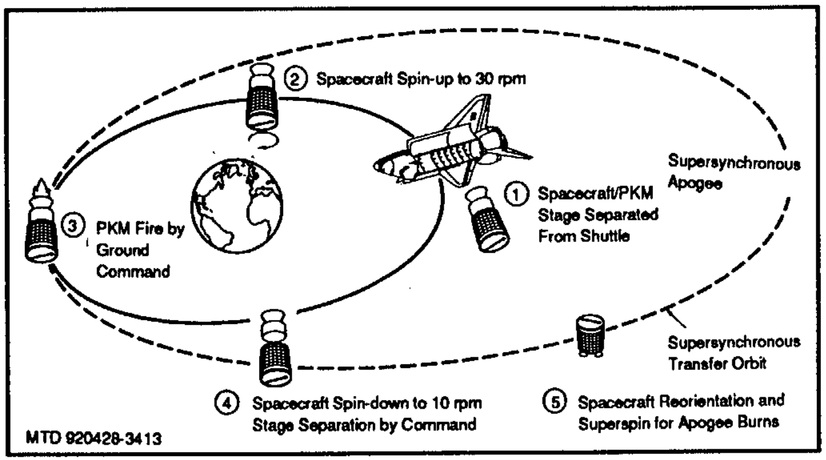


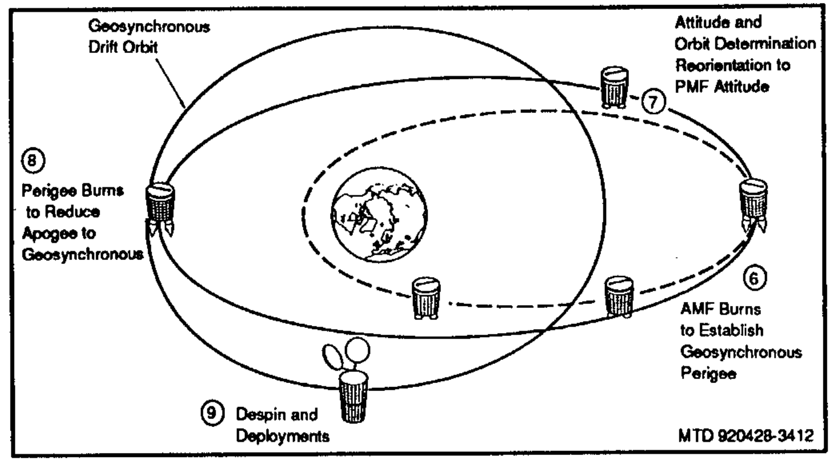
MTD 920428-3419

Spacecraft Adapter Docking Clamp

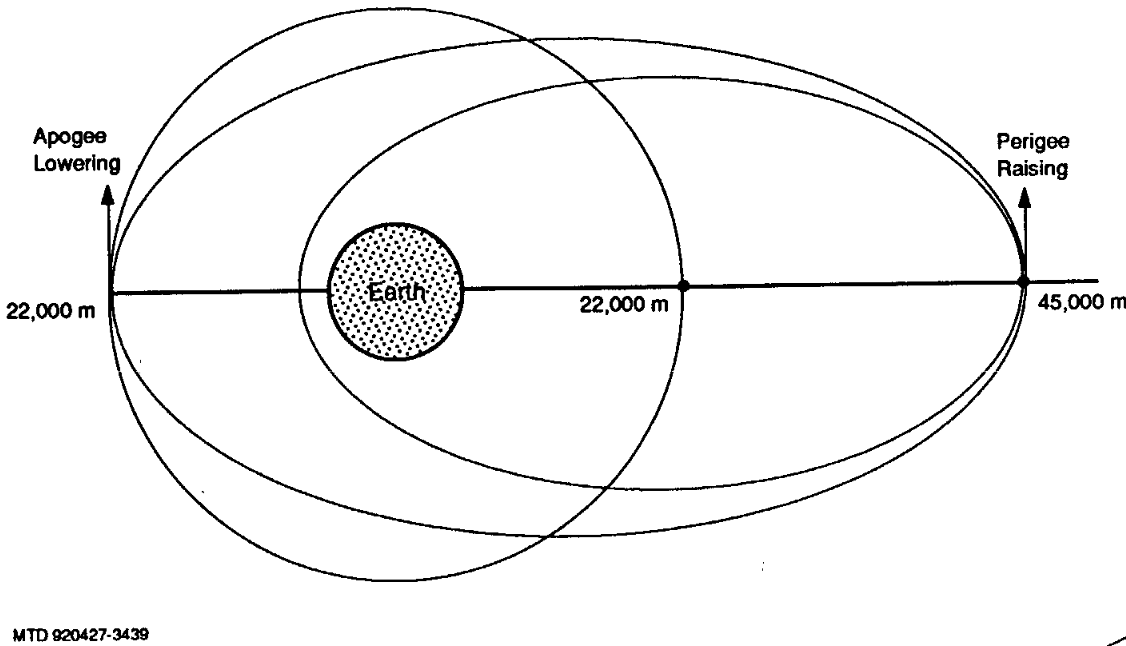


Rendezvous and Retrieval Phase

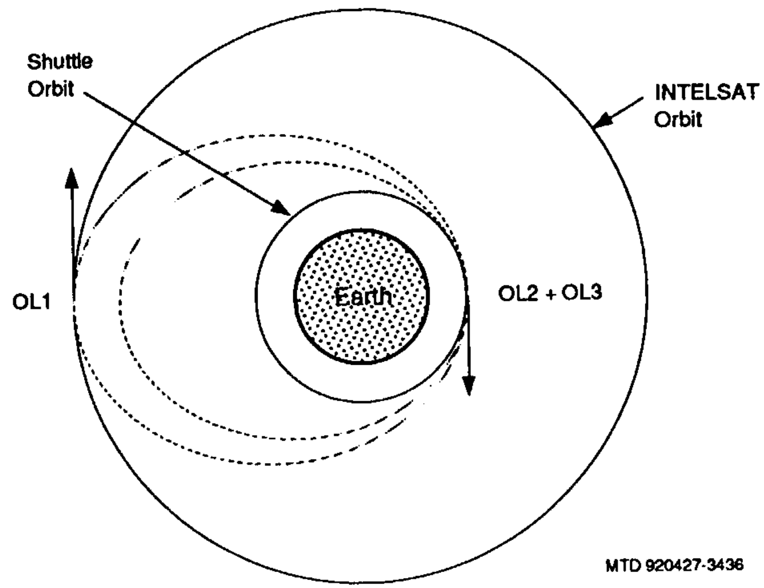




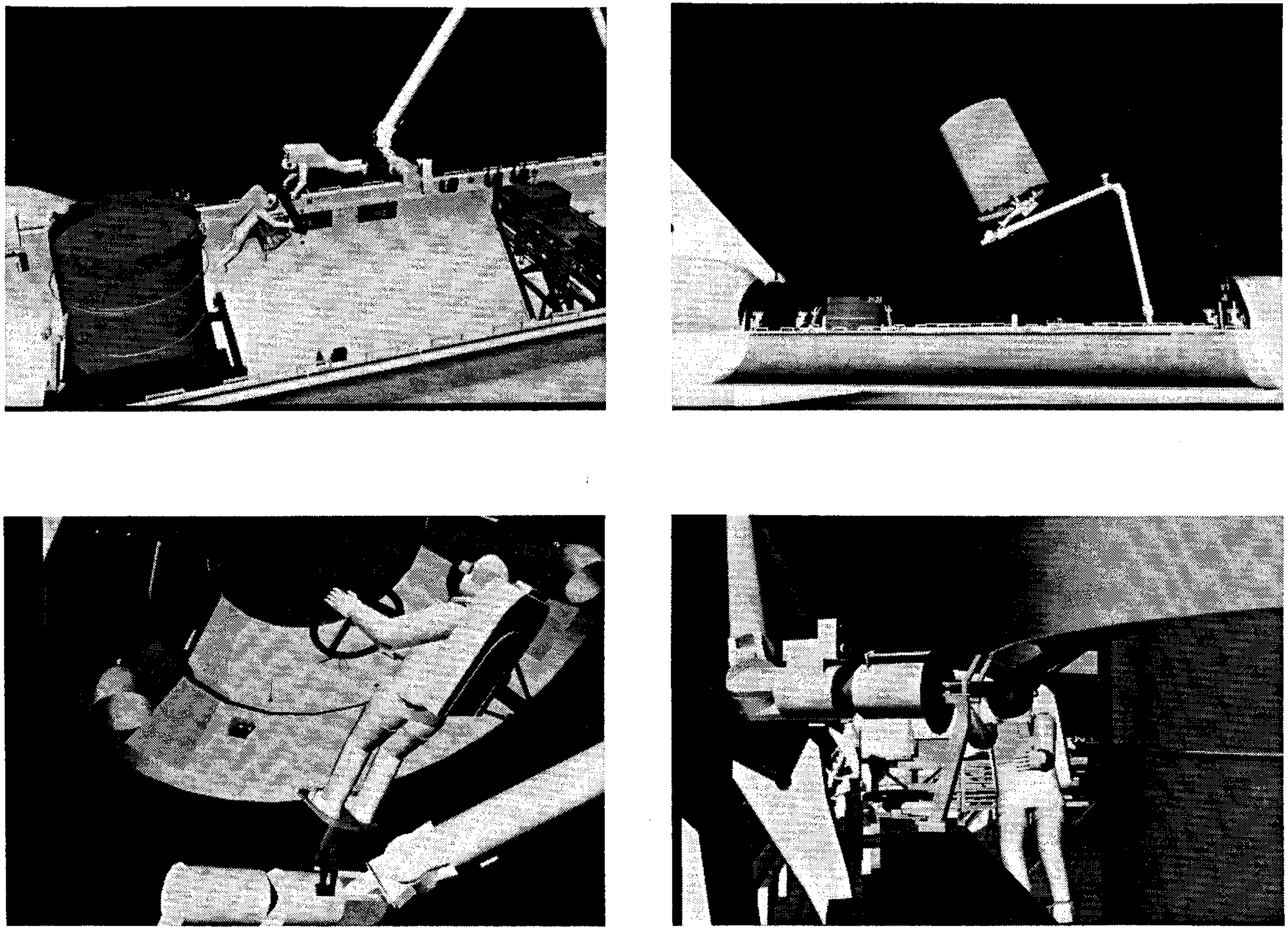
Transfer Orbit Phase



Apogee Motor Firings



Lowering of INTELSAT Orbit



INTELSAT VI Rescue

ASSEMBLY OF STATION BY EXTRAVEHICULAR ACTIVITY METHODS

This secondary payload, which shares Endeavour's cargo bay with INTELSAT VI, will be used by the crew members to demonstrate and evaluate assembly and maintenance techniques for Space Station Freedom. One major objective in performing these "space-station-like" operations is to conduct three extravehicular activities on three consecutive days with two teams of two astronauts each. The first day's EVA task is the INTELSAT reboost effort; the next two days (two 6-hour EVAs) are devoted to ASEM demonstrations.

EQUIPMENT

The major piece of ASEM equipment is a multipurpose experiment support structure that is used to stow ASEM hardware and doubles as a mass simulator during demonstrations of space station pallet installation and EVA manipulation of large objects. This MPESS carrier is equipped with two node boxes, a releasable grapple fixture and interface plate, a truss leg dispenser and legs and strut dispenser, and struts for the truss pyramid. Other ASEM hardware includes ball and socket fixtures, berthing adapters, and scuff plates. The weight of the ASEM payload is 5,700 pounds, which includes all orbiter attachment structures (longeron bridges, payload retention latch assemblies, and keel fittings), crew compartment supporting hardware, and crew self-rescue devices. The MPESS alone weighs 3,560 pounds; with the attachment fixture that will be constructed and added by the astronauts, it weighs 4,000 pounds.

OBJECTIVES

The objectives of performing selected tasks representative of planned on-orbit space station assembly and maintenance tasks are as follows:

- Demonstrate the ability to perform three EVAs on consecutive flight days—a requirement of planned station assembly missions.
- Evaluate operational concepts for attaching hardware to station truss structure. (Test various attachment techniques by using various degrees of berthing adjustment for the interface hardware.) Also examine handling, transport, and assembly techniques for the truss structure and its attachment hardware.
- Gather data for evaluation of various techniques and handling aids used to manipulate and berth large masses (the MPESS carrier, with and without truss structure, acting as the mass).
- Use Endeavour's remote manipulator system (mechanical arm) to position the MPESS carrier and EVA crew members forward and above the payload bay to assess these proposed space station assembly areas.
- While the mission specialist inside the shuttle operates the RMS to berth the MPESS carrier, evaluate the effectiveness of verbal cues and portable closed-circuit television from EVA crew members.
- Test and evaluate candidate crew self-rescue devices and techniques.

ACTIVITIES

Assembly Demonstrations

On flight day 5, EVA mission specialists Thornton and Akers will begin the ASEM demonstrations by connecting nodes and struts to assemble a pyramid truss attachment fixture for the MPESS in Endeavour's payload bay. The fixture acts as the space station structure and the MPESS simulates a pallet to be installed. From a portable foot restraint on the RMS, one crew member will unberth the MPESS manually. He and the MPESS will then be maneuvered by the RMS to investigate planned mass handling capabilities. The MPESS will also be passed between the two EVA crew members, positioned manually within 1 to 2 inches of the attachment points on the pyramid truss fixture, and then manually berthed by the crew member.

Next, the RMS will grapple and position the MPESS carrier so that the EVA crew can attach legs to it and mate it to the truss attachment fixture they previously constructed. Crew members will compare the effectiveness of the RMS and their own manual EVA efforts as attachment methods. While the RMS positions the assembly and EVA crew (one in the RMS foot restraint and one tethered to the RMS) above the crew compartment and the payload bay, the astronauts will remove the legs from the MPESS carrier, evaluating the qualities and various lighting conditions of both areas as possible work sites as they perform the task.

Similar tasks, with varying techniques, conditions, and mission specialists Thuot and Hieb, will be performed during the second ASEM EVA the following day, since most of the data to be collected is qualitative in nature, consisting of crew comments, opinions, and photographic/television documentation.

SELF-RESCUE

During the RMS maneuvers, the EVA crew will also test and evaluate the following devices and techniques for getting back on board the space station in the event that they accidentally lose contact with an EVA work station:

- Astrorope—a 20-foot nylon rope with two cleats that is thrown by hand and wraps around a structure; must be manually retracted before rethrow.

- Rigid, telescoping pole—a 12-foot pole with a grapple fixture at the top and tripod legs that are manually extended.

- Bi-stem pole—two strips of coiled spring steel that form a pole 20 feet long; deployed and retracted by an EVA power tool. It has a grapple fixture on one end that is capable of unlimited grapple attempts.

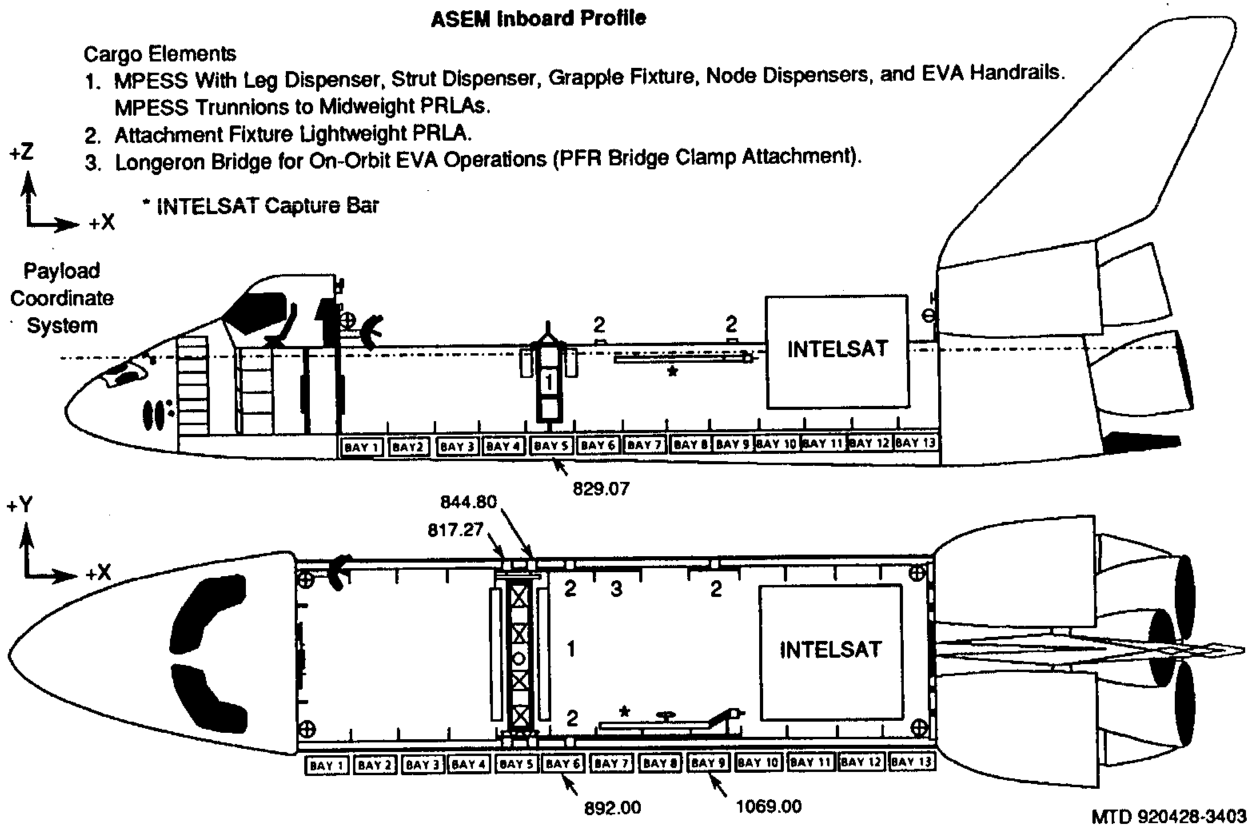
- Inflatable pole—a 12-foot cloth tube inflated with compressed nitrogen. It has a grapple fixture attached to one end that can perform unlimited grapple attempts. Once attached to the desired object, the pole is deflated and the user pulls himself to the object with a hand-over-hand approach. The pole cannot be reused.

