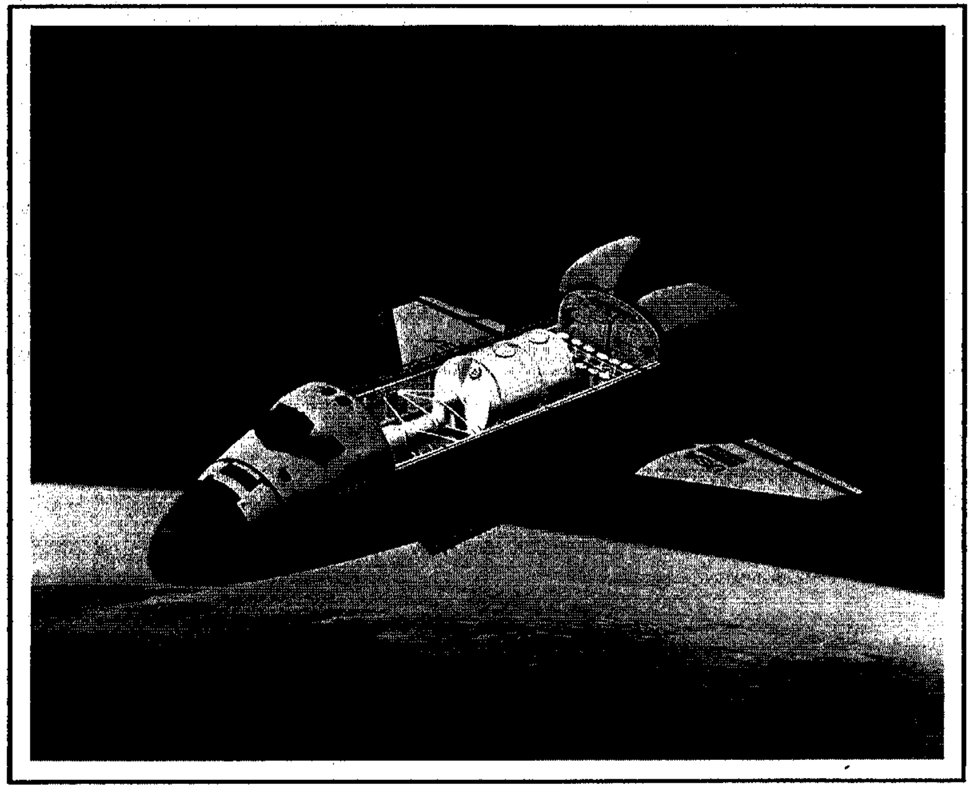


STS-42

PRESS INFORMATION

January 1992

Rockwell International
Space Systems Division

Office of Media Relations

PUB 3546-V Rev 1-92

CONTENTS

MISSION OVERVIEW

This is the 14th flight of Discovery and the 45th for the space shuttle.

The flight crew for the STS-42 mission is commander Ronald (Ron) J. Grabe, Col., USAF; pilot Stephen (Steve) S. Oswald; mission specialist David (Dave) C. Hilmers, Lt. Col., USMC; mission specialist Dr. Norman (Norm) E. Thagard; mission specialist William (Bill) F. Readdy; and payload specialists Ulf D. Merbold of the European Space Agency and Dr. Roberta L. Bondar of the Canadian Space Agency. The crew will be divided into a blue team, consisting of Grabe, Oswald, Thagard, and Bondar, and a red team, comprised of Hilmers, Readdy, and Merbold. Each team will work consecutive 12-hour shifts, providing for around-the-clock operations.

STS-42's primary mission objective is to perform the planned operations of the International Microgravity Laboratory (IML) 1 payload conducted in the Spacelab long module. IML-1 consists of a series of multidiscipline experiments that will investigate the effects of microgravity on materials processes and living organisms.

IML-1 materials science investigations include studies of the effects of microgravity on the growth of various types of crystals and fluid medium behavior, as well as measurements of space accelerations and the critical point at which many physical properties assume extreme values or at which profound changes in material properties occur. Life sciences investigations include biological investigations on plants, tissues, cells, bacteria, and insects; studies of space adaptation and space motion sickness; investigations of the radiobiological importance of cosmic ray particles of high mass number and energy and nuclear disintegration stars; crew mental performance in zero gravity; and measurements of the effect of radiation on biological materials in space. Several of the IML-1 experiments have flown previously on earlier Spacelab missions.

The IML-1 consists of a pressurized module located in Discovery's payload bay and connected to the crew cabin by an access tunnel. Most experiments are mounted in racks in the module, which is internally configured with eight double racks, four single racks, and 14 overhead stowage lockers. In Discovery's crew cabin, five middeck stowage lockers with two refrigerator/incubator modules (RIMs) are used for experiment stowage and ancillary items. Twelve getaway special (GAS) canisters located in the payload bay hold additional experiments.

Activation of the IML will immediately follow cabin unstow on Flight Day 1 and continue through to Flight Day 7.

Discovery will provide IML-1 with a stable attitude, power, and cooling. A tail down, "pseudo" gravity gradient attitude will be employed to minimize the number of orbiter reaction control system firings necessary during the mission, which can disturb microgravity experimentation. In addition, due to the orbital altitude and inclination at this time of year, Discovery will be in continuous sunlight for four days of the mission. This thermally challenging environment will be compensated for by the orbiter's cooling systems.

This maiden voyage of the IML series of Spacelab flights is a cooperative effort between NASA, six international space science research organizations, and over 200 scientists from 16 different nations. Marshall Space Flight Center, Huntsville, Ala., is responsible for IML mission management. Data collected from the first flight will be used in subsequent flights and will also become part of the research base for Space Station Freedom.

STS-42 is the latest effort in the U.S. manned space program's continuing investigations into materials processing and life sciences microgravity research. Several more flights are planned, including the STS-50 United States Microgravity Laboratory (USML) 1 mission in mid 1992 and the STS-47 Spacelab-J mission, currently scheduled in the September 1992 time frame.

Secondary objectives for STS-42 include a series of middeck and GAS experiments, including the following: Gelation of Sols: Applied Microgravity Research (GOSAMR); Investigations Into Polymer Membrane Processing (IPMP); Radiation Monitoring Equipment III; IMAX camera; two student experiments (Convection in Zero Gravity and Capillary Rise of Liquid Through Granular Porous Media); and 10 GAS canister experiments mounted on a GAS bridge assembly (GBA) in Discovery's payload bay. The crew of STS-42 will also conduct continuing life sciences research in preparation for planned extended duration orbiter (EDO) operations and will gather Earth observation data throughout the flight.

Gelation of Sols: Applied Microgravity Research (GOSAMR) is a middeck experiment that will investigate the influence of microgravity on the processing of advanced ceramics materials.

The research objective of the IPMP payload is to investigate the formation of polymer membranes in microgravity, research that could lead to possible advances in filtering technologies. The IPMP requires one half of a middeck locker and approximately 30 minutes of crew time.

The RME-III payload in Discovery's middeck takes measurements of the ionizing radiation levels in the orbiter crew compartment. The handheld unit contains a liquid crystal display for real-time data display and a keyboard for controlling its functions. It occupies half of a middeck locker.

The IMAX camera, a large-format camera flown on several shuttle missions as a joint project by NASA, the National Air and Space Museum, and the IMAX Film Corporation, will be used to film activities in the Spacelab module and crew compartment, emphasizing the space physiology experiments that have a bearing on future long-duration human presence in space. The crew will also take advantage of the high inclination of the STS-42 orbit to film Earth features at latitudes not overflown by most shuttle flights. The scenes will be used in an IMAX film now in production on mankind's future in space.

The objective of Student Experiment 81-09, Convection in Zero Gravity, is to study the effects of heat on surface tension-induced flows in microgravity. The experiment is housed in Discovery's middeck.

The objective of Student Experiment 83-02, Capillary Rise of Liquid Through Granular Porous Media, is to investigate the effects of gravity on the flow characteristics of a fluid through granular substances via capillary action. It is housed in Discovery's middeck.

Attached cargo operations will be performed with the 10 GAS canister experiments contained in the GAS bridge assembly mounted in Discovery's aft payload bay. Experiments from six countries (United States, Japan, Sweden, Germany, Australia, and China) will be conducted, encompassing materials processing, life sciences, fluid physics, and astronomical observations. Crew interface is minimal, requiring only switch activation/deactivation from the aft flight deck.

Sixteen development test objectives and nine detailed supplementary objectives are scheduled to be flown on STS-42.

MISSION STATISTICS

Vehicle: Discovery (OV-103), 14th flight

Launch Date/Time:

1/22/92	8:53 a.m., EST
	7:53 a.m., CST
	5:53 a.m., PST

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

Launch Window: 2 hours, 30 minutes

Launch Clearance Window for 1/22/92: 8:53 a.m. EST to 11:42 a.m. EST

Mission Duration: 7 days, 1 hour, 12 minutes

Landing: Nominal end-of-mission landing on Orbit 113

1/29/92	10:05 a.m., EST
	9:05 a.m, CST
	7:05 a.m., PST

Runway: Nominal end-of-mission landing on concrete runway 22, Edwards Air Force Base (EAFB) Calif. Weather alternates are KSC and Northrup Strip (NOR), White Sands, N.M.

Transatlantic Abort Landing: Zaragoza, Spain; alternates are Moron, Spain, and Ben Guerir, Morocco

Return to Launch Site: KSC

Abort-Once-Around: NOR; alternate is EAFB

Inclination: 57 degrees

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

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

Altitude: 163-nautical-mile (188-statute-mile) circular orbit

Space Shuttle Main Engine Thrust Level During Ascent: 104 percent

Space Shuttle Main Engine Locations:

No. 1 position: Engine 2026
No. 2 position: Engine 2022
No. 3 position: Engine 2027

Total Lift-off Weight: Approximately 4,507,474 pounds

Orbiter Weight, Including Cargo, at Lift-off: Approximately 243,395 pounds

Orbiter (Discovery) Empty, and 3 SSMEs: Approximately 172,707 pounds

Payload Weight Up: Approximately 28,663 pounds

Payload Weight Down: Approximately 28,663 pounds

Orbiter Weight at Landing: Approximately 218,016 pounds

Payloads—Payload Bay (* denotes primary payload): International Microgravity Laboratory (IML)-1*, getaway special (GAS) bridge, IMAX camera

Payloads—Middeck: Gelation of Sols: Applied Microgravity Research (GOSAMR)-1, Investigations Into Polymer Membrane Processing (IPMP), Radiation Monitoring Equipment (RME)-III, Student Experiment 81-09: Convection in Zero Gravity, Student Experiment 83-02: Capillary Rise of Liquid Through Granular Porous Media

Flight Crew Members:

Blue Team:

Commander: Ronald (Ron) J. Grabe, third space shuttle flight
Pilot: Stephen (Steve) S. Oswald, first space shuttle flight
Mission Specialist 1: Dr. Norman (Norm) E. Thagard, fourth space shuttle flight
Payload Specialist 1: Dr. Roberta L. Bondar, Canadian Space Agency, first space shuttle flight

Red Team

Mission Specialist 2: William (Bill) F. Readdy, first space shuttle flight
Mission Specialist 3: David (Dave) C. Hilmers, fourth space shuttle flight
Payload Specialist 2: Ulf D. Merbold, European Space Agency, second space shuttle flight

Grabe, Oswald, and Readdy make up the orbiter crew, which will operate the shuttle and Spacelab systems monitored by the Mission Control Center at Johnson Space Center (JSC). Hilmers, Bondar, and Merbold form the science crew, which will operate the IML-1 experiments monitored by the Payload Operations Control Center at Marshall Space Flight Center (MSFC).

Ascent Seating:

Flight deck, front left seat, commander Ronald (Ron) J. Grabe
Flight deck, front right seat, pilot Stephen (Steve) S. Oswald
Flight deck, aft center seat, mission specialist William (Bill) F. Readdy
Flight deck, aft right seat, mission specialist Dr. Norman (Norm) E. Thagard
Middeck, mission specialist David (Dave) C. Hilmers
Middeck, payload specialist Dr. Roberta L. Bondar
Middeck, payload specialist Ulf D. Merbold

Entry Seating:

Flight deck, front left seat, commander Ronald (Ron) J. Grabe
Flight deck, front right seat, pilot Stephen (Steve) S. Oswald
Flight deck, aft center seat, mission specialist William (Bill) F. Readdy
Flight deck, aft right seat, mission specialist David (Dave) C. Hilmers
Middeck, mission specialist Dr. Norman (Norm) E. Thagard
Middeck, payload specialist Dr. Roberta L. Bondar
Middeck, payload specialist Ulf D. Merbold

Extravehicular Activity Crew Members, If Required:

Extravehicular (EV) astronaut 1: mission specialist Dr. Norman (Norm) E. Thagard
EV-2: mission specialist William (Bill) F. Readdy

Intravehicular Astronaut: Pilot Stephen (Steve) S. Oswald

STS-42 Flight Directors:

Ascent/Entry: Wayne Hale
Orbit 1 Team: Jeff Bantle
Orbit 2 Team (lead): Bob Castle
Planning Team: Chuck Shaw

STS-42 Control Centers:

Space Shuttle and Spacelab module: JSC
IML-1: MSFC

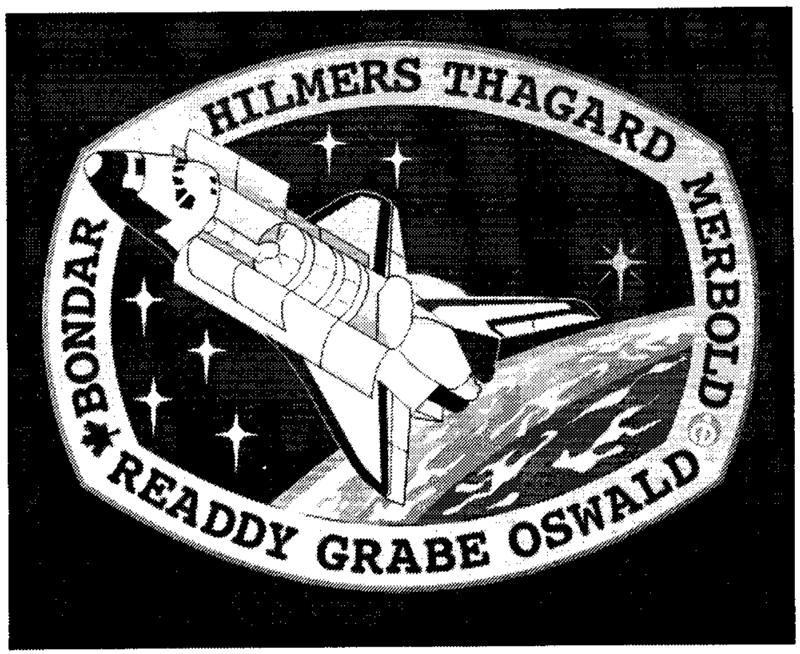
Entry: Automatic mode until subsonic, then control-stick steering

Notes:

- The remote manipulator system is not installed in Discovery's payload bay for this mission
- The galley is installed in Discovery's middeck
- Landing is planned at EAFB because of Discovery's heavier landing weight (return of the IML-1 laboratory)
- Upon its return to Florida, Discovery will be removed from flight status for the next 8-1/2 months to undergo major modifications, upgrades, and required inspections. Discovery's next flight, STS-53, a Department of Defense flight, is planned for this fall.

MISSION OBJECTIVES

- Primary Payload
  - International Microgravity Laboratory 1
- Secondary Payloads
  - Payload Bay
    - GAS bridge assembly with 10 getaway specials
    - IMAX camera
  - Middeck
    - Gelation of Sols: Applied Microgravity Research 1
    - Investigations Into Polymer Membrane Processing
    - Radiation Monitoring Equipment III
    - Student Experiment 81-09: Convection in Zero Gravity
    - Student Experiment 82-03: Capillary Rise of Liquid Through Granular Porous Media
- Development Test Objectives/Detailed Supplementary Objectives



STS-42 Crew Insignia

FLIGHT ACTIVITIES OVERVIEW

Flight Day 1

Launch
OMS-2
Unstow cabin
IML-1 activation
Transfer science specimens to Spacelab
IML-1 operations

Flight Day 2

IML-1 experiment operations

Flight Day 3

IML-1 experiment operations

Flight Day 4

IML-1 experiment operations

Flight Day 5

IML-1 experiment operations

Flight Day 6

IML-1 experiment operations

Flight Day 7

IML experiment operations
IML-1 deactivation
RCS hot fire test
FCS checkout
Cabin stow
Deorbit preparation
Deorbit burn

Flight Day 8

Landing

Notes:

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

- Due to power requirements and the length of the mission, an equipment powerdown (referred to as a Group B powerdown), is executed on flight day 1 to conserve cryogenics for a full mission duration plus two extension days (if required). Powerdown activities include powering off three of Discovery's four CRTs, placing three of Discovery's five general-purpose computers on standby, placing one of Discovery's three inertial measurement units on standby, and powering off three of Discovery's eight flight-critical multiplexers (two forward, one aft).

STS-42 CREW

STS-42 crew members are (from left) pilot Stephen S. Oswald, payload specialist Roberta L. Bondar, payload commander Norman E. Thagard, mission commander Ronald J. Grabe, mission specialist David C. Hilmers, payload specialist Ulf Merbold, and mission specialist William F. Readdy.

DEVELOPMENT TEST OBJECTIVES/DETAILED SUPPLEMENTARY OBJECTIVES

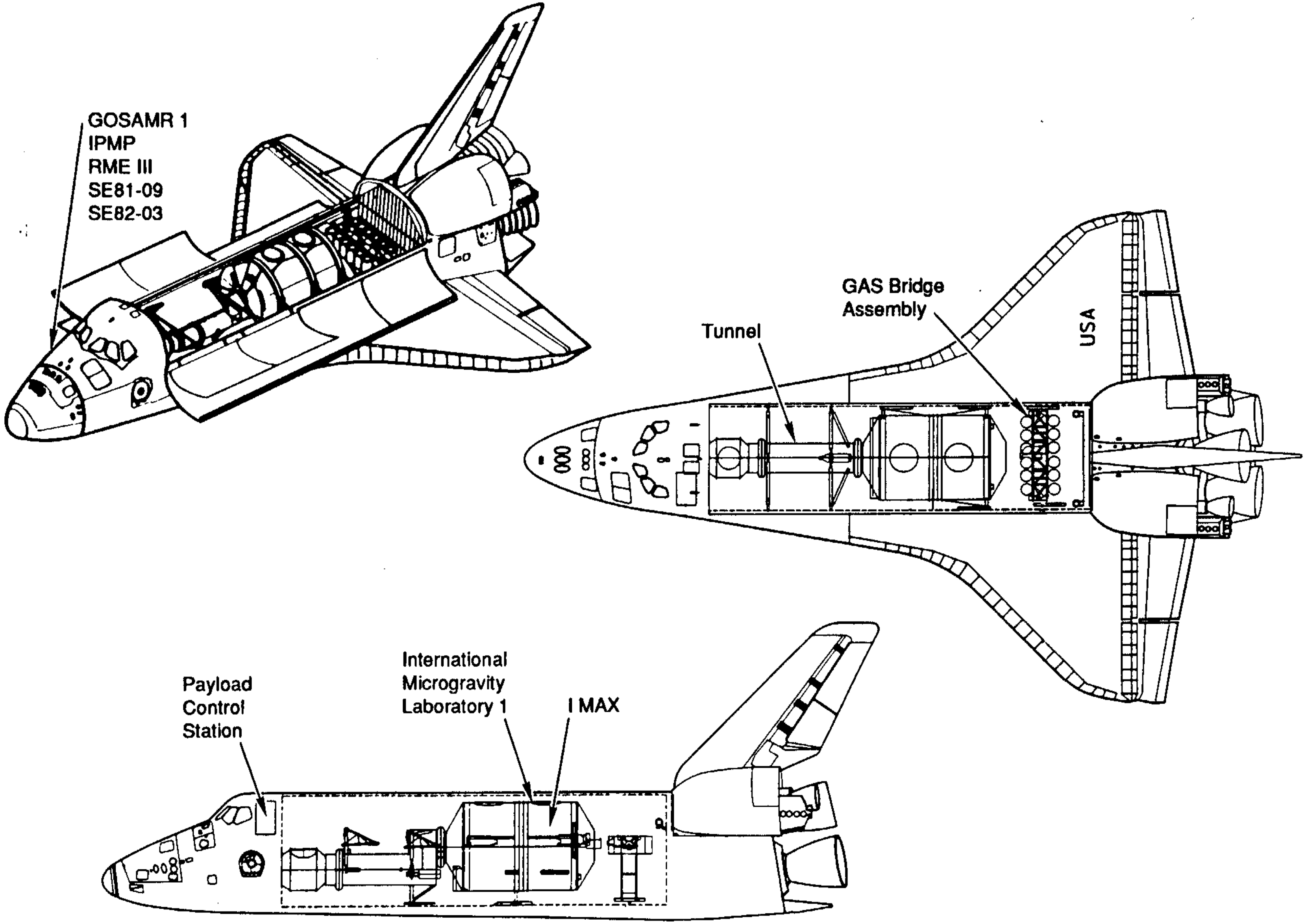
DTOs

- Entry aerodynamic control surfaces test (Part 6) (DTO 242)
- Ascent wing structural capability evaluation (DTO 301D)
- Ascent compartment venting evaluation (DTO 305D)
- Descent compartment venting evaluation (DTO 306D)
- Entry structural evaluation (DTO 307D)
- Vibration and acoustic evaluation (DTO 308D)
- ET TPS performance—crew photography after ET separation (DTO 312)
- Shuttle/payload low frequency environment (DTO 319D)
- Cabin air monitoring (DTO 623)
- Eyewash—zero-g eyewash kit test (DTO 635)
- On-orbit cabin air cleaner evaluation (DTO 637)
- Spacelab CO_2 control (DTO 641)
- Electronic still photography (DTO 648)
- EDO cycle ergometer hardware evaluation (DTO 651)
- Evaluation of the MK I rowing machine (DTO 653)
- Crosswind landing performance (DTO 805)

DSOs

- Variation in supine and standing heart rate, blood pressure, and cardiac size (DSO 466)
- In-flight radiation dose-distribution (DSO 469)
- The relationship of space adaption syndrome to middle cerebral artery blood velocity measured during entry, landing, and egress (DSO 470)
- Orthostatic equilibrium control during landing/egress (DSO 603B)
- Air monitoring instrument evaluation and atmosphere characterization (DSO 611)
- Changes in endocrine regulation of orthostatic tolerance following space flight (DSO 613)
- Documentary television (DSO 901)
- Documentary motion picture photography (DSO 902)
- Documentary still photography (DSO 903)

PAYLOAD CONFIGURATION



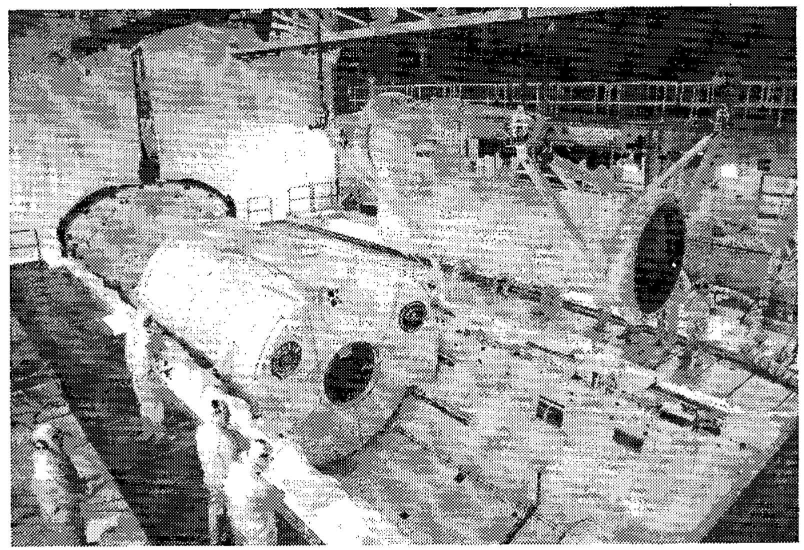
INTERNATIONAL MICROGRAVITY LABORATORY (IML)

An international group of space investigators will be intently watching from the Marshall Space Flight Center in Huntsville, Ala., as the crew of STS-42 conducts a battery of life science and materials science experiments during this 7-day mission. The experiments are part of the International Microgravity Laboratory mission, the first in a series of missions dedicated to life and materials sciences research in reduced gravity that will be launched on the space shuttle over the next 10 years. The IML-1 experiments will benefit the U.S. and international space exploration programs and expand mankind's knowledge not only of space, but also of Earth and perhaps even unlock some of the mysteries of physical processes, leading to improvements in life on Earth. For example, knowledge about biological processes can be applied to medical problems at home, and information about the effects of gravity and other physical phenomena on the processing of materials will be useful on the ground.

The experiments will be performed in the European Space Agency's Spacelab, a fully equipped laboratory that is carried in the payload bay of the space shuttle. In shirt-sleeve comfort, scientist-astronauts will investigate the effects of microgravity and other physical phenomena on plant and animal growth, on the human body, and on the production of materials, such as protein crystals.

The shuttle is an excellent platform for conducting these experiments. It provides experimenters the long-term access to space they need to conduct some of their investigations of materials processing and is able to minimize gravity to the lowest possible levels.

During the 7-day STS-42 mission, the crew members will conduct experiments on themselves to see how the human body adapts to weightlessness. They will also investigate the effects of weightlessness and radiation on plants and animals. NASA hopes that these studies will lead to discoveries that will enable astronauts to live and work safely and effectively in space for much longer periods of time.



Installation of IML-1 Transfer Tunnel

Half of the IML-1 materials science experiments have been performed on previous space shuttle missions. On this flight, investigators will try to build on the results from the previous flights and refine experiment techniques.

Previous experiments have suggested that materials are affected by weightlessness, but scientists are just beginning to understand the processes that affect the production of materials in space. On the IML-1 mission, investigators will test a variety of processing techniques to try to produce the pure, nearly perfect crystals that are needed for computers and other optical and electrical devices. It is impossible to produce them on Earth because of the effects induced by gravity, such as buoyancy and sedimentation. The scientists want to learn whether eliminating these effects in space will allow them to produce new alloys and composites and study the fundamental properties of fluid interactions.

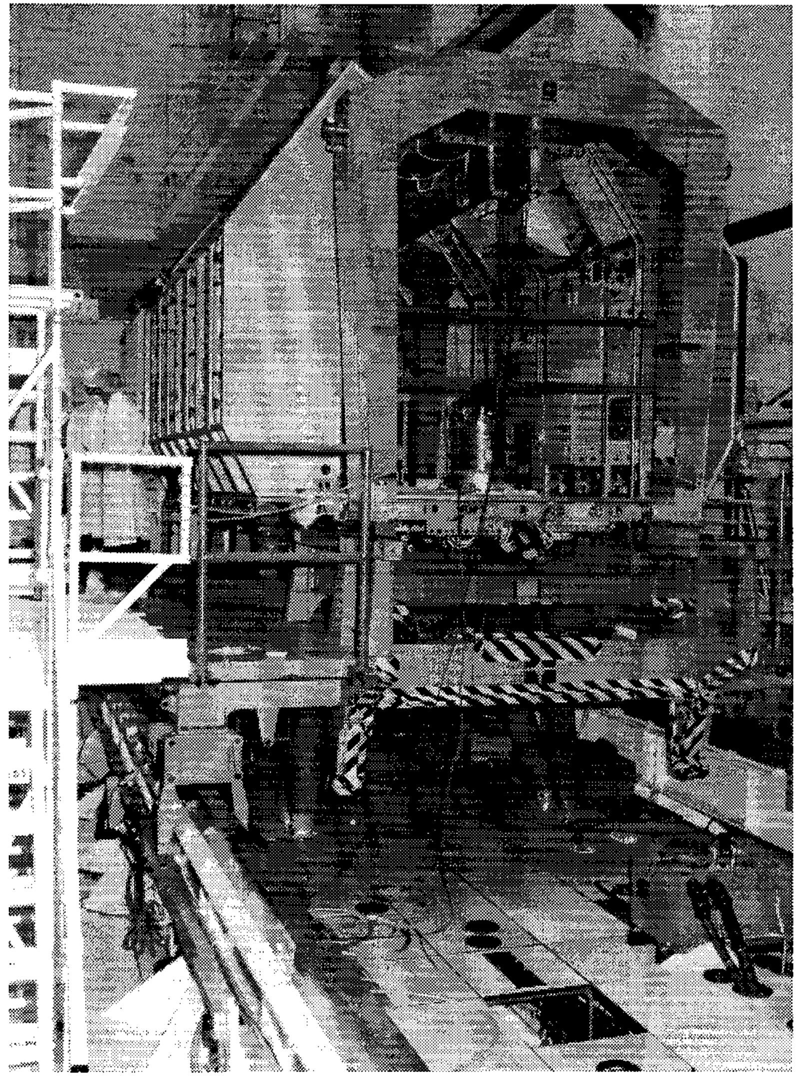
The scientists also hope that their experiments will lead to an understanding of processes that gravity either masks or distorts. This understanding is essential if the high-strength metals needed for new power plants, propulsion systems, and airplanes and spacecraft are to be produced.

The IML program brings together space scientists and engineers from the United States, Europe, Canada, and Japan in a cooperative venture that fosters the peaceful use of space. NASA's partners in the program are the 14-nation European Space Agency, the Canadian Space Agency, the French National Center for Space Studies, the German Space Agency and German Aerospace Research Establishment, and the Japanese National Space Development Agency. NASA manages the program, integrates the payloads in Spacelab, and provides transportation to and from space on the shuttle; the other agencies provide the experiment hardware.

IML-1 SCIENCE OPERATIONS

IML-1 science operations will be a cooperative effort between Discovery's crew in orbit and mission management, scientists, and engineers in the Payload Operations Control Center (POCC) at the Marshall Space Flight Center in Huntsville, Ala.

A high degree of interaction among the IML-1 science team members will be possible due to the ready availability of digital data, video, and voice communications between the shuttle and the POCC. With these links, controllers and experiment scientists can talk to the orbiting Spacelab crew, visually monitor crew and experiment activities, receive experiment data, and send commands directly to Spacelab to adjust experiment hardware, parameters, or protocols. Experiment information can be shared, data monitored and evaluated, problems solved, and experiment plans revised to take advantage of unexpected research opportunities.

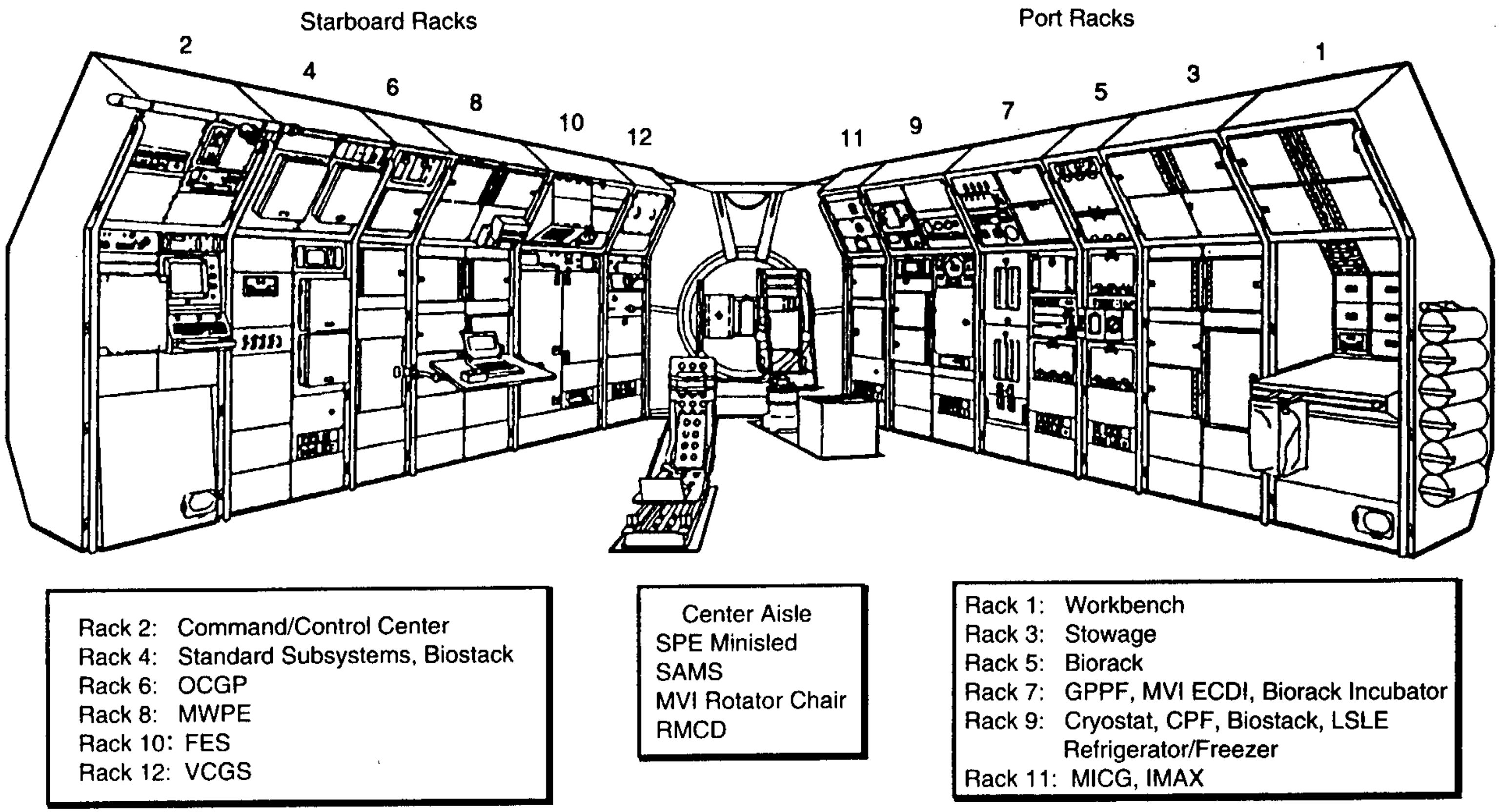


IML-1 Preflight Preparation

Many IML-1 experiments require a very smooth ride through space so that their delicate operations will not be disturbed. Therefore, when Discovery achieves its orbit of approximately 188 statute miles, it will be placed into a "gravity-gradient stabilized" attitude with its tail pointed toward Earth. This allows the orbiter's position to be maintained primarily by natural forces and reduces the need for frequent orbiter thruster firings that would disturb sensitive experiments.

To complete as many experiments as possible, the crew will work in 12-hour shifts around-the-clock. The payload crew will begin the mission by setting up equipment and turning on equipment facilities. Because the Spacelab module is placed in the shuttle's cargo bay weeks before launch, critical biological and materials samples, which degrade quickly, will be loaded into crew-cabin lockers a few hours before lift-off. Orbiter and payload crew members will transfer these samples to experiment facilities in the laboratory before science operations begin.

During the first days of the mission, the payload crew will activate critical biological and material experiments and set up those involving plants, cells, and crystals. Much of the crew time throughout the mission will be devoted to experiments that measure how their own bodies adapt to living in space. In the middle of the



IML Module Layout

mission, processing research will be continued and experiments that require precisely timed activities will be carried out. Experiments also will continue with plants, cells, and other biological specimens. The crew will check investigations periodically, make adjustments needed to enhance results, and, when necessary, replace specimens or preserve them for ground-based analysis. The payload crew aboard Spacelab will use both voice and video links to consult with scientists on the ground during critical operations and to modify experiments as required.

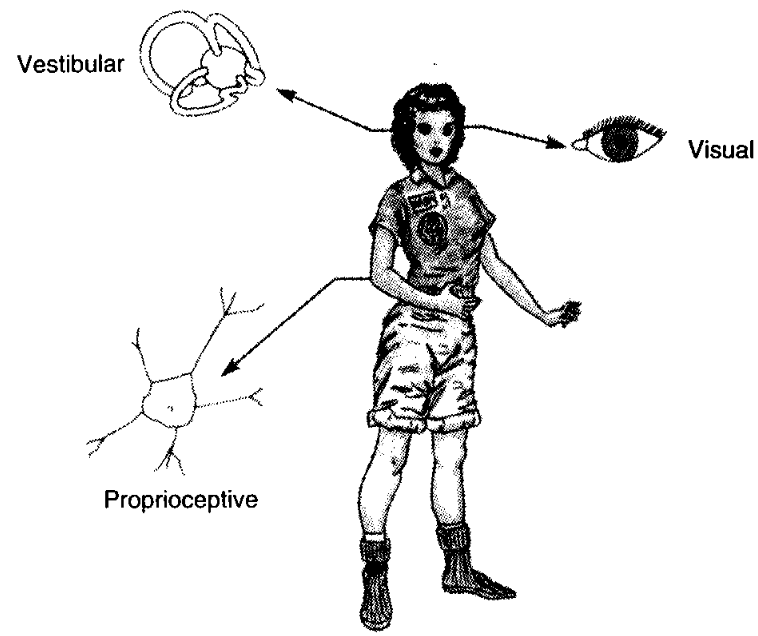
The last days will be spent completing investigations. The crew will repeat some experiments performed earlier in the mission to measure how their bodies have adapted to space over the course of the flight. On the final day, they will turn off the equipment, store samples and specimens, and prepare the laboratory for landing.

Complete analysis of all the data acquired during the mission may take from a few months to several years. Results will be shared with the worldwide scientific community through normal publication channels.

LIFE SCIENCES EXPERIMENTS

Microgravity Vestibular Investigations

During the microgravity vestibular investigations (MVI), investigators will try to better understand how the human body adapts to weightlessness by examining what space flight does to the human orientation system. The brain produces perceptions of location and position by integrating visual and auditory inputs with inputs from vestibular sensors (organs in the inner ear that detect the pull of gravity and motion) and proprioceptive information (motion, pressure, and temperature detected by sensors in the muscles, joints, tendons, and skin). The sensory inputs the brain receives under the influence of gravity are changed in the gravity-free environment of space. Until the body's nervous system adapts to the changed inputs, astronauts may experience a feeling of disorientation or space motion sickness. The MVI experiments are designed to provoke interactions among the vestibular, visual, and proprioceptive systems and measure the perceptual and sensorimotor reactions of the test subjects so that scientists can study the changes that occur during the process of adapting to weightlessness.



Microgravity Vestibular Investigations

Specially designed or modified equipment will be used in the MVI experiments. A chair that rotates and oscillates will test the visual and vestibular responses of crew members to movements of the head and body. The chair can move the crew member from left to right (around the yaw axis), backward and forward (around the pitch axis), and head over heels (around the roll axis). From a computer terminal, a second crew member can also control the chair's velocity pattern so that it travels back and forth over the same distance at the same speed and over varying distances at different speeds and starts and stops suddenly.

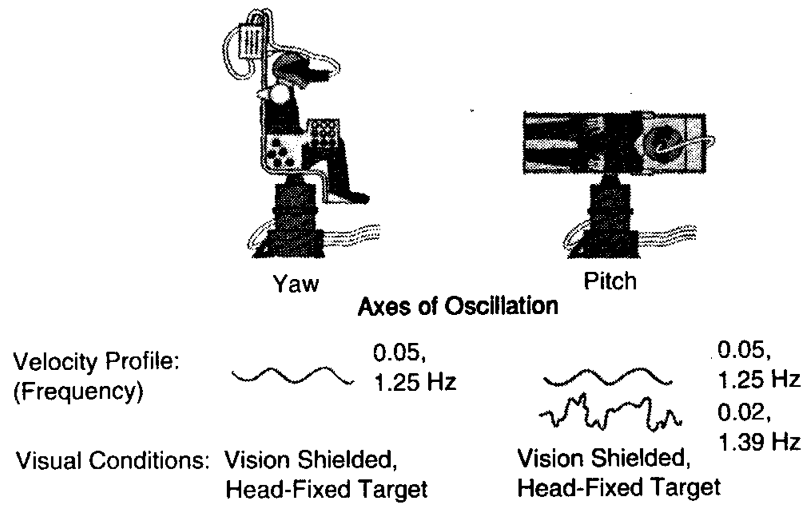
The subject of the test wears a helmet equipped with sensors that measure head movements and two independently movable visors that cover the left and right eyes. A video camera that mounts on the visors records involuntary spasmodic movements of the eyeballs that occur while the body is spinning and after it stops (per- and postrotatory nystagmus). Horizontal and vertical eye movements are also sensed by electrodes placed around the eyes and recorded. An optokinetic stimulus module that creates a moving visual display in front of the eye also mounts on the helmet visors. The test subject can also wear a pair of optokinetic stimulus goggles while he or she is floating in the Spacelab.

