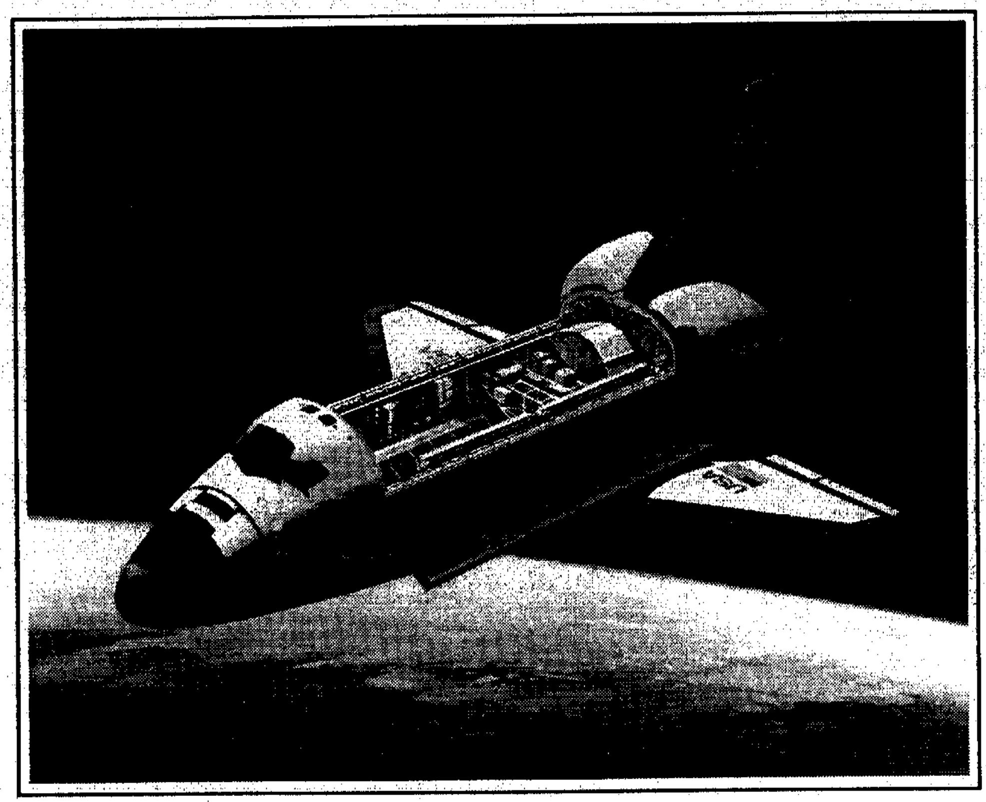

STS-52

PRESS INFORMATION

October 1992

Rockwell International
Space Systems Division

Office of External Communications &
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CONTENTS

MISSION OVERVIEW

This is the 13th flight of Columbia and the 51st for the space shuttle.

The flight crew for the 10-day STS-52 mission is commander James (Jim) D. Wetherbee; pilot Michael (Mike) A. Baker; mission specialists William (Bill) M. Shepherd, Tamara (Tammy) E. Jernigan, and Charles L. (Lacy) Veach; and payload specialist Steven (Steve) MacLean, of the Canadian Space Agency.

STS-52 will continue the shuttle program's investigation of our planet, advanced technologies, and advanced materials processing with applications on Earth and in space. The mission is challenging due to the large number of payloads (11) and their diversity, encompassing geophysics, materials sciences, biological research, and applied research for space station Freedom. Columbia's versatility as a satellite launcher, science platform, and technology test bed will all be demonstrated.

The mission has two primary objectives: deployment of the Laser Geodynamic Satellite (LAGEOS) and operations of the U.S. Microgravity Payload 1 (USMP-1).

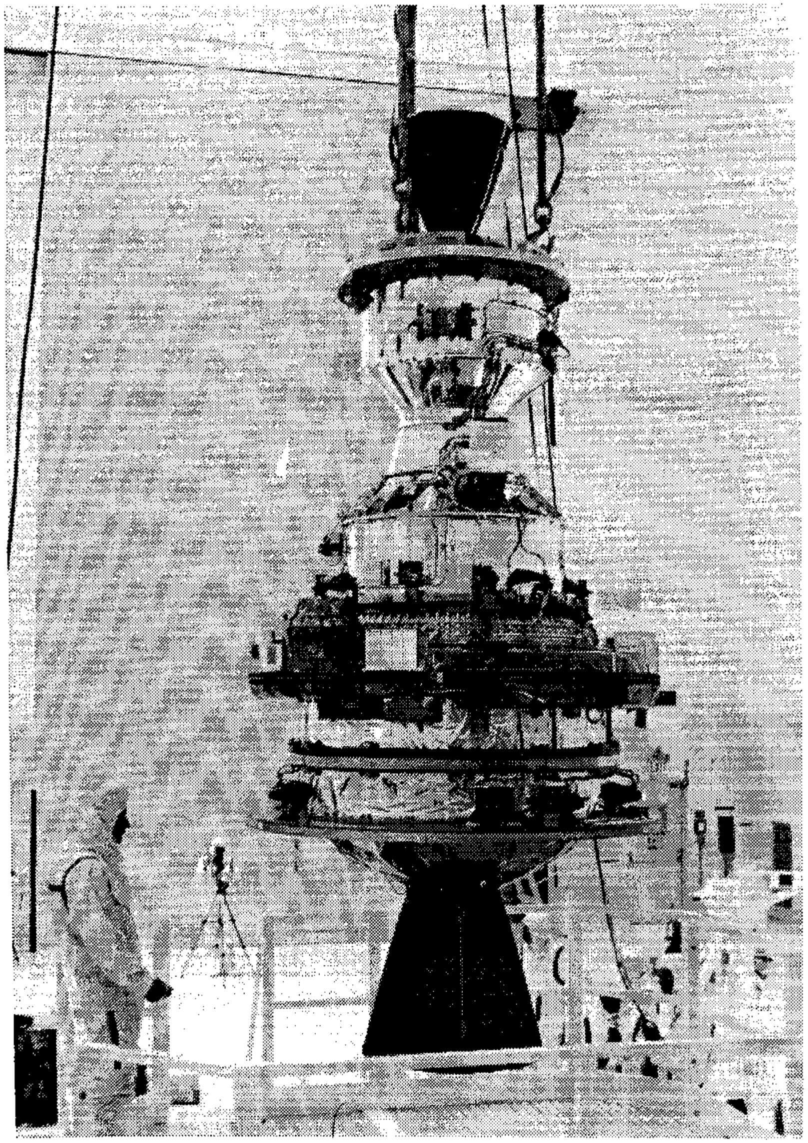
Columbia's crew will eject LAGEOS II from the orbiter's payload bay on the second mission day (Orbit 15) at an altitude of 160 nautical miles. Built by the Italian Space Agency using NASA blueprints, the 900-pound satellite will supplement the original LAGEOS launched in 1976 to provide geologists with ranging information through interaction with ground-based lasers. Laser ranging involves sending laser beams to a mirror-covered satellite and recording the round trip travel time. This measurement enables scientists to determine precisely the distances between laser ranging stations on Earth and the satellite.

LAGEOS will provide a reference point for laser ranging experiments that will monitor the motion of the Earth's crust, measure and understand the "wobble" in the Earth's axis of rotation, collect information on the Earth's size and shape, and more accurately determine the length of the day. The information will be particularly useful for monitoring regional fault movement in earthquake-prone areas. The data will be used by ground-based researchers from 30 countries. LAGEOS II will be placed in orbit by the Italian research interim stage (IRIS), a spinning solid upper stage perigee kick booster. The crew will command the deployment activities from the orbiter's aft flight deck. Forty-five minutes after deployment, the IRIS motor will fire and place LAGEOS II into the desired orbit.

The other primary payload is USMP-1, which consists of three experiments mounted on a new payload bay carrier: a mission-peculiar equipment support structure derived from a previously flown Materials Science Lab. The experiments are the Lamda Point Experiment (LPE), a new test measuring the heat capacity of cryogenic helium; Matériel Pour L'Étude des Phénomènes Intéressants la Solidification Sur Terre et en Orbite (MEPHISTO), which will study different parameters that influence crystalline growth; and the Space Acceleration Measurement System (SAMS), which will measure accelerations that affect LPE and MEPHISTO. SAMS will also store and transmit large blocks of data. The experiments will be operated by the Payload Operations Control Center at NASA's Marshall Space Flight Center, Huntsville, Ala.

STS-52 secondary objectives include the Attitude Sensor Package (ASP), Canadian Experiments (CANEX) 2, Commercial Protein Crystal Growth (CPCG), Heat Pipe Performance (HPP) Experiment, Physiological Systems Experiment (PSE), Shuttle Plume Impingement Experiment (SPIE), Crystals by Vapor Transport Experiment (CVTE), Commercial Materials ITA Experiment (CMIX), and Tank Pressure Control Experiment/Thermal Phenomena (TPCE/TP).

The ASP payload consists of three independent attitude sensors: the modular star sensor (MOSS); the yaw Earth sensor (YESS); and the low-altitude conical Earth sensor (LACES). The sensors are car-



LAGEOS II (Upper) Mated With IRIS in Spacecraft Assembly and Encapsulation Facility

ried on a hitchhiker platform in Columbia's payload bay. This European Space Agency payload will gather information on the performance and accuracy of new sensors. The data may be used in the design of sensors for future spacecraft.

The CANEX-2 payload, developed by the Canadian Space Agency, consists of eight sets of experiments, many of which are extensions of work carried out by Dr. Marc Garneau as part of the CANEX group of experiments that were flown on the shuttle in 1984. Results from CANEX-2 have potential applications in machine vision systems for use with robotic equipment in space and in environments such as mines and nuclear reactors. Other potential applications relate to the manufacturing of goods, the development of new protective coatings for spacecraft materials, improvements in materials processing, and a better understanding of Earth's stratosphere, which contains the protective ozone layer. Physiological experiments will also be conducted on back pain, body water changes, and the effect of weightlessness on the vestibular system.

The Space Vision System (SVS), the primary CANEX-2 experiment, is an experimental machine vision system to reinforce the accuracy of human vision in space. It uses the orbiter closed-circuit TV system, the remote manipulator system (RMS), and the Canadian target assembly (CTA), which is maneuvered on the RMS and then deployed on Flight Day 10.

The CTA is used as a test object for the SVS and for a NASA test objective on the effects of orbiter reaction control system plumes. It will not be retrieved. The CCTV system will track visual targets on the surface of the CTA.

The Material Exposure in Low Earth Orbit (MELEO) experiment consists of material samples on witness plates mounted on the RMS. The RMS will be maneuvered periodically to expose the plates at different positions and to permit the crew to observe the plates. MELEO will also measure atomic oxygen flux with the SPIE.

The Orbiter Glow (OGLOW) experiment will study the glow phenomenon generated on the orbiter surface at certain attitudes.

During the Sun Photospectrometer Earth Atmosphere Measurement (SPEAM) experiment, the crew will point a hand-held sun photospectrometer directly at the sun and moon through various orbiter windows to measure atmospheric absorption at several wavelengths during sunrise and sunset.

The Phase Partitioning in Liquids (PARLIQ) experiment is a middeck experiment that will study the phase partitioning process.

The Queen's University Experiment in Liquid Metal Diffusion (QUELD) consists of a small furnace operated in the middeck area.

The Space Adaptation Tests and Observations (SATO) experiment consists of a series of medical tests (space adaptation, vestibulo-ocular reflex, taste and smell, back pain, and proprioceptive illusions) performed by the payload specialist, Steven MacLean.

CPCG will supply information on the scientific methods and commercial potential for growing large, high-quality protein crystals in microgravity. The configuration on this flight, Block II, consists of a commercial refrigerator/incubator module (CRIM) and a protein crystallization facility (PCF).

The HPP payload in Columbia's middeck will study the behavior of heat pipes in the presence of spacecraft motion and the influence of the heat pipe on spacecraft motion.

The PSE will study the effects of a proprietary protein molecule on animal physiological systems in microgravity. The compound has possible use in combatting diseases that involve loss of bone mass. The PSE will be contained in two middeck lockers and two animal enclosure modules.

The SPIE payload consists of flux/fluence-sensing hardware mounted on the end effector of the shuttle's RMS, an electronics unit in the aft flight deck, and a payload and general-support computer for data recording. The SPIE hardware will record the effects of atomic oxygen on different materials and measure orbiter PRCS plume burns as a measure of contamination.

The CVTE middeck payload consists of two furnaces installed inside a middeck accommodations rack. On orbit, the CVTE will process material sample cartridges during low-g periods of the mission. Two samples will be processed on STS-52.

CMIX consists of an experiment housed in a refrigerator/incubator module. It consists of four material dispersion apparatus minilabs and occupies the space of one middeck locker. Protein crystal growth, collagen polymerization, and other phenomena will be studied. The data have potential applications in the biotechnology and pollution control fields.

TPCE/TP will verify models of fluid behaviors and flow patterns in tanks in microgravity that have application to the design of future cryogenic tanks for spacecraft. TPCE/TP is installed in a

Crew Insignia

sealed getaway special (GAS) canister attached to a GAS adapter beam in Columbia's payload bay.

Thirteen detailed test objectives and 13 detailed supplementary objectives are scheduled to be flown on STS-52.

MISSION STATISTICS

Vehicle: Columbia (OV-102), 13th flight

Launch Date/Time:

10/22/92	11:16 a.m., EDT
	10:16 a.m., CDT
	8:16 a.m., PDT

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

Launch Window: 2 hours, 13 minutes

Launch Period: 3 hours, 5 minutes

Mission Duration: 9 days, 20 hours, 46 minutes

Landing: Nominal end-of-mission landing on orbit 159

11/1/92	7:02 a.m., EST
	6:02 a.m., CST
	4:02 a.m., PST

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

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

Return to Launch Site: KSC

Abort-Once-Around: EAFB; alternates: KSC and NOR

Inclination: 28.45 degrees

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

The OMS-1 thrusting maneuver after main engine cutoff plus approximately 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.

Altitudes:
160 nautical miles (184 statute miles) circular orbit (LAGEOS deployment)
155 nautical miles (178 statute miles) circular orbit
113 nautical miles (130 statute miles) circular orbit (CANEX-2 CTA deployment)

Space Shuttle Main Engine Thrust Level During Ascent: 104 percent

Space Shuttle Main Engine Locations:

No. 1 position: Engine 2030
No. 2 position: Engine 2015
No. 3 position: Engine 2034

External Tank: ET-55

Solid Rocket Boosters: BI-054

Editor's note: The following weight data are current as of October 13,1992.

Total Lift-off Weight: Approximately 4,514,325 pounds

Orbiter Weight, Including Cargo, at Lift-off: Approximately 250,130 pounds

Orbiter (Columbia) Empty and 3 SSMEs: Approximately 181,169 pounds

Payload Weight Up: Approximately 20,077 pounds

Payload Weight Down: Approximately 14,419 pounds

Orbiter Weight at Landing: Approximately 215,114 pounds

Payloads—Payload Bay (*denotes primary payload): LAGEOS II/IRIS,* CANEX-2, USMP-1,* ASP, TPCE

Payloads—Middeck: PSE, HPP, CPCG, SPIE, CMIX, CVTE

Flight Crew Members:

Commander: James D. Wetherbee, second space shuttle flight
Pilot: Michael A. Baker, second space shuttle flight
Mission Specialist 1: Charles Lacy Veach, second space shuttle flight
Mission Specialist 2: William M. Shepherd, third space shuttle flight
Mission Specialist 3: Tamara E. Jernigan, second space shuttle flight
Payload Specialist 1: Steven MacLean, first space shuttle flight

Ascent and Entry Seating:

Flight deck, front left seat, commander James D. Wetherbee
Flight deck, front right seat, pilot Michael A. Baker
Flight deck, aft center seat, mission specialist William M. Shepherd
Flight deck, aft right seat, mission specialist Charles Lacy Veach
Middeck, mission specialist Tamara E. Jernigan
Middeck, payload specialist Steven MacLean

Extravehicular Activity Crew Members, If Required:

Extravehicular (EV) astronaut 1: William M. Shepherd
EV-2: Tamara E. Jernigan

Intravehicular Astronaut: Michael A. Baker

STS-52 Flight Directors:

Ascent, Entry: Jeff Bantle
Orbit 1 Team/Lead: Bob Castle
Orbit 2 Team: Rich Jackson
Planning: Chuck Shaw

Entry: Automatic mode until subsonic, then control stick steering

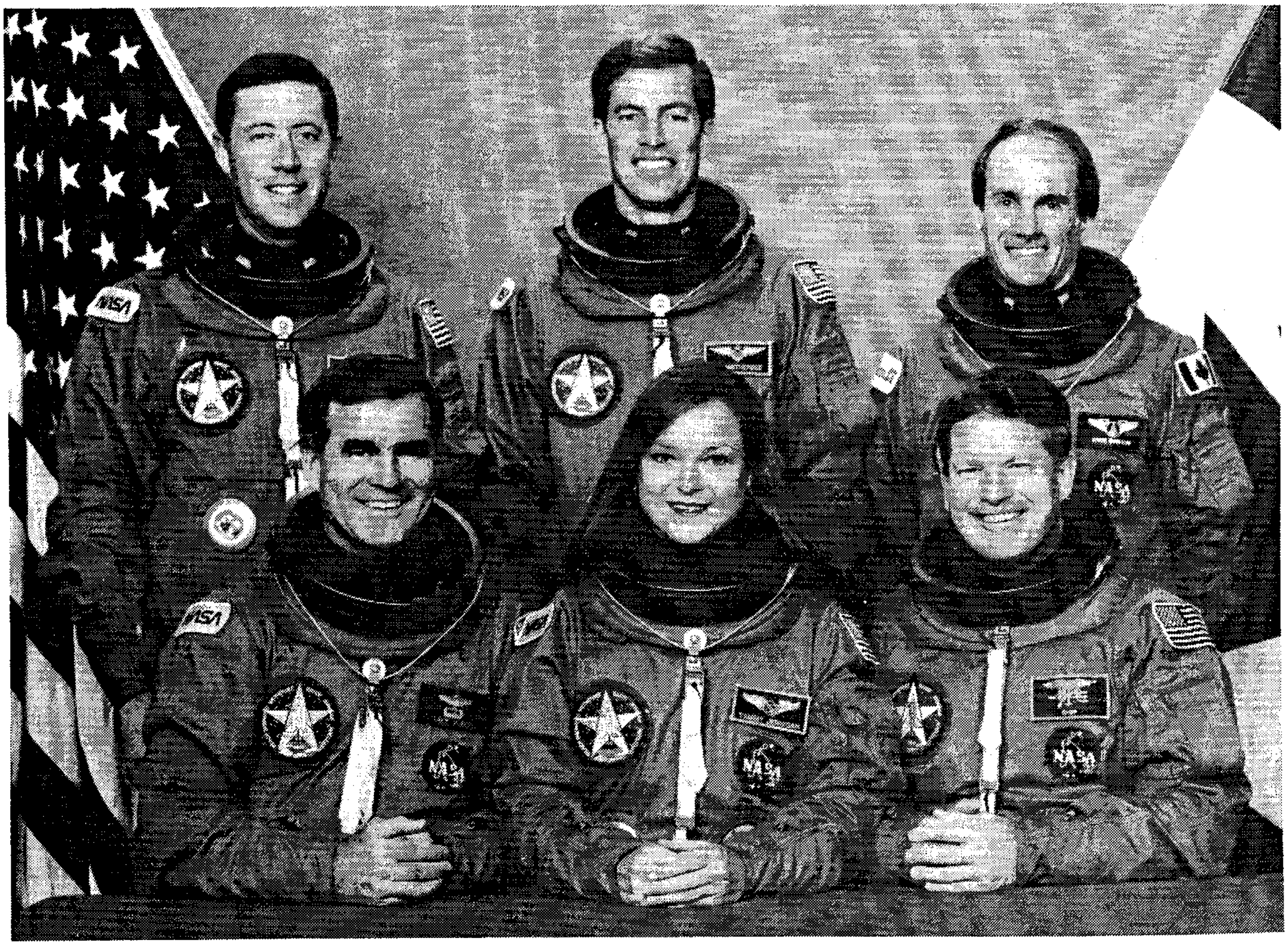
Notes:

- The remote manipulator system is installed in Columbia's payload bay for this mission.
- The galley is not installed in Columbia's middeck.
- Columbia will have the regenerative carbon dioxide removal system (RCRS) installed. One carbon dioxide absorber and one charcoal canister will be installed before launch. On orbit, the canisters are replaced by the use of the RCRS. However, enough LiOH will be stowed to cover ten days with extension. The crew will configure the system for on-orbit operations after insertion, and no further crew operation of this system is

required until midflight. The unit is then deactivated during deorbit preparation. One LiOH can will be installed for entry.