- Crew propulsive device—hand-held maneuvering unit powered by nitrogen; used during Gemini and Skylab.

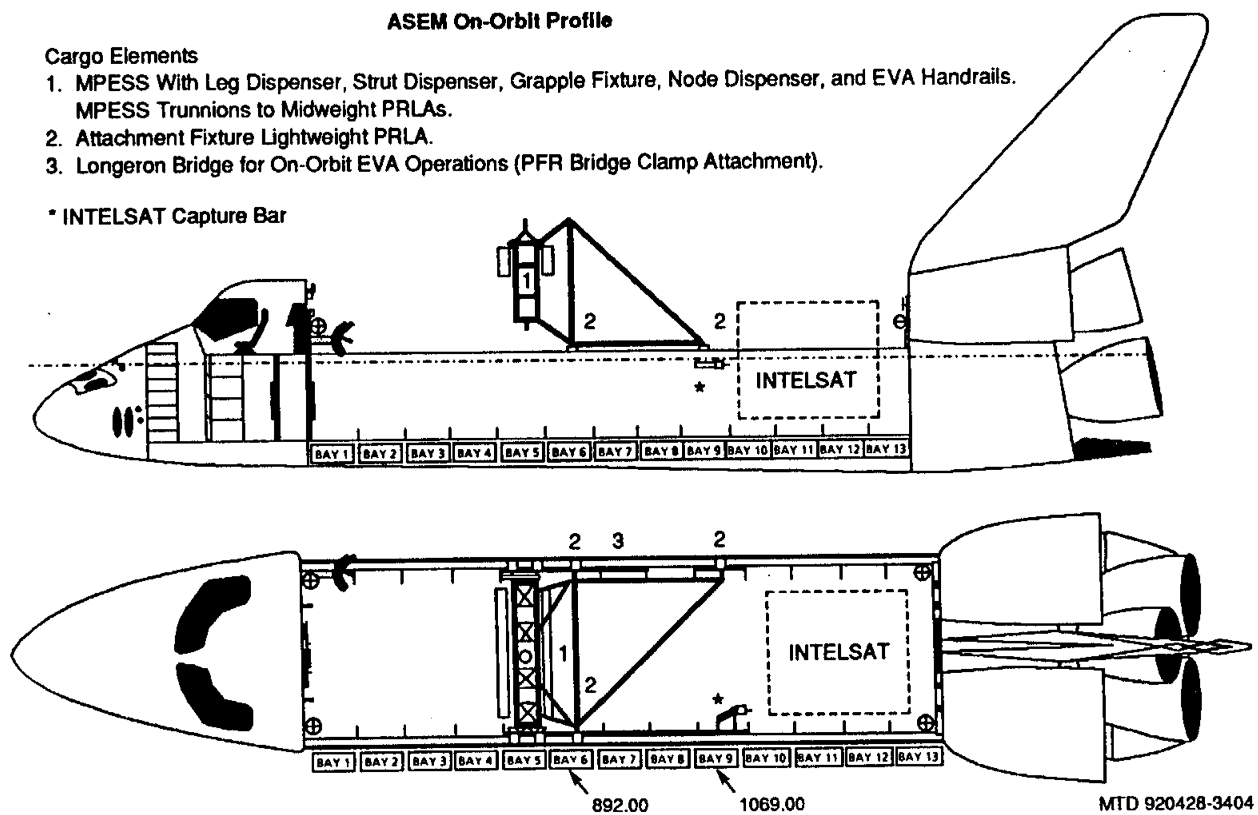
Test and evaluation of the crew propulsive device, the bi-stem and the inflatable pole are scheduled for flight days 5 and 6. The astrorope and telescoping pole will be evaluated as time permits during the spacewalks. The crew self-rescue hardware was developed by the Crew and Thermal Systems Division at the Johnson Space Center.

SPONSOR

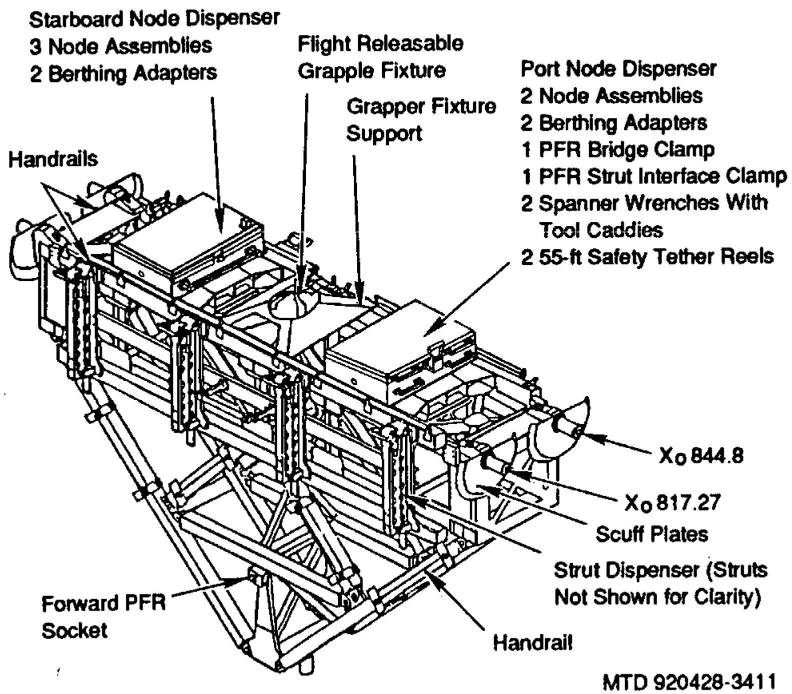
The ASEM demonstrations are sponsored by NASA's Goddard Space Flight Center, Langley Research Center, and Lyndon B. Johnson Space Center. Goddard supplies the MPESS carrier and the mission-peculiar equipment it contains (adapters and scuff plates).



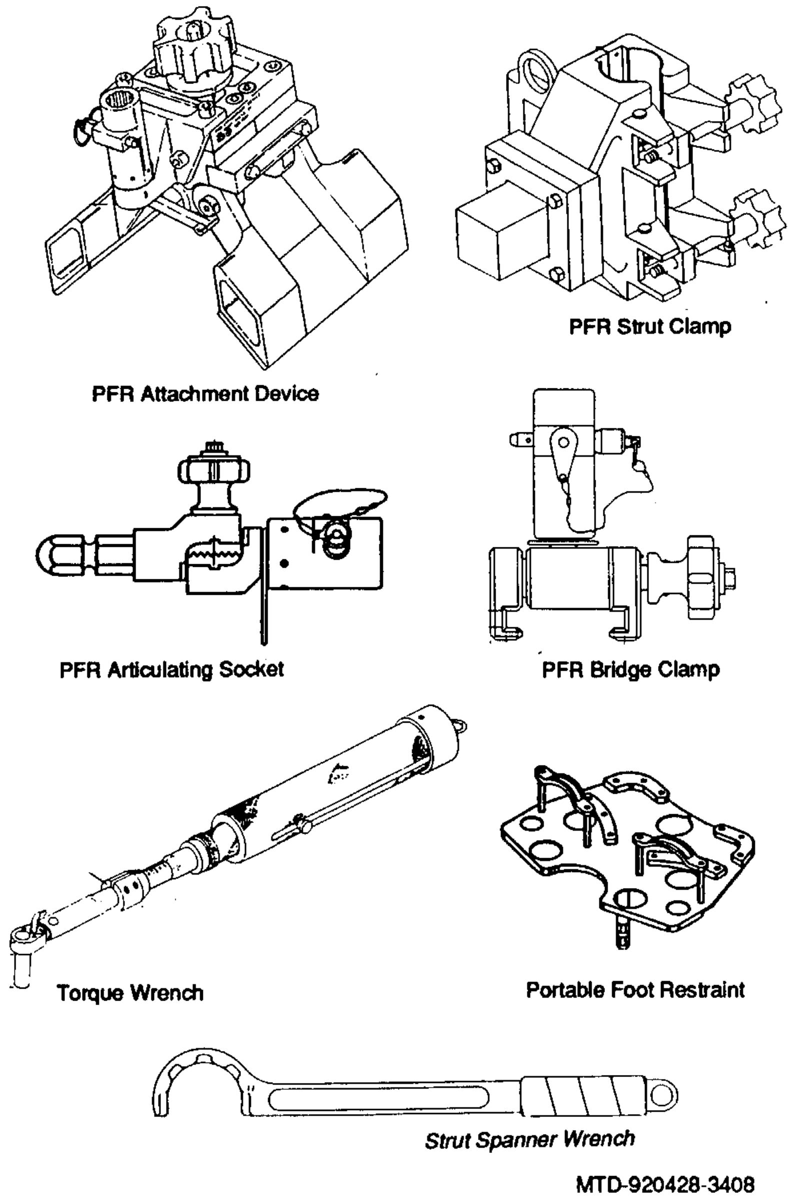
ASEM Launch and Landing Configuration



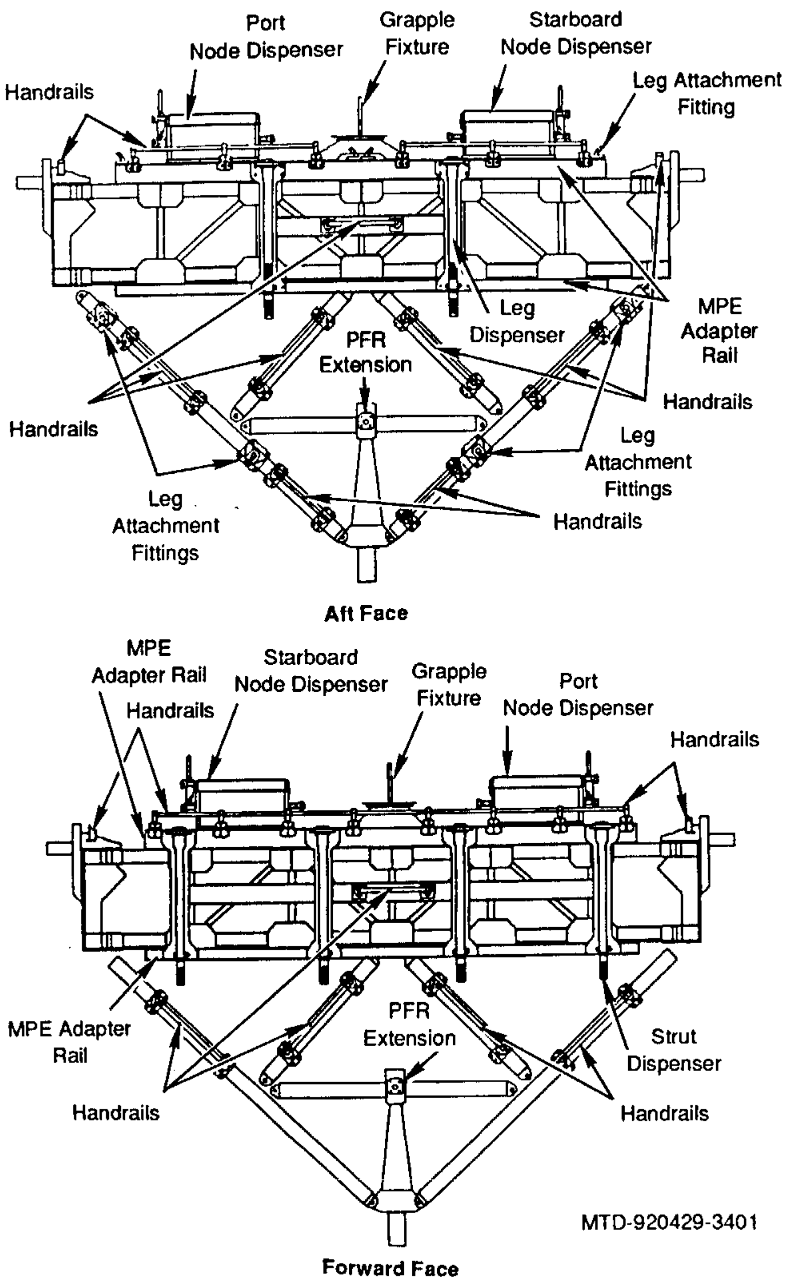
ASEM On-Orbit Configuration (MPESS/Attachment Fixture)

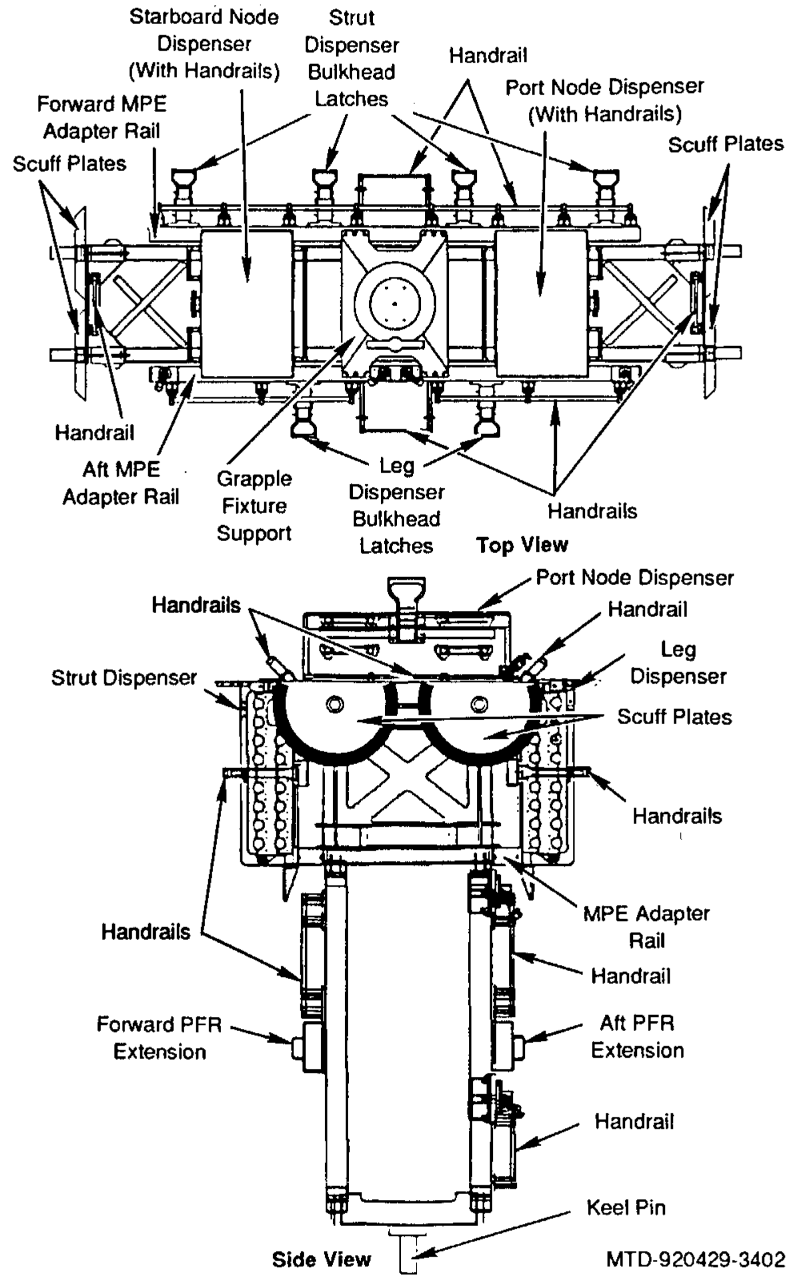


ASEM Launch and Landing Configuration (Struts Not Shown)

