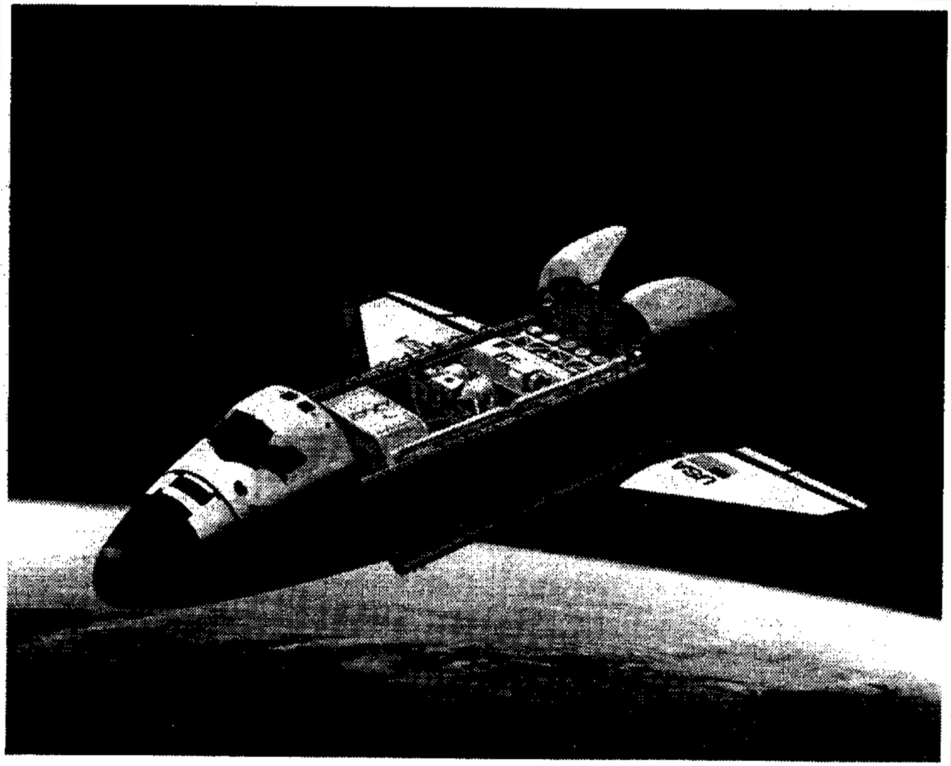

STS-57

PRESS INFORMATION AND MISSION TIME LINE

June 1993

Rockwell International
Space Systems Division

Office of External Communications &
Media Relations

PUB 3546-V Rev 6-93

CONTENTS

CONTENTS (CONT)

MISSION OVERVIEW

This is the 4th flight of Endeavour and the 56th for the space shuttle.

The flight crew for the STS-57 mission is commander Ronald (Ron) J. Grabe; pilot Brian J. Duffy; payload commander G. David (Dave) Low; and mission specialists Janice E. Voss, Nancy J. Sherlock, and Peter J. K. (Jeff) Wisoff.

STS-57 has two primary mission objectives: to provide the orbiter Endeavour as a science platform for experiments on the SPACEHAB 1 payload, and to rendezvous with and retrieve the European Space Agency's European Retrievable Carrier satellite.

STS-57 marks the first flight of SPACEHAB, a commercially developed, pressurized, man-rated module that provides approximately 1,100 cubic feet of additional pressurized volume to the shuttle's manned working space and supports primarily orbiter middeck-type experiments. Leased to NASA by SPACEHAB, Inc. (McDonnell Douglas and Alenia), SPACEHAB has two primary objectives: (1) to support NASA's commercial development of the space program by providing additional access to crew-tended, middeck locker or experiment rack space, which is necessary to test, demonstrate, or evaluate techniques or processes in microgravity, and (2) to foster the development of a space infrastructure that can be marketed by private firms to support commercial microgravity research payloads.

SPACEHAB is installed in the forward quarter section of the orbiter payload bay and is crew-accessible from the middeck via an airlock/tunnel adapter. Its configuration is flexible, significantly increasing its accommodation options for payload developers. Payloads are primarily mounted in middeck-type lockers (up to 60) or in a limited number of Spacelab-type racks. Experiments may also be mounted externally on the module top. The SPACEHAB subsys-

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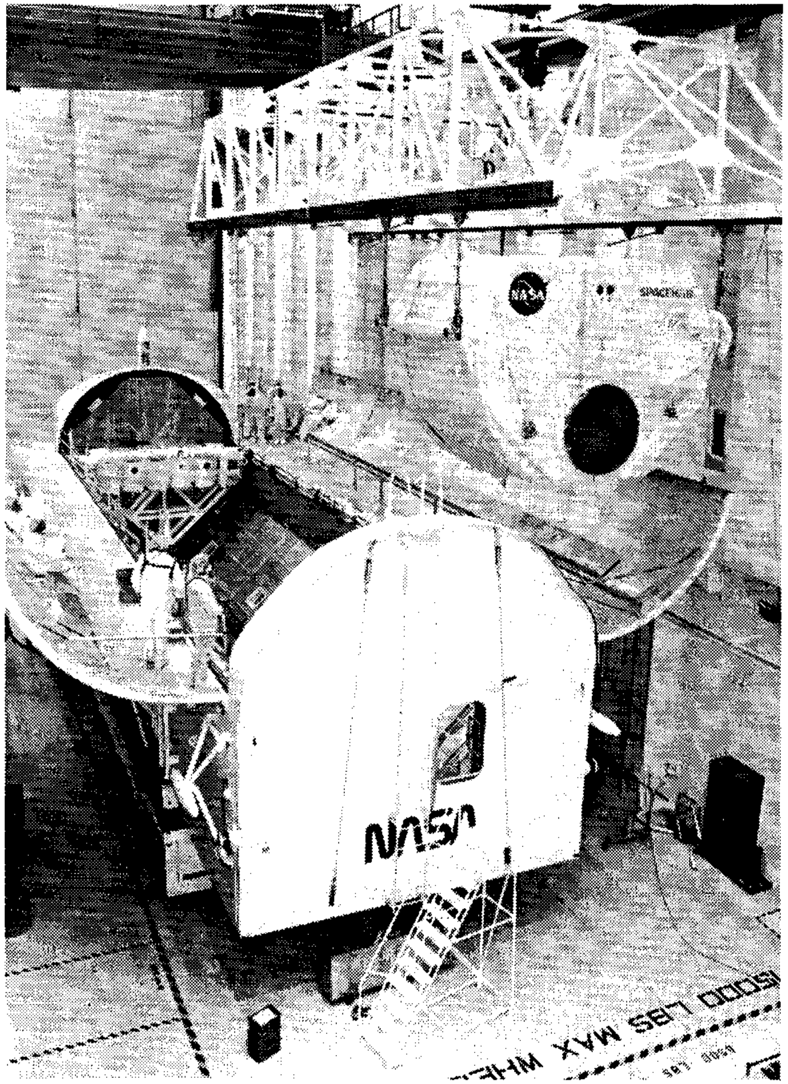


NASA Photo

SPACEHAB Module Being Moved From Test Stand to Transporter tems require orbiter resources including dc and ac power cooling via the Freon heat exchanger, atmosphere makeup (oxygen and nitrogen), humidity control, and carbon dioxide scrubbing.

SPACEHAB is expected to provide users with frequent flight opportunities with reduced lead time. SPACEHAB, Inc., may lease the SPACEHAB facility space to other commercial customers on upcoming flights. Currently, six flights are scheduled between June 1993 and June 1995; subsequent flights will be based upon market demand.

For STS-57, SPACEHAB will house 21 payloads, and 6 will reside in the orbiter's middeck. The cargo is primarily microgravity-oriented, emphasizing material science, life science, and human factors. Approximately 110 hours of SPACEHAB operations are planned.

SPACEHAB 1 experiments are as follows:

- Three-Dimensional Microgravity Accelerometer (3DMA) will measure the effects of deviations of microgravity on the SPACEHAB experiments.
- ASTROCULTURE (ASC-2) will provide water and nutrients to plants growing in microgravity.
- Application-Specific Preprogrammed Experimental Culture System (ASPEC) is a bioreactor that will grow human cells and tissue cultures.
- Bioserve Pilot Lab (BPL) consists of a refrigerator/incubator module and multiple mini-labs that will conduct several biomedical and fluid studies.
- Commercial Generic Bioprocessing Apparatus (CGBA) uses a refrigerator/incubator module to process biological fluids.
- Charged-Particle Directional Spectrometer (CPDS) will measure the intensity of certain types of charged radiation particles within the SPACEHAB module.
- Equipment for Controlled Liquid-Phase Sintering Experiment (ECLiPSE) uses a furnace to study liquid-phase sintering of metals in microgravity.
- ECLSS Flight Experiment (EFE) will evaluate three elements of the space station environmental control and life support system: a phase separator, unibed filter, and bellows tank.
- Gas-Permeable Polymer Materials (GPPM) will use a refrigerator/incubator module and a polymerization module to study on-orbit polymerization of materials.
- Human Factors Assessment (HFA) studies will include light- and sound-level measurements, human translation, and use of electronic media for tasks.
- Investigations Into Polymer Membrane Processing (IPMP) will study the transport processes for evaporation-casting of polymer membranes.
- Liquid-Encapsulated Melt Zone (LEMZ-1) will demonstrate the feasibility of the melt zone process and the influence of accelerations on the encapsulant and melt.
- Neutral Body Posture (NBP) will investigate the effects of posture changes in the human body in microgravity.
- Organic Separation (ORSEP) will determine whether the separation process for cells and heavy molecules in microgravity results in a purer product.
- Physiological Systems Experiment (PSE-3) is a continuation study of microgravity's effect on mammalian organ systems and the tissue healing process.

- Space Acceleration Measurement System (SAMS) measures low-level shuttle accelerations with three triaxial heads and stores the data on optical disks.

- Support of Crystal Growth (SCG) will demonstrate room-temperature growth of crystals from solutions to be used in ZCG.

- Tools and Diagnostic Systems (TDS) consists of hardware and procedures designed to increase knowledge of on-orbit system maintenance and repair.

- Direct-Control Protein Crystal Growth (PCG) will use a thermal enclosure system/crystal observation system (TES/COS) to observe equilibrium rates of the crystal growth process.

- Zeolite Crystal Growth (ZCG) will process multiple samples of zeolite crystals in a furnace, using the samples derived from SCG.

The flight crew will be required to perform various tasks during the mission in the SPACEHAB module, including activation/ deactivation, monitoring, and in-flight maintenance of SPACEHAB subsystems.

STS-57's second primary objective is the successful rendezvous and retrieval of the European Space Agency's European Retrievable Carrier (EURECA) satellite, a free-flying reusable platform dedicated primarily to microgravity experimentation (material and life sciences). Originally deployed by the space shuttle Atlantis on mission STS-46 in August 1992, EURECA is scheduled to be retrieved on orbit 48 of flight day 4 (mission elapsed time: 3/01:34) at an altitude of 259 by 252 nautical miles. To prepare for the capture, EURECA will orient to a solar inertial attitude and retract its two solar arrays and two antennas. The orbiter's remote manipulator system (RMS) will be used to retrieve and berth EURECA for return to Earth. An unscheduled EVA may be performed to retract or separate the EURECA antenna boom or to retract the solar array manually. Once EURECA is latched in the payload bay, power for thermal control will be provided by the remotely operated electrical umbilical.

STS-57 secondary objectives are described below.

The Superfluid Helium On-Orbit Transfer Experiment (SHOOT) will demonstrate the technology and critical operations (containment, management, and transfer) required to service payloads in orbit with liquid helium. SHOOT is the precursor to the Superfluid Helium Tanker being developed by NASA JSC for the replenishment of payloads from the shuttle and the space station. It will demonstrate remote autonomous servicing operations with ground and/or aft deck control. The payload consists of two liquid-helium dewars, a transfer line, and electronic controls and instrumentation mounted on a multipurpose experiment support structure with Hitchhiker M avionics. The payload will be mounted in the middle of the payload bay. All but two of the fluid transfers will be controlled by the Payload Operations Control Center. The crew will conduct two transfers with the payload and general support computer and supply reaction control system-induced accelerations required to calibrate and evaluate SHOOT equipment.

The Fluid Acquisition and Resupply Experiment (FARE) II, which last flew on STS-53 in November 1992, will investigate fill, refill, and expulsion of simulated propellant tanks and liquid motion in a low-gravity environment. The FARE configuration consists of a spherical receiver tank, spherical supply tank, pressurization system, vent system, structure and adapter plates, lights, ballast assembly (power control box), flow meter, fire hazard blanket, and airborne support equipment. The tanks are made of clear acrylic plastic to enable video recording of the fluid's behavior. The test fluid is treated water. The payload is operated manually and uses hardware from the storage fluid management demonstration experiment flown on STS-51C.

The Consortium for Materials Development in Space Complex Autonomous Payload (CONCAP) IV experiment is contained in a standard GAS canister mounted on the GAS bridge assembly in Endeavour's payload bay. CONCAP IV will grow crystals and thin films through physical vapor transport. It consists of nonlinear optical (NLO) organic materials in microgravity and is a continuation of the NLO crystal growth research conducted on a previous shuttle flight. Nonlinear optical materials are considered a key to many current and future optical applications, such as optical computing. The payload will be activated during ascent by a baroswitch and is controlled by the autonomous payload control system in the orbiter's aft flight deck. Deactivation is performed as late as possible in the mission to allow a long crystal growing period.

NASA's Getaway Special (GAS) Program, which has flown 87 payloads on 18 previous shuttle missions, allows individuals and organizations around the world access to space for scientific research. On STS-57, ten GAS payloads from the U.S., Canada, Japan, and Europe are manifested, plus the CONCAP IV payload and a ballast can. The GAS payload consists of various small self-contained experiments integrated in a customer-provided standard canister. Each canister can be made up of one or multidisciplinary experiments, each with its own support system. They are controlled by the autonomous payload controller, a small hand-held keyboard used by a crew member in the aft flight deck. The GAS payloads are mounted on a bridge assembly that spans the full width of the payload bay and is installed with standard orbiter longeron and keel fittings.

The STS-57 GAS experiments are as follows:

- G-022 (Periodic Volume Stimulus Method) will evaluate an on-orbit method for gauging liquids in tanks.
- G-324 (CAN DO—Earth Resources and Astronomical Photography) is a student experiment in which four cameras will take 1,000 photographs of Earth targets that will be compared with Skylab photos for evidence of global change. The canister also contains 350 small, passive student experiments.
- G-399 (Brine Shrimp Growth and Salt Ion Transport) experiments consist of creating insulin compounds, photographing brine shrimp (Artemia) growth, and recording salt ion transport across a permeable membrane.
- G-450 (American Institute of Aeronautics and Astronautics Experiment) consists of six self-contained experiment modules that will study saccharin crystal growth, cryogen transfer processes, bacterial growth under unfiltered radiation, seed sprouting, and diffusion of fluids through membranes.
- G-452 (Gallium-Arsenide Crystal Growth) is a Society of Japanese Aerospace Companies, Inc., experiment that will evaluate the formation of gallium-arsenide and indium-antimony crystals in microgravity. It consists of 12 small electric furnaces.
- G-453 (Formation of Alloys) is a Society of Japanese Aerospace Companies, Inc., experiment that will study the formation of heterogeneous alloys using gallium-arsenide and germanium, the formation of thin-filmed single crystals on indium-antimony, the formation of silicon-lead alloy, and bubble formation of a boiling organic solvent in weightlessness.
- G-454 (Crystal Growth of Indium-Gallium-Arsenide) is a Society of Japanese Aerospace Companies, Inc., experiment that involves the growth of an indium-gallium-arsenide crystal from vapor, growth of a selenium-niobium crystal from vapor, growth of an opto-electric crystal by diffusion, and formation of a superferromagnetic alloy.
- G-535 (Effects of Heat Flux and Liquid Subcooling) is a NASA Lewis Research Center experiment that will determine the effects of heat flux and liquid subcooling on nucleated pool boiling in a long-term reduced-gravity environment.

- G-601 (Solar Flux Experiment) will measure and analyze high-frequency variations in the solar flux.

- G-647 (Liquid-Phase Electroepitaxy Experiment) will examine a recently developed crystal growth technique in microgravity.

SAREX, sponsored by NASA, the American Radio Relay League/Amateur Radio Satellite Corporation, and the Johnson Space Center Amateur Radio Club, is a middeck payload that will establish two-way communication with amateur radio stations within the line of sight of the orbiter. An antenna is mounted in either window 1 or 6. Configuration C is planned for this mission and is capable of operating in a robot mode and voice mode. SAREX-II will operate in the robot mode for the majority of the flight. Intermittent voice operations will be performed by crew members Brian Duffy and Janice Voss as time permits.

The Air Force Maui Optical Site (AMOS) uses the orbiter during cooperative overflights of Maui, Hawaii, and Arecibo to obtain imagery and/or signature data to support the calibration of ground-based sensors and to observe plume phenomenology. No unique on-board hardware is associated with the AMOS test; however, crew and orbiter participation may be required to establish controlled conditions for cooperative overflights. Only tests over Maui are planned for STS-57.

On flight day 5, crew members G. David Low and Jeff Wisoff are scheduled to perform a four-hour extravehicular activity (DTO 1210) as a continuation of a series of spacewalks NASA plans to conduct to prepare for construction of the space station. The tests are designed to refine training methods for spacewalks; expand the EVA experience levels of astronauts, flight controllers and instructors; and clarify the differences between weightlessness in space and ground simulations used in training. The astronauts will also refine procedures being developed to service the Hubble Space Telescope on STS-61 in December 1993.

Sixteen development test objectives and 11 detailed supplementary objectives are scheduled for STS-57.

NOTE: The STS-57 mission is planned to be 6 days, 23 hours, 26 minutes in duration. However, it may be extended by one day immediately after launch if projections calculated at that time for available energy permit. If STS-57 remains a seven-day flight, the EVA scheduled for flight day 5 will be canceled and activities planned for the first four flight days will be unchanged. FCS checkout, RCS hot fire, and SPACEHAB deactivation would take place on flight day 7, and entry and landing would be on flight day 8.

STS-57 Insignia, Designed by Crew

MISSION STATISTICS

Vehicle: Endeavour (OV-105), 4th flight

Launch Date/Time:

6/20/93	9:37 a.m., EDT 8:37 a.m., CDT 6:37 a.m., PDT

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

Launch Window: 1 hour, 11 minutes

Mission Duration: 6 days, 23 hours, 26 minutes. A highly desirable additional day cannot be guaranteed due to consumables, but potentially could be achieved once the mission is under way. Planning will accommodate the longer duration wherever appropriate. Should the mission be extended, the mission duration will be 7 days, 22 hours, 56 minutes. The capability exists for two additional days for contingency operations and weather avoidance.

Landing: Nominal end-of-mission landing on orbit 108 (123 if mission extended)

6/27/93	9:03 a.m., EDT 8:03 a.m., CDT 6:03 a.m., PDT

If mission is extended:

6/28/93	8:33 a.m., EDT 7:33 a.m., CDT 5:33 a.m., PDT

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

Transatlantic Abort Landing: Banjul, Gambia; alternatives: Ben Guerir, Morocco; Moron, Spain

Return to Launch Site: KSC

Abort Once Around: EAFB; alternatives: KSC, NOR

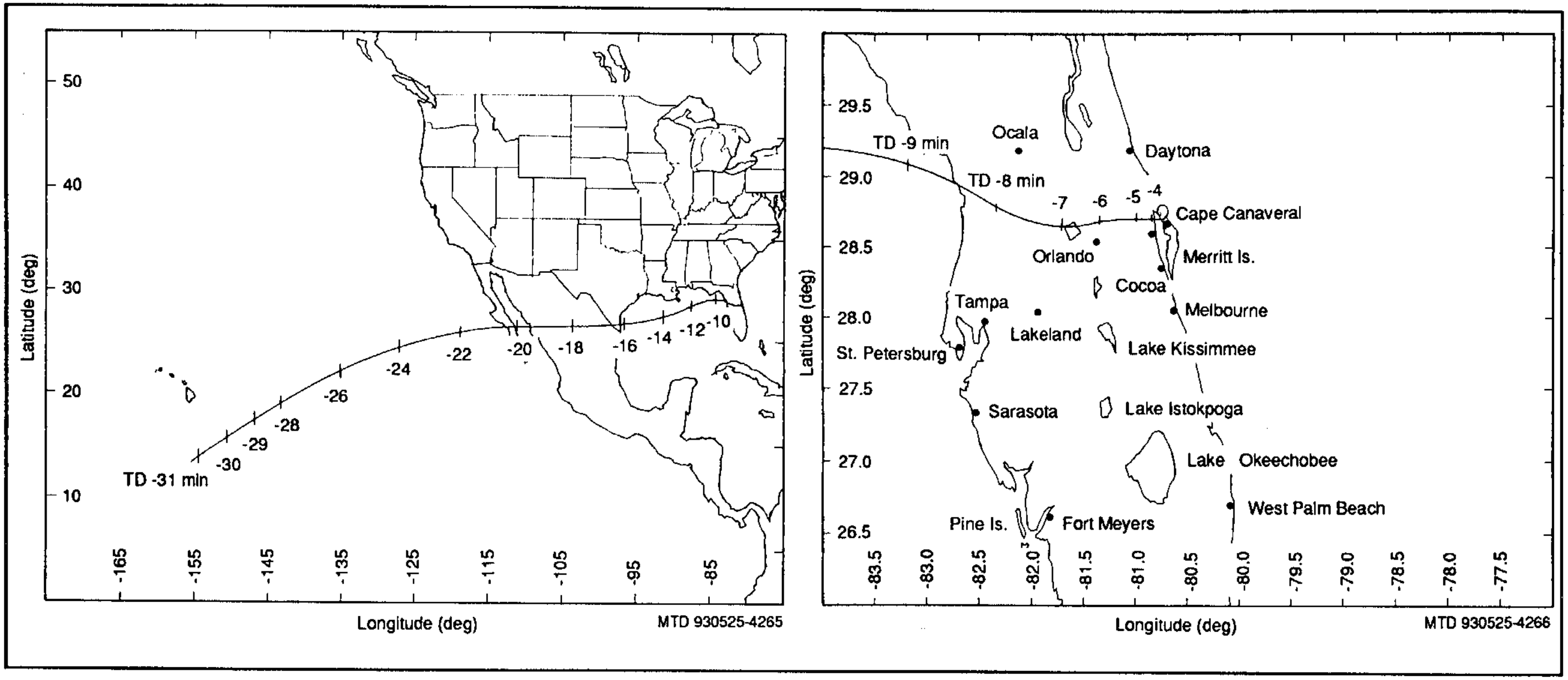
Inclination: 28.45 degrees

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 two 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: 250 nautical miles (287 statute miles)

Space Shuttle Main Engine Thrust Level During Ascent: 104 percent



End-of-Mission Descent Trajectory

Space Shuttle Main Engine Locations:

No. 1 position: Engine 2019
No. 2 position: Engine 2034
No. 3 position: Engine 2017

External Tank: ET-58

Solid Rocket Boosters: BI-059

Mobile Launcher Platform: 2

Editor's Note: The following weight data are current as of May 24, 1993.

Total Lift-off Weight: Approximately 4,516,459 pounds

Orbiter Weight, Including Cargo, at Lift-off: Approximately 252,359 pounds

Orbiter (Endeavour) Empty and 3 SSMEs: Approximately 172,943 pounds

Payload Weight Up: Approximately 19,691 pounds

Payload Weight Down: Approximately 28,925 pounds

Orbiter Weight at Landing: Approximately 224,490 pounds

Payloads—Payload Bay (*denotes primary payload): SPACEHAB 1 module,* European Retrievable Carrier (EURECA) retrieval,* Superfluid Helium On-Orbit Transfer Experiment (SHOOT), Consortium for Materials Development in Space Complex Autonomous Payload (CONCAP) IV, ten Getaway Special (GAS) payloads mounted on a GAS bridge assembly

Payloads—Middeck: Fluid Acquisition and Resupply Experiment (FARE) II, Shuttle Amateur Radio Experiment (SAREX) II, Air Force Maui Optical Site (AMOS)

Flight Crew Members:

Commander: Ronald (Ron) J. Grabe, fourth space shuttle flight
Pilot: Brian J. Duffy, second space shuttle flight
Payload Commander: G. David (Dave) Low, third space shuttle flight
Mission Specialist 2: Nancy J. Sherlock, first space shuttle flight
Mission Specialist 3: Peter J. K. (Jeff) Wisoff, first space shuttle flight
Mission Specialist 4: Janice E. Voss, first space shuttle flight

Ascent and Entry Seating:

Ascent:

Flight deck, front left seat, commander Ronald J. Grabe
Flight deck, front right seat, pilot Brian J. Duffy
Flight deck, aft center seat, mission specialist Nancy J. Sherlock
Flight deck, aft right seat, payload commander G. David Low
Middeck, mission specialist Peter J. K. (Jeff) Wisoff
Middeck, mission specialist Janice E. Voss

Entry:

Flight deck, front left seat, commander Ronald J. Grabe
Flight deck, front right seat, pilot Brian J. Duffy
Flight deck, aft center seat, mission specialist Nancy J. Sherlock
Flight deck, aft right seat, mission specialist Peter J. K. (Jeff) Wisoff
Middeck, payload commander G. David Low
Middeck, mission specialist Janice E. Voss

Extravehicular Activity Crew Members, If Required:

Extravehicular (EV) astronaut 1: payload commander G. David Low
EV-2: Peter J. K. (Jeff) Wisoff

Intravehicular Astronaut: Pilot Brian J. Duffy

STS-57 Flight Directors:

Ascent/Entry Team: Jeff Bantle
Orbit 1 (rendezvous) Team Lead: Al Pennington
Orbit 2 (deploy/EVA) Team: Phil Engelauf
Planning Team: Rob Kelso

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 shuttle orbiter repackaged galley is installed in Endeavour's middeck.
- Endeavour's radiator will be deployed on flight day 5 to conserve water, if required.

MISSION OBJECTIVES

- Primary objective
    - — SPACEHAB 1 operations
    - — European Retrievable Carrier (EURECA) retrieval
- Secondary objectives
    - — Payload bay

        Superfluid Helium On-Orbit Transfer Experiment (SHOOT)

        Consortium for Materials Development in Space Complex Autonomous Payload (CONCAP) IV

        Getaway Special (GAS) bridge assembly with ten payloads
    - — Middeck

        Fluid Acquisition and Resupply Experiment (FARE) II

        Shuttle Amateur Radio Experiment (SAREX) II

        Air Force Maui Optical Site (AMOS)
- 16 development test objectives/11 detailed supplementary objectives

FLIGHT ACTIVITIES OVERVIEW

NOTE: The STS-57 mission is planned to be 6 days, 23 hours, 19 minutes long. However, it may be extended by one day immediately after launch if projections calculated at that time for available energy permit. If STS-57 remains a seven-day flight, the EVA scheduled for flight day 5 will be canceled and activities planned for the first four flight days will be unchanged. FCS checkout, RCS hot fire, and SPACEHAB deactivation would take place on flight day 7, and entry and landing would be on flight day 8.

The following schedule assumes an extended 7-day, 23-hour (MET) mission:

Flight Day 1

Launch
OMS-2 burn
Payload bay doors open
Unstow cabin
SPACEHAB activation
SPACEHAB operations
NC-1 burn
Priority Group B powerdown

Flight Day 2

SHOOT operations
SPACEHAB operations
RMS checkout and payload bay survey
Gravity gradient (overnight for ZCG)
NPC and NC-2 burns

Flight Day 3

SHOOT operations
SPACEHAB operations
NC-3 burn
EMU checkout

Flight Day 4

Priority Group B powerup
EURECA retrieval in orbit of 259 by 256 nautical miles
NSR burn
NH-4 burn
TI burn
SPACEHAB operations
Priority Group B powerdown

Flight Day 5

EVA
SPACEHAB operations

Flight Day 6

SPACEHAB operations
FARE operations (three tests)
Fuel cell 3 shutdown
Radiator deploy

Flight Day 7

Gravity gradient (for ECLiPSE)
SPACEHAB operations
FARE operations (five tests)

Flight Day 8

SPACEHAB operations
FCS checkout
RCS hot fire
Crew conference
Fuel cell 3 powerup
Radiator stow
Ku-band antenna stow
SPACEHAB deactivation
Cabin stow

Flight Day 9

SPACEHAB deactivation completed
Priority Group B powerup
Deorbit preparations
Deorbit burn
Landing

NOTE: Each flight day includes a number of scheduled housekeeping activities: 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.

CREW ASSIGNMENTS

*Denotes backup responsibility

Commander: (Ronald J. Grabe)

Overall mission decisions
Payload—EURECA rendezvous, HFA light/sound (SPACEHAB), PSE (SPACEHAB), IPMP (SPACEHAB), GBA,* HFA translation (SPACEHAB),* NBP (SPACEHAB),* TES/COS (SPACEHAB)*

Pilot: (Brian J. Duffy)

Payload—SAREX, NBP (SPACEHAB), EURECA systems,* EURECA rendezvous,* FARE,* HFA light/sound (SPACEHAB),* ASC-2 (SPACEHAB)

Payload Commander (Mission Specialist 1): (G. David Low)

Payload—EURECA RMS, EVA, SPACEHAB systems, CRIM/VDA (SPACEHAB), EFE (SPACEHAB), SCG (SPACEHAB),* APCF (SPACEHAB),* CGBA (SPACEHAB),* CPDS (SPACEHAB),* 3-DMA (SPACEHAB),* ECLiPSE-HAB (SPACEHAB),* GPPM (SPACEHAB),* ORSEP (SPACEHAB),* SAMS (SPACEHAB),* ZCG (SPACEHAB)*

Mission Specialist 2: (Nancy J. Sherlock)

Payload—EURECA systems, EVA RMS, GBA, BPL (SPACEHAB), HFA translation (SPACEHAB), ASC-2 (SPACEHAB), EURECA RMS,* ASPECS (SPACEHAB),* HFA EPROC (SPACEHAB),* EFE (SPACEHAB)*

Mission Specialist 3: (Peter J. K. (Jeff) Wisoff)

Payload—EVA, FARE, ASPECS (SPACEHAB), CGBA (SPACEHAB), EURECA rendezvous,* SHOOT,* BPL (SPACEHAB),* LEMZ-1 (SPACEHAB)*

Mission Specialist 4: (Janice E. Voss)

Payload—SHOOT, HFA EPROC (SPACEHAB), SCG (SPACEHAB), TES/COS (SPACEHAB), APCF (SPACEHAB), CPDS (SPACEHAB), 3-DMA (SPACEHAB), ECLiPSE-HAB (SPACEHAB), GPPM (SPACEHAB), LEMZ-1 (SPACEHAB), ORSEP (SPACEHAB), SAMS (SPACEHAB), ZCG (SPACEHAB), EVA RMS,* SPACEHAB systems,* SAREX,* CRIM/VDA (SPACEHAB),* PSE (SPACEHAB),* CGBA (SPACEHAB)*

Crew members of the STS-57 shuttle mission are (from left) mission specialist Peter J.K. (Jeff) Wisoff, pilot Brain Duffy, mission specialists Nancy Jane Sherlock and Janice E. Voss, mission commander Ronald J. Grabe, and payload commander G. David Low.