- Columbia's radiators will nominally be deployed after IRIS/LAGEOS are deployed. The radiators will be stowed for ASP operations. Redeployment will be considered for thermal reasons, if necessary, after ASP operations are complete.

- A modified Group B power-down will be required for all on-orbit operations except those times when a partial power-up is needed.



STS-52 crew members are (front row, from left) mission specialists Charles Veach, Tamara Jernigan, and William Shepherd. In the back row are pilot Michael Baker, commander James Wetherbee, and payload specialist Steven MacLean.

MISSION OBJECTIVES

- Primary objectives
  - — Laser Geodynamic Satellite (LAGEOS) II/Italian Research Interim Stage (IRIS) deployment
  - — United States Microgravity Payload (USMP) 1 operations
- Secondary objectives
  - — Middeck
    - Physiological Systems Experiment (PSE) 02
    - Heat Pipe Performance (HPP) Experiment
    - Commercial Protein Crystal Growth (CPCG) Block II
    - Shuttle Plume Impingement Experiment (SPIE)
    - Commercial Materials Dispersion Apparatus Experiment (CMIX)
    - Crystals by Vapor Transport Experiment (CVTE)
  - — Payload bay
    - Canadian Experiments-2 (CANEX-2)
    - Attitude Sensor Package (ASP)
    - Tank Pressure Control Experiment/Thermal Phenomena (TPCE/TP)
- Development test objectives/detailed supplementary objectives

FLIGHT ACTIVITIES OVERVIEW

Flight Day 1

Launch
OMS-2
Open payload bay doors
Ku-band antenna deployment
Unstow cabin
IRIS/LAGEOS checkout
Payload activation
USMP operations
ASP operations
CANEX QUELD operations
CMIX operations
CPCG operations
Medical DSOs
SAMS calibration maneuvers

Flight Day 2

IRIS/LAGEOS deployment (Orbit 15)
RMS checkout
OMS-3 separation burn
IRIS/LAGEOS injection (PKM ignition)
RMS payload bay survey
OMS-4 orbit adjust burn to 155 nmi
OMS-5 circularization burn
CANEX-2 QUELD, SVS operations
CMIX operations
HPP operations
USMP operations

Flight Day 3

LBNP operations
First unberth/berth of CANEX-2 CTA
CANEX-2 SVS, PARLIQ, SPEAM, QUELD operations
HPP operations
PSE operations
USMP operations

Flight Day 4

CVTE activation
HPP operations
PSE operations
CANEX-2 SPEAM operations
CMIX operations
CPCG operations
USMP operations

Flight Day 5

LBNP operations
CANEX-2 SPEAM, QUELD operations
HPP operations
CMIX operations
CVTE operations
USMP operations

Flight Day 6

LBNP operations
CPCG operations
HPP operations
CANEX-2 QUELD, SPEAM, PARLIQ operations

CVTE setup/activation
USMP operations

Flight Day 7

LBNP operations
CPCG operations
CANEX-2 PARLIQ, QUELD, SPEAM, MELEO operations
CVTE operations
RMS deployment
USMP operations

Flight Day 8

CANEX-2 CTA unberth for SVS run
LBNP operations
CANEX-2 MELEO, QUELD, SPEAM operations
ASP maneuvers
Crew press conference

Flight Day 9

OMS-6 orbit adjust burn to 113 nmi
OMS-7 circularization burn
LBNP operations
CANEX-2 CTA unberthed for SVS run
CANEX-2 MELEO, SVS, OGLOW operations

Flight Day 10

CANEX CTA deployment (Orbit 140)
CANEX separation maneuver (Sep 2)
CANEX separation maneuver (Sep 3)
SPIE plume measurements
RCS hot-fire test
FCS checkout
Cabin stow

Flight Day 11

Deorbit preparation
Deorbit burn
Landing

Notes:

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

DEVELOPMENT TEST OBJECTIVES/DETAILED SUPPLEMENTARY OBJECTIVES

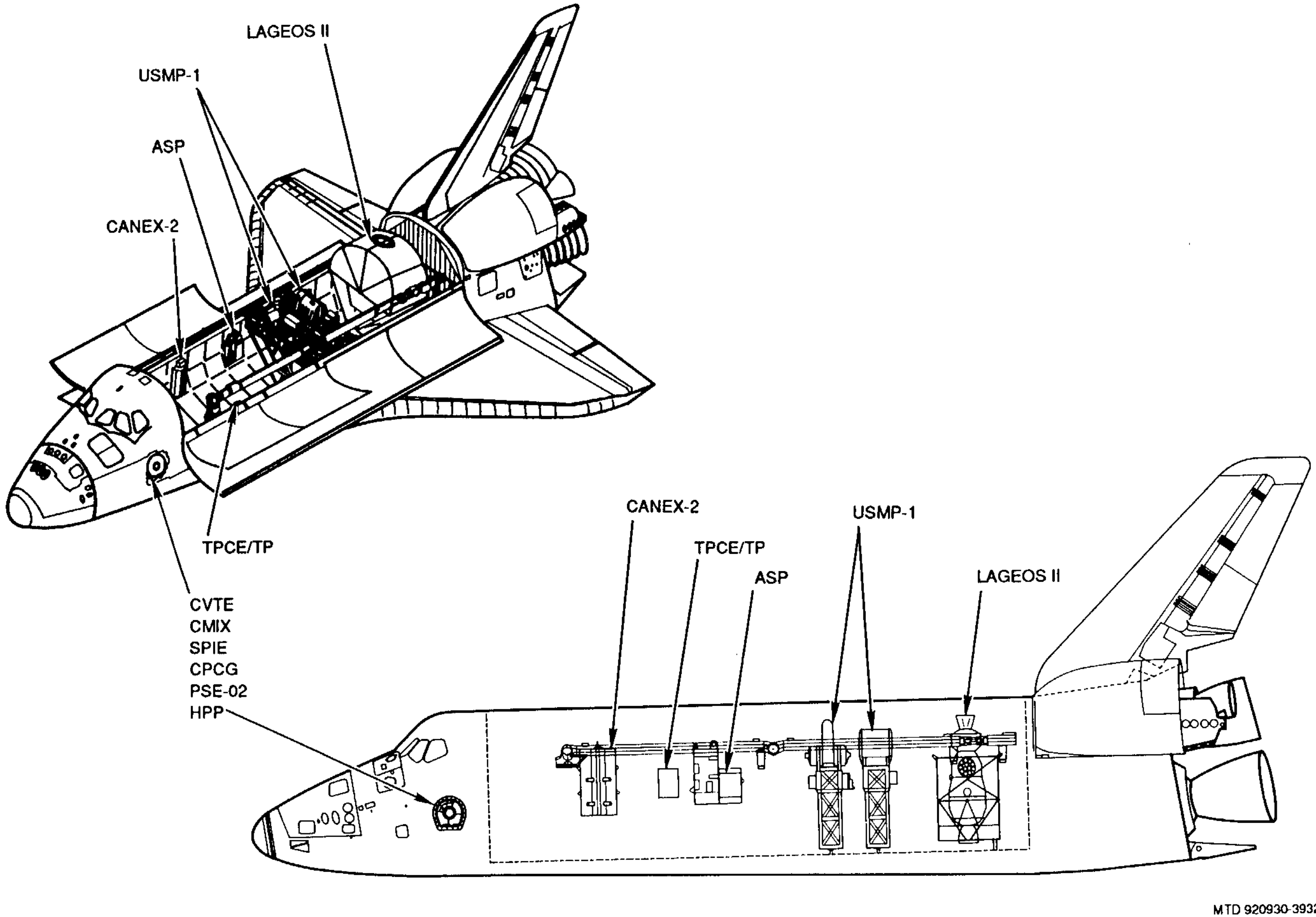
DTOs

- Ascent aerodynamic distributed loads verification on OV-102 (DTO 236)
- Entry aerodynamic control surfaces test—alternate elevon schedule, Part 4 (DTO 251)
- Ascent structural capability evaluation (DTO 301D)
- Entry structural capability evaluation (DTO 307D)
- ET TPS performance (methods 1 and 3) (DTO 312)
- Edwards lake bed runway bearing strength and rolling friction assessment for orbiter landing (DTO 520)
- EDO WCS fan separator evaluation (DTO 657)
- Acoustical noise dosimeter data (DTO 663)
- Interim portable on-board printer (DTO 669)
- Laser range and range rate device (DTO 700-2)
- Crosswind landing performance (DTO 805)
- Plume impingement model verification (DTO 828)
- Advanced portable computer evaluation (DTO 1209)

DSOs

- Intraocular pressure (DSO 472)
- Retinal photography (DSO 474)
- In-flight lower body negative pressure (LBNP) (DSO 478)
- Orthostatic function during entry, landing, and egress (DSO 603B)
- Visual-vestibular integration as a function of adaptation (OI-1 and OI-3, before and after flight only) (DSO 604)
- Postural equilibrium control during landing/egress (DSO 605)
- Evaluation of functional skeletal muscle performance following space flight (DSO 617)
- Effects of intense exercise during space flight on aerobic capacity and orthostatic functions (DSO 618)
- In-flight use of Florinef to improve orthostatic intolerance after flight (DSO 621)
- In-flight LBNP test of countermeasures and of end-of-mission countermeasures trial (DSO 623)
- Documentary television (DSO 901)
- Documentary motion picture photography (DSO 902)
- Documentary still photography (DSO 903)

PAYLOAD CONFIGURATION



LASER GEODYNAMIC SATELLITE (LAGEOS) II

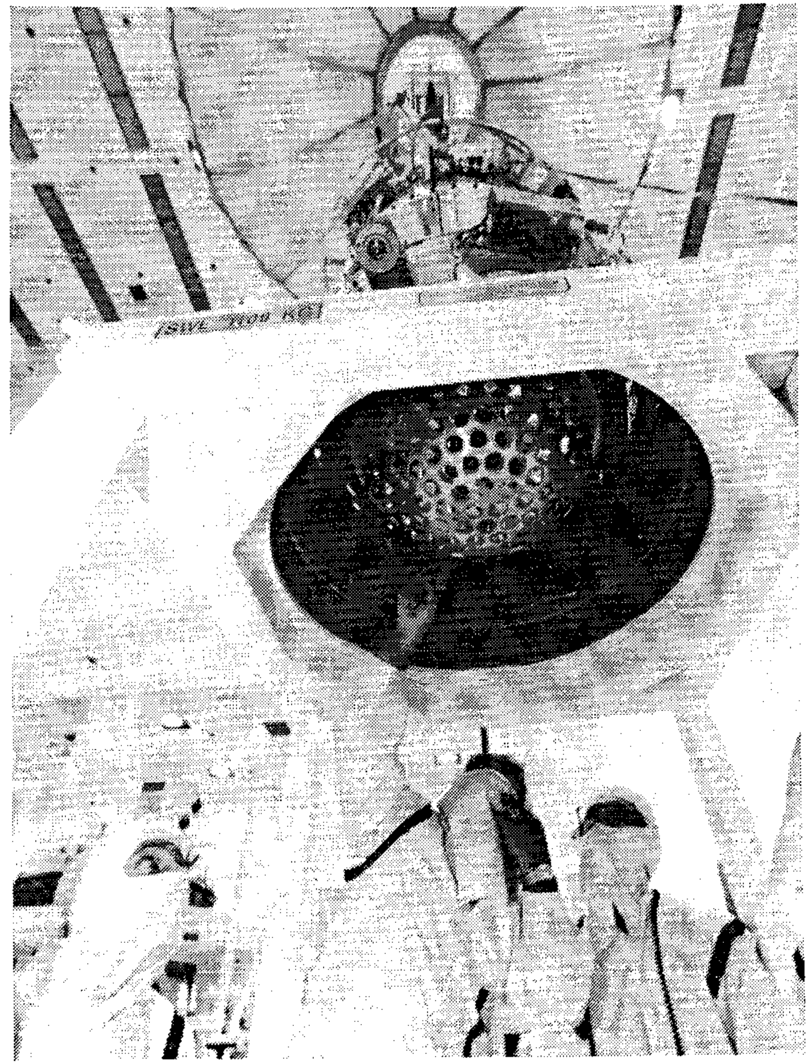
LAGEOS II is the second satellite in NASA's laser ranging system that monitors the behavior of the Earth's surface. The Italian-built satellite will be launched from the payload bay of Columbia on the second day of the flight and will join LAGEOS I, launched in 1976, in orbit.

The two satellites, which are covered with hundreds of retroreflectors, are the targets of laser beams fired from 10 Earth-based stations. The retroreflectors reflect the beams back to their source on Earth, and scientists can measure the precise distance between the satellite and station. Some of the ways they will use the data are to calculate crustal plate shifts, the Earth's rotation rate, and polar motion.

This technique allows scientists to precisely measure movements of the Earth's surface of as little as several inches in a year. Measurements obtained over a period of several years should enable them to characterize the movements and perhaps correlate them with what they have observed on the ground. Scientists are particularly interested in information that can be used to monitor the movement of faults in areas subject to earthquakes.

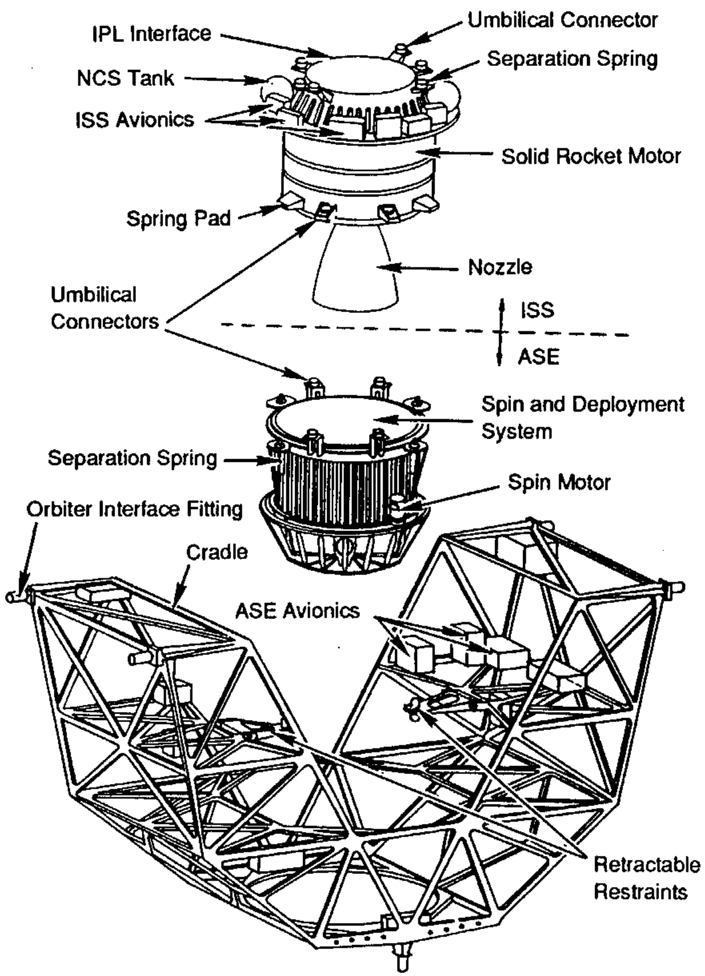
Investigators also hope their measurements will help them understand the wobble in the Earth's rotation and provide more accurate information on the size and shape of the Earth and the length of the day.

LAGEOS II is a spherical satellite that is 24 inches in diameter and weighs 900 pounds. A brass core surrounded by aluminum hemispheres gives the satellite the necessary amount of weight to minimize the effects of nongravitational forces. The materials selected also will reduce the effects of the Earth's magnetic field.



Workers at KSC Prepare to Mate LAGEOS II With IRIS

The surface of the satellite is covered with 426 retroreflectors, three-dimensional prisms that are about 1.5 inches in diameter. Fused-silica glass was used to make 422 of the retroreflectors. The others are made of germanium, a material that may be used with lasers of the future.

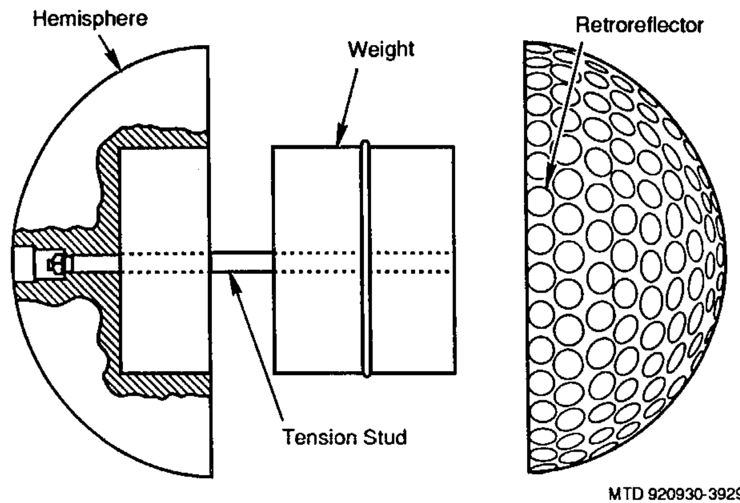


Italian Research Interim Stage

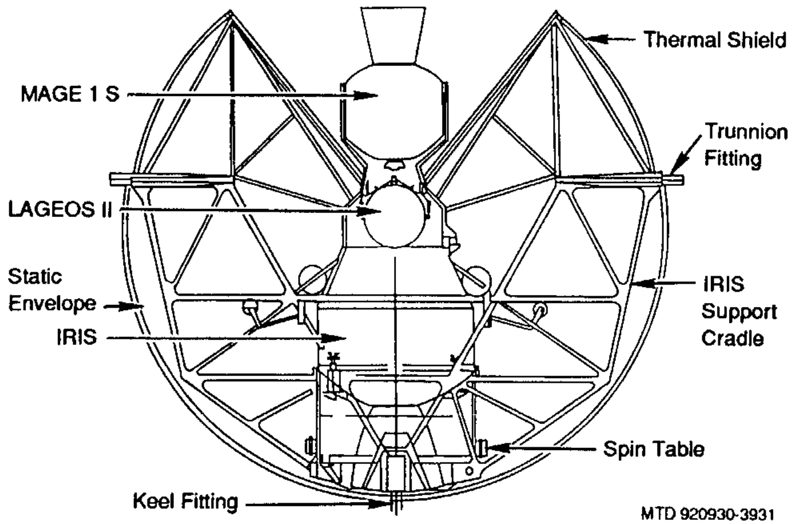
LAGEOS II was built by the Italian Space Agency from LAGEOS I drawings and specifications, which were provided by NASA's Goddard Space Flight Center. The Italians also provided the Italian research interim stage, a spinning solid fuel rocket that will lift LAGEOS II from Columbia's 184-mile orbit to a 3,666-mile orbit, and the satellite's apogee kick motor, which will place it in its circular orbit.

This is the first time the IRIS will be used to deploy a satellite from the shuttle. The mission will qualify the Italian upper stage for such use.

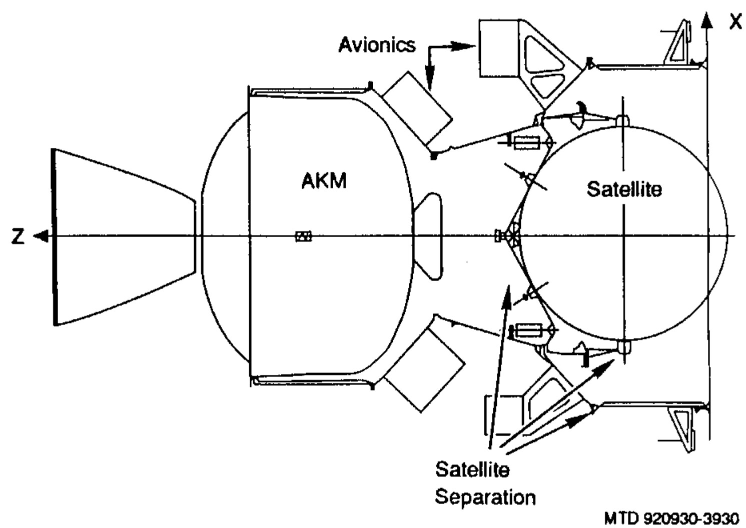
When the crew issues the command to begin deployment, a separation spring will release the mated satellite and rocket from the payload bay. The IRIS motor will fire 45 minutes later and lift LAGEOS to its orbital altitude. Closed-circuit television cameras in



LAGEOS II Satellite



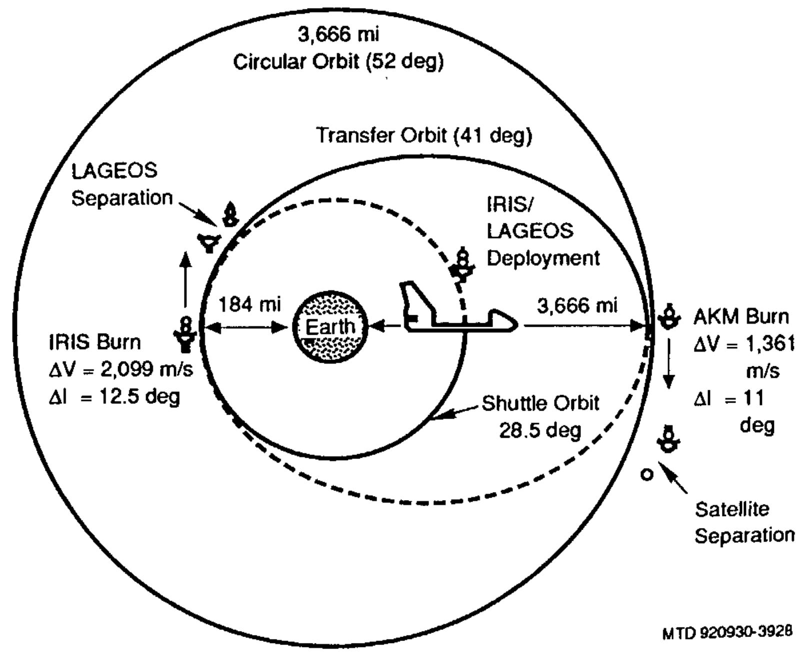
LAGEOS II Launch Configuration



LAGEOS Configuration

the payload bay will be used to monitor the deployment and rocket firing.