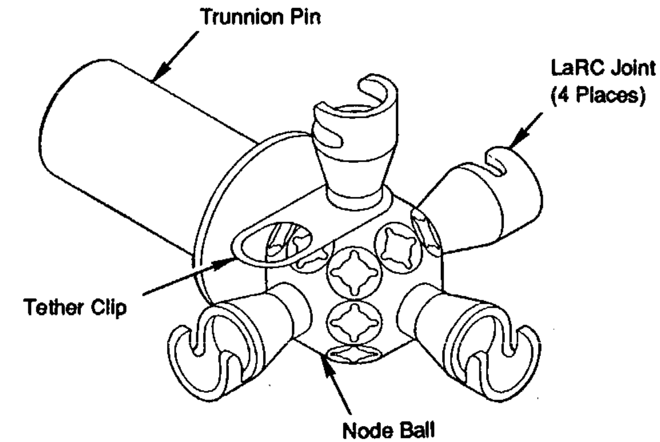


ASEM Equipment

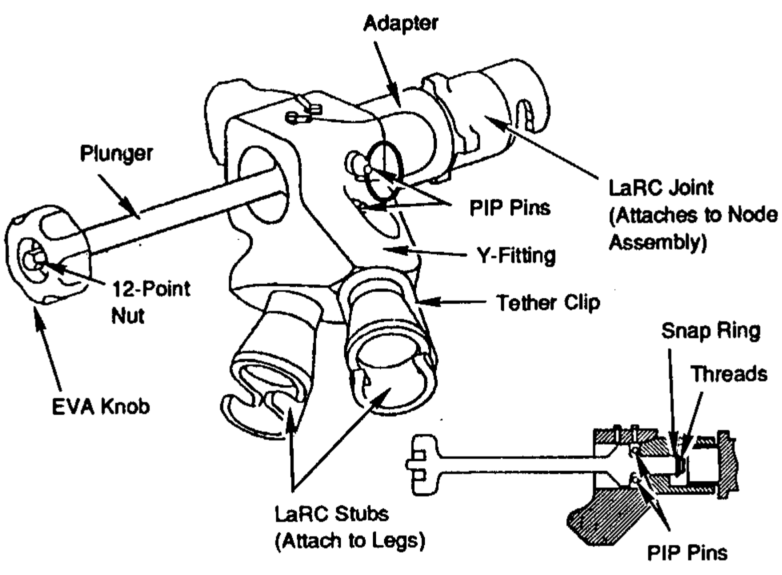




MPESS Interfaces



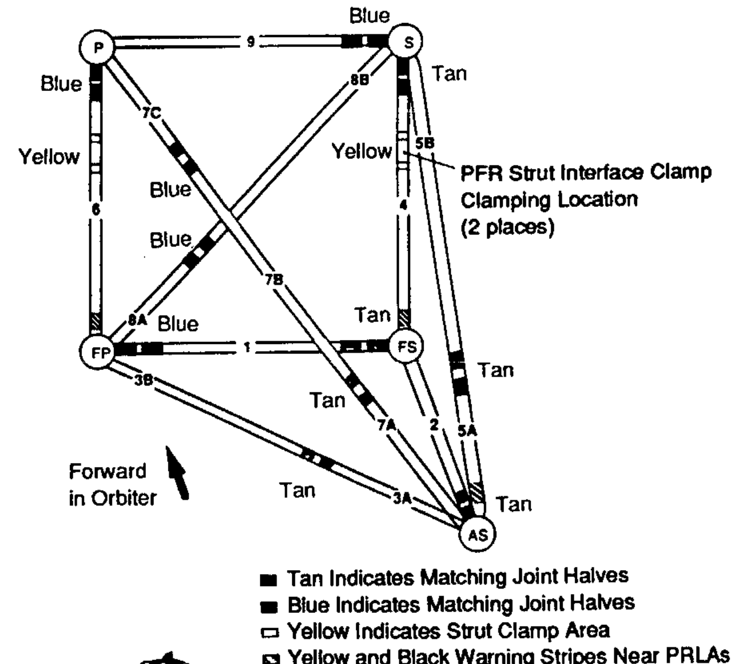
Node

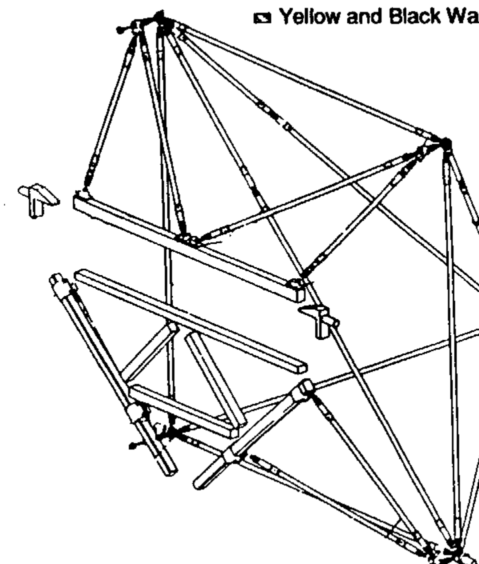


Y-Fitting

MTD-920428-3407

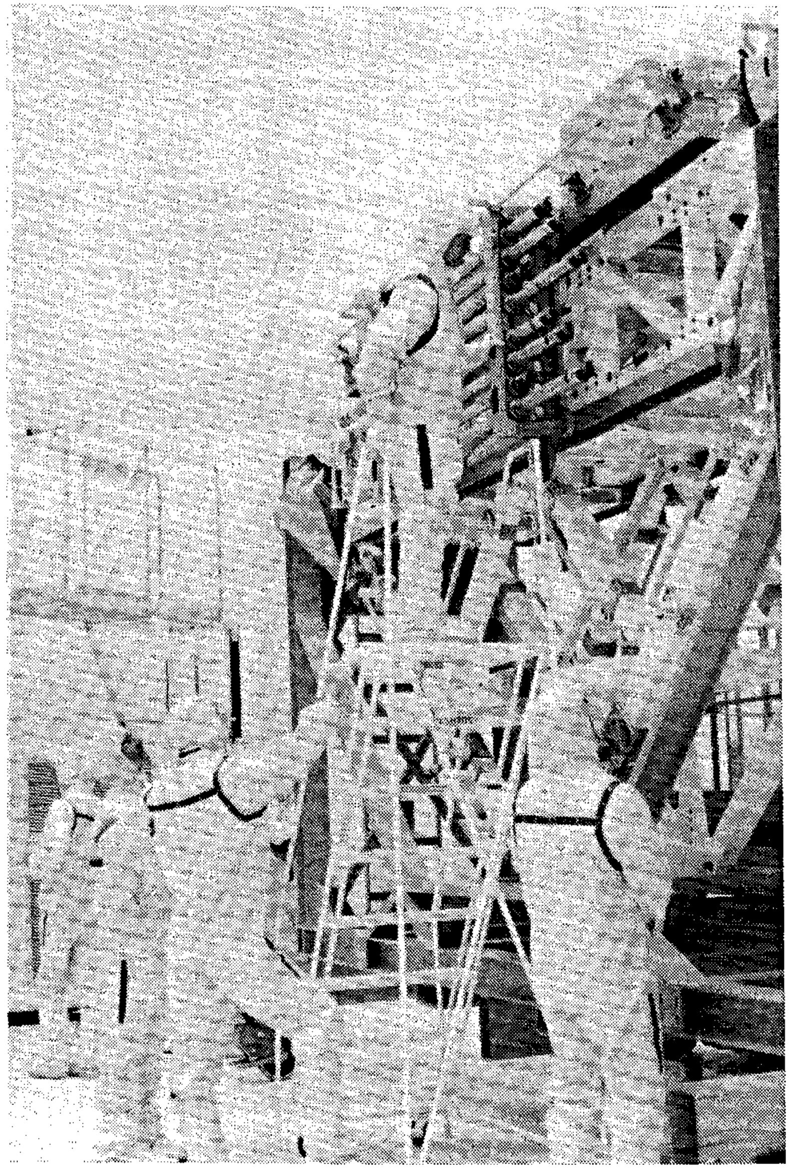
MPESS Node and Fitting



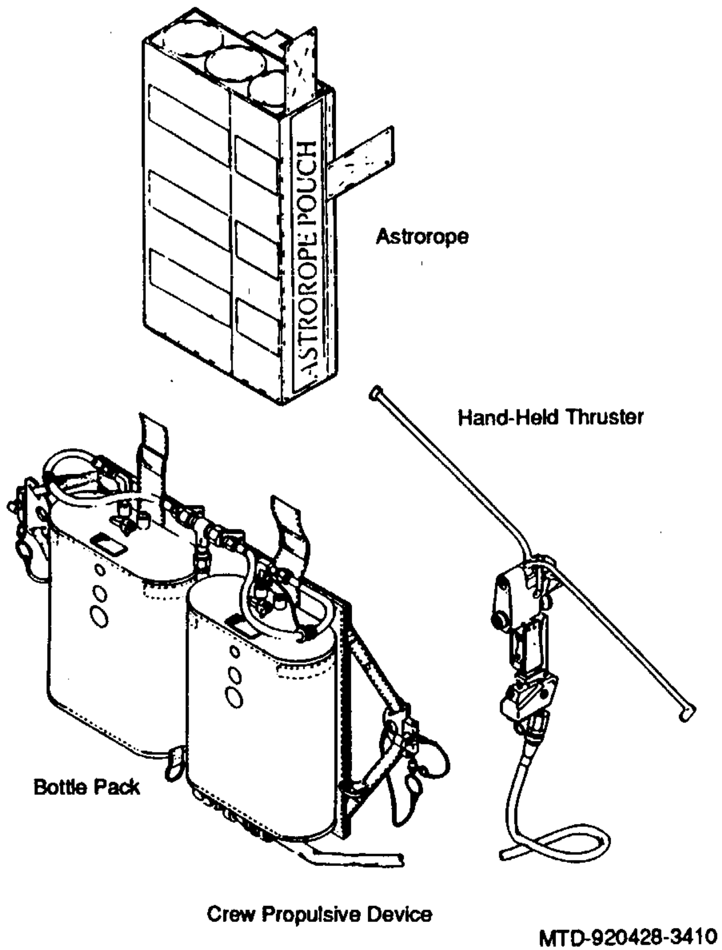


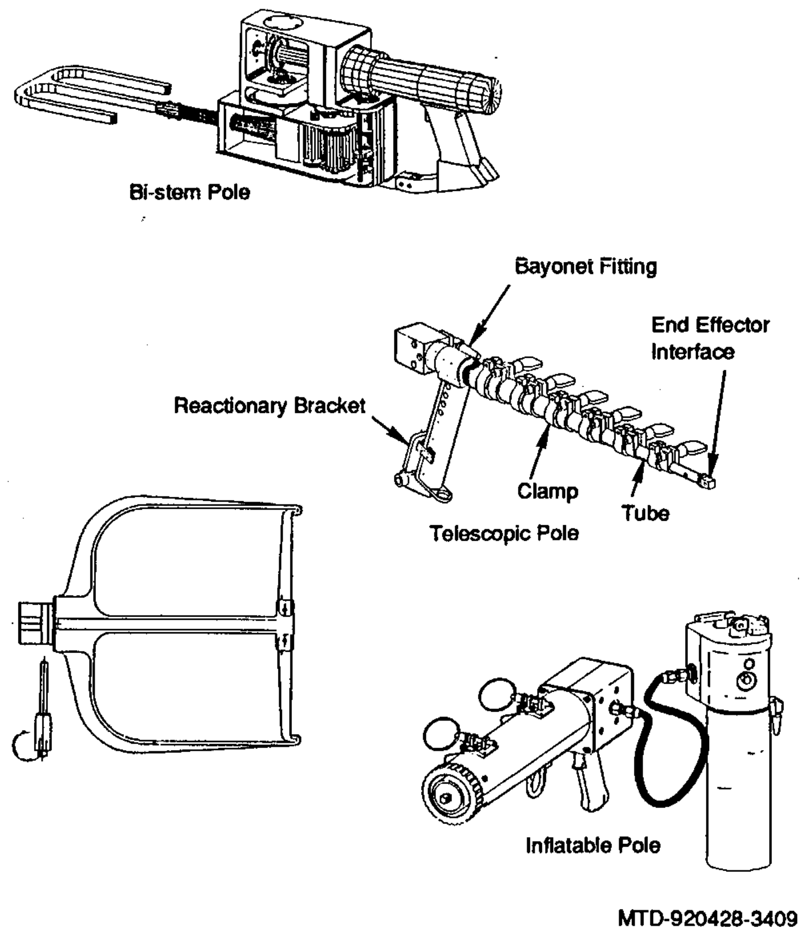
Assembled Fixture

MTD-920429-3405



Astronauts in Vertical Processing Facility Inspecting ASEM Experiment for Sharp Edges





Crew Self-Rescue Hardware

COMMERCIAL PROTEIN CRYSTAL GROWTH EXPERIMENT

In the past decade, rapid growth in protein pharmaceutical use has resulted in the successful application of proteins to insulin, interferons, human growth hormone and tissue plasminogen activator. The pharmaceutical industry seeks these pure protein crystals because their purity will simplify Federal Drug Administration approval of new protein–based drugs. Pure, well–ordered protein crystals of uniform size are in demand as special formulations for use in drug delivery.

During the past 6 years, several hardware configurations have been used to conduct protein crystal growth (PCG) experiments aboard 12 space shuttle flights. These experiments, however, have involved the processing of only minute quantities of sample materials. On STS–49, the protein crystallization facility (PCF), developed by the Center for Macromolecular Crystallography (CMC), a NASA Center for the Commercial Development of Space at the University of Alabama–Birmingham, will use much larger quantities of materials to grow crystals in batches, using temperature as a means to initiate and control crystallization.

The reconfigured PCF includes cylinders with the same height, but varying diameters to obtain different volumes (500, 200, 100, 20 ml). These cylinders allow for a relatively minimal temperature gradient and require less protein solution to produce quality crystals. The reconfiguration was driven by industry's need to reduce the cost and amount of protein sample needed to grow protein crystals in space, while, at the same time, increasing the quality and quantity of crystals.

Also flying on STS–49 as part of the CPCG payload complement is a newly–designed, state–of–the–art commercial refrigerator incubator module (CRIM) that allows for a pre–programmed temperature profile. The CRIM temperatures are programmed prior to launch and are monitored during flight by a feedback loop. Developed by Space Industries, Inc., Webster, Texas, for CMC, the CRIM also provides improved thermal capability and has a microprocessor that uses "fuzzy logic" (a branch of artificial intelligence) to control and monitor the CRIM's thermal environment. A thermoelectric device is used to electrically "pump" heat in or out of the CRIM.

The PCF serves as the growth chamber for significant quantities of protein crystals. Each of the PCF cylinders on STS–49 is encapsulated within individual aluminum containment tubes and supported by an aluminum structure. Prior to launch, the cylinders will be filled with bovine insulin solution and mounted into a CRIM set at 40 degrees C. Each cylinder lid will pass through the left wall of the aluminum structure and come into direct contact with a metal plate in the CRIM that is temperature–controlled by the thermoelectric device.

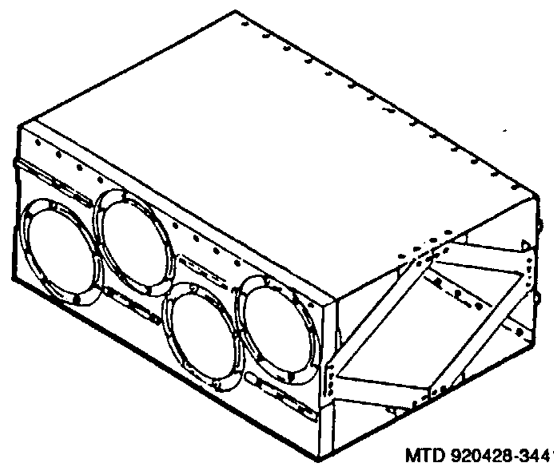
Shortly after achieving orbit, the crew will activate the PCF experiment by initiating the pre–programmed temperature profile. The CRIM temperature will be reduced automatically from 40 degrees C to 22 degrees C over a 4–day period. The change in CRIM temperature will be transferred from the cold plate throught the cylinder's lids to the insulin solution.

Decreasing the temperature of the solution by 18 degrees C will effect the resulting crystals' formation, which should be well ordered due to the reduced effects of the Earth's gravity. Once activated, the payload will not require any further crew interaction (except for periodic monitoring), nor will it require any modifications for landing.

In general, purified proteins have a very short lifetime in solution; therefore, the CPCG payload and CRIM will be loaded onto the shuttle no earlier than 24 hours prior to launch. Due to the instability of the resulting protein crystals, the CRIM will be retrieved from the shuttle within 3 hours of landing. The CRIM will be battery–powered continuously from the time the samples are placed in the CRIM and loaded onto the shuttle, until the time it is recovered and delivered to the investigating team. For launch delays of more than 24 hours, the payload will need to be replenished with fresh samples.

Once the samples are returned to Earth, they will be analyzed by morphometry to determine size distribution and absolute/relative crystal size. They also will be analyzed with X–ray crystallography and biochemical assays of purity to determine internal molecular order and protein homogeneity, respectively.

The Commercial Protein Crystal Growth payload is sponsored by NASA's Office of Commercial Programs and is developed and managed by the Center for Macromolecular Crystallography. Dr. Charles E. Bugg, Director, CMC, is lead investigator of the CPCG experiment. Dr. Marianna Long, CMC Associate Director for Commercial Development, is also a CPCG investigator.