DEVELOPMENT TEST OBJECTIVES/DETAILED SUPPLEMENTARY OBJECTIVES

DTOs

- 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 1—no +X burn, and method 3) (DTO 312)
- On-orbit fuel cell shutdown/restart (fuel cell 3) (DTO 412)
- APU shutdown (DTO 414)
- Orbiter drag chute system (DTO 521)
- Cabin air monitoring (DTO 623)
- EDO WCS evaluation (DTO 662)
- Acoustical noise dosimeter data (DTO 663)
- Acoustical noise sound-level data (DTO 665)
- EVA hardware for future scheduled EVA missions (DTO 671)
- Laser range and range rate device (DTO 700-2)
- Crosswind landing performance (DTO 805)
- EVA operations procedures/training (DTO 1210)

DSOs

- Inter-Mars tissue-equivalent proportional counter (ITEPC) (DSO 485)
- Orthostatic function during entry, landing, and egress (DSO 603B*)
- Visual-vestibular integration as a function of adaptation (DSO 604 OI-1*)
- Effects of prolonged space flight on head and gaze stability during locomotion (DSO 614*)
- Effects of intense exercise during space flight on aerobic capacity and orthostatic function (DSO 618*)
- Pre- and postflight measurement of cardiorespiratory responses to submaximal exercises (DSO 624*)
- Measurement of blood volumes before and after flight (DSO 625*)
- Cardiovascular and cerebrovascular responses to standing before and after space flight (DSO 626*)
- Documentary television (DSO 901)
- Documentary motion picture photography (DSO 902)
- Documentary still photography (DSO 903)

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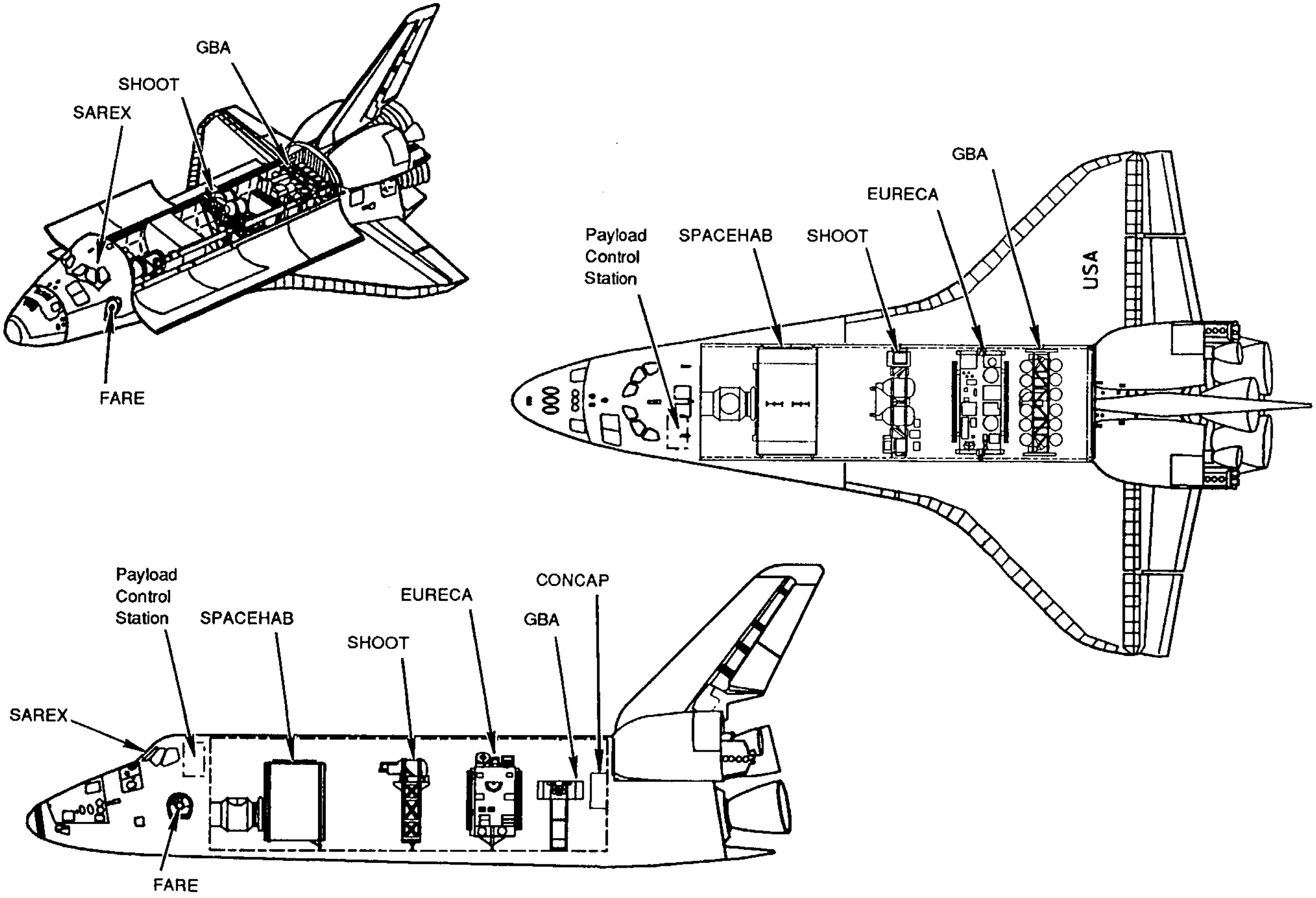
*EDO buildup medical evaluation

STS-57 PAYLOAD CONFIGURATION



SPACEHAB 1

Early in the shuttle program, it became evident that the orbiter middeck is the best place to conduct crew-tended experiments in space. Each shuttle orbiter has 42 middeck lockers but most are used to stow crew gear for a typical seven-day mission, leaving only seven or eight for scientific studies. Now, with the advent of SPACEHAB, the first crew-tended commercial payload carrier, a new era of space experimentation will begin.

The SPACEHAB module, 10 feet long and 13 feet in diameter, is like a second middeck that takes up a quarter of the orbiter's payload bay. It adds 1,100 cubic feet of pressurized work space that can hold 61 lockers, or experiment racks, or a combination of the two. The lockers are sized and equipped like those in the shuttle middeck so that experiments can be moved from one location to the other. A rack, which can be single or double, takes the space of ten lockers. Double racks are similar in size and design to those planned for space station so that they can serve as test beds for future projects.

For this first mission, the SPACEHAB interior will be arranged in the locker configuration. Astronauts Low and Voss will enter the module through a modified Spacelab tunnel adapter. Power, command and data services, cooling, vacuum, and other utilities are supplied by orbiter crew cabin and payload bay resources. The lockers accommodate up to 60 pounds of experiment hardware in about 2 cubic feet. A single rack can carry 625 pounds of hardware in 22.5 cubic feet.

SPACEHAB was privately developed and is privately operated by SPACEHAB, Inc., of Arlington, Va. NASA has agreed to lease two-thirds of the module's space for the first six flights, which are expected to occur twice a year. Eight SPACEHAB missions have been listed on the shuttle manifest so far. Both SPACEHAB, Inc., and NASA hope that commercial interests will also begin to lease experiment space.

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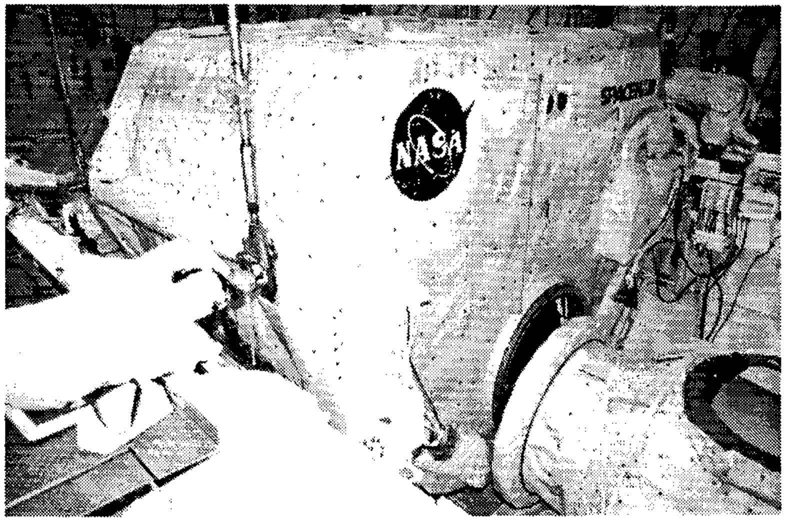
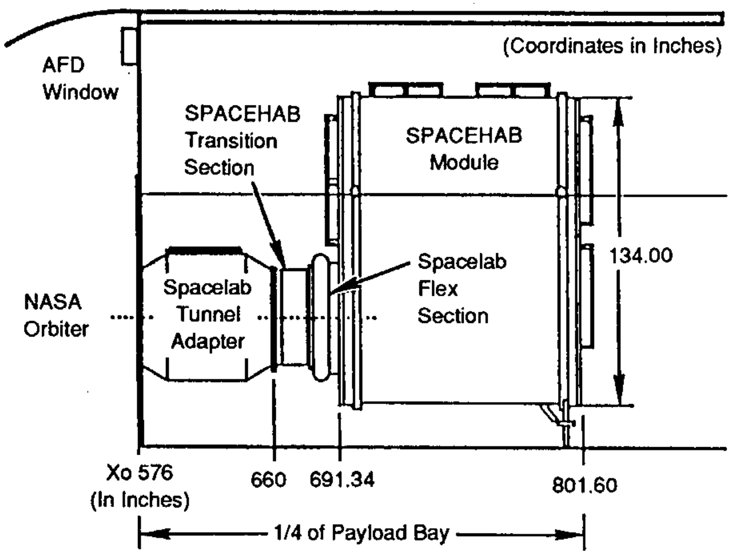


NASA Photo

SPACEHAB Module Placed in Endeavour Payload Bay by Transporter

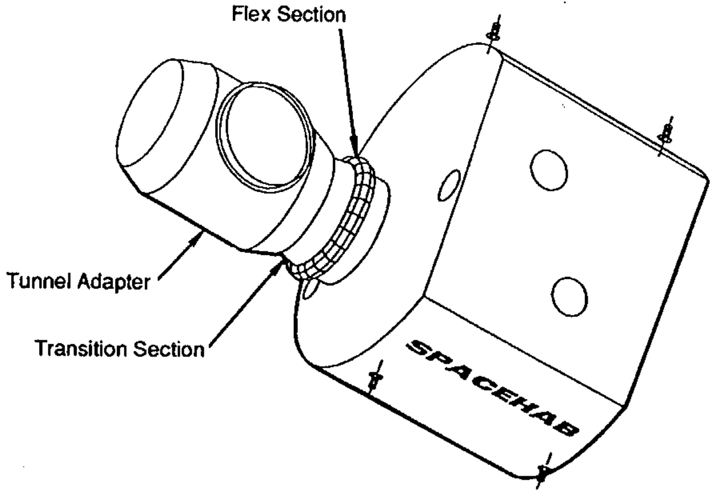
For STS-57, SPACEHAB will carry 21 experiments. Thirteen are devoted to material and life sciences. Twelve of those are sponsored by the NASA Centers for Commercial Development of Space (CCDS), and one is from NASA's Langley Research Center. NASA's Johnson Space Center contributed five experiments in biotechnology and human factors. There is also a space station technology demonstration and a microgravity measurement project.

Seventeen NASA CCDS groups are currently involved in developing space technologies in more than 60 different disciplines. They comprise universities, industries, and other government agencies brought together by NASA to stimulate commercial interest in space products and processes.



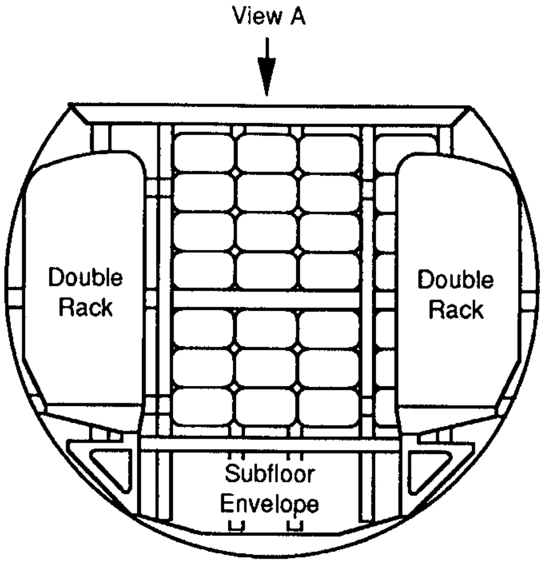
MTD 930525-4249

Orbiter/SPACEHAB Interface

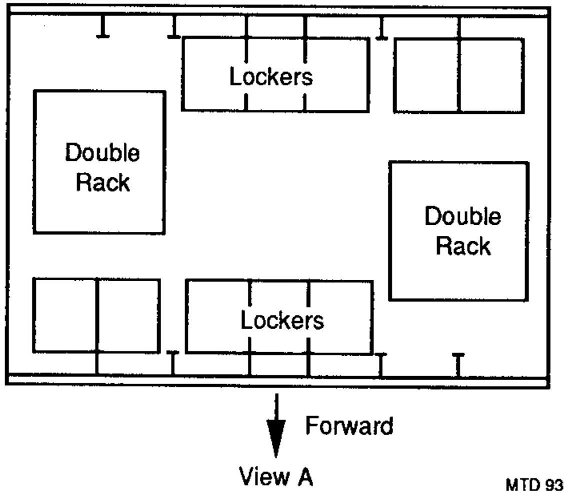


MTD 930601-4262

SPACEHAB External View



View Looking Aft



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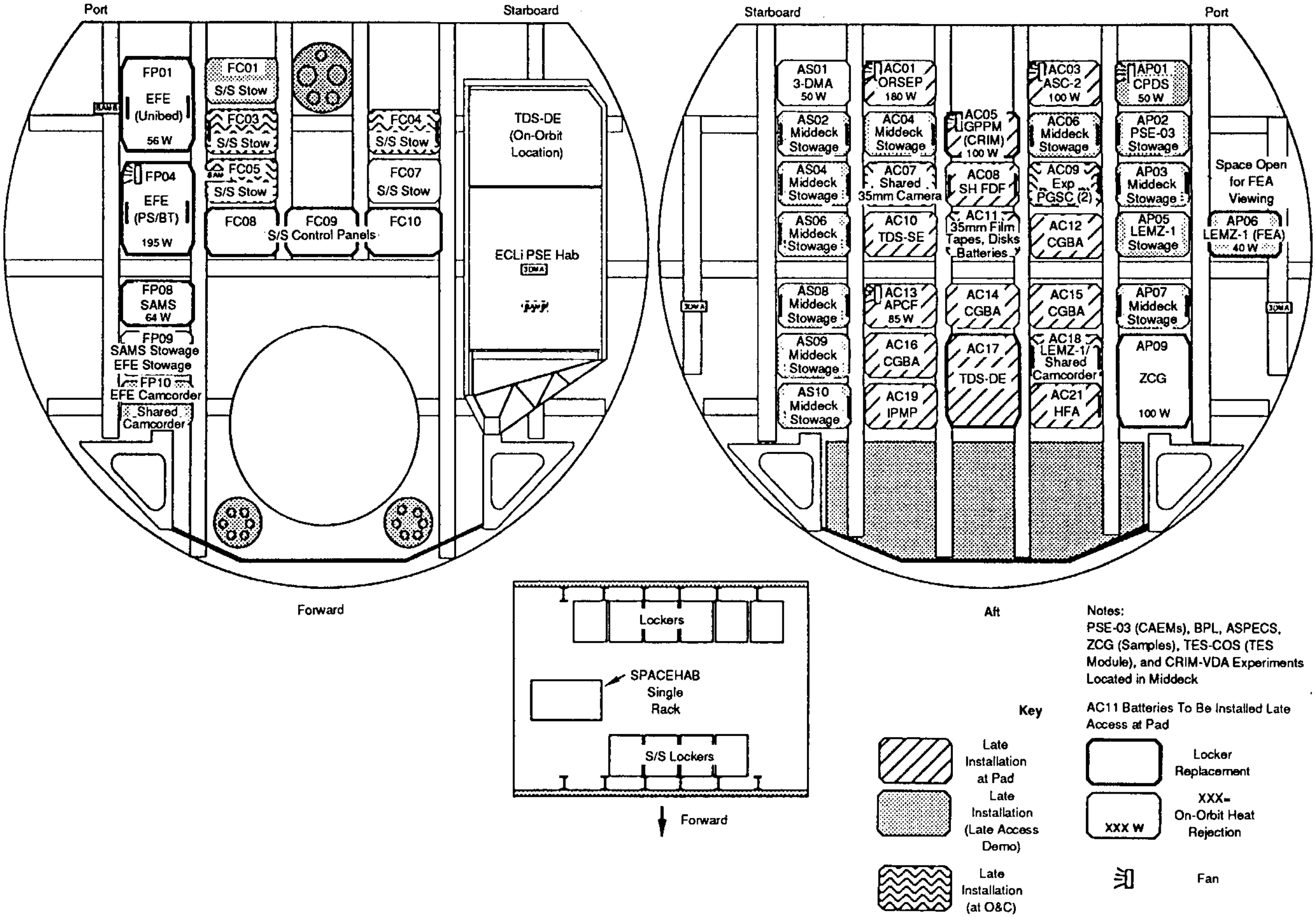
SPACEHAB Rack-Plus-Locker Configuration (Reference)

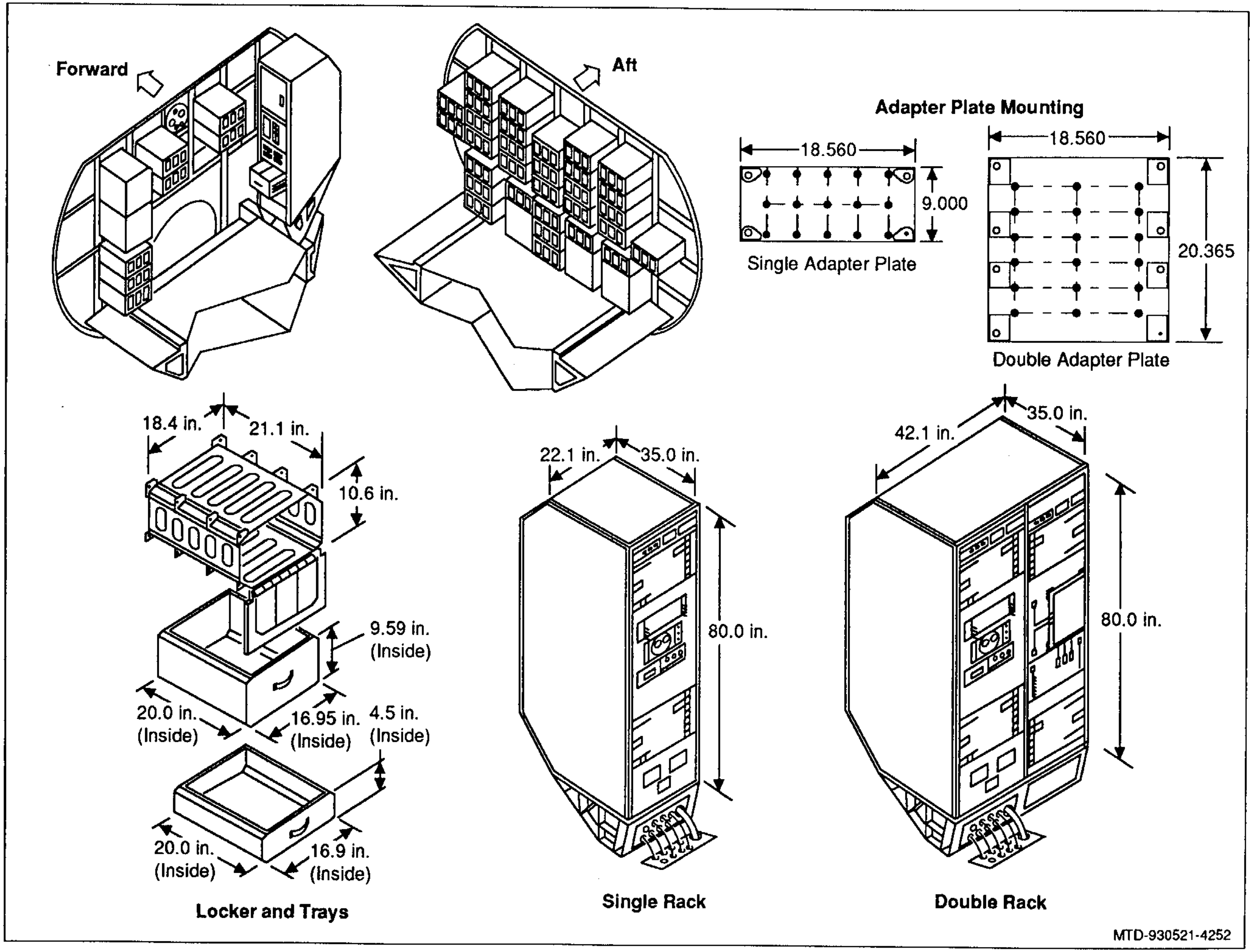


Notes:
PSE-03 (CAEMs), BPL, ASPECS, ZCG (Samples), TES-COS (TES Module), and CRIM-VDA Experiments Located in Middeck

AC11 Batteries To Be Installed Late Access at Pad

MTD 930525-4250

SPACEHAB Mission 1 Layout Configuration



Typical SPACEHAB Interior Configuration

Accommodation	Total	Locker	Rack		Remarks
			Single	Double	
Weight, lbm (kg) experiment hardware	3,000 (1,360)	60 (27.2)	655 (298)	1,210 (549)	Maximum weight per unit
Volume, ft^3 (m^3)	1,100 (312)	2 (0.057)	22.5 (0.64)	45 (1.27)	Usable interior volume per unit
Power					
dc (W)	1,400 or 3,150	115	1,000		Total power dependent on number (1 or 2) of SSP SMCHs available
Ascent/descent (W)	600	Available	Available		
ac (VA)	690	Available	Available		Derived from dc power
Heat rejection (W)	4,000 (total)				
Passive air		60			Nominal locker capability
Forced air	1,400 - 2,000	-115	1,000		Required fans are user provided
Water	4,000 (if all water)		1,000 (up), 2,000 (down)		Cooling depends on position in loop
Ascent/descent	600				
Vacuum venting	1 vent and line	Available	Interface at each rack		Capability dependent on system
Data					
Serial digital input (8 bits)	9	Mission dependent	2		
Acquisition channels					
Discrete input low (0-5 V)	88	Mission dependent	16		Minimum rack level based on locker requirements. 2-rack level available to 1 rack on mission-unique basis
Discrete input high (0-28 V)	72	Mission dependent	12		
Analog input high (0-5 V)	160	Mission dependent	32		
Telemetry downlink rate via PDI (kbps)	16	16*	16*		Includes subsystem data
Closed-circuit television	1 channel, user video	Mission dependent	1		Orbiter CCTV, camcorder
Video display recording	Orbiter supplied	Mission dependent	Mission dependent		8mm camcorder, orbiter supplied
Timing					Orbiter payload timing buffer interface, additional signals mission dependent
Orbiter GMT signal	1	Mission dependent	1		
Orbiter MET signal	1	Mission dependent	1		
Ku-band signal processor	1	Mission dependent	1		48 Mbps
Experiment control/recording	Orbiter supplied	Mission dependent	Mission dependent		PGSC laptop, orbiter supplied
Command					
Discrete outputs (28 V pulsed)	40	Mission dependent	8		
Serial digital output (16 bits)	12	Mission dependent	2		

* Total module capability

Some of the accommodations listed above are optional services

SPACEHAB Accommodations

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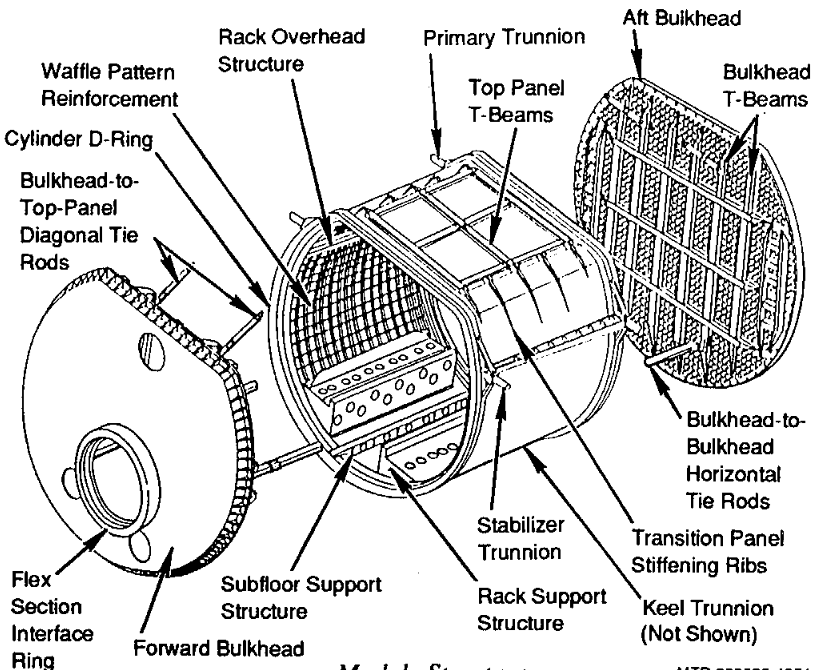


Module Structure

MTD 930525-4251

MATERIALS PROCESSING EXPERIMENTS

Equipment for Controlled Liquid-Phase Sintering Experiments (ECLiPSE)

The aim of this project is to develop composites of hard metals in a tough metal matrix. The combined properties of hardness for excellent wear and toughness for strength will create highly desirable new metals that are stronger, lighter, and more durable. The applications for such a composite are numerous—e.g., bearings, cutting tools, electrical brushes, contact points, and irregularly shaped parts for high-stress duty.

ECLiPSE investigates the liquid-phase sintering (LPS) of metallic systems. Sintering is a process by which metallic powders are consolidated into a metal at temperatures 25 to 50 percent lower than those required to melt all of the constituent phases. In LPS on Earth, a liquid coexists with the solid, which can produce sedimentation, resulting in a material that lacks homogeneity and dimensional stability. To control sedimentation effects, manufacturers limit the volume of the liquid. The ECLiPSE experiment will examine metallic composites at or above the liquid volume limit to more fully understand the processes and to produce materials that are dimensionally stable and homogeneous in the absence of gravity (no sedimentation).

This shuttle flight builds on the experience of other ECLiPSE flights on suborbital sounding rockets, which provide only one to three minutes of sample processing time. Now the longer flight durations of the shuttle are required. Because the ECLiPSE hardware was originally designed to fly in suborbital rockets, it is very automated and requires little crew interaction.

The Consortium for Materials Development in Space, a NASA CCDS based at the University of Alabama in Huntsville, developed the ECLiPSE equipment. It is planning more sounding rocket tests and future SPACEHAB missions as part of its sintered and alloyed materials project. Kennametal, Inc., and Wyle Laboratories are industrial partners on the project. The principal investigator is Dr. James E. Smith, Jr., of the University of Alabama.

Gas-Permeable Polymeric Materials

Monomers and activators will be mixed in a commercial refrigerator/incubator module to form membranes that can be permeated by gas. The space-made polymers will be compared with others made on the ground to determine any differences (and improvements) in characteristics.

Plastic materials are made of very large molecules called "polymers." Some polymers prevent gases, such as oxygen, from passing through. Others allow one or more gases to pass through. These gas-permeable polymeric materials have many uses. Possible applications include highly sensitive sensors, improved contact lenses, medical monitors, industrial process controllers, and commercial production of pure gases.

This experiment is sponsored by the Instrument Research Division of NASA's Langley Research Center through a joint NASA/industry program initiated in 1987. At least one more shuttle mission is planned.

Polymer Membrane Processing

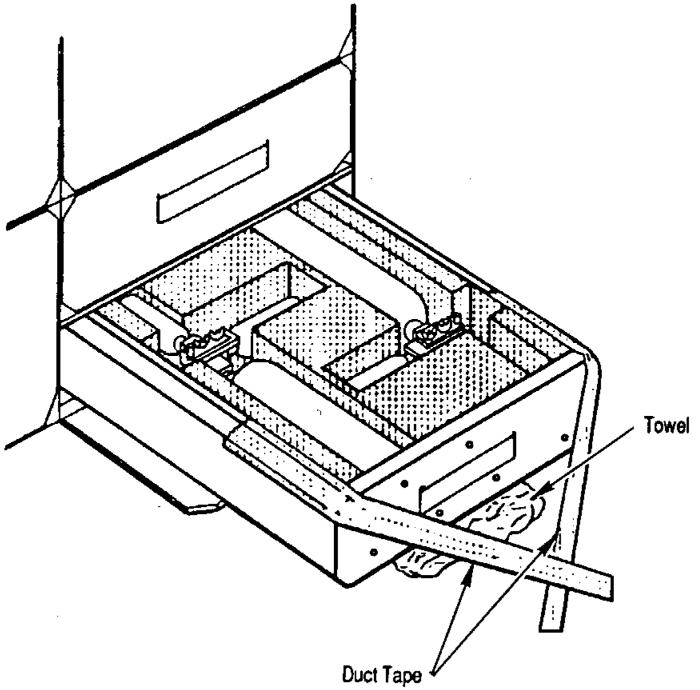
Mixed solvent systems will be evaporated in microgravity, and the porosity of polymer membranes will be controlled by induced convection so that investigators can learn more about the physical and chemical processes of polymer membrane formation in space. The improved knowledge base will be applied to commercial membrane processing techniques. The membranes, which are porous films, are widely used in industry as separation and filtration devices. They are also used to purify food, chemicals, drugs, and blood. Improved membranes may make their largest contribution in environmental monitoring by significantly reducing dangerous gas emissions.

This is the eighth shuttle flight for the PMP payload, sponsored by the Ohio-based Battelle Advanced Materials Center, a NASA CCDS. Amoco Chemical Co. and Du Pont Bend Industries are contributors. The principal investigator is Dr. Vince McGinnis of Battelle.

Liquid-Encapsulated Melt Zone

The float-zone process will be used to grow large, pure, homogeneous, and structurally perfect crystals. This is a major thrust in material science supported by the microgravity of space, which allows containerless processing for high purity and lack of stratification for uniformity. In this experiment, investigators will observe how the encapsulated material interacts with the melt and how gravity perturbation affects the system. The goal is to produce high-quality single crystals for semiconductors, complex diodes, nonlinear optics, and sensors needed by the next generation of high-speed digital circuits, optoelectronic devices, and transportation systems.