Although LAGEOS I and II will have the same circular orbit, the two satellites will circle the Earth at different angles from the equator so that they can cover a wider area of seismically active regions, such as California and the Mediterranean basin, and improve the accuracy of the measurements of the movements of the Earth's crust. LAGEOS I's orbit is 52 degrees from the equator; LAGEOS II's will be 110 degrees. Scientists hope the different



LAGEOS II Orbit Schematic

orbits will also provide answers to irregularities in the position of LAGEOS I.

Before LAGEOS II begins full science operations, it will be tracked for 30 days so the ground laser ranging stations can precisely calculate and predict its orbit.

Four of NASA's satellite laser ranging stations are transportable and can be easily moved from one location to another. Another four are mobile, semipermanent stations in Australia and North America, including one that is located at the Goddard Space Flight Center. Two other stations are operated by the University of Hawaii and the University of Texas at Austin.

Science investigators from the United States, Italy, Germany, France, the Netherlands, and Hungary will collect and interpret the data from the laser ranging. LAGEOS II data will be maintained in the Crustal Dynamics Data and Information System at GSFC and will be available to anyone investigating the dynamics of the Earth's crust.

The satellite is expected to remain in orbit indefinitely.

USMP-1 is the first in a series of scientific investigations of the effects of microgravity that will be conducted in the unpressurized payload bay of the space shuttle. The experiments that are part of the USMP program do not require the attention of crew members and are carried on a special payload bay structure rather than in the pressurized Spacelab module.

USMP-1 comprises three experiments mounted on mission-peculiar equipment support structures (MPESS) developed by the Marshall Space Flight Center, which manages the USMP program. The only involvement of the crew is to activate the experiments after Columbia arrives on orbit. The operation of the experiments will be monitored at the MSFC Payload Operations Control Center by science teams, which will also analyze data obtained from the experiments.

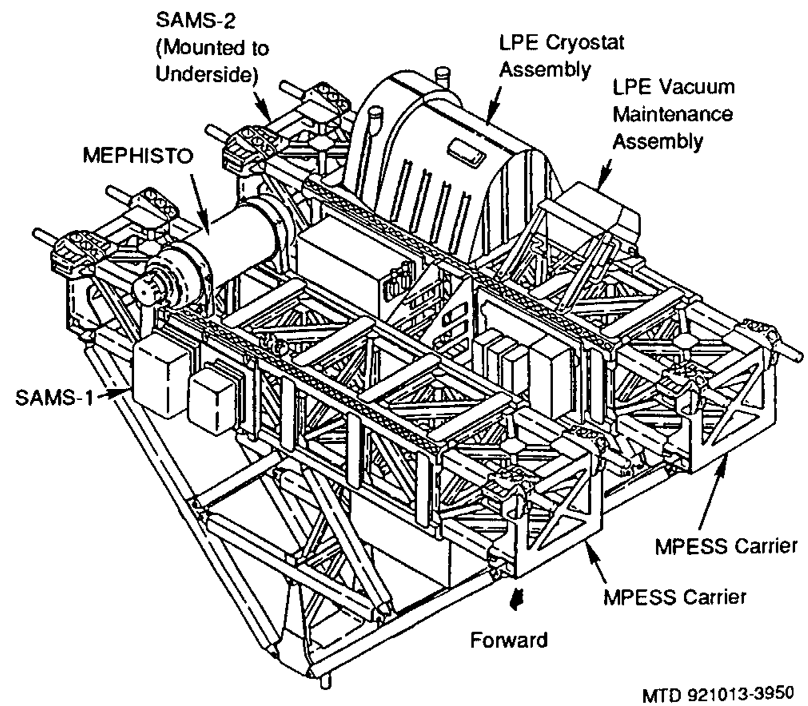
In the Lambda Point Experiment, liquid helium will be heated until it changes from its normal liquid state to a superfluid state, a change that occurs at liquid helium's lambda point (-456°F). It is difficult to study the transition to the superfluid state on Earth because the pressure of a liquid helium sample is lower at the top than at the bottom in gravity and the helium at the top changes to superfluid at higher temperatures than the helium at the bottom.

In this experiment, the temperature of a sample of liquid helium that has been cooled to well below its lambda point and placed in a thermoslike cryostat will be increased in stages past the helium's transition point. As the helium changes phases, its heat capacity will be measured by instruments inside the cryostat.

Superfluid helium has some interesting properties. It can pass through pores that would stop other fluids and is 1,000 times more effective than copper in conducting heat.

The principal investigator for the Lambda Point Experiment is Dr. J.A. Lipa of Stanford University.

NASA is cooperating with the French space agency, CNES, and the French Atomic Energy Commission in a series of six investigations of the effects of microgravity on metallurgical processes known as Materials for the Study of Interesting Phenomena of Solidification on Earth and in Orbit. This first flight of MEPHISTO (its French abbreviation) will investigate the effects of microgravity on the solidification of metals and semiconductors at the solid/liquid interface. The knowledge gained from this experiment could lead to



USMP-1 Payload

the development of more resilient metal alloys and composites for use in the engines of future airplanes and spacecraft.

Three identical samples of a tin-bismuth alloy will be melted and resolidified in the MEPHISTO equipment, which consists of a fixed furnace and a movable furnace. The movable furnace melts the samples as it moves away from the fixed furnace. The samples resolidify as the furnace returns to the fixed furnace.

Investigators will verify the rate of solidification of the samples by constantly measuring the temperature changes at the liquid/solid interface. They will also be able to study the interface after the mission by "freezing" it with electrical pulses during the last run of the experiment.

The principal investigator for this experiment is Dr. J.J. Favier of the French Atomic Energy Commission.

Microgravity is not the total absence of gravity, and investigators need to know to what extent the momentary vibrations caused by crew movement, equipment operation, and spacecraft maneuvers act like gravitational forces on their experiments and influence the results. The Space Acceleration Measurement System will be flown on this mission as part of USMP-1 to measure and record these low-level accelerations and vibrations during the operation of the other two USMP experiments and to characterize the effect of disturbances on the MPESS.

This is the first time SAMS has been used to monitor distubances in the cargo bay and the first time that data will be relayed to investigators on Earth to allow them to make real-time adjustments in their experiments. SAMS units have been flown on previous shuttle missions to measure accelerations in Spacelab and the orbiter middeck.

Two SAMS units will be used on this mission. Each unit has two remote sensors connected to the SAMS electronics by cables. Two SAMS sensors mounted on the Lambda Point Experiment and two placed near the MEPHISTO furnace will convert accelerations to output signals and send them to the main unit. The main unit will convert the signals to digital data and record the data on optical disks.

Some of the data will be transmitted to the Payload Operations Control Center at MSFC. There, the LPE and MEPHISTO principal investigators will examine the downlinked data for signs of accelerations that could affect the results of their experiments and command changes in their experiments based on the conditions in the shuttle cargo bay.

The SAMS scientific investigator is Charles Baugher of MSFC.

ATTITUDE SENSOR PACKAGE

Because of the lack of knowledge of and the inability to simulate the space environment, the performance of space instruments often cannot be predicted accurately on Earth. The Attitude Sensor Package (ASP) is a European Space Agency payload that exposes three advanced attitude sensors to actual space conditions in order to demonstrate their performance and accuracy. The sensors are being evaluated for possible use on future ESA programs.

ASP consists of three independent spacecraft attitude sensors, an on-board computer, and a support structure carried aboard a hitchhiker platform. The platform is side-mounted on the starboard side of Columbia's payload bay in cargo bay 3 using getaway special-type attach fittings provided by the Goddard Space Flight Center and an attitude sensor instrument group.

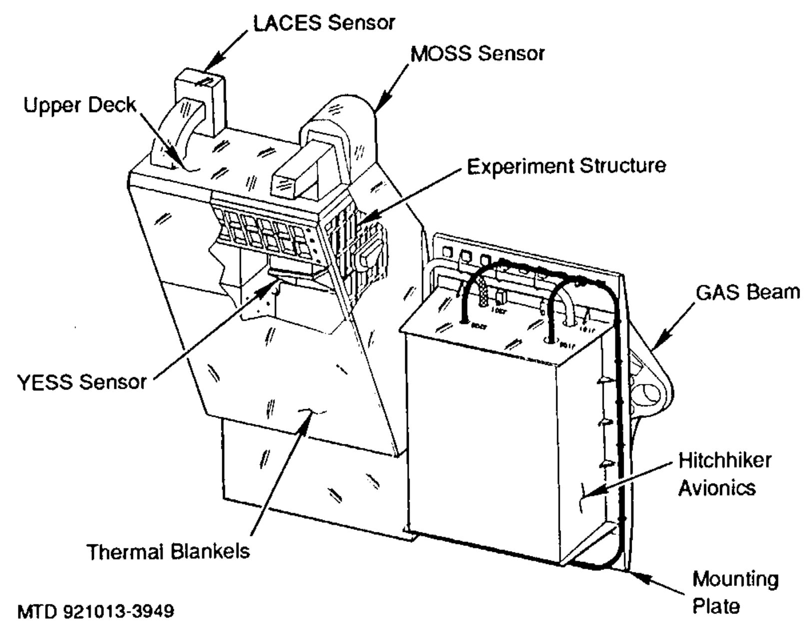
The primary sensor is the modular star sensor (MOSS); the other two are the yaw Earth sensor (YESS) and the low-altitude conical Earth sensor (LACES). All three sensors were developed by the Italian Officine Galileo under contract to ESA. The three sensors and their support structure are assembled on a hitchhiker small mounting plate. The hitchhiker avionics, which are mounted to another small mounting plate, provide power and signal interfaces between the ASP experiment and the orbiter.

The ASP sensors must have a clear field of view during the orbits. Ku-band channel 2 support is required for sensor measurements.

The hitchhiker Payload Operations Control Center (POCC) at NASA's GSFC, Greenbelt, Md., will operate the ASP for at least 16 orbits with the payload bay pointed toward Earth (the -ZLV attitude) using a payload signal processor. ESA personnel and contractors will operate ground support equipment in the POCC during the mission.

ASP is the third hitchhiker payload to fly in space. Hitchhikers are part of GSFC's Shuttle Small Payloads Project (SSPP). Their objective is to provide quick-response, economical flights for small attached payloads that have more complex requirements than getaway special experiments. The SSPP is managed by Goddard for NASA's Office of Space Flight. The Hitchhiker Program performs overall mission management duties for hitchhiker payloads flying on the orbiter, including experiment integration on the shuttle and operations management during the flight.

ASP was prepared by ESA's In-Orbit Technology Demonstration Programme (IOTDP), part of the European Space Technology and Engineering Center, Noordwijk, the Netherlands. The ESA IOTDP program manager is Manfred Trischberger. The ESA ASP payload manager is Roberto Aceti, and the ESA principal investigator is Peter Underwood. Theodore C. Goldsmith is the SSPP project manager, and Chris Dunker is GSFC's ASP mission manager.



Attitude Sensor Package

CANADIAN EXPERIMENTS 2 (CANEX-2)

CANEX-2 is a secondary payload that consists of seven technology, science, materials processing, and life sciences experiments, many of which are extensions of experiments that were flown in 1984 on STS 41-G. Canadian payload specialist Steve MacLean will perform the payload bay and middeck experiments from the shuttle crew cabin.

The research conducted as part of CANEX-2 has potential applications in the assembly of the proposed U.S. space station Freedom, vision systems for robots, manufacturing, and protective spacecraft coatings. Other objectives are to improve the understanding of the Earth's stratosphere, the portion of the atmosphere that contains the endangered protective ozone layer, and to increase knowledge of how humans adapt to microgravity.

CANEX-2 is sponsored by the Canadian Space Agency.

SPACE VISION SYSTEM (SVS)

The primary experiment of CANEX-2 is the experimental Space Vision System, which is a form of machine vision for robotic applications in space and on Earth.

The purpose of the SVS is to enable astronauts to better gauge the distance and speed of objects in space, a difficult task because of the scarcity of reference points in space and alternating periods of extremely dark and bright lighting. The SVS is designed for use on the space shuttle and as an aid in building the space station.

The SVS will use photogrammetry to calculate the exact location, orientation, and motion of a small spacecraft, the Canadian target assembly, that will be deployed from the shuttle's payload bay and maneuvered by the remote manipulator system, the shuttle's Canadian-built robotic arm. Photogrammetry is the science of using photographs to make reliable measurements. Its best-known use has been in aerial photography. A real-time photogrammetry unit (RPU) has been installed on the orbiter's aft flight deck for this experiment.

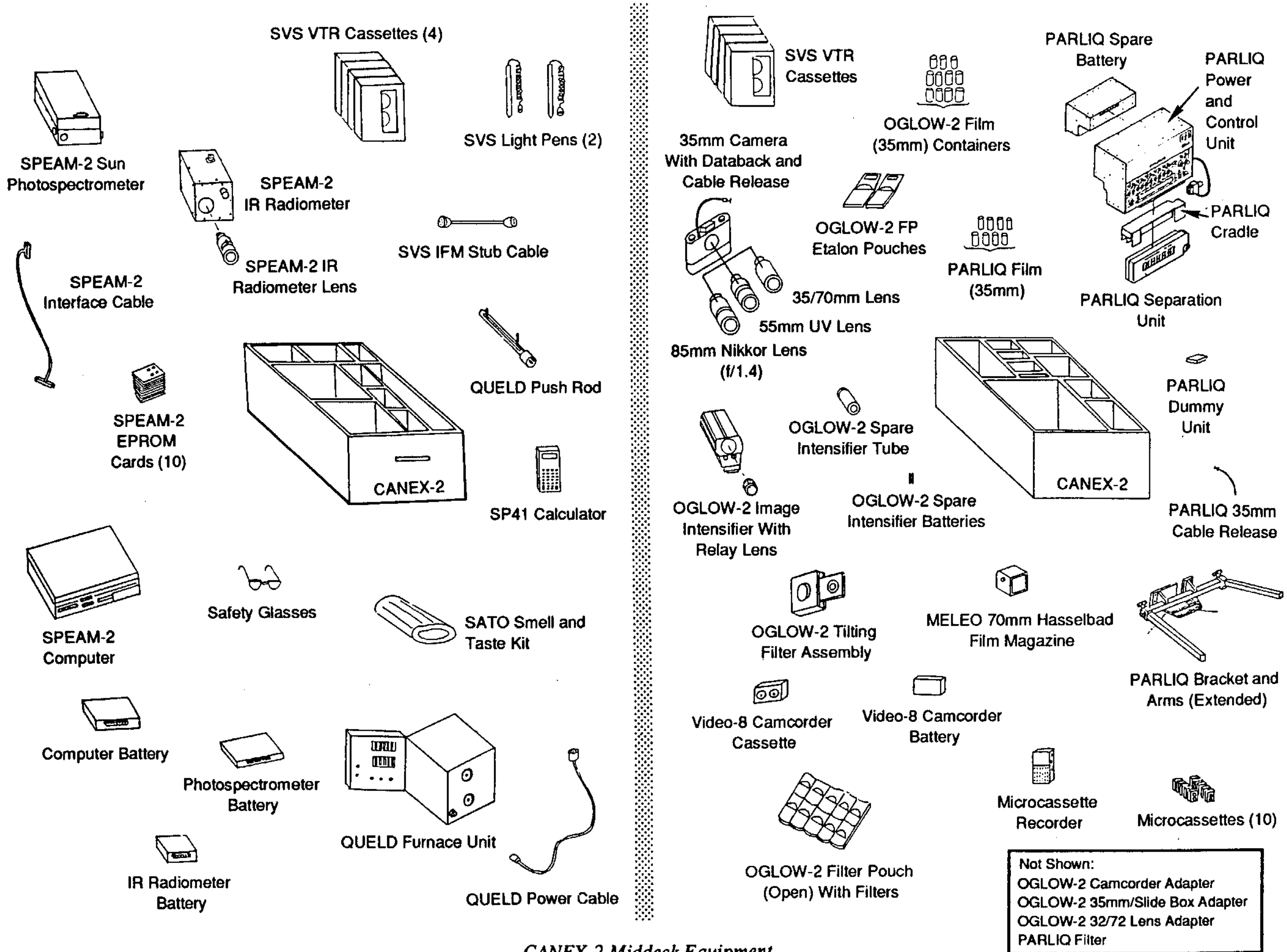
With the shuttle's closed-circuit television system, the payload specialist will monitor the movement of the 4-foot by 7-foot by 1.5-foot deployed spacecraft, whose surface is covered with many sets of dots of known spacing. By measuring the position of these targets, the SVS computer can display the location and orientation of the CTA on a television monitor on the aft flight deck. The information displayed by the SVS will be used by a mission specialist to take the CTA through a series of maneuvers.

A production model of the SVS could be used on the space shuttle as an aid in deploying, grappling, and berthing satellites; performing intricate control tasks with the RMS; measuring structural deflections; and supporting rendezvous, station-keeping, and proximity operations with other spacecraft. It could also be used to help construct and maintain the space station. Machine vision could also be used on Earth to improve manufacturing and in harsh environments such as mines and nuclear reactors.

The principal investigator on the SVS is Dr. H.F. Lloyd Pinkney of the National Research Council of Canada.

MATERIAL EXPOSURE IN LOW EARTH ORBIT (MELEO)

This experiment is designed to quantify the rate and degree of degradation of plastic and composite materials exposed to the harsh environment of space in low Earth orbit. MELEO is a continuation of efforts by many investigators to understand the physics and chemistry of the processes that cause spacecraft surfaces to degrade.