CPCG Block II Configuration

AIR FORCE MAUI OPTICAL SITE CALIBRATION TEST

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

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

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

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

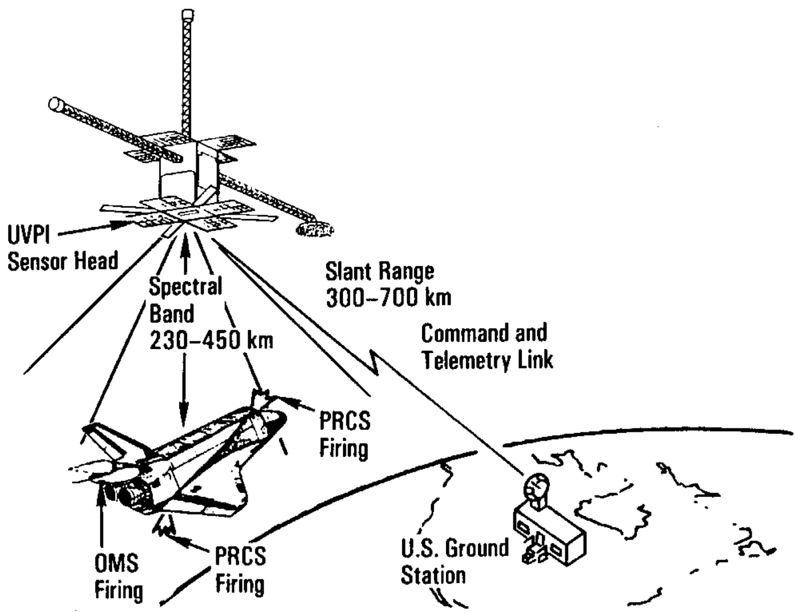
Flight planning and mission support activities for the AMOS test opportunities are performed by a detachment from AFSC's Space Systems Division at the Johnson Space Center in Houston. Flight operations are conducted at the JSC Mission Control Center in coordination with the AMOS facilities in Hawaii.

ULTRAVIOLET PLUME INSTRUMENT

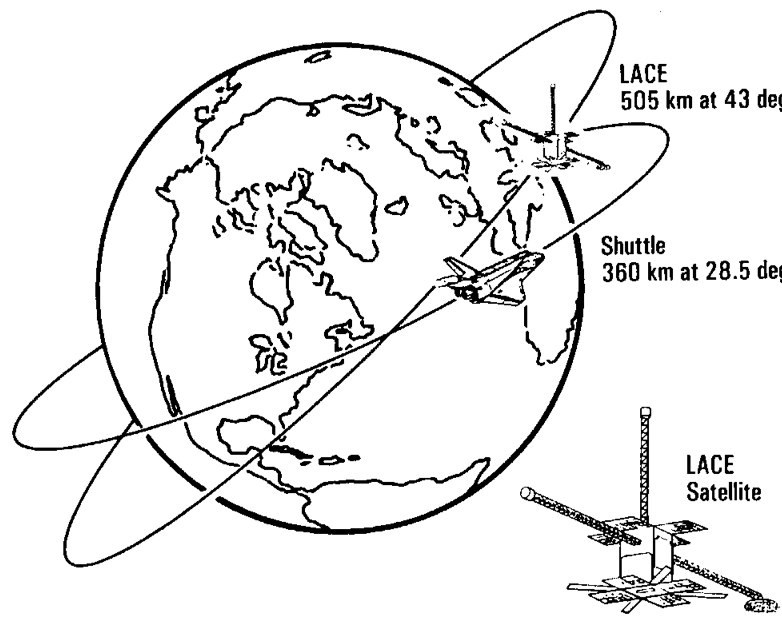
The Ultraviolet Plume Instrument is located on the Low-Power Atmospheric Compensation Experiment satellite, a Strategic Defense Initiative Organization satellite in low Earth orbit at an inclination of 43 degrees and an altitude of approximately 290 nautical miles. The UVPI's sensors will be trained on the orbiter to obtain imagery and/or signature data to calibrate the sensors and to observe orbiter jet firings during cooperative encounters of the orbiter with the LACE satellite. Orbiter maneuvers will include, in order of priority, an OMS burn test, primary reaction control system burn test, vernier reaction control system burn test, orbiter hardbody, and payload bay lighting test.

UVPI is a payload of opportunity. A UVPI test will be scheduled late in the mission if an orbiter encounter with the satellite fits within the crew's scheduling constraints and the orbiter has enough propellant. UVPI requires no flight hardware to be carried on the orbiter.

UVPI is sponsored by the Strategic Defense Initiative Organization.



LACE/Shuttle UVPI Encounter



LACE (UVPI)/Shuttle Encounter

FORWARD RCS FLIGHT TEST 12-SECOND PULSE (DTO 249). RCS flight test maneuvers will be initiated during entry to obtain flight data showing the aerodynamic effects created when the FRCS side firing thrusters are used as a means of eliminating RCS propellant. The flight data will be used to verify and validate existing wind tunnel data and verify the safety of performing a FRCS dump during a GRTLS or TAL abort. This test will be performed only if propellant is available.

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

ASCENT COMPARTMENT VENTING EVALUATION (DTO 305D). This DTO is intended solely to collect data to expand the data base to verify vent models.

DESCENT COMPARTMENT VENTING EVALUATION (DTO 306D). The purpose of this DTO is to expand the data base to verify vent models.

ENTRY STRUCTURAL CAPABILITY EVALUATION (DTO 307D). This DTO will collect structure load data for different payload weights and configurations to expand the data base of flight loads during entry.

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

WASTE/SUPPLY WATER DUMPS (DTO 325). The objective of this DTO is to perform in-flight verification of new water dump nozzle performance. The RMS end effector camera will be moved into position to view the waste and supply water dump nozzles. A simultaneous supply and waste dump will be performed on STS-49.

CARBON BRAKE SYSTEM TEST (DTO 519). The objective of this DTO is to evaluate the orbiter carbon brake system performance through a series of landing rollout brake tests on lake bed and concrete surfaces. Test conditions must be performed using the following vehicles: Discovery for 1, 2 and 3; Atlantis for 4; Columbia for 5; and Endeavour for 6.

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

ORBITER DRAG CHUTE SYSTEM (DTO 521). This DTO will evaluate the orbiter drag chute system performance through a series of landings with increasing deployment speeds. The DTO will be performed on vehicles equipped to measure drag forces imposed by the drag chute system. This DTO consists of two phases: Phase I will consist of three flights, with first flight drag chute deployment at or subsequent to nose gear touchdown, second flight will be nose gear touchdown incorporating delayed load relief, and the third flight with initiation at derotation. Upon completion of Phase I, the deceleration parachute will be operational for all vehicles. Phase II will consist of seven additional flights gradually increasing in speed from initiation at derotation 185 knots equivalent air speed (KEAS) to initiation at 205 KEAS.

CABIN AIR MONITORING (DTO 623). This DTO will use the solid sorbent sampler to continuously sample the orbiter atmosphere throughout the flight. The sampler collects trace levels of volatile contaminants which are used to determine spacecraft air quality and the effectiveness of the ECLSS in removing these compounds from the air.

HYDRAZINE MONITOR (DTO 640). During EVA the potential exists for hydrazine to contaminate the EVA suit and be inadvertently released into the shuttle atmosphere at the conclusion of an EVA. The hydrazine monitor will sample the airlock and cabin air to detect the presence of hydrazine or monomethylhydrazine after completion of an EVA to ensure the safety of the crew.

ELECTRONIC STILL PHOTOGRAPHY TEST (WITH DOWNLINK) (DTO 648). Electronic still photography is a new technology that provides the means for a hand-held camera to electronically capture and digitize an image with resolution approaching film quality. The digital image is stored on disks and can be converted to a format suitable for downlink transmission or enhanced using image processing software. The ability to enhance and/or downlink high resolution images in real time will greatly improve capabilities in Earth observations. The objective of this DTO is to determine camera response to the photographic conditions encountered on orbit, using a variety of lenses and camera settings.

CYCLE ERGOMETER HARDWARE EVALUATION (DTO 651). This DTO will evaluate the cycle ergometer as an alternative to the shuttle treadmill. Treadmill use has raised several concerns including noise, vibration, subject discomfort and inability to quantify workload. These concerns warrant evaluation of alternate in-flight exercise hardware. Vibration and physical discomfort will be documented and biomedical analysis will be performed in conjunction with various protocols/workloads. Heart rate will be recorded for evaluation of the resistive workload settings in zero-g.

REMOTE MANIPULATOR SYSTEM UNWANTED MOTION EVALUATION (DTO 659). This DTO will evaluate the effect of changing the port command bias parameter from a value of negative one to zero on unwanted motion during a simple translation and rotation of the RMS. The phenomena of unwanted motion has raised concerns during the deployment of heavy payloads such as the Long-Duration Exposure Facility, Hubble Space Telescope and Gamma-Ray Observatory. Unwanted motion is defined as payload motion in any axis that is not being commanded.

ACOUSTICAL DOSIMETER (DTO 663). This DTO will gather data on the acoustic environment. The CPCG, CRIM, ergometer and new galley may negatively influence the overall cabin noise levels. This data will provide information to help determine new specification levels for intermittent noises as well as a maximum 24-hour exposure level.

LASER RANGE AND RANGE RATE DEVICE (DTO 700-2). The purpose of this Laser Range and Range Rate DTO is to demonstrate the capability to provide the orbiter flight crew with range and range rate data for rendezvous, proximity operations, and deploy operations. The DTO will assess the usefulness of the data to assist the pilot in achieving the desired trajectory conditions.

KU-BAND ANTENNA FRICTION (DTO 728). The purpose of this DTO is to provide Ku-band antenna gimbal friction data by performing eight high-speed scans in radar mode.

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

IN-FLIGHT RADIATION DOSE-DISTRIBUTION (TEPC) (DSO 469C). The purpose of this DSO is to establish, evaluate, and verify analytical and measurement methods for assessing and managing health risks from exposure to space radiation. This DSO will measure the radiation environment inside the shuttle at a thinly shielded region: dosimetry #2 location (DLOC #2) on the right middeck wall (MR85B).

CARDIAC RHYTHM DISTURBANCES DURING EXTRAVEHICULAR ACTIVITY (DSO 482). The purpose of this DSO is to investigate the presence of dysrhythmias during EVA, preflight EVA training, and nominal daily activities using passive ECG recordings. Dysrhythmias can decrease cardiovascular efficiency, impacting EVA productivity.

ORTHOSTATIC FUNCTION DURING ENTRY, LANDING AND EGRESS (DSO 603). The objective of this DSO is to measure the changes in orthostatic function of crewmembers during the actual stresses of entry, landing and egress from the orbiter. Crewmembers will don equipment prior to donning the LES during deorbit preparation. Equipment consists of a blood pressure monitor, accelerometers, an impedance cardiograph, and transcranial Doppler hardware. The crewmember wears the equipment and records verbal comments through entry.

VISUAL VESTIBULAR INTEGRATION AS A FUNCTION OF ADAPTATION (OI-1) (DSO 604A). The objective of this DSO is to investigate visual vestibular and perceptual adaptive responses as a function of longer missions and to determine the operational impact on performance of entry, landing, and egress procedures. These data will be used to develop training and/or countermeasures to ensure the safety and success of extended missions by promoting optimal neurosensory function needed for entry, landing and possible emergency egress.

POSTURAL EQUILIBRIUM CONTROL DURING LANDING/EGRESS (DSO 605). This DSO will quantify the effects that in-flight neurosensory adaptations to zero-g have on postflight control of postural equilibrium.

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

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

EVALUATION OF FUNCTIONAL SKELETAL MUSCLE PERFORMANCE FOLLOWING SPACE FLIGHT (DSO 617). The purpose of this DSO is to determine the physiological effects of long-duration space flight on skeletal muscle strength, endurance, and power. It will provide knowledge necessary to support the development of future countermeasure prescriptions essential for nominal muscle performance.

IN-FLIGHT USE OF FLORINEF TO IMPROVE ORTHOSTATIC INTOLERANCE POSTFLIGHT (DSO 621). The purpose of this DSO is to evaluate the efficacy of florinef on postflight orthostatic tolerance using heart rate, blood pressure, stroke volume, and other cardiovascular responses to orthostatic stress.

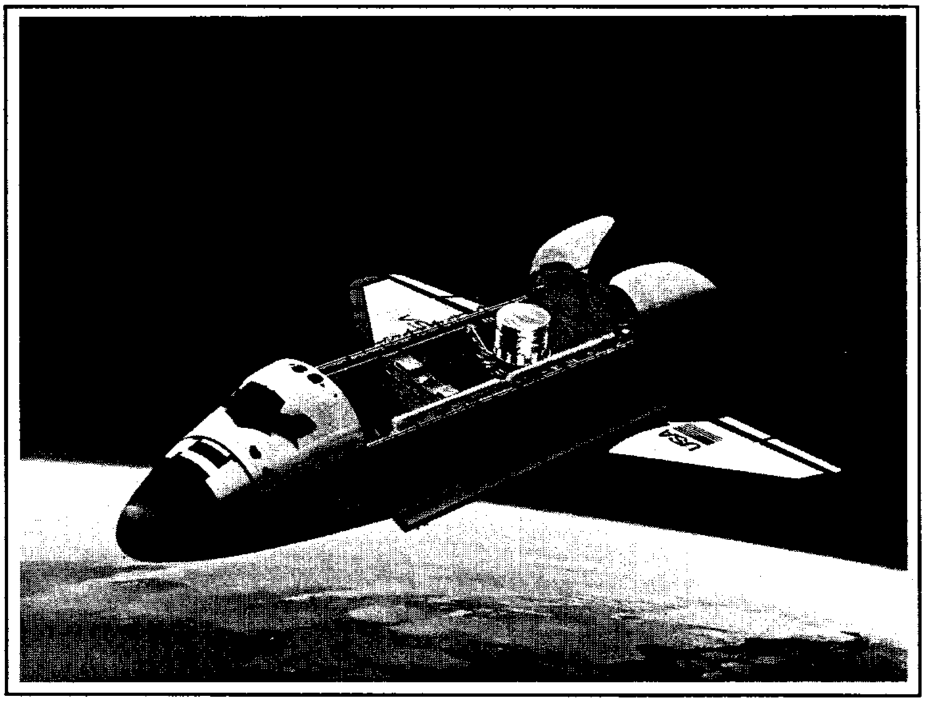
Florinef, a plasma expander, has been effective in restoring or maintaining plasma volume and orthostatic tolerances during postbedrest tests. A cardiovascular profile will be determined both pre- and postflight for the participating crew member.

EDUCATIONAL ACTIVITIES (DSO 802). The objective of this DSO is to use the attraction of spaceflight to capture the interest of students and motivate them toward careers in science, engineering, and mathematics. The Educational Activity Video for STS-49 will compare Captain Cook's voyage on the HMS sailing vessel Endeavour to the first flight of the space shuttle Endeavour.

DOCUMENTARY TELEVISION (DSO 901). This purpose of DSO 901 is to provide live television transmission or VTR dumps of crew activities, orbiter operations, payload deployment/retrieval and operations, Earth views, rendezvous and proximity operations. Telecasts are planned for communication periods with seven or more minutes of uninterrupted viewing time. The broadcast is accomplished with operational air-to-ground and/or operational intercom audio. VTR recording may be used when live television is not possible.

DOCUMENTARY MOTION PICTURE PHOTOGRAPHY (DSO 902). This DSO requires documentary and public affairs motion picture photography of the orbiter basic capabilities and key flight objectives. Documentation shall include launch, crew activities, payload deployment, landing and unscheduled activities of special interest.

DOCUMENTARY STILL PHOTOGRAPHY (DSO 903). This DSO requires still photography of crew activities, orbiter operations, payload deployment/retrieval and operations, Earth views and unscheduled items of interest.



STS-49

MISSION STATISTICS

PRELAUNCH COUNTDOWN TIMELINE

MISSION TIMELINE

May 1992

Rockwell International

Space Systems Division

Office of Media Relations

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MISSION OVERVIEW

This is the 1st flight of Endeavour and the 47th for the space shuttle.

The flight crew for the STS-49 mission is commander Daniel (Dan) C. Brandenstein; pilot Kevin P. (Chili) Chilton; and mission specialists Pierre J. Thuot, Kathryn (Kathy) C. Thornton, Richard (Rick) J. Hieb, Thomas (Tom) D. Akers, and Bruce E. Melnick.

In addition to testing and evaluating all of Endeavour's basic systems, Endeavour's seven-day maiden voyage will be highlighted by the retrieval, on-orbit repair, and reboosting of the International Telecommunications Satellite Organization (INTELSAT) VI (F-3) satellite, one of five INTELSAT commercial communications satellites that form a network designed to provide voice, video, and data services to Earth stations in 180 countries. INTELSAT VI was launched March 14, 1990, but a malfunction in its Titan booster left it stranded in an unusable low orbit.

The STS-49 INTELSAT VI mission will be the most complex satellite retrieval mission to date. Endeavour and her crew will engage in the first ever active dual rendezvous of two orbiting spacecraft and the first in-orbit attachment of a solid rocket motor. Following a complex set of maneuvers to rendezvous Endeavour and the satellite, mission specialists Thuot and Hieb will perform a space walk on flight day 4 to capture the satellite using a special capture bar. The orbiter's remote manipulator system arm will then be used to berth the satellite atop a new perigee kick motor mounted in the orbiter's payload bay. INTELSAT VI will then be released and maneuvered by INTELSAT ground controllers for reboost into geosynchronous orbit.