The test sequences will study the effect of microgravity on six physiological responses, including the eye's ability to track an object, the perception of rotation during and after spinning, function of the motion and gravity sensing organs in the inner ear, the interaction between visual cues and vestibular responses and sensory perception. Crew members will be tested both pre- and postflight to establish a comparison for the in-flight measurements.

Each of the MVI experiments will be performed at least three times during the mission. Early in the flight, changes in the vestibular sense of the test participants will be noted so that the investigators can observe adaptation. The subjects will be studied over a long period of time after the flight to determine if they have any aftereffects and to determine how long it takes the vestibular sense to regain its original function.

Results from the MVI experiments will aid in designing appropriate measures to counteract neurosensory and motion sickness problems on future space flights.

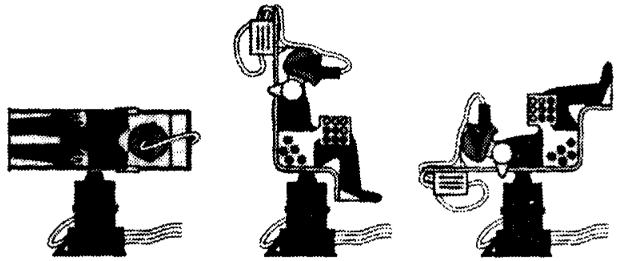
Suppression of the Vestibulo-Ocular Reflex. This experiment tests a subject's ability to suppress the vestibulo-ocular reflex, which relies on the motion sensors in the inner ear to maintain steady visual images during rapid head movements, and determine if space flight affects this ability. This reflex is suppressed when a person spins around while looking at an object held in front of the face, such as a finger. In the first part of the study, the subject is rotated in total darkness in the yaw and pitch axes while looking at an imaginary object in the distance to elicit the vestibulo-ocular reflex. The reflex is suppressed in the second part of the study by rotating the subject while he focuses on a target light affixed to the helmet.



Suppression of the Vestibulo-Ocular Reflex

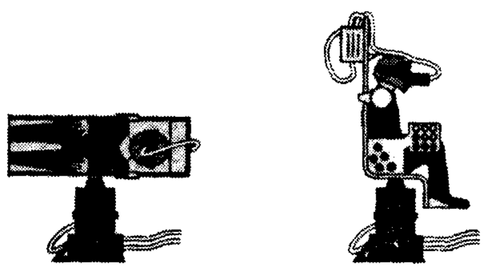
Per- and Postrotatory Nystagmus. Scientists hope to learn whether weightlessness affects the way that the body processes information from the vestibular, visual, and proprioceptive systems. While a person is spinning in total darkness, eye movements (perrotatory nystagmus) slow and finally cease. They resume when the spinning stops (postrotatory nystagmus). This experiment measures the time it takes for spasmodic eye movements to decay during and after rotation three times in the mission—early, in the middle, and late—to observe how the body responds to weightlessness.

Optokinetic Responses. This experiment records nystagmus in an astronaut while he or she is being rotated clockwise and counterclockwise. The first part of the experiment is conducted in light to generate an optokinetic response, an eye movement similar to the per- and postrotatory nystagmus. The second part is conducted in darkness, and the subject's optokinetic-after-nystagmus response is recorded.



	Pitch	Yaw	Roll
		Axes of Rotation	
Velocity Profile:	60 sec	60 sec	60 sec
Peak Velocity:	120 deg/sec	120 deg/sec	120 deg/sec
Acceleration/ Deceleration:	120 deg/sec^2	120 deg/sec^2	120 deg/sec^2

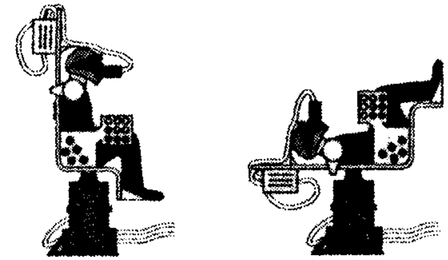
Per- and Postrotatory Nystagmus



	Pitch	Yaw
	Axes of Rotation	
Velocity/Profile:	270 sec	270 sec
Peak Velocity:	60 deg/sec	60 deg/sec
Acceleration/ Deceleration:	120 deg/sec^2	120 deg/sec^2
Visual Conditions:	Alternating Light and Dark Periods (45 sec Each)	Alternating Light and Dark Periods (45 sec Each)

Optokinetic Responses

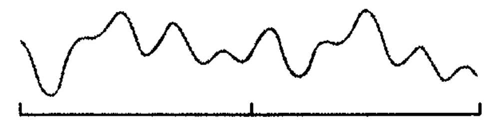
Semicircular Canal Dynamics. For this experiment, the chair changes direction and distance of travel randomly to stimulate the semicircular canals and otoliths in the subject's inner ear. The extent to which otolith receptors in the inner ear modify signals from the semicircular canals in weightlessness is indicated by the ratio of eye movements to the velocity of the chair and the relationship between the stimulus and eye movements.



Yaw　　Roll

Axes of Rotation

Velocity Profile:

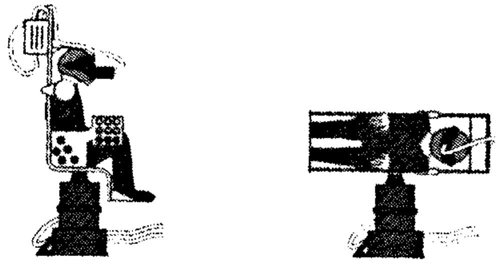


Frequencies: 0.02, 0.05, 0.11, 0.19, 0.47, 0.79, 1.39 Hz

Semicircular Canal Dynamics

Visual-Vestibular Interaction. This experiment examines the relationship between the vestibulo-ocular reflex and optokinetic nystagmus.

Sensory Perception. If the astronauts experience space motion sickness with illusions of body orientation during this flight, they will keep a detailed record of the incidents, including any antimotion sickness medication taken. These data will be analyzed after the mission to determine the conditions that caused the symptoms. Investigators hope that this will help them understand the neurosensory system and possibly prevent the symptoms of space motion sickness.



Yaw　　　　　Pitch

Axes of Oscillation

Velocity Profile: (Frequency)	0.2, 0.8 Hz	0.2, 0.8 Hz
Peak Velocity:	40 deg/sec	40 deg/sec
Checkerboard Pattern Movement:	Right-to-Left, Left-to-Right	Head-to-Foot, Foot-to-Head

Visual-Vestibular Interaction

These experiments will be performed by the Spacelab crew before the mission, and the results will be compared with the results from the tests performed during and after the mission. The experiments will also be performed by a control group of nonastronauts in an aircraft that produces brief periods of weightlessness.

The principal investigator for this NASA experiment is Dr. Millard F. Reschke of the Johnson Space Center in Houston, Texas.

Space Physiology Experiments

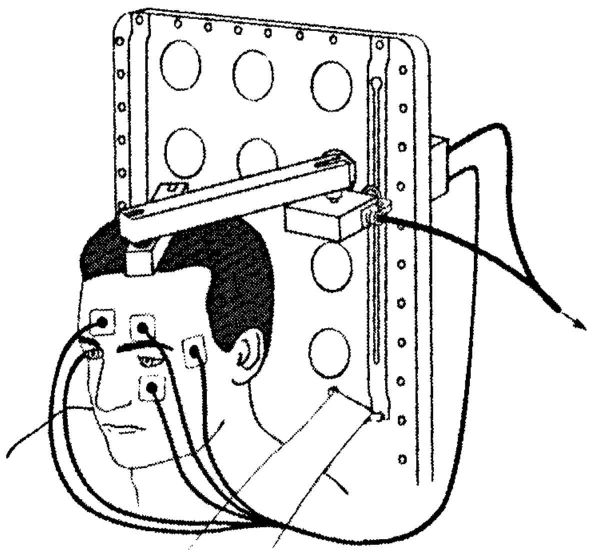
The space physiology experiments are designed to investigate the effects of microgravity on the human body and the separation of immiscible fluids (fluids that tend not to mix). These experiments are under the auspices of the Canadian Space Agency.

Space Adaptation Syndrome Experiments (SASE). Spacelab astronauts will perform seven tests to study the nervous system's adaptation to low gravity. Investigators hope these experiments will help them understand the causes of space adaptation syndrome, which leaves many astronauts feeling disoriented and nauseous. These symptoms may occur because of conflicting messages about body position and movement the brain receives from the eyes, the balance organs of the inner ear, and gravity sensing receptors in the muscles, tendons, and joints. Seven investigations to study the nervous system's adaptation to microgravity have been developed.

The sled experiment measures changes in low gravity in the pattern of signals output by the otoliths, which are balance organs in the inner ear. In the Earth's gravity, these organs enable humans to stand upright by activating the appropriate muscles of the body.

The subject is strapped into a device called the minisled located in the center aisle of the Spacelab module. The minisled slides along rails, stimulating the otoliths. Audio and visual stimuli are eliminated, and an electrode attached behind the subject's knee stimulates reflexive muscle responses in the leg. The stimulation of the inner ear by the minisled's movement changes the response to the electrical shocks to the leg, providing investigators a measure of otolith activity. The test should indicate whether the nervous system learns to reinterpret the information from the otoliths or ignores that information.

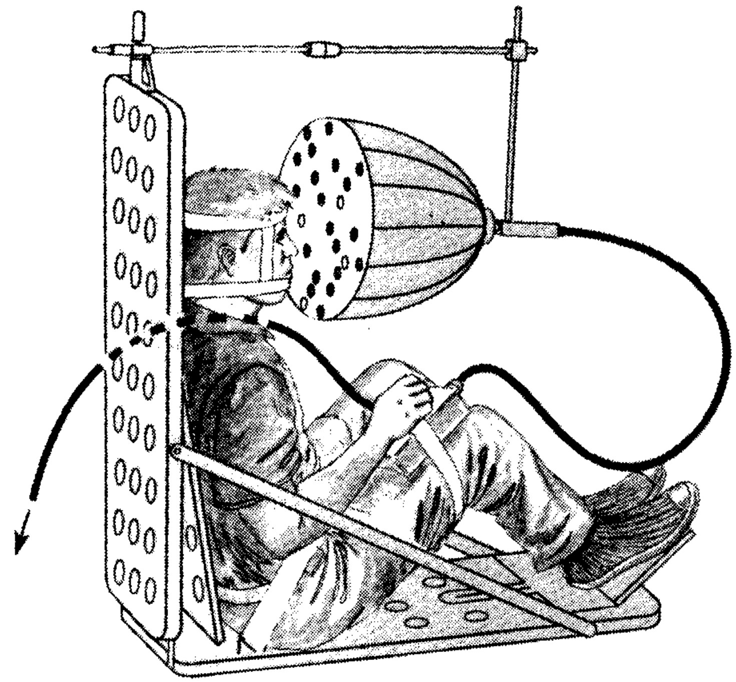
Changes in the semicircular canals are measured by the rotation experiment. These inner ear organs enable a person to maintain a steady gaze and clear vision even when the head is moved rapidly and unpredictably, an important capability in space as well as on Earth. Weightlessness may lessen the effectiveness of this function. An astronaut wearing electrodes and measuring devices that record his or her head and eye movements performs a series of tests to measure the effectiveness of the vestibulo-ocular reflex. Two tests are conducted involving the subject's ability to keep closed eyes fixed on a predetermined target while either rotating the head or moving it up and down. A third test requires subjects to shift their gaze to a series of targets projected onto a screen. This studies coordination between eye and head movements.



Electrodes Record Horizontal and Vertical Eye Movements Stimulated by Head Motions

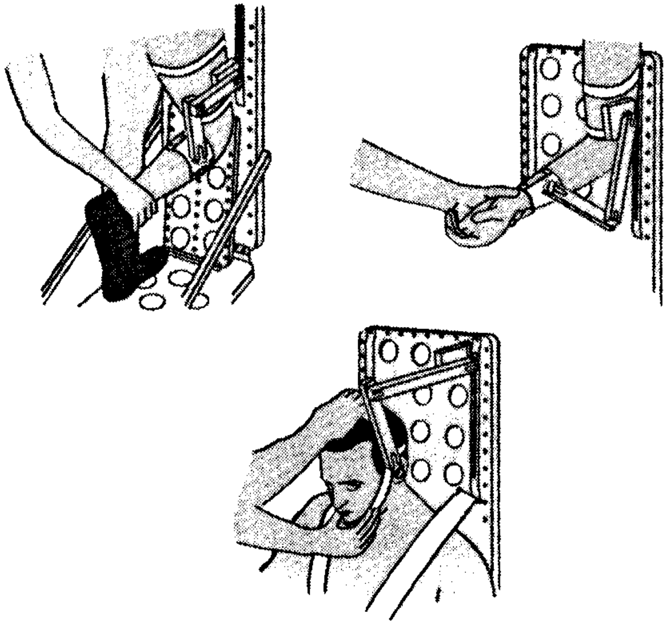
The visual stimulator experiment measures the relative importance of visual and balance organ information in determining body orientation. In space, circularvection, which is a false sense that the body is rotating when a person looks at a rotating field, occurs. On Earth, this sensation is limited by the otoliths. In weightlessness, however, the nervous system relies less on vestibular cues and more on visual information for body orientation, with the expected result of increased circularvection.

In this experiment, the subject, seated in the stationary minisled, stares at an umbrella-shaped dome with a pattern of colored dots that rotates at varying speeds. While watching the rotating dome, the subject turns a crank to indicate his or her perception of body rotation. The strength of circularvection is calculated by comparing the signals from the dome and the crank. The greater the false sense of circularvection, the more the subject is relying on visual information instead of otolith information.



Visual Stimulator Measures Response to Rotating Object in Microgravity

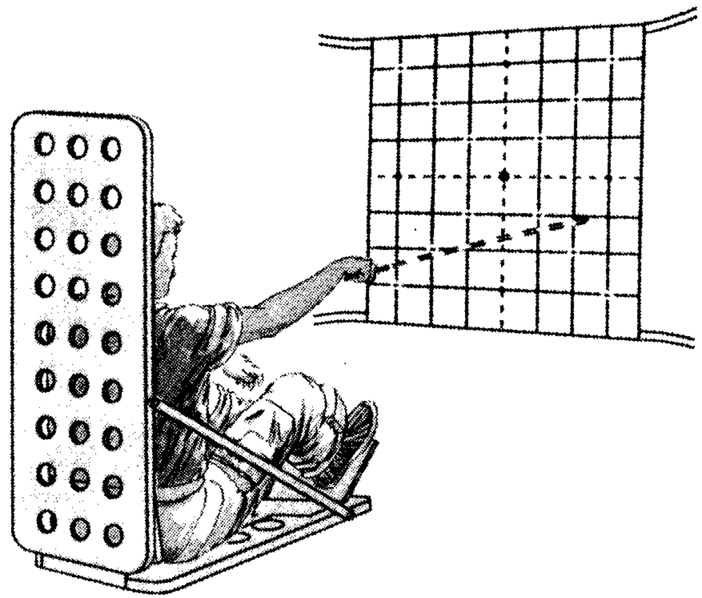
Four experiments examine how microgravity affects the body's proprioceptive system, which senses body and limb position and movement. A variety of receptors located in the muscles, tendons, and joints contribute information. Previous space flights suggest that crew members experience a decreased knowledge of limb position and while performing certain movements, experience illusions such as the floor moving up and down. It also has been shown that the vertebrae in the spine spread apart, possibly leading to partial nerve block. Closer investigations of these phenomena form the basis of these experiments. The proprioception (relaxed) experiment measures proprioceptive sensitivity of a passive, blindfolded subject and determines whether that sensitivity changes in weightlessness. The proprioception (active) experiment tests the ability of a subject to retain an accurate sense of his or her surroundings in the dark. The proprioception (illusions) experiment attempts to confirm reports by some astronauts that they have experienced the illusion of spacecraft motion in weightlessness. The tactile acuity experiment determines whether the elongation of the test subject's spine in low gravity causes nerve blocks, which can alter the sense of touch. Nerve problems also could affect the proprioception experiments.



Goniometers Measure the Angles of Knee, Elbow, and Head

The principal investigator for the space adaptation syndrome experiments is Dr. Douglas G.D. Watt of McGill University, Montreal, Canada.

Back Pain in Astronauts (BPA). In microgravity, the spine elongates by as much as 2.76 inches due to the vertebrae in the back spreading slightly apart. This elongation causes painful tension and possibly affects tactile acuity. More than two thirds of



A Grid Marked With Targets Measures Pointing Accuracy

U.S. and Soviet astronauts report suffering back pain and associated discomfort during space flight. This experiment correlates stereo photographs taken of a crew member's back in a series of positions with the crew member's log of back pains. Investigators hope this correlation will enable them to pinpoint the cause of back pain and recommend ways to prevent or alleviate pain.

The principal investigator is Dr. Peter C. Wing of the University of British Columbia, Vancouver, British Columbia.

Measurement of Venous Compliance and Evaluation of an Experimental Anti-Gravity Suit (MVC). A loss of body volume and other body fluids during space flight has been suggested as the primary cause of the lowering of the cardiovascular system's ability to withstand Earth's gravitational force field. Unprotected astronauts may feel tired and dizzy, lose peripheral vision, or faint upon returning to Earth. Drinking salt solutions and wearing anti-gravity suits that are inflated during re-entry have been shown to combat this aftereffect of space flight.

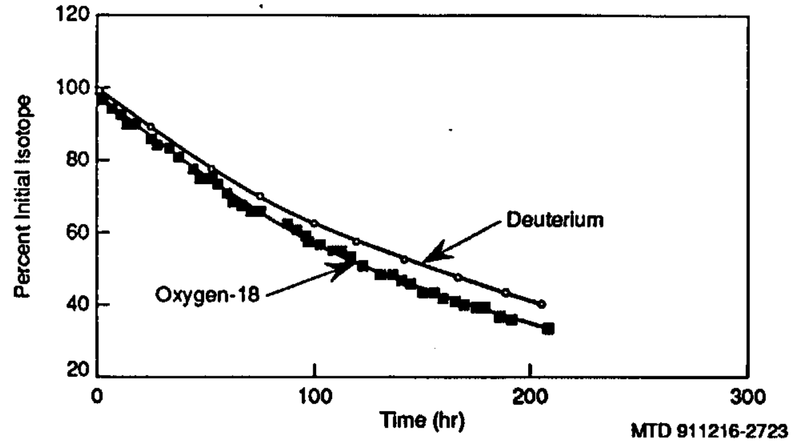
One feature of this experiment will measure the venous compliance (tone of the veins) before, during, and after the mission. Being able to determine how veins adapt to microgravity will be useful to engineers who design anti-gravity suits. Veins in the lower leg are measured using an electronic monitor and two large blood pressure cuffs that encircle the thigh and calf, altering the pressure by inflating the cuffs. Ensuing changes in blood volume in the veins are determined.

The evaluation of an experimental anti-gravity suit is another goal of this experiment. The suit employs 11 pressurized sections and is able to apply pressure to the legs and lower abdomen in many different ways. Effectiveness of the suit will be determined and compared to a conventional anti-gravity suit and to wearing no suit at all. Blood pressure and blood flow readings, and subjective impressions of the astronauts, will contribute to the results.

The principal investigator is Dr. Robert B. Thirsk of the Canadian Space Agency, Ottawa, Canada.

Energy Expenditure in Space Flight (EES). This experiment determines the amount of energy expended by astronauts while living and working in space and monitors changes in body chemistry in response to stress in space. The results will be used to define astronauts' nutritional requirements and to improve the care of patients on Earth.

The use of doubly labeled water is a method of measuring astronauts' rate of carbon dioxide production, which is an indicator of energy expenditure. In this experiment, several crew members drink precise amounts of doubly labeled water, which contains the nonradioactive isotopes deuterium and oxygen 18, on the first day of the mission and immediately after the flight. During the flight, samples of urine and water from the Shuttle's galley are collected, and the subjects log everything they eat and drink. Investigators will determine the amount of hydrogen and oxygen isotope in the water and urine samples and will study the astronauts' dietary logs, comparing their findings with measurements taken on the same subjects before and after the flight. These data will enable the investigators to correlate changes in the chemistry of the astronauts' bodies with energy expended on orbit.



The EES Experiment Records How Long It Takes the Body To Eliminate Isotopes of Oxygen and Hydrogen

The principal investigator for this experiment is Dr. Howard G. Parsons of the University of Calgary, Alberta, Canada.

Position and Spontaneous Nystagmus (PSN). Nystagmus is the normal oscillatory scanning motion of the eye. The vestibular system of the inner ear is closely related to nystagmus. When the inner ear is dysfunctional, it no longer gives the right signals to the eye, resulting in a different type of eye movement that could be accompanied by dizziness and blurred vision. Analysis of the nystagmus is a useful tool in diagnosing problems of the inner ear. This experiment investigates whether a person can experience positional nystagmus (involuntary spasmodic eye movements under the influence of gravity; eye oscillation rate varies according to head position) and spontaneous nystagmus (movement caused by different vestibular signals from the ears; the eye oscillates at the same rate regardless of head position) at the same time. Astronauts who exhibit positional nystagmus are the subjects of this experiment. Preflight measurements of nystagmus are taken while the subjects' heads are in a neutral position, which is assumed to be the position in which spontaneous nystagmus occurs, and as their heads are turned 90 degrees to either side. The measurements are then repeated in the weightlessness of space, where the absence of gravity should eliminate positional nystagmus. Investigators will compare the nystagmus in weightlessness to the nystagmus in the neutral position on Earth to see if they coincide. The experiment is designed to improve detection and treatment of inner ear disorders.

The principal investigator is Dr. Joseph A. McClure of the London Ear Clinic, London, Ontario, Canada.

Phase Partitioning Experiment (PPE). Phase partitioning is a very effective technique used by biochemists and cell biologists to obtain fairly pure cells. Cells are separated and collected in a mixture of two immiscible liquids (fluids that tend not to mix) by their surface characteristics. In the phase partitioning experiment, investigators think they will be able to separate closely related cells because cell density and convection flows are not factors in the phase partitioning process in space. They also want to study other factors that influence the process.

Phase partitioning is used to separate biological materials such as bone marrow cells for cancer treatment. It is of interest to medical researchers as it applies to separation and purification of cells for use in transplants and treatment of disease.

In this experiment, phase separations in six different concentrations of two immiscible polymers mixed in water are observed at various times during the flight. The solutions are exposed to electric fields of different strengths to investigate the effect of electric fields on the demixing process.

A payload specialist takes photographs at specific intervals to record conditions within the six chambers of the separation unit and the electric current, polarity, and temperature displayed on the experiment power control unit. Life science and materials science investigators will use the data from the photographs and their analysis of the separations to learn more about the behavior of liquid two-phase systems.

The principal investigator is Dr. Donald E. Brooks of the University of British Columbia, Vancouver, British Columbia.

Mental Workload and Performance Experiment

On a previous Spacelab mission, astronauts experienced difficulty working at a computer workstation designed for a person in what would be a typical standing position on Earth. For this mission, the workstation has been redesigned to evaluate the effects of microgravity on the ability of crew members to interact with a computer workstation. Information gained from this experiment will be used to design workstations for future Spacelab missions and Space Station Freedom.

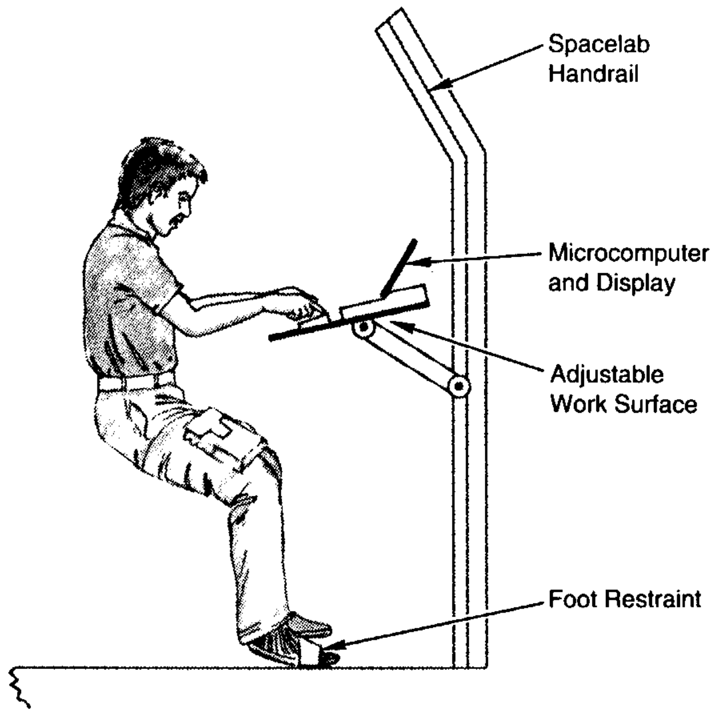
In this experiment, Spacelab astronauts perform record-keeping tasks and daily planning sessions at a workstation with an adjustable surface. Camera footage of crew members working at the station, measurements of the positions of the surface, and crew reports will enable designers to develop more efficient workstations.

A portable microcomputer attached to a Spacelab handrail is also used to test the astronauts' mental function, reaction times, and physical responses in zero gravity. The crew members follow a program on the computer that requires them to use the keyboard cursor keys, a joystick, and trackball. The crew will perform the activities several times before and after the mission to provide a comparison for the in-flight experiments. The results will be used to develop the most efficient method of performing certain computer tasks in space.

The principal investigator for this experiment is Dr. Harold L. Alexander of the Massachusetts Institute of Technology.

Gravitational Plant Physiology Facility

The Gravitational Plant Physiology Facility is a small botanical laboratory in Spacelab that enables scientists to study two

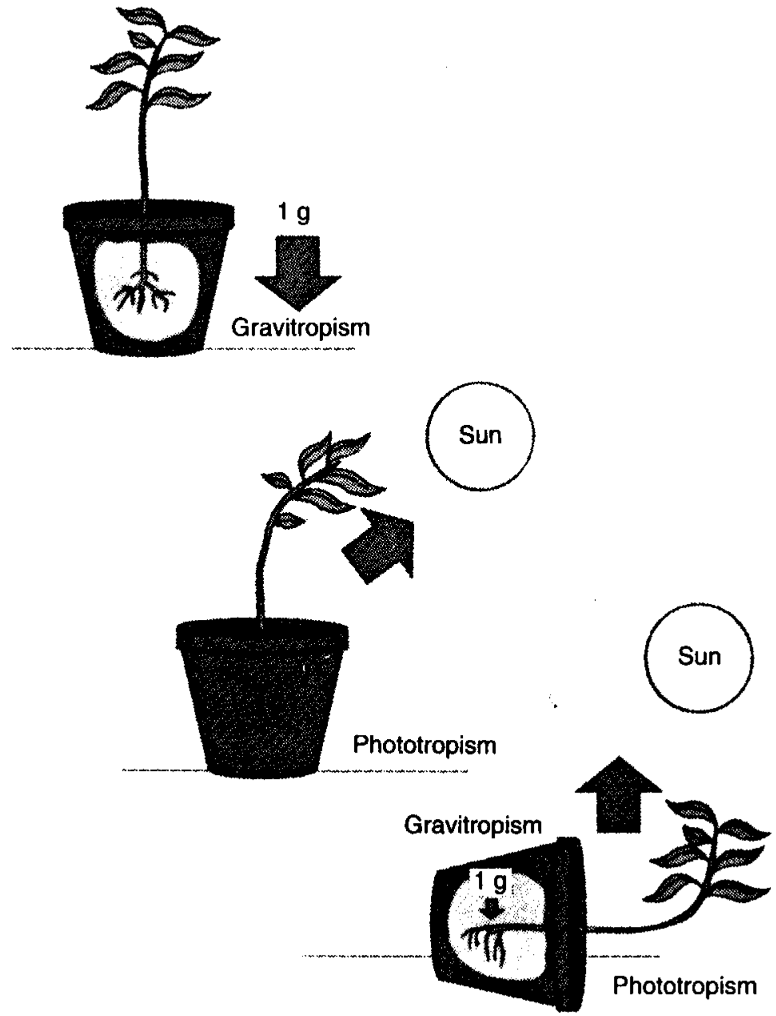


Crew Member Evaluates Effectiveness of Joystick, Keyboard, and Trackball in Moving the Computer's Cursor

characteristics of plant growth that are difficult to examine on Earth because of its constant gravitational pull. The weightlessness of space allows investigators to make more precise analyses of gravitropism (the tendency of plants to respond to gravity) and phototropism (their tendency to respond to light). The two experiments planned for this mission will help them understand the mechanisms that control these responses.

The Gravitational Plant Physiology Facility was designed and built in 1984 by the University of Pennsylvania. All hardware testing and payload implementation were provided by NASA Ames Research Center. The GPPF includes four centrifuges, lights, three videotape recorders, and plant-holding compartments.

The control unit serves both experiments and contains a microprocessor that controls the operation of the rotors (centrifuges), cameras, recording and stimulus chamber (REST), and videotape recorders.



Several Types of Plant Behavior Are Studied in the Gravitational Plant Physiology Facility

Two culture rotors operate independently at the force of gravity (1 g) to simulate Earth's gravitational field. Two variable-speed test rotors provide accurately controlled centripetal forces from 0 g to 1 g. Seedlings in plant cubes are placed in the rotors.

The REST provides the capability for time-lapse infrared video recording of plant positions in four FOTRAN cubes, both before and after exposure to blue light.

The mesocotyl suppression box (MSB) is located in the upper left of the GPPF double rack. It is used only for oat seedlings in the Gravity Threshold experiment. The MSB exposes the seedlings to red light, which suppresses the growth of the plant mesocotyl and makes them grow straight.

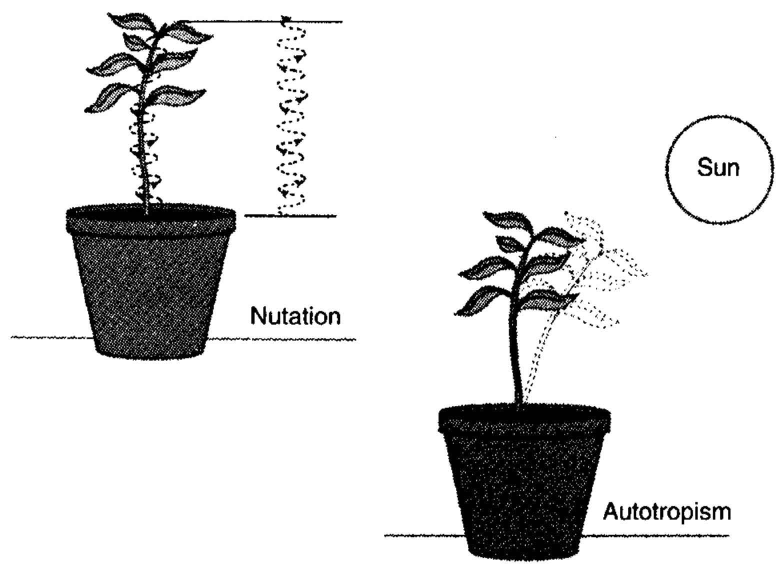
The plant carry-on container will hold 36 cubes cushioned in foam for launch, plus soil trays for in-flight plantings.

Gravity Threshold (GTHRES). This experiment explores the changes that occur in oat plants exposed to varying levels of gravity for different amounts of time and the effect of microgravity on the plants' structure. Four centrifuges in the gravitational plant physiology facility are used to determine the sensitivity and threshold of the gravity-detecting mechanism of oat plants. Some of the specimens have been germinated on the ground; others are to be planted in the gravitational plant physiology facility.

On orbit, some of the plants, in light-tight plant cubes, are placed in one of two centrifuges that subject them to a constant 1-g force. When they are ready to be used in the experiment, they are placed in another centrifuge and subjected to different degrees of gravitational pull free from interference from Earth's constant 1-g pull. The plant cubes then are placed on either of two other centrifuges to expose them to various combinations of acceleration durations. This allows scientists to study gravitational forces from 0.1 g to 1 g without interference from the constant 1-g force present on Earth. After the flight, scientists will examine time-lapse video photography of the plants, gas samples taken from the plant containers, and other data.

The principal investigator for the gravity threshold experiment is Dr. Allan H. Brown of the University of Pennsylvania.

Response to Light Stimulation: Phototropic Transients (FOTRAN). Besides studying the response of wheat seedlings to light, this experiment examines the effects of microgravity on two growth patterns: nutation, which is a more or less rhythmical change in the position of the organs of growing plants, and autotropism, which is the tendency of plants that become curved because of gravitropism or phototropism to straighten. The seedlings, some planted on Earth and some in space, are subjected to pulses of blue light in a zero-gravity chamber for varying durations to elicit a phototropic response. An infrared-sensitive time-lapse video camera records their responses, and samples of carbon dioxide and ethylene gas are taken for later analysis. Some of the seedlings will be preserved so that scientists can study the effect of microgravity on their growth after the flight.

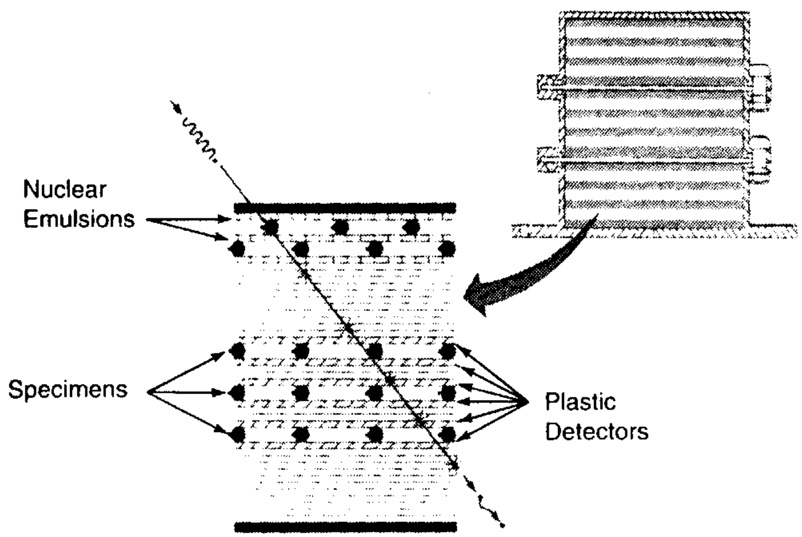


Scientists Will Study the Effects of Microgravity on Plant Nutation and Autotropism

The principal investigator for this experiment is Dr. David G. Heathcote of the University City Science Center, Philadelphia, Pa.

Biostack

This experiment studies the potential hazards of cosmic rays on biological organisms during space flight. Single layers of fungus spores, bacteria, shrimp eggs, and thale cress seeds are attached to sheets of nuclear emulsion and plastic radiation detectors. These sheets are stacked and placed in four sealed biostack containers under the Spacelab floor. High-energy cosmic particles passing through the biostack deposit their energies in the alternating layers of biological samples and radiation detectors. Scientists will analyze the resulting data to track the path an energized particle takes through biostack and then determine the level of radiation damage to the organisms. The data from this experiment will help scientists develop better radiation protection for spacecraft and improve their understanding of the action of high-energy particles on humans and other biological matter.



Cosmic Particles Deposit Their High Energies in Layers of Radiation Detectors and Live Specimens

This experiment is furnished by the German Aerospace Research Establishment. The principal investigator is Dr. H. Buecker of the German Aerospace Research Establishment's Institute for Flight Medicine in Cologne, Germany.

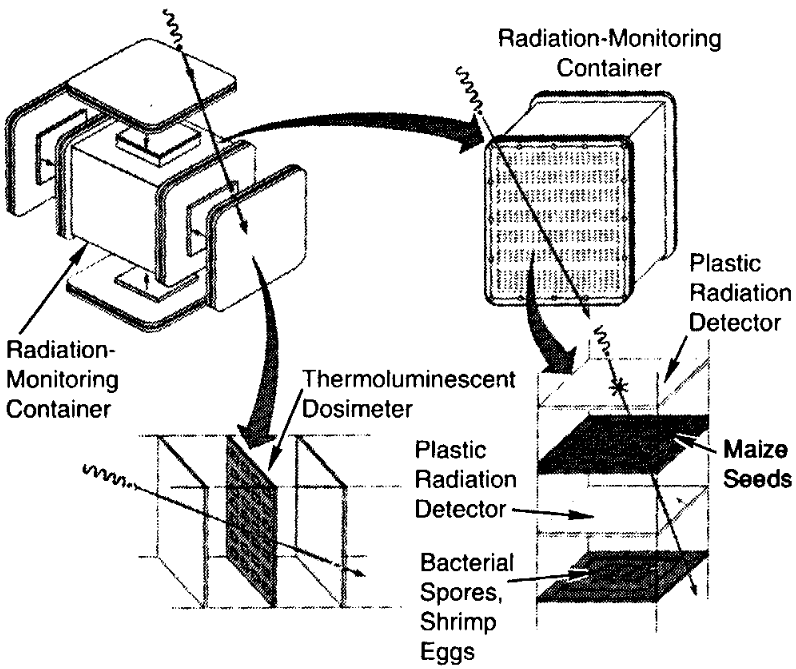
Radiation-Monitoring Container Device (RMCD)

The radiation-monitoring container, mounted in the aft end of the Spacelab, measures the levels of radiation in the Spacelab module and evaluates the effects of radiation on the development, formation of spores, germination, and hatching of biological samples in the device. The radiation-monitoring container holds layers of cosmic ray detectors, bacteria spores, maize seeds, and shrimp eggs. The boxlike container is enclosed on all sides by thermoluminescent dosimeters, which are gauges that measure radiation doses and emit visible light in proportion to the dose of radiation they receive. After being exposed to cosmic radiation for the duration of the mission, the plastic detectors will be chemically treated to reveal the three-dimensional radiation tracks showing the path the radiation traveled after entering the container. The specimens will be examined by biological and biochemical methods to determine the effects of radiation on the enclosed organisms. Scientists will use data gathered from this experiment to develop a sensitive solid-state nuclear detector for use on future space flights.

The radiation-monitoring container device is provided by the National Space Development Agency of Japan. The principal investigator is Dr. S. Nagaoka of NASDA.

Biorack

Biorack is a multipurpose facility developed by the European Space Agency to study the effects of microgravity and high-energy cosmic radiation on many small life forms. Five broad areas of research will be addressed by biorack: cell proliferation, cell differentiation, genetics, gravity sensing, and membrane behavior. The life forms studied—cells (frogs, fruit flies, mice, and humans), tissues, small organisms, and plants—are well suited for the



The Radiation-Monitoring Container Measures High-Energy Radiation Levels in Spacelab

Spacelab mission because they can be observed and manipulated in large numbers and they go through several stages of development during a mission. Specimens can be preserved at those stages and returned to Earth for analysis. Exposure to microgravity will alter the regulatory mechanisms at a cellular level. Eight of the 17 experiments on the IML-1 mission are modified versions of experiments that were flown on Spacelab in 1985; the others are new experiments.

Biological samples for the biorack experiments are stored in small containers on the middeck of the orbiter until during the launch. On orbit, the containers are moved to biorack's three incubators, where they are maintained at the proper temperatures. In the incubators, the experiments are performed in a simulated 1-g environment as well as in microgravity so that biologists can discriminate between the effects of microgravity and other space conditions. Identical control experiments are performed on the ground about 2 hours after the experiments begin in space.

The Spacelab astronauts examine the specimens in a sealed glove box to avoid contaminating the samples and prevent spills. The glove box is equipped with a microscope for observing microscopic organisms. A video camera that fits on the glove box door records observations.

Friend Leukemia Virus Transformed Cells Exposed to Microgravity in the Presence of DMSO. Previous experiments have shown that blood cells—both white blood cells that fight infection and red blood cells that transport oxygen throughout the body—are sensitive to gravity. On Earth, cells that normally would differentiate to become blood cells are sometimes transformed by the leukemia virus and become cancerous Friend leukemia cells.

Such cells do not produce hemoglobin, which plays an essential role in oxygen transport. Scientists have learned that cancerous Friend leukemia cells begin to produce hemoglobin after they are exposed to the drug DMSO (dimethysulfoxide); however, they do not know whether the drug activates a gene that regulates the synthesis of hemoglobin or inhibits mechanisms that repress the hemoglobin-producing gene. They hope that studying Friend leukemia cells exposed to DMSO in microgravity will provide the answer. They also want to learn if the cells differentiate and produce hemoglobin at a different rate in space than on Earth—an important consideration if people are to live in space for extended periods.

This ESA experiment is under the auspices of the Eidgenoessische Technische Hochschule/Controves Institute of Biotechnology in Zurich, Switzerland. The principal investigator is Dr. Augusto Cogoli.