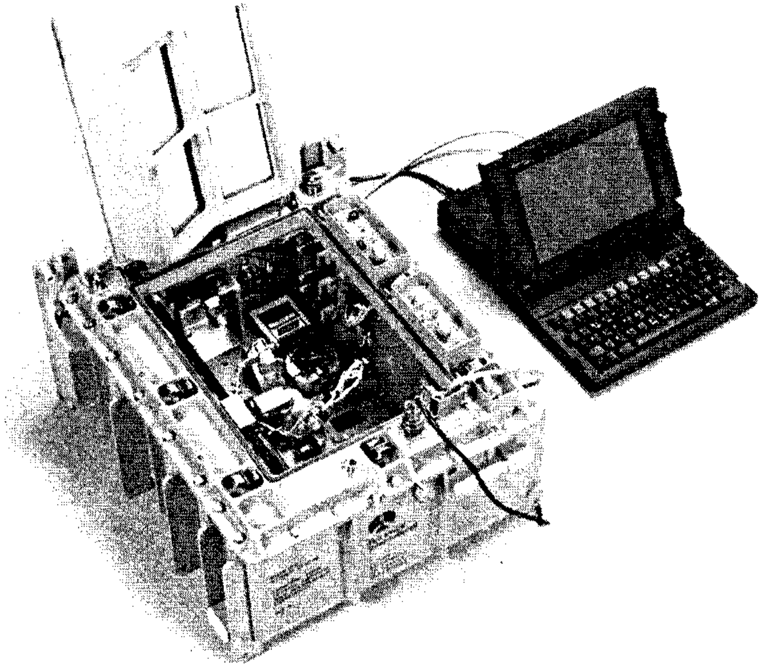
The hardware used in this experiment is the fluids experiment apparatus (FEA), a multipurpose experiment support system developed by a former industrial partner of the Consortium for Commercial Crystal Growth, Rockwell International's Space Systems Division. The FEA is a modular microgravity chemistry and physics laboratory operated by space shuttle flight crews. It supports materials processing research in crystal growth, general liquid chemistry,



IPMP Configuration

fluid physics, and thermodynamics. Experiment samples can be heated, cooled, mixed, stirred, or spun; processed in containers or in a semicontainerless floating-zone mode; installed, removed, or exchanged in flight; and measured for temperature, pressure, viscosity, etc. A portable computer can display and record data and control experiments.

In orbit, several indium-bismuth rods will be melted in the FEA. Indium-bismuth is a low-melting-temperature compound being used on STS-57 to test the value of liquid encapsulation. This is the first in a series of activities to determine the feasibility of producing commercial materials in space. Other materials of greater commercial interest will be used on future flights.



Fluids Experiment Apparatus

The experiment is sponsored by the Consortium for Commercial Crystal Growth based at Clarkson University in Potsdam, N.Y., a NASA CCDS. The payload was developed by the consortium's academic affiliate, the University of Florida at Gainsville. In addition to Rockwell International, the State of Florida Technology Research and Development Authority is part of the consortium team. The principal investigator is professor Reza Abbaschian of the University of Florida.

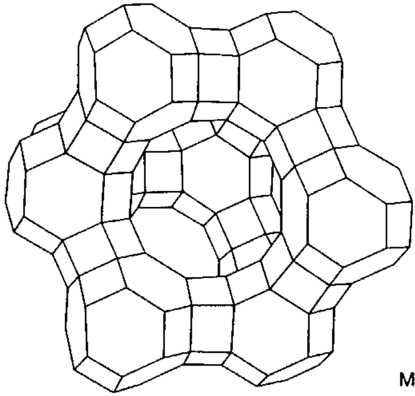
Zeolite Crystal Growth

Investigators will evaluate a furnace system for synthesizing zeolite crystals in space. Zeolites are complex arrangements of silica and alumina whose three-dimensional crystalline structure can be used to absorb elements or compounds selectively. This quality makes them ideal catalysts, molecular sieves, absorbents, and ion exchange materials. If superior space-grown crystals can be produced in mass quantities, they could drastically reduce the time required for dialysis, remove impurities from blood supplies, increase gasoline yield from crude oil processing, and make industrial processes more efficient.

This is the second flight of the ZCG payload, which was developed by the Battelle Advanced Materials Center in Columbus, Ohio, a NASA CCDS. The principal investigator is Dr. Albert Sacco, Jr., of the Worcester Polytechnic Institute in Worcester, Mass.

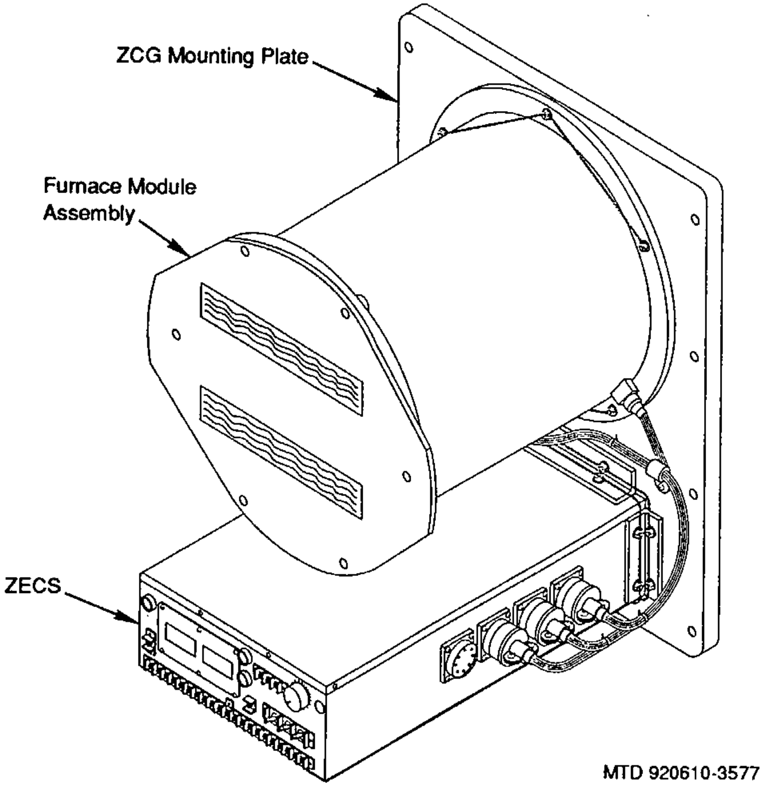
Support of Crystal Growth Experiment

This experiment will determine the proper autoclave mixing protocols for the zeolite crystal growth experiment to achieve best



MTD 920610-3601

Drawing of a Typical Zeolite Crystal



MTD 920610-3577

ZCG Flight Configuration

results. The crew member and principal investigator will observe and judge the mixture for several solutions and configurations, the goal being uniform mixing with minimum shear. Past experience in space, on the ground, and in sounding rockets demonstrates that optimum mixing is crucial to creating the optimum zeolite crystal. Sponsor and principal investigator are those listed above for ZCG.

LIFE SCIENCE EXPERIMENTS

ASTROCULTURE

Growing and tending plants in space will be necessary during long missions to reduce the cost of life support. Plants provide food, oxygen, and water, and they remove carbon dioxide from human space habitats. ASTROCULTURE is a self-contained hydroponic system designed to supply water and nutrients to plants grown in space. STS-57 is the second in a series of test flights to evaluate the system's critical humidification/dehumidification, irrigation, and lighting units before plants are introduced. Results are expected to reveal new information about efficient water and nutrient delivery in space, and on Earth. Each shuttle flight of ASTROCULTURE adds new capabilities and complexity.

Experiment hardware consists of two growth chambers containing inert material that serves as the root matrix; a porous stainless steel tube embedded in the matrix, a water reservoir, a pump, and appropriate valves for controlling the flow of water through the tube; a water recovery system; and a microprocessor for control and data acquisition functions.

In orbit, the water supply and recovery systems will be activated to circulate a nutrient solution through the porous tubes and into the matrix by capillary force. In the matrix, the small pores will be filled with the solution and the large pores with air. The recovery system will operate at several pressure levels to determine the rate at which the solution moves through the matrix and the capacity of the system to supply the matrix.

ASTROCULTURE is sponsored by the Wisconsin Center for Space Automation and Robotics, a NASA CCDS at the University of Wisconsin in Madison. The principal investigator is Dr. Raymond J. Bula of WCSAR. Industry affiliates include Automated Agriculture Association, Inc., Biotronic Technologies, Inc., Quantum Devices, Inc., and Orbital Technologies Corp.—all based in Wisconsin.

Bioserve Pilot Laboratory

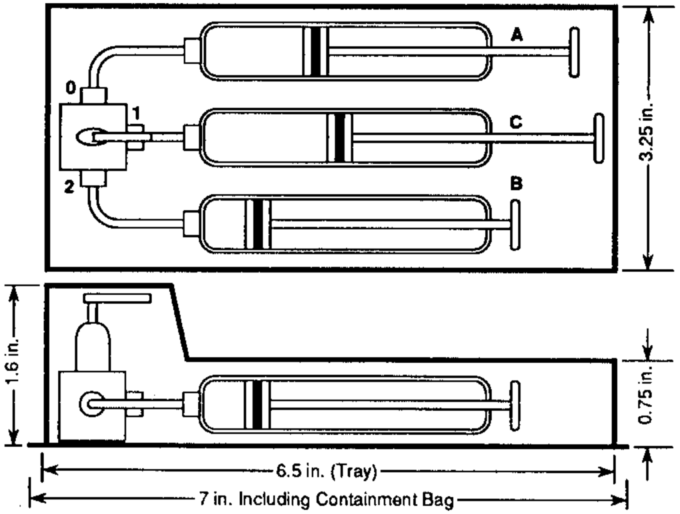
The purpose of Bioserve is to give businesses and scientists affordable access to space for preliminary experimentation in material and life sciences, particularly cell studies. It enables them to prove concepts and screen processes for more complex space research and development. On this flight, two series of tests concentrate on bacterial products and processes.

The first involves *Rhizobium trifolii,* bacteria that form a symbiotic relationship with legumes (e.g., alfalfa, clover, and soybeans): they infect the seedlings and feed off the nutrients while causing the growth of nodules on the roots that provide the plants with nitrogen from the air. Thus, legumes require no synthetic fertilizers, unlike important crops like wheat and corn that are never infected by the rhizobia. Investigators want to see if microgravity can influence infection in significant crops. The savings in fertilizer would be enormous.

The second test series concerns *E. Coli* bacteria, which live in the gastrointestinal tracts of mammals. Their genetic traits serve as models of bacterial infection and population dynamics as well as behavior useful in waste treatment and water reclamation. In addition, their genetic material has been manipulated to produce bacteria that secrete valuable pharmaceutical products. Bioserve tests will determine whether microgravity changes the growth or behavior of the bacteria—information that can be used to understand and control bacterial infection in closed biospheres, exploit bacteria and other micro-organisms in ecological life support and waste management systems, and enhance genetic engineering and pharmaceutical production of bacterial systems.

On STS-57, 40 bioprocessing modules stowed in a standard locker will contain the biological sample materials. Each module consists of an aluminum tray holding three syringes: one loaded with the cell culture and two containing fluids to start and end the process. For most of the investigations, simultaneous ground controls will be run with similar hardware and identical sample fluids so that ground personnel can activate and terminate processes in parallel with the flight crew.

Bioserve is sponsored by Bioserve Space Technologies, a NASA CCDS based at the University of Colorado at Boulder. Dr. Louis Stodieck and Dr. Michael Robinson are responsible for mission management.



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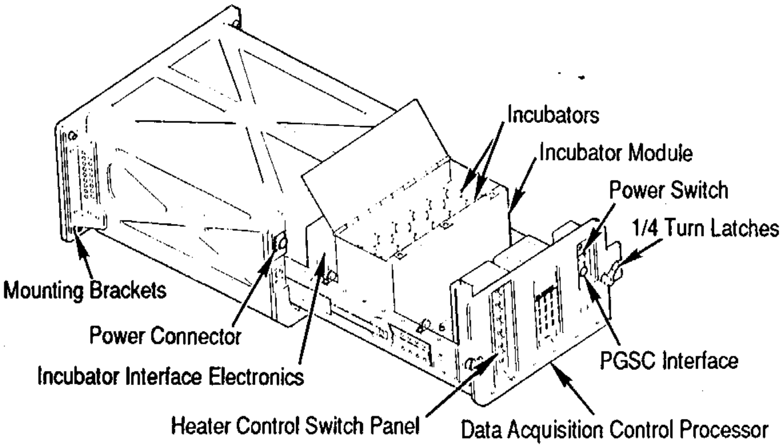
Bioprocessing Module

Commercial Generic Bioprocessing Apparatus

On this third of six planned flights, the CGBA will support 27 individual commercial studies in three broad areas.



GBA Module

Biomedical Testing and Drug Development. Eight biomedical test models will be used to study how microgravity affects biological organisms. Four focus on immune disorders; the other four concentrate on disorders in bone development, wound healing, and cell reproduction. The results should enhance understanding of cancer, osteoporosis, and AIDS.

Development of a Controlled Ecological Life Support System. Thirteen ecological test systems will be used to examine the effects of microgravity on micro-organisms, small animals, and plant life. Results will provide information with widespread application—e.g., new commercial opportunities in controlled agriculture, new pharmaceuticals that could be mass-produced on Earth, and manipulation of agricultural materials to produce valuable seed stock.

Manufacture of Biomaterials. Four kinds of biomaterial products and processes will be investigated: growth of large protein and RNA crystals for drug development, assembly of virus shells for drug delivery, bacterial formation of magnetosomes for use in electronics, and production of fibrin clots for potential replacement of skin, tendons, blood vessels, and corneas.

Results from all 27 tests will inform subsequent flight experiments and steps toward commercialization. The payload is sponsored by Bioserve Space Technologies and managed by those responsible for the Bioserve Pilot Laboratory.

Organic Separation

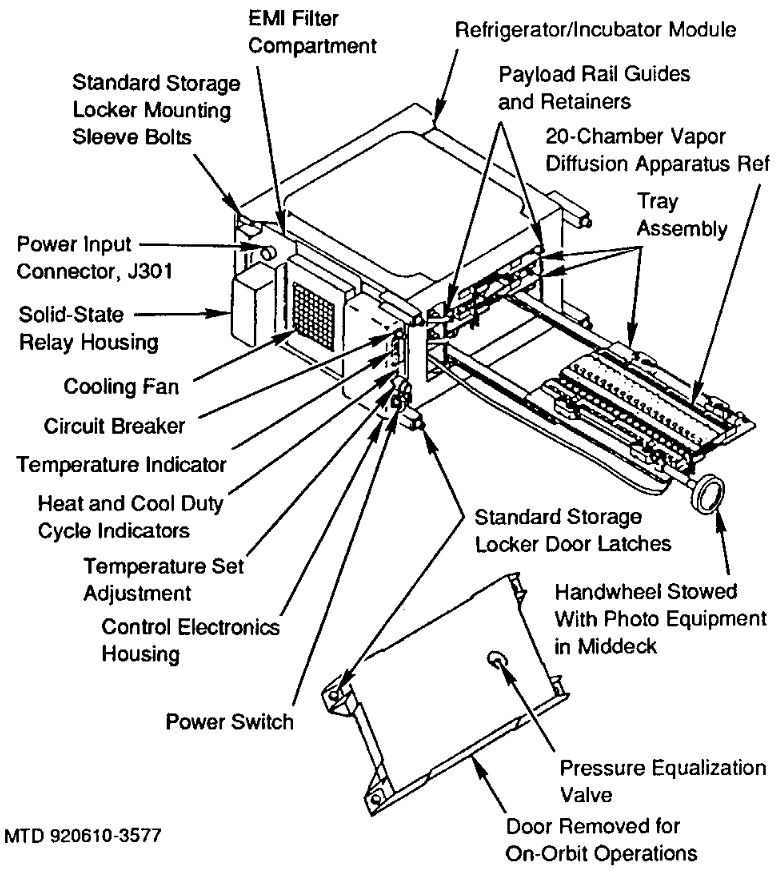
Techniques unavailable on Earth will be used to separate cells, particles, and molecules. These techniques produce purified samples for scientific study and reveal cell subpopulations that can be cultured and examined upon return to Earth. Four samples will be processed in SPACEHAB: Glutaraldehyde-stabilized cells, growth hormone granules, a dyed affinity ligand, and custom polystyrene latex particles.

A multisample, multistep, fully automated device built by Space Hardware Optimization Technology of Indiana separates nonbiological particles as well as biological cells, particles, macromolecular assemblies, and organelles by partitioning in liquid polymer two-phase systems. The hardware is designed to perform long-duration partitioning in microgravity because two to three hours are required for each separation step.

The Consortium for Materials Development in Space, a NASA CCDS based at the University of Alabama in Huntsville, developed the organic separation (ORSEP) payload. The principal investigator is Dr. James Van Alstine of the University of Alabama.

Protein Crystal Growth (PCG)

This payload will produce large, highly ordered crystals of various proteins that will be studied on Earth to determine their three-di-



PCG Flight Hardware

mensional structure. Proteins play a vital role in areas ranging from nutrition to disease fighting, and scientists want to know how structure causes function. They also want more information to refine the growth of high-quality crystals in space. Potential applications for space-grown protein crystals are numerous: new drugs, agricultural products, and bioprocesses for use in manufacturing and waste management.

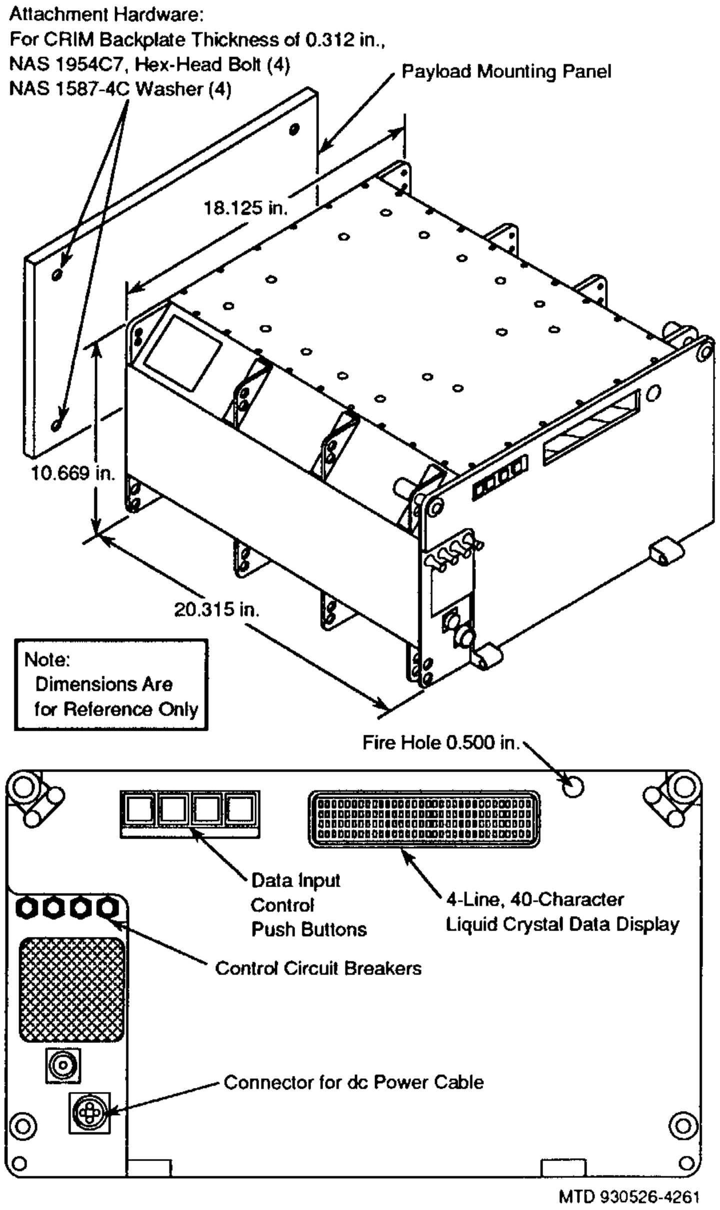
The sponsor of this experiment is the Center for Macromolecular Crystallography, a NASA CCDS based at the University of Alabama in Birmingham. This in the center's seventeenth protein crystal growth experiment aboard the shuttle. The principal investigator is Dr. Charles E. Bugg of the CMC. In addition, a number of companies are participating in the project: BioCryst Pharmaceuticals, Eli Lilly, Schering-Plough Research, Du Pont Merck Pharmaceuticals, Sterling Winthrop, Eastman Kodak, Upjohn, Smith Kline Beecham Pharmaceuticals, and Vertex Pharmaceuticals.

Vapor Diffusion Apparatus and Crystallization Facility Experiments. There are three PCG experiments on STS-57, two of which are contained in thermal control enclosures called commercial refrigerator/incubator modules (CRIMs). One CRIM will hold three vapor diffusion apparatus (VDA) trays at a temperature of 22°C. Protein and precipitant solutions will be stored and released by syringes.

A second CRIM will contain the protein crystallization facility (PFC), which uses changing temperature to produce protein crystals in microgravity. Each of its four containers holds up to 500 ml of protein solution. Once in orbit, the CRIM is programmed by the crew to begin slowly changing temperature in a profile that optimizes the crystallization process.

Direct-Control Protein Crystal Growth. A third crystallization system on STS-57 will test new protein crystal growth space hardware. Six syringes in a VDA tray will be contained in a thermal enclosure system (TES) that provides a hermetically sealed and thermally controlled environment. Within the TES, a crystal observation system (COS) will allow real-time crew monitoring during the growth period.

The COS video system allows crew members to observe individual experiments, focusing from the front of the droplet to the back, so that they can detect individual crystals, study their growth rate and morphology, and send video downlink images of the crystals to scientists in the Payload Operations and Control Center. This



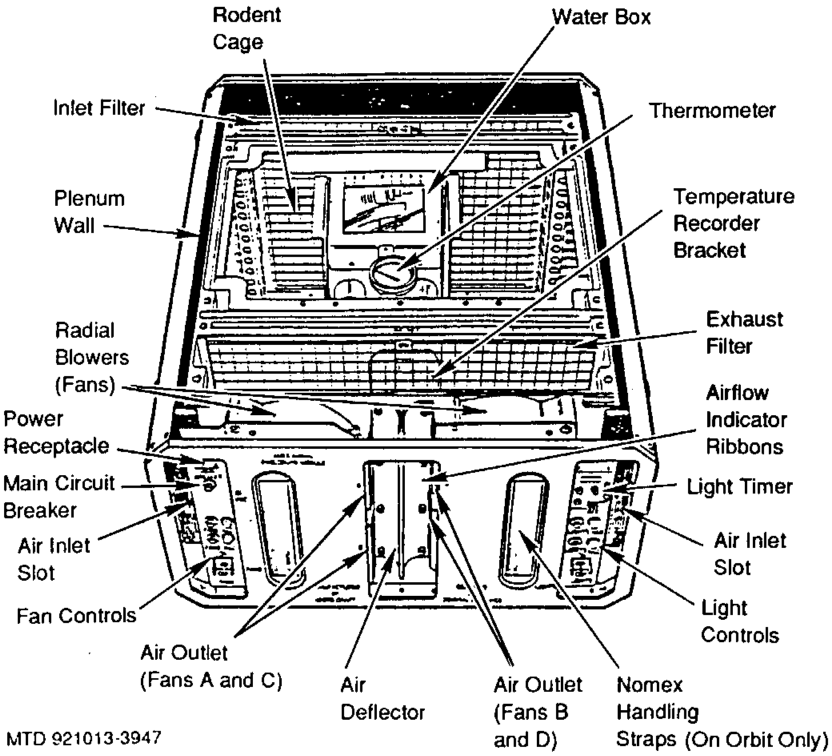
Commercial Refrigerator/Incubator Module Configuration

new hardware will provide critical information on differences in crystal growth rates and vapor equilibration times in the microgravity environment.

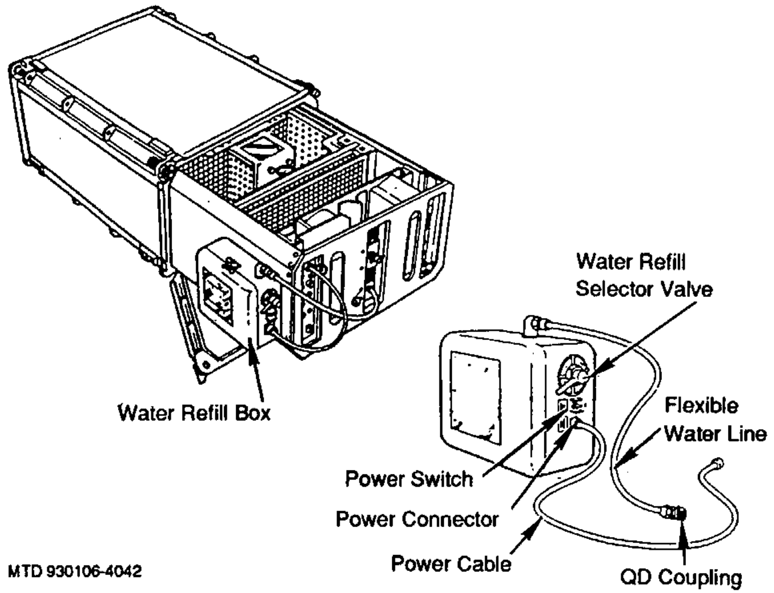
Industrial samples flown in each protein crystal growth system—the VDA, PFC, and COS—include malic enzyme, recombinant human insulin, and alpha-thrombin.

Physiological Systems Experiment

This experiment takes the first step in setting up a unique data base of space-related dermatology and conditions. Since microgravity seems to slow down the healing process, scientists want to con-



PSE Configuration



Water Refill Box Assembly

duct experiments that will enhance understanding of how growth factors regulate the tissue repair and regeneration process, not only in space but also on Earth. This information is relevant to long-term space missions and the treatment of Earth-bound burn victims, diabetics, elderly surgical patients, bed-sore sufferers, and other patients with slow-healing skin or soft-tissue injuries.

Twelve adult male rats implanted with growth factors will be housed in two completely self-contained units equipped with food and water. Upon return to Earth, the tissues surrounding the rats' implantation sites will be examined to determine the effect of the growth factors on the initial phases of tissue repair.

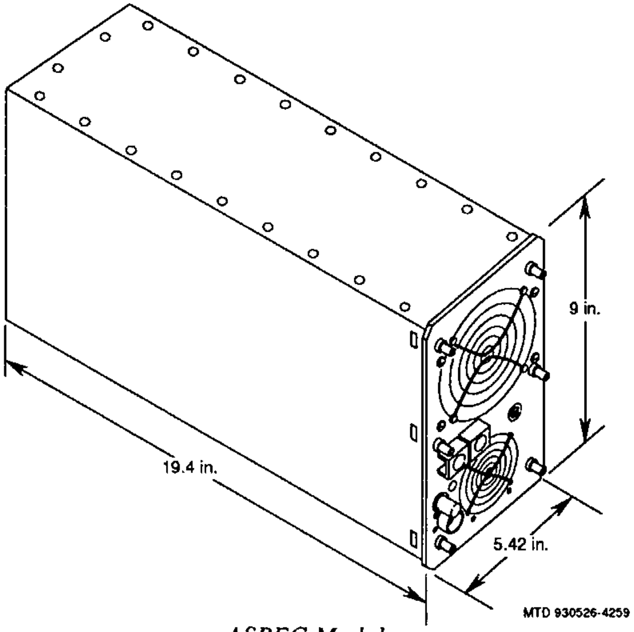
The Center for Cell Research, a NASA CCDS based at Pennsylvania State University, is sponsoring the experiment. This is the third physiological systems experiment the center has sponsored aboard the shuttle. Dr. W.C. Hymer and Dr. William W. Wilfinger of Penn State are co-investigators along with Dr. Steven R. Kohn of the Space Dermatology Foundation.

NASA JOHNSON SPACE CENTER INVESTIGATIONS

The following experiments are sponsored by the NASA Space and Life Sciences Directorate (SLSD) at JSC in Houston, Tex.

Application-Specific Preprogrammed Experiment Culture System

This system, which has flown a previous shuttle mission, is a set of self-contained cell-growing and maintenance units that can sustain a culture for up to 14 days. Suspension in microgravity allows high-fidelity cells to grow in every direction, which makes them ideal for testing treatments and understanding their growth processes. This payload will culture cancer cells as part of a bioreactor



ASPEC Module

project to develop hardware concepts that facilitate growth of human cells and tissue cultures in the weightlessness of space.

ASPEC is sponsored by the SLSD Medical Sciences Division. The shuttle ASPEC investigations serve as "foundation experiments" for the space station. Growing cells to full maturity may take several months, which requires a long-duration stay aboard the station. Dr. Glenn Spaulding is the principal investigator.

Charged-Particle Directional Spectrometer

Serving the functions of both a research instrument and working monitor, the CPDS detects and records the different kinds of nuclear radiation that bombard an orbiting spacecraft. It will gather information to characterize the orbital particles—cosmic rays and debris trapped by Earth's magnetic field—and record the level and kind of exposure crew members experience. The information will augment research in physics and medicine, and measurements of how much damage the particles cause when they pass through human beings will be used to establish guidelines for the long-term welfare of astronauts. Several CPDSs are expected to be standard equipment aboard a future space station.

The Solar System Exploration Division of SLSD is the CPDS sponsor. Dr. Gautam D. Badwar is the principal investigator.

Human Factors Assessment

Human factors engineers are mainly concerned with learning how human interfaces with equipment and the environment in microgravity affect crew productivity and mission success. This mission will evaluate three different factors: acoustic and lighting environments inside the shuttle orbiter, movement from the middeck through the transfer tunnel into SPACEHAB, and electronic performance of flight procedures versus paperwork. Results will contribute to design concepts for more efficient work areas and equipment in the future, particularly important for upcoming long-duration space missions.

The SLSD Crew Interface Analysis Section of the Flight Crew Support Division is the sponsor of this experiment. The principal investigator is Sue Adam.

Neutral Body Posture

The last in-depth study of changes in body posture during a space mission was conducted by the Skylab program in the early 1970s. Past experience shows that, over the course of time in a weightless environment, people assume a unique posture; their spines elongate, among other things. New data is needed for the design of future space facilities, workstations, and hardware.

The sponsor of this experiment is the SLSD Flight Crew Support Division. Principal investigator is Frances E. Mount.

Tools and Diagnostic Systems

Crew members inside SPACEHAB will demonstrate and evaluate equipment and methods for maintaining experiment hardware in orbit, a necessity for future space station missions. The tools and equipment, off-the-shelf items modified for use in space, are intended for diagnosis and repair of hardware aboard the space station. In this demonstration, a crew member will solder (first time on a U.S. space mission) and then desolder connection points on printed circuit boards while evaluating two types of foot restraints designed for precision tasks. To assess the diagnostic equipment, a crew member will respond to a simulated flight failure with a developmental space station caddie containing a function sweep generator, logic analyzer/oscilloscope, and multimeter.

The SLSD Flight Crew Support Division sponsors this demonstration. Jackie Bohannon is the principal investigator.

SPACE STATION ECLSS FLIGHT EXPERIMENT

The projected crew of four aboard the space station will use about 50 pounds of water a day. Without an efficient water reuse system, about 10 tons of water would have to be sent to the space station every 90 days on special space shuttle flights. This NASA flight experiment will test a new prototype water recycling system that is being developed for the space station. During tests conducted in 1992 at the Marshall Space Flight Center, the system successfully recycled shower/wash water and urine—even perspiration and respiration extracted from the air—into potable drinking water. Now NASA wants to see if it works as well in space.

Three pieces of recycling hardware—a bellows tank, a gas/water phase separator, and two unibeds (filters)—will be housed in two containers. The bellows tank features a see-through window that allows the crew to observe how gas and water behave inside the tank. The phase separator separates the gas from the mixture.

Potassium iodide (simulating a wastewater contaminant) will be introduced into a half-gallon of pure water. The mixture will then be run through the unibed filters to test both the efficiency of the unibeds in purifying the water and the rate at which the unibeds are depleted.

This experiment is sponsored by NASA's Space Station Office in Reston, Va. Industry affiliates are Boeing Aerospace, Life Systems, and Hamilton Standard. Principal investigators are MSFC in Huntsville, Ala., and Boeing Aerospace.