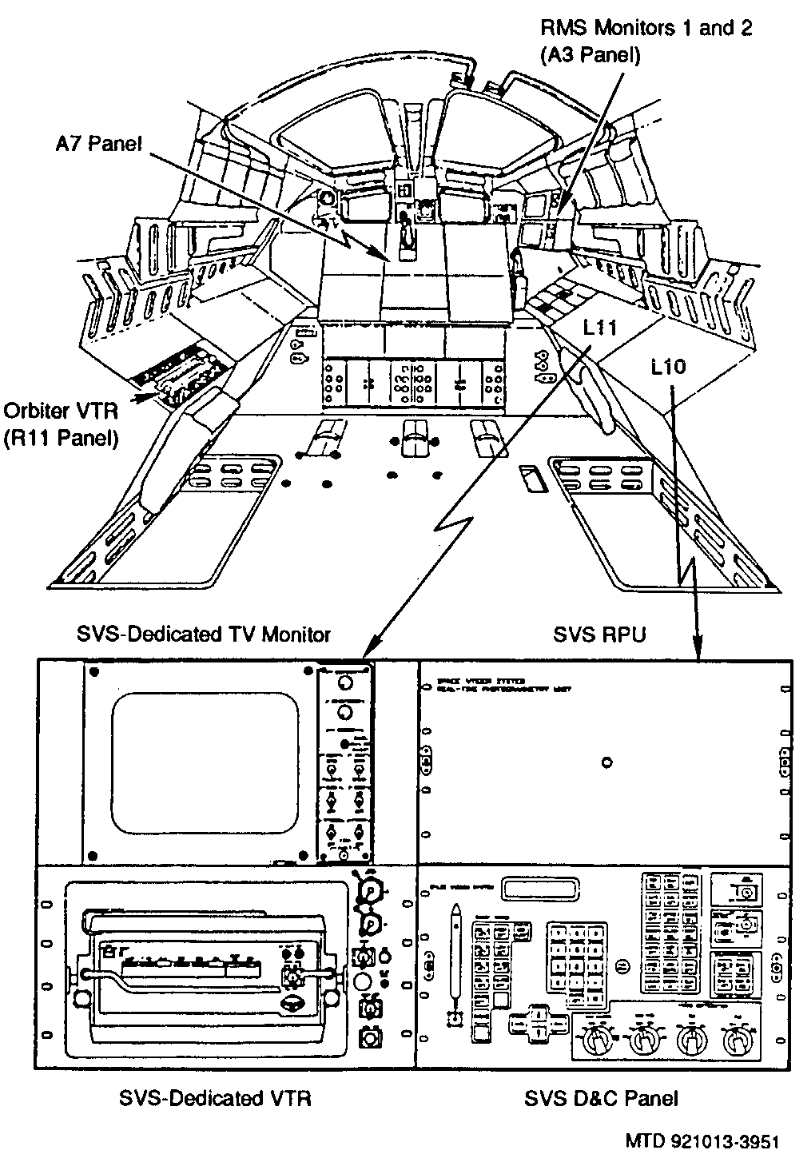


CANEX-2 Middeck Equipment

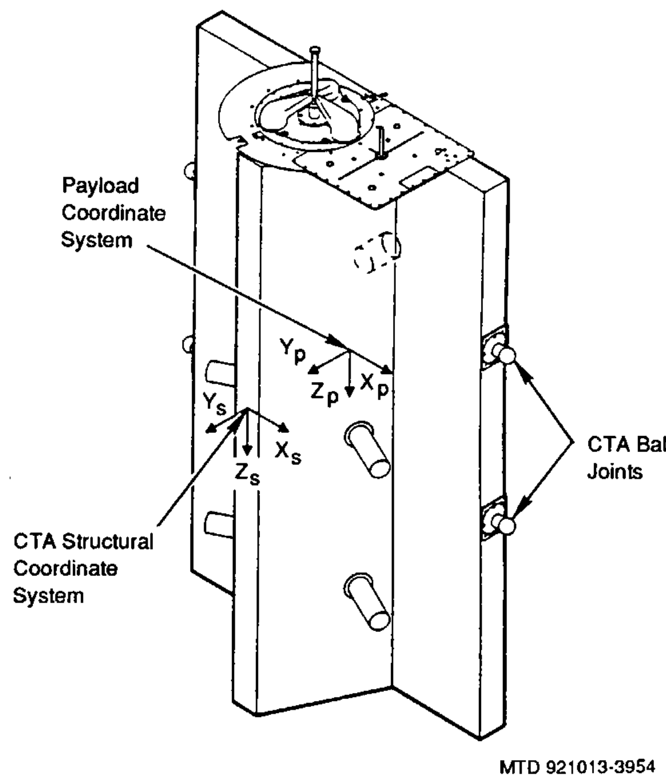
MTD 921013-3969

During the experiment, investigators will investigate the effectiveness of new protective materials; assess the response of materials chosen for specific uses, such as the mobile servicing system for the space station and a Canadian remote-sensing satellite that is scheduled to be launched in 1995; and quantify the flux and fluence of atomic oxygen. Investigators have found evidence that atomic oxygen induces chemical and physical reactions that cause certain spacecraft materials to lose mass, strength, stiffness, and stability of size and shape.

For 30 hours during the mission, more than 350 specimens of typical spacecraft materials and new coatings for protecting against atomic oxygen will be exposed to space. The specimens are mounted



SVS Aft Flight Deck Location

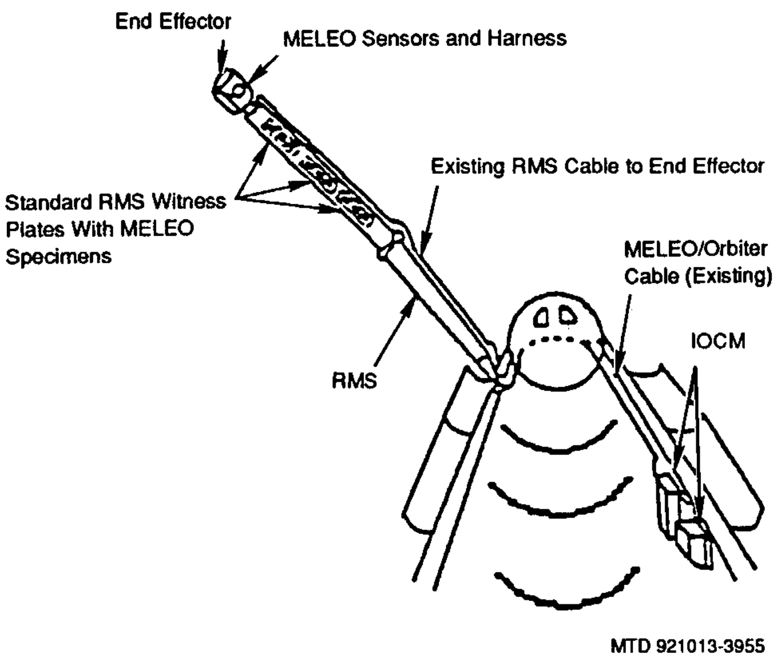


Canadian Target Assembly

on three witness plates on the shuttle's robotic arm, which will be maneuvered periodically to vary the exposure of the plates and permit the crew to observe them.

Dr. MacLean will record the stages of erosion by periodically photographing the specimens through the orbiter's windows. The specimens will be returned to Earth for postflight analysis as well. During the mission, Dr. MacLean will receive very accurate real-time data on the erosion process from quartz crystal microbalances attached to the shuttle RMS.

Dr. David G. Zimcik, of the Canadian Space Agency, is the principal investigator.



MELEO/IOCM/RMS Configuration

ORBITER GLOW-2 (OGLOW-2)

This experiment is an extension of the 1984 investigation of the glow that emanates from the body of the shuttle orbiter in the direction of motion. Researchers believe that the glow is caused by the impact of high-velocity atoms and the orbiter's surface temperature.

On this mission, the investigation will focus on the gaseous reactions caused by firings of the orbiter's reaction control system thrusters. Still photographs and video recordings will be taken of the tail section of the orbiter before, during, and after thruster firings. Investigators will study the thruster-induced spectrum after the flight.

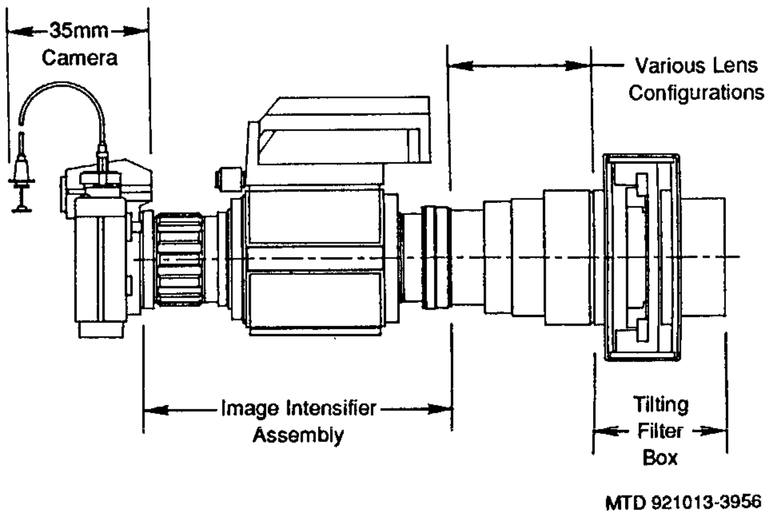
Dr. MacLean will also take photographs of five specimens of materials, each with a temperature indicator, mounted on the face of the Canadian target assembly. The shuttle robotic arm will position the CTA so that Dr. MacLean can photograph the specimens' glow through the ultraviolet-transparent side hatch window of the orbiter middeck with a camera equipped with UV optics, an image intensifier, narrow-band filters, and an etalon.

Dr. MacLean will also photograph glow from the upper atmosphere during this experiment.

The principal investigator is Dr. E. J. Llewellyn of the University of Saskatchewan, Canada.

QUEEN'S UNIVERSITY EXPERIMENT IN LIQUID-METAL DIFFUSION (QUELD)

The objective of this experiment is to help researchers develop a general theory for predicting the rate of diffusion for any metal and to generate information about the structure of liquid metals. For designing and producing alloys, it is important to know the intrinsic diffusion coefficient of metals, but gravity-caused convection makes it difficult to measure the rate at which atoms intermingle in



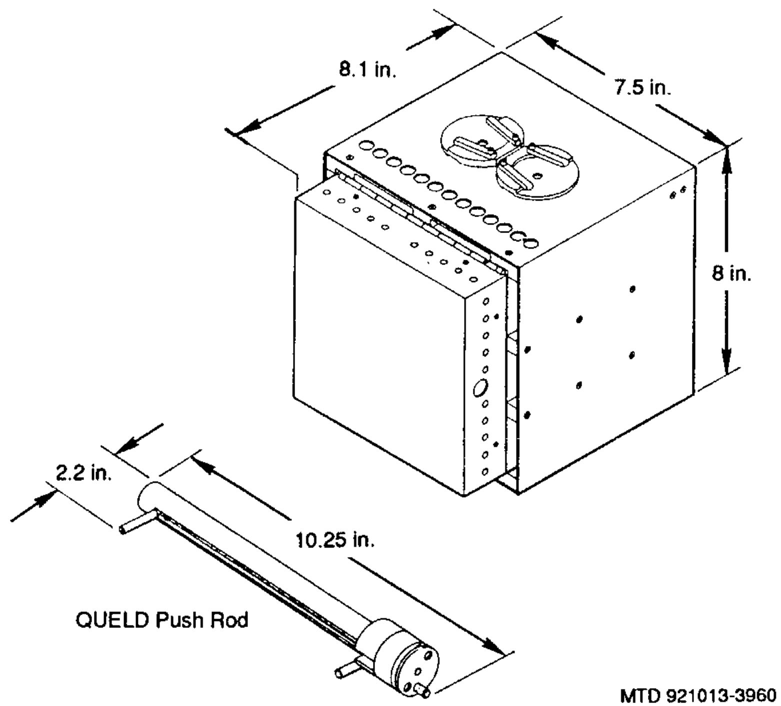
OGLOW-2 On-Orbit Configuration

the liquid state on Earth. In space, a more accurate determination of diffusion can be made because of the absence of gravity.

The QUELD experiment consists of 40 0.06-inch-diameter specimens of gold, silver, bismuth, manganese, and lead in various combinations. The specimens will be heated in sealed nickel-alloy crucibles until they become molten. After diffusing for 30 minutes or longer, the liquid metals will be removed from the furnace and then quenched so that they solidify rapidly. After the flight, the specimens will be analyzed to determine the effects of temperature, time, and dimensions on diffusion.

The knowledge gained from this experiment is expected to lead to the production of better crystals for use in computer microchips and radiation sensors and the development of alloys that cannot be produced on Earth.

Professor Reginald W. Smith, of Queen's University, Kingston, Ontario, is the principal investigator.



QUELD Hardware

SUN PHOTOSPECTROMETER EARTH ATMOSPHERE MEASUREMENTS (SPEAM) 2

Measuring the structure and composition of the Earth's atmosphere from space has greatly expanded the ability to monitor Earth's environment. This experiment is expected to reveal extremely useful information about the chemical processes taking place in the stratosphere and affecting the ozone layer.

The SPEAM equipment consists of two hand-held instruments and a computer. Dr. MacLean will aim the sun photospectrometer and the airborne infrared radiometer at the rising and setting sun and moon through the orbiter's side hatch window to measure the concentrations of ozone, oxygen and nitrogen compounds, and aerosols in the stratosphere. The AIR will also measure the air glow spectra associated with molecular oxygen and very reactive molecules of oxygen and hydrogen, which affect the concentration of ozone.

Data collected by the SPEAM-2 instruments will be compared to data gathered by ground-based instruments and other space-based instruments.

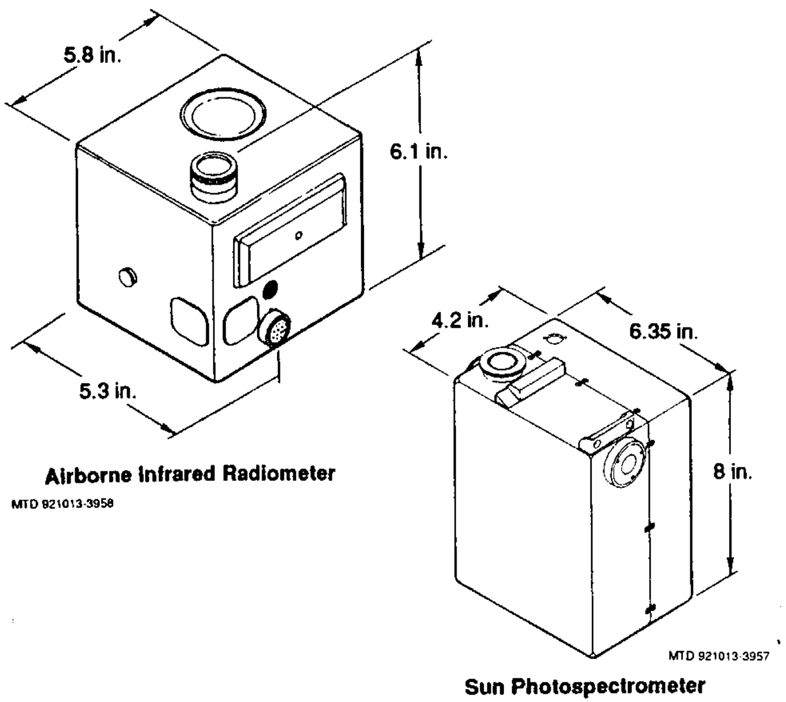
Dr. David I. Wardle, of Environment Canada, is the principal investigator.

PHASE PARTITIONING IN LIQUIDS (PARLIQ)

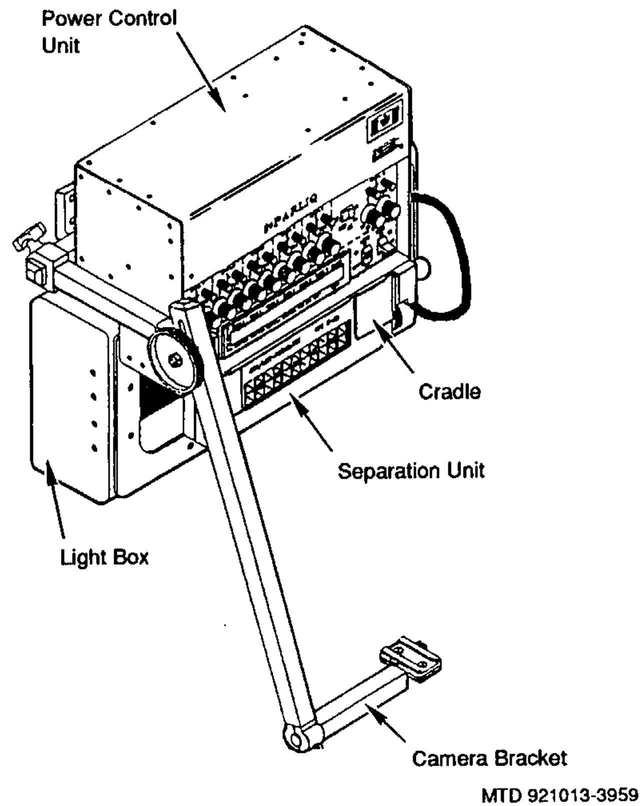
Researchers are studying the possible use of phase partitioning in microgravity to separate cells that have the maximum purity possible, something that is difficult to acheive on Earth because of the influence of gravity.

In this experiment, two immiscible polymer solutions, or phases, that have been dissolved in water will be mixed and allowed to separate. Cells added to the solutions are attracted to one solution or the other and are separated by type. The solutions and their cells will be isolated and returned to Earth.

It is hoped that phase partitioning will lead to an effective process for separating and purifying biological materials for use in treating disease.



SPEAM-2 Instruments



PARLIQ On-Orbit Configuration

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

SPACE ADAPTATION TESTS AND OBSERVATIONS (SATO)

Every space flight by a Canadian astronaut includes research into human adaptation to space flight. This flight includes four areas of research.

The principal investigator is Dr. Alan Mortimer of the Canadian Space Agency.

Vestibulo-Ocular Reflex Check

In this experiment, Dr. MacLean will investigate the ability to keep the eyes focused on an object while the head is in motion in weightlessness. In previous investigations, this ability did not deteriorate as had been expected. Those tests, however, were conducted several hours after the shuttle arrived on orbit. On this mission, the experiment will be conducted as the astronauts enter microgravity.

Body Water Changes in Microgravity

This experiment follows up on a Canadian study of metabolic rates conducted during STS-42 last January. The findings suggested that the proportion of total body mass of the astronaut subject changed during space flight due to water. Researchers know from previous studies that body fluids shift toward the head in microgravity and the body loses water. This experiment will calculate the changes in total body water that occur during the flight.

Dr. MacLean will take a small amount of heavy water at the beginning and end of the flight and collect saliva each day for post-flight analysis.

Researchers hope their findings will help them develop nutritional protocols for long space flights and countermeasures for use during reentry.

Assessment of Back Pain in Astronauts

More than two thirds of U.S. and Russian astronauts have reported suffering back pain during space flight. The pain is caused by the elongation of the spine. This experiment will continue the investigation into the causes of the pain in the hope of ultimately finding a way to alleviate back pain for astronauts and Earth-bound sufferers as well.

During the mission, Dr. MacLean will keep track of changes in his height and record the location and intensity of back pain.

Illusions During Movement

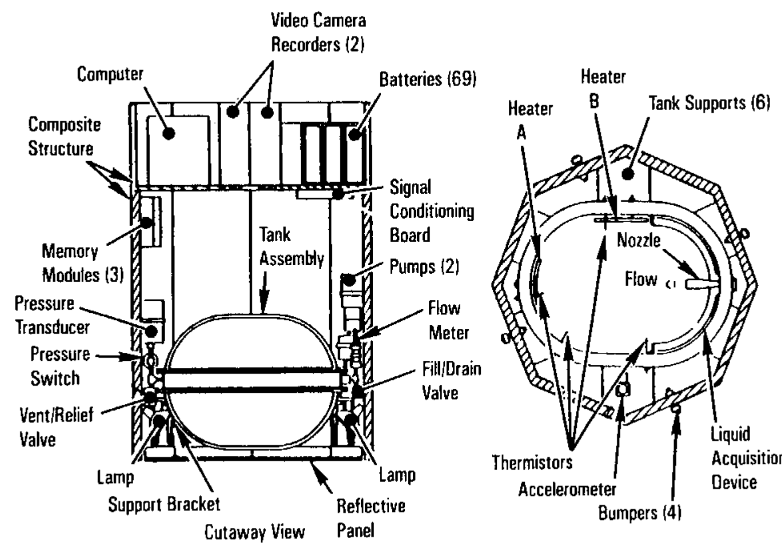
During this experiment, Dr. MacLean will investigate the disconcerting illusion experienced by astronauts while doing deep knee bends in space and on Earth after flight that the floor is moving. He will determine when the illusion occurs and investigate the affect of visual and tactile inputs on the illusion, such as holding onto a fixed object while doing knee bends.

The control of pressure in on-orbit storage tanks for cryogenic propellants and life support fluids, particularly liquid hydrogen, oxygen, and nitrogen, is an important issue in microgravity fluid management. New technology for managing fluids in low gravity will be required for future space systems, such as the space transfer vehicle, space station Freedom, space exploration initiatives, serviceable satellites, hypervelocity aerospace vehicles, and space defense systems. The Tank Pressure Control Experiment/Thermal Phenomena (TPCE/TP) is designed to provide some of the data required to develop the technology for pressure control of cryogenic tankage.

TPCE/TP will extend the data acquired in the TPCE that was conducted on STS-43 in 1991. That flight significantly increased the knowledge base for using jet mixing as a means of controlling tank pressures and equilibrating fluid temperatures in thermally stratified subcritical tanks. Mixing represents a positive means of limiting pressure buildup due to thermal stratification and may allow non-vented storage of cryogenics for some of the shorter missions. Larger missions, however, will require venting and will likely use thermodynamic vent systems for pressure control. The efficient design of either active or passive pressure control systems will depend on knowledge of the thermodynamic processes and phenomena controlling the pressure buildup in a low-g environment. The purpose of TPCE/TP is to focus on the thermal phenomena involved in the self-pressurization of subcritical tanks in a low-g environment.

The TPCE is contained in a standard 5-cubic-foot getaway special (GAS) cylindrical canister, mounted on a GAS adapter beam in the payload bay. The payload will be controlled by a crew member from the aft flight deck (AFD) using a small hand-held display encoder to signal the autonomous payload control system (APCS). Already-established orbiter wiring from the AFD connects the GAS commander encoder to the GAS control decoder located in the payload canister.