Another highlight of the flight will be the Assembly of Station by EVA Methods experiment, which will feature STS-49's second and record-breaking third space walks. Mission specialists Thornton and Akers (flight day 5) and Thuot and Hieb (flight day 6) will perform space walks to demonstrate and verify maintenance and assembly capabilities for Space Station Freedom. The astronauts will construct a space station truss pyramid structure, gathering data on techniques and handling aids for manipulating and berthing large items and examining the handling, transport, and assembly techniques for a truss structure and attached hardware. They will also evaluate crew self-rescue devices and techniques and RMS and manual berthing operations of a multiple-purpose experiment support structure pallet onto the space station truss, using both cameras for guidance and oral directions from space walkers.

Other secondary objectives for STS-49 include the Commercial Protein Crystal Growth experiment, Air Force Maui Optical Site, and the Ultraviolet Plume Instrument.

The primary objective of the CPCG experiment is to gather data on the methods and commercial potential for growing high-quality protein crystals in microgravity. CPCG is sponsored by NASA's Office of Commercial Programs and is managed by the Center for Macromolecular Crystallography, University of Alabama at Birmingham, a NASA-sponsored Center for the Commercial Development of Space.

The AMOS and UVPI experiments are both payloads of opportunity that will be conducted if time permits. Neither requires any on-board hardware. The primary objective of AMOS, sponsored by the U.S. Air Force Space Systems Division, is to use the orbiter during cooperative overflights of Maui, Hawaii, to obtain imagery and/or signature data to support the calibration of AMOS ground-based sensors and to observe plume phenomenology. Crew and orbiter participation may be required to establish the controlled conditions for the Maui cooperative overflight. UVPI is a Department of Defense payload located on the Low-Power Atmospheric Compensation Experiment satellite, a Strategic Defense Initiative Organization satellite in low Earth orbit. UVPI's sensors will be trained on the orbiter to obtain imagery and/or signature data to calibrate the sensors and to observe orbiter jet firings during cooperative encounters of the orbiter with the LACE satellite.

Endeavour is the fifth operational orbiter built by Rockwell International Corporation's Space Systems Division, Downey, Calif. Authority to proceed with construction of Endeavour was received on August 1, 1987, and Endeavour rolled out on schedule from SSD's orbiter assembly and modification facility in Palmdale, Calif., on April 25, 1991.

The new orbiter incorporates numerous design changes and upgrades made as part of NASA's orbiter continuous improvement program. New features include improved or redesigned avionics systems and updated mechanical systems, including the first shuttle program use of a drag chute that will be deployed after landing at Edwards Air Force Base to assist in slowing the orbiter during rollout. Endeavour is also partially outfitted for extended-duration missions of up to 28 days in length in the future.

Nineteen detailed test objectives and 13 detailed supplementary objectives are scheduled to be flown on STS-49.

MISSION STATISTICS

Vehicle: Endeavour (OV-105), 1st flight

Launch Date/Time:

5/7/92 7:06 p.m., EDT
6:06 p.m., CDT
4:06 p.m., PDT

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

Launch Window (planar): 7:06 p.m. - 7:52 p.m., EDT; 7:53 p.m. - 7:55 p.m., EDT (48 minutes total window duration)

Mission Duration: 7 days, 00 hours, 04 minutes

Landing: Nominal end-of-mission landing on orbit 111

5/14/92 7:10 p.m., EDT
6:10 p.m., CDT
4:10 p.m., PDT

Runway: Nominal end-of-mission landing on concrete runway 22, Edwards Air Force Base (EAFB), Calif. Weather alternates are Kennedy Space Center, Fla., and Northrup Strip (NOR), White Sands, New Mexico.

Transatlantic Abort Landing: Banjul, Gambia; alternates: Ben Guerir, Morocco; Rota, Spain

Return to Launch Site: KSC

Abort-Once-Around: EAFB

Inclination: 28.35 degrees

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

The OMS-1 thrusting maneuver after main engine cutoff plus approximately 2 minutes is eliminated in this direct-insertion ascent profile. The OMS-1 thrusting maneuver is replaced by a 5-foot-per-second reaction control system maneuver to facilitate the main propulsion system propellant dump.

Altitude: 183 by 95 nautical miles (211 by 109 statute miles) minimum orbit

Space Shuttle Main Engine Thrust Level During Ascent: 104 percent

Space Shuttle Main Engine Locations:

No. 1 position: Engine 2030
No. 2 position: Engine 2015
No. 3 position: Engine 2017

Editor's Note: The following weight data are current as of April 28, 1992.

Total Lift-off Weight: Approximately 4,519,418 pounds

Orbiter Weight, Including Cargo, at Lift-off: Approximately 256,597 pounds

Orbiter (Endeavour) Empty, and 3 SSMEs: Approximately 173,229 pounds

Payload Weight Up: Approximately 32,598 pounds

Payload Weight Down: Approximately 8,558 pounds

Orbiter Weight at Landing: Approximately 201,593 pounds

Payloads--Payload Bay (* denotes primary payload): INTELSAT-VI reboost mission hardware,* Assembly of Station by EVA Methods

Payloads--Middeck: Commercial Protein Crystal Growth (CPCG)

Other Mission Objectives--No Flight Hardware: Air Force Maui Optical Site (AMOS), Ultraviolet Plume Instrument (UVPI)

Flight Crew Members:

Commander: Daniel (Dan) C. Brandenstein, fourth space shuttle flight
Pilot: Kevin P. (Chili) Chilton, first space shuttle flight
Mission Specialist 1: Richard (Rick) J. Hieb, second space shuttle flight
Mission Specialist 2: Bruce E. Melnick, second space shuttle flight
Mission Specialist 3: Pierre J. Thuot, second space shuttle flight
Mission Specialist 4: Kathryn (Kathy) C. Thornton, second space shuttle flight
Mission Specialist 5: Thomas (Tom) D. Akers, second space shuttle flight

Ascent Seating:

Flight deck, front left seat, commander Daniel (Dan) C. Brandenstein
Flight deck, front right seat, pilot Kevin P. (Chili) Chilton
Flight deck, aft center seat, mission specialist Bruce E. Melnick
Flight deck, aft right seat, mission specialist Richard (Rick) J. Hieb
Middeck, mission specialist Kathryn (Kathy) C. Thornton
Middeck, mission specialist Pierre J. Thuot
Middeck, mission specialist Thomas (Tom) D. Akers

Entry Seating:

Flight deck, front left seat, commander Daniel (Dan) C. Brandenstein
Flight deck, front right seat, pilot Kevin P. (Chili) Chilton
Flight deck, aft center seat, mission specialist Bruce E. Melnick
Flight deck, aft right seat, mission specialist Thomas (Tom) D. Akers
Middeck, mission specialist Richard (Rick) J. Hieb
Middeck, mission specialist Pierre J. Thuot
Middeck, mission specialist Kathryn (Kathy) C. Thornton

Extravehicular Activity Crew Members, If Required:

Extravehicular (EV) astronaut 1: Pierre J. Thuot
EV-2: Richard (Rick) J. Hieb
EV-3: Kathryn (Kathy) C. Thornton
EV-4: Thomas (Tom) D. Akers

Intravehicular Astronauts: Daniel (Dan) C. Brandenstein, Kevin P. (Chili) Chilton, and Thomas (Tom) D. Akers

STS-49 Flight Directors:

Ascent/Entry: N. W. (Wayne) Hale
Orbit 1 (Rendezvous/EVA) Team (lead): G. A. (Al) Pennington
Orbit 2 (Deploy/EVA) Team (lead): P. L. (Phil) Engelauf
Planning Team: J. M. (Milt) Heflin

Entry: Automatic mode until subsonic, then control stick steering

Notes:

. The remote manipulator system is installed in Endeavour's payload bay for this mission

. The galley is installed in Endeavour's middeck

. Acceptable launch times will closely follow INTELSAT in-plane times. Launch can occur no earlier than 45 minutes before in-plane time or 9 minutes after in-plane time.

. The launch window duration is dictated by shuttle phasing capability and range safety constraints. The maximum window duration will be 54 minutes.

MISSION OBJECTIVES

. Primary Objective
  - INTELSAT-VI retrieval, repair, and reboost
. Secondary Objectives
  - Payload Bay
    . Assembly of Station by EVA Methods (ASEM)
  - Middeck
    . Commercial Protein Crystal Growth (CPCG)
  - Payloads of Opportunity (No Flight Hardware)
    . Air Force Maui Optical Site (AMOS)
    . Ultraviolet Plume Instrument (UVPI)
. Development Test Objectives/Detailed Supplementary Objectives

FLIGHT ACTIVITIES OVERVIEW

Flight Day 1

Launch
OMS-2
Unstow cabin
CPCG activation
Payload activation
First orbit raising burn

Flight Day 2

10.2 psi cabin depressurization
EMU checkout
RMS checkout
Second orbit raising burn

Flight Day 3

DTOs
DSOs
Orbit circularization plane corrections

Flight Day 4

INTELSAT rendezvous
EVA/PKM attachment
INTELSAT deploy

Flight Day 5

ASEM EVA 1

Flight Day 6

ASEM EVA 2

Flight Day 7

Crew press conference
RCS hot-fire test
FCS checkout
Cabin repressurization to 14.7 psi
Cabin stow
DTOs
DSOs

Flight Day 8

Payload deactivation
Deorbit preparation
Deorbit burn
Landing

Notes:

. Each flight day includes a number of scheduled housekeeping activities. These include inertial measurement unit alignment, supply water dumps (as required), waste water dumps (as required), fuel cell purge, Ku-band antenna cable repositioning, and a daily private medical conference.

STS-49 CREW ASSIGNMENTS

* Denotes primary responsibility

Commander (Daniel C. Brandenstein):

Overall mission decisions

Orbiter--caution and warning,* APU/hydraulics, communications/instrumentation,* crew equipment,* DPS,* ECLSS,* EPS, GN&C,* habitability,* MPS, OMS/RCS, training,* flight rules,* IFM

Payload--INTELSAT, AMOS

DTOs/DSOs--DTOs 249 and 648*; DSOs 613 (subject 1), 614 (subject 1), 802, 901, 902, and 903

Other--intravehicular astronaut

Pilot (Kevin P. Chilton):

Orbiter--APU/hydraulics,* caution and warning, communications/instrumentation, crew equipment, DPS, ECLSS, EPS,* GN&C, habitability, IFM, MPS,* OMS/RCS,* PDRS (ASEM), PGSC, flight rules

Payload--ASEM, AMOS

DTOs/DSOs--DTOs 249,* 651 (subject 2), and 700-2*; DSOs 613 (subject 2), 614 (subject 2), 617 (subject 1), 621 (subject 1), 802, 901, 902, and 903

Other--intravehicular astronaut*

Mission Specialist 1 (Richard J. Hieb):

Orbiter--IFM, medical,* photo/TV,* payload bay doors (mechanical--open 1), PGSC* training

Payload--EV2 (INTELSAT)

DTOs/DSOs--DTOs 648 and 700-2; DSOs 482 (subject 1), 603B (subject 1), 617 (subject 1), 621 (subject 1), 802, 901, 902, and 903

Other--Earth observations*

Mission Specialist 2 (Bruce E. Melnick):

Orbiter--IFM, PDRS (INTELSAT, ASEM), payload bay doors (mechanical--closed 2)

Payload--INTELSAT, ASEM

DTOs/DSOs--DTOs 325 and 651 (subject 1); DSOs 469 (subject 1), 614 (subject 3), 621 (subject 3), 802, 901, 902, and 903

Mission Specialist 3 (Pierre J. Thuot):

Orbiter--IFM

Payload--EV1 (INTELSAT)

DTOs/DSOs--DTO 640; DSOs 482 (subject 2), 603B (subject 2), 613 (subject 3), 617 (subject 3), 802, 901, 902, and 903

Other--intravehicular astronaut

Mission Specialist 4 (Kathryn C. Thornton):

Orbiter--IFM, medical, PDRS (INTELSAT)

Payload--INTELSAT, EV3 (ASEM)*, crew self rescue, CPCG*

DTOs/DSOs--DSOs 482 (subject 3), 604 (subject 1), 613 (subject 4), 621, 802, 901, 902, and 903

Mission Specialist 5 (Thomas D. Akers):

Orbiter--IFM, photo/TV, payload bay door (mechanical--open 2, close 1)

Payload--EV4 (ASEM), crew self rescue*, CPCG

DTOs/DSOs--DTOs 325,* 640,* and 728*; DSOs 482 (subject 4), 603B (subject 3), 613 (subject 5), 617 (subject 4), 802, 901, 902, and 903

Other--intravehicular astronaut*

DEVELOPMENT TEST OBJECTIVES/DETAILED SUPPLEMENTARY OBJECTIVES

DTOs

. Forward RCS flight test 12-second pulse (DTO 249)
. Ascent structural capability evaluation (DTO 301D)
. Ascent compartment venting evaluation (DTO 305D)
. Descent compartment venting evaluation (DTO 306D)
. Entry structural capability evaluation (DTO 307D)
. ET TPS performance--method 2 (DTO 312)
. Waste/supply water dumps (DTO 325)
. Carbon brake system test (DTO 519)
. Edwards lakebed runway bearing strength assessment (DTO 520)
. Orbiter drag chute system--test 1 (DTO 521)
. Cabin air monitoring (DTO 623)
. Hydrazine monitor (DTO 640)
. Electronic still photography test (with downlink) (DTO 648)
. EDO cycle ergometer hardware evaluation (DTO 651)
. Remote manipulator system unwanted motion evaluation (DTO 659)
. Acoustical noise dosimeter data (DTO 663)
. Laser range and range rate device (DTO 700-2)
. Ku-band antenna friction (DTO 728)
. Crosswind landing performance (DTO 805)

DSOs

. Inflight radiation dose distribution (TEPC) (DSO 469C)
. Cardiac rhythm disturbances during extravehicular activity (DSO 482)
. Orthostatic function during entry, landing, and egress (DSO 603)
. Visual-vestibular integration as a function of adaptation (OI-1) (DSO 604A)
. Postural equilibrium control during landing/egress (DSO 605)
. Changes in the endocrine regulation of orthostatic tolerance during space flight (DSO 613)
. Head and gaze stability during locomotion (DSO 614)
. Evaluation of functional skeletal muscle performance following space flight (DSO 617)
. In-flight use of florinef to improve orthostatic intolerance postflight (DSO 621)
. Educational activities (DSO 802)
. Documentary television (DSO 901)
. Documentary motion picture photography (DSO 902)
. Documentary still photography (DSO 903)

STS-49 PRELAUNCH COUNTDOWN

T - (MINUS) HR:MIN:SEC	TERMINAL COUNTDOWN EVENT
06:00:00	Verification of the launch commit criteria is complete at this time. The liquid oxygen and liquid hydrogen systems chill-down commences in order to condition the ground line and valves as well as the external tank (ET) for cryo loading. Orbiter fuel cell power plant activation is performed.
05:50:00	The space shuttle main engine (SSME) liquid hydrogen chill-down sequence is initiated by the launch processing system (LPS). The liquid hydrogen recirculation valves are opened and start the liquid hydrogen recirculation pumps. As part of the chill-down sequence, the liquid hydrogen prevalves are closed and remain closed until T minus 9.5 seconds.
05:30:00	Liquid oxygen chill-down is complete. The liquid oxygen loading begins. The liquid oxygen loading starts with a "slow fill" in order to acclimate the ET. Slow fill continues until the tank is 2-percent full.
05:15:00	The liquid oxygen and liquid hydrogen slow fill is complete and the fast fill begins. The liquid oxygen and liquid hydrogen fast fill will continue until that tank is 98-percent full.
05:00:00	The calibration of the inertial measurement units (IMUs) starts. The three IMUs are used by the orbiter navigation systems to determine the position of the orbiter in flight.
04:30:00	The orbiter fuel cell power plant activation is complete.
04:00:00	The Merritt Island (MILA) antenna, which transmits and receives communications, telemetry and ranging information, alignment verification begins.
03:45:00	The liquid hydrogen fast fill to 98 percent is complete, and a slow topping-off process is begun and stabilized to 100 percent.
03:30:00	The liquid oxygen fast fill is complete to 98 percent.

T - (MINUS) HR:MIN:SEC	TERMINAL COUNTDOWN EVENT
03:20:00	The main propulsion system (MPS) helium tanks begin filling from 2,000 psi to their full pressure of 4,500 psi.
03:15:00	Liquid hydrogen stable replenishment begins and continues until just minutes prior to T minus zero.
03:10:00	Liquid oxygen stable replenishment begins and continues until just minutes prior to T minus zero.
03:00:00	The MILA antenna alignment is completed.
03:00:00	The orbiter closeout crew goes to the launch pad and prepares the orbiter crew compartment for flight crew ingress.
03:00:00 Holding	Begin 2-hour planned hold. An inspection team examines the ET for ice or frost formation on the launch pad during this hold.
03:00:00 Counting	Two-hour planned hold ends.
02:55:00	Flight crew departs Operations and Checkout (O&C) Building for launch pad.
02:25:00	Flight crew orbiter and seat ingress occurs.
02:10:00	Post ingress software reconfiguration occurs.
02:00:00	Checking of the launch commit criteria starts at this time.
02:00:00	The ground launch sequencer (GLS) software is initialized.
01:50:00	The solid rocket boosters' (SRBs') hydraulic pumping units' gas generator heaters are turned on and the SRBs' aft skirt gaseous nitrogen purge starts.
01:50:00	The SRB rate gyro assemblies (RGAs) are turned on. The RGAs are used by the orbiter's navigation system to determine rates of motion of the SRBs during first-stage flight.
01:35:00	The orbiter accelerometer assemblies (AAs) are powered up.