MICROGRAVITY MEASUREMENTS

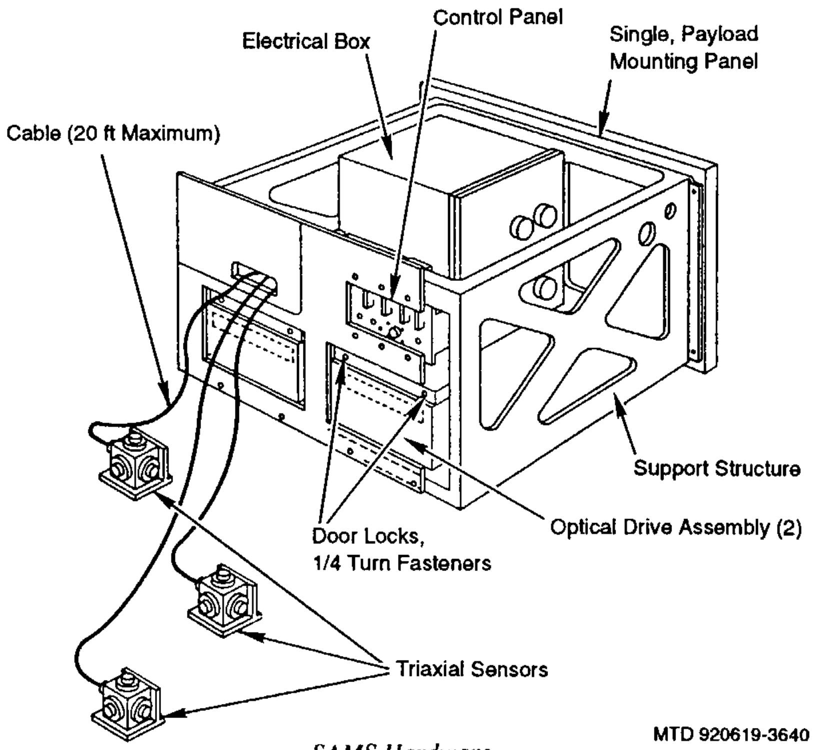
Three-Dimensional Microgravity Accelerometer

Three instruments will measure deviations from zero gravity in three dimensions inside SPACEHAB at different locations so that researchers can determine their effect on experiment results. Measurements of disturbances caused by the operation of the experiments, the orbiter's rotational motions, and vehicle drag will be used to calculate the level of SPACEHAB microgravity.

The Consortium for Materials Development in Space, a NASA CCDS based at the University of Alabama in Huntsville, is the sponsor of this payload. Jan Bijvoet of the University of Alabama is the principal investigator.

Space Acceleration Measurement System

SAMS will measure low-level accelerations caused by experiment operation, amplify the sensor signals, convert them to digital data, and store them on optical disks for downlink to a ground con-



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SAMS Hardware

trol center. There, scientists and principal investigators of SPACEHAB experiments will review the data for events that could affect their experiment results. This information, and data from previous missions, will be used to reduce and isolate experiment disturbances on future missions, including space station research projects.

SAMS is sponsored by NASA's Lewis Research Center, which also designed and developed the hardware. The principal investigator is Charles Baugher.

EUROPEAN RETRIEVABLE CARRIER (EURECA) RETRIEVAL

EURECA is a reusable free-flying spacecraft that was deployed from the shuttle Atlantis on STS-46, August 1, 1992, and has spent 10 months in orbit conducting microgravity processing and space science experiments. Sponsored by the European Space Agency, EURECA is an element of the ESA Spacelab development program and extends the capabilities of Spacelab because it can remain in orbit longer than Spacelab.

This first in a series of EURECA missions was devoted primarily to materials processing and life science payloads. Future missions will carry space science payloads, particularly in the fields of astronomy and solar physics, and Earth conservation payloads. The spacecraft can also be used to test interorbit communications, rendezvous, and docking. Much of the research conducted on EURECA applies to the future space station.

After the EURECA spacecraft was deployed from the shuttle's payload bay, its on-board propulsion unit boosted it to an operational altitude of about 270 nautical miles. During STS-57, the satellite will rendezvous with the orbiter, and the shuttle crew will capture the satellite with the orbiter's remote manipulator system, place it in the orbiter's payload bay, and return it to Earth, where investigators will evaluate the experiments and refurbish the satellite for its next mission.

EURECA has a five-mission or 10-year lifetime. It has been designed for low-cost ground and flight operations and for a short turnaround time between flights.

Besides offering frequent, low-cost flight opportunities, EURECA has been designed to meet all known requirements of space platform users and will establish a reusable-platform concept that can be adapted to meet evolving needs. Another important goal of the program is to develop an initial platform that meets the essential design, operational, and programmatic requirements of future space station elements.

The EURECA-1 mission consisted of 15 experiments in the fields of material science, life sciences, and radiobiology. Some of the investigations involve protein crystallization, the biological effects of space radiation, measurements of fluids' critical points in microgravity, measurements of solar irradiation, the solar-terrestrial relationship in aeronomy and climatology, and electric propulsion in space.

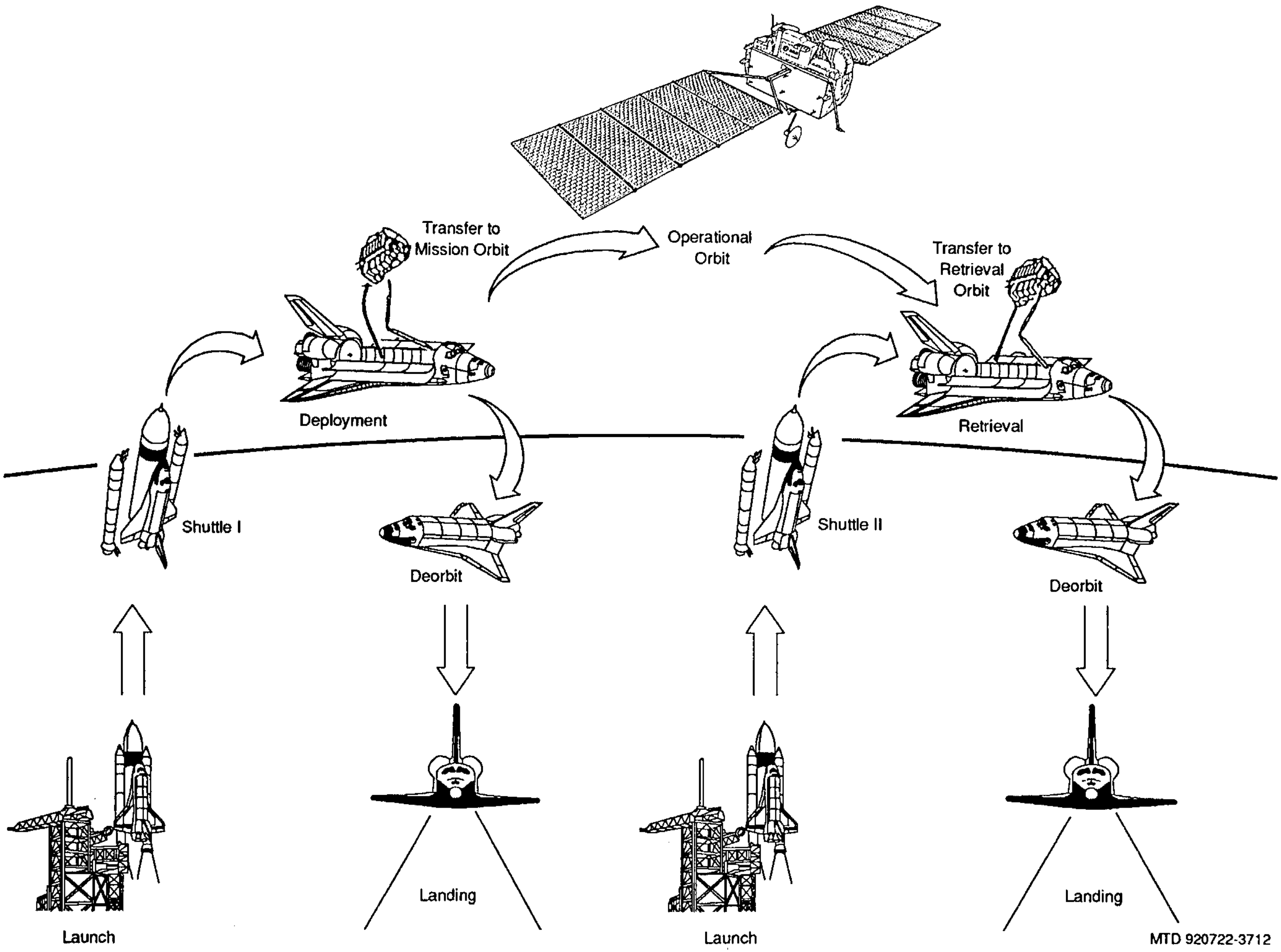
Scientists from Belgium, Germany, Denmark, France, Italy, Great Britain, and The Netherlands are participating in the mission.

The ESA Space Operations Centre in Darmstadt, Germany, controls all EURECA operations. During the deployment and retrieval of the satellite, ESOC operates as a remote payload operations control center of NASA's Mission Control Center in Houston and uses the orbiter as a relay station for commanding the EURECA spacecraft. During the operational phase, ESOC transmits commands to EURECA through two ground stations. Since EURECA is out of contact with the ground stations most of the time, it has been designed to operate with a high degree of autonomy.

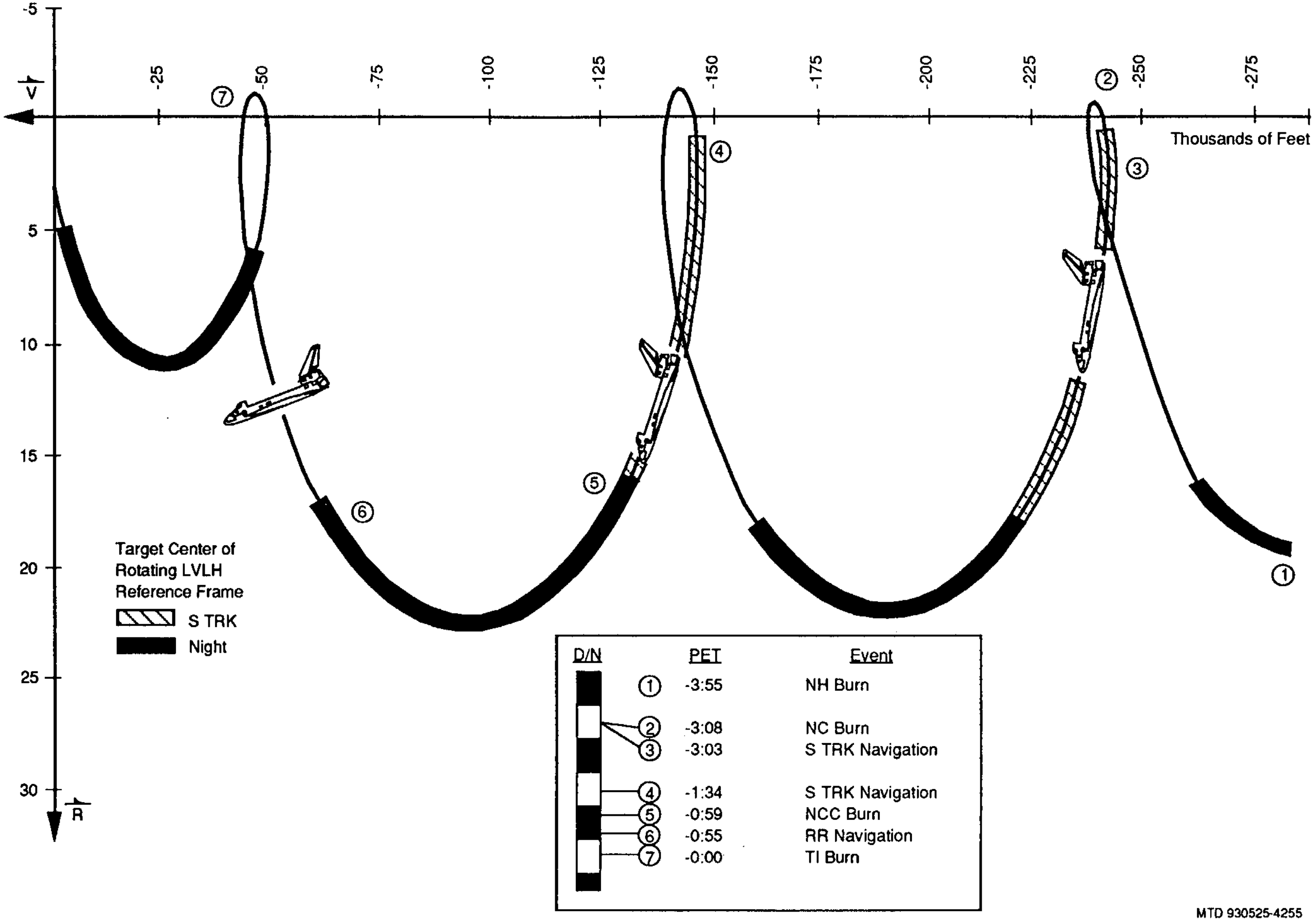
One of the payloads on EURECA-1, the interorbit communication package, is used to demonstrate communication via a data relay satellite. Such a system could significantly enhance real-time data coverage, and ESA plans to use the IOC on future EURECA missions.

EURECA RETRIEVAL

After STS-57 is successfully launched, the ESA Space Operations Centre in Darmstadt, Germany, will command EURECA to

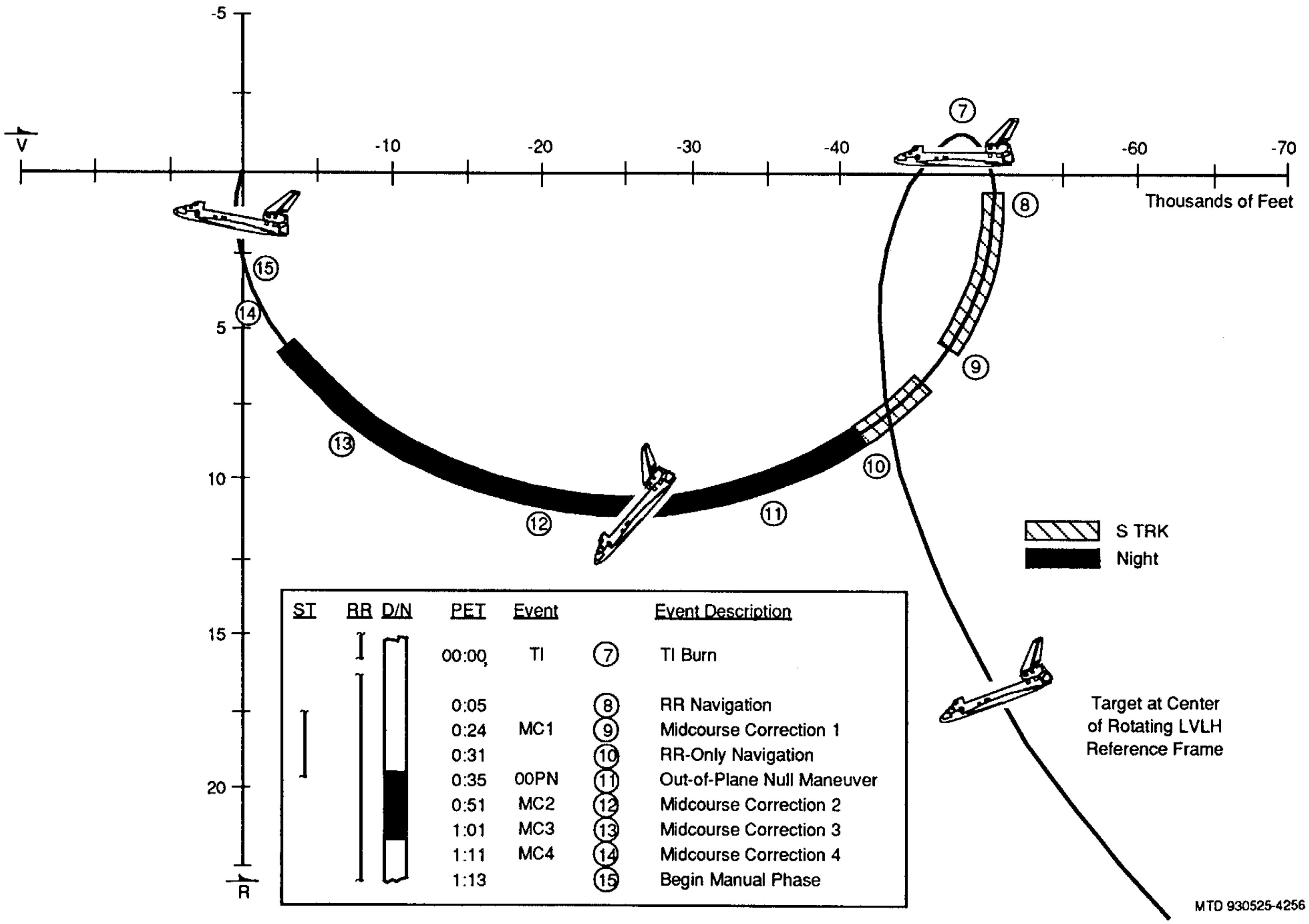


EURECA Flight Scenario



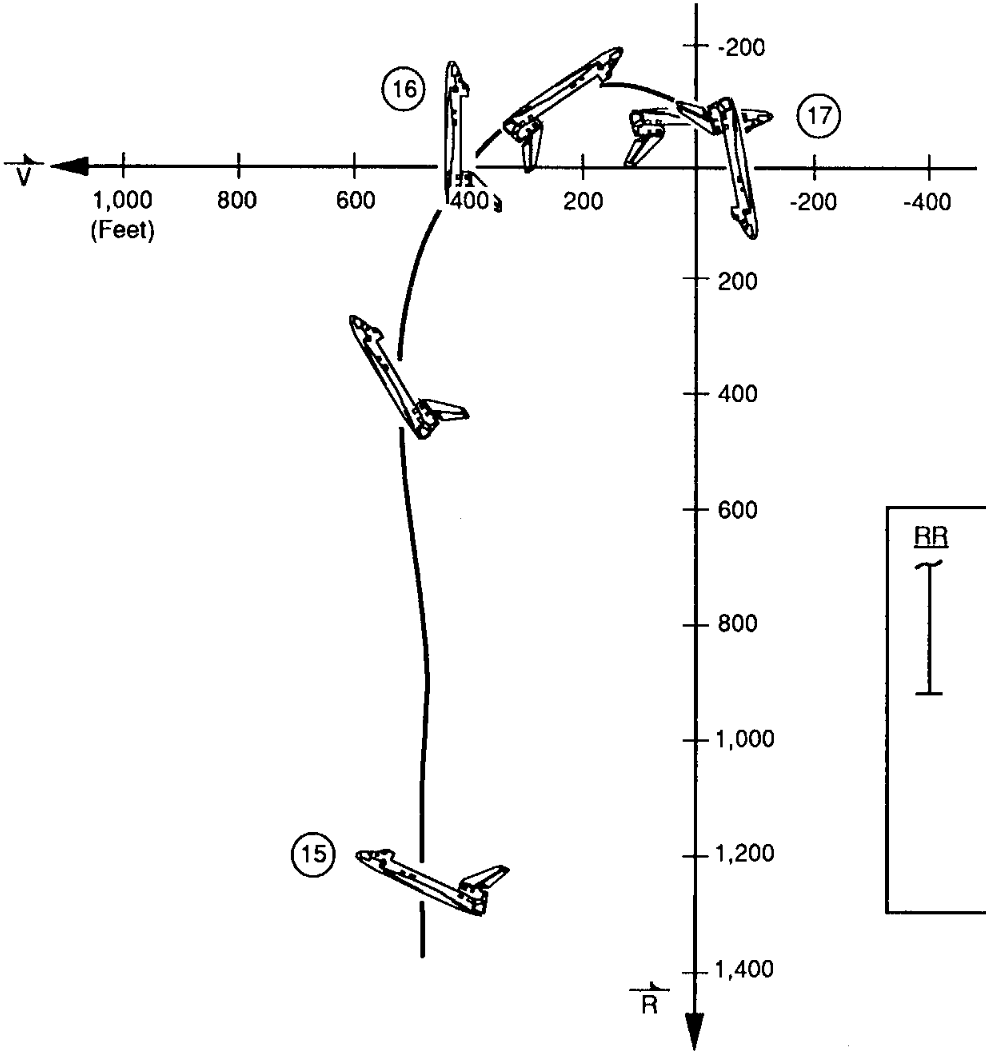
D/N		PET	Event
	①	-3:55	NH Burn
	②	-3:08	NC Burn
	③	-3:03	S TRK Navigation
	④	-1:34	S TRK Navigation
	⑤	-0:59	NCC Burn
	⑥	-0:55	RR Navigation
	⑦	-0:00	TI Burn

Rendezvous Profile



ST	RR	D/N	PET	Event		Event Description
			00:00	TI	⑦	TI Burn
			0:05		⑧	RR Navigation
			0:24	MC1	⑨	Midcourse Correction 1
			0:31		⑩	RR-Only Navigation
			0:35	00PN	⑪	Out-of-Plane Null Maneuver
			0:51	MC2	⑫	Midcourse Correction 2
			1:01	MC3	⑬	Midcourse Correction 3
			1:11	MC4	⑭	Midcourse Correction 4
			1:13		⑮	Begin Manual Phase

Post-TI Profile



RR	D/N		Time	Event Description
		⑮		Continuation of Manual Phase
		⑯	~1:37	V-Bar Crossing
				Continue Inertial Approach
		⑰	~2:15	Arrive at 35 ft

MTD 930525-4257

Manual Phase Profile

lower its orbit from 270 to 257 nautical miles above Earth, where it will become a stabilized, passive target for the shuttle. On the third day of the mission, the shuttle will rendezvous with the free flyer and use the remote manipulator system to grapple it. The solar panels will fold up flat against EURECA's sides, and the RMS will stow the whole package in the shuttle payload bay for return to Earth. As of May 1, 1993, 87 percent of the EURECA experiment requirements had been fulfilled.

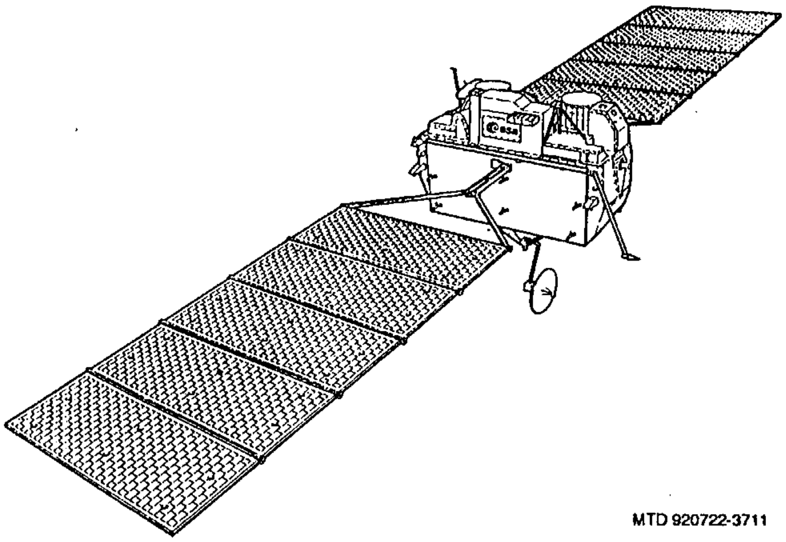
THE EURECA SPACECRAFT

EURECA's framework consists of high-strength carbon-fiber struts and titanium nodes. This structure is easy to assemble and maintain and is subject to relatively low thermal distortion. EURECA uses a standard three-point latching system for attaching to the shuttle payload bay. The spacecraft and its payloads weigh approximately 10,000 pounds.

EURECA uses active and passive heat transfer systems for thermal control. The active system consists of a Freon cooling loop that rejects heat generated by payloads to space. Multilayer insulation and electrical heaters form the passive system.

On orbit, EURECA generates, stores, conditions, and distributes electrical power to its subsystems and payloads. Retractable solar array panels and four 40-amp-hour nickel-cadmium batteries provide a continuous supply of 1,000 watts of electrical power.

For flight operations and orbit control maneuvers, attitude determination and spacecraft orientation and stabilization are provided by EURECA's attitude and orbit control subsystem. The AOCS has been designed to meet all mission requirements, even if the on-board subsystem that receives and executes instructions is not available for up to 48 hours. The AOCS includes the orbit transfer assembly, which boosts EURECA from its deployment altitude of 162 nautical miles to its operational orbit and returns it to the shuttle for retrieval.



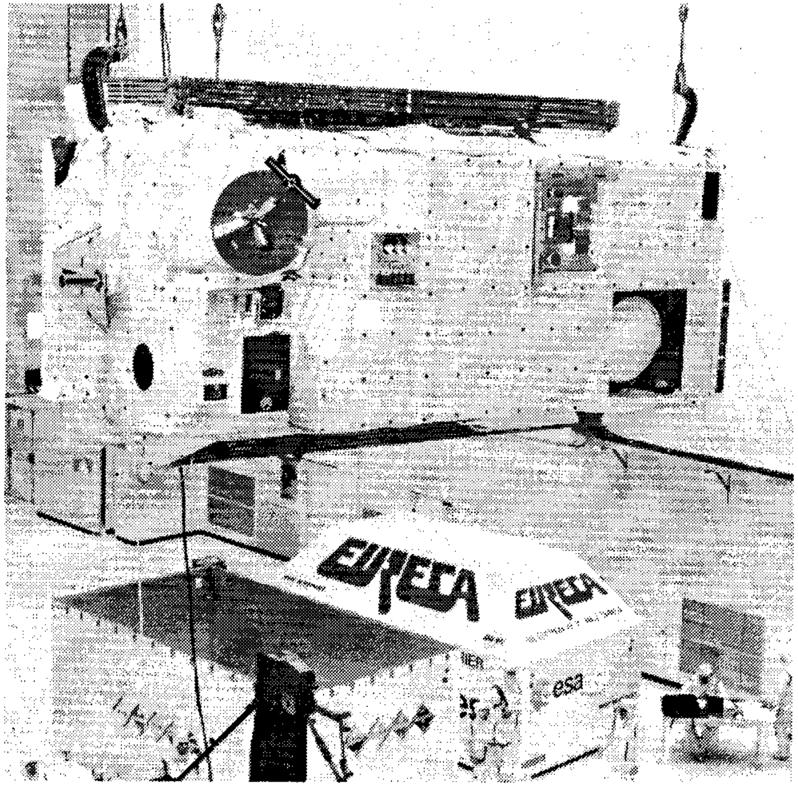
EURECA Flight Configuration

Remote control and autonomous operations are functions of the data handling subsystem. Instructions are stored and executed, telemetry data is stored and transmitted, and the spacecraft and its payloads are controlled when EURECA is out of contact with the ground through the DHS.

SCIENCE

Automatic Mirror Furnace (AMF)

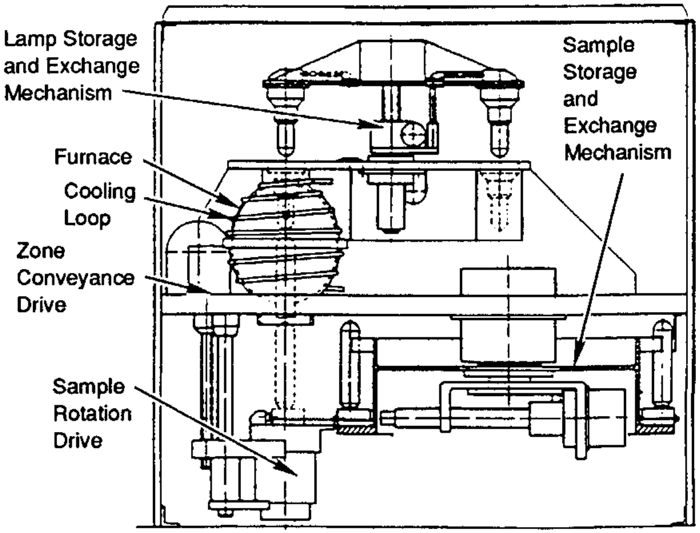
The objective of the AMF investigation is to grow single, uniform crystals from electronic materials in liquid or vapor phases using either the traveling heater or Bridgman method. The AMF is an optical radiation furnace that uses a halogen lamp to heat the samples. Radiation from the 300-watt lamp is focused on the material by



Workers in KSC Vertical Processing Facility Transfer EURECA to Test Cell

an ellipsoidal mirror. The AMF can produce temperatures of up to 1,200°C, depending on the sample being used.

Two mirror furnaces have been flown on Spacelab missions, but the AMF is the first of a new type of crystal growth facility that has a sample and lamp exchange mechanism. AMF operations are fully automatic, and it can process up to 20 samples during a 6-month mission.



MTD 920721-3713

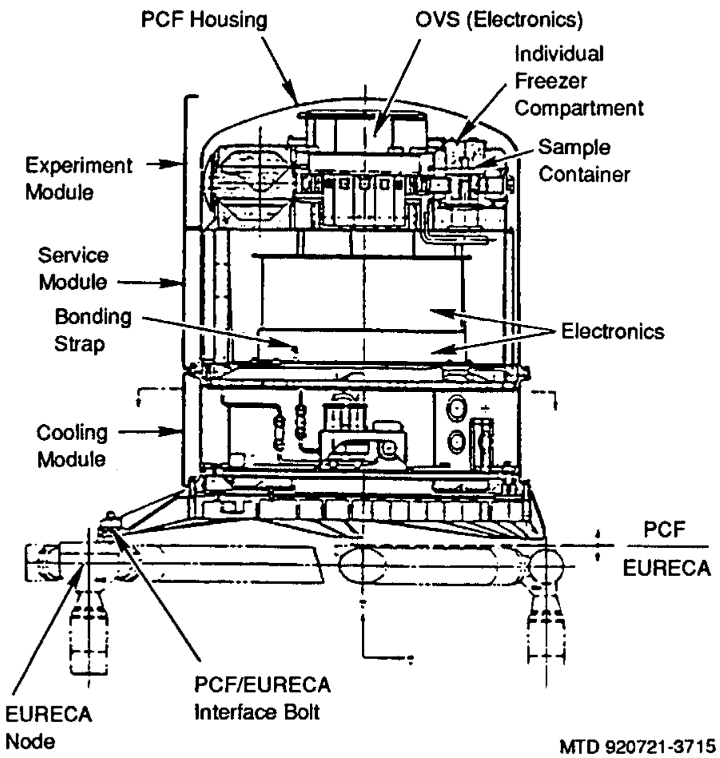
Automatic Mirror Furnace

K.W. Benz of the Kristallographisches Institut, University of Freiburg, Germany, is the principal investigator.

Protein Crystallization Facility (PCF)

The PCF is designed to take advantage of months-long exposure to microgravity to grow large, pure crystals from solutions. It can grow up to 12 crystals simultaneously in individual independently controlled experiments.

Each sample canister contains three solutions: protein, buffer, and salt. The protein and salt solutions diffuse into the buffer solution, and the salt causes the protein to form crystals. During the crystallization process, the processing temperature must remain within a small range, and the quality of the crystals produced depends on the temperature chosen.