The experiment uses two strategically placed heaters to heat a partially full tank of refrigerant fluid (Freon-113) that is initially at its saturation pressure and temperature. The heat will create a thermal gradient and increase the tank pressure. A low-velocity jet mixer will be activated to provide forced convection mixing and heat transfer. After a short time, the pressure will have returned to near its initial value, and the temperatures within the liquid and vapor will be approximately equal. This sequence will be activated during ascent, and will be repeated many times over an 18- to 32-hour period. Several of the tests will be made while Columbia is in a tail-into-the-velocity attitude, using orbital drag to keep the fluid at the heater end of the tank.



TPCE

Both TPCE and TPCE/TP are part of NASA's In-Space Technology Experiments Program (IN-STEP), which is managed by NASA's Office of Aeronautics and Space Technology. The TPCE/TP project manager is Richard Knoll of NASA's Lewis Research Center (LeRC), Cleveland, Ohio. Lewis investigators proposed and are managing the reflight. M.M. Hasan of NASA LeRC is the principal investigator. Boeing Aerospace Co., Seattle, Wash., developed the original flight hardware.

Currently, approximately 25 million Americans, most of them women, suffer from osteoporosis. The disease often progresses without symptoms or pain until a fracture occurs, typically in the hips, spine, or wrist, and annually causes an estimated 1.3 million fractures that can result in permanent disabilities, loss of independence, or even death.

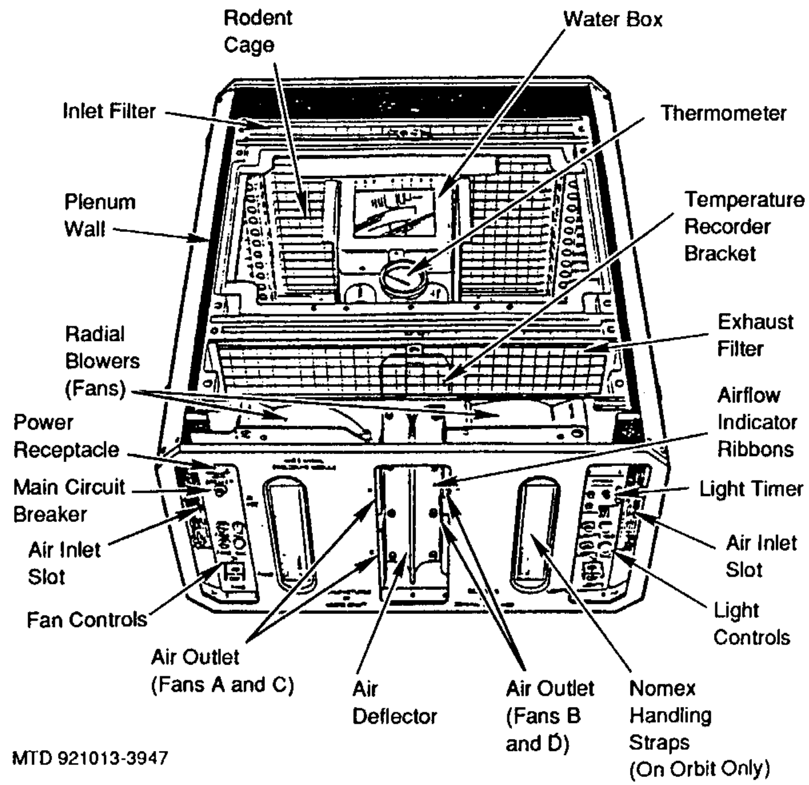
The Physiological Systems Experiment (PSE) 02 is a middeck payload jointly developed by Merck & Co., Inc., and the Center for Cell Research, a NASA Center for the Commercial Development of Space at Pennsylvania State University. PSE-02 will evaluate a proprietary protein molecule compound under development for the treatment of osteoporosis. The experiment will test the ability of the compound to slow or stop bone loss induced by microgravity. Merck scientists will examine whether the lower gravity experienced during space flight accelerates the rate at which bone mass is lost compared to losses observed when a limb is immobilized on Earth.

The compound to be tested is being used in large-scale human clinical studies as a treatment for osteoporosis associated with menopause. In postmenopausal women, this loss is a consequence of estrogen depletion.

PSE-02 may help determine if the protein compound will be useful in treating the bone loss caused by prolonged immobilization of weight-bearing limbs in bedridden or paralyzed patients. The experiment could also have a direct application in space as a preventative measure for bone loss that might affect astronauts on extended flights.

In the experiment, six healthy adolescent male albino rats will be treated with the developmental anti-osteoporotic compound prior to flight. A control group of another six flight rats will not be treated. The two groups will be housed in completely self-contained animal enclosure modules during the flight. The experiment will also occupy two middeck lockers. The AEMs contain food and water. No crew interaction is required on orbit. A clear plastic cover on the AEM will allow the crew to visually inspect the rats' condition daily. Photographic documentation is required.

The Animal Care and Use Committees of both NASA and Merck have reviewed and approved the PSE-02 experiment proto-

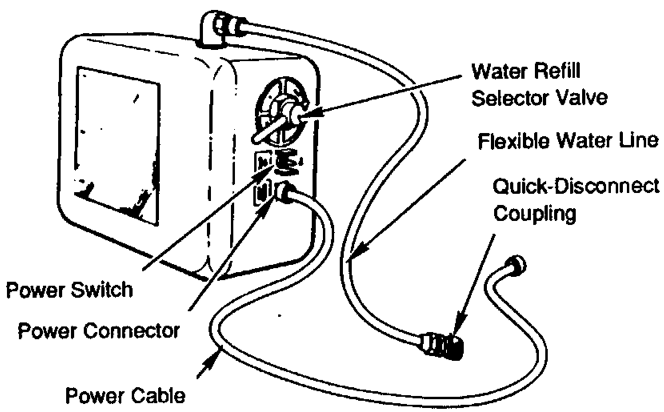


PSE Configuration

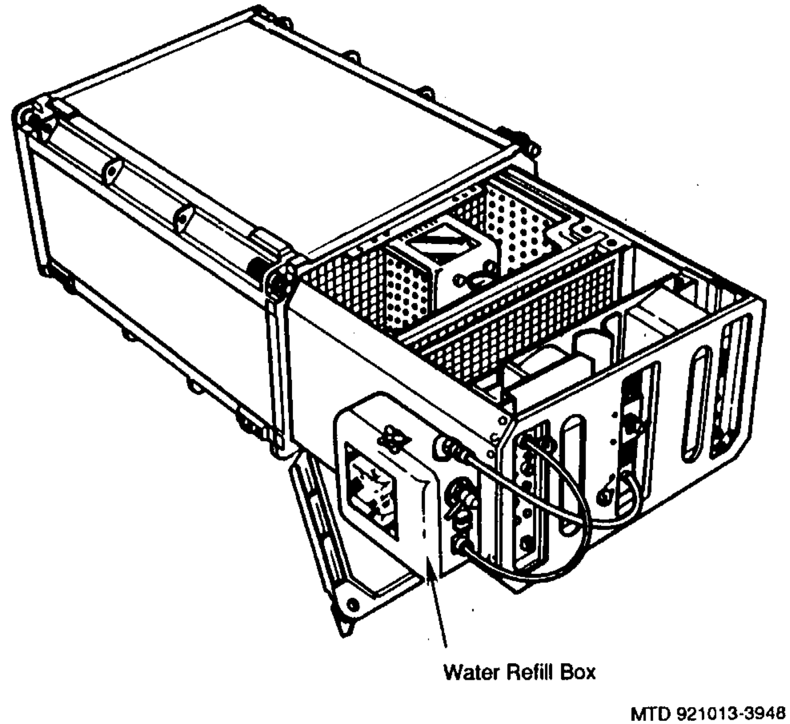
col. Veterinarians oversee the selection, care, and handling of the rats.

Tissues from the rats will be evaluated in a series of postflight studies by teams of scientists from both Merck and the CCR. The studies are expected to last from several months to a year.

Dr. W. C. Hymer is director of the Center for Cell Research at Penn State and co-investigator for PSE. Dr. William W. Wilfinger is the CCR director of Physiological Testing. Dr. Gideon Rodan of Merck is principal investigator.



Water Refill Box Assembly



PSE With Water Refill Box Assembly

HEAT PIPE PERFORMANCE (HPP) EXPERIMENT

The HPP experiment is part of a series of tests designed to develop technology that will make it easier for space vehicles to reject excess heat generated by their equipment and crews.

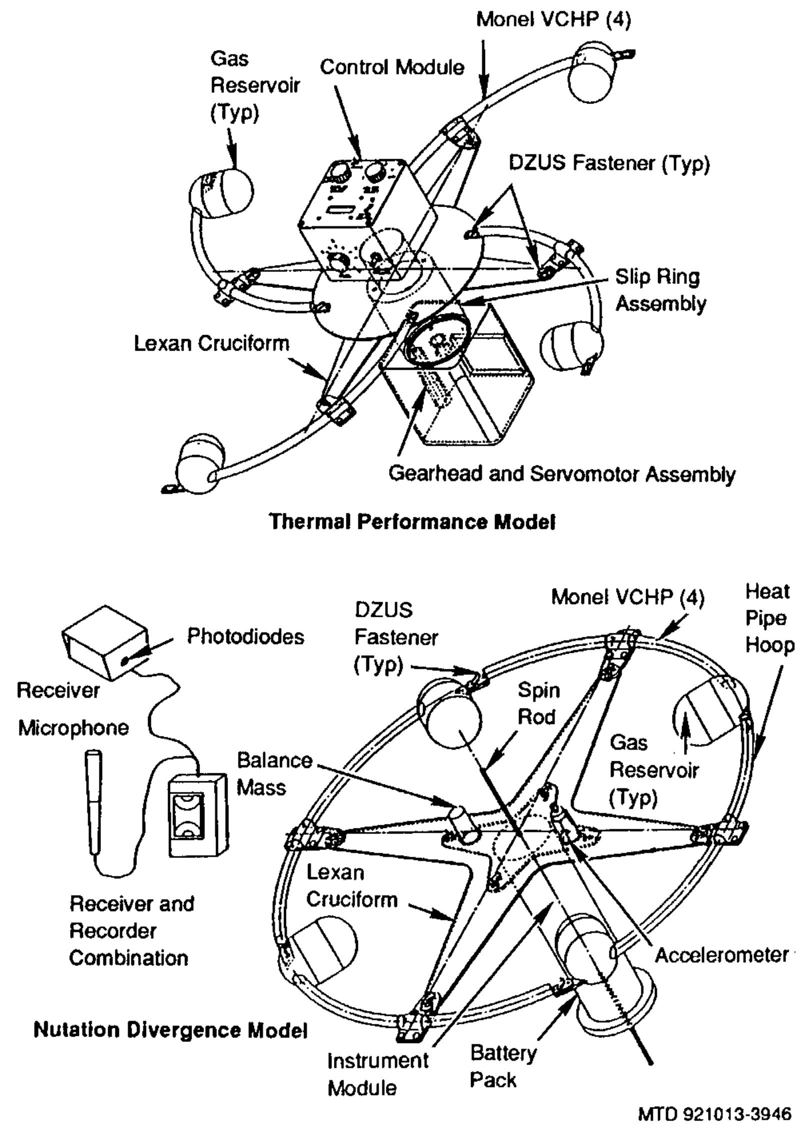
Currently, heat control technology on space vehicles, such as the shuttle orbiter, uses a complex system of pumps, valves, and radiators to dump waste heat into space. A fluid called Freon 21 circulates through a loop that collects heat which is then pumped between two flat plates that radiate the heat to space. However, such radiators are susceptible to damage by orbital debris, and mechanical pumping systems may not be reliable for longer missions.

A heat pipe system provides a simple, highly reliable way to reject heat. A closed, fluid-filled vessel without moving mechanical parts, it operates on the natural phenomenon of liquids absorbing heat to evaporate and releasing that heat when condensing. The waste heat generated by a spacecraft evaporates the liquid at one end of the heat pipe, and the vapor condenses and releases heat to space at the other end. The fluid is moved back to the evaporator end by capillary action.

The STS-52 HPP experiment will evaluate the sensitivity of state-of-the-art heat pipes to large and small spacecraft accelerations and the influence of the heat pipes on spacecraft motion and will gather data on the force needed to dry out heat pipes and the amount of time required for them to recover.

The STS-52 crew will test two designs for fluid return by capillary action: eight fixed-conductance heat pipes (FCHPs) with axial grooves and six variable-conductance heat pipes (VCHPs) with fibrous wicks. Some of the heat pipes consist of a copper vessel with triply distilled water as the working fluid; the others consist of aluminum with Freon 113.

The HPP payload hardware consists of heat pipes, spin-up devices, an instrument module, a video camcorder, and supporting



Heat Pipe Configurations

electronics. The assembly is driven by a motor on an instrument unit mounted to the middeck floor. A thermal performance configuration and a nutation configuration will be tested. Both the FCHPs and the VCHPs will be tested in each configuration.

During the mission, one or two astronauts will assemble the experiment in the orbiter middeck and conduct the tests. In each experiment run, four heat pipes will be evaluated by rotating them on a cross-shaped frame. A battery-powered data logger will record the data. The HPP experiment requires TV and photographic coverage.

The HPP device will spin at various rates to simulate different levels of spacecraft acceleration and body forces. Crew members also will perform "rewicking" tests to measure the time needed for the heat pipes to reprime and operate after excessive spin forces make them deprime. The plans are for 18.3 hours of HPP flight tests, with another 4.5 hours needed for setup and stowage.

The results of the tests will be carefully compared by researchers with existing computer models and static ground tests to determine their efficiency in predicting heat pipe performance in microgravity.

HPP is part of NASA's In-Space Technology Experiments Program (IN-STEP), which is designed to unite NASA, the aerospace community, and universities in researching potentially valuable space technologies using small, relatively inexpensive experiments.

NASA's Office of Aeronautics and Space Technology selects the experiments and manages the program. Hughes Aircraft Co. designed and built the HPP hardware. The experiment is managed at NASA's Goddard Space Flight Center, Greenbelt, Md.

SHUTTLE PLUME IMPINGEMENT EXPERIMENT (SPIE)

Contamination will be a part of space station Freedom operations because the shuttle will fire its thrusters as it docks and departs from the station on each visit. Designers assessing the materials planned for use in constructing space station Freedom want to know what and how much contamination should be planned for in building Freedom. The SPIE will measure and record contamination from shuttle thruster firings, the flux of atomic oxygen and other atmospheric constituents and particulates encountered on orbit, and sensor contaminate evaporation rates.

The SPIE package is positioned above the nose of the shuttle to measure contamination from Columbia's primary reaction control system steering jet, which will be fired in its vicinity. Quartz crystal microbalance sensors will measure the contaminants. Quartz sensor measurements will be recorded on the payload and general-support computer (PGSC). Any particles ejected by the thrusters will be collected by a sticky piece of Kapton material in the sensor package.

SPIE will also support the CANEX-2 MELEO experiment as it exposes materials to atomic oxygen around Columbia. During MELEO operations, the remote manipulator system will be positioned to place the SPIE sensor package in Columbia's direction of travel. Atomic oxygen levels will be recorded on the PGSC in Columbia's cabin.

The payload consists of flux/fluence-sensing hardware mounted on the end effector of Columbia's RMS arm, an experiment flight electronics unit mounted in the orbiter aft flight deck, and the PGSC, a portable lap-top computer in Columbia's crew cabin that is used to record data for ground analysis. The SPIE hardware components are interconnected from the RMS end effector in the payload bay to the aft flight deck using RMS and orbiter data and power cabling and payload-specific cabling.

The SPIE principal investigator is Steve Koontz of the Non-Metallic Materials section in the Structures and Mechanics Division at NASA's Johnson Space Center.

COMMERCIAL MATERIAL DISPERSION APPARATUS MINILAB/INSTRUMENTATION TECHNOLOGY ASSOCIATES, INC., EXPERIMENT (CMIX)

CMIX, which occupies one middeck locker, consists of four material dispersion apparatus minilabs housed in a refrigerator/incubator module. Initially developed to grow protein crystals in space, the minilabs have been flown on two shuttle missions and were redesigned to accommodate additional research areas. During STS-52, they will be used to conduct 31 different experiments in crystal growth, formation of thin-film membranes, bioprocessing, and live cells.

The goal of the protein crystal growth experiments is to produce larger, purer crystals than those produced on Earth. The pharmaceutical industry will use X-ray crystallographic analysis to study the crystals in hopes of deciphering the structure of proteins. Such information would be useful in the development of new drugs or treatments.

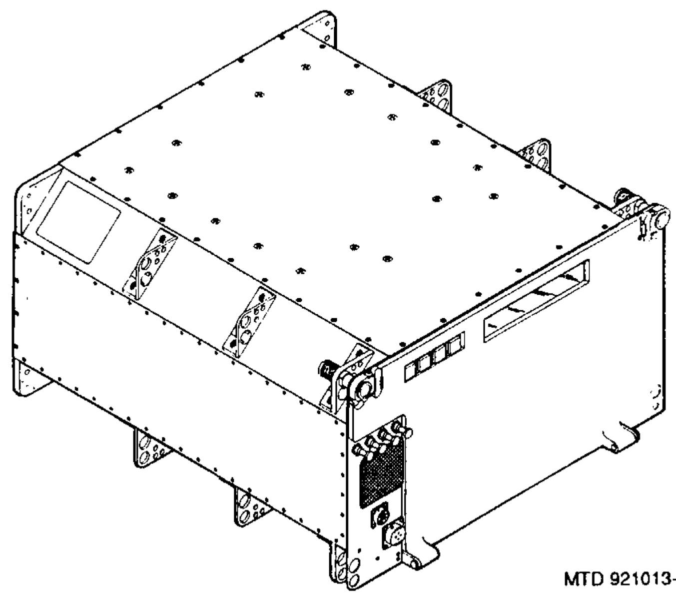
The thin-film membrane formation experiments are expected to increase understanding of membrane structures and enhance production of membranes on Earth. Potential applications of more uniform membranes include separation of gases, biotechnology, pollution control, and waste stream recovery.

Zeolites are porous minerals that have molecule-size holes that can be used as sieves. Those found on Earth or made by man are small and have erratic molecular structures. Results from the CMIX zeolite crystal growth experiment will be applied to the production of zeolites on Earth for use by the petrochemical industry to increase gasoline yield and by clean-up crews dealing with low-level nuclear waste and other hazardous substances.

The bioprocessing experiments will determine the advantages of space-based processing to identify improvements for bioprocessing on Earth. For instance, the self-assembly of macromolecules in microgravity may augment the development of new implant materials for heart valves, replacement joints, blood vessels, and replacement lenses for the human eye. In addition, the assembly of complex liposomes and virus particles may be used in drugs targeted to specific body cells to treat cancer.

The minilabs will also carry live human and mouse cells, which will be studied to identify low-response cells for possible development of drugs that mitigate the undesirable effects of space travel.

In addition to these 31 experiments sponsored by NASA's Centers for the Commercial Development of Space, 7 experiments designed by high school students will share the dispersion apparatus. The student experiments, sponsored by Instrumentation Technology Associates, Inc., as part of its space education program, include



CMIX Payload

studies of seed germination, brine shrimp growth, and crystal formation.

The material dispersion apparatus—the size of a brick—is an automated, self-contained processing device able to bring into contact and/or mix up to 100 different samples of fluids and solids at precisely timed intervals. It operates on the principles of liquid-to-liquid diffusion and vapor diffusion (osmotic dewatering).

Throughout the flight, the apparatus remains in a thermally controlled refrigerator/incubator module (RIM). The four minilabs inside the apparatus each have upper and lower blocks containing an equal number of reservoirs filled with different substances. As early as possible in the mission, the shuttle crew will open the RIM door, operate switches to activate each lab, and then close the door. Microgravity disturbances must be kept at a minimum for at least the next eight hours.

When the apparatus is activated, the blocks and their reservoirs automatically align so that the different substances can mix. While the activation of all labs is simultaneous, deactivation occurs automatically at different intervals, depending on the experiment within. When the shuttle mission is over, samples will be returned to researchers for postflight analyses.

The CMIX principal investigator is Dr. Marian Lewis of the University of Alabama in Huntsville Consortium for Materials Development in Space (one of 17 NASA Centers for the Commercial Development of Space). The flight hardware is supplied by Instrumentation Technology Associates, Inc., of Exton, Pa., an industry partner of the university consortium. John Cassanto, president of ITA, is co-investigator.