T - (MINUS) HR:MIN:SEC	TERMINAL COUNTDOWN EVENT
01:35:00	The orbiter reaction control system (RCS) control drivers are powered up.
01:35:00	The flight crew starts the communications checks.
01:25:00	The SRB RGA torque test begins.
01:20:00	Orbiter side hatch is closed.
01:10:00	Orbiter side hatch seal and cabin leak checks are performed.
01:01:00	IMU preflight align begins. Flight crew functions from this point on will be initiated by a call from the orbiter test conductor (OTC) to proceed. The flight crew will report back to the OTC after completion.
01:00:00	The orbiter RGAs and AAs are tested.
00:50:00	The flight crew starts the orbiter hydraulic auxiliary power units' (APUs') water boilers preactivation.
00:45:00	Cabin vent redundancy check is performed.
00:45:00	The GLS mainline activation is performed.
00:40:00	The eastern test range (ETR) shuttle range safety system (SRSS) terminal count closed-loop test is accomplished.
00:40:00	Cabin leak check is completed.
00:32:00	The backup flight control system (BFS) computer is configured.
00:30:00	The gaseous nitrogen system for the orbital maneuvering system (OMS) engines is pressurized for launch. Crew compartment vent valves are opened.
00:26:00	The ground pyro initiator controllers (PICs) are powered up. They are used to fire the SRB hold-down posts, liquid oxygen and liquid hydrogen tail service mast (TSM), and ET vent arm system pyros at lift-off and the SSME hydrogen gas burn system prior to SSME ignition.
00:25:00	Simultaneous air-to-ground voice communications are checked. Weather aircraft are launched.

T - (MINUS) HR:MIN:SEC	TERMINAL COUNTDOWN EVENT
00:22:00	The primary avionics software system (PASS) is transferred to the BFS computer in order for both systems to have the same data. In case of a PASS computer system failure, the BFS computer will take over control of the shuttle vehicle during flight.
00:21:00	The crew compartment cabin vent valves are closed.
00:20:00	A 10-minute planned hold starts.
Hold 10 Minutes	All computer programs in the firing room are verified to ensure that the proper programs are available for the final countdown. The test team is briefed on the recycle options in case of an unplanned hold.
	The landing convoy status is again verified and the landing sites are verified ready for launch.
	The IMU preflight alignment is verified complete.
	Preparations are made to transition the orbiter onboard computers to Major Mode (MM)-101 upon coming out of the hold. This configures the computer memory to a terminal countdown configuration.
00:20:00	The 10-minute hold ends.
Counting	Transition to MM-101. The PASS onboard computers are dumped and compared to verify the proper onboard computer configuration for launch.
00:19:00	The flight crew configures the backup computer to MM-101 and the test team verifies the BFS computer is tracking the PASS computer systems. The flight crew members configure their instruments for launch.
00:18:00	The Mission Control Center-Houston (MCC-H) now loads the onboard computers with the proper guidance parameters based on the prestated lift-off time.
00:16:00	The MPS helium system is reconfigured by the flight crew for launch.
00:15:00	The OMS/RCS crossfeed valves are configured for launch.
	All test support team members verify they are "go for launch."

T - (MINUS) HR:MIN:SEC	TERMINAL COUNTDOWN EVENT
00:12:00	Emergency aircraft and personnel are verified on station.
00:10:00	All orbiter aerosurfaces and actuators are verified to be in the proper configuration for hydraulic pressure application. The NASA test director gets a "go for launch" verification from the launch team.
00:09:00	A planned 10-minute hold starts.
Hold 10 Minutes	NASA and contractor project managers will be formally polled by the deputy director of NASA, Space Shuttle Operations, on the Space Shuttle Program Office communications loop during the T minus 9-minute hold. A positive "go for launch" statement will be required from each NASA and contractor project element prior to resuming the launch countdown. The loop will be recorded and maintained in the launch decision records. All test support team members verify that they are "go for launch." Final GLS configuration is complete.
00:09:00 Counting	The GLS auto sequence starts and the terminal countdown begins. From this point, the GLSs in the integration and backup consoles are the primary control until T-0 in conjunction with the onboard orbiter PASS redundant-set computers.
00:09:00	Operations recorders are on. MCC-H, Johnson Space Center, sends a command to turn these recorders on. They record shuttle system performance during ascent and are dumped to the ground once orbit is achieved.
00:08:00	Payload and stored prelaunch commands proceed.
00:07:30	The orbiter access arm (OAA) connecting the access tower and the orbiter side hatch is retracted. If an emergency arises requiring flight crew activation, the arm can be extended either manually or by GLS computer control in approximately 30 seconds or less.
00:06:00	APU prestart occurs.

T - (MINUS) HR:MIN:SEC	TERMINAL COUNTDOWN EVENT
00:05:00	Orbiter APUs start. The orbiter APUs provide pressure to the three orbiter hydraulic systems. These systems are used to move the SSME engine nozzles and aerosurfaces.
00:05:00	ET/SRB range safety system (RSS) is armed. At this point, the firing circuit for SRB ignition and destruct devices is mechanically enabled by a motor-driven switch called a safe and arm device (S&A).
00:04:30	As a preparation for engine start, the SSME main fuel valve heaters are turned off.
00:04:00	The final helium purge sequence, purge sequence 4, on the SSMEs is started in preparation for engine start.
00:03:55	At this point, all of the elevons, body flap, speed brake, and rudder are moved through a preprogrammed pattern. This is to ensure that they will be ready for use in flight.
00:03:30	Transfer to internal power is done. Up to this point, power to the space vehicle has been shared between ground power supplies and the onboard fuel cells. The ground power is disconnected and the vehicle goes on internal power at this time. It will remain on internal power through the rest of the mission.
00:03:25	The SSMEs' nozzles are moved (gimbaled) through a preprogrammed pattern to ensure that they will be ready for ascent flight control. At completion of the gimbal profile, the SSMEs' nozzles are in the start position.
00:02:55	ET liquid oxygen prepressurization is started. At this point, the liquid oxygen tank vent valve is closed and the ET liquid oxygen tank is pressurized to its flight pressure of 21 psi.
00:02:50	The gaseous oxygen arm is retracted. The cap that fits over the ET nose cone to prevent ice buildup on the oxygen vents is raised off the nose cone and retracted.
00:02:35	Up until this time, the fuel cell oxygen and hydrogen supplies have been adding to the onboard tanks so that a full load at lift-off is assured. This filling operation is terminated at this time.

T - (MINUS) HR:MIN:SEC	TERMINAL COUNTDOWN EVENT
00:02:30	The caution/warning memory is cleared.
00:01:57	Since the ET liquid hydrogen tank was filled, some of the liquid hydrogen has turned into gas. In order to keep pressure in the ET liquid hydrogen tank low, this gas was vented off and piped out to a flare stack and burned. In order to maintain flight level, liquid hydrogen was continuously added to the tank to replace the vented hydrogen. This operation terminates, the liquid hydrogen tank vent valve is closed, and the tank is brought up to a flight pressure of 44 psia at this time.
00:01:15	The sound suppression system will dump water onto the mobile launcher platform (MLP) at ignition in order to dampen vibration and noise in the space shuttle. The firing system for this dump, the sound suppression water power bus, is armed at this time.
00:01:00	The SRB joint heaters are deactivated.
00:00:55	The SRB MDM critical commands are verified.
00:00:47	The liquid oxygen and liquid hydrogen outboard fill and drain valves are closed.
00:00:40	The external tank bipod heaters are turned off.
00:00:38	The onboard computers position the orbiter vent doors to allow payload bay venting upon lift-off and ascent in the payload bay at SSME ignition. The SRB forward MDM is locked out.
00:00:37	The gaseous oxygen ET arm retract is confirmed.
00:00:31	The GLS sends "go for redundant set launch sequence start." At this point, the four PASS computers take over main control of the terminal count. Only one further command is needed from the ground, "go for main engine start," at approximately T minus 9.7 seconds. The GLS in the integration console in the launch control center still continues to monitor several hundred launch commit criteria and can issue a cutoff if a discrepancy is observed. The GLS also sequences ground equipment and sends selected vehicle commands in the last 31 seconds.

T - (MINUS) HR:MIN:SEC	TERMINAL COUNTDOWN EVENT
00:00:28	Two hydraulic power units in each SRB are started by the GLS. These provide hydraulic power for SRB nozzle gimbaling for ascent first-stage flight control. The orbiter vent door sequence starts.
00:00:21	The SRB gimbal profile is complete. As soon as SRB hydraulic power is applied, the SRB engine nozzles are commanded through a preprogrammed pattern to assure that they will be ready for ascent flight control during first stage.
00:00:21	The liquid hydrogen high-point bleed valve is closed. The SRB gimbal test begins.
00:00:18	The onboard computers arm the explosive devices, the pyrotechnic initiator controllers, that will separate the T-0 umbilicals, the SRB hold-down posts, and SRB ignition, which is the final electrical connection between the ground and the shuttle vehicle.
00:00:16	The sound suppression system water is activated.
00:00:15	If the SRB pyro initiator controller (PIC) voltage in the redundant-set launch sequencer (RSLS) is not within limits in 3 seconds, SSME start commands are not issued and the onboard computers proceed to a countdown hold.
00:00:13	The aft SRB MDM units are locked out. This is to protect against electrical interference during flight. The electronic lock requires an unlock command before it will accept any other command. SRB SRSS inhibits are removed. The SRB destruct system is now live.
00:00:12	The MPS helium fill is terminated. The MPS helium system flows to the pneumatic control system at each SSME inlet to control various essential functions.
00:00:10	LPS issues a "go" for SSME start. This is the last required ground command. The ground computers inform the orbiter onboard computers that they have a "go" for SSME start. The GLS retains hold capability until just prior to SRB ignition.

T - (MINUS) HR:MIN:SEC	TERMINAL COUNTDOWN EVENT
00:00:09.7	Liquid hydrogen recirculation pumps are turned off. The recirculation pumps provide for flow of fuel through the SSMEs during the terminal count. These are supplied by ground power and are powered in preparation for SSME start.
00:00:09.7	In preparation for SSME ignition, flares are ignited under the SSMEs. This burns away any free gaseous hydrogen that may have collected under the SSMEs during prestart operations. The orbiter goes on internal cooling at this time; the ground coolant units remain powered on until lift-off as a contingency for an aborted launch. The orbiter will redistribute heat within the orbiter until approximately 125 seconds after lift-off, when the orbiter flash evaporators will be turned on.
00:00:09.5	The SSME engine chill-down sequence is complete and the onboard computers command the three MPS liquid hydrogen prevalves to open. (The MPSs three liquid oxygen prevalves were opened during ET tank loading to permit engine chill-down.) These valves allow liquid hydrogen and oxygen flow to the SSME turbopumps.
00:00:09.5	Command decoders are powered off. The command decoders are units that allow ground control of some onboard components. These units are not needed during flight.
00:00:06.6	The main fuel and oxidizer valves in each engine are commanded open by the onboard computers, permitting fuel and oxidizer flow into each SSME for SSME start. All three SSMEs are started at 120-millisecond intervals (SSME 3, 2, then 1) and throttle up to 100-percent thrust levels in 3 seconds under control of the SSME controller on each SSME.
00:00:04.6	All three SSMEs are verified to be at 100-percent thrust and the SSMEs are gimbaled to the lift-off position. If one or more of the three SSMEs does not reach 100-percent thrust at this time, all SSMEs are shut down, the SRBs are not ignited, and an RSLS pad abort occurs. The GLS RSLS will perform shuttle and ground systems safing. Vehicle bending loads caused by SSME thrust buildup are allowed to initialize before SRB ignition. The vehicle moves towards ET including ET approximately 25.5 inches.

T - (MINUS) HR:MIN:SEC	TERMINAL COUNTDOWN EVENT
00:00:00	The two SRBs are ignited under command of the four onboard PASS computers, the four hold-down explosive bolts on each SRB are initiated (each bolt is 28 inches long and 3.5 inches in diameter), and the two T-0 umbilicals on each side of the spacecraft are retracted. The onboard timers are started and the ground launch sequence is terminated. All three SSMEs are at 104-percent thrust. Boost guidance in attitude hold.
00:00	Lift-off.

STS-49 MISSION HIGHLIGHTS TIMELINE

Editor's Note: The following timeline lists selected highlights only. For full detail, please refer to the NASA Mission Operations Directorate STS-49 Flight Plan, Ascent Checklist, Post Insertion Checklist, Rendezvous Checklist, Payload Operations Checklist, PDRS Operations Checklist, EVA Checklist, Deorbit Prep Checklist, and Entry Checklist.

T+ (PLUS) DAY/ HR:MIN:SEC	EVENT
DAY ZERO	
0/00:00:07	Tower is cleared (SRBs above lightning-rod tower).
0/00:00:10	180-degree positive roll maneuver (right-clockwise) is started. Pitch profile is heads down (astronauts), wings level.
0/00:00:18	Roll maneuver ends.
0/00:00:29	All three SSMEs throttle down from 104 to 71 percent for maximum aerodynamic load (max q).
0/00:00:55	All three SSMEs throttle to 104 percent.
0/00:01:04	Max q occurs.
0/00:02:06	SRBs separate.
	When chamber pressure (Pc) of the SRBs is less than 50 psi, automatic separation occurs with manual flight crew backup switch to the automatic function (does not bypass automatic circuitry). SRBs descend to approximately 15,400 feet, when the nose cap is jettisoned and drogue chute is deployed for initial deceleration.

T+ (PLUS) DAY/ HR:MIN:SEC	EVENT
	At approximately 6,600 feet, drogue chute is released and three main parachutes on each SRB provide final deceleration prior to splashdown in Atlantic Ocean, where the SRBs are recovered for reuse on another mission. Flight control system switches from SRB to orbiter RGAs.
0/00:03:58	Negative return. The vehicle is no longer capable of return-to-launch site abort at Kennedy Space Center runway.
0/00:06:52	Single engine press to main engine cutoff (MECO).
0/00:08:26	All three SSMEs throttle down to 67 percent for MECO.
0/00:08:31	MECO occurs at approximate velocity 25,906 feet per second, 32 by 180 nautical miles (37 by 207 statute miles).
0/00:08:49	ET separation is automatic with flight crew manual backup switch to the automatic function (does not bypass automatic circuitry).
	The orbiter forward and aft RCSs, which provide attitude hold and negative Z translation of 11 fps to the orbiter for ET separation, are first used.
	Orbiter/ET liquid oxygen/liquid hydrogen umbilicals are retracted.
	Negative Z translation is complete.

T+ (PLUS) DAY/ HR:MIN:SEC	EVENT
	In conjunction with this thrusting period, approximately 1,700 pounds of liquid hydrogen and 3,700 pounds of liquid oxygen are trapped in the MPS ducts and SSMEs, which results in an approximate 7-inch center-of-gravity shift in the orbiter. The trapped propellants would sporadically vent in orbit, affecting guidance and creating contaminants for the payloads. During entry, liquid hydrogen could combine with atmospheric oxygen to form a potentially explosive mixture. As a result, the liquid oxygen is dumped out through the SSME combustion chamber nozzles, and the liquid hydrogen is dumped out through the right-hand T-minus-zero umbilical overboard fill and drain valves.
	MPS dump terminates.
	APUs shut down.
	MPS vacuum inerting occurs.
	--Remaining residual propellants are vented to space vacuum, inerting the MPS.
	--Orbiter/ET umbilical doors close (one door for liquid hydrogen and one door for liquid oxygen) at bottom of aft fuselage, sealing the aft fuselage for entry heat loads.
	--MPS vacuum inerting terminates.
0/00:40	OMS-2 thrusting maneuver is performed, approximately 2 minutes, 15 seconds in duration, at 220 fps, 156 by 183 nautical miles.
0/00:51	Commander closes all current breakers, panel L4.
0/00:53	Mission specialist (MS)/payload specialist (PS) seat egress.
0/00:54	Commander and pilot configure GPCs for OPS-2.
0/00:57	MS configures preliminary middeck.

T+ (PLUS) DAY/ HR:MIN:SEC	EVENT
0/00:59	MS configures aft flight station.
0/01:02	MS unstows, sets up, and activates PGSC.
0/01:06	Pilot activates payload bus (panel R1).
0/01:08	Commander and pilot don and configure communications.
0/01:12	Pilot maneuvers vehicle to payload bay door opening attitude, biased negative Z local vertical, negative Y velocity vector attitude.
0/01:15	Orbit 2 begins.
0/01:17	Commander activates radiators.
0/01:19	If go for payload bay door operations, MS configures for payload bay door operations.
0/01:28	Pilot opens payload bay doors, manual/fit test procedures.
0/01:33	Commander switches star tracker (ST) power 2 (panel 06) to ON.
0/01:36	Mission Control Center (MCC), Houston (H), informs crew to "go for orbit operations."
0/01:37	MS activates payload powering switching unit heater.
0/01:37	Commander and pilot seat egress.
0/01:38	Commander and pilot clothing configuration.
0/01:39	MS/PS clothing configuration.
0/01:50	Pilot initiates fuel cell auto purge.
0/01:51	MS activates teleprinter (if flown).