Proliferation and Performance of Hybridoma Cells in Microgravity (HYBRID) (Provided by ESA). In this ESA experiment, hybridoma cells, which form when white blood cells fuse with cancerous melanoma cells, are grown to study how cells synthesize and secrete antibodies in microgravity. Activated white blood cells, derived from a human or an animal, carry the information required to produce antibodies of a certain specificity and can survive only a few days in culture. Myeloma cells are tumor cells that can grow indefinitely in culture. Therefore, the product of the fusion is a continuing cell line capable of producing homogeneous antibodies (monoclonal antibodies) more rapidly than white blood cells alone. The secretions of the space-grown cells will be compared with those of cells grown on Earth. If the space-grown cells produce antibodies more rapidly, it may be practical to manufacture some pharmaceutical products in space.

This experiment is under the auspices of the Eidgenoessische Technische Hochschule/Controves Institute of Biotechnology in Zurich, Switzerland. The principal investigator is Dr. Augusto Cogoli.

Dynamic Cell Culture System (CULTURE). One of the objectives of this ESA experiment is to assess the potential benefits of bioprocessing in space in order to develop a bioreactor for continuous cell cultures in space. This experiment will test the operation of an automated culture chamber, the dynamic cell culture system (DCCS), that was designed for use in a bioreactor in space.

The DCCS is a simple cell culture device in which media are reviewed or fresh nutrients needed for cell production are injected automatically with osmotic pumps. As culture nutrients flow into the cell container, old medium is forced out. The system is designed to operate automatically for two weeks.

Hamster kidney cells will be studied to determine if they reproduce faster and secrete more urokinase in shorter periods of time in microgravity.

This experiment is under the auspices of the Eidgenoessische Technische Hochschule/Controves Institute of Biotechnology in Zurich, Switzerland. The principal investigator is Dr. Augusto Cogoli.

Chondrogenesis in Micromass Cultures of Mouse Limb Mesenchyme Exposed to Microgravity (CELLS). This NASA experiment uses cells from the legs of embryo mice to study how embryonic limb bone cells produce cartilage in microgravity. The susceptibility of cartilage cells to gravitational changes is well documented. Cartilage impairments found in rodents flown on previous space flights are similar to those observed in skeletal malformations in children. Among these are changes in the collagen molecules—the major support fibers of cartilage and bone. From this study, investigators may learn about the subtle aspects of cartilage development on Earth and how bones heal in space. Aided by cameras, microscopes, and digital computers, investigators will be able to precisely analyze cartilage areas and structures inside cells.

The principal investigator for this experiment is Dr. P. J. Duke of the University of Texas Dental Science Institute, Houston, Texas.

Effects of Microgravity and Mechanical Stimulation on the In-Vitro Mineralization and Resorption of Fetal Mouse Bones (BONES). Astronauts experience a loss of minerals from their bones during exposure to microgravity. If calcium loss continues indefinitely during space flight, the likelihood that crew members will break these weakened bones increases the longer a mission lasts. Significant calcium loss also affects a person's ability to function in Earth's gravity after a mission. This ESA experiment uses embryonic mouse leg bones to study the effects of microgravity on the mineralization and resorption of skeletal tissues. Scientists want to understand the effects of microgravity on the growth, maintenance, and repair of bones before long space flights are planned. Scientists postulate that the uncompressed cultures grown outside the centrifuge (under microgravity conditions) should respond like bones that are unstressed in a weightless environment. To test this hypothesis, both the microscopic structure and the biochemical makeup of the cultures are analyzed to determine their mineralization and resorption rates. Mouse bones are being used because human and mouse bones react in the same way under normal atmospheric pressure, which suggests that they would respond to microgravity in the same way.

Dr. Jacobos-Paul Veldhuijzen of ACTA Free University, Amsterdam, is the principal investigator.

Why Microgravity Might Interfere With Amphibian Egg Fertilization and the Role of Gravity in Determining the Dorsal/Ventral Axis in Developing Amphibian Embryos (EGGS). Investigators at The Netherlands Center for Megaronics Construction designed this ESA experiment to study how gravity affects the determination of the front and back sides of bodies in the earliest stage of embryonic development. This experiment may help scientists clarify the role of gravity by studying fertilization of eggs and embryo formation of frogs in space.

Before fertilization, each frog egg is positioned inside a sticky membrane that holds the parts of the egg random with respect to gravity. After the egg is fertilized, gravity aligns the lightest part of the egg (the part with the least yolk) up and the heaviest part of the egg (with the most yolk) down.

In normal cases, the sperm's point of entry will become the front side of the embryo. However, if gravity disturbs the yolk distribution inside the fertilized egg, this may not happen. Scientists want to confirm that in space the sperm entrance point always becomes the front side of the embryo.

Eggs of the African clawed frog, *Xenopus laevis*, will be fertilized in space, incubated, and preserved during various phases of embryonic development. A similar experiment will be performed on a centrifuge in the Spacelab that produces the force of normal Earth gravity. After the flight, the samples will be compared to see if fertilization and development proceeded normally.

Dr. Geertje A. Ubbels of the Hubrecht Laboratory, Utrecht, The Netherlands, is the principal investigator.

Effect of the Space Environment on the Development of the **Drosophila Melanogaster *(FLY)*.** In this ESA experiment, scientists will examine fruit fly embryos to determine which stages of development are sensitive to microgravity. It is presumed that cogenesis, rather than further states of embryonic development, is sensitive to gravity. This hypothesis will be tested by collecting eggs layed at specific times in flight and after flight from flies exposed to 0 g and 1 g. An earlier identical experiment indicated that the fruit fly's development is altered by microgravity, but since this mission is longer, scientists can study embryos that develop entirely under microgravity conditions. Included is a study of male fruit flies to determine whether their average life span is reduced by weightlessness.

The principal investigator is Dr. Roberto Marco of the Department of Biochemistry, Institute of Biochemical Investigations, University of Madrid, Spain.

Genetic and Molecular Dosimetry of HZE Radiation (RADIAT). In this NASA experiment, scientists use microscopic soil nematodes, or roundworms, which are the best-understood animals available to biologists, to study the effects of cosmic rays, or high-energy and charge (HZE) particles. HZE particles account for about half of the absorbed radiation dose in space, and scientists want to know more about the biological effects of cosmic rays so that they can protect astronauts during long space flights. Exposure may place astronauts at risk for certain medical problems, such as cataracts, mutations, and cancers. The roundworms will be used to "capture" mutations caused by cosmic rays, to evaluate whether certain genetic processes occur normally in space, and to test whether development and reproduction proceed normally in microgravity for up to three generations.

The nematode used in this experiment is a small (maximum size 1 mm), transparent, free-living soil organism. Although small, it possesses most of the major organ systems and tissues found in other animals, including mammals. The worms are placed at various locations in the Spacelab in containers that record the number of HZE particles penetrating the containers and the total radiation dose. After the mission, scientists will examine the nematodes to determine if they suffered genetic mutations or their development was altered.

Dr. Gregory A. Nelson of NASA's Jet Propulsion Laboratory in Pasadena, Calif., is the principal investigator on this experiment.

Dosimetric Mapping Inside Biorack (DOSIMTR). The IML-1 experiments are done in an environment with electromagnetic radiation, charged particles and secondary radiation. This flux is not constant but changes with spacecraft inclination and altitude, solar activity and Earth's magnetic field. This experiment documents the changing radiation environment inside Spacelab and compares it with theoretical predictions. This information is necessary to determine whether changes that occur in experiments are caused by microgravity or radiation. Special emphasis is given to measuring the radiation environment in the neighborhood of those experiments that might be especially critical to radiation effects, and so have a way of determining if changes to samples are caused by radiation or microgravity.

The principal investigator is Dr. G. Reitz of the Institute for Flight Medicine, German Aerospace Research Establishment, Cologne, Germany.

Embryogenesis and Organogenesis of* Carausius Morosus *Under Space Flight Conditions (MOROSUS). The eggs of a stick insect (*Carausius morosus*) are exposed to heavy ions of radiation from the sun and other celestial objects at early stages of development to determine their biological effects. Sandwiched between detectors, the eggs hit by radiation can be determined precisely. Other detectors allow scientists to determine the nature, energy and direction of the incident particles. In an earlier Spacelab experiment (November 1985), the life span of stick insect larvae penetrated by heavy ions in space was shortened and their rate of deformities was unusually high. The questions the IML-1 scientists are interested in answering include the following: how many eggs hatch, how many insects develop abnormalities, and how many genetic changes occur in the insects that matured during the mission?

The principal investigator for this experiment is Dr. H. Bruecker of the Institute for Flight Medicine, German Aerospace Research Establishment, Cologne, Germany.

***Gravity-Related Behavior of the Acellular Slime Mold* Physarum Polycephalum (SLIME).** Many living things, including people, perform various activities, such as sleeping, at regular periods. Scientists are not certain whether these activities are controlled by an internal biological clock or by external cues such as day and night cycles or gravity. In space, these cues are absent, and investigators can examine organisms to see if these functions occur in regular circadian time frames. The slime mold *Physarum polycephalum*, which has regular contractions and dilations that slowly move the cell, is used to determine whether the regular activities of living things, such as sleeping, are affected by microgravity. Specifically, investigators are looking for any alteration of the slime mold's movement, which is caused by contractions and dilations of the cell. On Earth, gravity modifies the direction of cell movement and protoplasmic streaming. Results will be compared with results from the Spacelab D1 mission. On the Spacelab D1 mission, the slime mold's movement was altered at first but returned to normal as it adapted to weightlessness, which indicates that the slime mold's internal clock is unopposed by gravity.

Dr. Ingrid Block of the Institute for Flight Medicine, German Aerospace Research Establishment, Cologne, Germany, is the principal investigator.

Microgravitational Effects on Chromosome Behavior (YEAST). Scientists have measured the effects of microgravity and radiation on DNA and chromosomes in many different organisms. They have learned that microgravity alters chromosome structure during mitosis or normal cell division to produce new cells. Changes in DNA structure caused by radiation are then passed on during meiosis or cell division by reproductive cells that reduces the number of chromosomes. This NASA experiment studies the effects of microgravity and radiation on chromosomes by monitoring the frequencies of chromosomal loss and structural deformities and DNA mutation rates that occur in common yeast during cell division. Because yeast chromosomes are small, sensitive measurements can be made that can be extrapolated to higher organisms, including humans.

Postflight genetic studies of cells incubated in space will examine chromosome abnormalities, preference for sexual versus asexual reproduction, and viability of gametes.

The principal investigator is Dr. Carlo V. Bruschi of the Cell and Molecular Biology Division, Lawrence Berkeley Laboratory, Berkeley, California.

Growth and Sporulation in* Bacillus Subtilis *Under Microgravity. Cell differentiation—the way that cells with different functions are produced—normally does not occur in simple organisms like bacteria. However, some bacteria such as *Bacillus subtilis*, wrap up part of their cellular content into special structures called spores. Sporulation, resulting from the distribution of a particular enzyme, is considered to represent a very simple type of differentiation. In this experiment, scientists study the growth of spores in the *Bacillus subtilis* bacteria so that they can reach a better understanding of the way cells with different functions are produced through cell differentiation. After the mission, they will examine the structure and biochemistry of the spores to study the influence of microgravity on sporulation. When this experiment was conducted on the Spacelab D1 mission, a striking reduction in the rate of spore production, thus cell differentiation, was noted; but this result needs to be confirmed on IML-1 because the ground-based control experiment failed on the previous mission.

The principal investigator is Dr. Horst-Dieter Menningmann of the Institute for Microbiology of the University of Frankfurt, Germany.

Studies on Penetration of Antibiotics in Bacterial Cells in Space Conditions (ANTIBIO). To determine if bacteria are more resistant to antibiotics in space because the structure of their cell walls may be thicker, this ESA experiment exposes space-grown *Escherichia coli* bacteria to various concentrations of an antibiotic. The increased resistance of bacteria to antibiotics, together with their increased proliferation, is of prime importance for the future of very long duration space flight.

Immediately after the mission landing, investigators will determine the minimal amount of antibiotic that stopped the bacteria from growing. Later, scientists will measure the number of living cells in each culture and compare the proliferation rates of bacteria exposed to the antibiotic and bacteria that were not exposed. They will also compare both sets of bacteria to bacteria grown on Earth.

The principal investigator is Dr. René Tixador of the National Institute of Health and Medical Research, Toulouse, France.

Transmission of the Gravity Stimulus in Statocyte of the Lentil Root (ROOTS). This ESA experiment examines the growth of the roots of lentil seedlings to improve the understanding of how these plants sense gravity. On Earth, the roots of most plants can clearly perceive gravity since they grow downward. In space, under microgravity conditions, previous results from the D1 mission on Spacelab (November 1985) have shown that roots loose their ability to orient themselves. Exposed to 1 g, the roots reorient themselves in the direction of the simulated gravity. Root samples that have been exposed to microgravity are placed in a centrifuge that simulates gravity to see if they can still sense gravity. Some of the seedlings are monitored over an extended period of time with an automatic photography system so that investigators can determine how soon the seedlings regain their sensitivity to gravity and reorient their roots in the simulated 1-g exposure.

Dr. Gérald Perbal of the Laboratory of Cytology of the Pierre et Marie Curie University, Paris, France, is the principal investigator.

Genotypic Control of Graviresponse, Cell Polarity, and Morphological Development of* Arabidopsis Thaliana *in Microgravity (SHOOTS). This two-part ESA experiment examines the response to microgravity of two strains of thale cress (*Arabidopsis thaliana*)—a wild type whose roots grow down and whose shoots grow up (gravitropic) and a mutant strain called aux-1 whose shoots and roots grow in all directions (agravitropic). The first part investigates the development of sensors in the plants' root tips. It will also investigate its influence on the structure, orientation, and distribution of their amyloplasts. The second part looks at the effect of microgravity on the parts of the plants' seeds that form the first leaf or pair of leaves. Scientists would like to learn whether the gravitropic strain imitates the agravitropic growth of the mutant strain and whether the agravitropic strain's erratic growth pattern continues in microgravity.

The principal investigators for this experiment are Dr. Edmund Maher of the Open University of Scotland, Edinburgh; Greg Briarty of the University of Nottingham, Nottingham, England.

Effect of Microgravity Environment on Cell Wall Regeneration, Cell Divisions, Growth, and Differentiation of Plants From Protoplasts (PROTO). This ESA experiment uses protoplasts of carrots (*Daucus Carota*) and a fodder plant, rape (*Brassica napus*), to evaluate the effects of microgravity on the regeneration of cell walls and the division, growth, and differentiation of cells. Protoplasts are plant cells whose cell walls have been removed; they are capable of growing to mature plants. Cultures from the biorack's microgravity and simulated 1-g environments are studied periodically during the mission to determine whether the cell walls reform and the cells divide. These samples are preserved for postflight analysis. Samples that are allowed to grow throughout the mission in microgravity and 1 g and to continue to grow to maturity on Earth after the mission will be studied along with plants grown from protoplasts on the ground to help scientists better understand the role of gravity in plant growth and development. If plants are to be cultured in space to produce food, enzymes, hormones, and other products, this knowledge is essential.

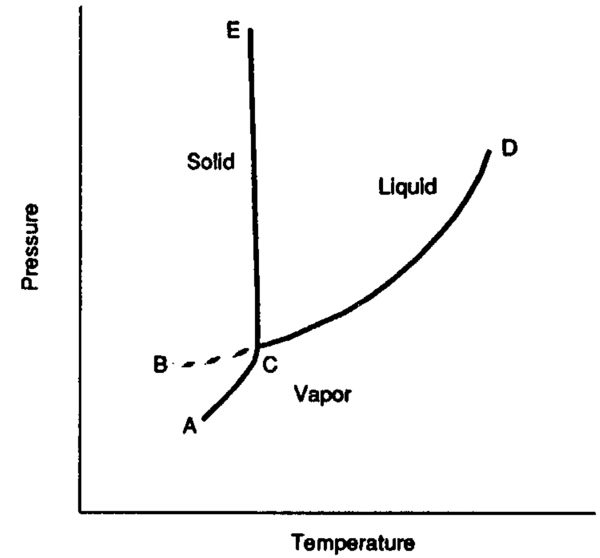
Dr. Ole Rasmussen of the Institute of Molecular Biology and Plant Physiology of the University of Aarhus, Denmark, is the principal investigator.

MATERIALS SCIENCE EXPERIMENTS

Critical Point Facility

European Space Agency scientists have designed four experiments to examine the critical points of transparent fluids in weightlessness. The critical point is the point at which the density of a fluid in the liquid and vapor states is the same. When the pressure and temperature of a fluid reach this point, regions of the fluid actually fluctuate between the two states in a wavelike manner.

Because different materials behave similarly at the critical point, scientists can relate their knowledge of critical point behavior to many disparate physics problems. However, experiments performed on Earth have been hampered by gravity, which distorts the density of samples.



C = Triple Point, Where Ice, Water, and Water Vapor Coexist
D = Critical Point, Where a Kilogram of Water and Kilogram of Water Vapor Have the Same Volume and Distinction Between the Two Phases Vanishes
BC = Curve of the Supercooled Liquid (Extension of CD)
AC = Sublimation Curve of the Solid (Corresponding to the Evaporation of Ice)
CE = Melting Curve
CD = Vapor Pressure Curve

MTD 911216-2725

Schematic Phase Diagram for a One-Component System Such as Water

The critical point facility consists of two interconnected drawers. One of the drawers contains electronics and data handling equipment and the power supply for the experiments. The electronic system runs the experiments automatically according to predefined procedures.

The experiment drawer holds a thermostat that heats or cools fluids in increments of a millidegree from 30 to 70°C. The thermostat contains a test cell that holds the samples. Mechanical and acoustic stirrers inside the test cell are used to mix the fluids. Cameras mounted on the thermostat record interference patterns produced by the refraction of a collimated red laser beam as it passes through the fluid. The patterns are used to provide density profiles of the fluids. The scattered light from a second laser beam is recorded and used to size the density or concentration domains of the fluids. Light that does not get scattered helps determine the fluids' turbidity, or appearance of cloudiness. Turbidity is a sign that a fluid is near the critical point.

Study of Density Distribution in a Near-Critical Simple Fluid. This ESA experiment examines and analyzes the density distributions in sulfur hexafluoride samples and how they equilibrate to reach a single density above and below the fluid's critical temperature. This fluid is used because its critical temperature is near room temperature, avoiding the need for large amounts of power to heat or cool the fluid. It also analyzes the influence of other forces that are weaker than gravity and examines the interface between coexisting phases. Visual observations of the samples' behavior are combined with interferometry and light-scattering techniques to collect data for 60 hours.

Dr. Antonius C. Michels of the Van Der Waals Laboratory in Amsterdam, The Netherlands, is the principal investigator.

Heat and Mass Transport in a Pure Fluid in the Vicinity of a Critical Point. This ESA experiment investigates whether the transport process in gas sulfur hexafluoride is influenced by diffusion, convection caused by orbiter accelerations, and container wall effects. The results will be compared with results from experiments conducted on the ground to see whether heat and mass transport is more efficient in microgravity.

The principal investigator for this experiment is Dr. Daniel Beysens of CEN, Saclay, France.

Phase Separation of an Off-Critical Binary Mixture. This ESA experiment studies the separation of phases in off-critical systems (e.g., fluids whose phases are not equal in volume) by examining the separation of a fluid into two separate phases at different temperatures to reveal how temperature changes affect the formation of the phases. Small-angle light scattering and direct observation will be used to study phase separation at various temperatures. Investigators hope that a comparison of the results from the experiment conduced in space with the results from experiments on Earth will indicate whether they can reproduce conditions on Earth like those found in microgravity.

Dr. Daniel Beysens is the principal investigator.

Critical Fluid Thermal Equilibration Experiment. In this experiment the temperature and destiny changes of sulfur hexafluoride, a fluid with a critical point just above room temperature, will be measured with a resolution not possible on Earth (at the critical point gas and liquid become indistinguishable). The cells are integrated into the ESA Critical Point Facility and will be observed via interferometry, visualization, and transmission under various conditions.

During the full experiment, accelerometry time correlated with the video records will identify the compressible fluid dynamics associated with space shuttle acceleration events and provide the investigators with insight concerning gravity effects on fluids in a non-vibration isolated shuttle experiment.

The principal investigator is Dr. Allen Wilkinson of the NASA Lewis Research Center in Cleveland, Ohio.

Fluids Experiment System (FES)

The fluids experiment system is a NASA-developed facility that produces optical images of fluid flows during the processing of materials in space. The system's sophisticated optics consist of a laser to make holograms of samples and a video camera to record images of flows in and around samples. Two experiments will be performed on this mission.

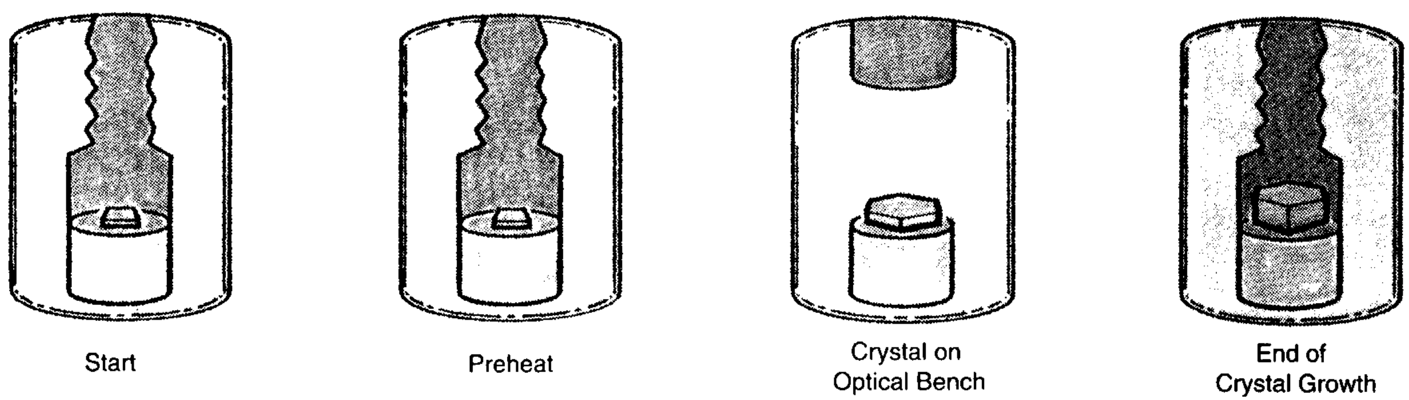
Study of Solution Crystal Growth in Low Gravity (TGS). Triglycine sulfate crystals have been grown on Earth in sizes suitable for use, but gravity-induced convective flows cause defects that limit the crystals' performance. Scientists will use the fluids experiment system to try to grow more nearly perfect crystals in microgravity, where convection should be limited. Triglycine sulfate crystals have potential for use as room-temperature infrared detectors with applications for military systems, astronomical telescopes, Earth observation cameras and environmental analysis monitors.

During this experiment, holographic images of the transparent triglycine sulfate solution are recorded so that scientists can study the effects of reduced convective flows and determine how crystals grow in solution in space. Black-and-white video images sent back to Earth during the experiment allow the principal investigator and his team to monitor the process and tell the astronauts to change the temperature to induce more uniform growth.

Two crystals are to be grown from cylindrical seed crystals. The original seed is a slice from the face of a larger crystal grown on Earth. In space, it is immersed in a solution of triglycine sulfate, which is initially heated slightly to remove any surface imperfections from the seed. As the seed is cooled, dissolved triglycine sulfate incorporates around the seed, forming new layers of growth.

The first crystal, grown for at least one day, gives scientists data to grow a high-quality crystal during the second run, which lasts several days. After the flight, the crystals will be returned to the principal investigator, who will analyze their structures and properties, especially the capability to detect infrared radiation.

The principal investigator for this NASA experiment is Dr. Ravindra B. Lal of Alabama A&M University.



Crystal Growth Process in the Fluids Experiment System

An Optical Study of Grain Formation: Casting and Solidification Technology (CAST). It may be possible to alter or improve the mechanical strength, corrosion resistance, and many other advantageous properties of the advanced metal alloys needed for jet engines, nuclear power plants, and future spacecraft by processing the alloys in space. Advanced alloys are made by combining two or more metals or a metal and a nonmetal. As alloys solidify, the components redistribute themselves through the liquid and in the solid. In this NASA experiment, investigators solidify a salt of ammonium chloride and water to study the way grains form in alloys, undercooling effects on metal structure, and the interface between the liquid and solid parts of a solidifying sample.

Three samples of ammonium chloride are used to study the solidification processes. Two samples are filled with a solution of water and 28-percent salt by weight; the third, with 15-percent salt by weight. Up to 11 experiments may be run. In most of the experiments, the samples are solidified under controlled conditions. In the others, the samples are undercooled and then solidified rapidly. The series of experiments enables scientists to study solidification under optimum conditions and conditions that enhance freckling, a phenomenon that limits the usefulness of alloy compositions, and crystallite formation ahead of the growth front where liquid and solid meet.

Temperature and concentration profiles are obtained, and video taken during the critical period when the solidification front moves through the solution is sent to the Earth. Investigators on the ground can monitor the experiment and request a crew member to make changes in the experiment during the current or future runs. Holograms taken during the growth runs will be used after the flight to show the formation of dendrites, the treelike crystals that play an important role in determining the microstructure of alloys, and the growing interface.

The principal investigator is Dr. Mary H. McCay of the University of Tennessee Space Institute, Tullahoma, Tenn.

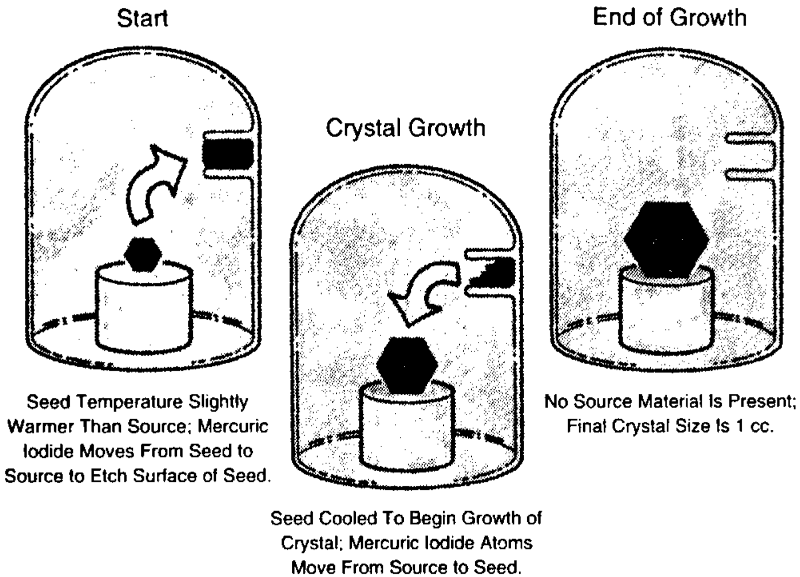
Mercuric Iodide

Mercuric iodide crystals have practical uses as sensitive X-ray and gamma ray detectors. In addition to their exceptional electronic properties, these crystals can operate at room temperature. This makes them potentially useful in portable detector devices for nuclear power plant monitoring, natural resource prospecting, biomedical applications, and astronomical observing. Although mercury iodide has greater potential than existing detectors, problems in the growth process cause crystal defects. For instance, the crystal is fragile and can be deformed by its own weight. Scientists believe the growth process can be controlled better in a microgravity environment and that such problems can be reduced or eliminated. Two facilities will be used to grow mercury iodide crystals during IML-1.

Vapor Crystal Growth System

The vapor crystal growth system and the mercury iodide crystal growth experiments both grow mercury iodide crystals using the vapor transport process, but temperature and pressure and other parameters are varied in the experiments to determine the best conditions for growing the crystals. Both experiments have been conducted on previous Spacelab missions and have produced crystals. On this mission, investigators try to refine their techniques and continue to study the crystal growth process.

Mercury iodide crystals have exceptional electronic properties and can operate at room temperature, which eliminates the bulky cooling systems required for other materials. However, crystals grown on Earth have defects, and scientists believe they can grow large, single crystals with few defects in microgravity. If the ideal growth conditions can be determined through the Spacelab experiments, scientists would like to grow these crystals for longer periods of time in a permanent space facility like Space Station Freedom.



Crystal Growth Process in the Vapor Crystal Growth System

Vapor Crystal Growth Studies of Single Mercury Iodide Crystals. A single mercury iodide crystal produced by the vapor crystal growth system on Spacelab 3 in 1985 was found to have better quality than the Earth-grown crystal used as a standard and an interior quality superior to mercury iodide crystals grown on Earth. On this mission, the goal is to grow the crystal twice as fast as the Spacelab 3 crystal: one of the lessons from the previous experiment was that the growing process was too slow.

In space, an ampule containing the seed crystal and mercury iodide source material is placed in a bell jar furnace, which is inserted in the experiment enclosure in the vapor crystal growth system. The ampule is heated to around 212 degrees F, and the ideal growth temperature is established. As the mercury iodide source material evaporates, the vapor is deposited on the seed, causing the seed to grow. As the growth continues for 100 hours, the crew members and investigators on the ground monitor the experiment temperature and change it when necessary to enhance growth.

After the flight, the principal investigator will compare the crystal to the one grown on Spacelab 3 and to crystals grown on Earth, examine its structure with X-ray and gamma-ray analyses, and test its high-energy radiation detection properties.

Dr. Lodewijk van den Berg of EG&G, Inc., Goleta, Calif., is the principal investigator for this NASA-provided experiment.

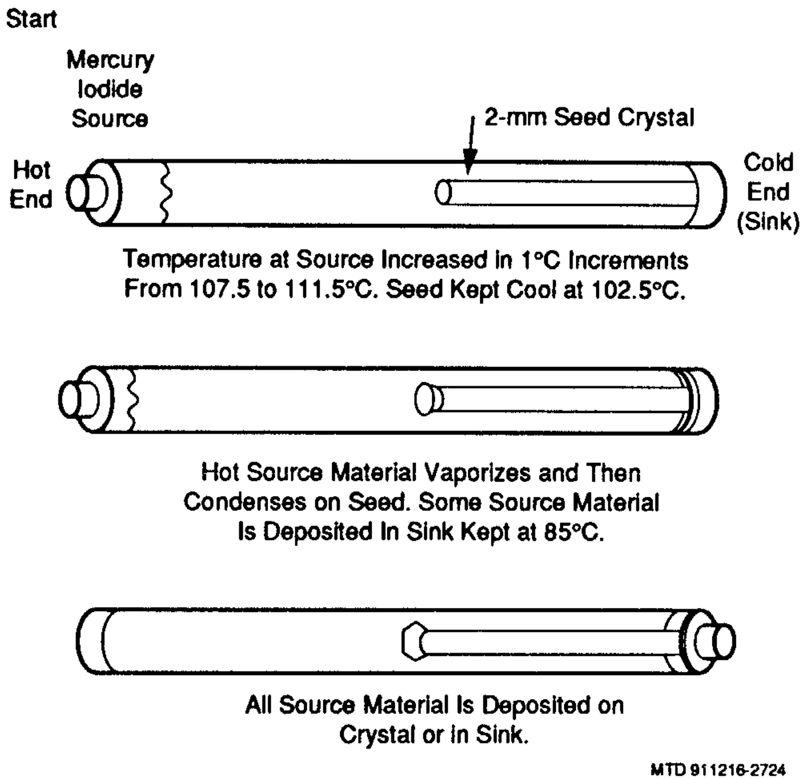
Mercury Iodide Crystal Growth (MICG)

Mercury Iodide Nucleations and Crystal Growth in Vapor Phase. In this experiment, investigators hope to produce nearly flawless mercury iodide crystals, something which is extremely difficult to achieve on Earth because of the effects of gravity-induced convection. Six seed crystals obtained from crystals grown on the ground are used in this experiment to grow large crystals under controlled conditions in separate ampules.

A crew member inserts three sample-containing ampules in the mercury iodide crystal growth facility and turns it on. As the mercury iodide source is heated, it evaporates and moves through the ampule. Some of the source material is distributed symmetrically around the seed crystal, which is mounted on a pedestal. Other source material is deposited in the cold end of the ampule at the base of the seed pedestal to prevent it from forming small crystallites near the seed crystal.

Although they cannot observe the growth process, scientists can precisely measure the total pressure and the concentration distribution of mercury iodide in the ampules. This information should help them determine the ideal pressure for growing crystals and how thermal diffusion affects the distribution of mercury iodide in the ampules and will complement the visual data from the vapor crystal growth system experiment.

The first three crystals are allowed to grow for an extended period of time. If time allows, the other three will also be grown. After the flight, the principal investigator will analyze the structures of the crystals and determine the pressure environment that affords the best growth conditions.



Crystals Are Grown in Individual Ampules in the Mercury Iodide Crystal Growth Furnace

The principal investigator is Dr. Robert Cadoret of the University of Clermont-Ferrand, Aubière, France.

Protein Crystal Growth (PCG)

The protein crystal growth experiment uses the vapor diffusion process to grow many types of protein crystals that are larger and less flawed than crystals that can be grown on Earth. Scientists can then study the architecture of these crystals, which may lead to the discovery of drugs that can be used in the fight against cancer and diseases of the immune system and in agricultural genetics research.

Crystals of better quality than any grown on Earth were produced on two previous Shuttle missions. They were large, had nearly perfect shapes, and their molecules were well ordered, which meant that scientists could obtain better resolution during X-ray analysis of the crystals. On STS-29 in 1989, scientists obtained greatly improved crystals of lectin, a plant seed protein, and have determined the structure of the protein from these crystals.

There are 120 protein crystal growth experiments on this mission. Each experiment takes place inside a chamber within one of two refrigerator/incubator modules located in Discovery's middeck. The experiment chamber contains a highly concentrated precipitating solution. A double-barreled syringe containing a protein solution and a low-concentration precipitating solution extends into the reservoir of the chamber, and a bubble of air separates the syringe from the high-concentration precipitating solution.

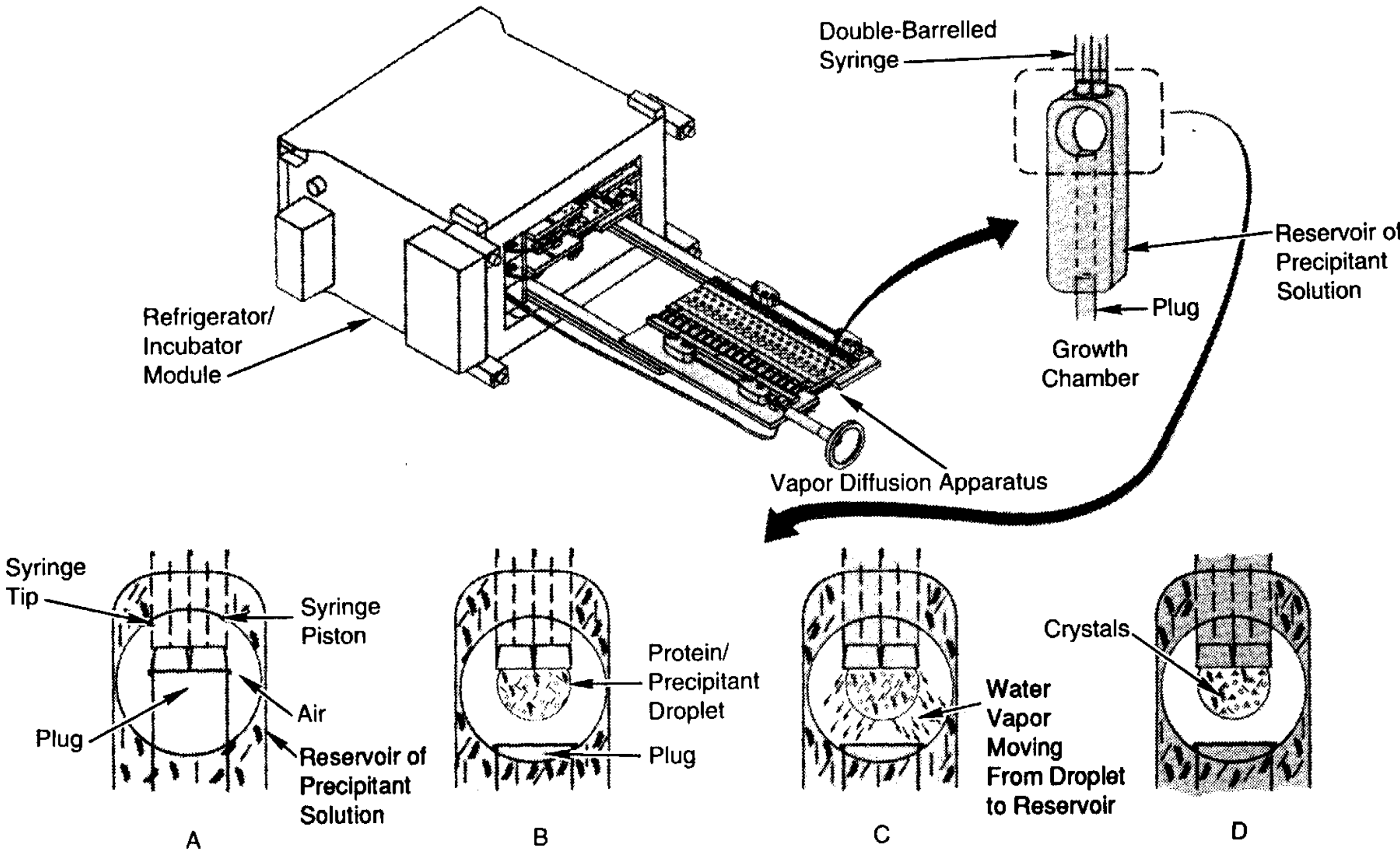
Liquid is extruded from both barrels of the syringe and forms a droplet on the tip of the syringe. Because of the difference in the concentrations of the two precipitating solutions, water vapor moves from the droplet to the reservoir of high-concentration solution. This causes the concentrations of protein and precipitating agents to increase, and crystals form.

Just before the mission ends, the droplets, and any crystals that have formed, are drawn back into the syringes to protect them during landing. After the flight, the crystals will be analyzed with X-ray crystallography, which produces patterns that resemble a symmetric array of spots and suggests the geometry of the protein.

The principal investigator for this NASA experiment is Dr. Charles E. Bugg of the University of Alabama at Birmingham.

Cryostat

For this German Space Agency experiment, three different types of proteins are grown by liquid diffusion under different thermal conditions in the temperature-controlled environment of the

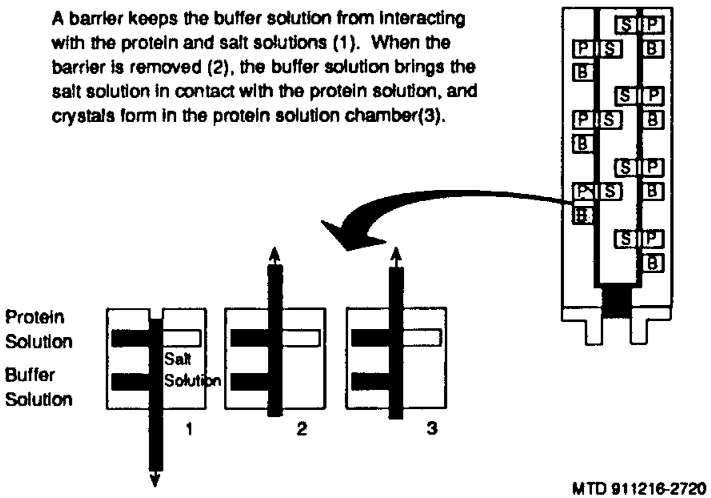


A. A Double-Barrelled Syringe Holds Protein Crystal Growth Materials Separate Before the Experiment Begins.
B. A Crew Member Turns One Handwheel To Withdraw the Plug and Another to Activate Pistons That Push the Two Solutions Out of the Syringe and Into an Air Space, Where They Form a Hanging Drop.
C. Water Vapor Moves Out of the Drop and Into a Reservoir Lining the Growth Chamber.
D. The Concentration of Precipitating Solution in the Droplet Increases and Stimulates Protein Crystal Growth.

Protein Crystal Growth

cryostat. The cryostat consists of two thermostat chambers—one that operates in a stabilizer mode at a constant temperature of 59 to 77 degrees F and one that operates in a freezer mode at temperatures that can be varied from 17.6 to 77 degrees F.

Two blocks, each containing seven samples, are used in this experiment, one block for each operating mode. The blocks are inserted into the thermostat chambers in space, and a computer preprogrammed with the temperature profiles for the experiments starts them automatically.



One of Two Cryostat Sample Containers (Right) Holds Seven Samples

The liquid diffusion process is used to grow the protein crystals. When the proper temperature is reached, a buffer solution is released and brings a salt precipitant and protein solution together. When the precipitant contacts the protein solution, crystals begin to form in the protein solution.

After the flight, the principal investigator will use X-ray crystallography to determine the quality of the crystals and, if possible, their structures. The space-grown crystals will also be compared to crystals grown in a cryostat and other facilities on Earth.