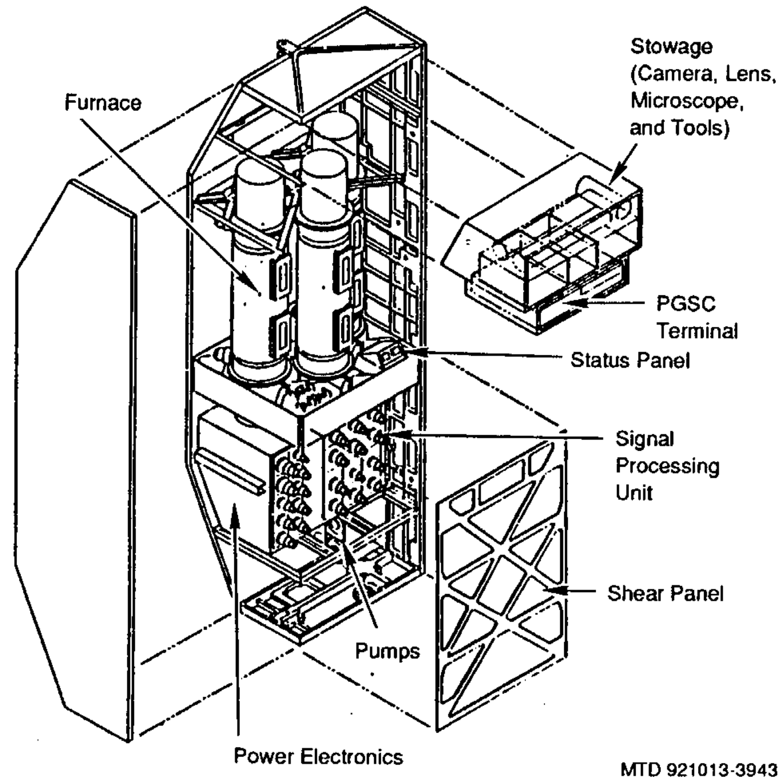
ITA is providing its MDA minilab under a "value exchange" agreement with the university consortium. NASA flies the lab for five missions or five years, whichever comes first, and receives a certain percentage of the capacity for use by its commercial development researchers.

The privately financed minilab offers users general turnkey space experiment equipment at a low cost. Users focus on their experiments and ITA handles the payload integration and documentation. This arrangement supports one of the aims of NASA's Centers for the Commercial Development of Space—to provide opportunities for materials development projects that can benefit from the unique attributes of space.

The ability of semiconductors to process and store information depends on the quality of the crystals used. Although today's computer chips contain very high quality silicon, certain effects caused by Earth's gravitational pull, such as thermal convection (turbulence induced by variations in densities caused by the temperature differences that occur in a material when it is heated), buoyancy (less dense materials rise), and sedimentation (denser materials sink), have limited scientists' ability to produce more advanced materials on Earth. The Crystal Vapor Transport Experiment (CVTE), developed by Boeing Defense & Space Group, Missiles & Space Division, Kent, Wash., will enable scientists to learn more about growing larger and more uniform industrial crystals for producing faster and more capable semiconductors for computers, sensors, and other electronic devices. The CVTE equipment designed to produce these crystals is a precursor to future crystal growth work planned aboard space station Freedom later in this decade.

The CVTE payload consists of two high-temperature furnaces installed inside a middeck accommodations rack (MAR), which replaces the orbiter galley. Each of the furnaces will provide a controlled environment for crystal growth. The CVTE system has a transparent window through which the crew can observe the growing crystal and adjust the crystal's position and the furnace's temperature to achieve optimum growth. On orbit, the crew will be required to activate, monitor, control, and adjust the operation of the CVTE. An SSP-provided payload and general-support computer will be used by the crew to activate the CVTE and will be dedicated to the CVTE during processing runs. Ground-commanded camcorder operations will be required during crew sleep periods to monitor MAR water loop temperatures.

CVTE will use two samples of cadmium telluride compound and a process called vapor transport to grow purer and more uniform crystals in microgravity. The cadmium telluride compound is a solid that is sealed in a glass tube placed inside the CVTE furnace and heated to 850°C. When heated, the compound vaporizes at one end of the glass tube and crystallizes at the other. The evaporate forms two gaseous materials: cadmium and tellurium. The process is reversed during crystallization. By carefully controlling the temperatures and temperature profile inside the glass tube, large single crystals can be produced. The high temperature used in this experiment is expected to produce samples as large in diameter as a dime.



CVTE Configuration

Previous crystal growth facilities have only been able to grow samples about the size of a pencil eraser.

Astronauts Bill Shepherd and Mike Baker trained with Boeing scientists to learn to work the CVTE equipment. With astronauts monitoring and observing the on-orbit crystal growth, it is hoped that they might be able to better interpret the resulting data and ultimately help industry produce superior crystals.

In addition to the astronauts monitoring the experiment, NASA still cameras will document the rate of crystal growth every several minutes.

CVTE is sponsored by NASA's Office of Commercial Programs. Dr. R.T. Ruggeri and Dr. Ching-Hua Su, both of Boeing, are principal investigators for CVTE. CVTE program manager is Barbara Heizer of Boeing. Boeing's David Garman is chief engineer.

COMMERCIAL PROTEIN CRYSTAL GROWTH EXPERIMENT

Metabolic processes involving proteins play an essential role in our lives, from providing nourishment to fighting disease. In the past decade, rapid growth in protein pharmaceutical use has resulted in the successful application of proteins to insulin, interferons, human growth hormone, and tissue plasminogen activator. The pharmaceutical industry seeks these pure protein crystals because their purity will simplify Federal Drug Administration approval of new protein-based drugs. Pure, well-ordered protein crystals of uniform size are in demand as special formulations for use in drug delivery.

Such research has attracted firms in the pharmaceutical, biotechnological, and chemical industries. In response, the Center for Macromolecular Crystallography (CMC), a NASA Center for the Commercial Development of Space at the University of Alabama in Birmingham, has formed affiliations with a variety of companies that are investing substantial amounts of time, research, and money developing protein samples for use in evaluating the benefits of microgravity. Structural information gained from CPCG activities can provide a better understanding of the body's immune system and aid in the design of safe and effective treatments for disease and infections.

Protein crystal growth investigations are conducted in space because space-grown crystals tend to be larger, purer, and more highly structured than Earth-grown crystals. Such crystals greatly facilitate the study of protein structures. Scientists want to learn about a protein's three-dimensional structure to understand how it works, how to reproduce it, or how to change it. X-ray crystallography is widely used to determine a protein's three-dimensional structure. This technique requires large, well-ordered crystals for analysis.

During the past four years, several hardware configurations have been used to conduct protein crystal growth middeck experiments on seven space shuttle flights. The objective of these experiments is to supply information on the scientific methods and commercial potential for growing large, high-quality protein crystals in microgravity. On STS-52, the protein crystallization facility (PCF), developed by CMC, will use much larger quantities of materials to grow crystals in batches, using temperature as a means to initiate and control crystallization, thereby virtually eliminating temperature-induced convection currents that can interfere with crystal growth.

The reconfigured PCF includes four plastic cylinders. These cylinders allow a relatively minimal temperature gradient and require less protein solution to produce quality crystals. The reconsideration was driven by industry's need to reduce the cost and amount of protein sample needed to grow protein crystals in space, while, at the same time, increasing the quality and quantity of crystals.

Also flying on STS-52 as part of the CPCG payload complement is a state-of-the-art commercial refrigerator/ incubator module (CRIM) that permits CRIM temperatures to be programmed prior to launch. The temperatures are monitored during flight by a feedback loop. Developed by Space Industries, Inc., of Webster, Texas, for CMC, the CRIM also has an improved thermal capability and a microprocessor that uses "fuzzy logic" (a branch of artificial intelligence) to control and monitor the CRIM's thermal environment. A thermoelectric device is used to electrically "pump" heat in or out of the CRIM.

The CPCG payload is installed in a middeck locker and requires nearly continuous 28-Vdc power.

The PCF serves as the growth chamber for significant quantities of protein crystals. Each of the PCF cylinders on STS-52 is encapsulated in individual aluminum tubes and supported by an aluminum structure. Prior to launch, the cylinders will be filled with bovine insulin solution and mounted in a CRIM set at 40°C. Each cylinder lid will pass through the left wall of the aluminum structure and come in direct contact with a metal plate in the CRIM that is temperature-controlled by the thermoelectric device.

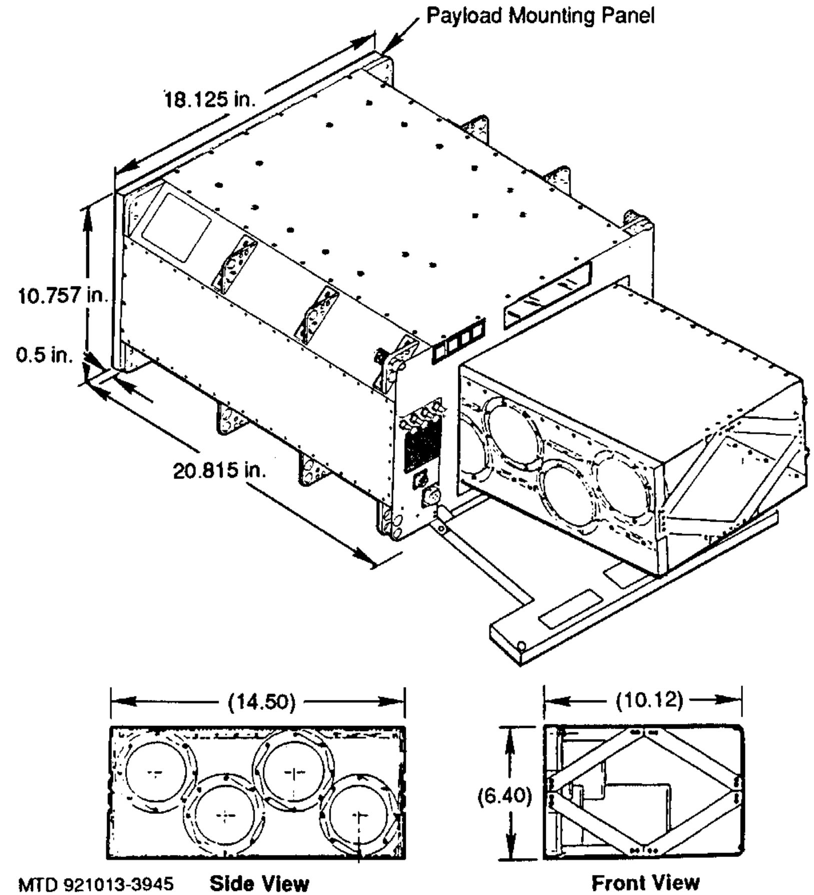
Shortly after reaching orbit, the crew will activate the PCF experiment by initiating the preprogrammed temperature profile. The CRIM temperature will be reduced automatically from 40°C to 22°C over a four-day period. The change in CRIM temperature will be transferred from the cold plate through the cylinder's lids to the insulin solution.

The crystals begin to form when the temperature of the solution is decreased 18°C. They should be well ordered because the effects of Earth's gravity are reduced. Once activated, the payload will not require any further crew interaction (except for periodic monitoring) or any modifications for landing.

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

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

The Commercial Protein Crystal Growth payload is sponsored by NASA's Office of Commercial Programs and is developed and managed by the Center for Macromolecular Crystallography. Dr. Charles E. Bugg, director of CMC, is lead investigator of the CPCG experiment. Dr. Marianna Long, CMC associate director for commercial development, is also a CPCG investigator, as is CMC deputy director Dr. Lawrence DeLucas.



Commercial Protein Crystal Growth CRIM Block II Configuration

Ascent aerodynamic distributed loads verification on Columbia (DTO 236). This DTO will collect data on wing aerodynamic distributed loads to allow verification of the aerodynamic data base.

Entry aerodynamic control surfaces test—alternate elevon schedule, Part 4 (DTO 251). This DTO will perform PTI maneuvers and one body flap maneuver during entry and TAEM to obtain aerodynamic response data for evaluating the effectivity of aerodynamic control surfaces. Analysis may enhance vehicle performance and safety. This DTO uses the alternate forward elevon schedule and contains six parts.

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.

Entry structural capability evaluation (DTO 307D). This DTO will collect structure loads data for different payload weights and configurations to expand the data base of flight loads during entry.

ET TPS performance (methods 1 and 3) (DTO 312). This DTO will photograph the external tank after separation to determine TPS charring patterns, identify regions of TPS material spallation, and evaluate overall TPS performance.

Edwards lake bed runway bearing strength and rolling friction assessment for orbiter landing (DTO 520). The purpose of this DTO is to obtain data to better understand the rolling friction of orbiters on Edwards dry lake beds as this data relates to heavyweight orbiters with a forward center of gravity.

EDO WCS fan separator evaluation (DTO 657). The purpose of this DTO is to verify the design worthiness of the new extended-duration orbiter (EDO) waste collector subsystem (WCS) fan separator under zero-g conditions for a prolonged period. This will also verify whether the new design will correct past fan separator deficiencies.

Acoustical noise dosimeter data (DTO 663). This DTO will use an audio dosimeter to gather baseline data on the time-averaged acoustical noise levels for the middeck during daytime and nighttime operations. Noise levels are a concern from crew operations, performance, and health standpoints. Data is sought on middeck payloads, intermittent equipment noises, voice/communications, the new RCRS, the WCS, the manned laboratory when laboratories are flown, inside the three- or four-tier sleep station, and on the middeck during sleep periods when no "hard" sleep station is flown. This data will provide information to help determine new specification levels for intermittent noises as well as a maximum 24-hour exposure level.

Interim portable on-board printer (DTO 669). This DTO will evaluate a portable thermal printer as an interim backup to the text and graphics system (TAGS) hard copier and teleprinter. This DTO will provide a backup system for quality text and graphics and will only be used in the event of a Ku-band or TAGS failure.

Laser range and range rate device (DTO 700-2). The purpose of this DTO is to demonstrate the capability to provide the orbiter flight crew with range and range rate data for rendezvous, proximity operations, and deploy operations using a hand-held device. This DTO will assess the usefulness of the data to assist the pilot in achieving the desired trajectory conditions.

Crosswind landing performance (DTO 805). This DTO will continue to gather data for a manually controlled landing with a crosswind.

Plume impingement model verification (DTO 828). This DTO will impinge the CTA with one or more PRCS engines and determine its range, attitude, and induced velocity using the Space Vision System (SVS) and/or the orbiter radar. Flight data will be used to support test validation of the orbiter RCS plume impingement math model.

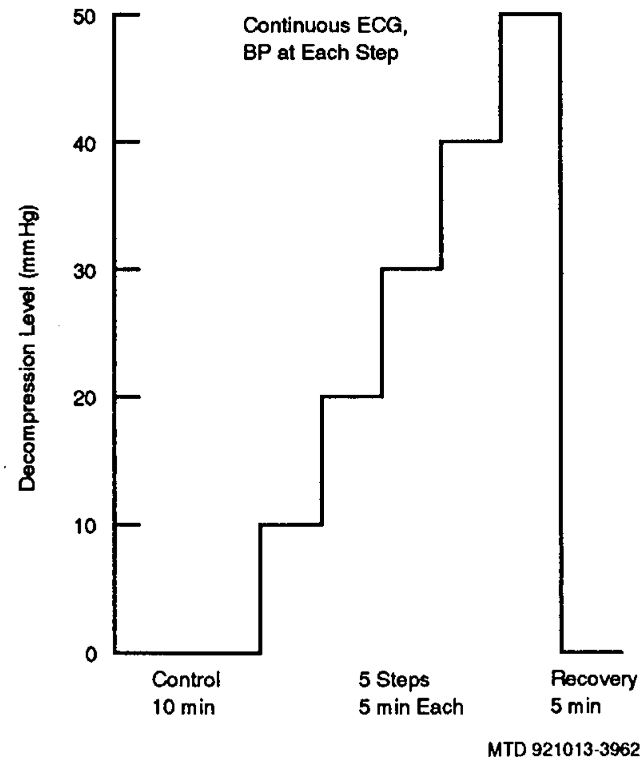
Advanced portable computer evaluation (DTO 1209). This DTO will evaluate advanced portable computer technology to develop the requirements needed to support space station Freedom crews.

Intraocular pressure (DSO 472). This DSO will gather data on headward fluid shifts in zero gravity, which can be used to evaluate crew health. Pressure measurements 20 to 25 percent above normal preflight levels were observed in bedrest studies, during zero gravity on the KC-135 aircraft, and on the STS 61-A shuttle mission. The deleterious effects of sustained deviations in intraocular pressure are difficult to predict since no statistically valid in-flight data exist. Even though a few days or weeks of elevated intraocular pressure would be harmless, months or years of sustained pressures, due to microgravity, could cause ocular disturbances. Significant baseline data are needed to define normal intraocular pressure ranges in microgravity and to determine the magnitude of pressure rises to be expected in crew members. A hand-held tonometer will be validated as a tool for diagnostic and scientific data collection on orbit.

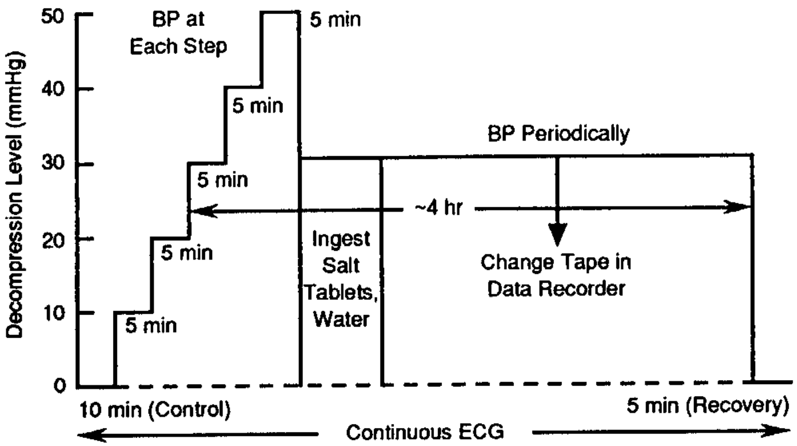
In-flight retinal vascular changes detected by digital image analysis and correlation with space adaptation syndrome (DSO 474). Retinal photography is a noninvasive method of detecting changes in intracranial pressure through changes in the retinal blood vessels and elevation of the optic disc. The purpose of this DSO is to analyze retinal photography taken on orbit and determine if microgravity-induced cephalad fluid shifts elevate intracranial pressure. It will also certify equipment to provide retinal images for diagnostic and investigative purposes.

In-flight lower body negative pressure (LBNP) (DSO 478). Fluid loading through ingesting salt tablets and water in association with lower body negative pressure treatment will protect tolerance to orthostasis (simulated in flight by LBNP). The objective of this study is to evaluate the effectiveness of fluid loading during LBNP in improving tolerance of an LBNP stress protocol.

Orthostatic function during entry, landing, and egress (DSO 603B). Heart rate and rhythm, blood pressure, cardiac output, and peripheral resistance of crew members will be monitored during entry, landing, seat egress, and orbiter egress in order to develop and assess countermeasures designed to improve orthostatic tolerance upon return to Earth. This data will be used to determine whether precautions and countermeasures are needed to protect crew members in the event of an emergency egress. It will also be used to determine the effectiveness of proposed in-flight countermeasures. Crew members will don equipment prior to donning the LES during deor-



LBNP Ramp Protocol



MTD 921013-3963

LBNP Soak Protocol

bit preparation. Equipment consists of a blood pressure monitor, accelerometers, an impedance cardiograph, and transcranial Doppler hardware. The crew members wear the equipment and record verbal comments throughout entry.

Visual-vestibular integration as a function of adaptation (OI-1 and OI-3, before and after flight only) (DSO 604). The objectives of this DSO are to investigate visual-vestibular and perceptual adaptive responses as a function of longer missions and to determine the operational impact on performance of entry, landing, and egress procedures. These data will be used to develop training and/or countermeasures to ensure the safety and success of extended missions by promoting optimal neurosensory function needed for entry, landing, and possible emergency egress.

Postural equilibrium control during landing/egress (DSO 605). Postural control as a function of mission duration will be assessed using a posture platform test performed before and after flight only. Results from this study will be used to develop countermeasures to assure postural stability during landing and egress.

Evaluation of functional skeletal muscle performance following space flight (DSO 617). The purpose of this DSO is to determine the physiological effects of long-duration space flight on skeletal muscle strength, endurance, and power by evaluating concentric and eccentric functional changes during the flight for the trunk and lower limbs. Additionally, neuromuscular dysfunction as measured by EMG will be determined. It will provide knowledge necessary to support the development of future countermeasure prescriptions essential for nominal muscle performance. On-orbit activities consist of maintaining an exercise log.