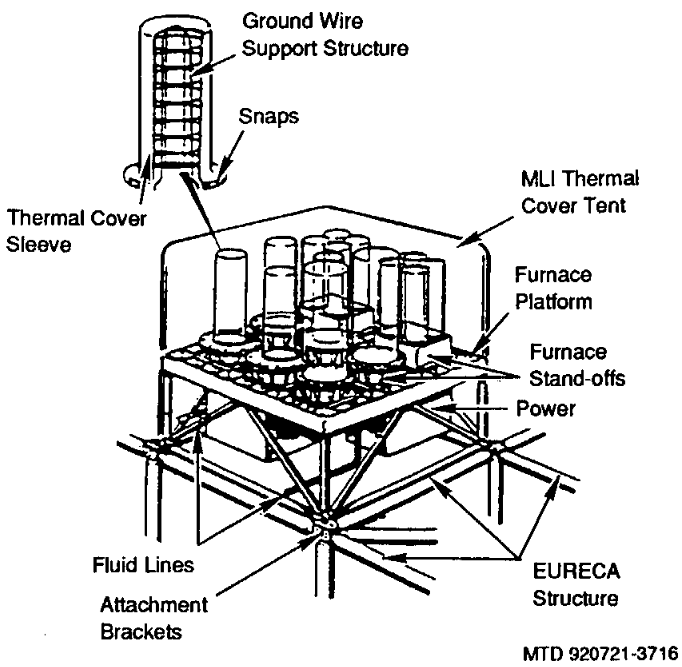
Protein Crystallization Facility (Excluding Battery Package)

The PCF is equipped with a video system that transmits still pictures of the processing to the ground to allow researchers to assess progress.

The principal investigator for the PCF is W. Littke of Chemisches Laboratorium, University of Freiburg.

Multifurnace Assembly (MFA)

The MFA accommodates as many as 12 furnaces that can process a wide range of materials. It subjects the material samples to predefined thermal conditions and can generate and transmit housekeeping data.



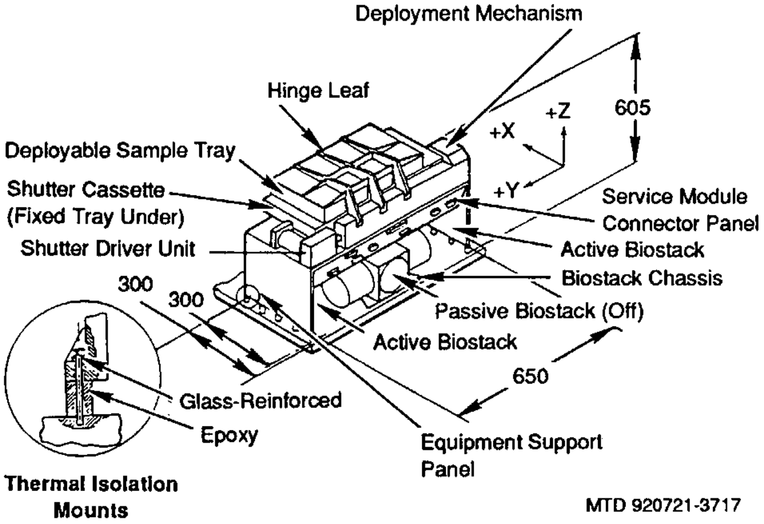
Multifurnace Assembly

The principal investigator is A. Passerone of the Italian National Research Council's Ist. di Chimica Fisica Applicata dei Materiali.

Exobiology and Radiation Assembly (ERA)

ERA experiments examine the biological effects of space radiation. It exposes biological and life science samples to the vacuum of space and deep-space radiation to increase knowledge of the interaction of cosmic ray particles with biological matter, the synergism of space vacuum and solar ultraviolet, and the spectral effectiveness of solar ultraviolet on viability.

The ERA is a boxlike structure that is open on one side. It houses six cylindrical biostacks that contain dormant biological samples and radiation detectors. Two of the biostacks also have electronic units that operate light-emitting diodes and monitor the biostacks' internal temperature. The ERA is equipped with deployable trays which expose biological samples to space radiation. Optical bandpass filters are used to select the type of radiation the samples are exposed to.

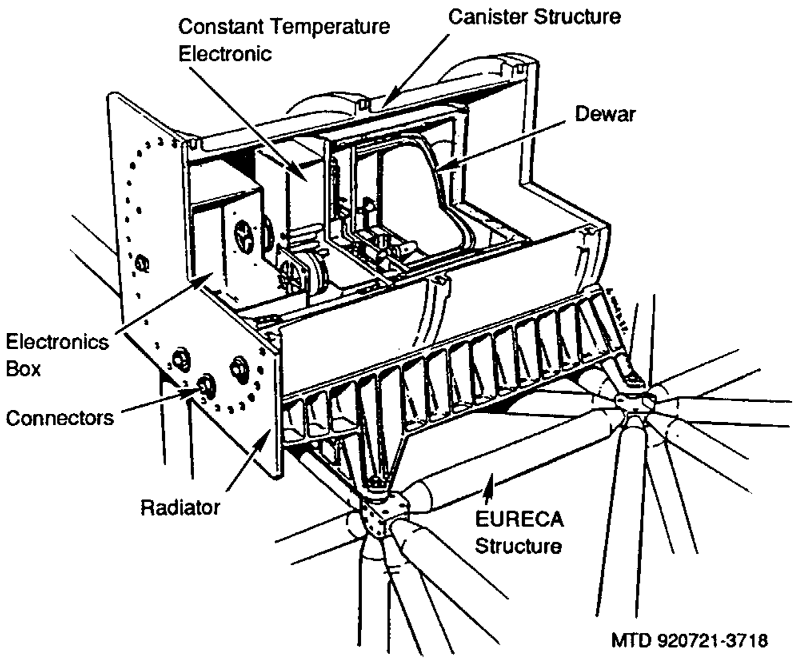


Exobiological and Radiation Assembly

H. Bücker of the German Aerospace Research Establishment's Institut für Flugmedizin Abteilung Biophysik is the principal investigator.

High-Precision Thermostat (HPT)

HPT measures the adsorption coefficient of sulfur hexafluoride close to its critical point on graphite carbon so that researchers can better understand the basic physics around the critical point of fluids. This experiment uses a new volumetric technique to measure the adsorption coefficient at various temperatures from the reference temperature to near the critical temperature. Results will be compared with measurements obtained on Earth and with theoretical predictions.



High-Precision Thermostat

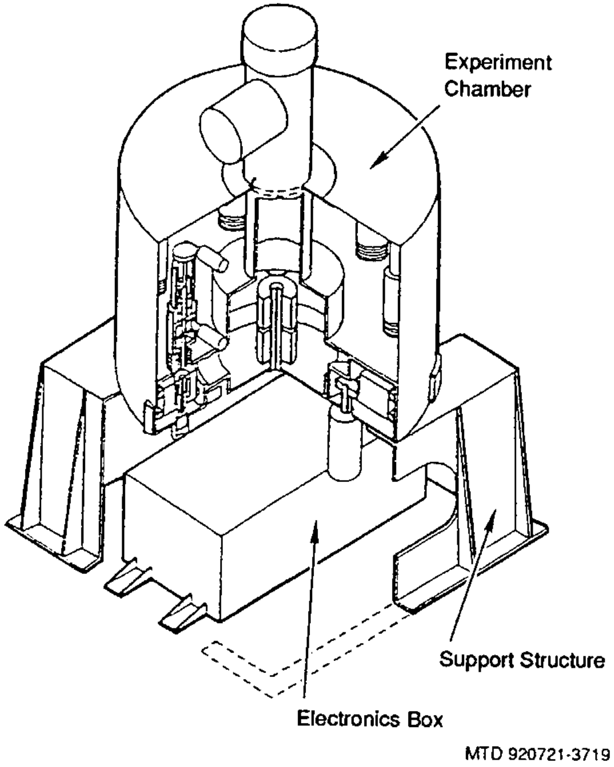
The experiment is housed in a getaway special container. It has two stepper motors that adjust the densities of the reference and measuring cells.

The principal investigator is G. Findenegg of the Ruhr University, Bochum, Germany.

Surface Forces Adhesion (SFA)

By investigating the mechanisms of adhesion between solid bodies, the SFA experimenters will refine their understanding of phenomena related to adhesion, such as friction and wear. The findings will allow them to investigate the use of cold welding techniques in space and will be used to assess the suitability of using adhesion to position solid bodies in microgravity.

The SFA fires small 0.3- to 0.5-kilogram spherical projectiles against a target plane. The restitution coefficient of the rebound after the collision is measured as a function of the incoming velocity of the projectile. Approximately 172,000 projectiles are launched at the targets.

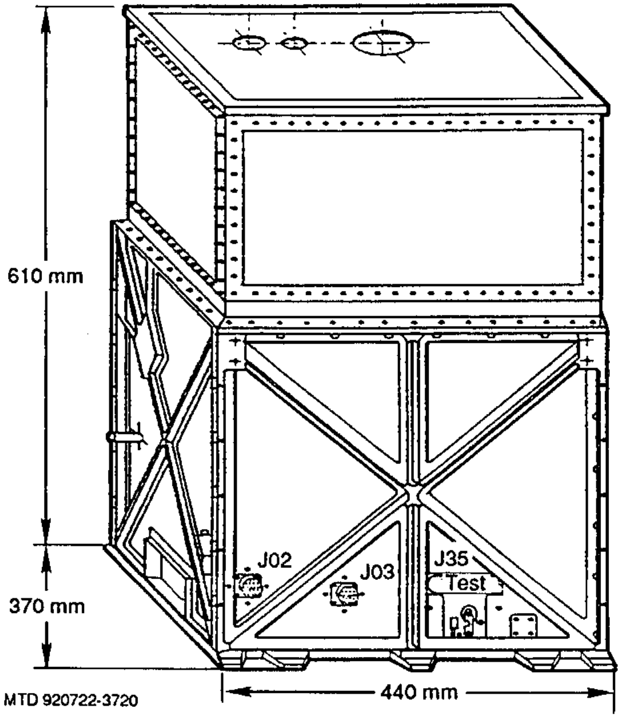


Surface Forces Adhesion

The principal investigator for SFA is G. Poletti of the University of Milan, Italy.

Solar Spectrum (SOSP)

The SOSP experiment studies solar physics and the solar-terrestrial relationship as it relates to the upper atmosphere and climate. The SOSP instrument measures the absolute solar irradiance and its variance from 170 to 3,200 nm. Two or three EURECA missions will be needed to measure and assess long-term variations in solar irradiance.

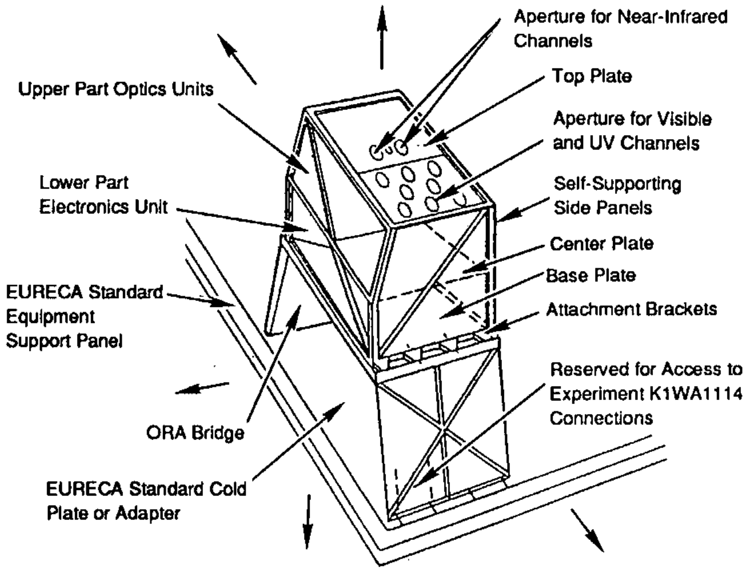


Solar Spectrum

G. Thuillier of Service d'Aeronomie du Centre National de Recherche Scientifique, France, is the principal investigator.

Occultation Radiometer (ORA)

The ORA samples the attenuated solar radiance during the sunrise and sunset phases of each orbit to measure the density of aerosols and trace gases in the Earth's menosphere and stratosphere. ORA has two separate optical detectors: one for visible and ultraviolet light and one for infrared light. The validity of its measurements is dependent on EURECA maintaining its sun-pointing accuracy.



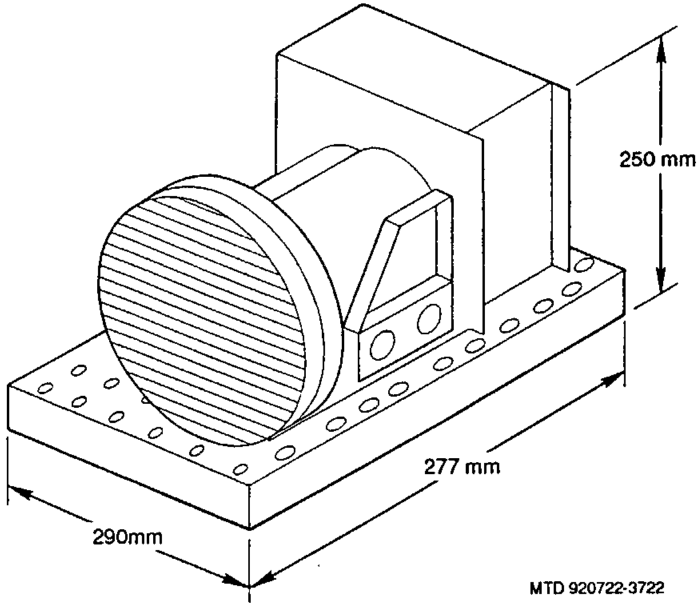
MTD 920722-3721

Occultation Radiometer

E. Arijs of Belgisch Instituut voor Ruimte Aeronomie, Brussels, Belgium, is the principal investigator.

Wide-Angle Telescope for Cosmic Hard X-ray Transients (WATCH)

The primary objective of this investigation is to detect and locate X-ray transients and gamma ray bursts. A secondary objective is to monitor persistent, bright X-ray sources within the instrument's field of view.



MTD 920722-3722

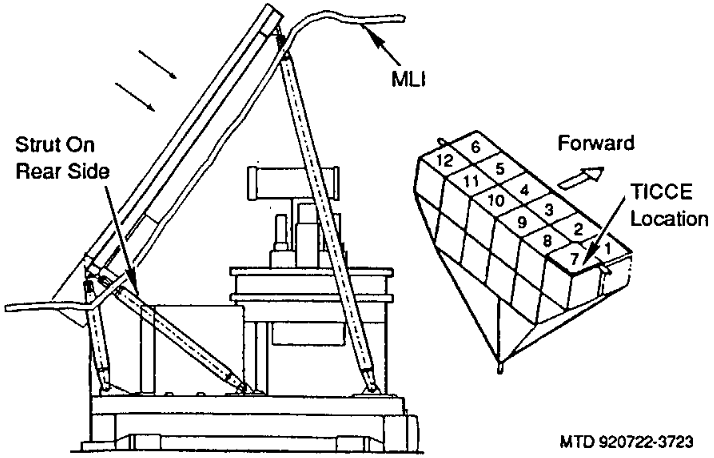
Wide-Angle Telescope for Cosmic Hard X-Ray Transients

WATCH can detect celestial gamma and X-ray sources with photon energies from 5 to 200 keV and determine their positions. The data gathered can be used for several purposes, including identifying regularities in the time variations related to orbital movement or rotation or spectral features that reveal more about the source.

The principal investigator is N. Lund of the Danish Space Research Institute, Lyngby, Denmark.

Timeband Capture Cell Experiment (TICCE)

The TICCE instrument captures micron-size particles in near-Earth space for postmission analysis. Investigators will examine the instrument after it is returned to Earth to determine the rate of particle impact, the angle of incidence, and the timeband when each particle arrived. They will also be able to identify the microparticle residue and arrive at conclusions about the origin of the particles.

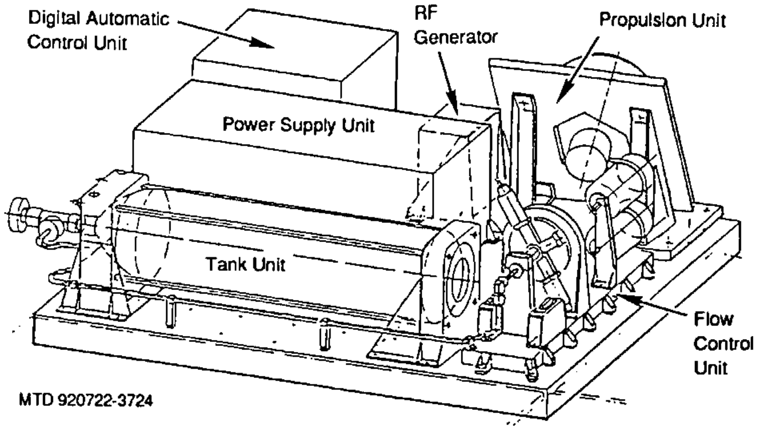


Timeband Capture Cell Experiment

J.A.M. McDonnell of the Unit for Space Science of the Physics Laboratory at the University of Kent, United Kingdom, is the principal investigator.

Radio Frequency Ion Thruster Assembly (RITA)

RITA is an experimental thruster designed to evaluate the use of electric propulsion for spacecraft. It uses xenon gas and is designed to operate for 2,000 hours.



Radio Frequency Ion Thruster Assembly

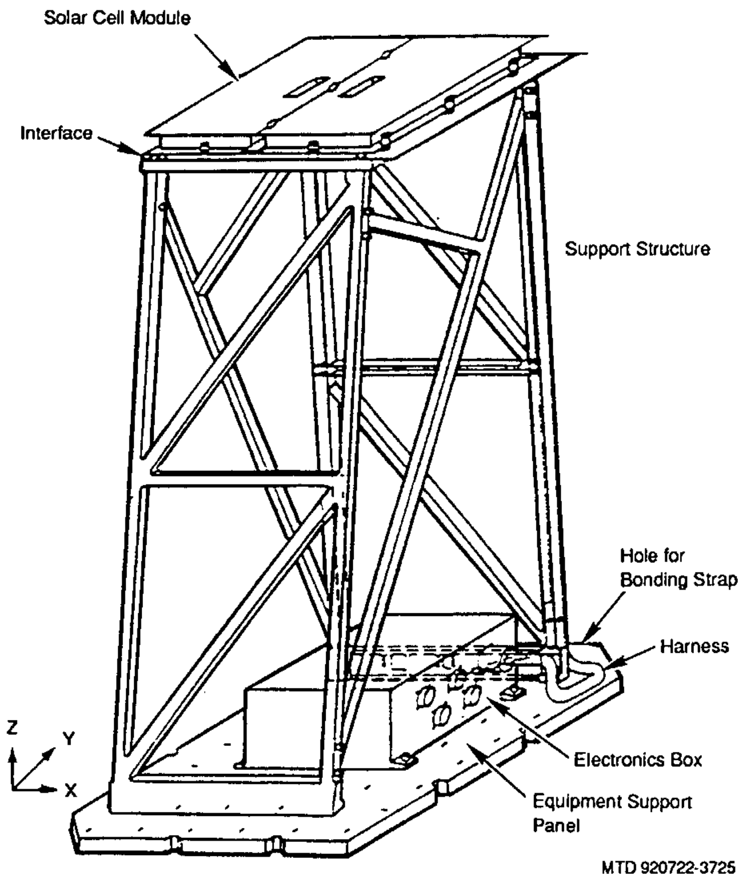
Electric propulsion is being studied for future long-duration space missions because conventional systems would be too bulky. RITA generates thrust by electrostatic acceleration of positive xenon ions. Electrons are fed into the ion beam to neutralize it in order to avoid charging RITA. Exhaust velocities are about an order of magnitude greater than those of chemical propulsion systems.

The principal investigator is H. Bassner of MBB Deutsche Aerospace, Munich, Germany.

Advanced Solar Gallium Arsenide Array (ASGA)

ASGA tests the performance of different types of gallium arsenide (GaAs) solar cells in low Earth orbit. During the EURECA mission, electrical I/V curves and thermal data relevant to the different strings of GaAs cells mounted on a fixed solar panel are recorded to establish the cells' performance trend.

GaAs solar cells have already been used on a trial basis on the Russian Mir space station. They are expected to be a critical part of the next generation of European solar energy generators.

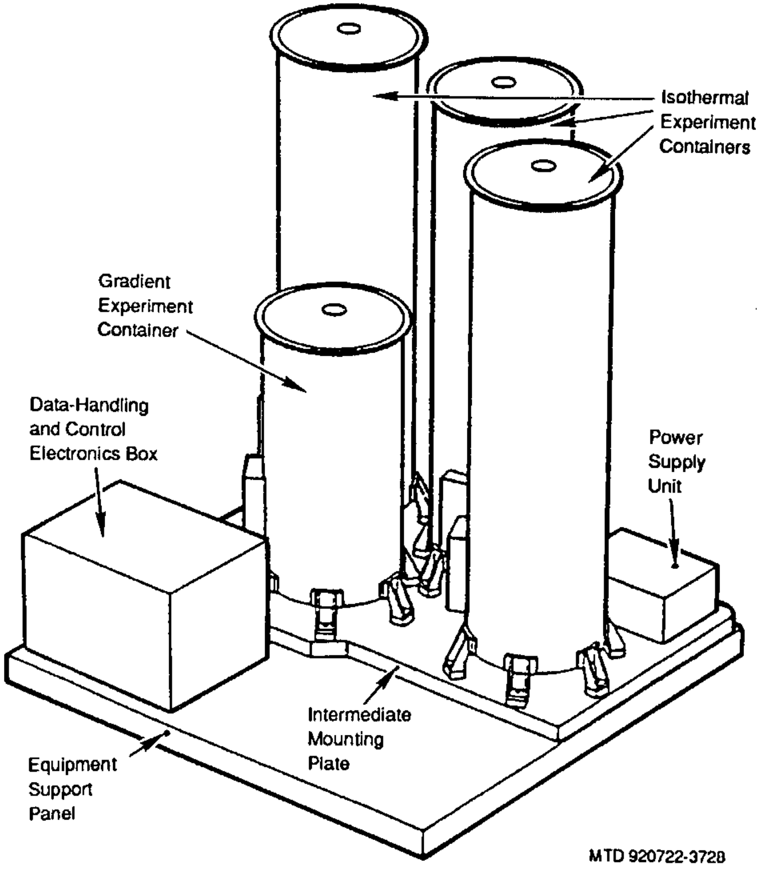


Advanced Solar GaAs Array

C. Flores of CISE SPA, Segrate, Italy, is the principal investigator.

Solution Growth Facility (SGF)

The SGF grows different types of crystals from solutions at temperatures from 35°C to 60°C. The SGF configuration consists of three identical chemical reactors for growing crystals and a fourth smaller container for measuring the ratio of the thermal to isothermal diffusion coefficient of 20 mixtures of liquids.

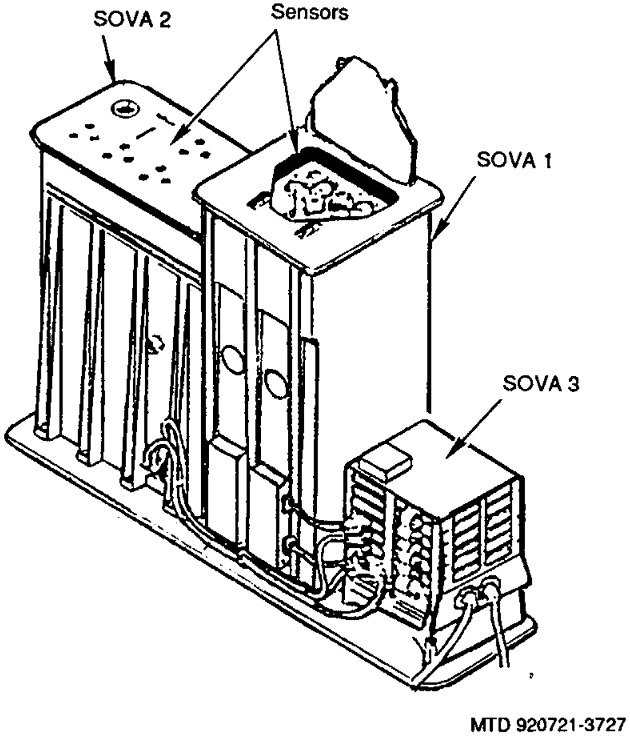


Solution Growth Facility

J.C. Legros of the Université Libre de Bruxelles, Brussels, Belgium, is the principal investigator.

Solar Constant and Variability Instrument (SOVA)

SOVA measures the solar constant and its variability and spectral distribution. It also measures variations in the total and spectral solar irradiance over periods of a few minutes to several hours, hours to a few months, and years (solar cycles).



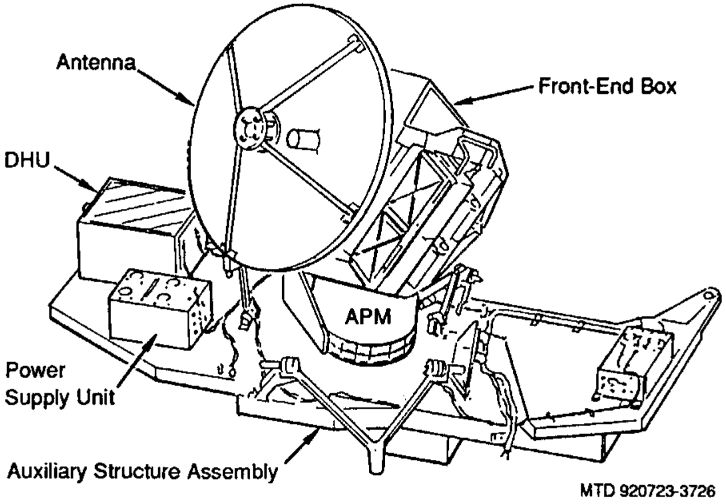
Solar Constant and Variability Instrument

The principal investigator is D. Crommelynck of the Institut Royal Météorologique de Belgique, Brussels, Belgium.

Interorbit Communication (IOC)

The IOC is a technology experiment that uses EURECA and the European Olympus communications satellite for a preoperational test and demonstration of the main functions, services, and equipment typical of a data relay system. The IOC exchanges test commands and data with an IOC ground station through the Olympus satellite. The IOC instrument has a mobile directional antenna to track Olympus, and Olympus is equipped with two steerable spot beam antennas, one pointed toward the IOC on EURECA and the other pointed toward the IOC ground station.

R. Tribes of the French Space Agency and N. Neale of the European Space Agency are the project managers.



Interorbit Communication Experiment

SUPERFLUID HELIUM ON-ORBIT TRANSFER DEMONSTRATION

The purpose of the SHOOT experiment is to develop and demonstrate technology for resupplying liquid helium to payloads in space. The objectives on STS-57 are twofold: (1) contain, manage, and transfer liquid helium under various conditions and environments that would be encountered during payload servicing in space; and (2) demonstrate remote autonomous servicing operations controlled from the ground and/or the orbiter aft flight deck.

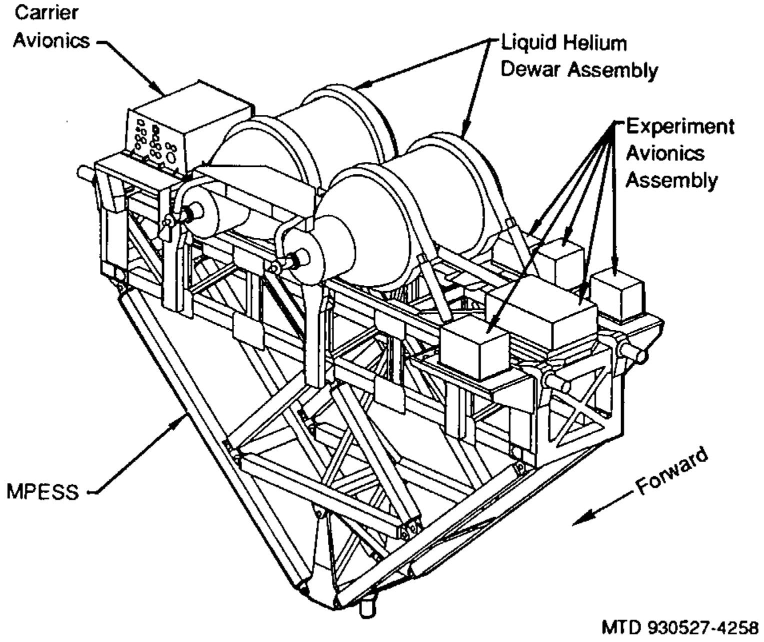
Mounted on a multipurpose experiment support structure (MPESS) and supported by avionics on the Hitchhiker bridge, which spans the width of the payload bay, are all of the critical components required to transfer helium: electronic instruments, two 55-gallon vacuum-insulated dewars (thermal containers) connected by an insulated transfer line and couplers, and an aft flight deck controller. Liquid helium will be pumped from one dewar to the other at rates ranging from 1.3 to 4.4 gallons per minute. Both dewars have similar components—plumbing, pumps, valves, and instrumentation—so that each can receive and supply helium.

Liquid helium is an extremely cold (-270°C) inert fluid used as a coolant on many spacecraft, especially those with high-sensitivity detectors for astrophysics and Earth observation. The liquid helium gradually vents to space as it cools the instruments, ending the instrument's useful life. It takes only a little heat to evaporate liquid helium. For example, a 100-watt light bulb left on in a 53-gallon dewar would evaporate all the liquid in less than 1.5 hours. Some satellites run out of liquid in 10 to 11 months of operation.

Since it has no viscosity, superfluid helium will leak through the smallest hole. Because the space around the cryogen tank must be a very good vacuum to insulate the liquid, no leak of any size can be tolerated. SHOOT has approximately 160 welds and 60 removable metal seals between the superfluid and the vacuum space. All of these have been checked and shown to be absolutely leak-tight.

SHOOT will experiment with liquid management in microgravity to fill a large gap in the knowledge of cryogen behavior in space. Controlling the position of cryogenic liquids in orbit is difficult. The evaporating gas must be allowed to leave the dewar but the liquid must be contained. On the ground this is easy, since the liquid is denser than the gas and gravity holds it in the bottom of the tank. In a low-gravity environment, liquid location is not well defined. Surface tension, heat inputs, and the small residual accelerations of a spacecraft all play a role in positioning the liquid.

SHOOT is part experiment and part demonstration. The first part of on-orbit operations will be to gather as much data as possible about how the liquid is delivered to the pumps by the acquisition devices, the behavior of the liquid/vapor discriminators, and the



SHOOT Payload Configuration

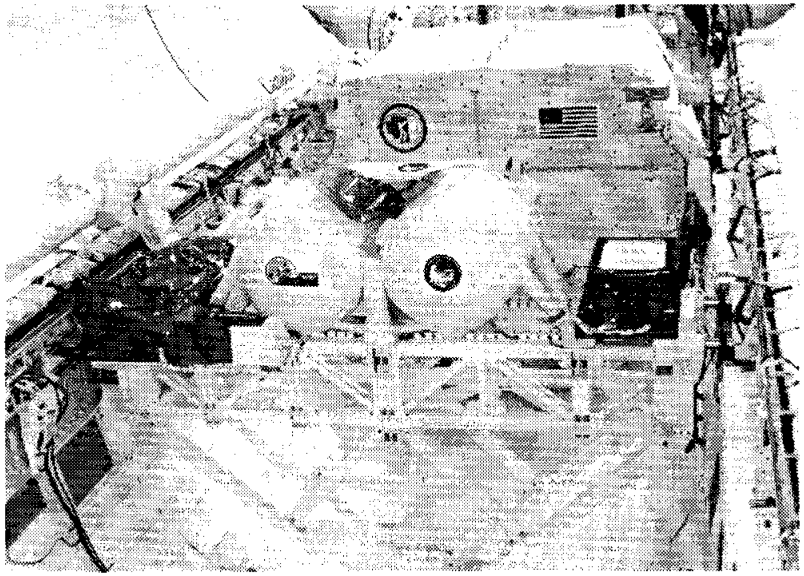
slosh and cool-down of the liquid. The experiment will be controlled from the ground, and the crew will monitor it from the aft flight deck at key times.