Single-Crystal Growth of Beta-Galactosidase and Beta-Galactosidase/Inhibitor Complex. Crystals of beta-galactosidase, the first protein crystalized in the cryostat on Spacelab 1 in 1983, and beta-galactosidase/inhibitor complex are grown in this experiment. Beta-galactosidase is a key enzyme in modern genetics that is found in the intestines of human and animal babies and aids in the digestion of milk and milk products. Scientists would like to discover its three-dimensional molecular structure to determine how the structure affects the molecule's function. For IML-1, scientists will attempt to grow higher quality crystals. Cryostat will be used in the freezer mode, at temperatures ranging from 24.8 to 68 degrees F, for this investigation.

The principal investigator is Dr. W. Littke of the University of Freiburg, Germany.

Crystal Growth of the Electrogenic Membrane Protein Bacteriorhodopsin. Bacteriorhodopsin is a well-known protein that converts light energy to voltages in the membranes of photosynthetic archaebacteria, which are primitive microorganisms. It is also nearly ideal for studying light-energy-driven vectorial membrane transport which developed in the early stages of the Earth's development.

Scientists have been able to grow two-dimensional crystals of bacteriorhodopsin on Earth, but they have not been able to define its three-dimensional structure, which would help biologists understand how the protein works. They hope to grow the large, highly ordered crystals needed for this definition on this mission.

This experiment uses the cryostat in the stabilizer mode, with the temperature being maintained at 68 degrees F.

Dr. G. Wagner of the University of Giessen's Plant Biology Institute 1, Giessen, Germany, is the principal investigator.

Crystallization of Proteins and Viruses in Microgravity by Liquid-Liquid Diffusion. The proteins canavalin and catalase and the satellite tobacco mosaic virus are crystallized in this NASA experiment. Canavalin is the major storage protein in leguminous plants and a major dietary protein, catalase is an important detoxifying enzyme in the liver, and satellite tobacco mosaic virus is a common plant pathogen and one of the smallest viruses.

One of the objectives of this experiment is to study the effects of microgravity on the polymorph distribution and size of crystals under diverse temperatures. Three samples of the proteins and virus are crystallized—in the freezer mode with a temperature gradient of 28.4 to 68 degrees F and in the stabilizer mode at a constant temperature of 68 degrees F.

Crystals of canavalin and satellite tobacco mosaic virus obtained in this experiment through the liquid diffusion process will be compared with crystals of the protein and virus grown using the vapor diffusion method on previous flights.

Dr. Alexander McPherson of the University of California Riverside is the principal investigator for this experiment.

Organic Crystal Growth Facility (OCGF)

Scientists will use the organic crystal growth facility to try to grow a large, high-quality organic crystal for use in studying the metallic conduction properties of compounds composed of charge transfer complexes. Because of the gravity-induced effects of sedimentation and thermal convection, they have not been able to grow crystals on Earth that are large enough to test their superconducting properties. Superconductors conduct electricity very efficiently and are key components in computers, communication satellites, and other electrical devices.

In this experiment, two crystals are grown from a solution of two complexes that transfer charges—tetrathiafalvelene (TTF) and $\{\text{Nickel }(\text{dmit})_2\}_2$. Crystals formed from these complexes are especially appealing to scientists because they are organic and act like a metal semiconductor.

The organic crystal growth facility consists of two chambers. In the larger chamber, researchers try to grow a crystal that is 10 times bigger than any that have been grown on Earth. A smaller crystal is grown in the other chamber, which is equipped with a window so that the crew members can observe the growth. A crew member periodically photographs the growth of the smaller crystal. Temperature and vibration data are automatically recorded in both chambers.

To start the experiment, a crew member lowers the seed crystals into the center sections of the chambers and opens two valves in the side chambers to let the TTF and nickel solutions enter the center chamber and condense on the seed. After 6 days, a crew member closes the valves and raises the crystal into a protective bladder that prevents the crystal from growing further under gravity after the flight. The principal investigator will analyze the structures, perfection, electrical and magnetic properties, and superconductivity of the crystals.

The principal investigator for this experiment is Dr. A. Kanbayashi of the National Space Development Agency of Japan.

SPACELAB

On Sept. 24, 1973, a memorandum of understanding was signed between the European Space Agency, formerly known as the European Space Research Organization, and NASA with NASA's George C. Marshall Space Flight Center as lead center for ESA to design and develop Spacelab, a unique laboratory facility carried in the cargo bay of the space shuttle orbiter that converts the shuttle into a versatile on-orbit research center.

The reusable laboratory can be used to conduct a wide variety of experiments in such fields as life sciences, plasma physics, astronomy, high-energy astrophysics, solar physics, atmospheric physics, materials sciences, and Earth observations.

Spacelab is developed on a modular basis and can be varied to meet specific mission requirements. Its four principal components are the pressurized module, which contains a laboratory with a shirt-sleeve working environment; one or more open pallets that expose materials and equipment to space; a tunnel to gain access to the module; and an instrument pointing subsystem. Spacelab is not deployed free of the orbiter. The open pallets and instrument pointing subsystem will not be used on STS-42.

The European Space Agency developed Spacelab as an essential part of the United States' Space Transportation System. Eleven European nations are involved: Germany, Belgium, Denmark, Spain, France, United Kingdom, Ireland, Italy, the Netherlands, Switzerland, and, as an observer state, Austria.

An industrial consortium headed by ERNO-VFW Fokker (Zentralgesellschoft VFW-Fokker mbh) was named by ESA in June 1974 to build the pressurized modules. Five 10-foot-long, unpressurized, U-shaped pallet segments were built by the British Aerospace Corporation under contract to ERNO-VFW Fokker. The IPS is built by Dornier.

Spacelab is used by scientists from countries around the world. Its use is open to research institutes, scientific laboratories, industrial companies, government agencies, and individuals. While many missions are government sponsored, Spacelab is also intended to provide services to commercial customers.

Each experiment accepted has a principal investigator assigned as the single point of contact for that particular scientific project. The principal investigators for all experiments on a given mission form what is called the Investigators Working Group. This group coordinates scientific activities before and during the flight.

The investigators prepare the equipment for their experiments in accordance with size, weight, power, and other limitations established for the particular mission.

Responsibility for experiment design, development, operational procedures, and crew training rests with the investigator. Only after it is completed and checked out is the equipment shipped to the Kennedy Space Center for installation on Spacelab.

Each mission has a mission scientist, a NASA scientist who, as chairman of the Investigators Working Group, serves as the interface between the science-technology community and NASA's payload management people. Through the mission scientist, the science-technology needs of the mission and the investigators' goals are injected into the decision-making process.

NASA astronauts called mission specialists, as well as non-career astronauts called payload specialists, fly aboard Spacelab to operate experiments. Payload specialists are nominated by the scientists sponsoring the experiments aboard Spacelab. They are accepted, trained, and certified for flight by NASA. Their training includes familiarization with experiments and payloads as well as information and procedures to fly aboard the space shuttle. From one to four payload specialists can be accommodated for a Spacelab flight. These specialists ride into space and return to Earth in the orbiter crew compartment cabin—but they work with Spacelab on orbit. Because Spacelab missions, once on orbit, may operate on a 24-hour basis, the flight crew is usually divided into two teams. The STS-42 crew will work 12-hour shifts.

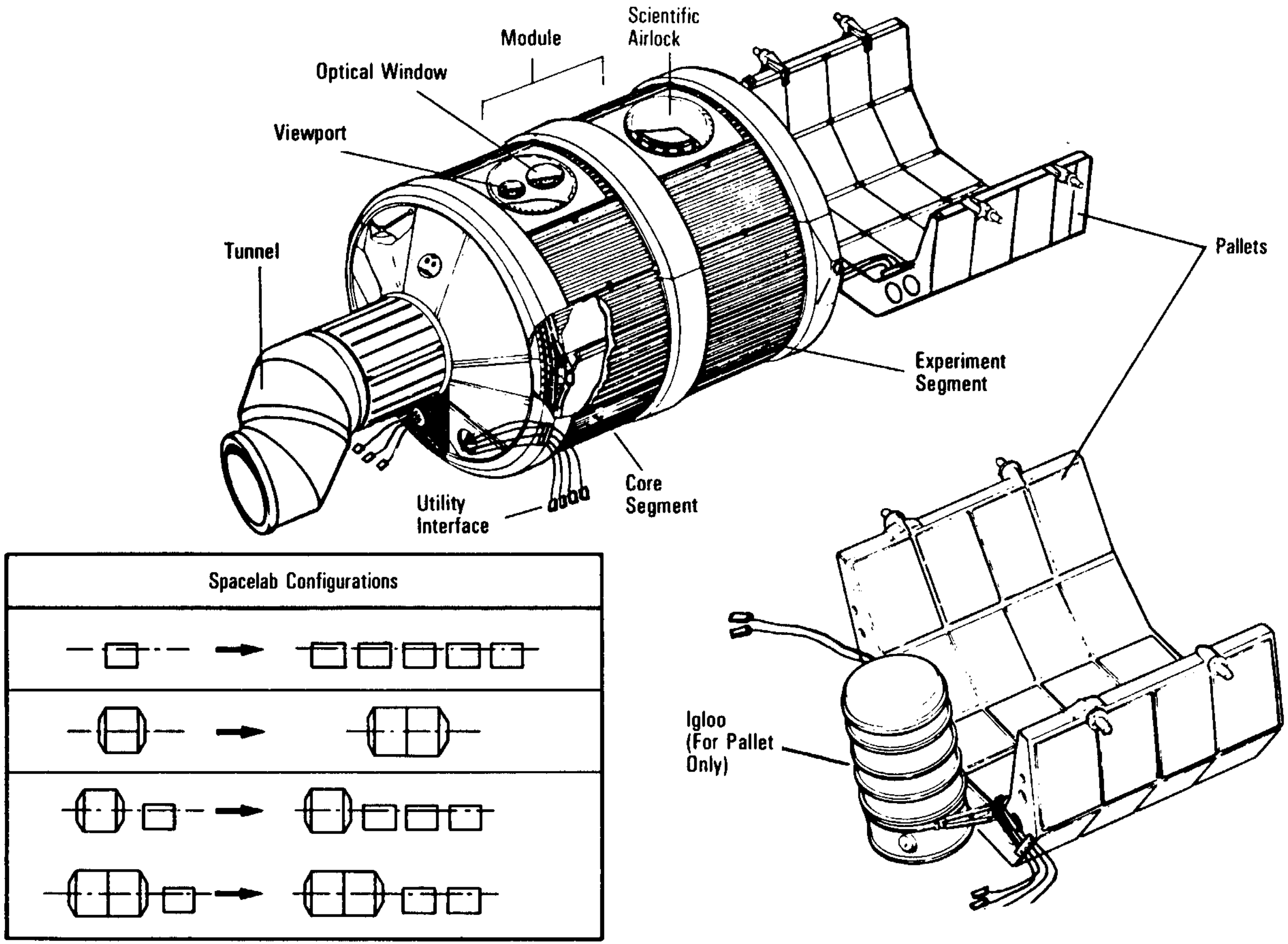
PRESSURIZED MODULE. The pressurized module, or laboratory, is available in two segments. One, called the core segment, contains supporting systems, such as data processing equipment and utilities for the pressurized modules and pallets (if pallets are used in conjunction with the pressurized modules). The laboratory has fixtures, such as floor-mounted racks and a workbench. The second, called the experiment segment, provides more working laboratory space and contains only floor-mounted racks. When only one segment is needed, the core segment is used. Each pressurized segment is a cylinder 13.1 feet in outside diameter and 9 feet long. When both segments are assembled with end cones, their maximum outside length is 23 feet. The long module configuration will be used on STS-42.

The pressurized segment or segments are structurally attached to the orbiter payload bay by four attach fittings consisting of three longeron fitting sets (two primary and one stabilizing) and one keel fitting. The segments are covered with passive thermal control insulation.

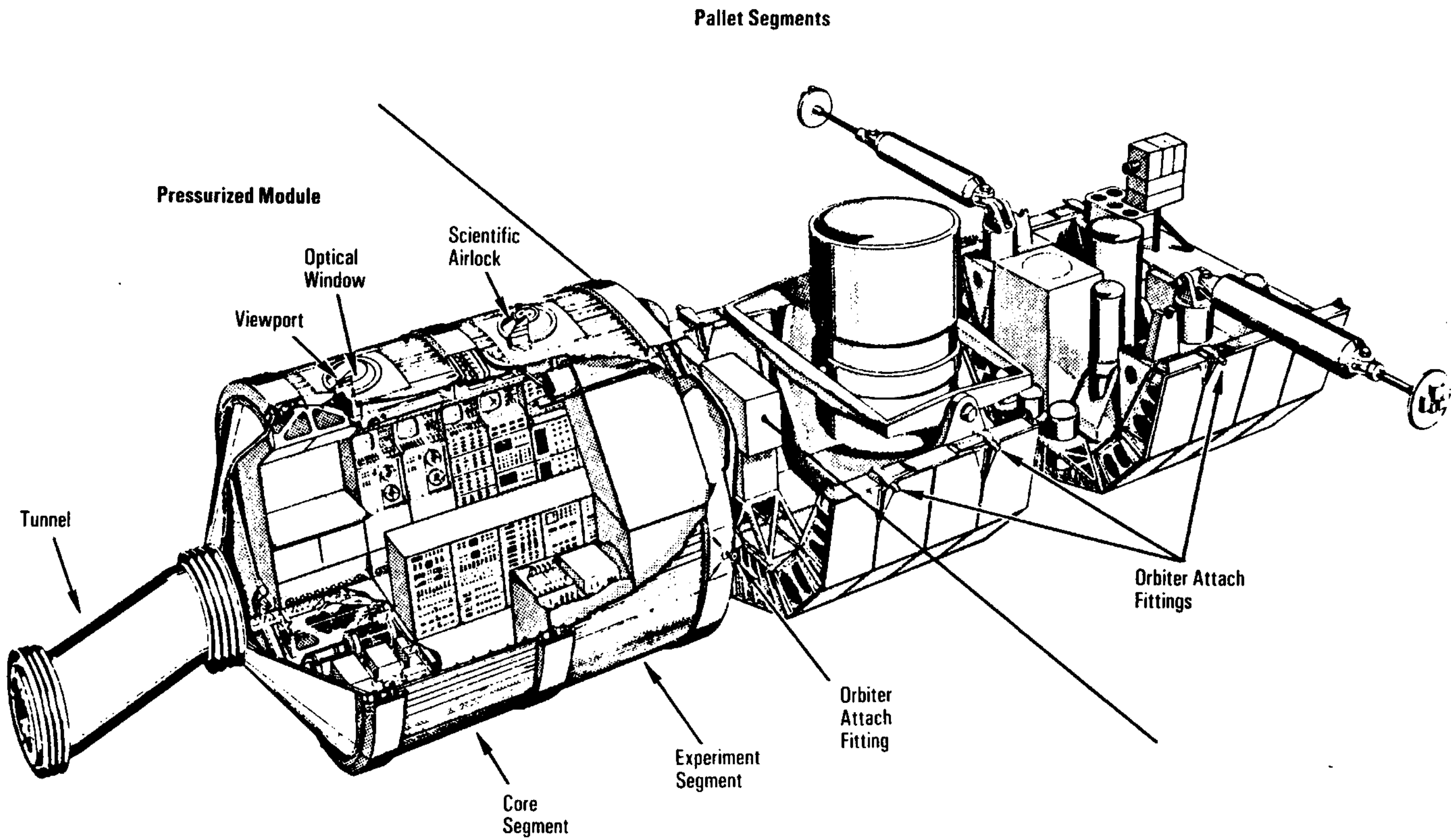
The ceiling skin panel of each segment contains a 51.2-inch-diameter opening for mounting a viewport adapter assembly, a Spacelab window adapter assembly, or scientific airlock; if none of these items are used, the openings are closed with cover plates that are bolted in place. The module shell is made from 2219-T851 aluminum plate panels. Eight rolled integral-machined waffle patterns are butt-welded together to form the shell of each module segment. The shell thickness ranges from 0.6 of an inch to 0.14 of an inch. Rings machined from aluminum-roll ring forgings are butt-welded to the skin panels at the end of each shell. Each ring is 20 inches long and 195.8 inches in diameter at the outer skin line. Forward and aft cones bolted to the cylinder segments consist of six aluminum skin panels machined from 2219-T851 aluminum plate and butt-welded to each other and to the two end rings. The end rings are machined from aluminum-roll ring forgings. The end cones are 30.8-inch-long truncated cones whose large end is 161.9 inches in outside diameter and whose small end is 51.2 inches in outside diameter. Each cone has three 16.4-inch-diameter cutouts: two located at the bottom of the cone and one at the top. Feedthrough plates for routing utility cables and lines can be installed in the lower cutouts of both end cones. The Spacelab viewport assembly can be installed in the upper cutout of the aft end cone, and the upper cutout of the forward end cone is for the pressurized module vent and relief valves. The pressurized modules are designed for a lifetime of 50 missions. Nominal mission duration is seven days.

Racks for experiment equipment that goes into the habitable module are standardized. The 19-inch-wide (48-centimeter) racks are arranged in single and double assemblies. Normally, the racks and floor are put together outside the module, checked out as a unit, and slid into the module where connections are made between the rack-mounted experiment equipment, the subsystems in the core segment, and the primary structure.

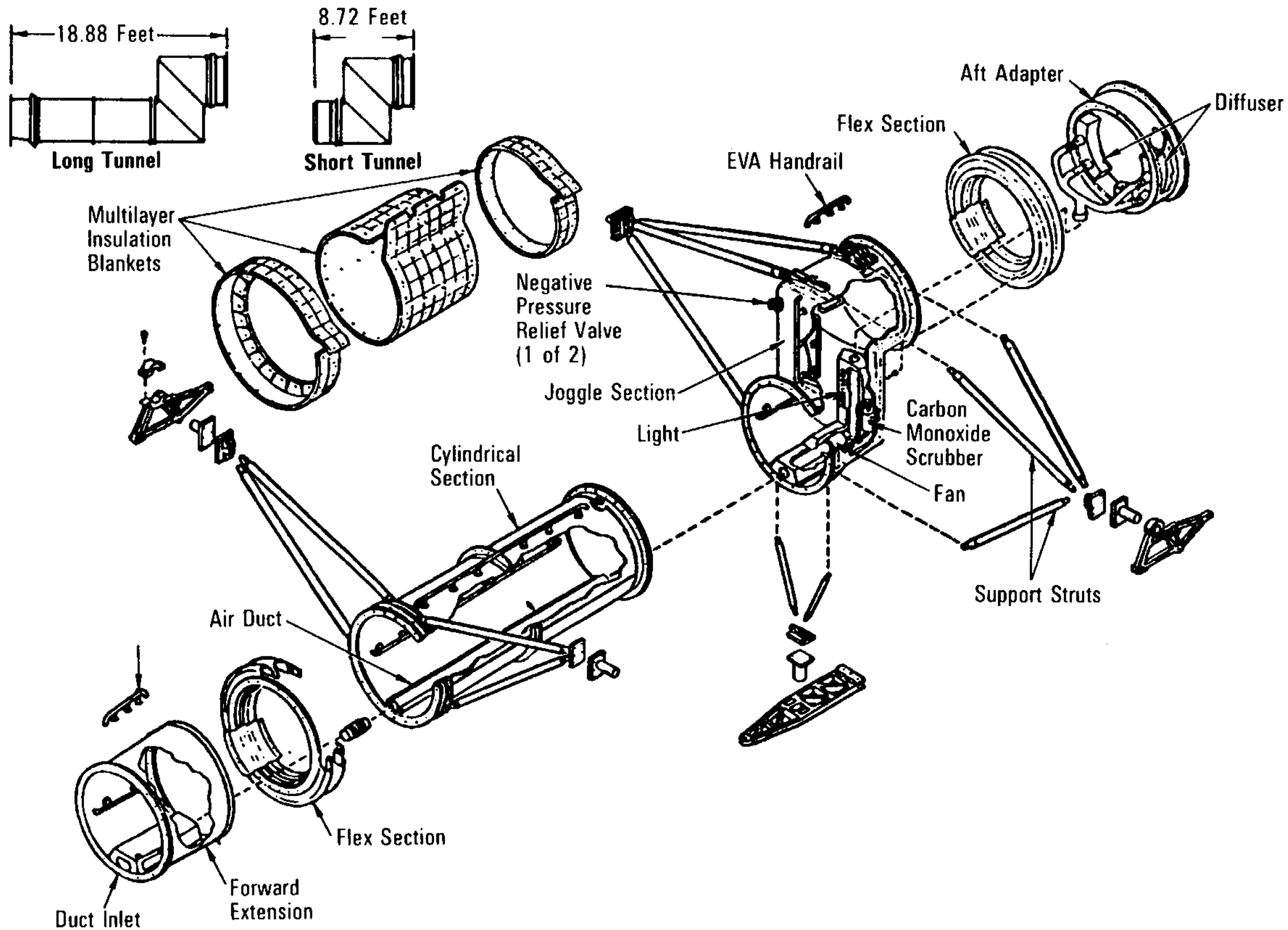
Because of the orbiter's center-of-gravity conditions, the Spacelab pressurized modules cannot be installed at the forward end of the payload bay. Therefore, a pressurized tunnel is provided for equipment and crew transfer between the orbiter's pressurized crew compartment and the Spacelab pressurized modules. The transfer tunnel is a cylindrical structure with an internal unobstructed diameter of 40 inches. The cylinder is assembled in sections to allow length adjustment for different module configurations. Two tunnel lengths can be used—a long tunnel of 18.88 feet and a short tunnel of 8.72 feet. The long tunnel configuration will be employed on STS-42. The joggle section of the tunnel compensates for the 42.1-inch vertical offset of the orbiter middeck to the Spacelab pressurized module's



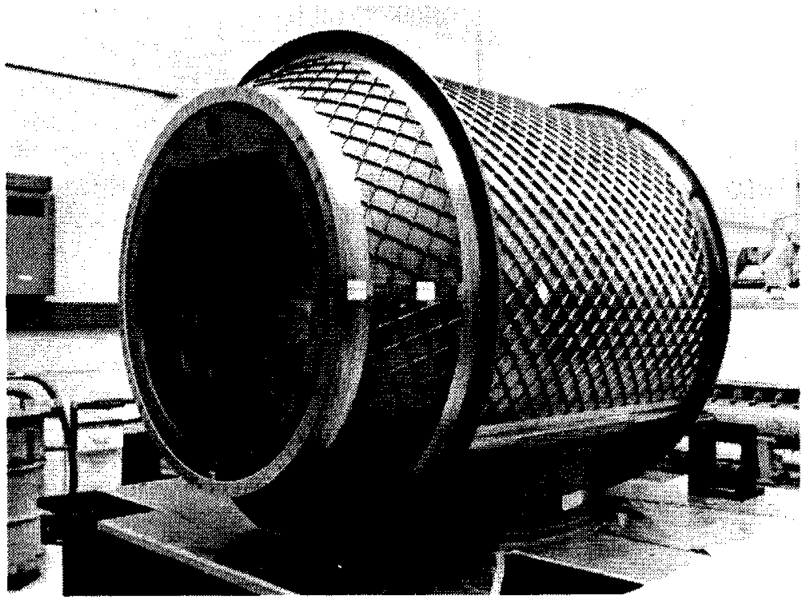
Spacelab External Design Features



European Space Agency's Spacelab



Spacelab Transfer Tunnel



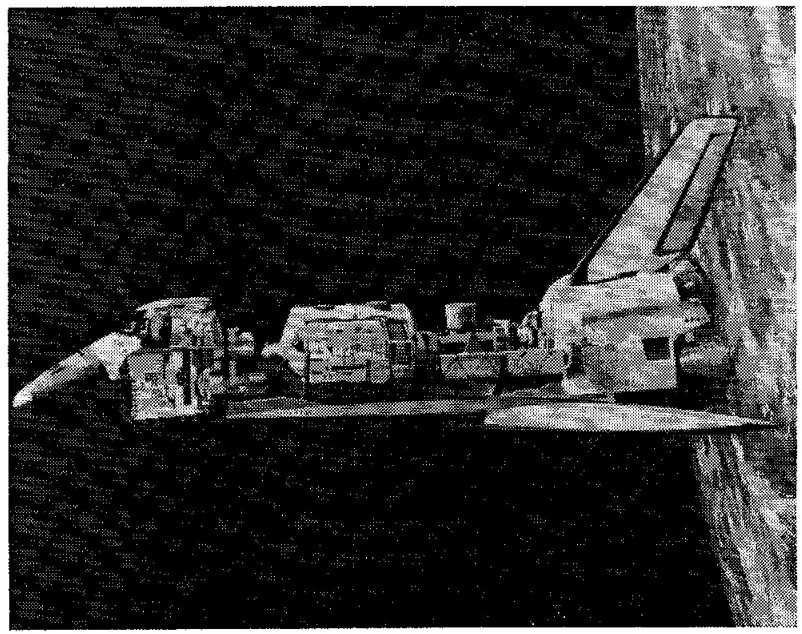
Tunnel Adapter

centerline. There are flexible sections on each end of the tunnel near the orbiter and Spacelab interfaces. The tunnel is built by McDonnell Douglas Astronautics Company, Huntington Beach, Calif.

The airlock in the middeck of the orbiter, the tunnel adapter, hatches, the tunnel extension, and the tunnel itself permit the flight crew members to transfer from the orbiter middeck to the Spacelab pressurized module or modules in a pressurized shirt-sleeve environment. The airlock, tunnel adapter, tunnel, and Spacelab pressurized modules are at ambient pressure before launch. In addition, the middeck airlock, tunnel adapter, and hatches permit crew members outfitted for extravehicular activity to transfer from the airlock/tunnel adapter in space suits to the payload bay without depressurizing the orbiter crew compartment and Spacelab modules. If an EVA is required, no flight crew members are permitted in the Spacelab tunnel or module.

INSTRUMENT POINTING SUBSYSTEM. Although not applicable to the STS-42 IML-1 mission, some research to be accomplished on Spacelab missions requires that instruments be pointed with very high accuracy and stability at stars, the sun, the Earth, or other targets of observation. The IPS provides precision pointing for a wide range of payloads, including large single instruments or a cluster of instruments or a single smallrocket-class instrument. The pointing mechanism can accommodate instruments of diverse sizes and weights (up to 15,432 pounds) and can point them to within 2 arc seconds and hold them on target to within 1.2 arc seconds.

The IPS consists of a three-axis gimbal system mounted on a gimbal support structure connected to the pallet at one end and to the aft end of a payload at the other, a payload clamping system to support the mounted experiment elements during launch and

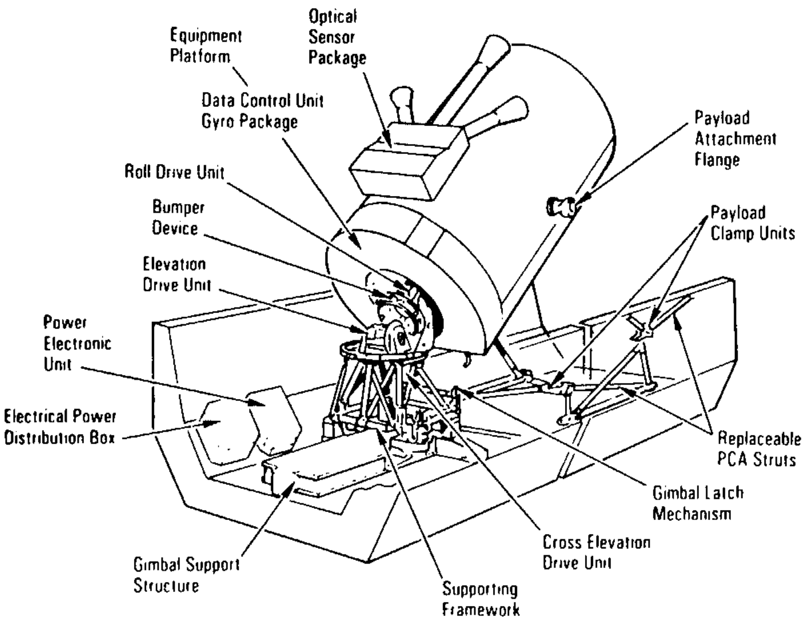


Spacelab

landing, and a control system based on the inertial reference of a three-axis gyro package and operated by a gimbal-mounted minicomputer.

The basic structural hardware is the gimbal system, which includes three bearing/drive units, a payload/gimbal separation mechanism, a replaceable extension column, an emergency jettisoning device, a support structure and rails, and a thermal control system. The gimbal structure itself is minimal, consisting only of a yoke, an inner gimbal, and an outer gimbal to which the payload is attached by the payload-mounted integration ring.

The three identical drive units are so arranged that their axes intersect at one point. From pallet to payload, the order of the axes is elevation, cross-elevation, and azimuth. Each drive assembly includes three wet-lubricated ball bearings, two brushless dc-torquers, and two single-speed/multispeed resolvers.



Instrument Pointing Subsystem

The gimbal/payload separation mechanism is located between the outer gimbal and the payload integration ring. This device prevents the payload and the pointing mechanism from exerting excessive loads on each other during launch and landing. For orbital operations, the outer gimbal and integration ring are pulled together and locked.

The operating modes of the different scientific investigations vary considerably. Some require manual control capability; others require long periods of pointing at a single object, slow scan mapping, or high angular rates and accelerations. Performance in all these modes requires flexibility, which is achieved by computer software. The IPS is controlled through the Spacelab subsystem computer and a data display unit and keyboard. It can be operated either automatically or by the Spacelab crew from the pressurized module and also from the payload station on the orbiter aft flight deck.

The IPS has two operating modes, which depend on whether the gimbal resolver or gyro is used for feedback control of attitude. An optical sensor package consisting of one boresighted fixed-head star tracker and two skewed fixed-head star trackers is used for attitude correction and also for configuring the IPS for solar, stellar, or Earth viewing.

PALLET ONLY. Each pallet is more than a platform for mounting instrumentation; with an igloo attached, it can also cool equipment, provide electrical power, and furnish connections for commanding and acquiring data from experiments. When only pallets are used, the Spacelab pallet portions of essential systems required for supporting experiments (power, experiment control, data handling, communications, etc.) are protected in a pressurized, temperature-controlled igloo housing.

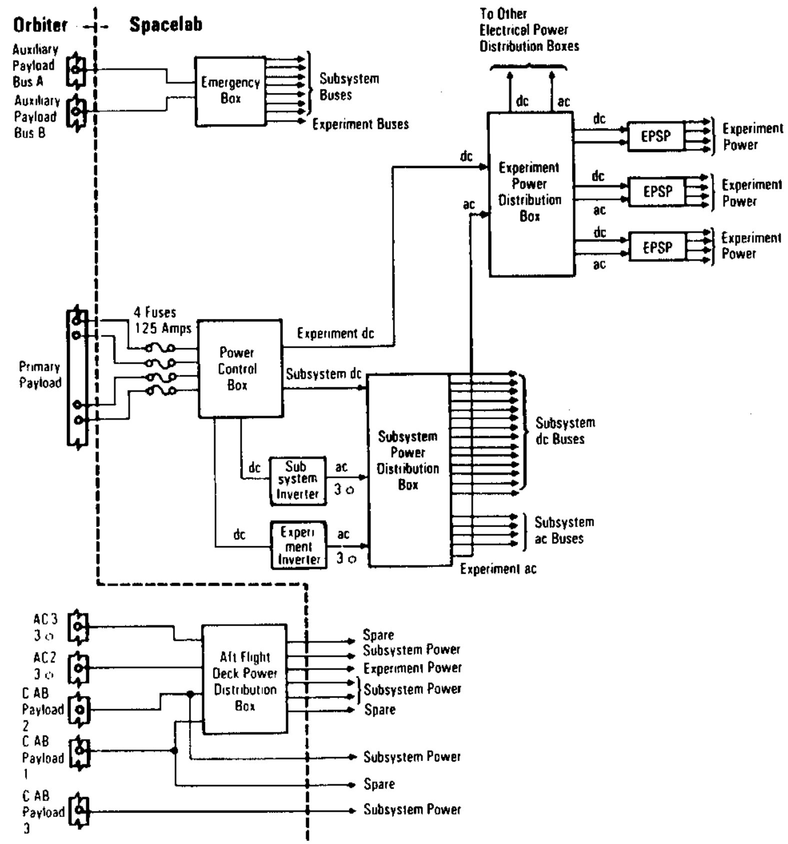
The pallets are designed for large instruments, experiments requiring direct exposure to space, or systems needing unobstructed or broad fields of view, such as telescopes, antennas, and sensors (e.g., radiometers and radars). The U-shaped pallets are covered with aluminum honeycomb panels. A series of hard points attached to the main pallet structure is provided for mounting heavy payload equipment. Up to five segments can be flown on a single mission. Each pallet train is held in place in the payload bay by a set of five attach fittings, four longeron sill fittings, and one keel fitting. Pallet-to-pallet joints are used to connect the pallets to form a single rigid structure called a pallet train. Twelve joints are used to connect two pallets.

The pallets are uniform. Each is a U-shaped aluminum frame and panel platform 13.1 feet wide and 10 feet long.

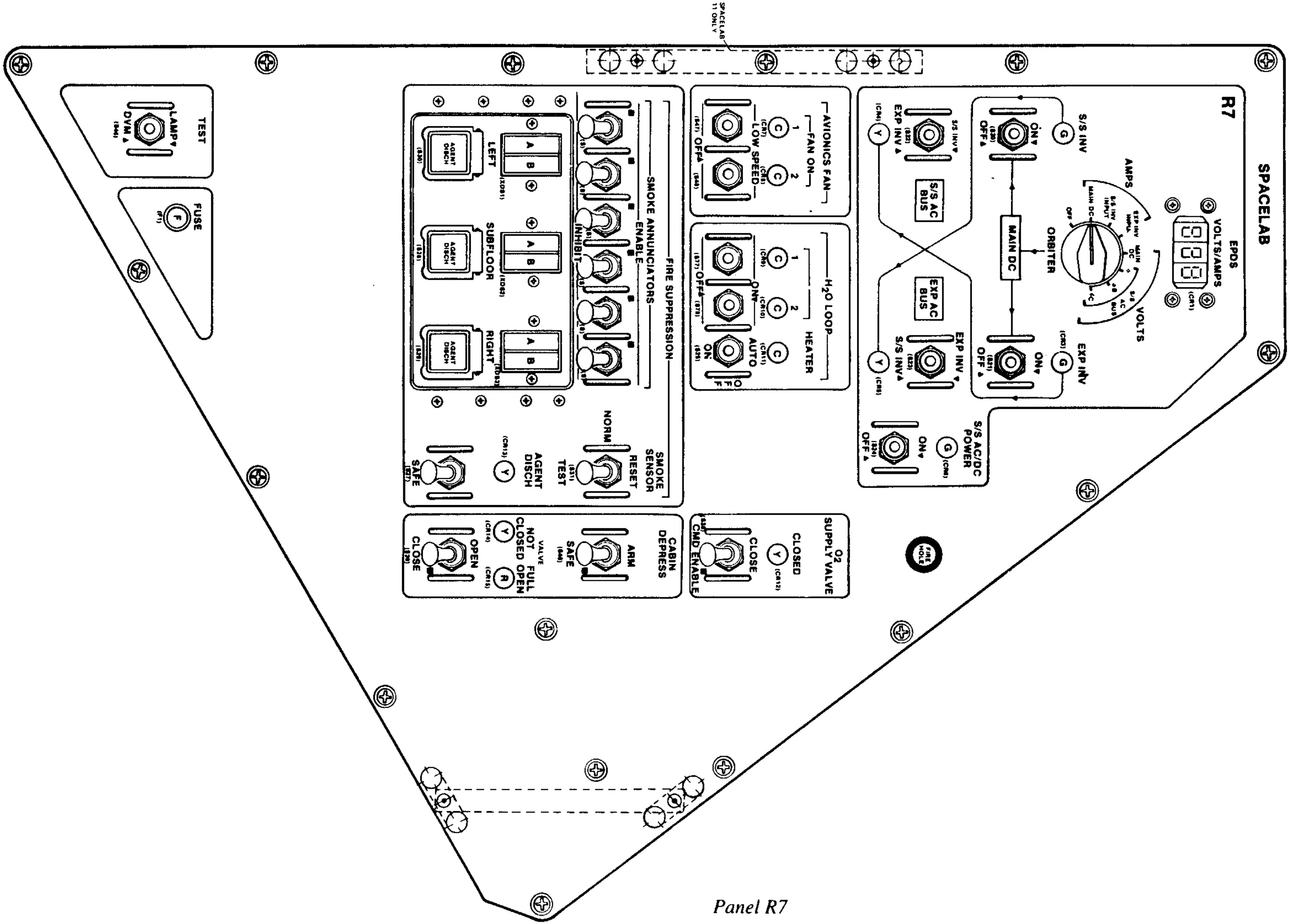
Cable ducts and cable support trays can be bolted to the forward and aft frame of each pallet to support and route electrical cables to and from the experiments and subsystem equipment mounted on the pallet. All ducts mounted on the right side of the pallet are used to route subsystem cables, and all ducts on the left side carry experiment utility cables. The ducts and cable trays are made of aluminum alloy sheet metal. In addition to basic utilities, some special accommodations are available for pallet-mounted experiments.

The igloo is attached vertically to the forward end frame of the first pallet. Its outer dimensions are approximately 7.9 feet in height and 3.6 feet in diameter. The igloo is a closed cylindrical shell made of aluminum alloy. A removable cover allows full access to the interior. The igloo houses subsystems and equipment in a pressurized, dry-air environment at sea-level atmospheric pressure (14.7 psia). Two feedthrough plates accommodate utility lines and a pressure relief valve. The igloo is covered with multilayer insulation.

ELECTRICAL POWER. The Spacelab electrical power distribution subsystem controls and distributes main, essential, and emergency dc and ac power to Spacelab subsystems and experiment equipment. Orbiter fuel cell power plants 2 and 3 provide dc power to orbiter main buses B and C, respectively. In addition, through the orbiter main bus tie system (managed and controlled from orbiter display and control panels R1 and F9), dc power is distributed from orbiter main bus C to the orbiter primary payload 1 bus and the Spacelab power control box through four (redundant) main dc power feeders. The orbiter electrical power distribution system is capable of distributing 7 kilowatts maximum continuous (12 kilowatts peak) power to Spacelab subsystems and experiments during on-orbit phases. This is equivalent to supplying 14 average homes with electrical power. If a single fuel cell fails on orbit, the system remains operational with a maximum power level of 5 kilowatts continuous and 8 kilowatts peak.