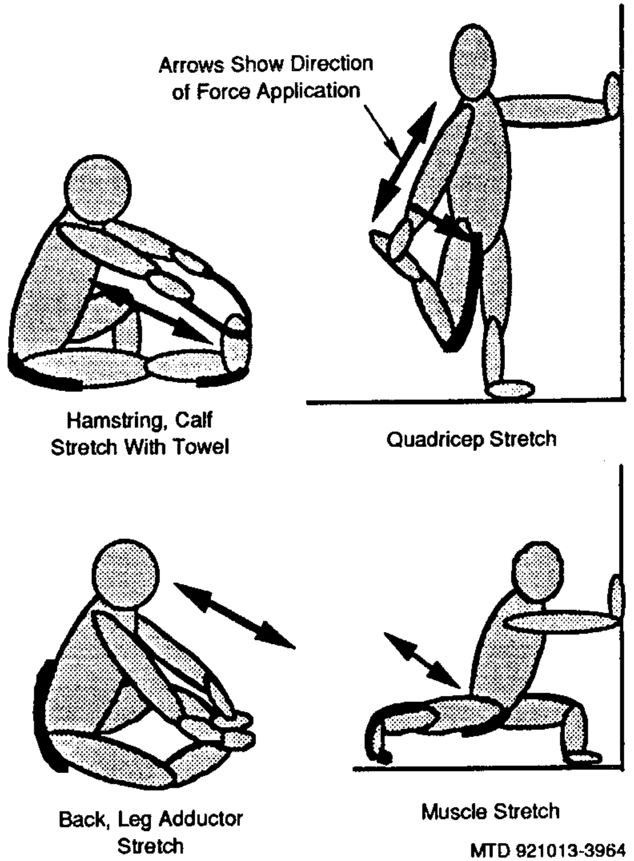
Effects of intense exercise during space flight on aerobic capacity and orthostatic function (DSO 618). The purpose of this DSO is to evaluate the effects of cycle ergometer exercise 18 to 24 hours before landing with similar exercise performed immediately after the flight to quantify deconditioning that occurs over the duration of the flight and to compare preflight, in-flight, and postflight heart rate responses to cycle ergometry.

In-flight use of Florinef to improve orthostatic intolerance after flight (DSO 621). The purpose of this DSO is to evaluate the efficacy of mineralocorticoid, commonly known as Florinef, to enhance postflight orthostatic capacity as determined by heart rate, blood pressure, stroke volume, and other cardiovascular responses to orthostatic stress. Florinef, a plasma expander, has been effective in restoring or maintaining plasma volume and orthostatic tolerances during postbedrest tests. A cardiovascular profile will be determined both before and after flight for the participating crew member.

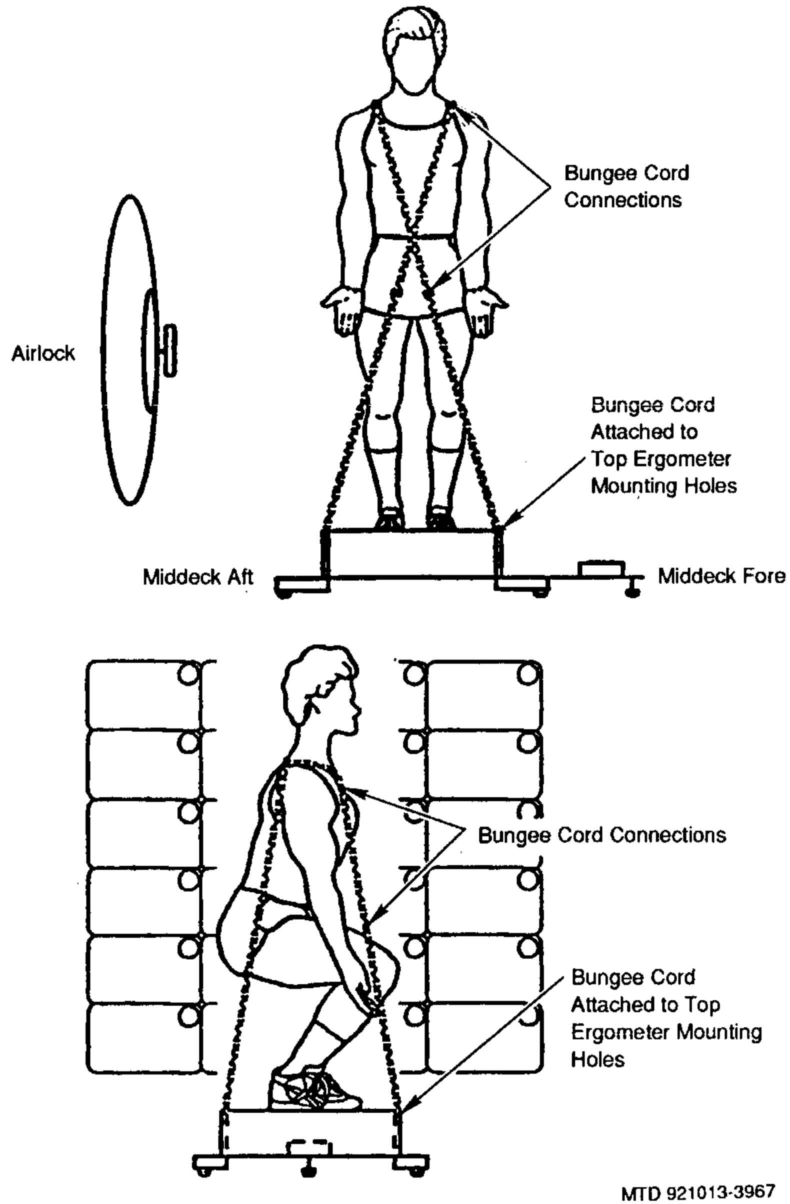
In-flight LBNP test of countermeasures and end-of-mission countermeasure trial (DSO 623). The primary objective of this DSO is to assess LBNP (soak) countermeasure effectiveness at the end of shuttle flights. A secondary objective of this study is to evaluate the effectiveness of fluid loading during in-flight LBNP in improving tolerance to an LBNP stress protocol.

Documentary television (DSO 901). The purpose of DSO 901 is to provide live television transmission or VTR dumps of crew activities and spacecraft functions, including payload bay views, shuttle and payload bay 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 flight objectives. This DSO includes the IRIS/LAGEOS deployment and burn, middeck activities, and crew photography. This photography provides a historical record of



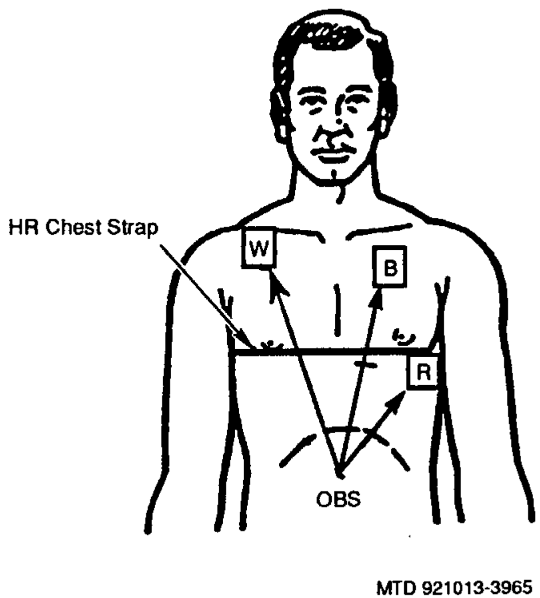
Stretching Routine for In-Flight Exercise and Preexercise Test



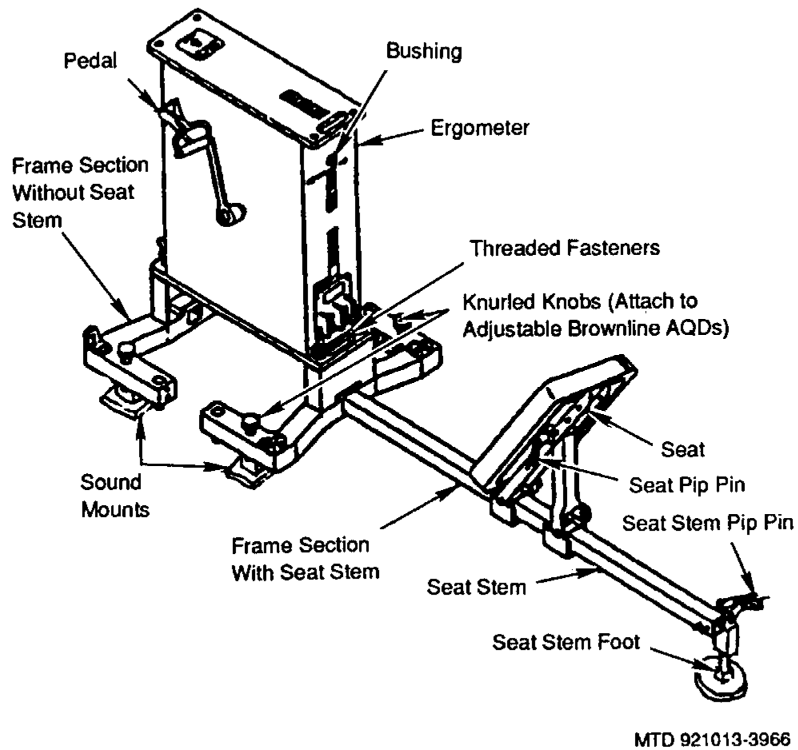
Alternate Exercise Bungee Attachments

the flight as well as material for release to the news media, independent publishers, and film producers.

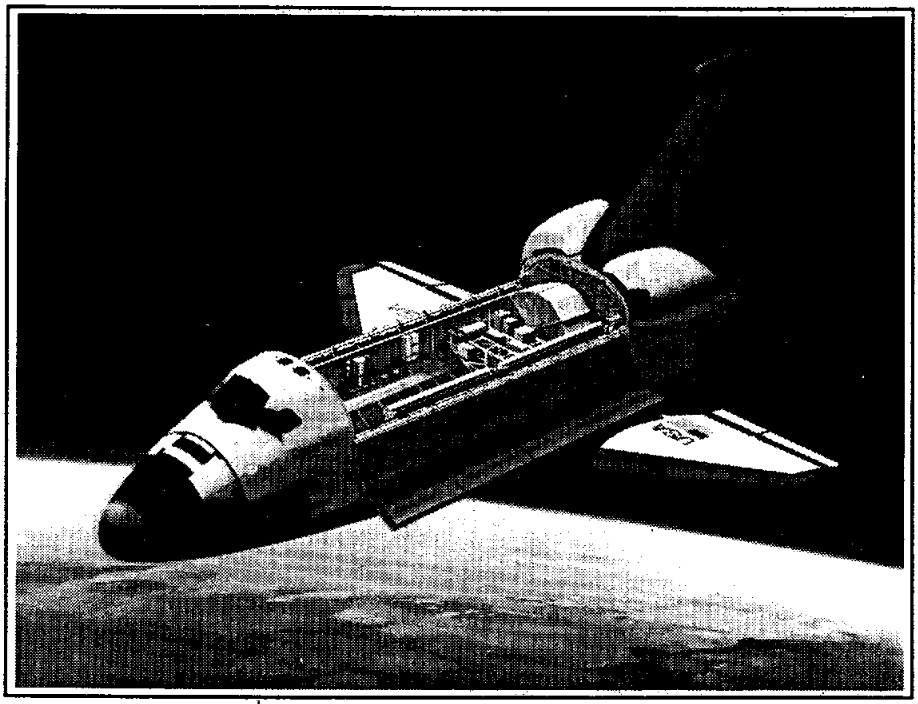
Documentary still photography (DSO 903). This DSO requires still photography of crew activities in the orbiter, spacecraft accommodations, and mission-related scenes of general public and historical interest. The CANEX-2 OGLOW-2 payload requires still photography in the 35mm format. The CANEX-2 MELEO payload requires still photography in the 70mm format.



OBS Electrode Placement



Ergometer



STS-52

MISSION STATISTICS

PRELAUNCH COUNTDOWN TIMELINE

MISSION TIMELINE

October 1992

Rockwell International
Space Systems Division

Office of External Communications &
Media Relations

CONTENTS

MISSION OVERVIEW

This is the 13th flight of Columbia and the 51st for the space shuttle.

The flight crew for the 10-day STS-52 mission is commander James (Jim) D. Wetherbee; pilot Michael (Mike) A. Baker; mission specialists William (Bill) M. Shepherd, Tamara (Tammy) E. Jernigan, and Charles L. (Lacy) Veach; and payload specialist Steven (Steve) MacLean, of the Canadian Space Agency.

STS-52 will continue the shuttle program's investigation of our planet, advanced technologies, and advanced materials processing, with applications on Earth and in space. The mission is challenging due to the large number of payloads (11) and their diversity, encompassing geophysics, materials sciences, biological research, and applied research for space station Freedom..Columbia's versatility as a satellite launcher, science platform, and technology testbed will all be demonstrated.

The mission has two primary objectives: deployment of the Laser Geodynamic Satellite (LAGEOS) and operations of the U.S. Microgravity Payload-1.

Columbia's crew will eject the Laser Geodynamic Satellite (LAGEOS)-II from the orbiter's payload bay on the second mission day (Orbit 15) at an altitude of 160 nautical miles. Built by the Italian Space Agency using NASA blueprints, the 900-pound LAGEOS satellite will supplement the original LAGEOS satellite launched in 1976 to provide geologists with ranging information through interaction with ground-based lasers. Laser ranging involves sending laser beams to a mirror-covered satellite and recording the round-trip travel time. This measurement enables scientists to measure precisely the distances between laser ranging stations on Earth and the satellite. LAGEOS will provide a reference point for laser ranging experiments that will monitor the motion of the Earth's crust, measure and understand the "wobble" in the Earth's axis of rotation, collect information on the Earth's size and shape, and more accurately determine the length of the day. The information will be particularly useful for monitoring regional fault movement in earthquake-prone areas. The data will be used by ground-based researchers from 30 countries. LAGEOS-II will be placed in orbit by the Italian Research Interim Stage (IRIS), a spinning solid upper stage perigee kick booster. The crew will command the deploy activities from the orbiter's aft flight deck. Forty-five minutes after deployment, the IRIS motor will fire and place LAGEOS-II into the desired orbit.

The other primary payload is the United States Microgravity Payload (USMP)-1. USMP-1 consists of three experiments mounted on a new payload bay carrier: a multipurpose experiment support structure derived from a previously flown Materials Science Lab. They consist of the Lamda Point Experiment (LPE), a new test measuring the heat capacity of cryogenic helium; Materiel Pour L'Etude Des Phenomenes Interssant La Solidification Sur Terre et en Orbite (MEPHISTO), which will study different parameters that influence crystalline growth; and Space Acceleration Measurement System (SAMS), which will measure accelerations for LPE and MEPHISTO. SAMS will also store and transmit large blocks of data. The experiments will be operated by the Payload Operations Control Center at NASA's Marshall Space Flight Center, Huntsville, Ala.

STS-52 secondary objectives include the Attitude Sensor Package (ASP), Canadian Experiments (CANEX)-2, Commercial Protein Crystal Growth (CPCG), Heat Pipe Performance Experiment (HPP), Physiological Systems Experiment (PSE), Shuttle Plume Impingement Experiment (SPIE), Crystals by Vapor Transport Experiment (CVTE), Commercial Materials ITA Experiment (CMIX), and Tank Pressure Control Experiment (TPCE).

The ASP payload consists of three independent attitude sensors: the Modular Star Sensor (MOSS); the Yaw Earth Sensor (YESS); and the Low Altitude Conical Earth Sensor (LACES). The sensors are carried on a Hitchhiker platform in Columbia's payload bay. This European Space Agency payload will gather information on the performance and accuracy of new sensors. The data may be used in the design of sensors for future spacecraft.

The CANEX-2 payload, developed by the Canadian Space Agency, consists of eight sets of experiments, many of which are extensions of work carried out by Dr. Marc Garneau as part of the CANEX group of experiments that flew on the shuttle in 1984. Results from CANEX-2 have potential applications in machine vision systems for use with robotic equipment in space and in environments such as mines and nuclear reactors. Other potential applications relate to the manufacturing of goods, the development of new protective coatings for spacecraft materials, improvements in materials processing, and a better understanding of Earth's stratosphere, which contains the protective ozone layer. Physiological experiments will also be conducted on back pain, body water changes, and the effect of weightlessness on the vestibular system.

Space Vision Systems (SVS), the primary CANEX-2 experiment, is an experimental machine vision system to reinforce the accuracy of human vision in space. It uses the orbiter closed-circuit TV system, the remote manipulator system (RMS), and the Canadian Target Assembly (CTA), which is maneuvered on the RMS and then deployed on Flight Day 10.

The CTA is used as a test object for the SVS and a NASA test objective on the effects of orbiter reaction control system plumes. It will not be retrieved. The CCTV system will track visual targets on the surface of the CTA.

The Material Exposure in Low Earth Orbit (MELEO) experiment consists of material samples on witness plates mounted to the RMS. The RMS will be periodically maneuvered to expose the plates at different positions and to permit observation of the plates by the crew. MELEO will also measure atomic oxygen flux with the Shuttle Plume Impingement Experiment (SPIE).

The Orbiter Glow (OGLOW) experiment will study the glow phenomenon generated on the orbiter surface at certain attitudes.

During Sun Photometer Earth Atmosphere Measurements (SPEAM), the crew will point a hand-held sun photometer directly at the sun and moon through various orbiter windows to measure atmospheric absorption at several wavelengths during sunrise and sunset.

The Phase Partitioning in Liquids (PARLIQ) experiment is a middeck experiment that will study the phase partitioning process.

The Queen's University Experiment in Liquid Metal Diffusion (QUELD) consists of a small furnace operated in the middeck area.

The Space Adaptation Tests and Observations (SATO) consists of a series of medical tests (space adaptation, vestibulo-ocular reflex, taste and smell, back pain, and proprioceptive illusions) performed upon the payload specialist, Steven MacLean, of Canada.

CPCG will supply information on the scientific methods and commercial potential for growing large, high-quality protein crystals in microgravity. The configuration on this flight, Block II, consists of a commercial refrigerator/incubator module (CRIM) and a protein crystallization facility (PCF).

The HPP payload in Columbia's middeck will study the behavior of heat pipes in the presence of spacecraft motion and the influence of the heat pipe on spacecraft motion.

The PSE will study the effects of a proprietary protein molecule on animal physiological systems in microgravity. The compound has possible use in combating diseases that involve loss of bone mass. The PSE will be contained in two middeck lockers and two Animal Enclosure Modules.

The SPIE payload consists of flux/fluence sensing hardware mounted on the end effector of the shuttle's RMS, an electronics unit in the aft flight deck, and a payload general support computer for data recording. The SPIE hardware will record the effects of atomic oxygen on different materials and measure orbiter PRCS plume burns as a measure of contamination.

The CVTE middeck payload consists of two furnaces installed inside a middeck accommodations rack. On orbit, the CVTE will process material sample cartridges during low-g periods of the mission. Two samples will be processed on STS-52.

CMIX consists of an experiment housed within a refrigerator/incubator module. It consists of four material dispersion apparatus minilabs and occupies the space of one middeck locker. Protein crystal growth, collagen polymerization, and other phenomena will be studied. The data have potential applications in the biotechnology and pollution control fields.

TPCE/TP will verify models of fluid behaviors and flow patterns in tanks in microgravity with application to design of future cryogenic tanks for spacecraft. TPCE/TP is installed in a sealed getaway special (GAS) canister attached to a GAS adapter beam in Columbia's payload bay.

Thirteen detailed test objectives and 13 detailed supplementary objectives are scheduled to be flown on STS-52.

MISSION STATISTICS

Vehicle: Columbia (OV-102), 13th flight

Launch Date/Time:

10/22/92 11:16 a.m., EDT
10:16 a.m., CDT
8:16 a.m., PDT

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

Launch Window: 2 hours, 13 minutes

Launch Period: 3 hours, 5 minutes

Mission Duration: 9 days, 20 hours, 46 minutes

Landing: Nominal end-of-mission landing on orbit 159

11/1/92 7:02 a.m., EST
6:02 a.m., CST
4:02 a.m., PST

Runway: Nominal end-of-mission landing on concrete runway 15, Kennedy Space Center, Fla. Weather alternates are Edwards Air Force Base (EAFB), Calif., and Northrup Strip (NOR), White Sands, New Mexico.

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

Return to Launch Site: KSC

Abort-Once-Around: EAFB; alternates: KSC and NOR

Inclination: 28.45 degrees

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

The OMS-1 thrusting maneuver after main engine cutoff plus approximately 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.

Altitudes: 160 nautical miles (184 statute miles) circular orbit (LAGEOS deployment)
155 nautical miles (178 statute miles) circular orbit
113 nautical miles (130 statute miles) circular orbit (CANEX-2 CTA deployment)

Space Shuttle Main Engine Thrust Level During Ascent: 104 percent

Space Shuttle Main Engine Locations:

No. 1 position: Engine 2030
No. 2 position: Engine 2015
No. 3 position: Engine 2034

External Tank: ET-55

Solid Rocket Boosters: BI-054

Editor's Note: The following weight data are current as of October 13, 1992.