At one point, the pilot will accelerate the orbiter to settle the liquid in one end of the dewar for sensor calibration. During two transfers, the orbiter will accelerate to move the liquid away from the pump and let investigators see if such disturbances interrupt the flow. Once the transfer of liquid stops, the acceleration will be stopped and the crew will monitor the return of the liquid to the pump.

Near the end of the operations, the crew members will control a transfer completely from the aft flight deck. They will use a program with expert system capabilities to control the transfer and diagnose any problems that may occur. This will be the first use of an expert system to control a payload on the orbiter.

SHOOT objectives are summarized below:

- Achieve the lowest temperature ever in orbit—1.1 K (-457°F, 1.1°F above absolute zero).
- Demonstrate the first active management of a liquid cryogen in space.
- Demonstrate the first use of an expert system in space.
- Demonstrate two types of acquisition systems for delivering liquid to the pump.
- Make the first observations of thermal layering and mixing of a cryogen in orbit.
- Demonstrate superfluid mass gauging to 1-percent accuracy.
- Demonstrate controlled cool-down of a warm dewar.



Endeavour Payload Bay With SHOOT (Foreground) and SPACEHAB Shrouded and Ready for Flight

Valuable SHOOT spin-off technologies are listed below:

- Cryogenic motor-driven valves that are leak-tight after hundreds of cycles
- A liquid/gas phase separator for use with normal liquid helium as well as superfluid, enabling easier ground servicing of small dewars
- Liquid/vapor discriminators that can be used for other cryogens as well as liquid helium
- A relatively simple thermometry system to obtain resolution of 0.00001 K or better

This demonstration is the precursor to a Superfluid Helium Tanker under development by NASA to replenish shuttle and space station payloads. Both SHOOT and the Hitchhiker bridge are developed and managed by NASA's Goddard Space Flight Center in Greenbelt, MD.

FLUID ACQUISITION AND RESUPPLY EQUIPMENT (FARE) II

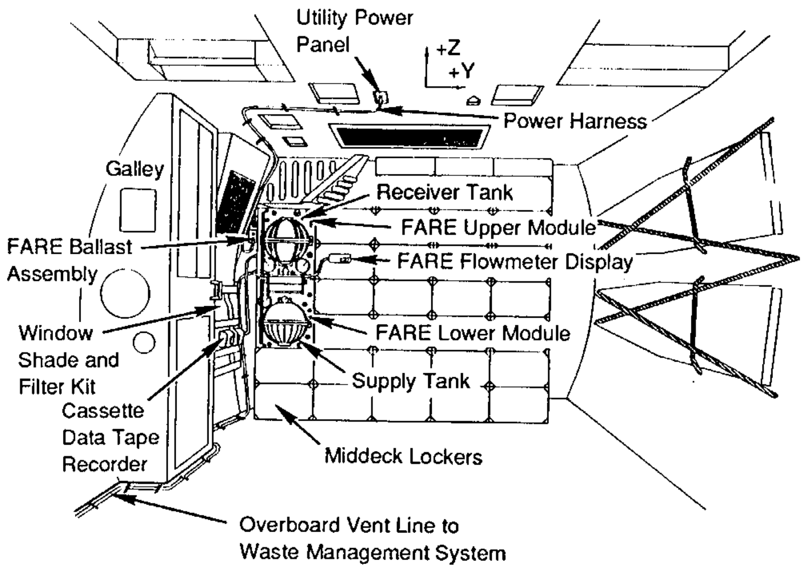
The purpose of FARE II is to investigate the dynamics of fluid transfer in microgravity and develop methods for transferring vapor-free propellants and other liquids that must be replenished in long-term space systems like satellites, extended-duration orbiters, and the space station. The experiment flew previously as FARE I on STS-53 in 1992 and also as the Storable Fluid Management Demonstration (SFMD) on STS-51C in 1985.

In space, liquid in a container does not readily settle on the bottom or leave a pocket of gas on top as it does on Earth. The position of liquids in weightlessness is highly unpredictable because the liquid and gas may locate or mix in any area within the container. To replenish on-board fluids and prolong the life of space vehicles like the space station, satellites and extended-duration orbiters, methods for transferring gas-free propellants and other liquids must be developed.

FARE I was conducted primarily to assess the ability of a screen-channel capillary system to drain liquids while working in a microgravity environment. Additionally, some experimentation was conducted regarding the control of liquid motion during tank refill sequences.

FARE II is designed to demonstrate the effectiveness of a device to alleviate the problems associated with vapor-free liquid transfer. The device exploits the surface tension of the liquid to control its position within the tank.

FARE hardware consists of two 12.5-inch spherical tanks made of transparent acrylic, one to supply and one to receive fluids. There are also liquid transfer lines, two pressurized air bottles, a calibrated cylinder, and the necessary valves, lines, fittings, pressure gauges, and flowmeter display. The experiment is self-contained except for the water-fill port, air-fill port, and an overboard vent connected to the orbiter waste management system. The experiment is housed in four middeck lockers.



Orbiter Middeck, Looking Forward

MTD 921117-4010

FARE Configuration

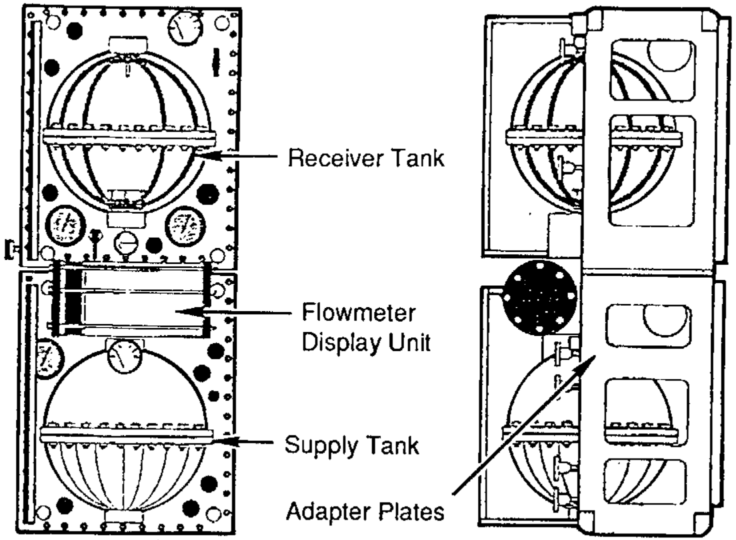
Eight times over an eight-hour test period, mission specialists will conduct the FARE experiment. A sequence of manual valve operations causes pressurized air from the bottles to force fluid (water with iodine, blue food coloring, a wetting solution, and an antifoaming agent) from the supply tank to the receiver tank and back again to the supply tank. Baffles in the receiver tank control fluid motion during transfer, a fine-mesh screen filters vapor from the fluid, and the overboard vent removes vapor from the receiver tank as the liquid rises.

Crew members will control and monitor the experiment from the FARE control panel, which has four pressure gauges and one temperature control gauge. During the transfer operations, they will tape the process with a video camcorder and take 35mm photographs. If necessary, they can also consult with the principal investigator through air-to-ground communications. (There is no real-time data downlink during the experiment.)

After the mission, analysts will evaluate the experiment equipment and review the videotape and photographs.

The FARE hardware is lighter, simpler, cheaper, and less likely to leak than the collapsible tanks that have previously been used in space. Experimenters are hoping FARE will be more effective as well.

FARE is managed by NASA's Marshall Space Flight Center in Huntsville, Ala. The basic equipment was developed by Martin Marietta for the Storable Fluid Management Demonstration, a configuration different from FARE that flew on STS-51C in 1985. Susan L. Driscoll is the principal investigator.



- Envelope: 45 in. x 22 in. x 19 in.
- Tanks
  - Material: Acrylic
  - Diameter: 12.5 in.
  - Volume: 1,022 in.^{3}
- Test Fluid:
  - Water and Additives
  - Amount: 5.4 Gallons

MTD 921117-4011

FARE Configuration

CONSORTIUM FOR MATERIALS DEVELOPMENT IN SPACE COMPLEX AUTONOMOUS PAYLOAD IV

The complex autonomous payload (CAP) manifested on STS-57 is a nonstandard secondary payload in NASA's CAP program. These use the small self-contained payload standard carrier system hardware (getaway special hardware) and are sponsored by NASA's Goddard Space Flight Center Shuttle Small Payload Project (SSPP).

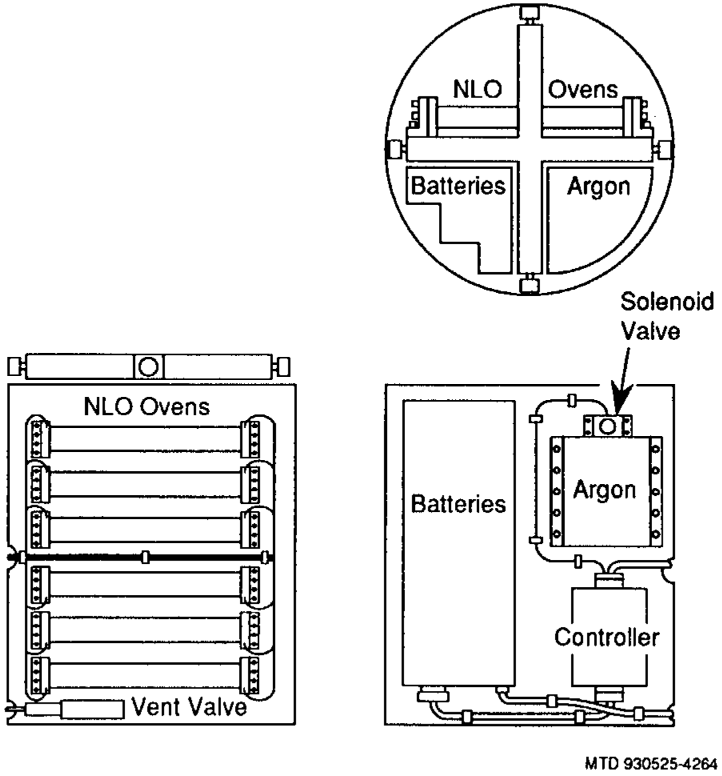
The payloads are controlled through the autonomous payload control system (APCS), which includes the command encoder known as the autonomous payload controller (APC), the auxiliary input/output (I/O) data line, GAS control decoders (GCDs), and payload power contactors (PPCs). The CAPs are compatible with the enhanced APC used by the IMAX cargo bay camera.

The CAPs are integrated into standard 5-cubic-foot GAS cylindrical canisters. They are mounted on 125-pound Johnson Space Center-supplied adapter beams in the payload bay, with connecting cables to provide communication to the experiment via the APC.

The Consortium for Materials Development in Space Complex Autonomous Payload IV (CONCAP IV) is sponsored by the University of Alabama in Huntsville (UAH) Consortium for Materials Development in Space (CMDS). The CMDS is one of the NASA Centers for the Commercial Development of Space (CCDS) managed by NASA's new Office of Advanced Concepts and Technology (OACT).

CONCAP IV is the fourth area of investigation in a series of payloads managed by the NASA Goddard Space Flight Center. The objective of the experiment, a continuation of crystal growth research begun in an STS-46 getaway special, is to produce nonlinear optical (NLO) organic materials in space. Physical vapor transport will be used to grow crystals and thin films that are expected to be more highly ordered with low dislocation density because of the absence of gravity-driven convection in space.

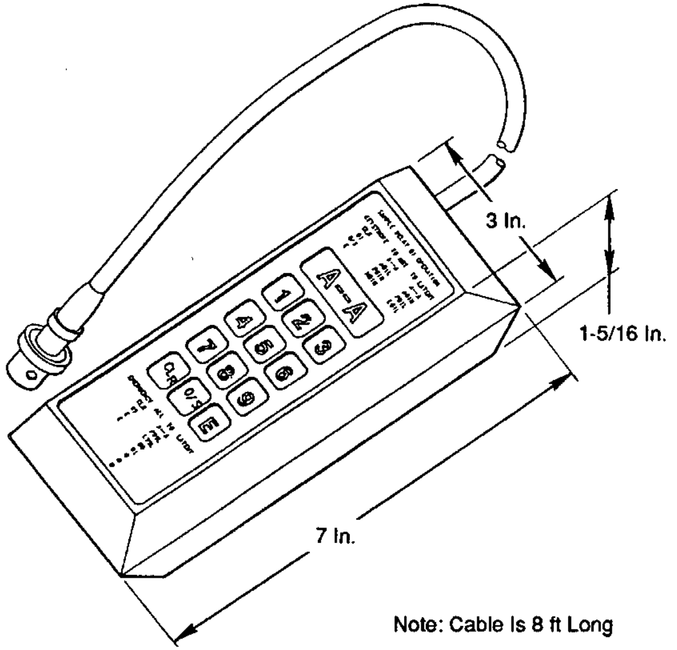
The experiment operation involves heating up a chamber containing the material to produce the crystal but keeping one spot on the chamber walls cooler than the rest of the chamber walls. This



CONCAP IV Configuration

method causes the vapor of the material to condense onto the cold spot so that the crystal grows there.

Within CONCAP IV there are six NLO "ovens," each containing two glass growth cells. Each cell is wrapped in a heater. The ovens are constructed from two aluminum cylinders, one inside the other, the area between them vented to space to form an insulating vacuum that reduces heat loss. The high and low temperatures in each chamber are controlled by a mini-computer designed and built specially for this purpose.



Note: Cable Is 8 ft Long

MTD 920723-3710

Autonomous Payload Controller

The crystals grown here have two important properties. First, when a laser beam passes through them, it comes out with twice the frequency (half the wavelength) of the original beam, doubling the range of frequencies available for laser applications. Currently, lasers operate efficiently only at certain frequencies, and some frequencies very important for scientific and commercial applications are missing.

Second, when an electric field is applied to some NLO materials, their refractive index changes, which changes the path of light traveling through the crystal. These crystals are like prisms that bend a light beam to different degrees when voltages are applied. By changing the path of a light beam, the crystal or thin film acts as a high-speed, nearly instantaneous switch.

These properties are extremely important to the optoelectronics and photonics industry, especially for optical computing. Without NLO materials, optical computers would be impossible. Someday, nonlinear optical materials may play the same role in revolutionizing photonics and optoelectronics that semiconductors did in the electronics industry. The CONCAP series of investigations will determine whether space-grown crystals can speed the evolution.

Displaytech, Inc., of Boulder, Colo., is participating with the UAH CMDS in CONCAP IV. Displaytech is a commercializer of high-performance electro-optical devices. The principal investigator is Dr. Thomas Leslie, associate professor in the chemistry department at UAH. The payload manager is William Carswell, a research associate at UAH.

GETAWAY SPECIAL PROGRAM

NASA's Getaway Special program, officially known as the Small, Self-Contained Payloads program, offers interested individuals or groups opportunities to fly small experiments aboard the space shuttle. To assure that diverse groups have access to space, NASA rotates payload assignments among three major categories of users: educational, foreign and commercial, and U.S. government.

Since the program was first announced in the fall of 1976, payloads have been reserved by foreign governments and individuals; U.S. industrialists, foundations, high schools, colleges and universities; professional societies; service clubs; and many others. Although persons and groups involved in space research have obtained many of the reservations, a large number of spaces have been reserved by persons and organizations outside the space community.

To date, 87 GAS cans have been flown on 18 missions. The GAS program began in 1982 and is managed by the Goddard Space Flight Center, Greenbelt, Md.

There are no stringent requirements to qualify for space flight. However, each payload must meet specific safety criteria and be screened for its propriety as well as its educational, scientific, or technological objectives. These guidelines preclude commemorative items, such as medallions, that are intended for sale as objects that have flown in space.

GAS requests must first be approved at NASA Headquarters in Washington, D.C., by the director of the Transportation Services Office. At that point NASA screens the propriety objectives of each request. To complete the reservation process for GAS payloads, each request must be accompanied or preceded by the payment of $500 earnest money.

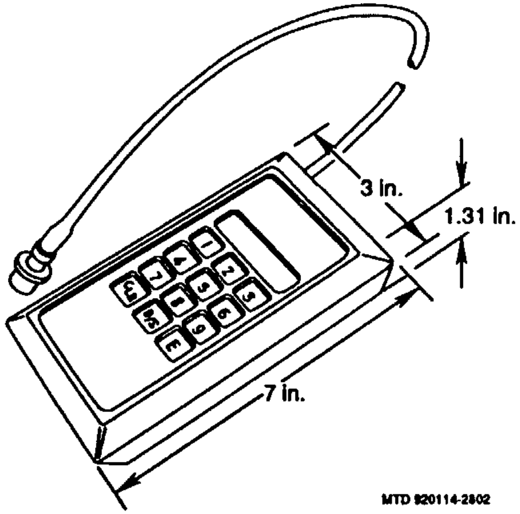
Approved requests are assigned an identification number and referred to the GAS team at the Goddard Space Flight Center, the designated lead center for the project. The GAS team screens the proposals for safety and provides advice and consultation on payload design. It certifies that proposed payloads are safe and will not harm or interfere with the operations of the space shuttle, its crew, or other experiments on the flight. The costs of any physical testing required to answer safety questions before launch are borne by the GAS customer.

NASA's space shuttle program has specific standards and conditions relating to GAS payloads. Payloads must fit NASA standard containers and weigh no more than 200 pounds. However, two or more experiments may be included in a single container if they fit in it and do not exceed weight limitations. The payload must be self-powered and not draw on the shuttle orbiter's electricity. In addition, payload designs should consider that the crew's involvement with GAS payloads will be limited to six simple activities (such as turning on and off up to three payload switches) because crew activity schedules do not provide opportunities to either monitor or service GAS payloads in flight.

The cost of this unique service depends on the size and weight of the experiment. Getaway specials of 200 pounds and 5 cubic feet cost $10,000; 100 pounds and 2.5 cubic feet, $5,000; and 60 pounds and 2.5 cubic feet, $3,000. The weight of the GAS container, experiment mounting plate and its attachment screws, and all hardware regularly supplied by NASA is not charged to the experimenter's weight allowance.

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

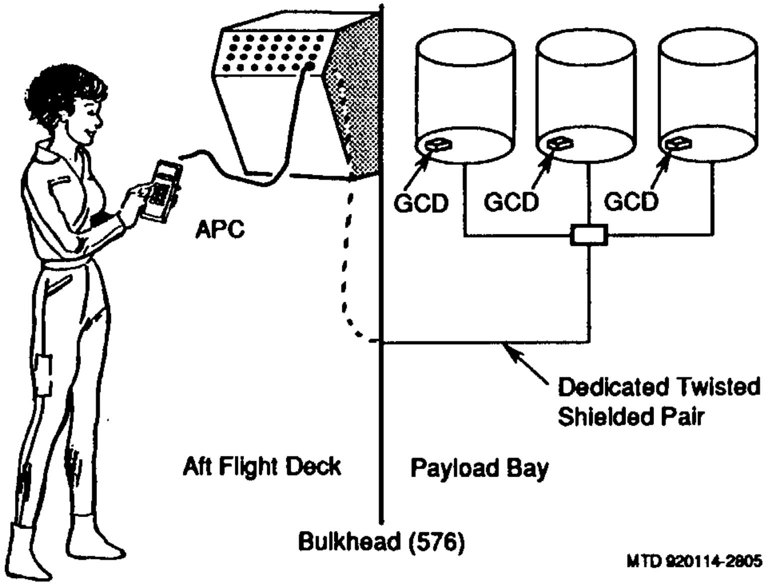
The GAS container is made of aluminum, and the circular end plates are 0.625-inch-thick aluminum. The bottom 3 inches of the



GAS Autonomous Payload Controller

container are reserved for NASA interface equipment, such as command decoders and pressure regulating systems. The container is a pressure vessel that can be evacuated before or during launch or on orbit and can be repressurized during reentry or on orbit, as required by the experimenter.

The getaway bridge, which is capable of holding 12 canisters, made its maiden flight on STS 61-C. The aluminum bridge fits across the payload bay of the orbiter and offers a convenient and economical way of flying several GAS canisters.



Getaway Special Control Concept

For additional information about NASA's Getaway Special program contact the program manager, Code MC, NASA Headquarters, Washington, D.C. 20546. The primary contact for payload users is the technical liaison, Code 740, NASA Goddard Space Flight Center, Greenbelt, Md. 20771.

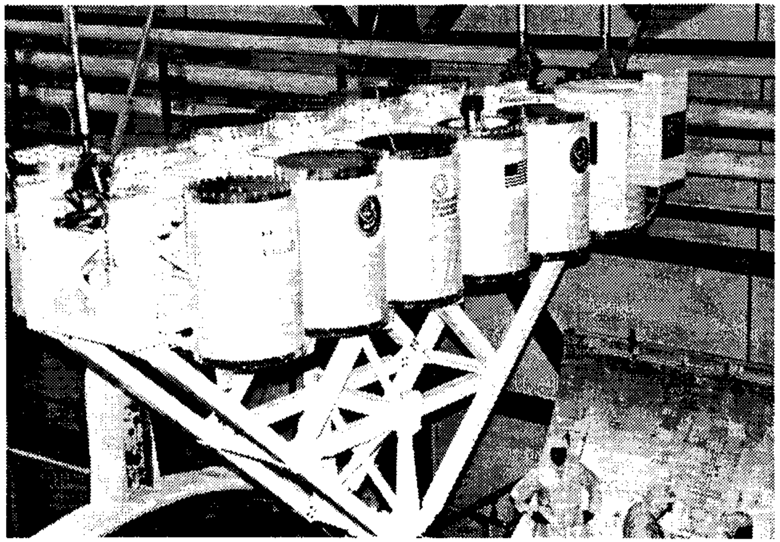
STS-57 GETAWAY SPECIAL EXPERIMENTS

On STS-57, the GAS bridge is flying with ten GAS payloads from the U.S., Canada, Japan, and Europe. Also on the bridge is one secondary payload, a commercialization experiment sponsored by the Consortium for Materials Development in Space at the University of Alabama in Huntsville, and one GAS ballast can. Clarke Prouty is GAS mission manager and Lawrence R. Thomas is customer support manager for the Shuttle Small Payloads Project at Goddard.

G-022, LIQUID GAUGING TECHNOLOGY EXPERIMENT

This experiment demonstrates two in-orbit methods of gauging liquids in tanks—periodic volume stimulus and foreign mass injection. Both approaches work well in the presence of gravity, but the peculiar properties of liquid under microgravity conditions could lead to lower measurement accuracy. This experiment will study, in particular, errors caused by the following effects: liquid distribution in the tank, unconnected liquid quantities, uneven heating, and unintentional intrusion of fluid in pipes, sensor apertures, etc.

KSC-93-PC-380



NASA Photo

GAS Bridge Assembly Installation

The customer is the European Space Agency, European Space Research and Technology Centre, Noordwijk, The Netherlands.

G-324, CAN DO

This experiment will take 1,000 photos of the Earth so that students can observe and document global change by comparing the CAN DO photos with matched Skylab photos. The canister also contains 350 small passive student experiments.

The primary payload is a GEOCAM containing four 35-mm cameras equipped with 250-exposure film backs. The system closely matches the larger Skylab film format in both coverage and quality, which allows direct examination and comparison of changes that have occurred on Earth in the last 20 years.

The student-designed experiments were submitted from more than 60 Charleston County classrooms and from invited school districts in Maryland, Virginia, Texas, Arizona, and Massachusetts. These experiments allow students to participate directly in research by testing the effect of space on various materials and to learn the skills of proper experiment design and valid scientific execution.

The customer is the Charleston County School District, Charleston, S.C.

G-399, INSULIN TAGGING AND ARTEMIA GROWTH EXPERIMENTS

This payload is composed of two student experiments: insulin tagging and brine shrimp Artemia physiology. They will educate students about all aspects of carrying out scientific experiments.

The customer is Dr. Ronald S. Nelson of Fresno, Calif.

G-450, MULTIPLE EXPERIMENTS

This is a multidisciplinary package composed of six self-contained modules, each housing multiple experiments designed and developed by California Central Coast elementary, middle, and high schools. Module 1 contains solidification/crystallization of saccharin and cryogen transfer. Module 2 addresses the effects of radiation on bacteria and the effects of microgravity on sprouting seeds. Module 3 studies bacteria survival in radiation and zero-point energy. Module 4 consists of electrode occlusion and bubble formation and microgravity bonding. Module 5 examines osmosis, reverse osmosis, and effects of radiation on seeds. And Module 6 contains crystal growth and fluids in microgravity.

The customer is the Vandenberg Section, American Institute of Aeronautics and Astronautics, Vandenberg Air Force Base, Calif.

G-452, CRYSTAL GROWTH OF GALLIUM-ARSENIDE

Twelve small electric furnaces will support four kinds of experiments: growth of a single gallium-arsenide crystal from liquid phase, growth of a gallium-arsenide-based mixed crystal, addition of a heavy element to gallium-arsenide, and addition of a heavy element to indium-antimony crystal.

The customer is the Society of Japanese Aerospace Companies, Tokyo, Japan.

G-453, SEMICONDUCTOR/SUPERCONDUCTOR EXPERIMENT

This GAS can contains four different kinds of experiments. Three are material experiments on semiconductors and a superconductor, and the other is on boiling an organic solvent in weightlessness.

The customer is the Society of Japanese Aerospace Companies, Tokyo, Japan.

G-454, CRYSTAL GROWTH

This experiment studies the crystal growth of indium-gallium-arsenic from vapor phase, the growth of three selenic-niobium crystals from vapor phase, the growth of an optoelectric crystal by diffusion, and formation of a superferromagnetic alloy.

G-535, POOL BOILING EXPERIMENT

The objective of this experiment is to improve understanding of the boiling process. A pool of liquid will come into contact with a surface that supplies heat. The heating and vapor dynamics associated with bubble growth/collapse and subsequent motion will be observed. The lack of gravity-driven motion makes the boiling process easier to study in space.

The customer is NASA Headquarters, Office of Space Science and Applications, Microgravity Sciences Division, Washington, D.C.

G-601, HIGH-FREQUENCY VARIATIONS OF THE SUN

This experiment will measure and analyze high-frequency variations of light that the sun releases to the Earth. It also will seek better understanding of the physics of the sun and other stars.

The customer is the San Diego Section, American Institute of Aeronautics and Astronautics, San Diego, Calif.

G-647, CONFIGURABLE HARDWARE FOR MULTI–DISCIPLINARY PROJECTS IN SPACE (CHAMPS)

This versatile payload, built by MPB Technologies in Montreal, combines the advantages of generic and dedicated research facilities for materials processing in space. It will examine a recently developed technique for crystal growth called liquid-phase electroepitaxy (LPEE) that regulates growth by passing an electric current through a subject material.

The customer is the Canadian Space Agency, Ottawa, Ontario, Canada.

GAS BALLAST PAYLOAD

GAS ballast payloads are flown for stability when a GAS payload drops out and no payload is available to replace it. This ballast payload contains a small accelerometer package furnished by NASA to record vibration during the mission.

SAMPLE RETURN EXPERIMENT

This experiment sits on top of the GAS ballast can. Its primary science objective is to quantify extraterrestrial particles and other orbital debris in the orbiter bay. A secondary objective is a realistic test for comet sample collection concepts. Sample particles to be encountered and collected have speeds of 15 to 22 mph and diameters of 10 to 200 micrometers.

The customer is the Jet Propulsion Laboratory, Pasadena Calif. Principal investigator is Dr. Peter Tsou.

SHUTTLE AMATEUR RADIO EXPERIMENT II

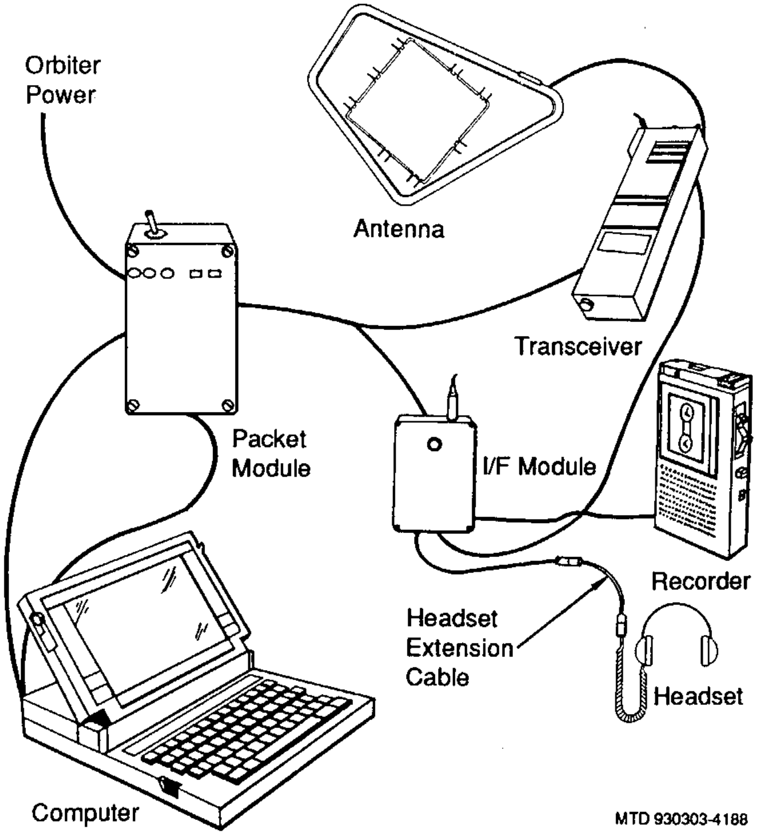
The Shuttle Amateur Radio Experiment (SAREX) was established by NASA, the American Radio Relay League/Amateur Radio Satellite Corporation, and the Johnson Space Center Amateur Radio Club to encourage public participation in the space program through a program to demonstrate the effectiveness of conducting shortwave radio transmissions between the shuttle and ground-based amateur radio operators at low-cost ground stations with amateur and digital techniques. SAREX also is an educational opportunity for students around the world to learn about space firsthand by speaking directly to astronauts aboard the shuttle via ham radio. Contacts with certain schools are included in the planning for the mission.

SAREX has been flown on missions STS-9, -51F, -35, -37, -45, -50, -47, -56, and -55 in different configurations. A modified configuration C will be flown on STS-57. The equipment complement is stowed in one and one-half middeck lockers.

SAREX communicates with amateur stations within Endeavour's line of sight in one of four transmission modes: voice, slow-scan TV (SSTV), data, or fast-scan TV (FSTV, uplink only). The voice transmissions are operated in the attended mode, while the SSTV, data, and FSTV transmissions can be operated in either the attended or unattended mode.

During the mission, SAREX-II will be operated at the discretion of two crew members who are licensed amateur radio operators: mission specialists Brian Duffy and Janice Voss. Operating times for school contacts are planned in the crew's activities.

SAREX-II will be operated during periods when the crew members are not scheduled for orbiter or other payload activities. The antenna's window location does not affect communications and therefore does not require a specific orbiter attitude for operations.