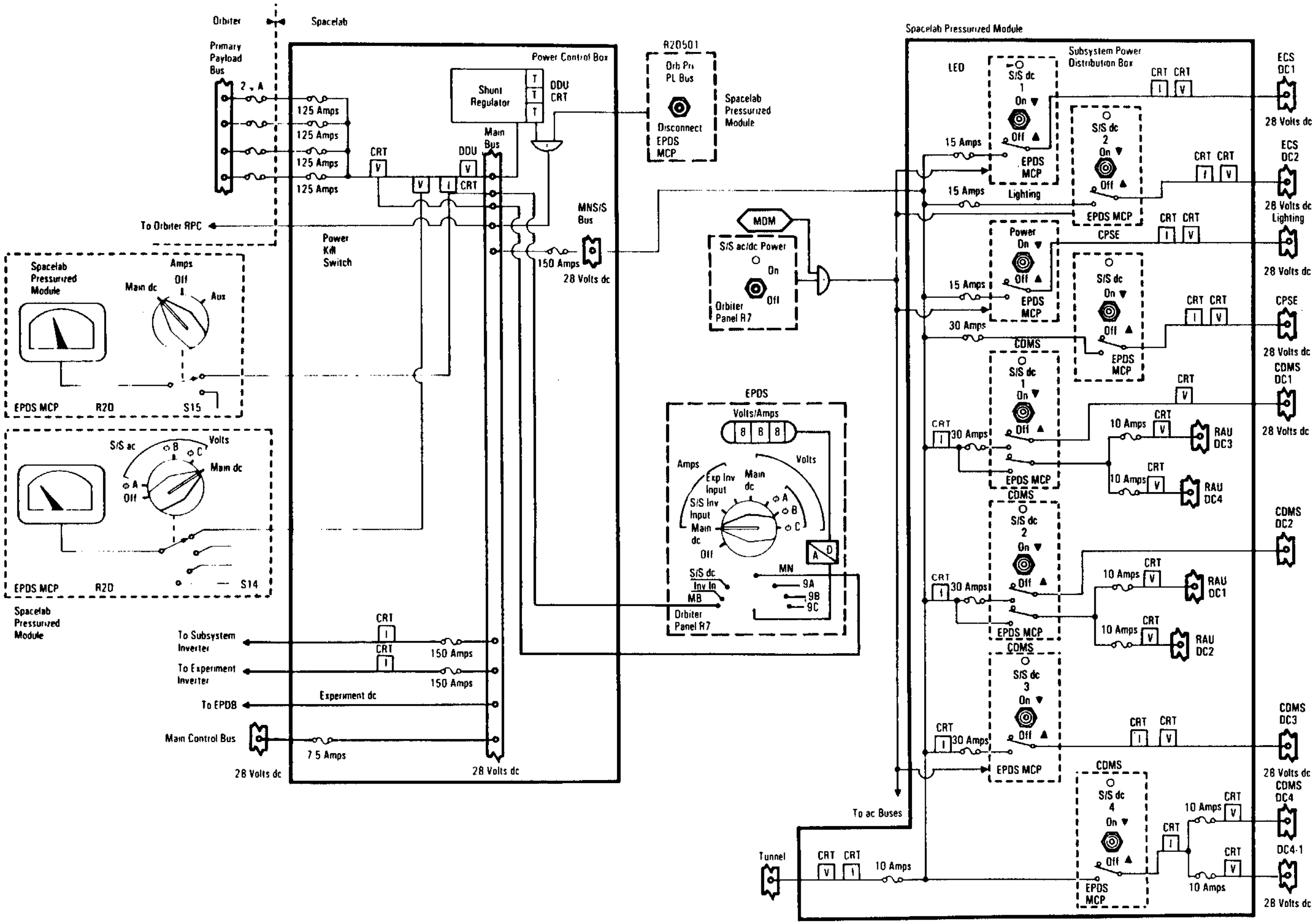


Orbiter Spacelab Electrical Power Distribution



R7
SPACELAB
EPDS
VOLTS/AMPS
S/S INV
ON
OFF
EXP INV
S/S AC BUS
EXP AC BUS
MAIN DC
ORBITER
AMPS
VOLTS
S/S AC/DC POWER
AVIONICS FAN
FAN ON
LOW SPEED
H2O LOOP
HEATER
AUTO
FIRE SUPPRESSION
SMOKE ANNUNCIATORS
ENABLE
INHIBIT
LEFT
SUBFLOOR
RIGHT
AGENT DISCH
SMOKE SENSOR
RESET
NORM
TEST
SAFE
CABIN DEPRESS
ARM
VALVE
NOT CLOSED
FULL OPEN
OPEN
CLOSE
O2 SUPPLY VALVE
CLOSED
CMD ENABLE
TEST
LAMP
DVM
FUSE
FIRE HOLE
SPACELAB 11 ONLY

Panel R7



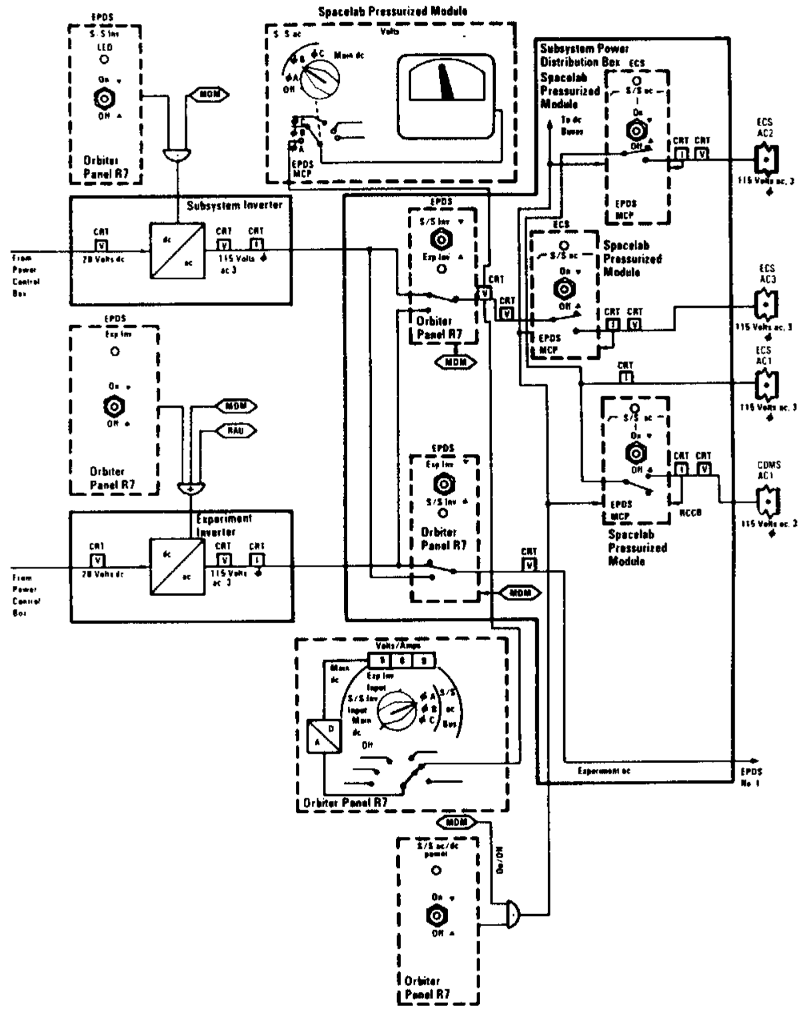
Orbiter-to-Spacelab Electrical Power Distribution—Subsystem dc Power Distribution

The primary dc power received in the Spacelab from the orbiter primary payload bus is nominally 28 volts, a maximum of 32 volts, and a worst-case minimum of 23 volts. The four redundant power feeders from the orbiter supply the Spacelab power control box with power through 125-amp fuses. Spacelab main bus voltage and current readings are available on orbiter CRT Spacelab displays. For the igloo/pallet configuration, the main bus dc voltage and amperage are also available to the flight crew from the EPDS *volts/amps* digital meter and rotary switch on panel R7 at the orbiter crew compartment aft flight deck mission specialist station. The Spacelab power control box is installed in the subfloor of the Spacelab pressurized core segment and in the igloo of the pallet-only configuration.

In the Spacelab pressurized module configuration, the main dc voltage and amperage are available in the pressurized module on the control center rack EPDS monitoring and control panel. The voltage reading is obtained by setting the *volts* rotary switch on the EPDS MCP to the *main dc* position, and the amperage reading is obtained by setting the amps rotary switch to the *main dc* position. The meters on the EPDS MCP panel have only colored zones to indicate nominal (green) or off-nominal (red) readings. The amp readout for main dc power has an additional color field (yellow) to indicate a peak power loading condition.

In the pressurized module configuration, the EPDS MCP provides a manually operated *orb PRI PL bus* disconnect switch, which acts as a kill-power switch for the main dc power to the module. When this switch is positioned momentarily to the *disconnect* position, all Spacelab subsystem functions supplied by normal dc and ac power cease to operate, and the Spacelab water pump, Freon pump, and avionics delta pressure caution channels are activated.

The Spacelab subsystem power distribution box distributes the subsystem dc bus and ac bus power into subsystem-dedicated feeders. In the pressurized module configuration, all outputs except the tunnel and environmental control subsystem ac and experiment ac outputs are remotely switched by latching relays. Power protection circuits and command activation are controlled by the remote amplification and advisory box. In the subsystem power distribution box, the dc power line feeds several subsystem power buses controlled by switches on the electrical power



Spacelab Electric Power Distribution—
Subsystem ac Power Distribution

distribution subsystem monitoring and control panel. In the pallet-only configuration, all outputs are remotely switched by latching relays.

Various Spacelab systems' operations are controlled on orbit from panel R7 in the orbiter crew compartment aft flight station. In either the pallet-only or pressurized module configuration, Spacelab power protection circuits and command activation are controlled from the remote amplification and advisory box. The subsystem power distribution box is controlled by the *S/S ac/dc power on/off* switch on the orbiter aft flight deck panel R7 or by an item command on several orbiter CRT Spacelab displays. The status of this switch on panel R7 is displayed on the orbiter CRT and indicated by a green LED above the manual switch on panel R7. The voltages and currents of the various Spacelab subsystem buses are also available to the flight crew on the orbiter CRT Spacelab subsystem power display.

The dc power in the Spacelab power control box is directed through two parallel 150-amp fuses, one to the Spacelab subsystem dc/ac inverter and the other to a Spacelab experiment dc/ac inverter. Normally, only the subsystem inverter is used to power both subsystem and experiment ac requirements, and the experiment inverter is used as a backup. Each inverter generates three-phase ac power at 117/203 volts, 400 hertz. It is possible to connect the ac experiment bus to the subsystem inverter and, conversely, the subsystem ac bus to the experiment inverter.

In the Spacelab pressurized module configuration, the inverters are mounted on cold plates in the control center rack of the core segment. In the pallet-only configuration, the inverters are mounted on cold plates on the first (forward) pallet in the orbiter payload bay.

The Spacelab subsystem inverter is activated by the *S/S inv on/off* switch on panel R7 or by orbiter Spacelab CRT command. Positioning the switch to *on* activates the subsystem inverter, and a green LED above the switch on panel R7 is illuminated, indicating the inverter is operating. Positioning the momentary left *S/S inv, exp inv* switch to *S/S inv* permits the subsystem inverter to supply ac power to the Spacelab subsystem ac bus. Similarly, positioning the momentary right *S/S inv, exp inv* switch to *S/S inv* supplies ac power to the experiment ac bus, and the yellow light below the switch is illuminated to indicate the subsystem inverter is supplying the experiment ac bus.

The Spacelab experiment inverter is activated by the *exp inv on/off* switch on panel R7 or by orbiter Spacelab CRT command. Positioning the switch to *on* activates the experiment inverter, and a green LED light above the switch is illuminated, indicating the inverter is in operation. Positioning the momentary right *exp inv, S/S inv* switch to *exp inv* supplies ac power to the experiment ac bus. Positioning the momentary left *S/S inv, exp inv* switch to *exp inv* supplies ac power to the subsystem ac bus, and the yellow light below the switch is illuminated to indicate the experiment inverter is supplying the subsystem ac bus.

The switching of Spacelab inverters between the two ac power buses may also be commanded and monitored through the orbiter CRT Spacelab subsystem ac power supply. Readings presented on the orbiter CRT display include inverter on/off status, inverter output voltage, inverter input voltage, and inverter output current. The subsystem inverter input, experiment inverter input, and main dc amps are available via the digital readout and rotary switch on panel R7. The main dc and subsystem ac bus phase A, B, and C volts also are available via the digital readout and rotary switch on panel R7. In the Spacelab pressurized module configuration, the Spacelab EPDS monitoring and control panel provides a color readout of each subsystem ac phase.

The Spacelab inverters are protected against overvoltage and overcurrent. They are shut down automatically if the voltage exceeds 136 volts root mean square per phase. Current levels are limited to 12 amps rms per phase, and all three phases are shut down if one phase draws a current of 10 amps rms for 120 seconds.

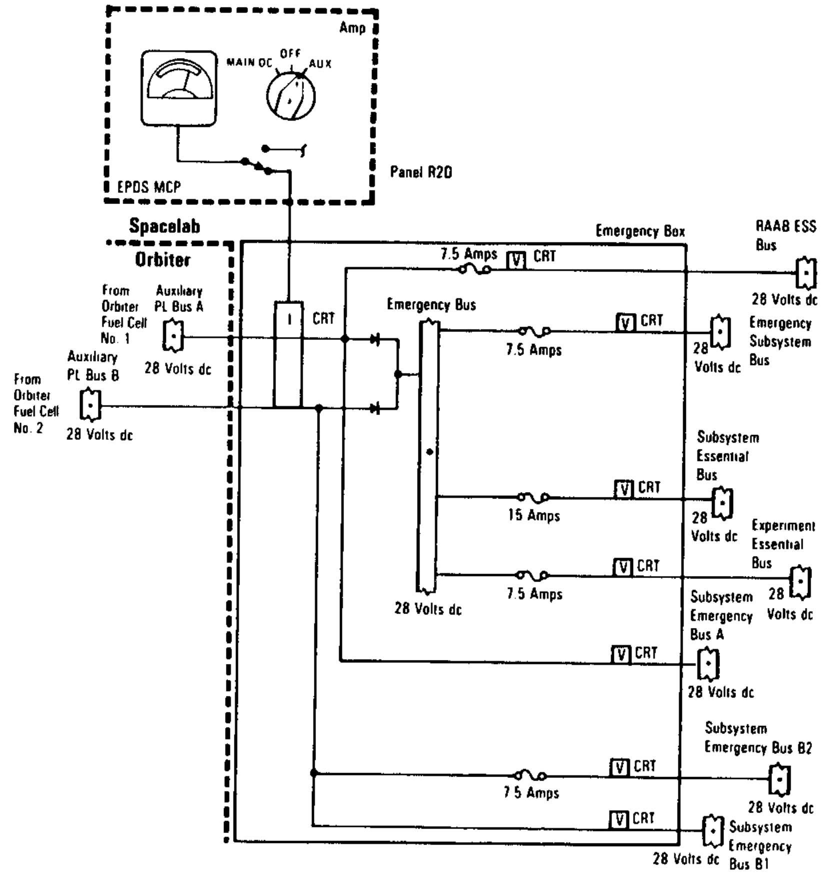
In the pressurized module configuration, the subsystem power distribution box ac bus feeds several Spacelab subsystem power buses controlled by switches on the Spacelab EPDS MCP. All functions on this panel can be initiated simultaneously by the *S/S ac/dc power on/off* switch on orbiter panel R7 or by item commands from the orbiter CRT Spacelab displays. The status of the commanded relays is available via orbiter CRT Spacelab displays and indicated by the green LED light above the respective switch on panel R7.

In the pallet-only configuration, subsystem ac bus power feeds several Spacelab subsystems' power buses, which can be initiated by the *S/S ac/dc power on/off* switch on orbiter panel R7 or by item commands from the orbiter CRT Spacelab displays. The status of the commanded relays is available via orbiter CRT Spacelab displays and the green LED light above the respective switches on panel R7.

Emergency and essential dc power for the pressurized module configuration is provided by the orbiter auxiliary payload buses A and B to the Spacelab emergency box. The Spacelab emergency box supplies emergency and essential power for Spacelab critical environmental control subsystem sensors and valves, fire and smoke suppression equipment, ECS water line heaters, module emergency lighting, tunnel emergency lighting, the Spacelab intercom system, and the Spacelab caution and warning panel. The outputs are protected by fuses. One separately fused outlet, an experiment essential bus, is dedicated to experiments. This power is available during all flight phases and when degraded power is delivered to Spacelab. The Spacelab emergency box is located in the subfloor of the core segment.

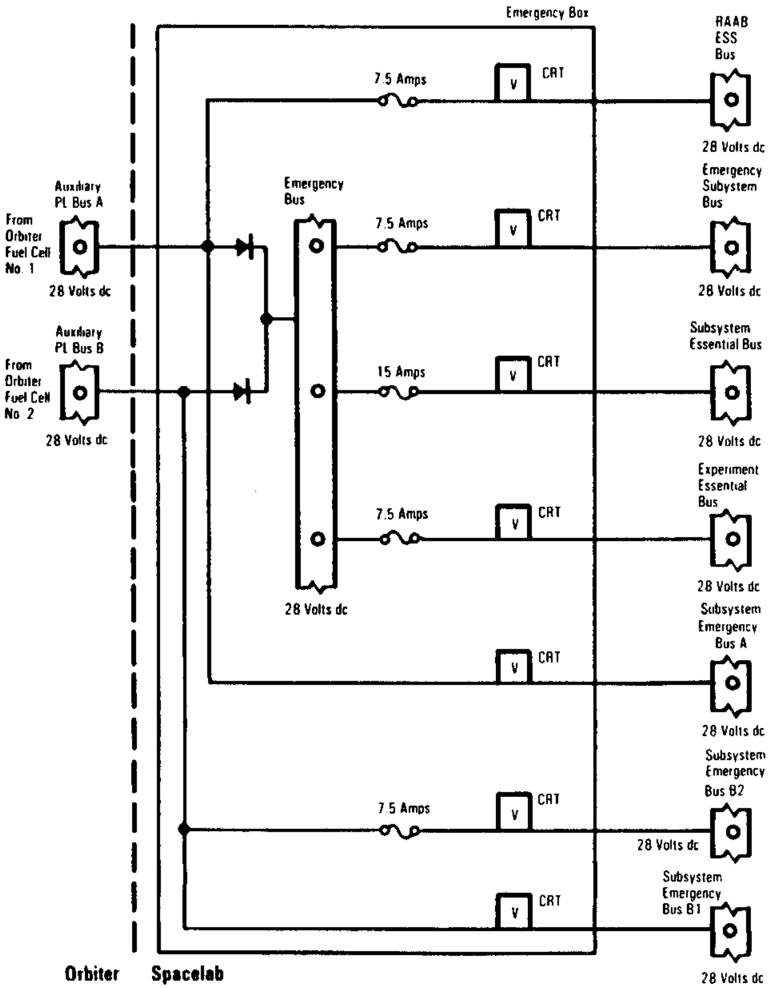
Emergency and essential dc power for the pallet-only configuration is also provided by orbiter auxiliary payload buses A and B, which send dc power to the Spacelab emergency box located in the igloo. The Spacelab emergency box provides emergency or essential power to Spacelab subsystem equipment. The outputs are protected by fuses. One separately fused outlet, an experiment essential bus, is dedicated to experiments. The Spacelab emergency box is in the igloo. This power is available during all flight phases and when degraded power is delivered to Spacelab.

In the Spacelab pressurized module configuration, experiment power distribution boxes provide distribution, control, and monitoring facilities for the experiment electrical power distribution system, which consists of a nominal redundant 28-volt

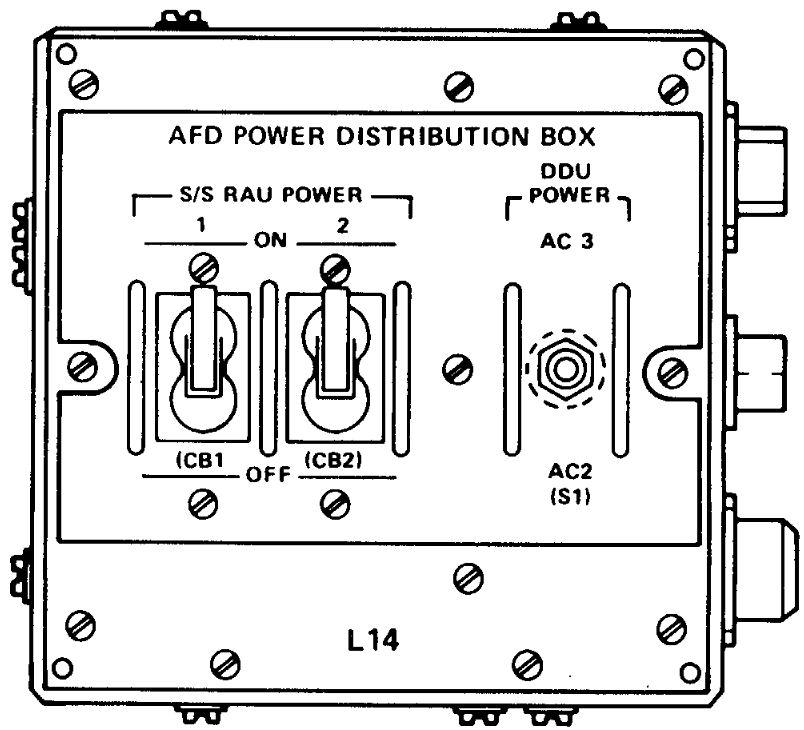


Spacelab Pressurized Module Emergency and Essential Power Distribution experiment main dc supply and a 115-volt, 400-hertz ac experiment supply. One distribution box (EPDB 1) is located under the core segment floor on a support structure; for the long module configuration, two additional units (EPDBs 2 and 3) are installed. In the pallet-only configuration, the experiment power distribution box is mounted with other assemblies with an adapter plate on a cold plate that is fitted on a support structure and attached to the pallet.

The orbiter pressurized module CRT Spacelab displays present emergency and essential bus current, voltages for auxiliary buses A and B, output voltages for Spacelab subsystem emergency buses, output voltage for the Spacelab subsystem essential bus, and output voltage for the Spacelab remote amplification and advisory box essential bus. The orbiter CRT Spacelab displays for activation/deactivation, subsystem dc power, and system summary indicate an undervoltage condition for auxiliary buses A and B. Nominal auxiliary bus amperage from the orbiter can be



Spacelab Pallet Emergency and Essential Power Distribution



Panel L14

monitored on the *amps* meter (color zone only) of the Spacelab EPDS monitoring and control panel.

In the pallet-only configuration, the orbiter CRT Spacelab displays include emergency and essential bus current, voltages for auxiliary buses A and B, output voltages for Spacelab subsystem emergency buses, output voltage for the Spacelab subsystem essential bus, and output voltage for the Spacelab remote amplification and advisory box essential bus. The orbiter CRT Spacelab activate/deactivate, Spacelab subsystem dc power, and Spacelab system summary displays will indicate an undervoltage condition for auxiliary buses A and B.

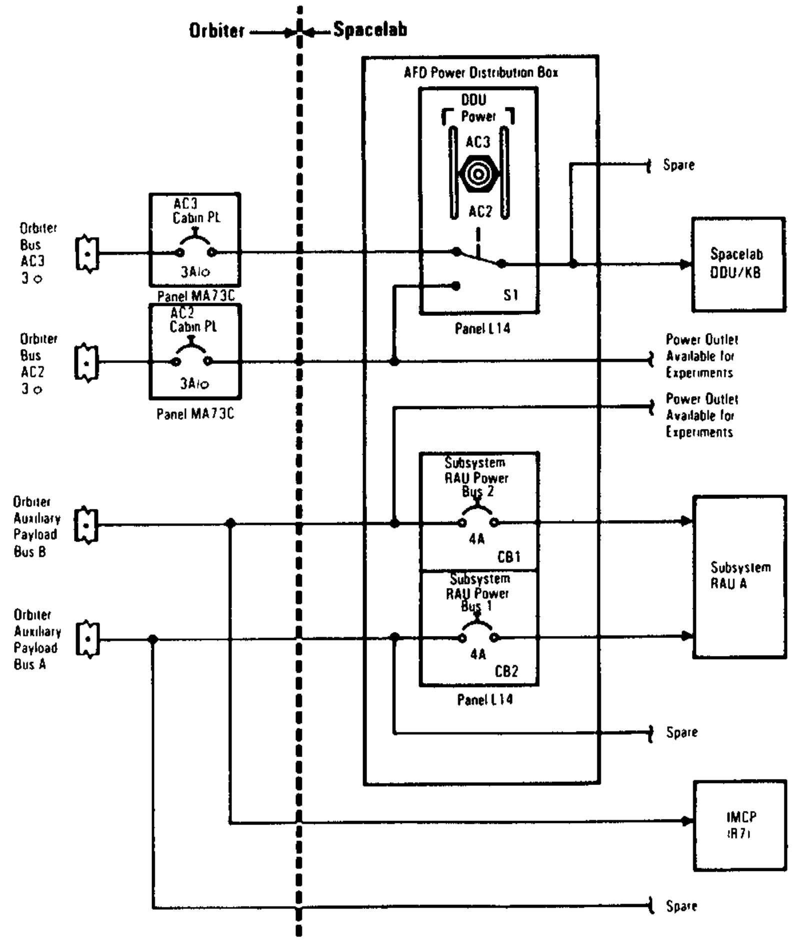
The Spacelab power distribution box at the orbiter aft flight deck payload station distributes dc and ac power to the Spacelab subsystem remote acquisition unit and the Spacelab data display system (a data display unit and keyboard). When a Spacelab data display system is installed at the mission station, ac power is provided from orbiter ac bus 2 or 3 via the orbiter mission station distribution panel.

Spacelab subsystem remote acquisition unit dc power comes from orbiter fuel cell 1 main bus A through auxiliary payload bus A and from orbiter fuel cell 2 main bus B to auxiliary payload bus B through the payload station distribution panel. This power is not affected by the kill switch of the primary payload bus. The aft flight deck power distribution panel L14 *S/S RAU power 1 on/off* and *S/S RAU power 2 on/off* circuit breakers are used to feed power to the RAU from either bus.

Control of the ac power supplied to the Spacelab DDU and keyboard from orbiter ac buses 2 and 3 is made possible by positioning the panel L14 *DDU power* switch to *AC2* or *AC3*. This 115-volt ac, three-phase, 400-hertz power is available only during on-orbit flight phases. Panel L14 provides no fuse protection.

In the pallet-only configuration, ac power is supplied to the Spacelab pallet or pallets from orbiter ac buses 2 and 3 by positioning the panel L14 *DDU power* switch to *AC2* or *AC3*. This power (115 volts ac, three phase, 400 hertz) is available only during on-orbit flight phases.

In the Spacelab module, the experiment power switching panel provides facilities for branching and switching dc and ac power



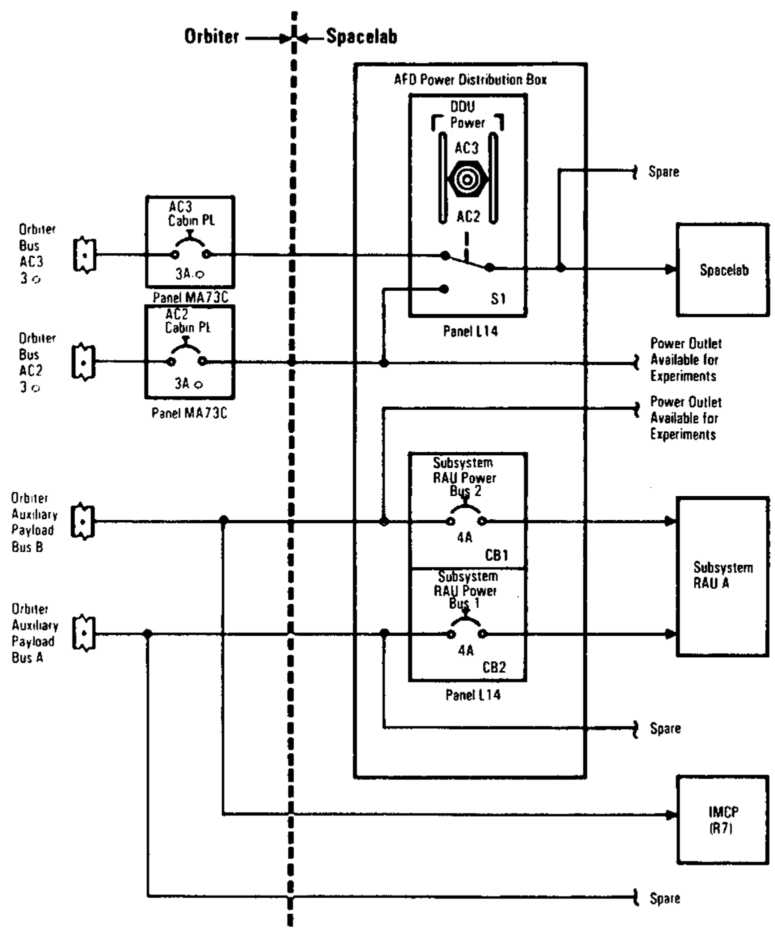
Pressurized Module Configuration—Orbiter Aft Flight Deck Power Distribution delivered by a dedicated experiment power control box. The dc and ac output is distributed to experiments and experiment-supporting RAUs (dc only). The number of switching panels and their locations depend on the mission configuration.

The orbiter crew compartment aft flight deck panel configurations vary for Spacelab pressurized module configurations and pallet-only configurations. A Spacelab pressurized module configuration may consist of a payload specialist station data display unit at panel L11, a standard switch panel at panel L12, a keyboard at panel L11, a systems management tone generator and interconnect station at panel L14, a mission specialist station with a data display system and interconnect station at panel R14, and a floor-mounted remote acquisition unit at the payload station.

A pallet-only configuration may consist of a payload specialist station data display system at panel L11, a Spacelab-unique switch panel at panel L12, a video tape recorder at panel R11, a high-data-rate recorder at panel L10, a systems management tone generator and interconnect station at panel L14, a Spacelab power distribution box at panel L14, and a floor-mounted Spacelab RAU at the payload station.

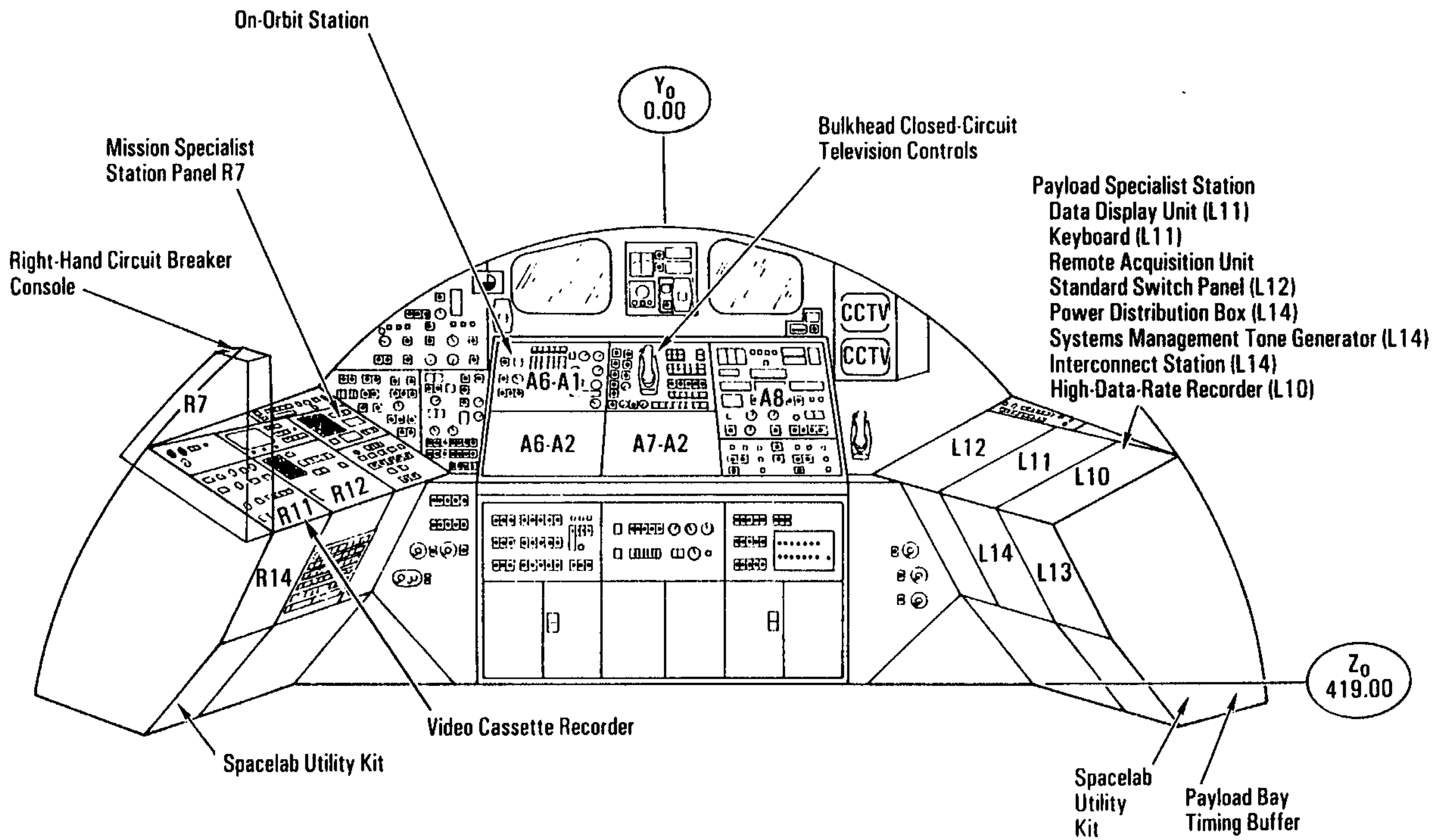
COMMAND AND DATA MANAGEMENT SYSTEM. The Spacelab command and data management system provides a variety of services to Spacelab experiments and subsystems. Most of the CDMS commands are carried out through the use of the computerized system aboard Spacelab, called the data processing assembly. The DPA formats telemetry data and transfers the information to the orbiter for transmission, receives command data from the orbiter and distributes them to Spacelab subsystems, transfers data from the orbiter to experiments, and distributes timing signals from the orbiter to experiments.

The CDMS includes three identical computers and assorted peripherals. One computer is dedicated to Spacelab experiments, one supports Spacelab subsystems, and the third is a backup. The flight crew monitors and operates Spacelab subsystems and

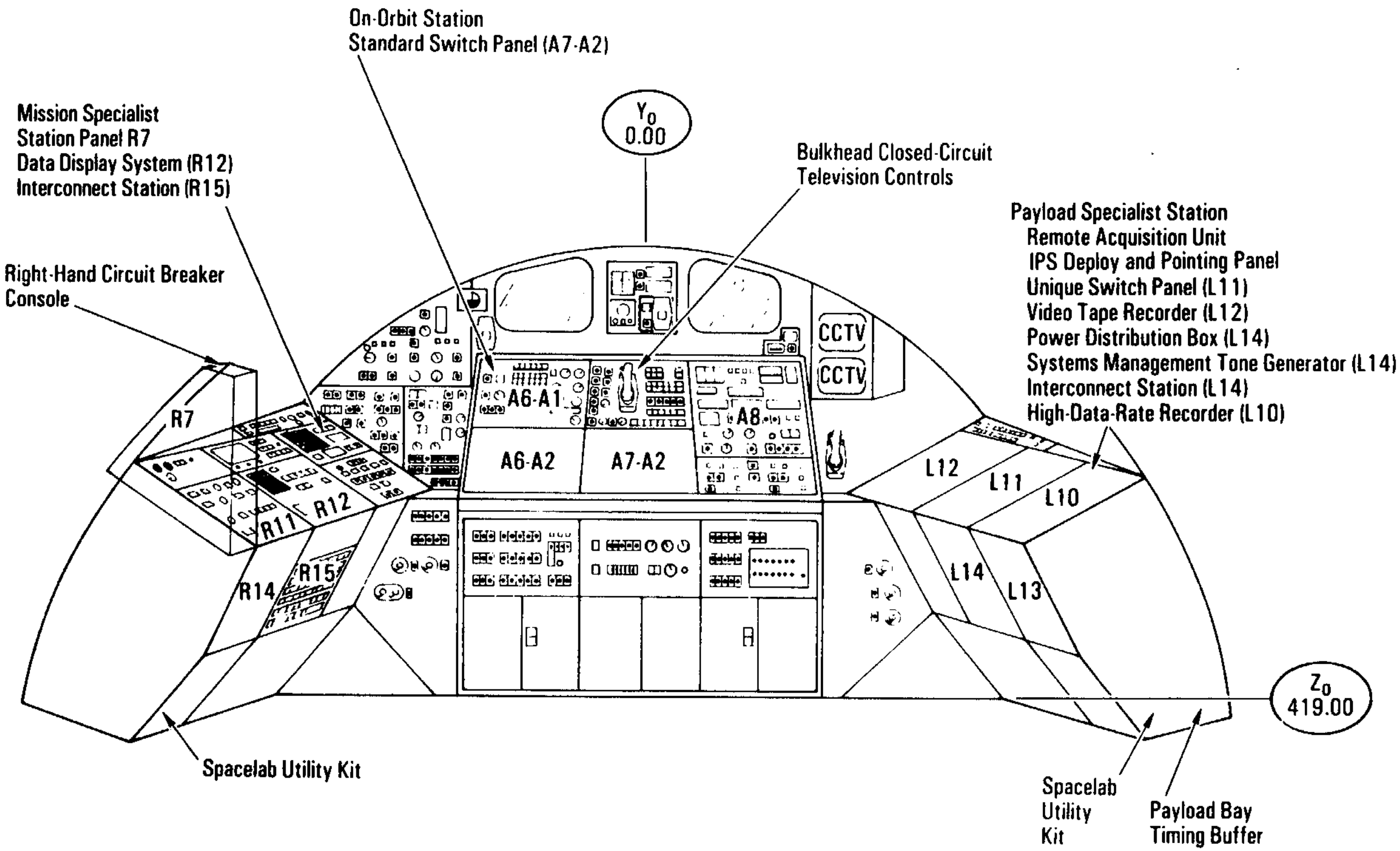


Pallet-Only Configuration—Orbiter Aft Flight Deck Power Distribution

payload experiments through data display and keyboard units. The previously used three identical MATRA 125/MS computers have been changed to the upgraded AP-101SL orbiter computers. The experiment computer activates, controls, and monitors payload operations and provides experiment data acquisition and handling. The subsystem computer provides control and data management



Example of a Spacelab Pressurized Module Aft Flight Deck Panel Configuration



Example of a Spacelab Pallet-Only Aft Flight Deck Panel Configuration for basic Spacelab services that are available to support experiments, such as electrical power distribution, equipment cooling, and scientific airlock operations (in the case of the pressurized module). The backup computer can function in the place of either computer.

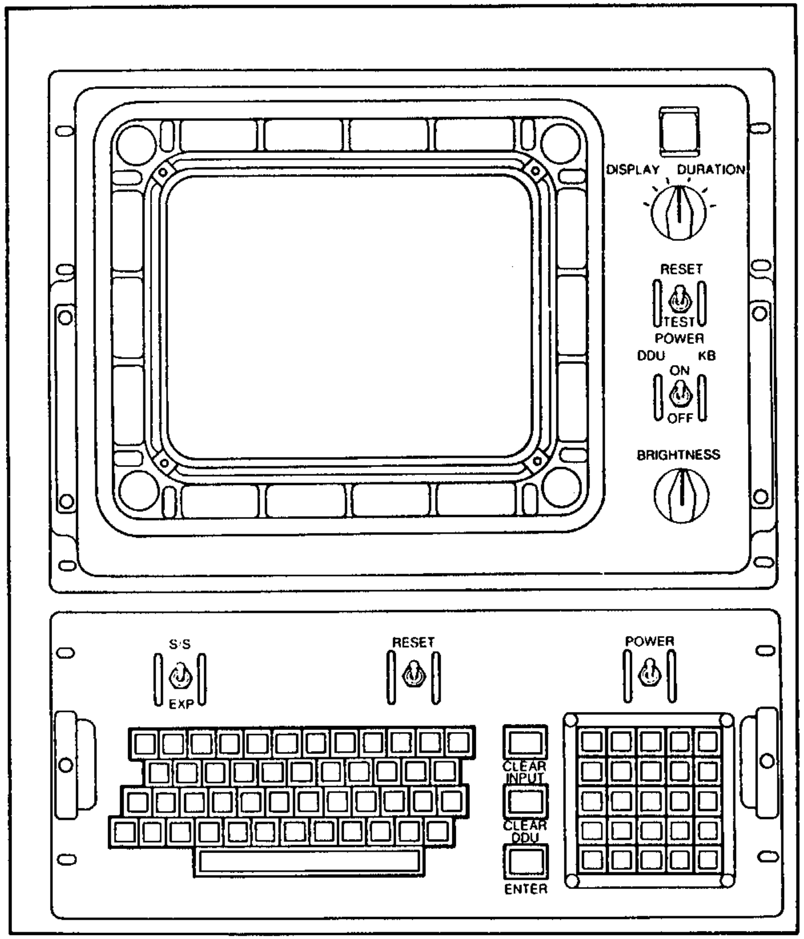
An input/output unit buffers all communications between the computer and the rest of the subsystem. The experiment computer also has at least one RAU (and as many as eight, depending on the payload) for interfacing between experiments and the subsystem. The subsystem computer may have as many as nine acquisition units, depending on the Spacelab configuration.

The experiment and subsystem computers and their associated input/output units, as well as the shared mass memory unit and backup computer, are located in the workbench rack of the pressurized module core segment. In the pallet-only configuration, they are located in the igloo.

Mass Memory Unit. The MMU is a tape recorder that contains all of the operating system and applications software for the subsystem and experiment computers. The memory unit provides the initial program load for the Spacelab subsystem, experiment, and backup computers; it can also be used to completely reload computer memory if required. The MMU stores various files, time lines, and displays. Writing onto the unit during flight is possible. Approximately half of the unit's storage capability is available for software and data supporting Spacelab experiments.

Data Display Systems. The data display systems are the primary on-board interface between the CDMS and the Spacelab flight crew. Each display system consists of a keyboard and a CRT data display unit. One display is located at the orbiter aft flight deck station, one at the control center rack in the pressurized module and, possibly, one at the experiment rack in the pressurized module. In the pallet-only configuration, two CRTs and DDUs can be located at the crew compartment aft flight deck station.