T+ (PLUS) DAY/ HR:MIN:SEC	EVENT
0/01:52	Commander begins post-payload bay door operations and radiator configuration.
0/01:55	MS/PS remove and stow seats.
0/01:56	Commander starts ST self-test and opens door.
0/01:57	MS configures middeck.
0/01:58	Pilot closes main B supply water dump isolation circuit breaker, panel ML86B, opens supply water dump isolation valve, panel R12L.
0/02:01	Pilot activates auxiliary power unit steam vent heater, panel R2, boiler controller/heater, 3 to A, power, 3 to ON.
0/02:10	Commander configures vernier drivers.
0/02:10	CPCG activation.
0/02:12	Commander, pilot configure controls for on-orbit operations.
0/02:20	MS performs on-orbit initialization.
0/02:21	Pilot enables hydraulic thermal conditioning.
0/02:24	MS resets caution/warning (C/W).
0/02:28	Pilot plots fuel cell performance.
0/02:30	Maneuver vehicle to IMU alignment attitude.
0/02:35	Unstow cabin.
0/02:45	IMU alignment: ST.
0/02:46	Orbit 3 begins.
0/02:50	Maneuver vehicle to -ZLV, -YVV attitude.

T+ (PLUS) DAY/ HR:MIN:SEC	EVENT
0/03:05	Deploy Ku-band antenna.
0/03:05	Set up quickdon mask.
0/03:15	Activate Ku-band antenna.
0/03:25	Aft controller checkout.
0/03:35	Snack.
0/04:05	Deactivate APU heater.
0/04:16	Orbit 4 begins.
0/04:25	Cryogenic oxygen sensor check.
0/04:25	DTO 623--cabin air monitoring.
0/04:30	Crew begins presleep activities.
0/04:50	OMS burn.
0/05:13	NC1 corrective burn at 8 fps, 156 by 183 nautical miles.
0/05:20	CPCG activation.
0/05:30	Maneuver vehicle to IMU alignment attitude.
0/05:45	IMU alignment: ST.
0/05:47	Orbit 5 begins.
0/05:50	Maneuver vehicle to -ZLV, +YVV attitude.
0/06:05	APU heater reconfiguration A.
0/06:15	Private medical conference.
0/07:17	Orbit 6 begins.

T+ (PLUS) DAY/ HR:MIN:SEC	EVENT
0/07:30	Crew begins sleep period.
0/08:47	Orbit 7 begins.
0/10:17	Orbit 8 begins.
0/11:48	Orbit 9 begins.
0/13:18	Orbit 10 begins.
0/14:48	Orbit 11 begins.
0/15:30	Crew begins postsleep activities.
0/16:19	Orbit 12 begins.
0/16:40	Initiate supply water dump.
0/17:20	Terminate supply water dump.
0/17:35	Maneuver vehicle to IMU alignment attitude.
0/17:40	EVA aspirin protocol.
0/17:49	Orbit 13 begins.
0/17:50	IMU alignment: ST.
0/17:55	Maneuver vehicle to COAS calibration attitude.
0/18:10	COAS calibration--forward station.
0/18:15	Maneuver vehicle to -ZLV, -YVV attitude.
0/18:30	Electronic still camera PDU assembly.
0/19:00	DSO 469C--radiation dose distribution.
0/19:05	Open payload retention latch assemblies.

T+ (PLUS) DAY/ HR:MIN:SEC	EVENT
0/19:20	Orbit 14 begins.
0/19:35	Preparation for 10.2 psi cabin depressurization.
0/19:45	10.2 psi cabin depressurization.
0/20:20	RMS heater activation/manipulator controller interface unit filter check.
0/20:20	10.2 psi cabin configuration.
0/20:25	DTO 648--electronic still camera.
0/20:30	DSO 604A--visual vestibular integration (OI-1).
0/20:40	OMS burn.
0/20:50	Orbit 15 begins.
0/21:08	NH-1 height adjustment burn, 12.5 fps, 156 by 190 nautical miles.
0/21:10	Maneuver vehicle to biased -ZLV, -YVV attitude.
0/21:10	DTO 648--electronic still camera.
0/21:15	P/TV05 setup, middeck.
0/21:30	RMS powerup.
0/21:45	RMS checkout.
0/21:45	P/TV05 activities, middeck.
0/21:55	DTO 640--hydrazine monitor baseline warmup equipment preparation.
0/22:15	DTO 700-2--laser range finder checkout.
0/22:20	Orbit 16 begins.

T+ (PLUS) DAY/ HR:MIN:SEC	EVENT
0/22:30	RMS payload bay survey.
0/22:35	Filter cleaning.
0/22:35	P/TV11 activation--RMS payload bay.
0/22:55	Standard switch panel checkout.
0/23:00	RMS powerdown.
0/23:15	DTO 651--fluid load (pilot, MS2).
0/23:15	Laser stow (DTO 700-2).
0/23:30	Meal.
0/23:51	Orbit 17 begins.

MET DAY ONE

1/00:30	DTO 640--hydrazine monitor (baseline data take).
1/00:30	P/TV05 activation, middeck.
1/00:30	EMU checkout (four EMUs).
1/01:00	P/TV02 setup, flight deck.
1/01:20	DTO 651--fluid load (pilot, MS2).
1/01:22	Orbit 18 begins.
1/01:30	P/TV02/05 activation, flight deck and middeck.
1/01:40	DTO 651--ergometer.
1/02:52	Orbit 19 begins.
1/03:25	DTO 648--electronic still camera.

T+ (PLUS) DAY/ HR:MIN:SEC	EVENT
1/04:10	IMU alignment: ST.
1/04:20	DTO 651--fluid load (pilot, MS2).
1/04:22	Orbit 20 begins.
1/04:25	DTO 623--cabin air monitoring.
1/04:30	Crew begins presleep activities.
1/04:35	10.2 psi maintenance.
1/05:00	RCS burn.
1/05:25	NC2 phasing burn, 4 fps, 143 by 190 nautical miles.
1/05:30	Maneuver vehicle to -ZLV, -YVV attitude.
1/05:53	Orbit 21 begins.
1/05:55	Private medical conference.
1/07:24	Orbit 22 begins.
1/07:30	Crew begins sleep period.
1/08:54	Orbit 23 begins.
1/10:25	Orbit 24 begins.
1/11:55	Orbit 25 begins.
1/13:26	Orbit 26 begins.
1/14:56	Orbit 27 begins.
1/15:30	Crew begins postsleep activities.
1/16:15	Maneuver vehicle to IMU/COAS calibration attitude.

T+ (PLUS) DAY/ HR:MIN:SEC	EVENT
1/16:27	Orbit 28 begins.
1/16:30	IMU alignment: ST.
1/16:35	COAS calibration--aft station.
1/16:40	Maneuver vehicle to -ZLV, -YVV attitude.
1/17:20	RMS heater activation/manipulator controller interface unit filter check.
1/17:58	Orbit 29 begins.
1/18:00	P/TV03 setup.
1/18:20	10.2 psi maintenance.
1/18:30	RMS powerup.
1/18:35	P/TV03 activation--DTO 325.
1/18:45	DTO 325--waste and supply water dump.
1/19:28	Orbit 30 begins.
1/20:00	RMS powerdown.
1/20:05	OMS burn.
1/20:38	Circularization burn, 55 fps, 190 by 190 nautical miles.
1/20:45	P/TV10 setup.
1/20:58	Orbit 31 begins.
1/21:00	P/TV10, DSO 802--educational activities.
1/21:05	OMS burn.

T+ (PLUS) DAY/ HR:MIN:SEC	EVENT
1/21:30	NPC phasing correction burn, 3.6 fps, 190 by 190 nautical miles.
1/21:35	Maneuver vehicle to biased -ZLV, -YVV attitude.
1/22:00	INTELSAT control box start time.
1/22:30	Orbit 32 begins.
1/22:30	DTO 651--fluid load (pilot, MS2).
1/23:00	Meal.

MET DAY TWO

2/00:00	P/TV05 setup, middeck.
2/00:00	DTO 651--fluid load (pilot, MS2).
2/00:02	Orbit 33 begins.
2/00:30	DTO 651--ergometer.
2/00:40	RCS burn.
2/00:40	P/TV05 activation, middeck.
2/01:00	P/TV10, DSO 802--educational activities.
2/01:04	NSR coeliptic burn, 0.0 fps, 189 by 190 nautical miles.
2/01:10	Maneuver vehicle to biased -ZLV, -YVV attitude.
2/01:33	Orbit 34 begins.
2/01:40	DTO 648--electronic still camera.
2/02:20	DTO 648--electronic still camera.
2/02:30	INTELSAT EVA review.

T+ (PLUS) DAY/ HR:MIN:SEC	EVENT
2/03:00	IMU alignment: ST.
2/03:00	DTO 651--fluid load (pilot, MS2).
2/03:05	Orbit 35 begins.
2/03:15	DTO 623--cabin air monitoring.
2/03:25	OMS burn.
2/03:30	Crew begins presleep activities.
2/04:00	Maneuver vehicle to biased -ZLV, -YVV attitude.
2/04:20	10.2 psi maintenance.
2/04:30	Private medical conference.
2/04:33	NC-3 burn, 4.7 fps, 187 by 190 nautical miles.
2/04:36	Orbit 36 begins.
2/05:30	Start first INTELSAT spindown (30 rpm to 7.5 rpm).
2/06:07	Orbit 37 begins.
2/06:30	Crew begins sleep period.
2/07:38	Orbit 38 begins.
2/09:10	Orbit 39 begins.
2/10:00	Second INTELSAT spindown (7.5 rpm to 5 rpm).
2/10:42	Orbit 40 begins.
2/12:12	Orbit 41 begins.
2/13:43	Orbit 42 begins.

T+ (PLUS) DAY/ HR:MIN:SEC	EVENT
2/14:30	Crew begins postsleep activities.
2/15:15	Orbit 43 begins.
2/15:15	Maneuver vehicle to IMU alignment attitude.
2/16:00	10.2 psi maintenance.
2/16:10	Manipulator controller interface unit filter.
2/16:25	INTELSAT rendezvous operations.
2/16:47	Orbit 44 begins.
2/17:30	P/TV04 setup, INTELSAT.
2/17:31	NH-2 height adjustment burn, 12.1 fps, 187 by 197 nautical miles.
2/18:10	Safing of INTELSAT for rendezvous.
2/18:17	NC-4 correction burn, 10.5 fps, 193 by 197 nautical miles.
2/18:18	Orbit 45 begins.
2/19:15	EVA preparation.
2/19:15	EVA support.
2/19:15	P/TV04 activation, INTELSAT.
2/19:40	NCC corrective combination maneuver.
2/19:45	RMS heater activation/manipulator controller interface unit filter check.
2/19:50	Orbit 46 begins.
2/20:30	INTELSAT safed.

T+ (PLUS) DAY/ HR:MIN:SEC	EVENT
2/20:40	Start 40-minute in-suit prebreathe.
2/20:45	RMS powerup.
2/21:00	EVA support.
2/21:20	TI terminal ignition burn, 3.5 fps, 195 by 197 nautical miles.
2/21:22	Orbit 47 begins.
2/21:30	Airlock depressurization.
2/21:45	INTELSAT EVA begins.
2/21:55	Payload bay setup.
2/22:10	Portable foot restraint attachment device installation/capture bar preparation.
2/22:20	V-bar maneuver.
2/22:20	Ingress portable foot restraint.
2/22:25	Capture bar checkout/prebreathing preparation.
2/22:30	Position RMS for proximity operations.
2/22:40	Wait for stationkeeping.
2/22:53	Orbit 48 begins.
2/22:55	Position RMS for capture bar installation.
2/23:00	Deploy capture bar attachment.
2/23:20	INTELSAT grapple.
2/23:30	Maneuver vehicle to -ZLV, -YVV attitude.

T+ (PLUS) DAY/ HR:MIN:SEC	EVENT
2/23:45	Position RMS for portable foot restraint attachment device egress.

MET DAY THREE

3/00:05	Portable foot restraint attachment device egress.
3/00:10	RMS berthing preparation.
3/00:20	INTELSAT berthing preparation.
3/00:25	Orbit 49 begins.
3/00:30	Position RMS for thermal cover removal.
3/00:50	Thermal cover removal.
3/00:50	Maneuver vehicle to -ZLV, -XVV attitude.
3/01:00	INTELSAT berthing.
3/01:20	Spacecraft mating.
3/01:30	RMS ungrapple.
3/01:35	Maneuver vehicle to -ZLV, +YVV attitude.
3/01:50	Post mating reconfiguration/predeploy checklist/stage and boost activation.
3/01:55	RMS powerdown.
3/01:56	Orbit 50 begins.
3/02:25	Maneuver vehicle to INTELSAT deploy attitude.
3/02:35	DTO 640--hydrazine monitor (EVA warmup).
3/02:40	Return to airlock/give go for deploy.

T+ (PLUS) DAY/ HR:MIN:SEC	EVENT
3/02:45	Deployment of INTELSAT VI from payload bay.
3/02:50	Return to worksite.
3/02:55	Payload bay cleanup and stowage.
3/03:15	Airlock ingress.
3/03:15	Safe INTELSAT VI/orbiter separation distance achieved.
3/03:25	Airlock repressurization.
3/03:25	DTO 640--middeck data take.
3/03:28	Orbit 51 begins.
3/03:35	Tracking maneuver.
3/03:40	Post EVA activities.
3/03:40	DTO 640--airlock data take.
3/03:48	RCS separation 1 burn, 2.0 fps, 196 by 197 nautical miles.
3/04:10	DTO 623--cabin air monitoring.
3/04:11	RCS separation 2 burn, 18.0 fps, 196 by 207 nautical miles.
3/04:20	Flash evaporator system A on.
3/04:20	EMU maintenance.
3/04:20	Laser stow.
3/04:25	DSO 482--cardiac rhythm (EV1, EV2).
3/04:30	10.2 psi maintenance.
3/04:30	Crew begins presleep activities.

T+ (PLUS) DAY/ HR:MIN:SEC	EVENT
3/04:50	Maneuver vehicle to IMU alignment attitude.
3/05:00	Orbit 52 begins.
3/05:05	IMU alignment: ST.
3/05:10	Window protection maneuver.
3/05:35	Private medical conference.
3/06:32	Orbit 53 begins.
3/07:30	Crew begins sleep period.
3/08:04	Orbit 54 begins.
3/09:35	Orbit 55 begins.
3/11:08	Orbit 56 begins.
3/12:39	Orbit 57 begins.
3/14:12	Orbit 58 begins.
3/15:30	Crew begins post sleep activities.
3/15:43	Orbit 59 begins.
3/17:00	Maneuver vehicle to IMU alignment attitude.
3/17:15	Orbit 60 begins.
3/17:15	IMU alignment: ST.
3/17:20	Maneuver vehicle to biased -ZLV, -YVV attitude.
3/17:30	ASEM EVA review.
3/17:35	Initiate supply water dump.

T+ (PLUS) DAY/ HR:MIN:SEC	EVENT
3/17:45	Fuel cell purge--manual.
3/17:55	10.2 psi maintenance.
3/18:10	Humidity separator configuration A.
3/18:30	EMU reconfiguration.
3/18:30	P/TV07 setup, ASEM.
3/18:35	Terminate supply water dump.
3/18:45	EVA aspirin protocol.
3/18:45	ASEM maneuver, -XLV, +ZVV attitude.
3/18:47	Orbit 61 begins.
3/18:50	EVA preparation.
3/18:50	P/TV07 activation, ASEM.
3/19:15	RCS regulator.
3/19:40	RMS heater activation/manipulator controller interface unit filter check.
3/19:50	Heater reconfiguration.
3/20:10	ECLSS checkout.
3/20:18	Orbit 62 begins.
3/20:20	Cabin temperature control reconfiguration.
3/20:25	Start 40-minute in-suit prebreathe.
3/20:35	Middeck battery recharge.
3/20:40	RMS powerup.

T+ (PLUS) DAY/ HR:MIN:SEC	EVENT
3/20:55	ASEM assembly viewing.
3/21:05	Airlock depressurization.
3/21:20	ASEM EVA (EVA 2).
3/21:30	Payload bay setup.
3/21:45	Bottom plane installation.
3/21:50	Orbit 63 begins.
3/22:05	Vertical/diagonal installation.
3/22:15	Final/diagonal installation.
3/22:28	Maneuver to MPESS grasp position.
3/22:35	Portable foot restraint attachment device/wheel installation on RMS.
3/22:45	Portable foot restraint attachment device ingress.
3/22:47	Active keel assembly/payload retention latch assembly release.
3/22:50	MPESS removal.
3/22:57	Maneuver to MPESS handling position.
3/23:07	MPESS handling evaluation.
3/23:12	Return to MPESS grasp position.
3/23:22	Orbit 64 begins.
3/23:24	MPESS installation.
3/23:30	Active keel assembly/payload retention latch assembly latch.