SAREX-II Configuration

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

The primary frequencies intended for use during the mission are 145.55 MHz for downlink from Endeavour and 144.91, 144.93, 144.95, 144.97, and 144.99 MHz for uplink. A spacing of 600 kHz was deliberately chosen for this primary pair to accommodate those whose split-frequency capability is limited to the customary repeater offset. Digital packet will operate on 145.55 MHz for downlink transmission and 144.49 MHz for uplink transmission.

Contacts with Endeavour will be possible between 42 degrees north latitude to 42 degrees south latitude, covering the lower half of the Continental United States and Hawaii, all of Africa, and most of South America, Australia, the East and the Far East.

Information about orbital elements, contact times, frequencies, and crew operating schedules will be available during the mission from NASA, ARRL and AMSAT.

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

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

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

SAREX Insignia

AIR FORCE MAUI OPTICAL SITE (AMOS) CALIBRATION TEST

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

This experiment is a continuation of tests made during the STS-29, -30, -34, -32, -31, -41, -35, -37, -43, -48, -44, -49, and -56 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.

EXTRAVEHICULAR ACTIVITY

The four-hour EVA scheduled for mission day 5 continues the on-orbit testing performed on STS-54 and previous missions. The basic goals are the same: determine specific differences between ground training and actual EVA operations in space, make qualitative and quantitative assessments of the ability to work productively on general-purpose and space station tasks, and broaden the flight experience of the EVA community.

For this flight, two specific objectives have been added: demonstrate improved tools for general application and assist in evaluating techniques and tools to be used in the STS-61 Hubble Space Telescope (HST) maintenance mission. This EVA, however, is not critical to HST mission success. It was added to the existing manifest and may be canceled if time is short; EURECA retrieval, SPACEHAB experiments, and the SHOOT demonstration take precedence over the EVA.

EVA TASKS

Crew assignments for the EVA are as follows: G. David Low and Jeff Wisoff will do the tasks outside of the crew compartment, Nancy Sherlock will operate the shuttle remote manipulator system (RMS), Brian Duffy will monitor the tasks, and Janice Voss will record EVA data.

Handling of Large Masses

This task simulates handling large components that will be installed for HST maintenance or space station assembly and maintenance. Crew members will enact the specific scenario of handling the HST wide-field planetary camera. One crew member anchored by a foot restraint on the orbiter RMS will maneuver the other crew member, who represents the mass of a large space component. This exercise will be conducted both with and without disturbances from the orbiter thrusters and RMS movements.

Fine Alignment of Large Masses

This task simulates the installation of large HST and space station components. One crew member strapped to the RMS will maneuver the other, attempting to position his boots next to an EVA foot restraint. The RMS will remain stationary, and the simulation will be conducted with and without disturbances from the orbiter thrusters.

Restraint for High Torque

While anchored by a foot restraint on the RMS, a crew member will use a manual torque wrench to install and remove a bolt. He will try socket extensions of different lengths, various approach angles and hand positions, and a series of torques up to 50 foot-pounds to simulate the release and installation of HST and space station bolted components.

Tool Evaluations

Crew members will evaluate the following EVA equipment improvements: (1) a short, self-tending equipment tether that should cause fewer snags and impact with loose hardware than the longer, fixed-length variety, (2) a safety tether between the crew member and vehicle that stays close to his body, allowing him to reach and perform tasks with minimum snagging and impact with the surrounding structure, (3) a chest-mounted tool carrier and body restraint with more than one hook, allowing the specific task at hand and ease of hook operation to dictate use.

CONDITIONS

This will be the first shuttle EVA in which the Spacelab tunnel adapter with standard airlock is used for egress and ingress between the crew cabin and the payload bay. During the EVA, the orbiter's belly will point at the sun to simulate the cold environment of HST maintenance and some space station tasks.

Most of the preflight ground training to which the crew members will compare their EVA experience was conducted under water in a neutral buoyancy tank with a full-scale RMS. A precision air-bearing floor was used to simulate mass handling outside of the tank without the drag effects of underwater movement.

Ascent Wing Structural Capability Evaluation (DTO 301D). Verify that the orbiter wing structure is at or near its design condition during lift-off and ascent with near maximum weight payloads. Determine flight loads, structural capability, and presence of any unacceptable dynamic effects.

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

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

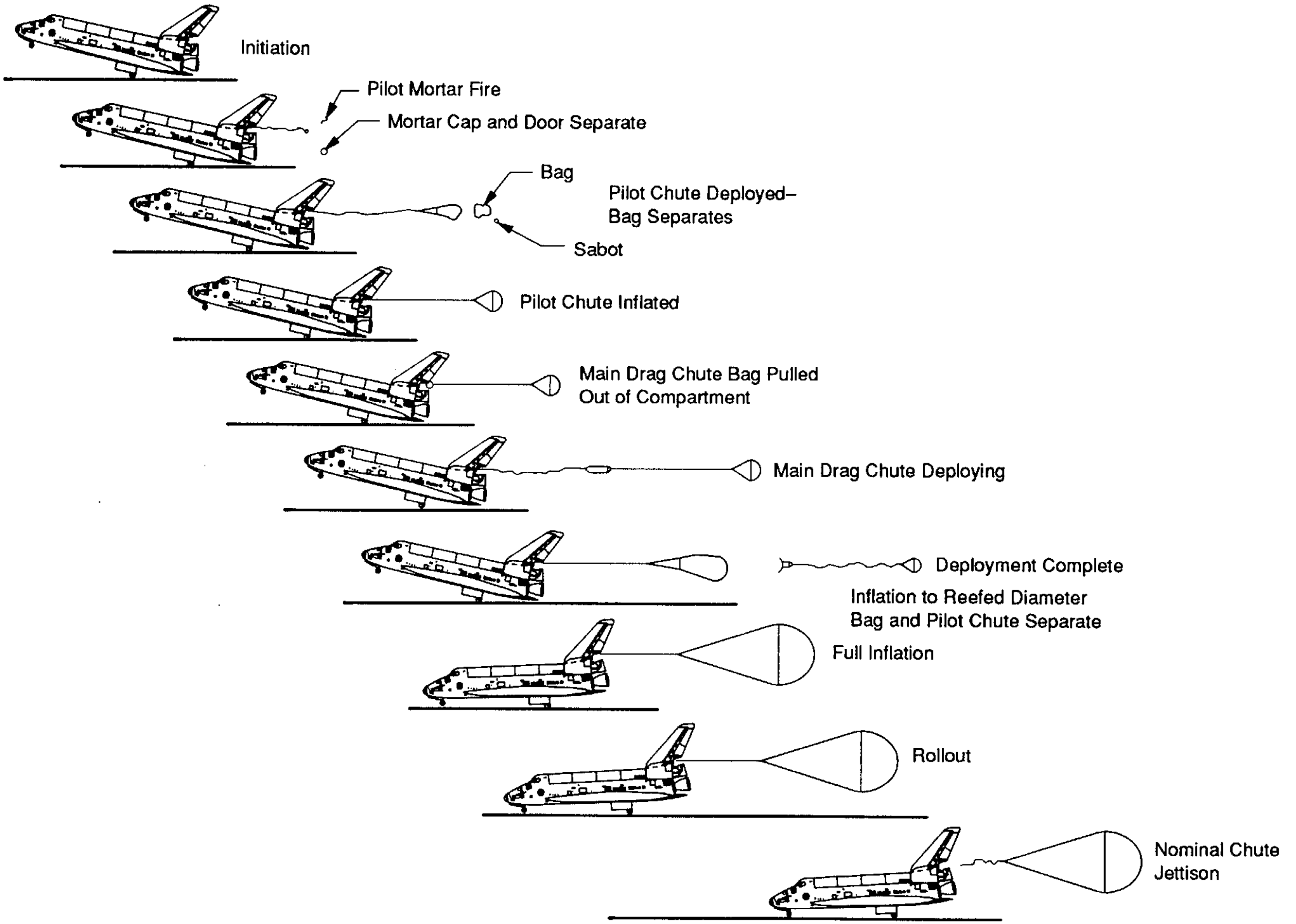
Entry Structural Capability (DTO 307D). Collect data during entry, approach, and landing to verify the adequacy of the structure at design conditions and to verify the stress/temperature response of critical structural components.

ET TPS Performance, Method 1 (No +X) and Method 3 (DTO 312). Obtain photographs of the external tank after separation to determine TPS charring patterns, identify regions of TPS material spallation, and evaluate overall TPS performance. Method 1 will not have the STD +X translation burn.

On-Orbit Fuel Cell Shutdown/Restart (Fuel Cell 3) (DTO 412). Demonstrate the capability of shutting down and restarting a fuel cell on orbit. Current flight rules assume the capability to restart a fuel cell once it has been shut down; the capability has never been verified. It will determine the magnitude of voltage degradation due to shutdown. It will also determine how fast the fuel cell will cool down and what temperature it will reach. The data will be used to support space station (assembly and man-tended operations) and long-duration flights requiring fuel cell shutdown for extended periods. The selected fuel cell will be shut down for 46 hours (attitude/temperature permitting). Shutdown will occur approximately EOM minus two days after EURECA retrieval. Fuel cell restart will occur at EOM minus one to allow for troubleshooting prior to EOM, should the fuel cell not be restartable. Fuel cell purge will not be performed on the shut-down fuel cell. This DTO will be performed over a series of three flights (a different fuel cell position will be shut down on each flight). This is the second flight of DTO 412.

APU Shutdown (DTO 414). Explore the hypothesis that delays between shutting down individual auxiliary power units on ascent can lead to "backdriving" of the non-operational hydraulic system's speed brake motor. A review of mission data has shown that when an individual APU is shut down prematurely on ascent while the remaining APUs are operating, there is the possibility of extended hydraulic supply pressure (i.e., the hydraulic pressure of the shutdown system remains at an elevated level for a significant period of time). The explanation for this behavior is that the operational hydraulic systems are "backdriving" the speed brake motor of the system that has been shut down. Performing this DTO during flight will give the most representative data for this behavior. This DTO will be flown on multiple missions in order to gather a representative data base. The APUs will be shut down in the following order: 3, 1, 2. The pilot will wait at least five seconds between each APU shutdown.

Orbiter Drag Chute System (DTO 521). Evaluate orbiter drag chute system performance through a series of landings with increasing deployment speeds. The DTO will be performed on vehicles equipped to measure drag forces imposed by the drag chute system. This DTO has two phases. Phase I consisted of two flights, with the first-flight drag chute deployment at nose gear touchdown (STS-49), and the second-flight initiation at initiation of derotation.



MTD 930301-4166

Nominal Sequence of Drag Chute Deployment, Inflation, and Jettison

Now that Phase I testing is complete, the drag chute is cleared for deployment under the same conditions in subsequent missions. Phase II, consisting of seven additional flights gradually increasing in speed from initiation at derotation of 185 knots equivalent air speed (KEAS) to initiation at 205 KEAS, will use concrete runways whenever possible. For STS-57, the drag chute will be deployed at the initiation of derotation, 175 knots. A 90-percent reefed drag chute will be used. If the crosswinds are greater than 10 knots peak, the drag chute will not be deployed.

Cabin Air Monitoring (DTO 623). Use the solid sorbent sampler to continuously sample the cabin atmosphere for possible impurities caused by outgassing and particulate matter in new and refurbished vehicles.

Extended-Duration-Orbiter WCS Evaluation (DTO 662). Verify the design of the new extended-duration-orbiter waste collection system under zero-gravity conditions for a prolonged period.

Acoustical Noise Dosimeter Data (DTO 663). Use an acoustical dosimeter to obtain acoustic data on the EMU battery charger. The data will be gathered while the EMU batteries are being recharged after the scheduled EVA.

Acoustical Noise Sound-Level Data (DTO 665). Use the HFA sound-level meter (SPACEHAB 1 experiment) to obtain octave-band acoustical noise levels for the EMU battery charger. The acoustic noise levels will be measured when the battery charger is at its peak acoustical output.

EVA Hardware for Future Scheduled EVA Missions (DTO 671). Conduct high-torque evaluations and tether management evaluation tests. This DTO provides part of the hardware used to support the activities/procedures scheduled for DTO 1210. Prior flight experience has revealed limitations in our ability to assess hardware operability during ground simulations and subsequently predict on-orbit EVA performance with new and infrequently used hardware and/or associated techniques. The information collected will be used to modify hardware design and/or associated EVA techniques to increase the probability of success for future scheduled EVA missions.

Laser Range and Range Rate Device (DTO 700-2). Demonstrate the capability to provide the orbiter flight crew with range and range rate data for rendezvous, proximity operations, and deploy operations. The major objective is to show that a hand-held laser can provide accurate and reliable range and range rate information, even if the target does not have a laser reflector. The DTO will assess the best means of displaying the data, addressing location, and updating frequency.

Crosswind Landing Performance (DTO 805). Continue to gather data for a manually controlled landing in a crosswind.

EVA Operations Procedure/Training (14.7-psi Protocol) (DTO 1210). Isolate and demonstrate specific differences between training facility simulations and operations in the actual extravehicular activity environment. This will also broaden EVA procedures and training experience bases, and increase proficiency in preparation for future EVAs involving the Hubble Space Telescope and space station. The EVA is scheduled for flight day 5, as mission duration and EURECA operations permit. The crew will perform tasks to evaluate in-cabin familiarization: handhold translation, portable foot restraint setup, ingress, egress, reduced surface lighting and marking, and safety tether management options.

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

Orthostatic Function During Entry, Landing, and Egress (DSO 603B*). Monitor heart rate and rhythm, blood pressure, cardiac output, and peripheral resistance of crew members during entry, landing, seat egress, and orbiter egress in order to develop and assess countermeasures designed to improve orthostatic tolerance upon return to Earth. This data will be used to determine whether precautions and countermeasures are needed to protect crew members in the event of an emergency egress. It will also be used to determine the effectiveness of proposed in-flight countermeasures. Crew members 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 crew member wears the equipment and records verbal comments throughout entry. This will be flown as a DSO of opportunity.

Visual-Vestibular Integration as a Function of Adaptation (DSO 604*). Investigate visual-vestibular and perceptual adaptive responses as a function of mission duration. Note the operational impact of these responses on the crew members' ability to conduct 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.

Head and Gaze Stability During Locomotion (DSO 614*). 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.

Effects of Intense Exercise During Space Flight on Aerobic Capacity and Orthostatic Function (DSO 618*). Evaluate the effects of intense in-flight cycle ergometry exercise performed 18 to 24 hours before landing on postflight orthostatic function and aerobic responses to maximum cycle exercise tests performed immediately after flight. Quantify the degree of in-flight aerobic deconditioning that occurs during space flight by comparing flight day 3 and last flight day responses to exercise.

Pre- and Postflight Measurement of Cardiorespiratory Responses to Submaximal Exercise (DSO 624*). Maintain a log of exercise activities to assist in the development of optimal exercise prescriptions. A smaller decline between pre- and postflight aerobic capacity has been detected in individuals who perform regular in-flight aerobic activity.

Measurement of Blood Volumes Before and After Space Flight (DSO 625*). Measure the effects of space flight on blood volume.

Cardiovascular and Cerebrovascular Responses to Standing Before and After Space Flight (DSO 626*). Characterize the

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*Indicates EDO buildup medical/evaluation DSO integrated response of arterial pressure control system to standing before and after space flight.

Documentary Television (DSO 901). Provide live television transmission or VTR dumps of the following crew activities and spacecraft functions: payload bay views, shuttle and payload crew activities, VTR downlink of crew activities, in-flight crew press conference, orbiter operations, payload deployment/retrieval and operations, Earth views, rendezvous and proximity operations, and unscheduled activities. Telecasts are planned for communication periods with seven or more minutes of uninterrupted viewing time. Activities are broadcast by 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). Take documentary and public affairs motion picture photography of significant activities that best depict the basic capabilities of the space shuttle and key flight objectives. This DSO includes photography of payload bay activities, flight deck activities, middeck activities, and any unscheduled motion picture photography. This photography provides a historical record of the flight as well as material for release to the news media, independent publishers, and film producers.

Documentary Still Photography (DSO 903). Photograph crew activities in the orbiter, spacecraft functions, and mission-related scenes of general public and historical interest. A 70mm format is used for exterior photography and a 35mm format is used for interior photography.

STS-57 PRELAUNCH COUNTDOWN TIME LINE

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

T - (MINUS) HR:MIN:SEC	EVENT
04:30:00	The orbiter fuel cell power plant activation is complete.
04:00:00	The Merritt Island (MILA) antenna, which transmits and receives communications, telemetry and ranging information, alignment verification begins.
03:45:00	The liquid hydrogen fast fill to 98 percent is complete, and a slow topping-off process is begun and stabilized to 100 percent.
03:30:00	The liquid oxygen fast fill is complete to 98 percent.
03:20:00	The main propulsion system (MPS) helium tanks begin filling from 2,000 psi to their full pressure of 4,500 psi.
03:15:00	Liquid hydrogen stable replenishment begins and continues until just minutes prior to T minus zero.
03:10:00	Liquid oxygen stable replenishment begins and continues until just minutes prior to T minus zero.
03:00:00	The MILA antenna alignment is completed.
03:00:00	The orbiter closeout crew goes to the launch pad and prepares the orbiter crew compartment for flight crew ingress.

T - (MINUS) HR:MIN:SEC	EVENT
03:00:00 Holding	Begin 2-hour planned hold. An inspection team examines the ET for ice or frost formation on the launch pad during this hold.
03:00:00 Counting	Two-hour planned hold ends.
02:55:00	Flight crew departs Operations and Checkout (O&C) Building for launch pad.
02:25:00	Flight crew orbiter and seat ingress occurs.
02:10:00	Postingress software reconfiguration occurs.
02:00:00	Checking of the launch commit criteria starts at this time.
02:00:00	The ground launch sequencer (GLS) software is initialized.
01:50:00	The solid rocket boosters' (SRBs') hydraulic pumping units' gas generator heaters are turned on and the SRBs' aft skirt gaseous nitrogen purge starts.
01:50:00	The SRB rate gyro assemblies (RGAs) are turned on. The RGAs are used by the orbiter's navigation system to determine rates of motion of the SRBs during first-stage flight.
01:35:00	The orbiter accelerometer assemblies (AAs) are powered up.
01:35:00	The orbiter reaction control system (RCS) control drivers are powered up.
01:35:00	The flight crew starts the communications checks.
01:25:00	The SRB RGA torque test begins.
01:20:00	Orbiter side hatch is closed.
01:10:00	Orbiter side hatch seal and cabin leak checks are performed.
01:01:00	IMU preflight align begins. Flight crew functions from this point on will be initiated by a call from the orbiter test conductor (OTC) to proceed. The flight crew will report back to the OTC after completion.
01:00:00	The orbiter RGAs and AAs are tested.
00:50:00	The flight crew starts the orbiter hydraulic auxiliary power units' (APUs') water boilers preactivation.
00:45:00	Cabin vent redundancy check is performed.
00:45:00	The GLS mainline activation is performed.
00:40:00	The eastern test range (ETR) shuttle range safety system (SRSS) terminal count closed-loop test is accomplished.
00:40:00	Cabin leak check is completed.
00:32:00	The backup flight control system (BFS) computer is configured.

T - (MINUS) HR:MIN:SEC	EVENT
00:30:00	The gaseous nitrogen system for the orbital maneuvering system (OMS) engines is pressurized for launch. Crew compartment vent valves are opened.
00:26:00	The ground pyro initiator controllers (PICs) are powered up. They are used to fire the SRB hold-down posts, liquid oxygen and liquid hydrogen tail service mast (TSM), and ET vent arm system pyros at lift-off and the SSME hydrogen gas burn system prior to SSME ignition.
00:25:00	Simultaneous air-to-ground voice communications are checked. Weather aircraft are launched.
00:22:00	The primary avionics software system (PASS) is transferred to the BFS computer in order for both systems to have the same data. In case of a PASS computer system failure, the BFS computer will take over control of the shuttle vehicle during flight.
00:21:00	The crew compartment cabin vent valves are closed.
00:20:00	A 10-minute planned hold starts.
Hold 10 Minutes	All computer programs in the firing room are verified to ensure that the proper programs are available for the final countdown. The test team is briefed on the recycle options in case of an unplanned hold.
	The landing convoy status is again verified and the landing sites are verified ready for launch.
	The IMU preflight alignment is verified complete.
	Preparations are made to transition the orbiter on-board computers to Major Mode (MM)-101 upon coming out of the hold. This configures the computer memory to a terminal countdown configuration.
00:20:00	The 10-minute hold ends.
Counting	Transition to MM-101. The PASS on-board computers are dumped and compared to verify the proper on-board computer configuration for launch.
00:19:00	The flight crew configures the backup computer to MM-101 and the test team verifies the BFS computer is tracking the PASS computer systems. The flight crew members configure their instruments for launch.
00:18:00	The Mission Control Center-Houston (MCC-H) now loads the on-board computers with the proper guidance parameters based on the prestated lift-off time.
00:16:00	The MPS helium system is reconfigured by the flight crew for launch.

T - (MINUS) HR:MIN:SEC	EVENT
00:15:00	The OMS/RCS crossfeed valves are configured for launch. All test support team members verify they are "go for launch."
00:12:00	Emergency aircraft and personnel are verified on station.
00:10:00	All orbiter aerosurfaces and actuators are verified to be in the proper configuration for hydraulic pressure application. The NASA test director gets a "go for launch" verification from the launch team.
00:09:00	A planned 10-minute hold starts.
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 on-board orbiter PASS redundant-set computers.
00:09:00	Operations recorders are on. MCC-H, Johnson Space Center, sends a command to turn these recorders on. They record shuttle system performance during ascent and are dumped to the ground once orbit is achieved.
00:08:00	Payload and stored prelaunch commands proceed.
00:07:30	The orbiter access arm (OAA) connecting the access tower and the orbiter side hatch is retracted. If an emergency arises requiring flight crew activation, the arm can be extended either manually or by GLS computer control in approximately 30 seconds or less.
00:06:00	APU prestart occurs.
00:05:00	Orbiter APUs start. The orbiter APUs provide pressure to the three orbiter hydraulic systems. These systems are used to move the SSME engine nozzles and aerosurfaces.
00:05:00	ET/SRB range safety system (RSS) is armed. At this point, the firing circuit for SRB ignition and destruct devices is mechanically enabled by a motor-driven switch called a safe and arm device (S&A).

T - (MINUS) HR:MIN:SEC	EVENT
00:04:30	As a preparation for engine start, the SSME main fuel valve heaters are turned off.
00:04:00	The final helium purge sequence, purge sequence 4, on the SSMEs is started in preparation for engine start.
00:03:55	At this point, all of the elevons, body flap, speed brake, and rudder are moved through a preprogrammed pattern. This is to ensure that they will be ready for use in flight.
00:03:30	Transfer to internal power is done. Up to this point, power to the space vehicle has been shared between ground power supplies and the on-board fuel cells. The ground power is disconnected and the vehicle goes on internal power at this time. It will remain on internal power through the rest of the mission.
00:03:25	The SSMEs' nozzles are moved (gimbaled) through a preprogrammed pattern to ensure that they will be ready for ascent flight control. At completion of the gimbal profile, the SSMEs' nozzles are in the start position.
00:02:55	ET liquid oxygen prepressurization is started. At this point, the liquid oxygen tank vent valve is closed and the ET liquid oxygen tank is pressurized to its flight pressure of 21 psi.
00:02:50	The gaseous oxygen arm is retracted. The cap that fits over the ET nose cone to prevent ice buildup on the oxygen vents is raised off the nose cone and retracted.
00:02:35	Up until this time, the fuel cell oxygen and hydrogen supplies have been adding to the on-board tanks so that a full load at lift-off is assured. This filling operation is terminated at this time.
00:02:30	The caution/warning memory is cleared.
00:01:57	Since the ET liquid hydrogen tank was filled, some of the liquid hydrogen has turned into gas. In order to keep pressure in the ET liquid hydrogen tank low, this gas was vented off and piped out to a flare stack and burned. In order to maintain flight level, liquid hydrogen was continuously added to the tank to replace the vented hydrogen. This operation terminates, the liquid hydrogen tank vent valve is closed, and the tank is brought up to a flight pressure of 44 psia at this time.
00:01:15	The sound suppression system will dump water onto the mobile launcher platform (MLP) at ignition in order to dampen vibration and noise in the space shuttle. The firing system for this dump, the sound suppression water power bus, is armed at this time.
00:01:00	The SRB joint heaters are deactivated.
00:00:55	The SRB MDM critical commands are verified.

T - (MINUS) HR:MIN:SEC	EVENT
00:00:47	The liquid oxygen and liquid hydrogen outboard fill and drain valves are closed.
00:00:40	The external tank bipod heaters are turned off.
00:00:38	The on-board computers position the orbiter vent doors to allow payload bay venting upon lift-off and ascent in the payload bay at SSME ignition.
	The SRB forward MDM is locked out.
00:00:37	The gaseous oxygen ET arm retract is confirmed.
00:00:31	The GLS sends "go for redundant set launch sequence start." At this point, the four PASS computers take over main control of the terminal count. Only one further command is needed from the ground, "go for main engine start," at approximately T minus 9.7 seconds. The GLS in the integration console in the launch control center still continues to monitor several hundred launch commit criteria and can issue a cutoff if a discrepancy is observed. The GLS also sequences ground equipment and sends selected vehicle commands in the last 31 seconds.
00:00:28	Two hydraulic power units in each SRB are started by the GLS. These provide hydraulic power for SRB nozzle gimbaling for ascent first-stage flight control.
	The orbiter vent door sequence starts.
00:00:21	The SRB gimbal profile is complete. As soon as SRB hydraulic power is applied, the SRB engine nozzles are commanded through a preprogrammed pattern to assure that they will be ready for ascent flight control during first stage.
00:00:21	The liquid hydrogen high-point bleed valve is closed.
	The SRB gimbal test begins.
00:00:18	The on-board computers arm the explosive devices, the pyrotechnic initiator controllers, that will separate the T-0 umbilicals, the SRB hold-down posts, and SRB ignition, which is the final electrical connection between the ground and the shuttle vehicle.
00:00:16	The sound suppression system water is activated.
00:00:15	If the SRB pyro initiator controller (PIC) voltage in the redundant-set launch sequencer (RSLS) is not within limits in 3 seconds, SSME start commands are not issued and the on-board computers proceed to a countdown hold.
00:00:13	The aft SRB MDM units are locked out. This is to protect against electrical interference during flight. The electronic lock requires an unlock command before it will accept any other command.

T - (MINUS) HR:MIN:SEC	EVENT
	SRB SRSS inhibits are removed. The SRB destruct system is now live.
00:00:12	The MPS helium fill is terminated. The MPS helium system flows to the pneumatic control system at each SSME inlet to control various essential functions.
00:00:10	LPS issues a "go" for SSME start. This is the last required ground command. The ground computers inform the orbiter on-board computers that they have a "go" for SSME start. The GLS retains hold capability until just prior to SRB ignition.
00:00:09.7	Liquid hydrogen recirculation pumps are turned off. The recirculation pumps provide for flow of fuel through the SSMEs during the terminal count. These are supplied by ground power and are powered in preparation for SSME start.
00:00:09.7	In preparation for SSME ignition, flares are ignited under the SSMEs. This burns away any free gaseous hydrogen that may have collected under the SSMEs during prestart operations. The orbiter goes on internal cooling at this time; the ground coolant units remain powered on until lift-off as a contingency for an aborted launch. The orbiter will redistribute heat within the orbiter until approximately 125 seconds after lift-off, when the orbiter flash evaporators will be turned on.
00:00:09.5	The SSME engine chill-down sequence is complete and the on-board computers command the three MPS liquid hydrogen prevalves to open. (The MPS's three liquid oxygen prevalves were opened during ET tank loading to permit engine chill-down.) These valves allow liquid hydrogen and oxygen flow to the SSME turbopumps.
00:00:09.5	Command decoders are powered off. The command decoders are units that allow ground control of some on-board components. These units are not needed during flight.
00:00:06.6	The main fuel and oxidizer valves in each engine are commanded open by the on-board computers, permitting fuel and oxidizer flow into each SSME for SSME start. All three SSMEs are started at 120-millisecond intervals (SSME 3, 2, then 1) and throttle up to 100-percent thrust levels in 3 seconds under control of the SSME controller on each SSME.
00:00:04.6	All three SSMEs are verified to be at 100-percent thrust and the SSMEs are gimbaled to the lift-off position. If one or more of the three SSMEs does not reach 100-percent thrust at this time, all SSMEs are shut down, the SRBs are not ignited, and an RSLS pad abort occurs. The GLS RSLS will perform shuttle and ground systems safing. Vehicle bending loads caused by SSME thrust buildup are allowed to initialize before SRB ignition. The vehicle moves towards ET including ET approximately 25.5 inches.

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

STS-57 MISSION HIGHLIGHTS TIME LINE

T + (PLUS) DAY/ HR:MIN:SEC	EVENT
	DAY ZERO
0/00:00:07	Tower is cleared (SRBs above lightning rod tower).
0/00:00:10	180-degree positive roll maneuver (right-clockwise) is started. Pitch profile is heads down, wings level.
0/00:00:19	Roll maneuver ends.
0/00:00:28	All three SSMEs throttle down from 100 to 67 percent for maximum aerodynamic load (max q).
0/00:01:00	All three SSMEs throttle to 104 percent.
0/00:01:05	Max q occurs.
0/00:02:04	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, where the nose cap is jettisoned and drogue chute is deployed for initial deceleration. At approximately 6,600 feet, drogue chute is released, and three main parachutes on each SRB provide final deceleration prior to splashdown in Atlantic Ocean. The SRBs are recovered for reuse on another mission. Flight control system switches from SRB to orbiter RGAs.
0/00:04:05	Negative return. The vehicle is no longer capable of return-to-launch site abort at Kennedy Space Center runway.
0/00:06:44	Single engine press to main engine cutoff (MECO).
0/00:08:26	All three SSMEs throttle down to 67 percent for MECO.
0/00:08:33	MECO occurs at approximate velocity of 26,026 feet per second, 35 by 251 nautical miles (40 by 289 statute miles).
0/00:08:41	Zero thrust.

Editor's Note: This time line lists selected highlights only. For full detail, please refer to the NASA Mission Operations Directorate STS-57 Flight Plan, Ascent Checklist, Postinsertion Checklist, Rendezvous, Deorbit Prep Checklist, and Entry Checklist. The schedule assumes an extended 7-day, 23-hour (MET) mission.

T + (PLUS) DAY/ HR:MIN:SEC	EVENT
0/00:08:51	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 obiter for ET separation, are first used.
	Orbiter/ET liquid oxygen/liquid hydrogen umbilicals are retracted.
	Negative Z translation is complete.
	In conjunction with this thrusting period, approximately 1,700 pounds of liquid hydrogen and 3,700 pounds of liquid oxygen are trapped in the MPS ducts and SSMEs, which results in an approximate 7-inch center-of-gravity shift in the orbiter. The trapped propellants would sporadically vent in orbit, affecting guidance and creating contaminants for the payloads. During entry, liquid hydrogen could combine with atmospheric oxygen to form a potentially explosive mixture. As a result, the liquid oxygen is dumped out through the SSME combustion chamber nozzles, and the liquid hydrogen is dumped out through the right-hand T-minus-zero umbilical overboard fill and drain valves.
	MPS dump terminates.
	APUs shut down.
	MPS vacuum inerting occurs.
	— Remaining residual propellants are vented to space vacuum, inerting the MPS.
	— Orbiter/ET umbilical doors close (one door for liquid hydrogen and one door for liquid oxygen) at bottom of aft fuselage, sealing the aft fuselage for entry heat loads.
	— MPS vacuum inerting terminates.
0/00:44	OMS-2 thrusting maneuver is performed, approximately 3 minutes, 56 seconds in duration, at 312 fps, 249 by 251 nautical miles.
0/00:51	Commander closes all current breakers, panel L4.
0/00:53	Mission specialist (MS) seat egress.
0/00:54	Commander and pilot configure GPCs for OPS-2.
0/00:57	MS configures preliminary middeck.
0/00:59	MS configures aft flight station.
0/01:02	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, positive Y velocity vector attitude.