The keyboard consists of 25 function keys and 43 alphabet, numeral, punctuation, and symbol keys of the familiar standard typewriter keyboard as well as the standard typewriter action keys, such as space and backspace. The data display unit is a 12-inch diagonal CRT screen providing a 22-line display (47 characters per line) in three colors (green, yellow, and red). In addition to 128 alphanumeric symbols, the unit can also display



Data Display Unit and Keyboard

vector graphics (1,024 different lengths and 4,096 angles). A high-intensity green flashing mode is also provided.

The display units are connected to the experiment and subsystem input/output units. Each data display unit can present information from both computers simultaneously, and each keyboard can communicate with either computer. Flight crew members can call various displays onto the screen from the keyboard for experiment evaluation and control.

Command and data management system software consists of experiment computer software and subsystem computer software, each of which includes operating systems and applications. Within the experiment computer both the operating system and the application software are wholly dedicated to the direct support of Spacelab payload experiments. The operating system provides such general services as activation, control, monitoring, and deactivation of experiments as well as experiment data acquisition, display, and formatting for transmission. Application software is developed for experiments that have data handling requirements beyond the capabilities of the operating system.

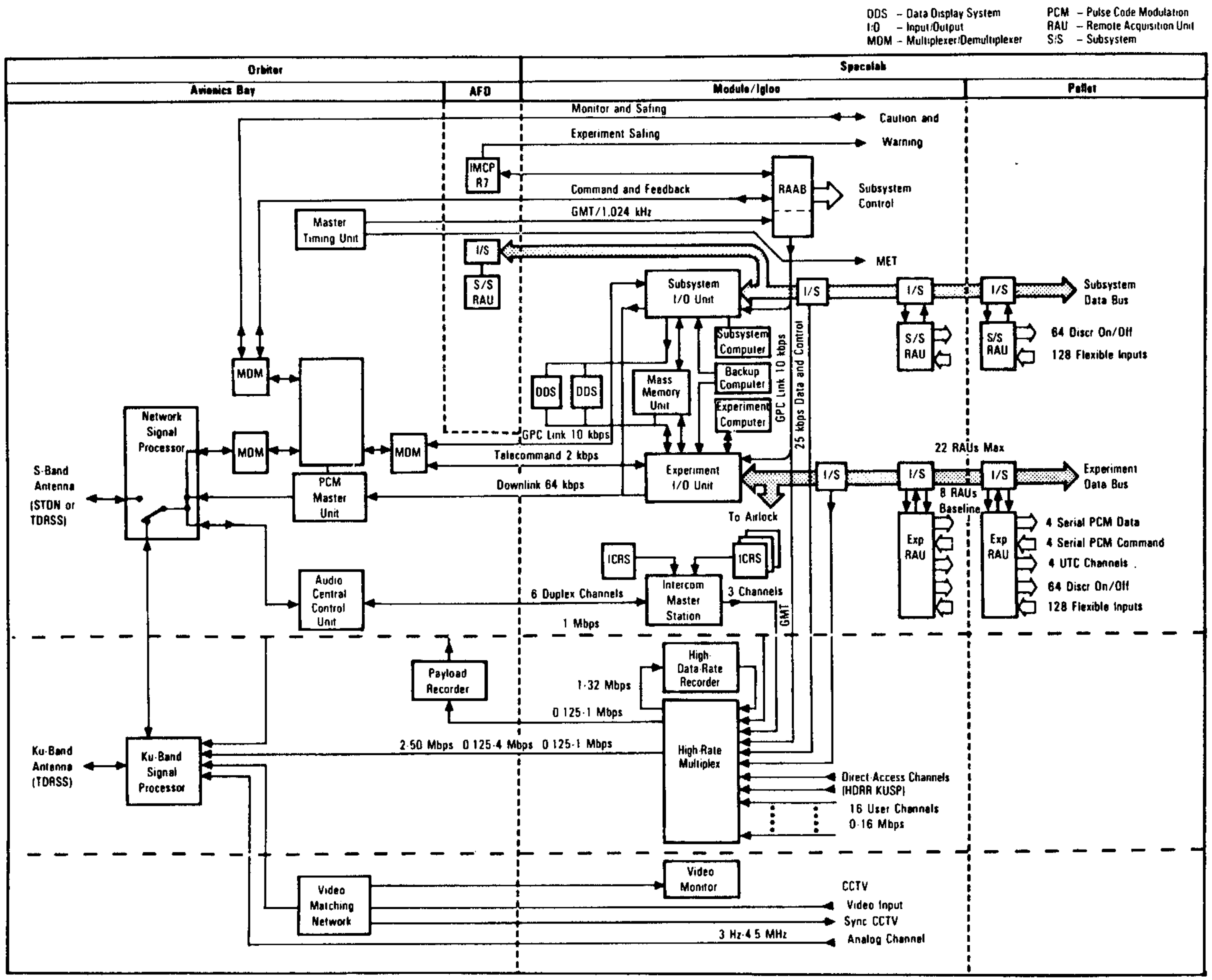
The subsystem computer functions mainly to monitor and control other Spacelab subsystems and equipment, such as the electrical power distribution subsystem and the environmental control subsystem. These functions are performed by the subsystem computer operating software.

Two orbiter payload multiplexers/demultiplexers (PF1 and PF2) are used for data communications between the orbiter general-purpose computers and the Spacelab CDMS computers. The payload MDMs are under orbiter GPC control. The orbiter pulse code modulation master units under control of the orbiter computers can access Spacelab data for performance monitoring and limit sensing. The PCMMUs contain a fetch command sequence and a random-access memory for storing fetched data. Data from the PCMMU RAM are combined with orbiter pulse code modulation data and sent to the orbiter network signal processors for transmission on the return link (previously referred to as downlink) through S-band or Ku-band. The 192-kbps data stream normally carries 64 kbps of Spacelab experiment and subsystem data.

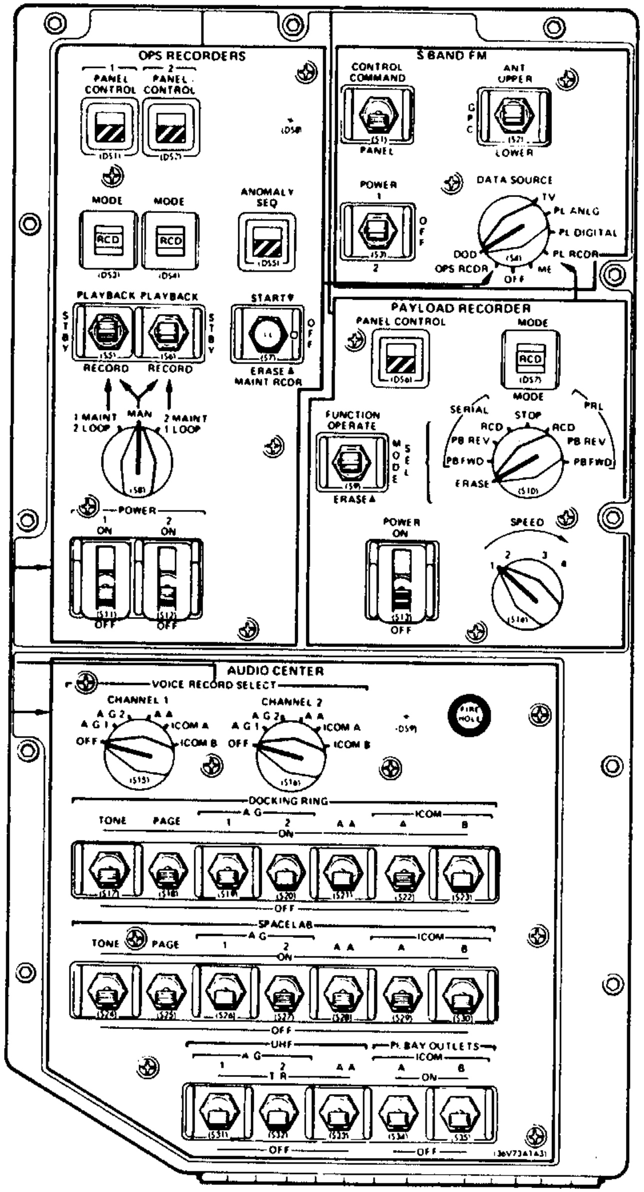
The Spacelab experiment computer interfaces with two telemetry systems. The orbiter PCMMU allows the orbiter to acquire data for on-board monitoring of systems and provides the Mission Control Center in Houston with system performance data for real-time display and recording through the orbiter network signal processor and S-band or Ku-band. The other telemetry system, the Spacelab high-rate multiplexer, is a high-rate link to the Ku-band signal processors that sends scientific data to the Payload Operations Control Center for real-time display and to the Goddard Space Flight Center for recording.

Spacelab high-rate data acquisition is provided by a high-rate multiplexer and a high-data-rate recorder. The HRM multiplexes up to 16 experiment channels, each with a maximum of 16 Mbps, two direct-access channels with data rates up to 50 Mbps, data from the Spacelab subsystem computer, experiment data from the Spacelab experiment computer, and up to three analog voice channels from the Spacelab intercom master station in the pressurized module configuration. The three digitized channels are premultiplexed onto a single 128-kbps channel for interleaving in the format along with Greenwich Mean Time signals from the orbiter master timing unit. This composite output data stream is routed to the Ku-band signal processor for transmission on Ku-band or is sent to one of the two recorders. The HRM is located on the control center rack in the pressurized module and in the igloo for the pallet-only configuration.

In the pressurized module, the high-data-rate recorder is located at the control center rack next to the data display system; in the pallet-only configuration, it is at the aft flight deck panel L10. It records real-time, multiplexed data or data from two direct-access channels and stores the information at rates from 1 to 32 Mbps during mission periods with no downlink capability or degraded downlink capability for playback when the capability is available. The HDRR dumps in reverse order at 2, 4, 8, 12, 16, 24,



Spacelab Command and Data Management System Interfaces With the Orbiter



Panel AIA3

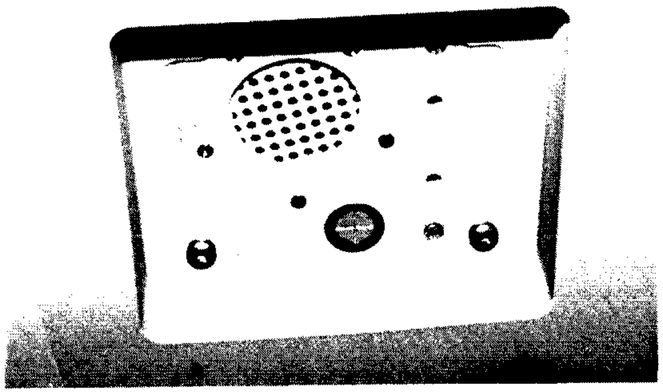
or 32 Mbps. At a rate of 32 Mbps, a tape runs for 20 minutes. The recorder can be changed manually by the flight crew; however, no tape changes are planned because the time required to change tapes is very long and it is much more efficient to dump the tape.

The orbiter payload recorder serves as a backup for the Spacelab HDRR for data rates from 0.125 to 1 Mbps and can record only real-time, multiplexed data. The orbiter payload timing buffer provides mission elapsed time and Greenwich Mean Time; and the master timing unit provides 100-hertz, 1-kHz, 1,024-kHz, and 4,608-kHz timing signals to the Spacelab data processing assembly. Activation of the Spacelab DPA is controlled and monitored from the orbiter CRT Spacelab displays.

Closed-Circuit Television. The Spacelab pressurized module video system interfaces with the orbiter closed-circuit television system and the orbiter Ku-band signal processor. The orbiter CCTV system accepts three video inputs from the Spacelab system. The orbiter monitors the TV received and/or transmits it to telemetry. A sync command signal provided by the orbiter synchronizes and remotely controls cameras within Spacelab. The orbiter also has one video output for a Spacelab TV monitor. The Spacelab accommodates a video switching unit that enables Spacelab video recorder capability. The Spacelab analog channel for experiments is directed to the orbiter Ku-band signal processor at 3 to 4.5 MHz.

In the pallet-only configuration, the orbiter's CCTV can be used along with a video tape recorder. The TV cameras installed in the payload bay vary according to mission requirements. Television data downlinked on Ku-band channel 3 are time-shared by the orbiter's CCTV system, the Spacelab TV/analog output and the Spacelab high-rate multiplexer data.

Pressurized Module Intercom. The Spacelab intercom master station interfaces with the orbiter audio central control unit and the orbiter EVA/ATC transceiver for communications through orbiter duplex (simultaneous talk and listen) audio channels.



Spacelab Pressurized Module Aural Annunciator Located Below Panel L14

Audio channel 1 is air-to-ground 2, channel 2 is intercom B, and channel 3 is air-to-ground 1.

Each orbiter channel, with the exception of page, may be selected on each of the three Spacelab full-duplex channels—A/G 1 for the Payload Operations Control Center, Spacelab and A/G 2 for the orbiter/Mission Control Center—using rotary switches on the Spacelab intercom master station. The page channel is used for general address and calling purposes. Page signals can originate in the orbiter, Spacelab, or both.

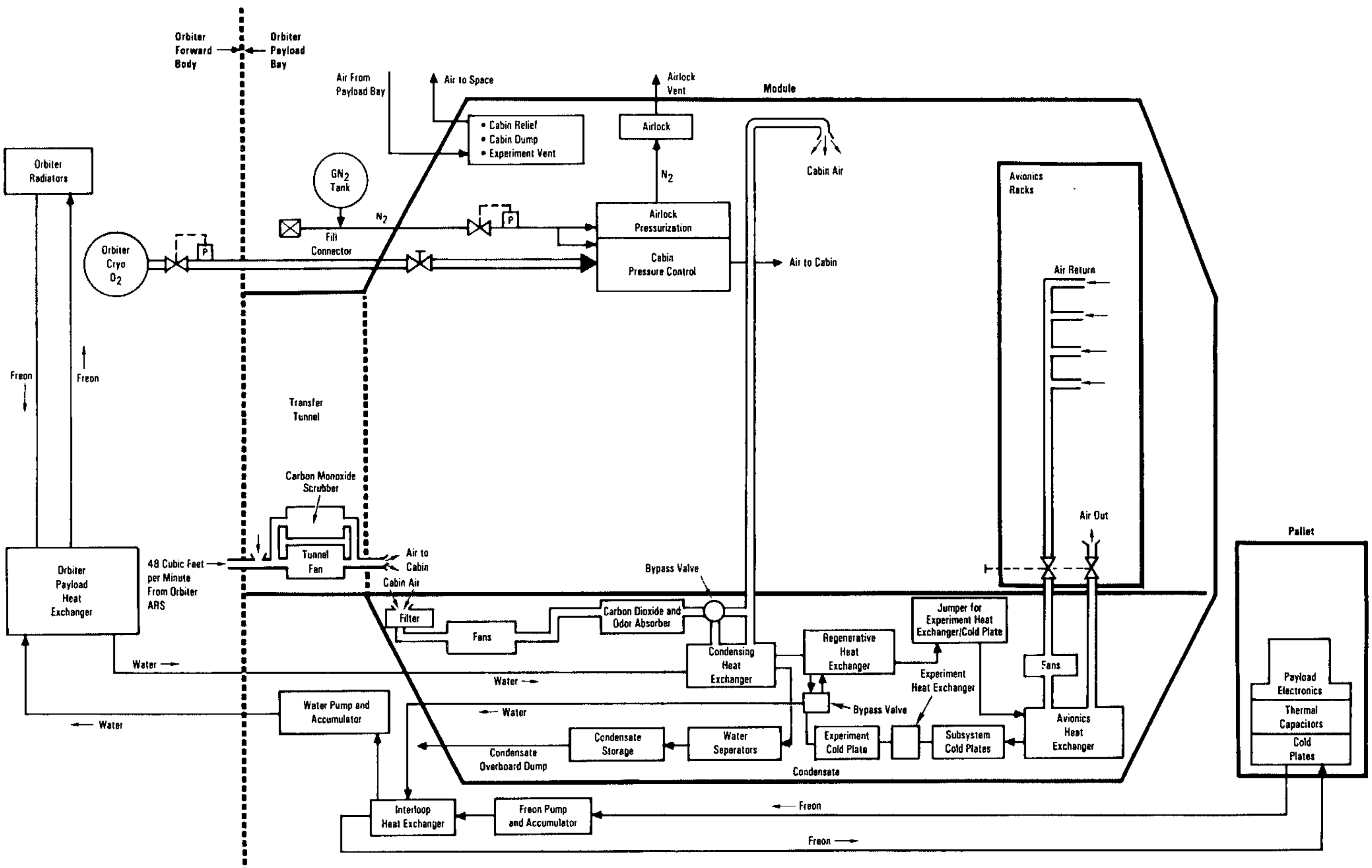
Access to orbiter channels is controlled within the orbiter. Normal voice recordings are made on the orbiter operations recorders. The Spacelab talk and listen lines are combined for distribution to the Spacelab voice digitizer in the Spacelab high-rate multiplexer for all three Spacelab channels.

PRESSURIZED MODULE ENVIRONMENTAL CONTROL SUBSYSTEM AND LIFE SUPPORT. The Spacelab environmental control subsystem consists of the atmosphere storage and control subsystem and the atmosphere revitalization system.

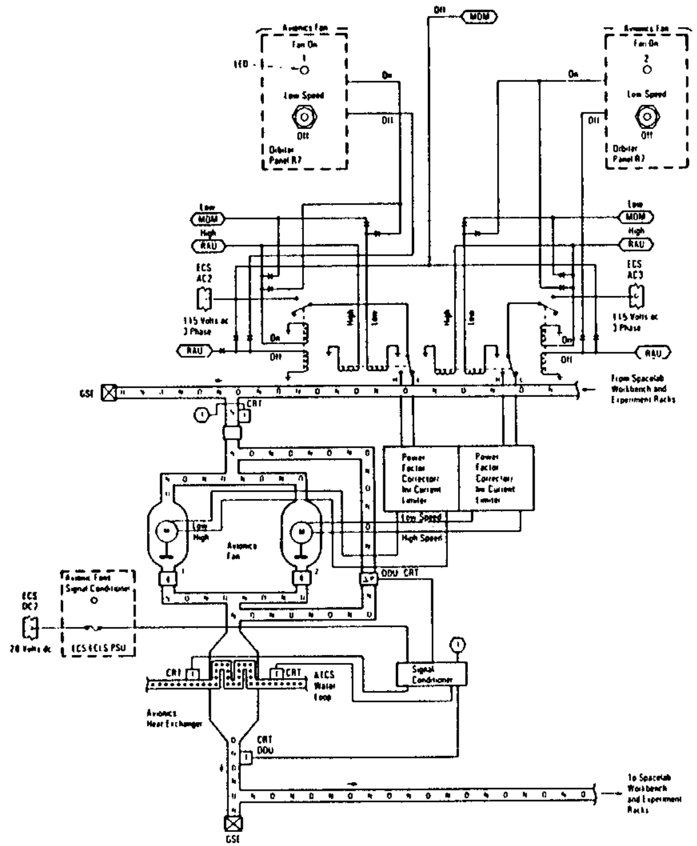
The atmosphere storage and control subsystem receives gaseous oxygen from the orbiter power reactant storage and distribution system and gaseous nitrogen from a tank located on the Spacelab module's exterior. The Spacelab ASCS regulates the gaseous oxygen and nitrogen pressure and flow rates to provide a shirt-sleeve environment for the Spacelab module compatible with the orbiter cabin atmosphere.

Gaseous oxygen from the orbiter PRSD enters the Spacelab module through the upper feedthrough in the Spacelab forward end cone at 100 psi and a maximum flow rate of 14 pounds per hour. A motor-controlled valve in the Spacelab module controls the flow of gaseous oxygen. This valve, operated by Spacelab RAU commands, opens when the *O2 supply valve* switch on panel R7 is in the *cmd enable* position. It closes when the switch is in the *close* position for such situations as contingency cabin atmosphere dump. A yellow LED above the switch on panel R7 is illuminated to indicate that the valve is closed. The oxygen supply valve receives 28 volts from the Spacelab emergency bus.

The Spacelab cabin depressurization assembly is primarily for contingency dump of Spacelab cabin atmosphere in case of fire that cannot be handled by the Spacelab fire suppression system. It consists of a vent with two filters, a manual shutoff valve, and a motor-driven shutoff valve. The motor-driven shutoff valve is powered by the Spacelab environmental control subsystem emergency bus and controlled by the *cabin depress valve open/close* switch, a *cabin depress arm/safe* switch, and valve status LEDs on orbiter panel R7. The *cabin depress arm* switch arms the Spacelab cabin depressurization motor-driven valve; and when the *cabin depress valve* switch is positioned to *open*, the



Spacelab Pressurized Module and Orbiter Environmental Control and Life Support System Interface



Spacelab Avionics Loop

Spacelab cabin depressurization assembly in the Spacelab forward end cone opens, depressurizing the Spacelab module at 0.4 pound per second. The red LED above the switch on panel R7 is illuminated to indicate that the motor-operated depressurization valve is fully open. The yellow LED above the switch on panel R7 is illuminated to indicate that the Spacelab cabin depressurization valve is not closed when the *cabin depress* switch is in *arm* and the *cabin depress valve* switch is in the *closed* position.

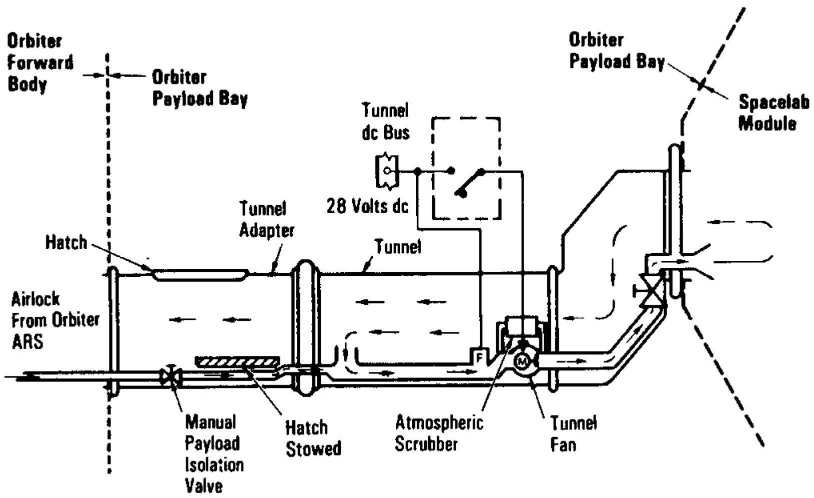
Air in the Spacelab avionics air loop is circulated by one of two dual-redundant fans, with check valves to prevent recirculation through the inactive fan and a filter upstream to protect both fans. For ascent and descent flight phases, as well as low-power modes on orbit, the avionics fans operate when only a few experiments are operating and require cooling.

The fans are designed to switch from four-pole to eight-pole operation. The air flow through one fan is reduced from 1,923 to 639 pounds per hour, and the power is reduced from 643 to 110 watts. The two fans, powered by separate 115-volt ac buses, are activated and deactivated at low speed (eight-pole) by the *avionics fan 1/2 low speed/off* switches on orbiter panel R7. Each switch has a yellow LED that is illuminated above the respective switch to indicate that the respective fan is activated. The fans' on/off status is also available on orbiter CRT displays and the Spacelab DDU avionics power/cooling display.

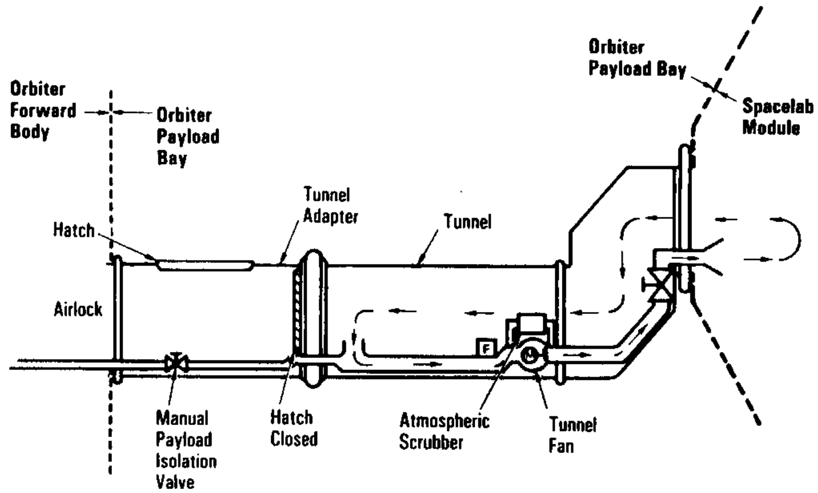
The Spacelab avionics fans can also be activated in the low-speed mode by commands from the orbiter CRT keyboard. The fans are activated in the high-speed mode (four-pole) by commands from the orbiter CRT keyboards. The orbiter MDM deactivation command deactivates both fans simultaneously, and the Spacelab RAU deactivation command turns off each fan separately. The high-speed status of the Spacelab avionics fans is available on the orbiter CRT display and the Spacelab DDU display.

Pressurized Module/Tunnel Air Loop. The switch for the fan located in the transfer tunnel cannot be accessed until the tunnel/Spacelab hatch is opened and the flight crew initially transfers to the Spacelab from the orbiter.

When the airlock hatch and the tunnel adapter/Spacelab hatches are open, the orbiter air revitalization system provides air at 48 cubic feet per minute through a duct that branches off of the orbiter cabin air loop downstream of the orbiter cabin heat exchanger and enters the tunnel adapter. In the tunnel adapter, the



Tunnel Adapter Hatch Open—48 Cubic-Feet-Per-Minute Duct Operating



Tunnel Adapter Hatch Closed—48 Cubic-Feet-Per-Minute Duct Not Operating

duct can be controlled by a manual shutoff valve before it passes into the transfer tunnel itself. For the transfer tunnel to be entered, the tunnel adapter/Spacelab hatch must be opened and the duct passed through the tunnel hatch, where the duct expands. The fan located in the transfer tunnel draws additional air into the duct through an air inlet located just on the tunnel side of the tunnel adapter hatch.

The fan draws in additional air at a rate of 77 cubic feet per minute for a total nominal duct flow of 125 cubic feet per minute. This flow rate is delivered to the Spacelab cabin. The return air passes through the transfer tunnel itself, initially at 125 cubic feet per minute. However, 77 cubic feet per minute of air is sucked into the duct inlet at the Spacelab side of the tunnel/adapter hatch, and 48 cubic feet per minute of air enters the orbiter cabin through the tunnel adapter and airlock hatch. A scrubber in the tunnel duct removes carbon monoxide. The scrubber, located in parallel with the tunnel fan, produces an air flow of 1.5 to 4 cubic feet per minute.

The tunnel fan receives dc power from the Spacelab electrical power distribution subsystem. A delta pressure sensor located in the tunnel provides telemetry data for calculating air flow. If the Spacelab module is operating with the tunnel adapter hatch closed, air exchange is not possible. In this case, the tunnel fan can be used to circulate air at 125 cubic feet per minute in the tunnel.

Pressurized Module Active Thermal Control Subsystem. The Spacelab active thermal control subsystem consists of a water loop to remove heat from the Spacelab module and a Freon loop to remove heat from equipment on any pallets that may be flown with the pressurized module. The water loop is normally active only during on-orbit flight phases, but the need to cool experiments during ascent and descent requires operation of the water loop in a degraded performance mode during these phases.

The Spacelab water loop is circulated by a water pump package consisting of dual-redundant pumps (primary and backup) with inlet filters, manually adjustable bypass valves, check valves to prevent recirculation through the inactive pump, and an accumulator assembly to compensate for thermal expansion within the loop and maintain a positive pump inlet pressure.

The pump package is contained in a housing and mounted on the outside of the Spacelab module's forward end cone. The nominal flow rate through one pump is 500 pounds per hour.

The Spacelab water pumps are powered by separate 115-volt buses. They are activated and deactivated by the *H_2O loop pump 1/2 on/off* switches on orbiter panel R7 or by commands from the orbiter CRT keyboards. The green LED above each switch on panel R7 is illuminated to indicate that the pump is in operation. The on/off status of the Spacelab water pumps is also shown on the orbiter CRT displays.

The Spacelab Freon coolant loop removes heat from any pallets that may be flown with the pressurized module and transfers the heat of the interloop heat exchanger to the Spacelab water loop system. The flow rate is approximately 3,010 pounds per hour. From the Spacelab water loop system, the water passes through the orbiter payload heat exchanger, which transfers all the heat it has collected to the orbiter Freon coolant loops.

Pressurized Module Caution and Warning. The orbiter receives caution and warning inputs from Spacelab through the orbiter payload MDMs. Four channels in the Spacelab systems are dedicated to sending payload warning signals to the orbiter, and four channels in the Spacelab systems send payload caution signals to the orbiter. Nineteen remaining caution and warning input channels to the orbiter payload MDMs are available for Spacelab experiment limit sensing in the orbiter GPCs. The orbiter provides a maximum of 36 safing commands for use in response to Spacelab caution and warning conditions with 22 reserved for experiment safing commands. All safing commands are initiated at the orbiter CRT and keyboard.

The orbiter GPC can obtain data from the Spacelab command and data management system through the orbiter PCMMU as an alternative source for caution and warning.

Pressurized Module Emergency Conditions. There are two categories of Spacelab emergency conditions: fire/smoke in the Spacelab module and rapid Spacelab cabin depressurization. The orbiter and Spacelab annunciate these conditions and can issue safing commands if they occur. These signals are available during all flight phases.

Redundant Spacelab fire/smoke inputs are generated by two ionization chamber smoke sensors at three locations in the Spacelab. The six fire/smoke discrete signals are hard-wired to six annunciator indicators located on panel R7. These indicators are divided into three pairs labeled *left A&B*, *subfloor A&B*, and *right A&B*. The six *smoke annunciators enable/inhibit* switches on panel R7 can be used to inhibit each fire/smoke sensor's output individually. The *smoke sensor reset/norm/test* switch on panel R7 is used to reset or test all six sensors simultaneously.

Three signals, each from a different sensor location, are ORed (run through an OR gate) and connected to orbiter panel L1, which has a payload fire/smoke detection light. The three remaining signals are treated in the same manner.

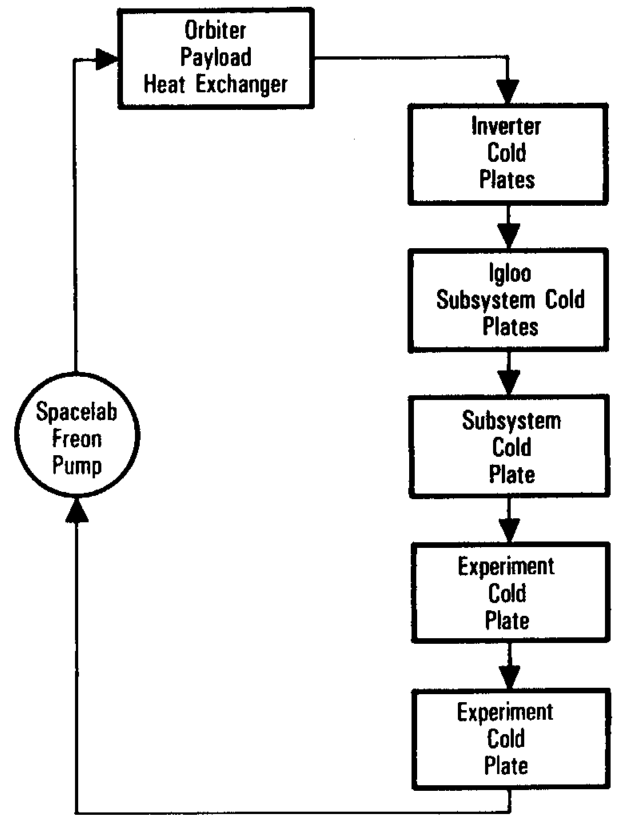
When a Spacelab fire/smoke signal is detected, an emergency tone (siren) generated by the orbiter caution and warning circuitry is transmitted by the orbiter audio central control unit and announced in the Spacelab module by the loudspeaker, and the Spacelab *master alarm* light is illuminated. The six fire/smoke signals are also connected to six orbiter MDM inputs for display as emergency alert parameters on the orbiter CRT and for telemetry.

Two methods are provided for extinguishing a fire in the Spacelab module: discharging a fire suppressant into the affected area or dumping the Spacelab cabin atmosphere, when appropriate. The fire suppressant discharge consists of 15 orbiter-common fire suppression modules, each filled with the Freon 1301 suppressant agent.

The *agent discharge arm/safe* switch on orbiter panel R7 or the panel in the Spacelab module is used to safe or arm the discharge function. Each panel has a yellow indicator light that is illuminated when the discharge circuit is armed. The arming of the suppressant discharge function also shuts off the Spacelab module cabin and avionics fans to avoid diluting the suppressant's concentration. The agent can be discharged from either orbiter panel R7 or the panel in the Spacelab module by three identical sets of *agent discharge* switches, one each for the left, subfloor, and right areas. The switches are protected by individual guards. Positioning one of these switches completely discharges the contents of all suppressant bottles in the indicated area of the Spacelab module. In addition, the Spacelab module *O_2 supply valve close/cmd enable* switch on orbiter panel R7 can be used to close off the oxygen supply from the orbiter oxygen system to deprive the fire of oxygen. Spacelab cabin atmosphere dumping is controlled by the *cabin depress arm/safe* and *valve open/close* switches on orbiter panel R7. The Spacelab motor-controlled cabin dump valve's status is indicated by the yellow *not closed* and the red *full open* indicators on orbiter panel R7 as well as by the orbiter CRT.

PALLET-ONLY ENVIRONMENTAL CONTROL SUBSYSTEM. The environmental control subsystem provides thermal control of Spacelab experiments and subsystems. The Spacelab Freon-21 coolant loop services the pallet systems and collects heat dissipated by the subsystem and experiment equipment. The Spacelab Freon-21 coolant loop collects heat from the pallet-mounted subsystems and experiments through cold plates, some of which have thermal capacitors to store peak heat loads. The cold plates in the Freon loop are bolted to an intermediate support structure that is attached to the pallet. A maximum of eight cold plates can be used on the pallets for a particular mission.

The subsystem equipment mounted in the igloo is also serviced by the Freon loop, which interfaces directly with the orbiter's payload heat exchanger. The Freon pump package is mounted on the front frame of the first pallet (forward) in the orbiter payload bay. Thermal coatings are applied to minimize heat leakage and the effects of solar radiation. A special paint is used to reduce the hot-case temperature of the pallet structure itself. An insulated shield installed between the pallet-mounted cold plates and the pallet structure reduces radiation exchange between them. Multilayer insulation thermal tents also protect pallet-mounted subsystems; any unused tents are available for experiments.



Freon-21 Coolant Loop for Spacelab Pallets

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, 67 GAS cans have been flown on 16 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.

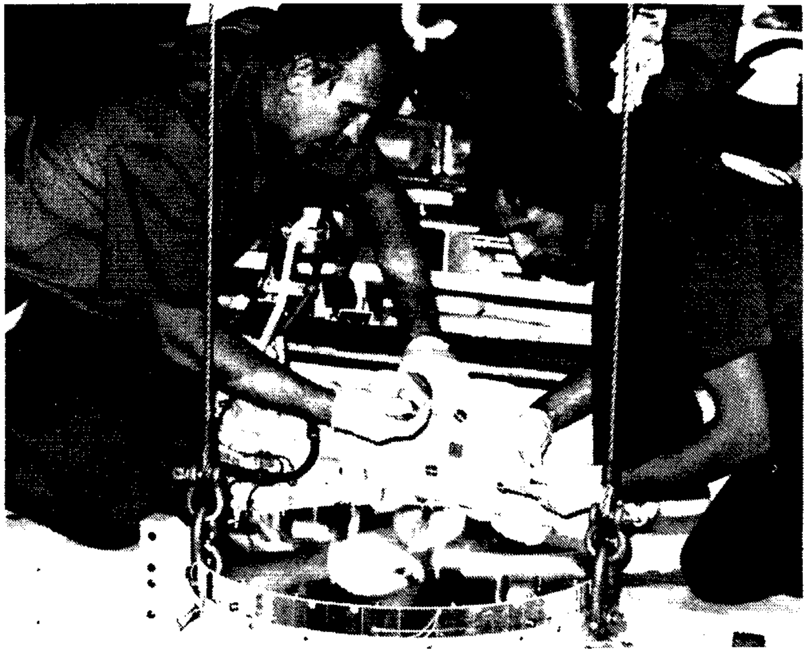
GAS requests must first be approved at NASA Headquarters in Washington, D.C., by the director of the Transportation Services Office. At that point NASA screens the propriety objectives of each request. To complete the reservation process for GAS payloads, each request must be accompanied or preceded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

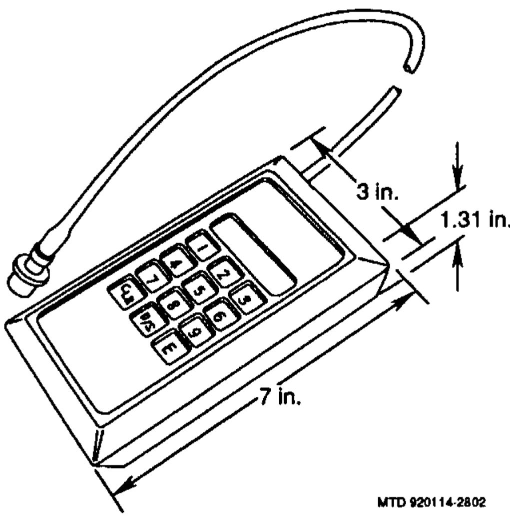
NASA's space shuttle program has specific standards and conditions relating to GAS payloads. Payloads must fit NASA standard containers and weigh no more than 200 pounds. However, two or more experiments may be included in a single container if they fit in it and do not exceed weight limitations. The 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.



Getaway Special Container in Payload Bay



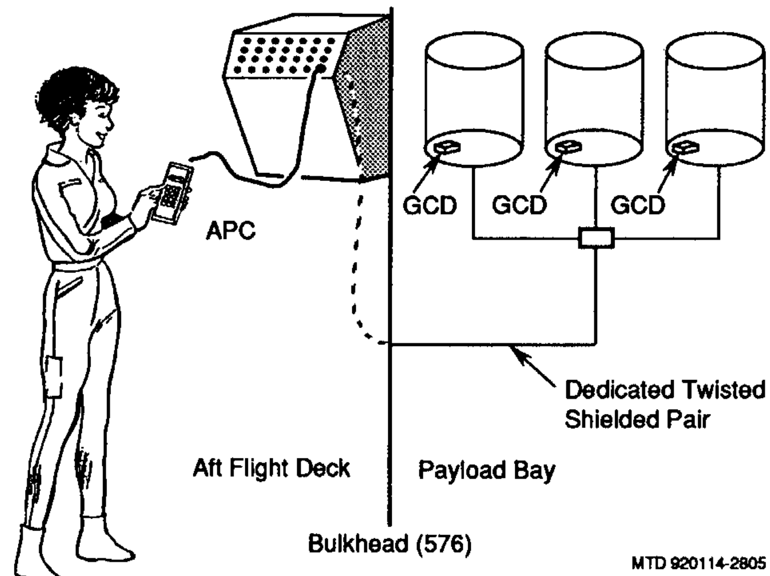
GAS Autonomous Payload Controller

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 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 re-entry or on orbit, as required by the experimenter.

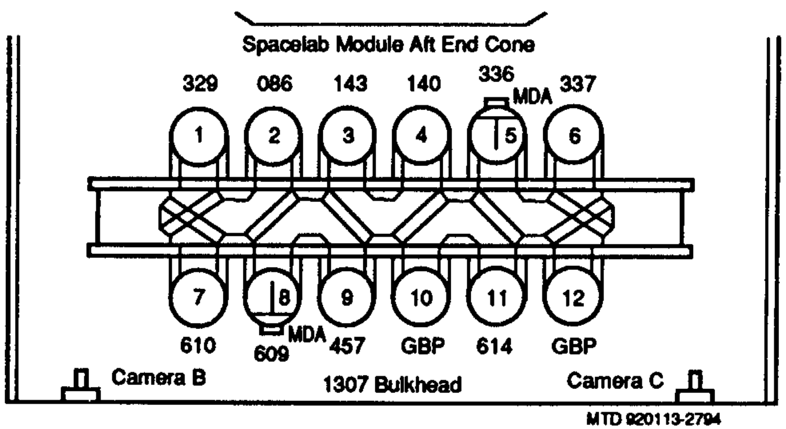
The getaway bridge, which is capable of holding 12 canisters, made its maiden flight on STS 61-C. The aluminum bridge fits across the payload bay of the orbiter and offers a convenient and economical way of flying several GAS canisters.

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.