T+ (PLUS) DAY/ HR:MIN:SEC	EVENT
3/23:34	Portable foot restraint attachment device egress.
3/23:34	CPD setup.
3/23:39	CPD evaluation.
3/23:50	MPESS unberth operations.
3/23:59	Maneuver to MPESS access position.

MET DAY FOUR

4/00:11	Port legs installation.
4/00:21	Starboard legs installation.
4/00:31	Portable foot restraint setup.
4/00:35	Return from MPESS access position.
4/00:41	Maneuver to pre-attach position.
4/00:46	Position for mating.
4/00:54	Orbit 65 begins.
4/00:58	Pallet installation No. 1.
4/01:06	Pallet disconnect from MPESS.
4/01:08	Return to pre-attach position.
4/01:12	Position for mating.
4/01:23	Pallet installation No. 2.
4/01:31	Pallet disconnect from MPESS.
4/01:33	Raise MPESS for EVA mount.

T+ (PLUS) DAY/ HR:MIN:SEC	EVENT
4/01:35	Interim stow.
4/01:45	Mount RMS.
4/01:50	Return to pre-attach position.
4/01:54	Return to hover position.
4/02:00	Maneuver to Space Station Freedom position 1.
4/02:06	Assembly area No. 1.
4/02:16	Maneuver to Space Station Freedom position No. 2.
4/02:20	Assembly area No. 2.
4/02:26	Orbit 66 begins.
4/02:30	Return from Space Station Freedom position.
4/02:40	Maneuver to MPESS access position.
4/02:45	Dismount RMS.
4/02:49	Return from MPESS access position.
4/02:53	EMU TV berthing.
4/02:53	Bipole, inflatable pole evaluation.
4/02:55	DTO 640--hydrazine monitor (EVA warmup).
4/03:08	Payload bay cleanup.
4/03:23	Airlock engress.
4/03:33	Airlock repressurization.
4/03:40	DTO 640--hydrazine monitor (middeck data take).

T+ (PLUS) DAY/ HR:MIN:SEC	EVENT
4/03:55	RMS powerdown.
4/03:55	Post EVA activities.
4/03:55	DTO 640--hydrazine monitor (airlock data take).
4/03:58	Orbit 67 begins.
4/04:15	TDRS/IMU maneuver.
4/04:20	Middeck battery recharge.
4/04:30	VTR setup 07, ASEM.
4/04:35	EMU maintenance.
4/04:45	VTR playback, ASEM.
4/04:50	EMU reconfiguration.
4/05:10	Middeck battery recharge.
4/05:10	EMU maintenance recharge.
4/05:30	Orbit 68 begins.
4/05:30	IMU alignment: ST.
4/05:40	DTO 623--cabin air monitoring.
4/05:45	Humidity separator configuration B.
4/05:50	Crew begins presleep activities.
4/06:00	DSO 482--cardiac rhythm (EV3, EV4).
4/06:10	Maneuver vehicle to -ZLV, -YVV attitude.
4/06:25	10.2 psi maintenance.

T+ (PLUS) DAY/ HR:MIN:SEC	EVENT
4/07:02	Orbit 69 begins.
4/07:10	Private medical conference.
4/08:33	Orbit 70 begins.
4/08:50	Crew begins sleep period.
4/10:06	Orbit 71 begins.
4/11:37	Orbit 72 begins.
4/13:09	Orbit 73 begins.
4/14:41	Orbit 74 begins.
4/15:50	Crew begins post sleep activities.
4/16:13	Orbit 75 begins.
4/17:30	IMU/COAS maneuver.
4/17:45	Orbit 76 begins.
4/17:45	IMU alignment: ST.
4/17:50	COAS calibration, aft station.
4/17:50	ASEM EVA review.
4/17:55	Maneuver vehicle to biased -ZLV, -YVV attitude.
4/18:10	Initiate supply water dump.
4/18:50	Terminate supply water dump.
4/18:50	P/TV07 setup, ASEM.
4/18:50	EVA preparation.

T+ (PLUS) DAY/ HR:MIN:SEC	EVENT
4/18:55	EVA aspirin protocol.
4/19:00	Initiate waste dump.
4/19:10	P/TV07 activation, ASEM.
4/19:15	Filter cleaning.
4/19:17	Orbit 77 begins.
4/19:20	RMS heater activation/manipulator controller interface unit filter check.
4/19:35	10.2 psi maintenance.
4/20:00	Terminate waste dump.
4/20:10	ASEM maneuver, -XLV, +ZVV attitude.
4/20:25	Start 40-minute in-suit prebreathe.
4/20:25	RMS powerup.
4/20:40	MPESS grapple operations.
4/20:48	Orbit 78 begins.
4/20:50	Unberth operations.
4/21:05	RMS to access position.
4/21:05	Airlock depressurization.
4/21:20	ASEM EVA (EVA 3).
4/21:30	Payload bay setup.
4/21:45	Port legs installation.
4/21:55	Starboard legs installation.

T+ (PLUS) DAY/ HR:MIN:SEC	EVENT
4/22:05	Portable foot restraint setup.
4/22:11	Return from MPESS access position.
4/22:17	Maneuver to pre-attach position.
4/22:20	Orbit 79 begins.
4/22:22	Position for mating.
4/22:34	Pallet installation No. 3.
4/22:42	Pallet disconnect.
4/22:45	Return to pre-attach position.
4/22:49	Position for mating.
4/23:00	Pallet installation No. 4.
4/23:08	Ungrapple and backaway.
4/23:10	Portable foot restraint attachment device/wheel installation.
4/23:18	Maneuver to stack grasp position.
4/23:25	Equipment repositioning.
4/23:25	Portable foot restraint attachment device ingress.
4/23:30	Stack removal.
4/23:32	Payload retention latch assembly release.
4/23:37	Maneuver to stack handling position.
4/23:43	Stack handling evaluation.
4/23:48	Return to stack grasp position.

T+ (PLUS) DAY/ HR:MIN:SEC	EVENT
4/23:52	Orbit 80 begins.
4/23:53	Stack installation.

MET DAY FIVE

5/00:03	Payload retention latch assembly latch.
5/00:05	Portable foot restraint attachment device egress.
5/00:06	Setup for leg stow.
5/00:11	Regrapple.
5/00:19	Pallet disconnection.
5/00:21	Return to pre-attach position.
5/00:22	Bipole, IP setup.
5/00:25	Maneuver to MPESS access position.
5/00:29	Starboard legs stow.
5/00:39	Port legs stow.
5/00:48	Return from MPESS access position.
5/00:50	Bipole, IP evaluation.
5/00:50	EVA voice berthing.
5/01:05	Interim stow.
5/01:09	Ungrapple and backaway/assembly viewing.
5/01:15	Final/diagonal stow.
5/01:23	Orbit 81 begins.

T+ (PLUS) DAY/ HR:MIN:SEC	EVENT
5/01:30	Vertical/diagonal stow.
5/01:40	Bottom plane stow.
5/01:55	CPD evaluation.
5/02:10	Middeck battery recharge.
5/02:25	Payload bay cleanup.
5/02:40	Airlock ingress.
5/02:50	DTO 640--hydrazine monitor (EVA warmup).
5/02:55	Orbit 82 begins.
5/03:05	Airlock repressurization.
5/03:40	DTO 640--hydrazine monitor (middeck data take).
5/03:55	RMS powerdown.
5/03:55	Post EVA activities.
5/03:55	DTO 640--hydrazine monitor (airlock data take).
5/04:15	Maneuver vehicle to -ZLV, -YVV attitude.
5/04:15	DTO 623--cabin air monitoring.
5/04:28	Orbit 83 begins.
5/04:35	EMU maintenance.
5/04:35	Crew begins presleep activities.
5/04:40	DSO 621--florinef.
5/04:50	10.2 psi maintenance.

T+ (PLUS) DAY/ HR:MIN:SEC	EVENT
5/05:00	DSO 482--cardiac rhythm (EV1, EV2).
5/05:55	Maneuver vehicle to IMU alignment attitude.
5/05:59	Orbit 84 begins.
5/06:10	IMU alignment: ST.
5/06:15	Maneuver vehicle to -ZLV, -YVV attitude.
5/06:30	Private medical conference.
5/07:30	Crew begins sleep period.
5/07:32	Orbit 85 begins.
5/09:04	Orbit 86 begins.
5/10:35	Orbit 87 begins.
5/12:08	Orbit 88 begins.
5/13:38	Orbit 89 begins.
5/15:11	Orbit 90 begins.
5/15:30	Crew begins post sleep activities.
5/16:40	Maneuver vehicle to IMU alignment attitude.
5/16:43	Orbit 91 begins.
5/16:55	IMU alignment: ST.
5/17:00	Maneuver vehicle to biased -ZLV, -YVV attitude.
5/17:15	Initiate supply water dump.
5/17:40	10.2 psi maintenance.

T+ (PLUS) DAY/ HR:MIN:SEC	EVENT
5/18:00	DSO 621--florinef.
5/18:05	Terminate supply water dump.
5/18:14	Orbit 92 begins.
5/18:15	EVA aspirin protocol.
5/18:30	Manipulator controller interface unit filter.
5/18:30	P/TV05 setup, middeck.
5/18:55	DSO 482--cardiac rhythm (EV3, EV4).
5/19:00	Post EVA entry preparation.
5/19:00	P/TV05 activation, middeck.
5/19:35	P/TV10 setup.
5/19:47	Orbit 93 begins.
5/19:50	P/TV10, DSO 802--educational activities.
5/20:05	APU heater activation.
5/20:15	P/TV08 setup, crew press conference.
5/20:30	TDRS maneuver.
5/20:40	P/TV08 activation, crew press conference.
5/20:50	RCS hot fire.
5/20:50	Crew press conference audio/TV check.
5/21:05	FCS checkout.
5/21:05	VTR setup 07, ASEM.

T+ (PLUS) DAY/ HR:MIN:SEC	EVENT
5/21:18	Orbit 94 begins.
5/21:20	VTR playback, ASEM.
5/21:45	DSO 604A--visual vestibular integration.
5/22:20	P/TV08 activation, crew press conference.
5/22:25	APU heater reconfiguration.
5/22:30	Crew press conference.
5/22:50	Orbit 95 begins.
5/22:55	Maneuver vehicle to -ZLV, -YVV attitude.
5/23:15	Meal.

MET DAY SIX

6/00:20	P/TV05 setup, middeck.
6/00:23	Orbit 96 begins.
6/00:30	14.7 psi repressurization.
6/00:40	DTO 728--Ku-band antenna friction.
6/00:50	P/TV05 activation, middeck.
6/01:00	DTO 651 stow.
6/01:00	Cabin stow.
6/01:05	DTO 648--electronic still camera.
6/01:10	DSO 469C stowage--radiation dose distribution--tissue equivalent proportional counter.
6/01:54	Orbit 97 begins.

T+ (PLUS) DAY/ HR:MIN:SEC	EVENT
6/03:26	Orbit 98 begins.
6/03:45	Ku-band antenna stow.
6/03:45	DTO 623--cabin air monitoring.
6/04:00	Crew begins presleep activities.
6/04:00	DSO 621--florinef.
6/04:20	Private medical conference.
6/04:55	Maneuver vehicle to IMU alignment attitude.
6/04:57	Orbit 99 begins.
6/05:10	IMU alignment: ST.
6/05:15	COAS maneuver.
6/05:30	COAS calibration--forward station.
6/05:35	Maneuver vehicle to -ZLV, -YVV attitude.
6/06:29	Orbit 100 begins.
6/07:00	Crew begins sleep period.
6/08:02	Orbit 101 begins.
6/09:33	Orbit 102 begins.
6/11:05	Orbit 103 begins.
6/12:37	Orbit 104 begins.
6/14:08	Orbit 105 begins.
6/15:00	Crew begins post sleep activities.

T+ (PLUS) DAY/ HR:MIN:SEC	EVENT
6/15:40	Orbit 106 begins.
6/16:45	DSO 621--florinef.
6/16:55	Private medical conference.
6/17:10	Maneuver vehicle to IMU alignment attitude.
6/17:13	Orbit 107 begins.
6/17:25	IMU alignment: ST.
6/17:30	Maneuver vehicle to -XSI attitude.
6/17:30	DSO 482--cardiac rhythm (EV3, EV4).
6/17:50	DSO 603--orthostatic function.
6/18:00	DSO 604A entry preparation--visual vestibular integration (OI-1).
6/18:37	Mission Control Center updates IMU star pad, if required.
6/18:44	Orbit 108 begins.
6/18:45	DTO 623--cabin air monitoring.
6/18:45	Begin deorbit preparation.
6/18:45	CRT timer setup.
6/19:07	Commander initiates coldsoak.
6/19:16	Stow radiators, if required.
6/19:34	Commander configures DPS for deorbit preparation.
6/19:37	Mission Control Center updates IMU star pad, if required.
6/19:46	MS configures for payload bay door closure.

T+ (PLUS) DAY/ HR:MIN:SEC	EVENT
6/19:50	Maneuver vehicle to IMU alignment attitude.
6/19:55	Ku-band antenna stow.
6/19:57	MCC-H gives "go/no-go" command for payload bay door closure.
6/20:05	IMU alignment/payload bay door operations.
6/20:17	Orbit 109 begins.
6/20:20	Burn maneuver.
6/20:45	MCC gives the crew the go for OPS 3.
6/20:48	Maneuver vehicle to deorbit burn attitude.
6/20:52	Pilot starts repressurization of SSME systems.
6/20:56	Commander and pilot perform DPS entry configuration.
6/21:05	MS deactivates ST and closes ST doors.
6/21:07	All crew members verify entry payload switch list.
6/21:22	All crew members perform entry review.
6/21:24	Crew begins fluid loading, 32 fluid ounces of water with salt over next 1.5 hours (2 salt tablets per 8 ounces).
6/21:37	Commander and pilot configure clothing.
6/21:50	Orbit 110 begins.
6/21:52	MS/PS configure clothing.
6/22:02	Commander and pilot seat ingress.
6/22:04	Commander and pilot set up heads-up display (HUD).

T+ (PLUS) DAY/ HR:MIN:SEC	EVENT
6/22:06	Commander and pilot adjust seat, exercise brake pedals.
6/22:14	Final entry deorbit update/uplink.
6/22:20	OMS thrust vector control gimbal check is performed.
6/22:22	APU prestart.
6/22:37	Close vent doors.
6/22:41	MCC-H gives "go" for deorbit burn period.
6/22:47	Maneuver vehicle to deorbit burn attitude.
6/22:50	MS/PS ingress seats.
6/22:59	First APU is activated.
6/23:04	Deorbit burn period.
6/23:09	Initiate post-deorbit burn period attitude.
6/23:13	Terminate post-deorbit burn attitude.
6/23:21	Dump forward RCS, if required.
6/23:23	Orbit 111 begins.
6/23:29	Activate remaining APUs.
6/23:33	Entry interface, 400,000 feet altitude.
6/23:36	Enter communication blackout.
6/23:38	Automatically deactivate RCS roll thrusters.
6/23:45	Automatically deactivate RCS pitch thrusters.
6/23:49	Initiate first roll reversal.

T+ (PLUS) DAY/ HR:MIN:SEC	EVENT
6/23:53	Exit communications blackout.
6/23:53	Initiate second roll reversal.
6/23:53	TACAN acquisition.
6/23:56	Initiate third roll reversal.
6/23:57	Initiate air data system (ADS) probe deploy.
6/23:58	Begin entry/terminal area energy management (TAEM).
6/23:58	Initiate payload bay venting.

MET DAY SEVEN

7/00:00	Automatically deactivate RCS yaw thrusters.
7/00:03	Begin TAEM/approach/landing (A/L) interface.
7/00:03	Initiate landing gear deployment.
7/00:04	Vehicle has weight on main landing gear.
7/00:04	Vehicle has weight on nose landing gear.
7/00:04	Initiate main landing gear braking.
7/00:05	Wheel stop.

GLOSSARY

A/G	air-to-ground
AA	accelerometer assembly
ACS	active cooling system
ADS	air data system
AFB	Air Force base
A/L	approach and landing
AMOS	Air Force Maui Optical Site
AOS	acquisition of signal
APC	autonomous payload controller
APU	auxiliary power unit
ASE	airborne support equipment
ASEM	assembly of station by EVA methods
BFS	backup flight control system
CCD	charge-coupled device
CDMS	command and data management subsystem
COAS	crewman optical alignment sight
CPCG	commercial protein crystal growth
CRT	cathode ray tube
C/W	caution/warning
DAP	digital autopilot
DOD	Department of Defense
DPS	data processing system
DSO	detailed supplementary objective
DTO	development test objective
EAFB	Edwards Air Force Base
ECLSS	environmental control and life support system
EDO	extended duration orbiter
EHF	extremely high frequency
ELV	expendable launch vehicle
EMU	extravehicular mobility unit
EOM	end of mission
EPS	electrical power system
ET	external tank
ETR	Eastern Test Range
EV	extravehicular