T + (PLUS) DAY/ HR:MIN:SEC	EVENT
0/01:17	Commander activates radiators.
0/01:18	If go for payload bay door operations, MS configures for payload bay door operations.
0/01:28	MS opens payload bay doors.
0/01:30	Commander loads payload data interleaver DFL.
0/01:36	Mission Control Center (MCC), Houston (H), informs crew to "go for orbit operations."
0/01:37	Commander and pilot seat egress.
0/01:38	MS activates SHOOT.
0/01:38	Commander and pilot clothing configuration.
0/01:39	MS/PS clothing configuration.
0/01:51	MS activates teleprinter (if flown).
0/01:52	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, and opens supply water dump isolation valve, panel R12L.
0/02:00	MS configures water loop.
0/02:01	Pilot activates auxiliary power unit steam vent heater, panel R2, boiler controller/heater, 3 to A, power, 3 to ON.
0/02:05	Commander configures vernier controls.
0/02:09	Commander, pilot configure controls for on orbit.
0/02:17	MS performs on-orbit initialization.
0/02:19	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	SPACEHAB activation.
0/02:30	Ergometer setup.
0/03:00	Stow middeck.
0/03:15	Ku-band antenna deployment.
0/03:25	Ku-band antenna activation.
0/03:30	SPACEHAB module setup.
0/04:00	ASC-2 activation.
0/04:00	TES-COS activation.
0/04:30	ASPECS check.

T + (PLUS) DAY/ HR:MIN:SEC	EVENT
0/04:30	CRIM-VDA activation.
0/04:30	LEMZ-1 setup.
0/04:50	DTO 623.
0/05:00	APCF activation.
0/05:10	CPDS activation.
0/05:24	NC-1 burn.
0/05:25	ORSEP activation.
0/05:30	SAMS activation.
0/05:30	Crew begins presleep activities.
0/05:30	Priority Group B powerdown.
0/05:40	GPPM activation.
0/05:45	ORSEP.
0/05:50	PSE operations.
0/08:30	Crew begins sleep period.
0/16:30	Crew begins postsleep activities.
0/19:15	SHOOT PGSC checkout.
0/19:30	ASC-2 download.
0/19:30	BPL activation.

T + (PLUS) DAY/ HR:MIN:SEC	EVENT
0/19:30	LEMZ-1 activation.
0/19:55	SPACEHAB middeck status checks.
0/20:10	SPACEHAB module status checks.
0/20:15	Fuel cell purge--manual.
0/20:25	ORSEP.
0/20:30	SAMS disk change.
0/20:30	SAREX setup.
0/21:10	TES-COS.
0/21:20	3DMA activation.
0/21:30	EFE activation.
0/21:40	SHOOT operations.
0/21:40	BPL deactivation.
0/22:00	EURECA payload retention latch assembly/SSP check.
0/22:29	SH-1 burn.
0/22:40	LEMZ check.
0/22:40	DSO 604.
0/22:50	CGBA initiation.
0/22:55	SCG activation.

T + (PLUS) DAY/ HR:MIN:SEC	EVENT
0/23:05	SAREX voice operations.
0/23:15	SHOOT monitor.
	MET DAY ONE
1/00:00	CPA operations.
1/00:05	RMS powerup.
1/00:20	RMS checkout.
1/00:30	TES-COS.
1/00:30	LEMZ-1 translation 2.
1/01:15	SCG activation.
1/01:15	APC unstow.
1/01:20	RMS payload bay survey.
1/01:20	DTO 700-2 laser checkout.
1/01:40	Laser stow.
1/01:50	HFA translation.
1/02:00	PSE operations.
1/02:15	DSO 604.
1/02:20	BPL deactivation.
1/02:25	Viewport close.
1/02:25	SAREX voice operations.
1/02:35	DSO 902.
1/02:40	ZCG activation.
1/02:40	RCS burn.
1/02:45	ASC-2 download.
1/03:07	NPC burn.
1/03:10	HFA translation.
1/03:25	Group A GAS (activate G-324 and G-601; verify CONCAP, G-450, G-535).
1/03:35	DSO 604.
1/03:45	SAREX voice operations.
1/03:50	EFE video.
1/03:55	SAMS disk change.
1/03:55	Group B GAS (deactivate G-601).
1/04:00	ORSEP.
1/04:05	SPACEHAB module status checks.
1/04:15	RCS burn.
1/04:20	Viewport open.
1/04:42	NC-2 burn.

T + (PLUS) DAY/ HR:MIN:SEC	EVENT
1/04:50	CGBA termination.
1/05:15	SPACEHAB middeck status checks.
1/05:25	LEMZ video.
1/05:25	Group C GAS (activate G-022, G-300, G-450, G-452, G-453, G-647).
1/05:30	TES-COS.
1/05:30	Crew begins presleep activities.
1/05:55	ZCG check.
1/07:35	ZCG check.
1/08:30	Crew begins sleep period.
1/16:30	Crew begins postsleep activities.
1/19:15	TES-COS.
1/19:25	HFA EPROC paper.
1/19:25	LEMZ video.
1/19:30	SPACEHAB module status checks.
1/19:35	SHOOT operations.
1/19:45	ORSEP.
1/19:50	SAMS disk change.

T + (PLUS) DAY/ HR:MIN:SEC	EVENT
1/19:50	SHOOT operations.
1/19:55	EFE video.
1/20:00	ZCG check.
1/20:05	SPACEHAB middeck status checks.
1/20:15	SH-2 burn.
1/20:30	BPL deactivation.
1/20:35	LEMZ-1 translation 3.
1/20:40	SAREX voice operations.
1/20:50	Group H GAS (G-324).
1/21:10	SHOOT operations.
1/21:25	SHOOT operations.
1/21:30	CGBA initiation.
1/21:40	CGBA termination.
1/21:49	SH-3 burn.
1/21:55	TDS-SE solder.
1/22:00	Viewport close.
1/22:15	LEMZ-1 termination.
1/22:15	Group D GAS (activate G-601; deactivate G-452, G-453, G-568).

T + (PLUS) DAY/ HR:MIN:SEC	EVENT
1/22:45	Group B GAS (deactivate G-601).
1/22:45	Viewport open.
1/23:00	ASC-2 download.
1/23:00	EFE video.
1/23:10	SHOOT operations.
	MET DAY TWO
2/00:00	HFA EPROC questionnaire.
2/00:00	SHOOT operations.
2/00:55	SAREX voice operations.
2/01:00	TES-COS.
2/01:00	HFA EPROC-SE.
2/01:10	SHOOT operations.
2/01:20	DTO 623.
2/01:30	TDS-SE desolder.
2/01:40	Group H GAS (G-324).
2/02:00	LEMZ-2 activation.
2/02:00	CPA operations.
2/02:00	DSO 618.

T + (PLUS) DAY/ HR:MIN:SEC	EVENT
2/02:15	SAREX voice operations.
2/02:55	PSE operations.
2/03:15	Group H GAS (G-324).
2/03:15	ZCG check.
2/03:20	SAMS disk change.
2/03:20	Dual G2 GPC operations.
2/03:25	TES-COS.
2/03:35	EURECA SSP check.
2/03:35	OMS burn.
2/03:40	ORSEP.
2/03:45	SPACEHAB middeck status checks.
2/03:45	SPACEHAB module status checks.
2/04:00	EVA equipment preparation.
2/04:02	NSR burn.
2/04:05	ASC-2 deactivation.
2/04:05	HFA EPROC-SE.
2/04:10	1 GNC GPC.
2/04:30	EMU checkout.

T + (PLUS) DAY/ HR:MIN:SEC	EVENT
2/04:55	RCS burn.
2/05:00	Crew begins presleep activities.
2/05:20	NC-3 burn.
2/08:00	Crew begins sleep period.
2/16:00	Crew begins postsleep activities.
2/18:25	Priority Group B powerup.
2/18:45	SPACEHAB middeck status checks.
2/18:55	EURECA retrieval begins.
2/19:00	SPACEHAB module status checks.
2/19:00	EFE unibed reverse flow.
2/19:00	BPL deactivation.
2/19:10	ORSEP.
2/19:15	ZCG check.
2/19:15	SAMS disk change.
2/19:20	PSE water refill.
2/19:20	CGBA termination.
2/19:24	NH burn.
2/19:40	TES-COS.

T + (PLUS) DAY/ HR:MIN:SEC	EVENT
2/19:50	EFE data backup.
2/20:00	LEMZ check.
2/20:11	NC-4 burn.
2/20:30	HFA EPROC computer.
2/21:40	TES-COS.
2/22:21	NCC burn.
2/23:19	Ti burn.

MET DAY THREE

T + (PLUS) DAY/ HR:MIN:SEC	EVENT
3/01:34	EURECA grapple.
3/02:00	EURECA berth.
3/03:15	Middeck preparation.
3/03:15	Priority Group B powerdown.
3/03:45	Preparation for donning EMUs (drink bags and antifog).
3/03:55	ZCG check.
3/04:00	LEMZ check.
3/04:15	SAMS disk change.
3/04:20	ORSEP.
3/04:25	PSE operations.

T + (PLUS) DAY/ HR:MIN:SEC	EVENT
3/04:45	SPACEHAB middeck status checks.
3/04:45	DTO 623.
3/04:45	SPACEHAB module status checks.
3/04:45	CPA operations.
3/04:55	ASC-2 activation.
3/05:00	Crew begins presleep activities.
3/08:00	Crew begins sleep period.
3/16:00	Crew begins postsleep activities.
3/18:00	EVA preparation (14.7 psi).
3/19:00	RMS powerup.
3/19:15	TES-COS.
3/19:35	Middeck stow.
3/19:40	EVA four-hour prebreathe begins.
3/19:45	Group H GAS (G-324).
3/19:45	SPACEHAB middeck status checks.
3/19:55	SPACEHAB module status checks.
3/20:10	SAMS disk change.
3/20:15	ZCG check.
3/20:20	ORSEP.
3/20:30	LEMZ-2 termination.
3/20:45	In-cabin familiarization (EVA preparation).
3/20:55	HFA EPROC questionnaire.
3/21:15	Group H GAS (G-324).
3/21:25	EVA preparation.
3/21:30	ASC-2 download.
3/21:35	CGBA termination.
3/21:55	SPACEHAB experiment pre-EVA preparation.
3/22:10	In-airlock familiarization (EVA preparation).
3/22:25	SPACEHAB system pre-EVA preparation.
3/22:25	Dual G2 GPC operations.
3/22:30	Payload pre-EVA configuration.
3/22:40	OMS burn.
3/23:00	EVA preparation.
3/23:05	Orbit adjust burn.
3/23:15	Egress viewing.
3/23:25	1 GNC GPC.

T + (PLUS) DAY/ HR:MIN:SEC	EVENT
3/23:40	Airlock depressurization.
	MET DAY FOUR
4/00:00	DTO 1210—EVA (4 hours).
4/03:45	RMS powerdown.
4/04:00	Airlock repressurization.
4/04:00	RMS survey.
4/04:10	PSE operations.
4/04:15	Post-EVA period begins.
4/04:15	SPACEHAB system post-EVA operations.
4/04:30	SPACEHAB experiment post-EVA operations.
4/04:30	TES-COS.
4/04:45	Payload post-EVA operations.
4/04:45	EVA suit dry.
4/04:45	ASC-2 download.
4/04:50	DTO 623.
4/04:55	BPL deactivation.
4/04:55	EVA survey.
4/04:55	CPA operations.
4/05:00	ORSEP.
4/05:05	SAMS disk change.
4/05:10	ZCG check.
4/05:10	Crew begins presleep activities.
4/05:15	SPACEHAB module status checks.
4/05:30	SPACEHAB middeck status checks.
4/08:00	Crew begins sleep period.
4/16:00	Crew begins postsleep activities.
4/18:50	FARE dumpline.
4/19:00	SPACEHAB module status checks.
4/19:00	SPACEHAB middeck status checks.
4/19:00	FARE setup.
4/19:05	Group H GAS (G-324).
4/19:15	ORSEP.
4/19:15	HFA EPROC paper.
4/19:20	SAMS disk change.
4/19:20	FARE line setup.
4/19:20	PCS configuration.

T + (PLUS) DAY/ HR:MIN:SEC	EVENT
4/19:30	EMU battery recharge.
4/19:30	ASC-2 download.
4/19:40	DTO 663 activation.
4/19:50	EFE bellows fill.
4/20:00	TES-COS.
4/20:10	ZCG download.
4/20:20	TDS DE activation.
4/20:30	FARE test 1.
4/20:30	CPA operations.
4/20:45	LEMZ-3 activation.
4/20:45	Group H GAS (G-324).
4/21:00	CGBA termination.
4/21:00	HFA sound measurements.
4/21:45	EFE phase separation.
4/22:00	DTO 412.
4/22:30	HFA EPROC-SE.
4/22:40	HFA sound teardown.
4/23:15	HFA questionnaire.
4/23:45	Maneuver vehicle to FARE initiation attitude.

MET DAY FIVE

T + (PLUS) DAY/ HR:MIN:SEC	EVENT
5/00:00	TES-COS.
5/00:00	EFE tape.
5/00:00	LEMZ-3 activation.
5/00:05	FARE test 5.
5/00:20	TDS DE deactivation.
5/00:20	HFA questionnaire.
5/01:15	PAO event setup.
5/01:45	FARE test 8.
5/02:00	PAO event.
5/02:05	CGBA camcorder operations.
5/02:30	TES-COS.
5/02:35	DTO 665.
5/03:05	ZCG check.
5/03:10	LEMZ-3 translation 2.
5/03:10	SAMS disk change.
5/03:15	ORSEP.

T + (PLUS) DAY/ HR:MIN:SEC	EVENT
5/03:20	EFE video.
5/03:20	Radiator deployment.
5/03:25	SPACEHAB module status checks.
5/03:30	BPL deactivation.
5/03:40	PSE operations.
5/03:40	DTO 663.
5/03:40	ASC-2 deactivation.
5/03:45	Group E GAS (activate G-454).
5/03:45	SPACEHAB middeck status checks.
5/03:50	EMU battery powerdown.
5/04:00	Crew begins presleep activities.
5/04:15	DTO 623.
5/07:00	Crew begins sleep period.
5/15:00	Crew begins postsleep activities.
5/17:45	FARE line setup.
5/18:00	ORSEP.
5/18:00	HFA translation.
5/18:00	EFE data backup.
5/18:00	FARE test 2.
5/18:00	SPACEHAB middeck status checks.
5/18:05	ECLiPSE activation.
5/18:15	LEMZ-3 termination.
5/18:20	TES-COS.
5/18:30	HFA questionnaire.
5/18:35	SPACEHAB module status checks.
5/18:45	EFE fill/drain.
5/18:50	CGBA initiation.
5/18:50	SAMS disk change.
5/19:00	CGBA termination.
5/19:00	FARE test 3.
5/19:10	ECLiPSE.
5/19:15	Post-EVA entry preparation.
5/19:30	ZCG furnace deactivation.
5/19:45	HFA light measurement.
5/19:55	FARE test 4.
5/20:00	ECLiPSE.

T + (PLUS) DAY/ HR:MIN:SEC	EVENT
5/20:30	LEMZ-4 activation.
5/20:35	ECLiPSE.
5/20:40	PAO radio event.
5/20:45	EFE tape.
5/20:55	HFA translation.
5/21:05	FARE test 6.
5/21:20	IPMP activation.
5/21:45	ECLiPSE.
5/21:45	BPL deactivation.
5/22:40	TES-COS.
5/23:00	FARE test 7.
5/23:00	ECLiPSE.
5/23:00	IPMP deactivation.
5/23:15	CPA operations.
5/23:45	HFA EPROC computer.

MET DAY SIX

T + (PLUS) DAY/ HR:MIN:SEC	EVENT
6/00:00	FARE stow.
6/00:00	NBP.
6/00:00	LEMZ-4 activation.
6/00:35	ECLiPSE.
6/00:40	EFE video.
6/00:55	HFA EPROC questionnaire.
6/01:05	ECLiPSE.
6/01:10	NBP operations.
6/01:20	NBP operations.
6/01:30	NBP operations.
6/01:40	NBP operations.
6/01:40	HFA EPROC questionnaire.
6/01:45	ECLiPSE deactivation.
6/01:50	PSE operations.
6/02:30	LEMZ-4 translation 2.
6/02:30	TES-COS.
6/02:45	EFE video.
6/02:45	DTO 623.
6/02:50	SAMS disk change.
6/02:55	ORSEP.

T + (PLUS) DAY/ HR:MIN:SEC	EVENT
6/03:00	SPACEHAB middeck status checks.
6/03:00	SPACEHAB module status checks.
6/03:00	Crew begins presleep activities.
6/06:00	Crew begins sleep period.
6/14:00	Crew begins postsleep activities.
6/16:15	CPA operations.
6/16:30	LEMZ-4 translation 3.
6/16:50	SPACEHAB middeck status checks.
6/16:50	EFE data backup.
6/16:55	SPACEHAB module status checks.
6/17:05	ORSEP.
6/17:10	SAMS disk change.
6/17:10	ZCG deactivation.
6/17:15	HFA questionnaire.
6/17:30	FCS checkout.
6/18:00	CRIM-VDA photos.
6/18:15	CGBA camcorder operations.
6/18:30	EFE deactivation.
6/19:10	DSO 604.
6/19:20	TES-COS.
6/19:30	LEMZ-4 termination.
6/19:30	DTO 412.
6/19:45	Group H GAS (G-324).
6/19:45	DSO 604.
6/19:55	Circulation pump (post-DTO 412 configuration).
6/20:00	ORSEP download.
6/20:00	DSO 604.
6/20:05	Group H GAS (G-324).
6/20:15	HFA questionnaire.
6/20:20	CGBA termination.
6/20:30	Group F GAS (deactivate CONCAP experiment).
6/20:55	ORSEP.
6/22:00	Crew press conference.
6/22:30	CGBA termination.
6/22:30	DSO 618.

T + (PLUS) DAY/ HR:MIN:SEC	EVENT
6/22:30	SPACEHAB module teardown.
6/22:35	RCS hot fire.
6/22:45	Group G GAS (deactivate G-022, G-324, G-399, G-454, G-647).
6/23:00	SPACEHAB module status checks.
6/23:00	LEMZ stow.
6/23:00	Group H GAS (G-324).
6/23:00	SAREX stow.
6/23:10	PSE operations.
6/23:15	SAMS disk change.
6/23:20	SPACEHAB middeck status checks.
6/23:20	APC stow.
6/23:30	Cabin stow.

MET DAY SEVEN

T + (PLUS) DAY/ HR:MIN:SEC	EVENT
7/01:00	Ergometer stow.
7/02:00	TES-COS deactivation.
7/02:15	Radiator stow.
7/02:25	Ku-band antenna stow.
7/02:30	Crew begins presleep activities.
7/05:30	Crew begins sleep period.
7/13:30	Crew begins postsleep activities.
7/15:45	CRIM-VDA deactivation.
7/15:50	APCF deactivation.
7/16:00	SAMS deactivation.
7/16:15	ASPECS check.
7/16:20	ORSEP deactivation.
7/16:20	SPACEHAB module teardown.
7/16:25	GPPM deactivation.
7/16:30	3DMA deactivation.
7/16:35	CPDS deactivation.
7/16:40	ASPECS check.
7/16:40	SPACEHAB deactivation.
7/16:45	OCAC stow.
7/16:50	Priority Group B powerup.
7/17:00	SHOOT deactivation.
7/17:20	DSO 603.

T + (PLUS) DAY/ HR:MIN:SEC	EVENT
7/17:48	Begin deorbit preparation.
7/17:51	CRT timer setup.
7/17:54	Commander initiates cold soak.
7/18:03	Stow radiators, if required.
7/18:11	Ku-band antenna stow.
7/18:21	Commander configures DPS for deorbit preparation.
7/18:24	Mission Control Center updates IMU star pad, if required.
7/18:33	MS configures for payload bay door closure.
7/18:44	MCC-H gives “go/no-go” command for payload bay door closure.
7/18:50	Maneuver vehicle to IMU alignment attitude.
7/19:05	IMU alignment/payload bay door operations.
7/19:28	MCC gives the crew the go for OPS-3.
7/19:35	Pilot starts repressurization of SSME systems.
7/19:39	Commander and pilot perform DPS entry configuration.
7/19:48	MS deactivates ST and closes ST doors.
7/19:50	All crew members verify entry payload switch list.
7/20:05	All crew members perform entry review.
7/20:07	Crew begins fluid loading, 32 fluid ounces of water with salt over next 1.5 hours (2 salt tablets per 8 ounces).
7/20:20	Commander and pilot configure clothing.
7/20:35	MS/PS configure clothing.
7/20:46	Commander and pilot seat ingress.
7/20:48	Commander and pilot set up heads-up display (HUD).
7/20:50	Commander and pilot adjust seat, exercise brake pedals.
7/20:58	Final entry deorbit update/uplink.
7/21:04	OMS thrust vector control gimbal check is performed.
7/21:05	APU prestart.
7/21:20	Close vent doors.
7/21:24	MCC-H gives “go” for deorbit burn period.
7/21:33	Maneuver vehicle to deorbit burn attitude.
7/21:36	MS/PS ingress seats.

T + (PLUS) DAY/ HR:MIN:SEC	EVENT
7/21:43	First APU is activated.
7/21:48	Deorbit burn.
7/21:51	Initiate post-deorbit burn period attitude.
7/21:55	Terminate post-deorbit burn attitude.
7/22:03	Dump forward RCS, if required.
7/22:11	Activate remaining APUs.
7/22:25	Entry interface, 400,000 feet altitude.
7/22:29	Automatically deactivate RCS roll thrusters.
7/22:36	Automatically deactivate RCS pitch thrusters.
7/22:36	Initiate first roll reversal.
7/22:41	First manual body flap.
7/22:43	Initiate second roll reversal.
7/22:45	TACAN acquisition.
7/22:47	Second manual body flap.
7/22:48	Initiate third roll reversal.
7/22:49	Initiate air data system (ADS) probe deploy.
7/22:50	Begin entry/terminal area energy management (TAEM).
7/22:50	Initiate payload bay venting.
7/22:52	Automatically deactivate RCS yaw thrusters.
7/22:55	Begin TAEM/approach/landing (A/L) interface.
7/22:55	Initiate landing gear deployment.
7/22:56	Vehicle has weight on main landing gear.
7/22:56	Vehicle has weight on nose landing gear.
7/22:56	Initiate main landing gear braking.
7/22:57	Wheel stop.

GLOSSARY

A/G	air-to-ground
AG	airglow
AA	accelerometer assembly
ACS	active cooling system
ADS	air data system
AFB	Air Force base
A/L	approach and landing
AMF	automatic mirror furnace
AMOS	Air Force Maui Optical Site
AOS	acquisition of signal
APC	autonomous payload controller
APC	adaptive payload carrier
APCF	Advanced Protein Crystallization Facility
APCS	autonomous payload control system
APU	auxiliary power unit
ASC-2	ASTROCULTURE
ASE	airborne support equipment
ASGA	advanced solar gallium arsenide array
ASPEC	Application-Specific Preprogrammed Experimental Culture System
BFS	backup flight system
BPL	Bioserve Pilot Lab
CAP	complex autonomous payload
CCD	charge-coupled device
CCDS	Center for the Commercial Development of Space
CDMS	command and data management subsystem
CGBA	Commercial Generic Bioprocessing Apparatus
CMDS	Corsortium for Materials Development in Space
COAS	crewman optical alignment sight
CONCAP	Consortium for Materials Development in Space Complex Autonomous Payload
CPDS	Charged-Particle Directional Spectrometer
CRIM	commercial refrigerator/incubator module
CRT	cathode ray tube
C/W	caution/warning
DA	detector assembly
DACA	data acquisition and control assembly
DAP	digital autopilot
DC	detector controller
DOD	Department of Defense
DPS	data processing system
DSO	detailed supplementary objective
DTO	development test objective
EAFB	Edwards Air Force Base
ECLiPSE	Equipment for Controlled Liquid-Phase Sintering Experiment
ECLSS	environmental control and life support system
EDO	extended-duration orbiter
EDOMP	extended-duration orbiter medical project
EFE	ECLSS Flight Experiment
EHF	extremely high frequency
ELV	expendable launch vehicle
EMP	enhanced multiplexer/demultiplexer pallet
EMU	extravehicular mobility unit
EOM	end of mission
EPS	electrical power system
ERA	exobiology and radiation assembly
ESC	electronic still camera
ESA	European Space Agency
ESOC	ESA Space Operations Centre
ESS	equipment support section
ET	external tank

ETR	Eastern Test Range
EURECA	European Retrievable Carrier
EV	extravehicular
EVA	extravehicular activity
FARE	Fluid Acquisition and Resupply Experiment
FC	fuel cell
FCP	fuel cell power plant
FCS	flight control system
FDF	flight data file
FEA	fluids experiment apparatus
FES	flash evaporator system
FPA	fluid processing apparatus
fps	feet per second
FRCS	forward reaction control system
G-022	periodic volume stimulus method GAS
G-324	CAN DO—Earth resources and astronomical photography GAS
G-399	brine shrimp growth and salt ion transport GAS
G-450	American Institute of Aeronautics and Astronautics Experiment GAS
G-452	gallium-arsenide crystal growth GAS
G-453	formation of alloys GAS
G-454	crystal growth of indium-gallium-arsenide GAS
G-535	effects of heat flux and liquid subcooling GAS
G-601	solar flux experiment GAS
G-647	liquid-phase electroepitaxy experiment GAS
GAP	group activation pack
GAS	getaway special
GCD	GAS control decoders
GLS	ground launch sequencer
GN&C	guidance, navigation, and control
GPC	general-purpose computer
GPPM	Gas-Permeable Polymer Materials
GSFC	Goddard Space Flight Center
HAINS	high-accuracy inertial navigation system
HFA	Human Factors Assessment
HPT	high-precision thermostat
HRM	high-rate multiplexer
HST	Hubble Space Telescope
HUD	heads-up display
IFM	in-flight maintenance
IMU	inertial measurement unit
I/O	input/output
IOC	interorbit communication
IPMP	Investigations Into Polymer Membrane Processing
IR	infrared
ITEPC	inter-Mars tissue-equivalent proportional counter
IUS	inertial upper stage
IV	intravehicular
JSC	Johnson Space Center
KEAS	knots equivalent air speed
KSC	Kennedy Space Center
LBNP	lower body negative pressure
LCD	liquid crystal display
LEMZ	Liquid-Encapsulated Melt Zone
LES	launch escape system
LPEE	liquid-phase electroepitaxy
LPS	launch processing system
LPS	liquid-phase sintering
LRU	line replaceable unit
MCC-H	Mission Control Center—Houston
MDM	multiplexer/demultiplexer

MECO	main engine cutoff
MET	mission elapsed time
MFA	multifurnace assembly
MILA	Merritt Island
MLP	mobile launcher platform
MM	major mode
MPM	manipulator positioning mechanism
MPESS	multipurpose experiment support structure
MPS	main propulsion system
MS	mission specialist
MSFC	Marshall Space Flight Center
NBP	Neutral Body Posture
NC-1 through NC-4	burns that adjust the rate at which orbiter is closing on EURECA
NCC	corrective combination maneuver
NH	differential height adjustment that adjusts the altitude of orbiter's orbit
NLO	nonlinear optical
nmi	nautical mile
NOR	Northrup Strip
NPC	plane change maneuver--aligns orbiter's orbit directly below EURECA's orbit
NSR	coelliptic maneuver that circularizes orbiter's orbit
O&C	operations and checkout
OAA	orbiter access arm
OACT	Office of Advanced Concepts and Technology
OCP	Office of Commercial Programs
OG	orbiter glow
OMS	orbital maneuvering system
OPF	orbiter processing facility
ORA	occultation radiometer
ORSEP	Organic Separation
OTC	orbiter test conductor
PAO	public affairs officer
PASS	primary avionics software system
PC	proportional counter
PCF	protein crystallization facility
PCG	protein crystal growth
PCMMU	pulse code modulation master unit
PCS	pressure control system
PDU	playback/downlink unit
PGSC	payload and general support computer
PI	payload interrogator
PIC	pyro initiator controller
POCC	Payload Operations Control Center
PPC	payload power contactor
PRCS	primary reaction control system
PRD	payload retention device
PRLA	payload retention latch assembly
PRSD	power reactant storage and distribution
PS	payload specialist
PSE	Physiological Systems Experiment
PTI	preprogrammed test input
P/TV	photo/TV
RAAN	right ascension of the ascending node
RCRS	regenerable carbon dioxide removal system
RCS	reaction control system
RF	radio frequency
RGA	rate gyro assembly
RITA	radio frequency ion thruster assembly
RMS	remote manipulator system
ROEU	remotely operated electrical umbilical
rpm	revolutions per minute
RSLS	redundant-set launch sequencer
RSS	range safety system

RTLS	return to launch site
S&A	safe and arm
SA	solar array
SAF	Secretary of the Air Force
SAMS	space acceleration measurement system
SAREX	shuttle amateur radio experiment
SCG	Support of Crystal Growth
SFA	surface forces adhesion
SGF	solution growth facility
SH-1 through SH-3	burns that are performed as part of the SHOOT experiment
SHF	superhigh frequency
SHOOT	Superfluid Helium On-Orbit Transfer Experiment
sm	statute mile
SOSP	solar spectrum
SOVA	solar constant and variability instrument
SPASP	small payload accommodations switch panel
SPOC	shuttle payload of opportunity carrier
SRB	solid rocket booster
SRM	solid rocket motor
SRSS	shuttle range safety system
SSCE	solid surface combustion experiment
SSME	space shuttle main engine
SSP	standard switch panel
SSPP	Shuttle Small Payload Project
SSPP	solar/stellar pointing platform
ST	star tracker
STA	structural test article
STS	space transportation system
SURS	standard umbilical retraction/retention system

TAEM	terminal area energy management
TAGS	text and graphics system
TAL	transatlantic landing
TDRS	Tracking and Data Relay Satellite
TDRSS	Tracking and Data Relay Satellite system
TDS	Tools and Diagnostic Systems
TES-COS	thermal enclosure system/crystal observation system
TFL	telemetry format load
TI	thermal phase initiation burn that begins orbiter's proximity operations with EURECA
TICCE	timeband capture cell experiment
TIG	time of ignition
TPS	thermal protection system
TSM	tail service mast
TT&C	telemetry, tracking, and communications
TV	television
TVC	thrust vector control
UHF	ultrahigh frequency
VDA	vapor diffusion apparatus
VRCS	vernier reaction control system
VTR	videotape recorder
WATCH	Wide-Angle Telescope for Cosmic Hard X-ray Transients
WCCS	wireless crew communication system
WCS	waste collection system
ZCG	Zeolite Crystal Growth
3DMA	three-dimensional microgravity accelerometer