Getaway Special Control Concept

Attached cargo operations will be performed with the 10 getaway special (GAS) canister experiments contained in the GAS bridge assembly (GBA) mounted in Discovery's aft payload bay in Bay 12. The GBA consists of a GAS bridge structure and 12 GAS payloads in 5-cubic-foot containers (canisters). The GBA measures approximately 100 inches in length. Two canisters have motorized door assemblies.



GBA Configuration

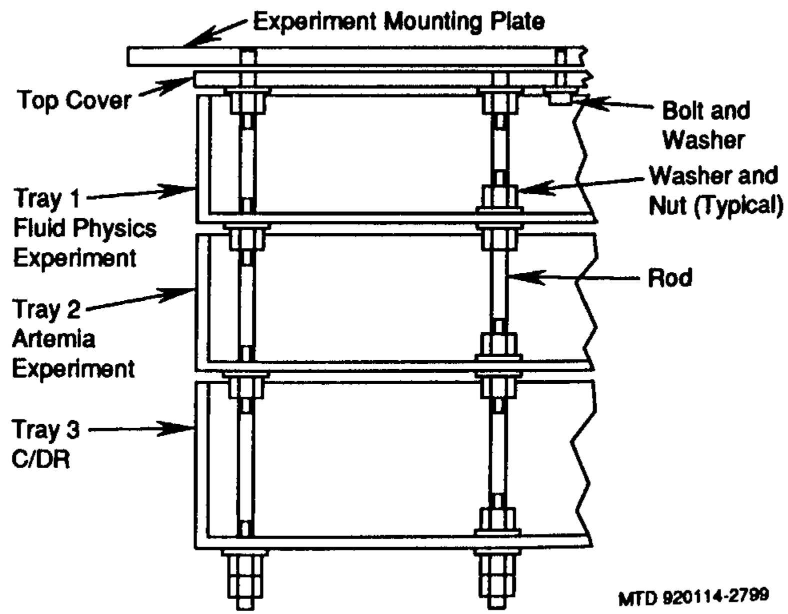
Twelve GAS payloads were originally scheduled to fly on this mission. However, two GAS payloads dropped out because of technical difficulties. In their place, two GAS ballast payloads were adjusted to match the weight of the payloads they replaced.

Experiments from six countries (United States, Japan, Sweden, Germany, Australia, and China) will be conducted, encompassing materials processing, life sciences, fluid physics, and astronomical observations. Crew interface is minimal, requiring only switch activation/deactivation from the aft flight deck.

The 10 GAS experiments aboard STS-42 are as follows:

1. **Brine Shrimp/Air Bubbles in Microgravity (G-086)**
   Sponsor: Booker T. Washington High School, Houston, Texas

In one experiment, artemia (brine shrimp) will be flown to observe the behavioral and physiological effects of microgravity on cysts hatched in space. The second experiment will examine the thermal conductivity and bubble velocity of air and water. In that experiment, measured amounts of air are injected into a chamber filled with distilled water, resulting in air bubbles of different sizes. Research indicates the direction and speed of bubble movements should depend on both bubble size and temperature. The NASA technical manager (NTM) is Tom Dixon.



G-086 Payload Configuration

2. **Marangoni Convection in a Floating Zone (G-140)**
Sponsor: Deutsche Forschungs und Versuchsanstalt fur Luft und Raumfahrt (DFVLR), Germany

G-140 and G-143 are material science autonomous experiments (MAUS) developed by scientists of the German Aerospace Research Establishment (DLR)/Gottingen and the Technical University Clausthal. The MAUS project is managed by the German Space Agency (DARA) representing Germany for space activities.

This materials processing experiment will study heat and mass transfer during materials processing as controlled through Marangoni convection. Some of the objectives of the experiment are to detect higher modes of the oscillatory Marangoni convection in floating zones and to study the influence of the rotation on the steady and the oscillatory Marangoni convection. Silicon monocrystals will be suspended in a liquid between two discs that can be individually rotated. Heating of the discs will begin Marangoni convection in the floating zone that can be affected by rotation. The motion of the crystals will be recorded with a high-speed motion picture camera by means of a HE-NE laser illuminated light-cut technique. Scientists hope to understand such flow phenomena to better control and facilitate crystal growth. The NTM is Tom Dixon.

3. **Glass Fining (G-143)**
Sponsor: Deutsche Forschungs und Versuchsanstalt fur Luft und Raumfahrt (DFVLR), Germany

The objective of this materials processing experiment is to gain further insight into the process of glass fining: i.e., the removal of all visible gaseous inhomogeneities from a glass melt. Purer data regarding present methods of refining is expected to be obtained in microgravity since the gas bubble being studied will maintain its spherical symmetry. Distortion of gas bubbles on Earth due to gravity prevents scientists from obtaining pure data. Operation of the unit entails heating of a cylindrical glass sample implanted with an artificial helium bubble in an isothermal furnace to 1,300 degrees Celsius. Photographs will document the bubble's transformation state every 45 seconds for 2-1/2 hours. The glass melts and the helium dissolves in the melt, causing the bubble to shrink. The NTM is Tom Dixon.

4. **The Effect of Gravity on the Solidification Process of Alloys (G-329)**
Sponsor: Swedish Space Corporation

The objective of this materials processing experiment is to study solidification phenomena in metal alloys. The payload includes three experimental furnaces and an energy buffer, which protects the payload from excessive temperatures. The 200-pound experiment contains four samples of different quantities of lead-tin alloy. Each sample will be melted and then resolidified three times. The resultant unidirectionally solidified samples will be studied for dendritic growth and the effect of the absence of convection on metal alloy samples. The flight samples will be compared with results from Earth-processed samples. The NTM is Tom Dixon.

5. **Visual Photometric Experiment (VIPER) (G-336)**
Sponsor: United States Air Force, Phillips Laboratory, Hanscom Air Force Base, Mass.

The objective of VIPER is to measure the visible light reflected by intergalactic dust. Using a high-sensitivity photometer and a low-light level television system, the VIPER can store up to eight hours of video images, radiometer measurements, and housekeeping data. The data will be used to validate and update existing data and will help provide background measurements of visible light for use in space surveillance. The NTM is Tom Dixon.

6. **Space Thermoacoustic Refrigerator (G-337)**
Sponsor: Naval Postgraduate School, Monterey, Calif.

The objective of this experiment is to measure the performance of a new thermoacoustic refrigerator that uses sound to pump heat and does so with only one moving part under microgravity conditions. Unlike conventional refrigerators that use compressors and ozone-depleting chlorofluorocarbons (CFCs), the thermoacoustic refrigerator uses standing sound waves and inert gas to produce refrigeration. Operation of the unit requires that power be applied to the acoustic drive that resonates the dry nitrogen gas within the refrigerator. The resonance causes the temperature of the cold heat exchanger to decrease. The acoustic driver is then turned off and the rate of temperature rise is measured to find the intrinsic heat leak. This procedure is repeated several times at various driver powers and ambient temperatures to gather data regarding its operation and efficiency. The NTM is Tom Dixon.

7. Separation of Gas Bubbles From Liquid (G-457)
Sponsor: The Society of Japanese Aerospace Companies, Inc.

This fluid physics experiment is a preliminary study of a method of gas-liquid separation under conditions of microgravity. Gas bubbles will be separated out of a liquid by artificial gravity generated by an impeller. After separation, the gas is circulated by a pump and injected into liquid again in a mixing box. A video camera will document the separation and subsequent bubble movement for postflight analysis. The NTM is Herb Foster.

8/9. Endeavor, the Australian Space Telescope (G-609/G-610)
Sponsor: Australian Space Office and Auspace Limited

The scientific objectives of these experiments are to make ultraviolet observations of violent events in deep space using Endeavor, an Australian ultraviolet light telescope designed and built by Auspace Limited for the Australian Space Office. Specific observations include galactic supernova remnants, the distribution of hot gas in the Magellanic Clouds, hot galactic halo emission, and emission associated with galactic cooling flows and jets. The 10-cm-diameter mirror coaxial binocular telescope will have one broad bandpass telescope and one narrow bandpass telescope. The telescopes will image onto the photon-counting array detector. Data will be documented on two video recorders. Two GAS canisters are required: one contains the optical elements, a large-format photon-counting array detector, and a control computer. The other contains a flight battery and two tape recorders for recording data produced by the detector.

10. A Study of Motion of Debris in Microgravity and Investigation of Mixing of Low-Melting Point Materials in Microgravity

Co-sponsors: Chinese Society of Astronautics/American Association for Promotion of Science in China

This payload contains two materials processing experiments. The first will study the motion of debris in the shuttle under microgravity conditions. Small lumps of different materials will be stored in a container with a side wall covered with a sheet of adhesive paper. A movie camera will photograph the motion of debris upon their release in microgravity. The second contains two low-melting point materials (paraffin and wood's metal). Eight small cylindrical containers will be premixed in various ratios and manners in the solid form on Earth and remelted on orbit, then left to cool and resolidify. The experiments were designed by students selected in 1986 from more than 7,000 proposals.

SPACE ACCELERATION MEASUREMENT SYSTEM

The primary objective of NASA's Space Acceleration Measurement System (SAMS) is to measure and record low-level acceleration that the Spacelab experiences during typical on-orbit activities. Data obtained from SAMS will enable engineers and scientists to study how vibrations or movements caused by crew members, equipment, or other activities are transferred through the vehicle to the experiment racks.

SAMS consists of a main unit, up to three triaxial sensor heads, and sensor harnesses and optical disks. The three SAMS sensor heads are mounted on or near experiments to measure the acceleration environment experienced by the research package. The main unit consists of the data acquisition system (electrical box), two optical disk drives for data collection, and a control panel, all of which are mounted into a support structure with covers in the Spacelab's center aisle. The triaxial sensor heads are separated from the main unit by an umbilical cable (sensor harness) for remote positioning into another payload. A sensor head is mounted under the floor of the microgravity vestibular investigation rotating chair in the Spacelab's center aisle.

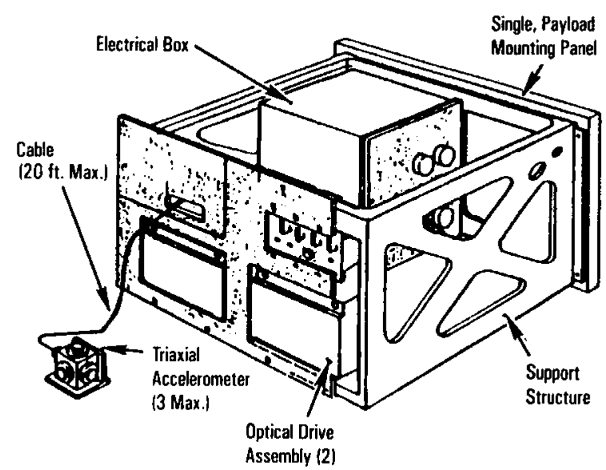
SAMS' primary support on STS-42 will be for experiments conducted in the Fluid Experiment Systems rack and the Vapor Crystal Growth System rack. Typically, crystal growth experiments conducted in these racks take several days to grow and are sensitive to low-frequency acceleration. Therefore, it is important to understand how movement affects the development of the crystal during the growth period. Two sensor heads are mounted in the Fluid Experiment Systems rack.

In operation, the triaxial sensor head produces output signals in response to acceleration inputs. The signals are amplified, filtered, and converted into digital data, which is then stored on optical disks. The data transfer and storage are controlled by the internal microprocessor.

The SAMS payload will be activated by the crew no sooner than 2.5 hours after launch. While in orbit, the crew must reset the central processing unit (CPU), activate the data recorder, and change out the optical disk. Acceleration data will be gathered throughout the flight and can be taken during specific events that require acceleration, such as OMS/RCS burns.

SAMS flew previously on STS-40 and -43.

SAMS is sponsored by NASA's Lewis Research Center.



SAMS

GELATION OF SOLS: APPLIED MICROGRAVITY RESEARCH

The GOSAMR-1 payload is a middeck materials processing experiment that will investigate the influence of microgravity on the processing of gelled sols—dispersions of solid particles in a liquid often referred to as colloids—which are used in the production of advanced ceramics materials. Stoke's law predicts that there will be more settling of the denser and larger-sized particulates in Earth's unit gravity as compared to the differentiation that should occur in a microgravity environment. The payload, flown under the sponsorship of a joint endeavor agreement between NASA's Office of Commercial Programs and 3M's Science Research Laboratories, St. Paul, Minn., involves chemical gelation to form precursors for advanced ceramics materials that may have a more uniform structure, finer grain size, and superior physical properties than similar materials produced on Earth.

The potential commercial impact of GOSAMR applied research on enhanced ceramic composite materials will be in the areas of abrasives and fracture-resistant materials. 3M currently sells film coated with diamond-loaded silica beads for polishing computer disk drive heads and VCR heads. Zirconia-toughened alumina is a premium performance abrasive grit and functions extremely well as a cutting tool for the machining of metals. The performance of these materials may be enhanced by improving their structural uniformity through processing in space.

The GOSAMR experiment will attempt to form precursors for advanced ceramic materials by using chemical gelation (disrupting the stability of a sol and forming a semi-solid gel). These precursor gels will be returned to 3M, dried, and fired to temperatures ranging from 900 to 2,900 degrees F to complete the fabrication of the ceramic composites. These composites will then be evaluated to determine if processing in space resulted in better structural uniformity and superior physical properties.

On STS-42, 80 samples (5 cc each) will be generated by varying the particle sizes and loadings, the length of gelation times, and the sol sizes. The chemical components will consist of either colloidal silica sols doped with diamond particles or colloidal alumina sols doped with zirconia particulates. Both sols will also be mixed with a gelling agent of aqueous ammonium acetate.

About a month before launch, the GOSAMR payload is pre-packed into a middeck stowage locker and surrounded with half an inch of isolator material. The experiment contains an internal battery source and uses no power from the shuttle orbiter. The payload is designed to operate at ambient cabin temperature and pressure to insure scientific success of the experiment, maintaining temperatures above 40 degrees F and below 120 degrees F at all times.

The GOSAMR container consists of a back cover, 5 identical and independent apparatus modules holding 10 mixing systems, and a front cover. The modules and covers comprise a common sealed apparatus container that provides an outermost level of chemical containment. The front cover contains two ambient temperature-logging devices, two purge ports for venting and backfilling the container with inert gas, and the electrical feedthrough between the sealed apparatus and the control housing. The control housing at the front of the payload contains power switches for payload activation, indicator lights for payload status, and a test connector used during ground-based checkout. Once the payload is installed in the locker, the control housing will be the only portion of the payload accessible to the flight crew.

Each of GOSAMR-1's five modules has two mixing systems with eight double syringes (5 cc each) containing one of the two chemical components. Prior to on-orbit activation, the two components will be kept isolated from each other by a seal between the syringe couplers. The coupled syringes in each assembly will contain a gelling agent (either aqueous ammonium acetate or nitric acid) in one syringe and one of the two chemical components in the other.

Once on orbit, a crew member will sequentially activate the five power switches on the control housing. When the payload is activated, a pilot light for each module will be illuminated, indicating that mixing has begun and that the syringe-to-syringe seal has been broken. The sample mixing process for each system will last about 10 to 20 seconds and once the mixing cycle is complete, an internal limit switch will automatically stop each mixing system.

The flight crew will monitor the experiment status by observing the control-housing indicator lights, which will be illuminated during the motor-driven mixing of each system. The pilot lights will be extinguished once the mixing is complete, and a crew member will deactivate each module. The payload will require no further crew interaction. However, physical changes in the samples will continue passively and unattended for a minimum of 24 hours in the microgravity environment. Total crew interaction will be less than 1 hour, and only during this period will the locker door be open.

After landing, the payload will be removed from the orbiter during normal destowage operations and returned to 3M within 24 hours where postflight processing and analyses will be conducted on space- and ground-processed samples to ascertain the differences in physical structure and properties.

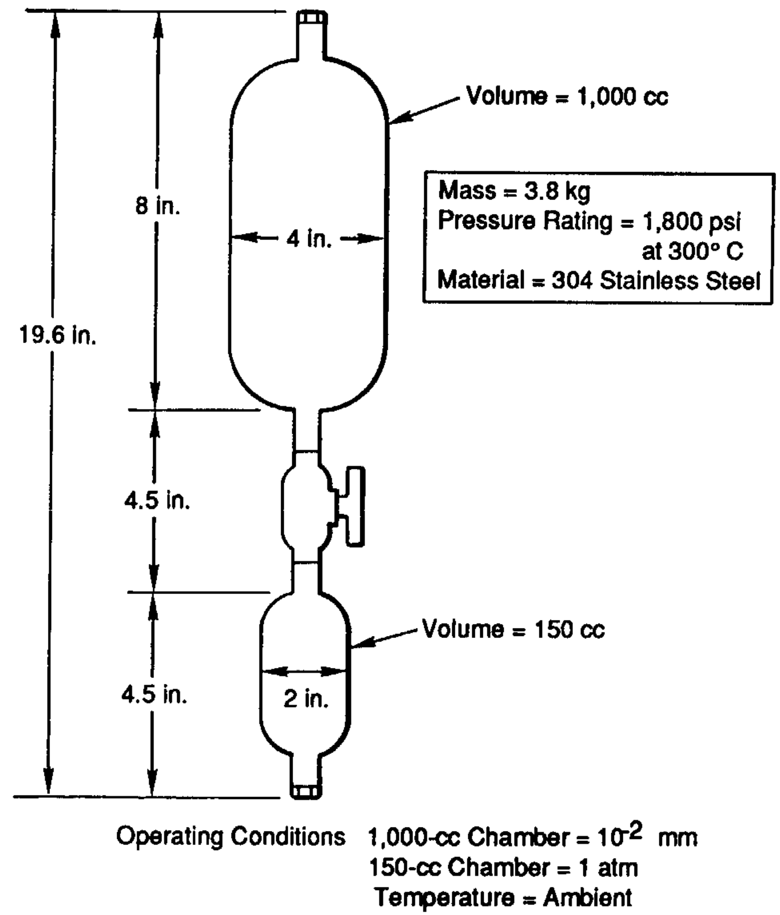
The 3M GOSAMR management team includes Dr. Theodore F. Bolles, technical director; Dr. Earl L. Cook, program manager; and Dr. Bruce A. Nerad, principal scientist.

Investigations Into Polymer Membrane Processing will make its fifth space shuttle flight for the Office of Commercial Programs-sponsored Battelle Advanced Materials Center for the Commercial Development of Space in Columbus, Ohio. IPMP flew previously on STS-31, -41, -43, and -48. The objective of the IPMP is to investigate the physical and chemical processes that occur during the formation of polymer membranes in microgravity so that the improved knowledge base can be applied to commercial membrane processing techniques. Supporting the overall program objective, the STS-42 mission will provide additional data on the polymer precipitation process.

Polymer membranes have been used in the separation industry for many years for such applications as desalination of water, filtration during the processing of food products, atmospheric purification, purification of medicines, and dialysis of kidneys and blood. Polymer membranes frequently are made using a two-step process. A sample mixture of polymer and solvents is applied to a casting surface. The first step involves the evaporation of solvents from the mixture. In the second step, the remaining sample is immersed in a fluid bath (typically water) to precipitate the membrane from the solution and complete the process.

The IPMP payload on STS-42 consists of two experimental units containing different solvent solutions that occupy a single small stowage tray (half of a middeck locker). Each unit consists of two 304L stainless steel sample cylinders measuring 4 inches and 2 inches in diameter. The cylinders are connected to each other by a stainless steel packless valve with an aluminum cap. The IPMP payload weighs approximately 17 pounds.

Before the mission, a thin-film polymer membrane is swollen in a solvent solution, rolled, and inserted into the smaller canisters and then sealed at ambient pressure (approximately 14.7 psia). The valve is sealed with Teflon tape. The larger canister is evacuated and sealed with threaded stainless steel plugs using a Teflon tape threading compound.

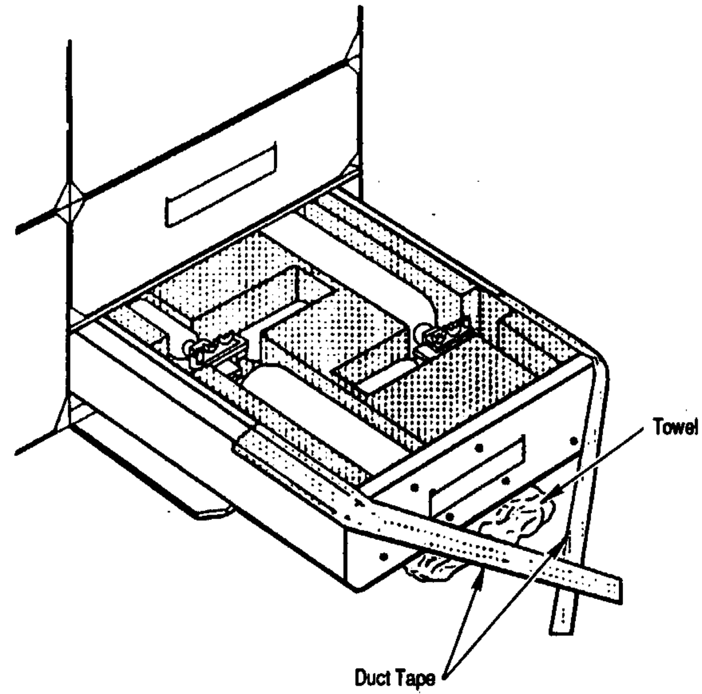


Investigations Into Polymer Membrane Processing

On the STS-42 mission, commander Ron Grabe and mission specialist Bill Readdy will operate the IPMP experiment. They will begin by accessing the units in their stowage location in a middeck locker. By turning the unit's valve to the first stop, the evaporation process is begun. On this flight, the effects of varying the time between initiation of solvent evaporation and quenching will be studied—1 unit at 5 minutes, the other at approximately 8 hours. Then, a quench procedure will be initiated. The quench consists of introducing a humid atmosphere which will allow the polymer membrane to precipitate out. Ground-based research indicates that the precipitation process should be complete after approximately 10 minutes, and the entire procedure is at that point effectively quenched.

Following the flight, the samples will be retrieved and returned to Battelle for testing. Portions of the samples will be sent to the CCDS's industry partners for quantitative evaluation consisting of comparisons of the membranes' permeability and selectivity characteristics with those of laboratory-produced membranes.

The principal investigator for the IPMP is Dr. Vince McGinness of Battelle. Lisa A. McCauley, associate director of the Battelle CDS, is program manager.



IPMP Configuration

RADIATION MONITORING EQUIPMENT III

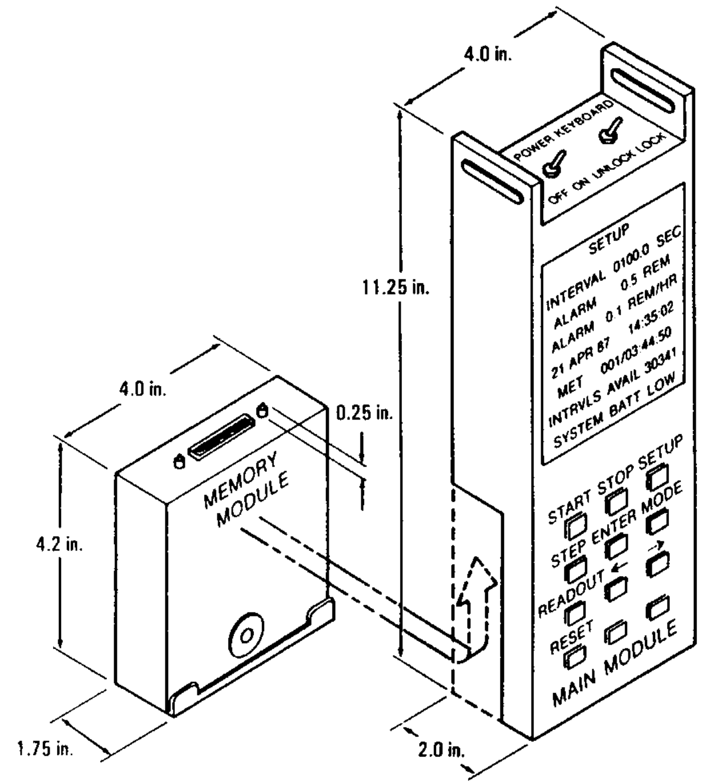
Radiation Monitoring Equipment III will measure and record the rate and total dosage of the crew's exposure to ionizing radiation at different locations in Discovery's crew compartment. RME-III measures gamma ray, electron, neutron and proton radiation and calculates, in real time, exposure in RADS-tissue equivalent.

RME-III consists of a hand-held instrument with replaceable memory modules. The equipment contains a liquid crystal display for real-time data presentation and a keyboard for controlling its functions. The self-contained experiment has four zinc-air and five AA batteries in each memory module and four zinc-air batteries in the main module. RME weighs approximately 23 pounds.

RME-III will be stored in a middeck locker during flight except for when it is turned on and when memory modules are being replaced. It will be activated as soon as possible following orbit insertion and will be programmed to operate throughout the entire mission. A crew member will be required only to enter the correct mission elapsed time upon activation and to change the memory module every two days. The equipment takes measurements of the radiation environment at a specified sample rate. All data stored in the memory modules will be analyzed upon return.

RME-III, which was flown on STS-31, STS-41, STS-37, STS-39, STS-48, and STS-44, replaces two earlier configurations.

RME-III is sponsored by the Department of Defense in cooperation with the Human Systems Division of NASA's Space Radiation Advisory Group.



RME Configuration

IMAX CAMERA

The IMAX project is a collaboration between NASA, the Smithsonian Institution's National Air and Space Museum, IMAX Corporation, and the Lockheed Corporation to document significant space activities using the IMAX film medium. This system, developed by the IMAX Systems Corp. of Toronto, Canada, uses specially designed 70mm cameras and projectors to record and display very high definition color motion pictures on a screen that is nine times larger than a conventional screen, producing a feeling of "being there."

IMAX cameras have been flown on space shuttle missions STS 41-C, 41-D, 41-G, 29, 34, 32, and 31 to document crew operations in the payload bay and the orbiter's middeck and flight deck as well as to film spectacular views of space and Earth. Film from those missions was used as the basis for the IMAX productions "The Dream Is Alive" and "The Blue Planet."

On STS 61-B, an IMAX camera mounted in the payload bay recorded extravehicular activities involving space construction demonstrations.

On its last mission, the IMAX cameras located in Discovery's payload bay and in the crew compartment covered the deployment of the Hubble Space Telescope and gathered material on the use of observations of Earth from space for the production "The Blue Planet."

On this mission, the crew will use the camera to film activities in the Spacelab module and the crew compartment, emphasizing the space physiology experiments that have a bearing on future long duration human presence in space. The crew will also take advantage of the high inclination of the STS-42 orbit (57 degrees) to film Earth features at latitudes not overflown by most shuttle flights. The scenes will be used in an IMAX film now in production on mankind's future in space.

Activation of the IMAX camera will be done at crew preference during various times in flight.

SHUTTLE STUDENT INVOLVEMENT PROGRAM EXPERIMENTS

Two Shuttle Student Involvement Program experiments will be conducted on STS-42: Student Experiment 81-09, Convection in Zero Gravity, and Student Experiment 83-02, Zero-G Capillary Rise of Liquid Through Granular Porous Media.

STUDENT EXPERIMENT 81-09: CONVECTION IN ZERO GRAVITY

SE81-09 is a middeck experiment selected in 1981 that studies surface tension induced flows in microgravity. Its purpose is to study the various phenomena of surface tension convection in near zero-gravity. Experiment data will be used to help develop materials processing operations in space. It was conceived and developed by Scott Thomas while a student at Richland High School, Johnstown, Pa. The experiment flew previously on the STS-5 mission. It is being reflown because a safety shield interfered with the initial operation of the experiment.

The experiment is comprised of two components: a control box and a pan assembly. The control box houses 12 syringes containing Krytox oil in which aluminum powder is suspended in order to facilitate flow visualization. The control box contains a computer that regulates the amount of heat applied into each. Forty batteries housed in the control box are used to power the unit.

The pan assembly contains six pans ranging from 3/4-in. to 4 in. in diameter. Each pan has a self-contained heater that begins the heating of the Krytox oil, which, in turn, undergoes the convection process that will be documented by a NASA-supplied video camera. The computer will record heating rate, temperatures, various liquid depths, and background jitter. A crew member removes and secures the experiment from the middeck locker, sets up a television camera, injects a pan with oil, and activates the heater and camera. The heater will run for 10 minutes, ample time for convection to occur. The camera will observe the flow patterns produced by aluminum powder in Krytox oil. After six cycles, the experiment is concluded and returned to the locker. Crew member activation and operation of the experiment are required for approximately two hours.

Thomas is a doctoral candidate of physics at the University of Texas, Austin. After high school, he attended Utah State University, majoring in physics. His teacher advisor is Wayne E. Lehman (formerly with Richland High School). The experiment is sponsored by Thiokol Corp. Dr. Lee Davis, Thiokol Corp., and R. Gilbert Moore, Utah State University, are the science advisors of the experiment.

STUDENT EXPERIMENT 83-02: ZERO-G CAPILLARY RISE OF LIQUID THROUGH GRANULAR POROUS MEDIA

SE83-02 is a middeck experiment that investigates the flow characteristics of fluid movement in a porous medium in the microgravity environment. Both pure capillary and forced flow behavior will be investigated. The experiment was conceived by Constantine N. Costes while he attended Randolph High School, Huntsville, Ala.

Knowledge of the mechanisms of capillary liquid transport through porous media is of primary importance to many disciplines, including soil physics, agriculture, ground hydrology, petroleum engineering, and water purification techniques.

The experiment weighs 53 pounds and stows in one middeck locker. It consists of an aluminum box supporting three glass tubes, each measuring 15 in. in length and 2 in. in diameter. Each tube is densely packed with one of three sizes of glass beads (0.25 mm, 1 mm, and 3 mm).

A pressure vessel will drive blue tinted water through the tubes. Other components include a fluid expansion tank, pressure readout, fluid temperature indicator, toggle valves, pressure regulators, and associated pneumatic and fluid system hardware.

One hour of crew time will be used to operate the unit. Each tube is partially filled with fluid by opening the atmospheric vent toggle valve and rotating the selector valve to the correct pressure position. Once the fluid has been moved into the tube, the driving pressure will be stopped, allowing the fluid to progress through the column without any driving pressure other than capillary action.

A video camera with crew observations and comments will document the on-orbit flow behavior. The data will be compared to data gathered from an Earth-based experiment.

Costes is a doctoral candidate of mathematics at Harvard. He received his undergraduate degree from Harvard and pursued two years of graduate studies at Oxford under a G.C. Marshall Fellowship granted by the United Kingdom. The experiment is sponsored by USBI, Inc., Huntsville. Jeff Fisher, a USBI design engineer, designed the experiment apparatus. George Young of MSFC is the science advisor for the experiment.

ENTRY AERODYNAMIC CONTROL SURFACES TEST, PART 6 (DTO 242). The purpose of this DTO is to perform a series of programmed test input maneuvers and one manual body flap maneuver during the entry and terminal area energy management phases to obtain aerodynamic response data. This data will be used to evaluate the effectiveness of various aerodynamic control surfaces.

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

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

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

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

VIBRATION AND ACOUSTIC EVALUATION (DTO 308D). This DTO is for the collection of data to expand the data base vibration and acoustic data during ascent.

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

SHUTTLE/PAYLOAD LOW FREQUENCY ENVIRONMENT (DTO 319D).

CABIN AIR MONITORING (DTO 623). This DTO will use the solid sorbent sampler to continuously sample the orbiter atmosphere throughout the flight. The solid sorbent sampler is to be flown on all Spacelab manned module flights.

EYEWASH (DTO 635). The purpose of this DTO is to demonstrate the utility of the shuttle emergency eyewash (SEE) system, which has been proposed as an addition to the shuttle orbiter medical system (SOMS). The SEE is a device designated to rinse an individual's eyes with large volumes of water in the event of exposure to toxic chemicals or irritants.

ON-ORBIT CABIN AIR CLEANER EVALUATION (DTO 637). This DTO tests a proposed system to be used to filter the cabin air. The system's primary use location is mounted in the starboard interdeck passageway. Additional methods are provided to temporarily mount the system in other locations using the seat mounting provisions. Objectives include evaluation of the air velocity produced by the fan, noise generation, and general air quality.

SPACELAB CO_2 CONTROL (DTO 641). The purpose of this DTO is to evaluate on-orbit $PPCO_2$ levels in the orbiter and Spacelab crew compartments with only the orbiter carbon dioxide removal system operating. This information is needed to determine whether the regenerative CO_2 removal system (RCRS), which is being developed for extended duration orbiter (EDO) missions, is capable of controlling CO_2 levels on missions involving Spacelab as an attached habitable volume.

ELECTRONIC STILL PHOTOGRAPHY (DTO 648). Electronic still photography is a new technology that provides the means for a handheld camera to electronically capture and digitize an image with resolution approaching film quality. The digital image is stored on disks and can be converted to a format suitable for downlink transmission or enhanced using image processing software. The ability to enhance and/or downlink high resolution images in real time will greatly improve capabilities in Earth observations. The objective of this DTO is to determine camera response to the photographic conditions encountered on orbit, using a variety of lenses and camera settings. There will be no downlink from this flight.

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

EVALUATION OF THE MK I ROWING MACHINE (DTO 653). This DTO will evaluate the MK I rowing machine as an alternative to the shuttle treadmill. Noise and vibration associated with the MK I are anticipated to be significantly less than in the case of the treadmill. In-flight simulated rowing is anticipated to provide total body exercise, including aerobic and anaerobic conditioning. Heart rate will be recorded to determine the effectiveness of changes in the resistive settings of the device.

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

VARIATION IN SUPINE AND STANDING HEART RATE, BLOOD PRESSURE, AND CARDIAC SIZE (DSO 466).

IN-FLIGHT RADIATION DOSE DISTRIBUTION (DSO 469). The objective of this investigation is to establish, evaluate, and verify analytical and measurement methods for assessing and managing health risks from exposure to space radiation. It will measure the radiation in the Spacelab tunnel. The DSO is also a part of the Extended Duration Orbiter Medical Project (EDOMP).

THE RELATIONSHIP OF SPACE ADAPTION SYNDROME TO MIDDLE CEREBRAL ARTERY BLOOD VELOCITY MEASURED IN FLIGHT BY DOPPLER (DSO 470). The purpose of this test is to explore in flight the use of a small, lightweight portable instrument that measures blood flow velocities. Also, the test will document the changes in cerebral and regional blood flows that occur in the microgravity environment and try to correlate these changes with the onset and severity of space adaption syndrome.

ORTHOSTATIC EQUILIBRIUM CONTROL DURING LANDING/EGRESS (DSO 603B). The purpose of this DSO is to document the changes in orthostatic function of crew members during the actual stresses of entry, landing, and egress from the seat and from the cabin as mission duration increases. These 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 through entry.

AIR MONITORING INSTRUMENT EVALUATION AND ATMOSPHERE CHARACTERIZATION (DSO 611). The purpose of this DSO is to evaluate and verify air monitoring equipment to ensure proper function and operation in flight. Data will be collected on contaminant levels during missions of varying durations to be used to establish baseline levels and to evaluate potential risks to crew health and safety.

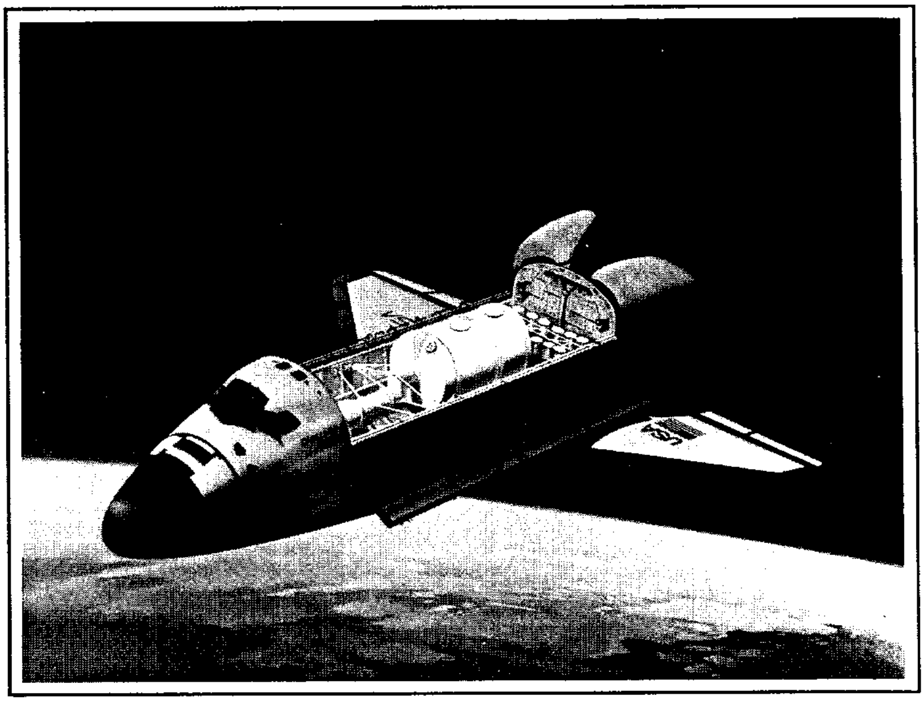
CHANGES IN ENDOCRINE REGULATION OF ORTHOSTATIC TOLERANCE FOLLOWING SPACE FLIGHT (DSO 613). This DSO will characterize the extent and pattern of changes in plasma volume during space flights of up to 16 days. It will also determine whether resting levels of catecholamines are elevated immediately after flight and whether catecholamine release in response to varying degrees of orthostatic and cardiovascular stresses is impaired after space flight. On-orbit activities consist of maintaining a dietary log.

DOCUMENTARY TELEVISION (DSO 901). This DSO requires live television transmission or VTR dumps of crew activities and spacecraft functions, including payload bay views; STS and payload crew activities, VTR downlink of crew activities, in-flight crew press conference; and unscheduled TV activities.

DOCUMENTARY MOTION PICTURE PHOTOGRAPHY (DSO 902). This DSO requires documentary and public affairs motion picture photography of significant activities that best depict the basic capabilities of the space shuttle and key objectives. This DSO includes motion picture photography of

Spacelab module activities, flight deck activities, middeck activities, and any unscheduled motion picture photography.

DOCUMENTARY STILL PHOTOGRAPHY (DSO 903). This DSO requires still photography of crew activities in the orbiter, Spacelab, and mission-related scenes of general public and historical interest. Still photography with 70 mm format for exterior photography and 35 mm format for interior photography is required.



STS-42

MISSION STATISTICS

PRELAUNCH COUNTDOWN TIMELINE

MISSION TIMELINE

January 1992

Rockwell International
Space Systems Division

Office of Media Relations

CONTENTS

MISSION OVERVIEW

This is the 14th flight of Discovery and the 45th for the space shuttle.

The flight crew for the STS-42 mission is commander Ronald (Ron) J. Grabe, Col., USAF; pilot Stephen (Steve) S. Oswald; mission specialists David (Dave) C. Hilmers, Lt. Col., USMC; mission specialist Dr. Norman (Norm) E. Thagard; mission specialist William (Bill) F. Readdy; and payload specialists Ulf D. Merbold of the European Space Agency and Dr. Roberta L. Bondar of the Canadian Space Agency. The crew will be divided into a blue team, consisting of Grabe, Oswald, Thagard, and Bondar; and a red team, comprised of Hilmers, Readdy, and Merbold. Each team will work consecutive 12-hour shifts, providing for around the clock operations.

STS-42's primary mission objective is to perform the planned operations of the International Microgravity Laboratory (IML)-1 payload, conducted in the Spacelab long module. IML-1 consists of a series of multidiscipline experiments that will investigate the effects of microgravity on materials processes and living organisms.

IML-1 materials science investigations include studies of the effects of microgravity on the growth of various types of crystals and fluid medium behavior, as well as measurements of space accelerations and the critical point at which many physical properties assume extreme values or at which profound changes in material properties occur. Life sciences investigations include biological investigations on plants, tissues, cells, bacteria, and insects; studies of space adaptation and space motion sickness; investigations of the radiobiological importance of cosmic ray particles of high mass number and energy and nuclear disintegration stars; crew mental performance in zero gravity; and measurements of the effect of radiation on biological materials in space. Several of the IML-1 experiments have flown previously on earlier Spacelab missions.

The IML-1 consists of a pressurized module located in Discovery's payload bay and connected to the crew cabin by an access tunnel. Most experiments are mounted in racks in the module, which is internally configured with eight double racks, four single racks, and 14 overhead stowage lockers. In Discovery's crew cabin, five middeck stowage lockers with two refrigerator/incubator modules (RIMs) are used for experiment stowage and ancillary items. Twelve Getaway Special (GAS) canisters located in the payload bay hold additional experiments.

Activation of the IML will immediately follow cabin unstow on Flight Day 1 and continue through to Flight Day 7.

Discovery will provide IML-1 with a stable attitude, power, and cooling. A tail down, "pseudo" gravity gradient attitude will be employed to minimize the number of orbiter reaction control system firings necessary during the mission, which can disturb microgravity experimentation. In addition, due to the orbital altitude and inclination at this time of year, Discovery will be in continuous sunlight for four days of the mission. This thermally challenging environment will be compensated for by the orbiter's cooling systems.

This maiden voyage of the IML series of Spacelab flights is a cooperative effort between NASA, six international space science research organizations, and over 200 scientists from 16 different nations. Marshall Space Flight Center, Huntsville, Ala., is responsible for IML mission management. Data collected from the first flight will be used in subsequent flights and will also become part of the research base for Space Station Freedom.

STS-42 is the latest effort in the U.S. manned space program's continuing investigations into materials processing and life sciences microgravity research. Several more flights are planned, including the STS-50 United States Microgravity Laboratory (USML)-1 mission in mid 1992 and the STS-47 Spacelab-J mission, currently scheduled in the September 1992 time frame.

Activation of the IML will immediately follow cabin unstow on Flight Day 1 and continue through to Flight Day 7.

Secondary objectives for STS-42 include a series of middeck and GAS experiments, including the following: Gelation of Sols: Applied Microgravity Research (GOSAMR); Investigations Into Polymer Membrane Processing (IPMP); Radiation Monitoring Equipment (RME)-III; IMAX camera; two student experiments (Convection in Zero Gravity and Capillary Rise of Liquid Through Granular Porous Media); and 10 GAS canister experiments mounted on a GAS Bridge Assembly (GBA) in Discovery's payload bay. The crew of STS-42 will also conduct continuing life sciences research in preparation for planned extended duration orbiter (EDO) operations and will gather Earth observation data throughout the flight.

Gelation of Sols: Applied Microgravity Research (GOSAMR) is a middeck experiment that will investigate the influence of microgravity on the processing of advanced ceramics materials.

The research objective of the IPMP payload is to investigate the formation of polymer membranes in microgravity, research that could lead to possible advances in filtering technologies. The IPMP requires one-half of a middeck locker and approximately 30 minutes of crew time.

The RME-III payload in Discovery's middeck takes measurements of the ionizing radiation levels in the orbiter crew compartment. The handheld unit contains a liquid crystal display for real-time data display and a keyboard for controlling its functions. It occupies half of a middeck locker.

The IMAX camera, a large format camera flown on several shuttle missions as a joint project by NASA, the National Air and Space Museum, and the IMAX Film Corporation, will be used to film activities in the Spacelab module and orbiter crew compartment, emphasizing the space physiology experiments that have a bearing on future long-duration human presence in space. The crew will also take advantage of the high inclination of the STS-42 orbit to film Earth features at latitudes not overflown by most Shuttle flights. The scenes will be used in an IMAX film now in production on mankind's future in space.

The objective of Student Experiment 81-09, Convection in Zero Gravity, is to study the effects of heat on surface tension-induced flows in microgravity. The experiment is housed in Discovery's middeck.

The objective of Student Experiment 83-02, Capillary Rise of Liquid Through Granular Porous Media, is to investigate the effects of gravity on the flow characteristics of a fluid through granular substances via capillary action. It is housed in Discovery's middeck.

Attached cargo operations will be performed with the 10 GAS canister experiments contained in the GAS bridge assembly mounted in Discovery's aft payload bay. Experiments from six countries (United States, Japan, Sweden, Germany, Australia, and China) will be conducted, encompassing materials processing, life sciences, fluid physics, and astronomical observations. Crew interface is minimal, requiring only switch activation/deactivation from the aft flight deck.

Sixteen development test objectives and nine detailed supplementary objectives are scheduled to be flown on STS-42.

MISSION STATISTICS

Vehicle: Discovery (OV-103), 14th flight

Launch Date/Time:

1/22/92 8:53 a.m., EST
7:53 a.m., CST
5:53 a.m., PST

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

Launch Window: 2 hours, 30 minutes

Launch Clearance Window for 1/22/92: 8:53 a.m. EST to 11:42 a.m. EST.

Mission Duration: 7 days, 1 hour, 12 minutes

Landing: Nominal end of mission landing on Orbit 113

1/29/92 10:05 a.m., EST
9:05 a.m., CST
7:05 a.m., PST

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

Transatlantic Abort Landing: Zaragoza, Spain; alternates are Moron, Spain; and Ben Guerir, Morocco

Return to Launch Site: KSC

Abort-Once-Around: NOR; alternate is EAFB

Inclination: 57 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 cut 'f plus approximately 2 minutes is eliminated in this direct-insertion ascent profile. The VIS-1 thrusting maneuver is replaced by a 5-foot-per-second reaction control syst ı maneuver to facilitate the main propulsion system propellant dump.

Altitude: 163-nautical-mile (188-statute-mile) circular orbit

Space Shuttle Main Engine Thrust Level During Ascent: 104 percent

Space Shuttle Main Engine Locations:

No. 1 position: Engine 2026
No. 2 position: Engine 2022
No. 3 position: Engine 2027

Total Lift-off Weight: Approximately 4,507,474 pounds

Orbiter Weight, Including Cargo, at Lift-off: Approximately 243,395 pounds

Orbiter (Discovery) Empty, and 3 SSMEs: Approximately 172,707 pounds

Payload Weight Up: Approximately 28,663 pounds

Payload Weight Down: Approximately 28,663 pounds

Orbiter Weight at Landing: Approximately 218,016 pounds

Payloads--Payload Bay (* denotes primary payload): International Microgravity Laboratory (IML)-1*, Getaway Special (GAS) bridge, IMAX camera

Payloads--Middeck: Gelation of Sols: Applied Microgravity Research (GOSAMR)-1, Investigations Into Polymer Membrane Processing (IPMP), Radiation Monitoring Equipment (RME)-III, Student Experiment 81-09: Convection in Zero Gravity, Student Experiment 83-02: Capillary Rise of Liquid Through Granular Porous Media

Flight Crew Members:

Blue Team:

Commander: Ronald (Ron) J. Grabe, third space shuttle flight
Pilot: Stephen (Steve) S. Oswald, first space shuttle flight
Mission Specialist 1: Dr. Norman (Norm) E. Thagard, fourth space shuttle flight
Payload Specialist 1: Dr. Roberta L. Bondar, Canadian Space Agency, first space shuttle flight

Red Team:

Mission Specialist 2: William (Bill) F. Readdy, first space shuttle flight
Mission Specialist 3: David (Dave) C. Hilmers, fourth space shuttle flight
Payload Specialist 2: Ulf D. Merbold, European Space Agency, second space shuttle flight

Grabe, Oswald, and Readdy make up the orbiter crew, which will operate the shuttle and Spacelab systems monitored by the Mission Control Center at Johnson Space Center (JSC). Hilmers, Bondar, and Merbold form the science crew, which will operate the IML-1 experiments monitored by the Payload Operations Control Center at Marshall Space Flight Center (MSFC).

Ascent Seating:

Flight deck, front left seat, commander Ronald (Ron) J. Grabe
Flight deck, front right seat, pilot Stephen (Steve) S. Oswald
Flight deck, aft center seat, mission specialist William (Bill) F. Readdy
Flight deck, aft right seat, mission specialist Dr. Norman (Norm) E. Thagard
Middeck, mission specialist David (Dave) C. Hilmers
Middeck, payload specialist Dr. Roberta L. Bondar
Middeck, payload specialist Ulf D. Merbold

Entry Seating:

Flight deck, front left seat, commander Ronald (Ron) J. Grabe
Flight deck, front right seat, pilot Stephen (Steve) S. Oswald
Flight deck, aft center seat, mission specialist William (Bill) F. Readdy
Flight deck, aft right seat, mission specialist David (Dave) C. Hilmers
Middeck, mission specialist Dr. Norman (Norm) E. Thagard
Middeck, payload specialist Dr. Roberta L. Bondar
Middeck, payload specialist Ulf D. Merbold

Extravehicular Activity Crew Members, If Required:

Extravehicular (EV) astronaut-1: mission specialist Dr. Norman (Norm) E. Thagard
EV-2: mission specialist William (Bill) F. Readdy

Intravehicular Astronaut: pilot Stephen (Steve) S. Oswald

STS-42 Flight Directors:

Ascent/Entry: Wayne Hale
Orbit 1 Team: Jeff Bantle
Orbit 2 Team (lead): Bob Castle
Planning Team: Chuck Shaw

STS-42 Control Centers:

Space Shuttle and Spacelab module: JSC
IML-1: MSFC

Entry: Automatic mode until subsonic, then control-stick steering

Notes:

. The remote manipulator system is not installed in Discovery's payload bay for this mission
. The galley is installed in Discovery's middeck
. Landing is planned at EAFB due to Discovery's heavier landing weight (return to Earth of the IML-1 laboratory)
. Upon its return to Florida, Discovery will be removed from flight status for the next 8-1/2 months to undergo major modifications, upgrades, and required inspections. Discovery's next flight is STS-53, a scheduled fall 1992 mission for the Department of Defense.

MISSION OBJECTIVES

. Primary Payload
  - International Microgravity Laboratory-1
. Secondary Payloads
  - Payload Bay
    . GAS Bridge Assembly with 10 Getaway Specials
    . IMAX camera
  - Middeck
    . Gelation of Sols: Applied Microgravity Research (GOSAMR)-1
    . Investigations Into Polymer Membrane Processing (IPMP)
    . Radiation Monitoring Equipment III
    . Student Experiment 81-09: Convection in Zero Gravity
    . Student Experiment 82-03: Capillary Rise of Liquid Through Granular Porous Media. .
. Development Test Objectives/Detailed Supplementary Objectives

FLIGHT ACTIVITIES OVERVIEW

Flight Day 1

Launch
OMS-2
Unstow cabin
IML-1 activation
Transfer science specimens to Spacelab
IML experiment operations

Flight Day 2

IML-1 experiment operations

Flight Day 3

IML-1 experiment operations

IML-1 experiment operations

Flight Day 4

IML experiment operations

Flight Day 5

IML experiment operations

Flight Day 6

IML experiment operations

Flight Day 7

IML experiment operations
IML-1 deactivation
RCS hot fire test
FCS checkout
Cabin stow
Deorbit preparation

Flight Day 7 (continued)

Deorbit burn

Flight Day 8

Landing

Notes:

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

- Due to power requirements and the length of the mission, an equipment powerdown (referred to as a Group B powerdown), is executed on flight day 1 to conserve cryogenics for a full mission duration plus two extension days (if required). Powerdown activities include powering off three of Discovery's four CRT's, placing three of Discovery's five general-purpose computers on standby, placing one of Discovery's three inertial measurement units on standby mode, and powering off three of Discovery's eight flight-critical multiplexers (two forward, one aft).

DEVELOPMENT TEST OBJECTIVES/DETAILED SUPPLEMENTARY OBJECTIVES

DTOs

. Entry aerodynamic control surfaces test (Part 6) (DTO 242)
. Ascent wing structural capability evaluation (DTO 301D)
. Ascent compartment venting evaluation (DTO 305D)
. Descent compartment venting evaluation (DTO 306D)
. Entry structural evaluation (DTO 307 D)
. Vibration and accoustic evaluation (DTO 308D)
. ET TPS performance--crew photography after ET separation (DTO 312)
. Shuttle/payload low frequency environment (DTO 319D)
. Cabin air monitoring (DTO 623)
. Eyewash--zero-g eyewash kit test (DTO 635)
. On-orbit cabin air cleaner evaluation (DTO 637)
. Spacelab CO2 control (DTO 641)
. Electronic still photography (DTO 648)
. EDO cycle ergometer hardware evaluation (DTO 651)
. Evaluation of the MK I rowing machine (DTO 653)
. Crosswind landing performance (DTO 805)

DSOs

. Variation in supine and standing heart rate, blood pressure, and cardiac size (DSO 466)
. In-flight radiation dose-distribution (DSO 469)
. The relationship of space adaption syndrome to middle cerebral artery blood velocity measured during entry, landing, and egress (DSO 470)
. Orthostatic equilibrium control during landing/egress (DSO 603B)
. Air monitoring instrument evaluation and atmosphere characterization (DSO 611)
. Changes in endocrine regulation of orthostatic tolerance following space flight (DSO 613)
. Documentary television (DSO 901)
. Documentary motion picture photography (DSO 902)
. Documentary still photography (DSO 903)

STS-42 PRELAUNCH COUNTDOWN

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

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

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

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

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

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

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

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

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

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

STS-42 MISSION HIGHLIGHTS TIMELINE

Editor's Note: The following timeline lists selected highlights only. For full detail, please refer to the NASA Mission Operations Directorate STS-42 Flight Plan, Ascent Checklist, Post Insertion Checklist, Spacelab Activation/Deactivation Checklist, Deorbit Prep Checklist, and Entry Checklist.

T+ (PLUS) DAY/ HR:MIN:SEC	EVENT
DAY ZERO	
0/00:00:07	Tower is cleared (SRBs above lightning-rod tower).
0/00:00:10	180-degree positive roll maneuver (right-clockwise) is started. Pitch profile is heads down (astronauts), wings level.
0/00:00:18	Roll maneuver ends.
0/00:00:26	All three SSMEs throttle down from 104 to 70 percent for maximum aerodynamic load (max q).
0/00:00:59	All three SSMEs throttle to 104 percent.
0/00:01:04	Max q occurs.
0/00:02:06	SRBs separate.
	When chamber pressure (Pc) of the SRBs is less than 50 psi, automatic separation occurs with manual flight crew backup switch to the automatic function (does not bypass automatic circuitry). SRBs descend to approximately 15,400 feet, when the nose cap is jettisoned and drogue chute is deployed for initial deceleration.

T+ (PLUS) DAY/ HR:MIN:SEC	EVENT
	At approximately 6,600 feet, drogue chute is released and three main parachutes on each SRB provide final deceleration prior to splashdown in Atlantic Ocean, where the SRBs are recovered for reuse on another mission. Flight control system switches from SRB to orbiter RGAs.
0/00:04:04	Negative return. The vehicle is no longer capable of return-to-launch site abort at Kennedy Space Center runway.
0/00:07:01	Single engine press to main engine cutoff (MECO).
0/00:08:26	All three SSMEs throttle down to 67 percent for MECO.
0/00:08:32	MECO occurs at approximate velocity 24,919 feet per second, 17 by 163 nautical miles (20 by 188 statute miles).
0/00:08:50	ET separation is automatic with flight crew manual backup switch to the automatic function (does not bypass automatic circuitry).
	The orbiter forward and aft RCSs, which provide attitude hold and negative Z translation of 11 fps to the orbiter for ET separation, are first used.
	Orbiter/ET liquid oxygen/liquid hydrogen umbilicals are retracted.
	Negative Z translation is complete.

T+ (PLUS) DAY/ HR:MIN:SEC	EVENT
	In conjunction with this thrusting period, approximately 1,700 pounds of liquid hydrogen and 3,700 pounds of liquid oxygen are trapped in the MPS ducts and SSMEs, which results in an approximate 7-inch center-of-gravity shift in the orbiter. The trapped propellants would sporadically vent in orbit, affecting guidance and creating contaminants for the payloads. During entry, liquid hydrogen could combine with atmospheric oxygen to form a potentially explosive mixture. As a result, the liquid oxygen is dumped out through the SSME combustion chamber nozzles, and the liquid hydrogen is dumped out through the right-hand T-minus-zero umbilical overboard fill and drain valves.
	MPS dump terminates.
	APUs shut down.
	MPS vacuum inerting occurs.
	--Remaining residual propellants are vented to space vacuum, inerting the MPS.
	--Orbiter/ET umbilical doors close (one door for liquid hydrogen and one door for liquid oxygen) at bottom of aft fuselage, sealing the aft fuselage for entry heat loads.
	--MPS vacuum inerting terminates.
0/00:36	OMS-2 thrusting maneuver is performed, approximately 2 minutes, 41 seconds in duration, at 263 fps, 164 by 163 nautical miles.
0/00:51	Commander closes all current breakers, panel L4.
0/00:53	Mission specialist (MS)/payload specialist (PS) seat egress.
0/00:54	Commander and pilot configure GPCs for OPS-2.
0/00:57	MS configures preliminary middeck.

T+ (PLUS) DAY/ HR:MIN:SEC	EVENT
0/00:59	MS configures aft flight station.
0/01:02	MS unstows, sets up, and activates PGSC.
0/01:06	Pilot activates payload bus (panel R1).
0/01:08	Commander and pilot don and configure communications.
0/01:12	Pilot maneuvers vehicle to payload bay door opening attitude, biased negative Z local vertical, positive Y velocity vector attitude.
0/01:13	Orbit 2 begins.
0/01:17	Commander activates radiators.
0/01:19	If go for payload bay door operations, MS configures for payload bay door operations.
0/01:28	Pilot opens payload bay doors.
0/01:33	Commander switches star tracker (ST) power 2 (panel 06) to ON.
0/01:36	Mission Control Center (MCC), Houston (H), informs crew to "go for orbit operations."
0/01:37	Commander and pilot seat egress.
0/01:38	Commander and pilot clothing configuration.
0/01:39	MS/PS clothing configuration.
0/01:50	Pilot initiates fuel cell auto purge.
0/01:51	MS activates teleprinter (if flown).
0/01:52	Commander begins post-payload bay door operations and radiator configuration.

T+ (PLUS) DAY/ HR:MIN:SEC	EVENT
0/01:55	MS/PS remove and stow seats.
0/01:56	Commander starts ST self-test and opens door.
0/01:57	MS configures middeck.
0/01:58	Pilot closes main B supply water dump isolation circuit breaker, panel ML86B, opens supply water dump isolation valve, panel R12L.
0/02:01	Pilot activates auxiliary power unit steam vent heater, panel R2, boiler controller/heater, 3 to A, power, 3 to ON.
0/02:10	Commander configures for RCS vernier control.
0/02:10	Initiate Spacelab activation.
0/02:12	Commander and pilot configure controls for on-orbit operations.
0/02:20	Pilot stows and deploys radiator.
0/02:20	Ku-band antenna deployment.
0/02:21	Pilot enables hydraulic thermal conditioning.
0/02:22	MS resets caution/warning (C/W).
0/02:26	Pilot switches APU coolant system (panel R2) fuel pump/ valve A to OFF, B to AUTO.
0/02:28	Pilot plots fuel cell performance.
0/02:30	Ku-band antenna activation.
0/02:30	Red team begins presleep activities.
0/02:57	Orbit 3 begins.

T+ (PLUS) DAY/ HR:MIN:SEC	EVENT
0/03:10	Priority Group B powerdown.
0/03:25	Maneuver vehicle to IMU align/COAS calibration attitude.
0/03:25	Blue team Spacelab ingress.
0/03:30	Red team begins sleep period.
0/03:40	IMU alignment: ST.
0/03:40	Blue team continues Spacelab activation procedures.
0/03:45	COAS calibration, aft station.
0/03:55	Tracking maneuver.
0/04:28	Orbit 4 begins.
0/04:40	Payload activation (Spacelab).
0/05:00	Biorack activation.
0/05:00	Maneuver vehicle to COAS calibration attitude.
0/05:00	Blue team IML activities.
0/05:10	COAS calibration, forward station.
0/05:20	Tracking maneuver.
0/05:58	Orbit 5 begins.
0/06:25	RME-III activation and checkout.
0/06:35	DTO 623--cabin air monitoring.
0/06:40	TEPC setup (DSO 469--radiation dose distribution).
0/07:00	IML EGGS/BONES experiments.

T+ (PLUS) DAY/ HR:MIN:SEC	EVENT
0/07:28	Orbit 6 begins.
0/08:10	OCAC setup.
0/08:30	DSO 611--air monitoring (AOS).
0/08:59	Orbit 7 begins.
0/09:20	Blue team begins presleep activities.
0/09:30	Red team begins postsleep activities.
0/10:15	Blue team handover to red team.
0/10:30	Orbit 8 begins.
0/11:00	Red team IML activities.
0/11:05	Blue team begins sleep period.
0/12:00	Orbit 9 begins.
0/12:00	Group A getaway specials.
0/13:00	IML CELLS experiment.
0/13:30	DSO 611--air monitoring (MAS).
0/13:31	Orbit 10 begins.
0/15:02	Orbit 11 begins.
0/15:30	IMU alignment: ST.
0/16:32	Orbit 12 begins.
0/17:00	IML SLED experiment.
0/17:50	IML MVI experiments.

T+ (PLUS) DAY/ HR:MIN:SEC	EVENT
0/18:03	Orbit 13 begins.
0/18:30	Group B getaway specials.
0/19:05	Blue team begins postsleep activities.
0/19:30	DTO 651--exercise.
0/19:33	Orbit 14 begins.
0/20:30	Blue team IML activities.
0/20:45	DSO 470--transcranial doppler.
0/21:04	Orbit 15 begins.
0/21:10	Red team handover to blue team.
0/21:45	Red team begins presleep activities.
0/22:34	Orbit 16 begins.
0/23:00	DTO 651--exercise.

MET DAY ONE

1/00:00	Red team begins sleep period.
1/00:05	Orbit 17 begins.
1/00:25	IML SLED/YEAST experiments.
1/01:35	Orbit 18 begins.
1/03:05	Orbit 19 begins.
1/03:55	IMU alignment: ST.
1/04:30	DSO 611--air monitoring (AOS).

T+ (PLUS) DAY/ HR:MIN:SEC	EVENT
1/04:35	IML SPE experiment.
1/04:36	Orbit 20 begins.
1/05:30	IML MVI experiments.
1/06:06	Orbit 21 begins.
1/06:45	Group C getaway specials.
1/07:00	Tracking maneuver.
1/07:30	Group D getaway specials.
1/07:37	Orbit 22 begins.
1/08:00	DTO 651--exercise.
1/08:00	Red team begins postsleep activities.
1/09:07	Orbit 23 begins.
1/09:30	Blue team handover to red team.
1/09:45	DTO 653--exercise.
1/09:45	Blue team begins presleep activities.
1/09:45	Red team IML activities.
1/10:38	Orbit 24 begins.
1/11:15	IML VCGS experiment.
1/12:00	IML crystal growth (TGS) experiment.
1/12:00	Blue team begins sleep period.
1/12:08	Orbit 25 begins.

T+ (PLUS) DAY/ HR:MIN:SEC	EVENT
1/13:39	Orbit 26 begins.
1/15:00	Tracking maneuver.
1/15:09	Orbit 27 begins.
1/15:45	Group E getaway specials.
1/16:15	IMU alignment: ST.
1/16:40	Orbit 28 begins.
1/18:10	Orbit 29 begins.
1/19:41	Orbit 30 begins.
1/20:00	Blue team begins postsleep activities.
1/20:15	IML CELLS experiment.
1/21:11	Orbit 31 begins.
1/21:30	Red team handover to blue team.
1/21:45	Red team begins presleep activities.
1/21:45	Blue team IML activities.
1/22:42	Orbit 32 begins.

MET DAY TWO

2/00:00	Red team begins sleep period.
2/00:12	Orbit 33 begins.
2/00:15	RME-III memory module replacement.
2/01:00	IML SPE experiment.

T+ (PLUS) DAY/ HR:MIN:SEC	EVENT
2/01:43	Orbit 34 begins.
2/02:00	Group F getaway specials.
2/03:13	Orbit 35 begins.
2/04:00	IMU alignment: ST.
2/04:30	DSO 611--air monitoring (AOS).
2/04:44	Orbit 36 begins.
2/05:00	IML PCG experiment.
2/05:05	IML MVI experiments.
2/06:14	Orbit 37 begins.
2/06:30	Group G getaway specials.
2/07:00	Tracking maneuver.
2/07:45	Orbit 38 begins.
2/07:45	DTO 651--exercise.
2/08:00	Red team begins postsleep activities.
2/08:30	DTO 653--exercise.
2/09:15	Orbit 39 begins.
2/09:30	Blue team handover to red team.
2/09:45	Group H getaway specials.
2/09:45	Blue team begins presleep activities.
2/09:45	Red team IML activities.

T+ (PLUS) DAY/ HR:MIN:SEC	EVENT
2/10:46	Orbit 40 begins.
2/11:45	Group I getaway specials.
2/12:00	IML SLIME experiment.
2/12:00	Blue team begins sleep period.
2/12:16	Orbit 41 begins.
2/12:45	Group J getaway specials.
2/13:47	Orbit 42 begins.
2/14:30	IMU alignment: ST.
2/15:00	Tracking maneuver.
2/15:17	Orbit 43 begins.
2/16:47	Orbit 44 begins.
2/17:00	SE83-02: capillary rise of liquid.
2/18:00	Group K getaway specials.
2/18:18	Orbit 45 begins.
2/19:48	Orbit 46 begins.
2/19:50	DTO 651--exercise.
2/20:00	Blue team begins postsleep activities.
2/20:35	IML TGS experiment.
2/21:19	Orbit 47 begins.
2/21:30	Red team handover to blue team.

T+ (PLUS) DAY/ HR:MIN:SEC	EVENT
2/21:45	Group L getaway specials.
2/21:45	Blue team IML activities.
2/21:45	Red team begins presleep activities.
2/22:50	Orbit 48 begins.
2/23:00	DTO 651--exercise.

MET DAY THREE

3/00:00	Red team begins sleep period.
3/00:00	IML material science experiment (CAST).
3/00:20	Orbit 49 begins.
3/01:50	Orbit 50 begins.
3/03:21	Orbit 51 begins.
3/03:35	IMU alignment: ST.
3/04:30	DSO 611--air monitoring (AOS).
3/04:52	Orbit 52 begins.
3/05:00	IML CELLS experiment.
3/06:10	Group M getaway specials.
3/06:22	Orbit 53 begins.
3/06:25	IMAX operations.
3/07:00	Tracking maneuver.
3/07:53	Orbit 54 begins.

T+ (PLUS) DAY/ HR:MIN:SEC	EVENT
3/08:00	Red team begins postsleep activities.
3/08:30	DTO 653--exercise.
3/09:23	Orbit 55 begins.
3/09:30	Blue team handover to red.
3/09:45	Blue team begins presleep activities.
3/09:45	Red team IML activities.
3/10:00	IML CAST experiment.
3/10:54	Orbit 56 begins.
3/11:00	DTO 653--exercise.
3/12:00	Blue team begins sleep period.
3/12:24	Orbit 57 begins.
3/12:45	Group N getaway specials.
3/13:15	DSO 611--air monitoring (MAS).
3/13:55	Orbit 58 begins.
3/14:50	Tracking maneuver.
3/15:15	IMU alignment: ST.
3/15:25	Orbit 59 begins.
3/16:55	Orbit 60 begins.
3/17:00	IPMP activation.
3/18:10	RME-III memory module replacement.

T+ (PLUS) DAY/ HR:MIN:SEC	EVENT
3/18:26	Orbit 61 begins.
3/19:15	IML SLIME experiment.
3/19:55	Orbit 62 begins.
3/20:00	IML PPE experiment.
3/20:00	Blue team begins postsleep activities.
3/21:27	Orbit 63 begins.
3/22:00	Red team handover to blue team.
3/22:15	DTO 651--exercise.
3/22:15	Blue team IML activities.
3/22:57	Orbit 64 begins.
3/23:15	Red team begins presleep activities.
MET DAY FOUR	
4/00:00	GOSAMR activation.
4/00:20	IPMP deactivation.
4/00:28	Orbit 65 begins.
4/00:50	IMAX operations.
4/01:30	DTO 635--eye wash.
4/01:30	Red team begins sleep period.
4/01:58	Orbit 66 begins.
4/03:20	IMU alignment: ST.

T+ (PLUS) DAY/ HR:MIN:SEC	EVENT
4/03:28	Orbit 67 begins.
4/04:50	DSO 611--air monitoring (AOS).
4/04:59	Orbit 68 begins.
4/05:40	SE81-09: Convection.
4/06:00	IML MVI experiments.
4/06:30	Orbit 69 begins.
4/08:00	Orbit 70 begins.
4/09:30	Orbit 71 begins.
4/09:30	DTO 653--exercise.
4/09:30	Red team begins postsleep activities.
4/10:45	Blue team handover to red team.
4/11:00	Red team IML activities.
4/11:00	Blue team begins presleep activities.
4/11:02	Orbit 72 begins.
4/12:30	Blue team begins sleep period.
4/12:31	Orbit 73 begins.
4/13:55	IML SLED experiment.
4/14:02	Orbit 74 begins.
4/14:10	IMAX operations.
4/15:20	IMU alignment: ST.

T+ (PLUS) DAY/ HR:MIN:SEC	EVENT
4/15:33	Orbit 75 begins.
4/17:03	Orbit 76 begins.
4/17:55	IML MVI experiments.
4/18:33	Orbit 77 begins.
4/20:05	Orbit 78 begins.
4/20:30	Blue team begins postsleep activities.
4/21:34	Orbit 79 begins.
4/21:35	DTO 651--exercise.
4/22:45	Red team handover to blue team.
4/23:00	DTO 653--exercise.
4/23:00	Blue team IML activities.
4/23:05	Orbit 80 begins.
4/23:45	DTO 651--exercise.
4/23:45	Red team begins presleep activities.

MET DAY FIVE

5/00:00	DTO 651--exercise.
5/00:35	Orbit 81 begins.
5/01:15	IMAX operations.
5/02:00	Red team begins sleep period.
5/02:06	Orbit 82 begins.

T+ (PLUS) DAY/ HR:MIN:SEC	EVENT
5/02:30	DSO 611--air monitoring (AOS).
5/02:55	IMU alignment: ST.
5/03:36	Orbit 83 begins.
5/03:50	IML ROOTS experiment.
5/05:06	Orbit 84 begins.
5/06:37	Orbit 85 begins.
5/06:40	IML MVI experiments.
5/08:07	Orbit 86 begins.
5/09:00	RME-III memory module replacement.
5/09:38	Orbit 87 begins.
5/10:00	Red team begins postsleep activities.
5/10:45	Blue team handover to red team.
5/11:00	Blue team begins presleep activities.
5/11:08	Orbit 88 begins.
5/11:30	Red team IML activities.
5/12:30	Blue team begins sleep period.
5/12:39	Orbit 89 begins.
5/13:40	IML SLED experiment.
5/14:09	Orbit 90 begins.
5/14:30	IMU alignment: ST.

T+ (PLUS) DAY/ HR:MIN:SEC	EVENT
MET DAY SIX	
5/15:40	Orbit 91 begins.
5/16:20	IMAX operations.
5/17:10	Orbit 92 begins.
5/18:00	IML MVI experiments.
5/18:40	Orbit 93 begins.
5/20:11	Orbit 94 begins.
5/20:20	DTO 653--exercise.
5/20:30	Blue team begins postsleep activities.
5/21:42	Orbit 95 begins.
5/22:00	FCS checkout.
5/23:12	Orbit 96 begins.
5/23:20	Red team handover to blue team.
5/23:35	Crew press conference.
6/00:00	Blue team IML activities.
6/00:43	Orbit 97 begins.
6/01:00	TEPC stow (DSO 469--radiation dose distribution).
6/01:20	DSO 611--air monitoring (MAS).
6/01:30	DTO 653--exercise.
6/01:40	Red team begins presleep activities.

T+ (PLUS) DAY/ HR:MIN:SEC	EVENT
6/02:13	Orbit 98 begins.
6/02:30	DTO 651--exercise.
6/02:45	DSO 611--air monitoring (AOS).
6/03:00	IMU alignment: ST.
6/03:43	Orbit 99 begins.
6/03:55	Red team begins sleep period.
6/05:13	Orbit 100 begins.
6/06:30	IML PCG deactivation.
6/06:44	Orbit 101 begins.
6/07:30	Biorack unload.
6/08:15	Orbit 102 begins.
6/08:55	OCAC stow.
6/09:45	Orbit 103 begins.
6/09:55	IMAX operations.
6/10:55	Blue team begins presleep activities.
6/11:15	Orbit 104 begins.
6/11:55	Red team begins postsleep activities.
6/12:10	Blue team handover to red team.
6/12:25	Blue team begins presleep activities.
6/12:40	Blue team begins sleep period.

T+ (PLUS) DAY/ HR:MIN:SEC	EVENT
6/12:46	Orbit 105 begins.
6/13:25	Cabin stow.
6/13:30	IMAX stow.
6/14:10	DTO 623--cabin air monitoring.
6/14:17	Orbit 106 begins.
6/15:00	IMU alignment: ST.
6/15:47	Orbit 107 begins.
6/15:30	Group R getaway specials.
6/15:55	Initiate PTC.
6/16:25	Payload deactivation.
6/16:55	Spacelab deactivation.
6/17:17	Orbit 108 begins.
6/17:55	Spacelab egress.
6/18:25	Priority Group B powerup.
6/18:40	Blue team begins postsleep activities.
6/18:47	Orbit 109 begins.
6/19:08	Terminate PTC.
6/19:10	Maneuver vehicle to biased -XSI attitude.
6/19:30	RCS hot fire test.
6/20:00	DSO 603--entry preparation.

T+ (PLUS) DAY/ HR:MIN:SEC	EVENT
6/20:14	Begin deorbit preparation.
6/20:14	CRT timer setup.
6/20:18	Orbit 110 begins.
6/20:19	Commander initiates coldsoak.
6/20:28	Stow radiators, if required.
6/20:46	Commander configures DPS for deorbit preparation.
6/20:49	Mission Control Center updates IMU star pad, if required.
6/20:58	MS configures for payload bay door closure.
6/21:19	Maneuver vehicle to IMU alignment attitude.
6/21:20	MCC-H gives "go/no-go" command for payload bay door closure.
6/21:34	IMU alignment: ST/payload bay door closing operations.
6/21:48	Orbit 111 begins.
6/21:54	Commander and pilot configure dedicated displays for entry.
6/21:57	MCC gives the crew the go for OPS 3.
6/22:00	Maneuver vehicle to deorbit burn attitude.
6/22:04	Pilot starts repressurization of SSME systems.
6/22:09	Commander and pilot perform DPS entry configuration.
6/22:18	MS deactivates ST and closes ST doors.
6/22:20	All crew members verify entry payload switch list.
6/22:35	All crew members perform entry review.

T+ (PLUS) DAY/ HR:MIN:SEC	EVENT
6/22:37	Crew begins fluid loading, 32 fluid ounces of water with salt over next 1.5 hours (2 salt tablets per 8 ounces).
6/22:50	Commander and pilot configure clothing.
6/23:05	MS/PS configure clothing.
6/23:15	Commander and pilot seat ingress.
6/23:17	Commander and pilot set up heads-up display (HUD).
6/23:19	Orbit 112 begins.
6/23:19	Commander and pilot adjust seat, exercise brake pedals.
6/23:27	Final entry deorbit update/uplink.
6/23:33	OMS thrust vector control gimbal check is performed.
6/23:34	APU prestart.
6/23:49	Close vent doors.
6/23:53	MCC-H gives "go" for deorbit burn period.
6/23:59	Manuever vehicle to deorbit burn attitude.

MET DAY SEVEN

7/00:00	MS/PS ingress seats.
7/00:08	First APU is activated.
7/00:14	Deorbit burn period, approximately 3 minutes, 5 seconds in duration, at 268 fps, 161 by 160 nm.
7/00:19	Initiate post-deorbit burn period attitude.
7/00:23	Terminate post-deorbit burn attitude.

T+ (PLUS) DAY/ HR:MIN:SEC	EVENT
7/00:31	Dump forward RCS, if required.
7/00:39	Activate remaining APUs.
7/00:40	Entry interface, 400,000 feet altitude.
7/00:43	Enter communication blackout.
7/00:45	Automatically deactivate RCS roll thrusters.
7/00:49	Orbit 113 begins.
7/00:51	Initiate first roll reversal.
7/00:53	Automatically deactivate RCS pitch thrusters.
7/00:55	Exit communications blackout.
7/01:00	Begin PTI sequence.
7/01:00	Initiate second roll reversal.
7/01:04	Initiate third roll reversal.
7/01:05	Initiate air data system (ADS) probe deploy.
7/01:06	Begin entry/terminal area energy management (TAEM).
7/01:06	Initiate payload bay venting.
7/01:08	Automatically deactivate RCS yaw thrusters.
7/01:08	End PTI sequence.
7/01:11	Begin TAEM/approach/landing (A/L) interface.
7/01:11	Initiate landing gear deployment.
7/01:12	Vehicle has weight on main landing gear.

T+ (PLUS) DAY/ HR:MIN:SEC	EVENT
7/01:12	Vehicle has weight on nose landing gear.
7/01:12	Initiate main landing gear braking.
7/01:13	Wheel stop.

GLOSSARY

A/G	air-to-ground
AA	accelerometer assembly
ACS	active cooling system
ADS	air data system
AFB	Air Force base
A/L	approach and landing
AMU	attitude match update
APU	auxiliary power unit
ASE	airborne support equipment
BFS	backup flight control system
BR	biorack
BSK	biostack
CATS	composite activation test sample
CCD	charge-coupled device
COAS	crewman optical alignment sight
CPA	combustion products analyzer
CPF	critical point facility
CRT	cathode ray tube
CRY	cryostat
C/W	caution/warning
DAP	digital autopilot
DOD	Department of Defense
DPS	data processing system
DSO	detailed supplementary objective
DTO	development test objective
EAFB	Edwards Air Force Base
ECLSS	environmental control and life support system
EDO	extended duration orbiter
EHF	extremely high frequency
ELV	expendable launch vehicle
EMU	extravehicular mobility unit
EOM	end of mission
EPS	electrical power system
ESS	equipment support section
ET	external tank

ETR	Eastern Test Range
EV	extravehicular
EVA	extravehicular activity
FCS	flight control system
FES	flash evaporator system
FES	fluids experiment system
FDF	flight data file
FPS	feet per second
FRCS	forward reaction control system
FTA	fluid test article
GAS	getaway special
GBA	GAS bridge assembly
GPPF	gravitational plant physiology facility
GLS	ground launch sequencer
GN&C	guidance, navigation, and control
GOSAMR	gelation of solutions: applied microgravity research
GPC	general-purpose computer
GSFC	Goddard Space Flight Center
HAINS	high accuracy inertial navigation system
HRA	helmet retention assembly
HRM	high-rate multiplexer
HUD	heads-up display
IFM	in-flight maintenance
IMAX	IMAX camera
IML	International Microgravity Laboratory
IMU	inertial measurement unit
IOCM	interim operational contamination monitor
IPMP	investigations into polymer membrane processing
IR	infrared
IV	intravehicular
JSC	Johnson Space Center
KSC	Kennedy Space Center
LCD	liquid crystal display
LES	launch escape system
LPS	launch processing system
LRU	line replaceable unit

MAS	microbial air sampler
MCC-H	Mission Control Center--Houston
MDM	multiplexer/demultiplexer
MECO	main engine cutoff
MICG	mercuric iodide crystal growth
MET	mission elapsed time
MILA	Merritt Island
MLP	mobile launcher platform
MM	major mode
MPS	main propulsion system
MS	mission specialist
MSFC	Marshall Space Flight Center
MVI	microgravity vestibular investigations
MWPE	mental workload and performance experiment
NMI	nautical miles
NOR	Northrup Strip
O&C	operations and checkout
OAA	orbiter access arm
OCGP	organic crystal growth experiment with g-jitter preventive measurement
OMS	orbital maneuvering system
OTC	orbiter test conductor
PAM	particle anticoincidence mantle
PASS	primary avionics software system
PCG	protein crystal growth
PCMMU	pulse code modulation master unit
PCRS	payload cover removal system
PCS	pressure control system
PGSC	payload and general support computer
PI	payload interrogator
PIC	pyro initiator controller
PRLA	payload retention latch assembly
PS	payload specialist
PTI	preprogrammed test input
P/TV	photo/TV
RAAN	right ascension of the ascending node
RCS	reaction control system
RF	radio frequency
RGA	rate gyro assembly
R/IM	refrigerator/incubator module

RMCD	radiation monitoring container/dosimeter
RME	radiation monitoring equipment
RMS	remote manipulator system
ROEU	remotely operated electrical umbilical
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
SE	student experiment
SHF	superhigh frequency
SLM	star line maneuver
SM	statute miles
SPE	space physiology experiments
SPOC	shuttle portable on-board computer
SRB	solid rocket booster
SRM	solid rocket motor
SRSS	shuttle range safety system
SSF	Space Station Freedom
SSME	space shuttle main engine
SSP	standard switch panel
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
TCD	timing control distributor
TDRS	tracking and data relay satellite
TDRSS	tracking and data relay satellite system
TI	thermal phase initiation
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
USAF	U.S. Air Force
UVPI	ultraviolet plume instrument
VCDS	vapor crystal growth system
VTR	videotape recorder
WCS	waste collection system

PUB 3556-W REV 1-92