Total Lift-off Weight: Approximately 4,514,325 pounds

Orbiter Weight, Including Cargo, at Lift-off: Approximately 250,130 pounds

Orbiter (Columbia) Empty, and 3 SSMEs: Approximately 181,169 pounds

Payload Weight Up: Approximately 20,077 pounds

Payload Weight Down: Approximately 14,419 pounds

Orbiter Weight at Landing: Approximately 215,114 pounds

Payloads--Payload Bay (* denotes primary payload): LAGEOS-II/IRIS,* CANEX-2, USMP-1,* ASP, TPCE

Payloads--Middeck: PSE, HPP, CPCG, SPIE, CMIX, CVTE

Flight Crew Members:

Commander: James D. Wetherbee, second space shuttle flight
Pilot: Michael A. Baker, second space shuttle flight
Mission Specialist 1: Charles Lacy Veach, second space shuttle flight
Mission Specialist 2: William M. Shepherd, third space shuttle flight
Mission Specialist 3: Tamara E. Jernigan, second space shuttle flight
Payload Specialist 1: Steven MacLean, first space shuttle flight

Ascent Seating:

Flight deck, front left seat, commander James D. Wetherbee
Flight deck, front right seat, pilot Michael A. Baker
Flight deck, aft center seat, mission specialist William M. Shepherd
Flight deck, aft right seat, mission specialist Charles Lacy Veach
Middeck, mission specialist Tamara E. Jernigan
Middeck, payload specialist Steven MacLean

Entry Seating:

Flight deck, front left seat, commander James D. Wetherbee
Flight deck, front right seat, pilot Michael A. Baker
Flight deck, aft center seat, mission specialist William M. Shepherd
Flight deck, aft right seat, mission specialist Tamara E. Jernigan
Middeck, mission specialist Charles Lacy Veach
Middeck, payload specialist Steven MacLean

Extravehicular Activity Crew Members, If Required:

Extravehicular (EV) astronaut 1: William M. Shepherd
EV-2: Tamara E. Jernigan

Intravehicular Astronaut: Michael A. Baker

STS-52 Flight Directors:

Ascent, Entry: Jeff Bantle
Orbit 1 Team/Lead: Bob Castle
Orbit 2 Team: Rich Jackson
Planning: Chuck Shaw

Entry: Automatic mode until subsonic, then control stick steering

Notes:

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

. The galley is not installed in Columbia's middeck

. Columbia will have the regenerative carbon dioxide removal system installed. One carbon dioxide absorber and one charcoal canister is installed prior to launch. On orbit, the canisters are replaced by use of the RCRS. However, enough LiOH will be stowed to cover 10 days with extension. The crew will configure the system for on-orbit operations during Post Insertion and no further crew operation of this system is required until midflight. The unit is then deactivated in the deorbit prep time frame. One LiOH can will be installed for entry.

. Columbia's radiators will nominally be deployed after IRIS/LAGEOS deploy. The radiators will be stowed for ASP operations, and re-deploy will be considered for thermal reasons, if necessary, after ASP operations are complete.

. A modified Group B powerdown will be required for all on-orbit operations, except for those times when a partial powerup is needed.

MISSION OBJECTIVES

. Primary Objectives
  - Laser Geodynamic Satellite (LAGEOS)-II/Italian Research Interim Stage (IRIS) deployment
  - United States Microgravity Payload (USMP)-1 operations
. Secondary Objectives
  - Middeck
    . Physiological Systems Experiment (PSE)-02
    . Heat Pipe Performance (HPP) Experiment
    . Commercial Protein Crystal Growth (CPCG) Block II
    . Shuttle Plume Impingement Experiment (SPIE)
    . Commercial Materials Dispersion Apparatus Experiment (CMIX)
    . Crystals by Vapor Transport Experiment (CVTE)
  - Payload Bay
    . Canadian Experiments (CANEX)-2
    . Attitude Sensor Package (ASP)
    . Tank Pressure Control Experiment/Thermal Phenomena (TPCE/TP)
. Development Test Objectives/Detailed Supplementary Objectives

FLIGHT ACTIVITIES OVERVIEW

Flight Day 1

Launch
OMS-2
Open payload bay doors
Ku-band antenna deployment
Unstow cabin
IRIS/LAGEOS checkout
Payload activation
USMP operations
ASP operations
CANEX QUELD operations
CMIX operations
CPCG operations
Medical DSOs
SAMS calibration maneuvers

Flight Day 2

IRIS/LAGEOS deployment (Orbit 15)
RMS checkout
OMS-3 separation burn
IRIS/LAGEOS injection (PKM ignition)
RMS payload bay survey
OMS-4 orbit adjust burn to 155 nmi.
OMS-5 circularization burn
CANEX-2 QUELD, SVS operations
CMIX operations
HPP operations
USMP operations

Flight Day 3

LBNP operations
First unberth/berth of CANEX-2 CTA
CANEX-2 SVS, PARLIQ, SPEAM, QUELD operations
HPP operations
PSE operations
USMP operations

Flight Day 4

CVTE activation
HPP operations
PSE operations
CANEX-2 SPEAM operations
CMIX operations
CPCG operations
USMP operations

Flight Day 5

LBNP operations
CANEX-2 SPEAM, QUELD operations
HPP operations
CMIX operations
CVTE operations
USMP operations

Flight Day 6

LBNP operations
CPCG operations
HPP operations
CANEX-2 QUELD, SPEAM, PARLIQ operations
CVTE setup/activation
USMP operations

Flight Day 7

LBNP operations
CPCG operations
CANEX-2 PARLIQ, QUELD, SPEAM, MELEO operations
CVTE operations
RMS deployment
USMP operations

Flight Day 8

CANEX-2 CTA unberth for SVS run
LBNP operations
CANEX-2 MELEO, QUELD, SPEAM operations
ASP maneuvers
Crew press conference

Flight Day 9

OMS-6 orbit adjust burn to 113 nmi.
OMS-7 circularization burn
LBNP operations
CANEX-2 CTA unberthed for SVS run
CANEX-2 MELEO, SVS, OGLOW operations

Flight Day 10

CANEX CTA deployment (Orbit 140)
CANEX separation maneuver (Sep 2)
CANEX separation maneuver (Sep 3)
SPIE plume measurements
RCS hot-fire test
FCS checkout
Cabin stow

Flight Day 11

Deorbit preparation
Deorbit burn
Landing

Notes:

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

DEVELOPMENT TEST OBJECTIVES/DETAILED SUPPLEMENTARY OBJECTIVES

DTOs

. Ascent aerodynamic distributed loads verification on OV-102 (DTO 236)
. Entry aerodynamic control surfaces test -- alternate elevon schedule, part 4 (DTO 251)
. Ascent structural capability evaluation (DTO 301D)
. Entry structural capability evaluation (DTO 307D)
. ET TPS performance (methods 1 & 3) (DTO 312)
. EDO WCS fan separator evaluation (DTO 657)
. Acoustical noise dosimeter data (DTO 663)
. Interim portable onboard printer (DTO 669)
. Laser range and range rate device (DTO 700-2)
. Crosswind landing performance (DTO 805)
. Plume impingement model verification (DTO 828)
. Advanced portable computer evaluation (DTO 1209)

DSOs

. Intraocular pressure (DSO 472)
. Retinal photography (DSO 474)
. In-flight lower body negative pressure (LBNP) (DSO 478)
. Orthostatic function during entry, landing, and egress (DSO 603B)
. Visual-vestibular integration as a function of adaptation (OI-1 and OI-3 (pre and post flight only) (DSO 604)
. Postural equilibrium control during landing/egress (DSO 605)
. Evaluation of functional skeletal muscle performance following space flight (DSO 617)
. Effects of intense exercise during space flight on aerobic capacity and orthostatic functions (DSO 618)
. In-flight use of Florinef to improve orthostatic intolerance postflight (DSO 621)
. In-flight LBNP test of countermeasures and of end of mission countermeasures trial (DSO 623)
. Documentary television (DSO 901)
. Documentary motion picture photography (DSO 902)
. Documentary still photography (DSO 903)

STS-52 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-52 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-52 Flight Plan, Ascent Checklist, Post Insertion Checklist, Deploy 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.
0/00:00:14	Roll maneuver ends.
0/00:00:29	All three SSMEs throttle down from 100 to 67 percent for maximum aerodynamic load (max q).
0/00:01:00	Max q occurs.
0/00:01:06	All three SSMEs throttle to 104 percent.
0/00:02:04	SRBs separate.
	When chamber pressure (Pc) of the SRBs is less than 50 psi, automatic separation occurs with manual flight crew backup switch to the automatic function (does not bypass automatic circuitry). SRBs descend to approximately 15,400 feet, 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.
0/00:04:05	Negative return. The vehicle is no longer capable of return-to-launch site abort at Kennedy Space Center runway.
0/00:07:02	Single engine press to main engine cutoff (MECO).
0/00:08:26	All three SSMEs throttle down to 67 percent for MECO.
0/00:08:31	MECO occurs at approximate velocity 25,874 feet per second, 35 by 156 nautical miles (40 by 180 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.
0/00:42	OMS-2 thrusting maneuver is performed, approximately 2 minutes, 20 seconds in duration, at 222 fps, 160 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.
0/01:17	Commander activates radiators.
0/01:19	If go for payload bay door operations, MS configures for payload bay door operations.
0/01:28	MS 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.
0/01:40	Commander and pilot clothing configuration.
0/01:40	MS/PS clothing configuration.
0/01:51	MS activates teleprinter (if flown).
0/01:52	Commander begins post-payload bay door operations and radiator configuration.
0/01:55	MS/PS remove and stow seats.
0/01:56	Commander starts ST self-test and opens door.

T+ (PLUS) DAY/ HR:MIN:SEC	EVENT
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.
0/02:02	Pilot activates auxiliary power unit steam vent heater, panel R2, boiler controller/heater, 3 to A, power, 3 to ON.
0/02:04	Commander configures vernier control.
0/02:07	Commander, pilot configure controls for on-orbit.
0/02:10	Commander maneuvers to IMU alignment attitude.
0/02:15	Commander performs IMU alignment using ST.
0/02:17	MS performs on-orbit initialization.
0/02:21	MS enables hydraulic thermal conditioning.
0/02:24	MS resets caution/warning (C/W).
0/02:28	Pilot plots fuel cell performance.
0/02:35	Unstow cabin.
0/02:35	USMP activation.
0/03:00	IRIS/LAGEOS checkout.
0/03:35	Ku-band antenna deployment.
0/04:10	ASP activation.
0/04:35	CANEX QUELD operations.
0/04:40	SAMS calibration maneuvers.
0/05:00	TPCE activation.

T+ (PLUS) DAY/ HR:MIN:SEC	EVENT
0/05:10	DSO 604.
0/05:25	DSOs 472/474.
0/05:36	CMIX MDA activation.
0/05:55	CPCG activation.
0/06:00	Crew begins presleep activities.
0/09:00	Crew begins sleep period.
0/17:00	Crew begins postsleep activities.
0/19:20	RMS checkout.
0/20:47	LAGEOS deployment and shuttle separation.
0/21:02	Shuttle OMS-3 separation burn.
0/21:15	CANEX-2 QUELD operations.
0/21:32	LAGEOS solid motor ignition.
0/21:45	RMS checkout.
0/22:40	RMS payload bay survey.
0/22:50	RMS power down.
0/23:12	OMS-4 orbit adjust burn to 155 nmi.
0/23:59	OMS-5 circularization burn.

MET DAY ONE

1/00:15	SVS systems checkout.
1/00:30	HPP test run.

T+ (PLUS) DAY/ HR:MIN:SEC	EVENT
1/03:30	CMIX operations.
1/03:55	QUELD operations.
1/04:00	DSO 472.
1/04:50	DTO 657 setup.
1/05:00	TPCE deactivation.
1/05:50	DTO 663.
1/06:00	Crew begins presleep activities.
1/09:00	Crew begins sleep period.
1/17:00	Crew begins postsleep activities.
1/18:45	QUELD operations.
1/19:20	SPEAM sunrise.
1/20:00	DTO 663.
1/21:50	LBNP ramp run.
1/22:00	DSO 618.
1/22:05	PARLIQ setup.

MET DAY TWO

2/02:20	SVS grapple CTA task.
2/04:20	PSE operations.
2/05:00	DTO 663.
2/05:00	Crew begins presleep activities.

T+ (PLUS) DAY/ HR:MIN:SEC	EVENT
2/08:00	Crew begins sleep period.
2/16:00	Crew begins postsleep activities.
2/19:00	DTO 663.
2/19:35	CVTE setup/activation.
2/20:00	CPCG operations.
2/23:20	HPP test runs.

MET DAY THREE

3/02:30	SPEAM operations.
3/02:30	DTO 657.
3/03:00	DTO 669.
3/03:15	PSE operations.
3/04:00	Crew begins presleep activities.
3/07:00	Crew begins sleep period.
3/15:00	Crew begins postsleep activities.
3/17:00	QUELD operations.
3/18:00	DSO 623.
3/18:25	SPEAM operations.
3/18:30	LBNP ramp run-pilot.
3/21:00	DTO 663.

T+ (PLUS) DAY/ HR:MIN:SEC	EVENT
MET DAY FOUR	
4/01:05	HPP operations.
4/02:30	CVTE operations.
4/02:45	DTO 663.
4/03:15	DSO 621.
4/03:00	Crew begins presleep activities.
4/06:00	Crew begins sleep period.
4/14:00	Crew begins postsleep activities.
4/15:30	DSO 621.
4/17:00	DTO 663.
4/20:00	CVTE setup/activation.
4/20:15	CPCG operations.
4/20:20	SPEAM operations.
4/20:45	QUELD operations.
4/22:15	LBNP soak--commander.
MET DAY FIVE	
5/03:00	DSO 621.
5/03:30	Crew begins presleep period.
5/06:00	Crew begins sleep period.
5/14:00	Crew begins postsleep activities.

T+ (PLUS) DAY/ HR:MIN:SEC	EVENT
5/16:00	DSO 621.
5/16:00	QUELD activation.
5/17:45	SPEAM operations.
5/20:15	CVTE deactivation.
5/22:00	USMP (MEPHISTO deactivation).

MET DAY SIX

6/03:00	Crew begins presleep activities.
6/05:00	DSO 621.
6/06:00	Crew begins sleep period.
6/14:00	Crew begins postsleep activities.
6/15:45	DSO 621.
6/17:15	CANEX CTA grapple.
6/17:30	DTO 700-2.
6/17:45	LBNP ramp-pilot.
6/19:50	USMP LPE deactivation.
6/22:00	SPEAM operations.
6/23:45	Crew press conference.

MET DAY SEVEN

7/02:50	PSE operations.
7/03:00	Crew begins presleep activities.

T+ (PLUS) DAY/ HR:MIN:SEC	EVENT
7/03:20	MELEO activation.
7/03:30	QUELD deactivation.
7/05:00	ASP operations.
7/06:00	Crew begins sleep period.
7/14:00	Crew begins postsleep activities.
7/15:15	DSO 621.
7/16:45	SVS operations.
7/16:55	CANEX CTA grapple.
7/17:05	CTA unberth.
7/20:00	OMS-6 orbit adjust burn.
7/20:20	OMS-7 circularization burn.
7/22:00	OGLOW operations.
7/23:10	CTA unberth.

MET DAY EIGHT

8/01:30	DSO 604.
8/02:15	Crew begins presleep activities.
8/03:00	MELEO exposure.
8/05:15	Crew begins sleep period.
8/13:15	Crew begins postsleep activities.
8/15:20	MELEO deactivation.

T+ (PLUS) DAY/ HR:MIN:SEC	EVENT
8/15:30	SPIE activation.
8/16:50	CTA release and separation.
8/17:05	Shuttle separation burn 2.
8/17:28	Shuttle separation burn 3.
8/18:00	DSO 618.
8/19:15	RMS powerdown.
8/19:25	FCS checkout.
8/19:30	SPIE bakeout.
8/20:25	CMIX deactivation.
8/20:44	RCS hotfire test.
8/22:15	Cabin stowage.

MET DAY NINE

9/01:15	Ku-band antenna stow.
9/01:15	Crew begins presleep activities.
9/04:15	Crew begins sleep period.
9/12:15	Crew begins postsleep activities.
9/15:10	ASP deactivation.
9/15:20	SPIE deactivation.
9/16:00	Begin deorbit preparation.
9/16:00	CRT timer setup.

T+ (PLUS) DAY/ HR:MIN:SEC	EVENT
9/16:02	Commander initiates coldsoak.
9/16:11	Stow radiators, if required.
9/16:29	Commander configures DPS for deorbit preparation.
9/16:32	Mission Control Center updates IMU star pad, if required.
9/16:41	MS configures for payload bay door closure.
9/16:50	Ku-band antenna stow.
9/16:52	MCC-H gives "go/no-go" command for payload bay door closure.
9/17:02	Maneuver vehicle to IMU alignment attitude.
9/17:17	IMU alignment/payload bay door operations.
9/17:40	MCC gives the crew the go for OPS 3.
9/17:47	Pilot starts repressurization of SSME systems.
9/17:51	Commander and pilot perform DPS entry configuration.
9/18:00	MS deactivates ST and closes ST doors.
9/18:02	All crew members verify entry payload switch list.
9/18:17	All crew members perform entry review.
9/18:19	Crew begins fluid loading, 32 fluid ounces of water with salt over next 1.5 hours (2 salt tablets per 8 ounces).
9/18:32	Commander and pilot configure clothing.
9/18:47	MS/PS configure clothing.
9/18:57	Commander and pilot seat ingress.

T+ (PLUS) DAY/ HR:MIN:SEC	EVENT
9/18:59	Commander and pilot set up heads-up display (HUD).
9/19:01	Commander and pilot adjust seat, exercise brake pedals.
9/19:09	Final entry deorbit update/uplink.
9/19:15	OMS thrust vector control gimbal check is performed.
9/19:17	APU prestart.
9/19:32	Close vent doors.
9/19:36	MCC-H gives "go" for deorbit burn period.
9/19:42	Maneuver vehicle to deorbit burn attitude.
9/19:45	MS/PS ingress seats.
9/19:52	First APU is activated.
9/19:57	Deorbit burn.
9/20:02	Initiate post-deorbit burn period attitude.
9/20:06	Terminate post-deorbit burn attitude.
9/20:14	Dump forward RCS, if required.
9/20:22	Activate remaining APUs.
9/20:14	Entry interface, 400,000 feet altitude.
9/20:17	Enter communication blackout.
9/20:20	Automatically deactivate RCS roll thrusters.
9/20:26	Automatically deactivate RCS pitch thrusters.
9/20:29	Initiate first roll reversal.

T+ (PLUS) DAY/ HR:MIN:SEC	EVENT
9/20:30	Initiate PTIs.
9/20:34	Initiate second roll reversal.
9/20:35	Exit communications blackout.
9/20:38	Initiate third roll reversal.
9/20:39	Initiate air data system (ADS) probe deploy.
9/20:39	Terminate PTIs.
9/20:40	Begin entry/terminal area energy management (TAEM).
9/20:40	Initiate payload bay venting.
9/20:42	Automatically deactivate RCS yaw thrusters.
9/20:45	Begin TAEM/approach/landing (A/L) interface.
9/20:45	Initiate landing gear deployment.
9/20:46	Vehicle has weight on main landing gear.
9/20:46	Vehicle has weight on nose landing gear.
9/20:46	Initiate main landing gear braking.
9/20:47	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
AOS	acquisition of signal
APC	autonomous payload controller
APCS	autonomous payload control system
APU	auxiliary power unit
ASE	airborne support equipment
BFS	backup flight control system
CCD	charge-coupled device
CDMS	command and data management subsystem
COAS	crewman optical alignment sight
CRT	cathode ray tube
C/W	caution/warning
DACA	data acquisition and control assembly
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
EDOMP	extended duration orbiter medical project
EHF	extremely high frequency
ELV	expendable launch vehicle
EMP	enhanced multiplexer/demultiplexer pallet
EMU	extravehicular mobility unit
EOM	end of mission
EPS	electrical power system
ESA	European Space Agency
ET	external tank
ETR	Eastern Test Range

EV	extravehicular
EVA	extravehicular activity
FC	fuel cell
FCS	flight control system
FDF	flight data file
FES	flash evaporator system
FPS	feet per second
FRCS	forward reaction control system
GAS	getaway special experiment
GLS	ground launch sequencer
GN&C	guidance, navigation, and control
GPC	general-purpose computer
GSFC	Goddard Space Flight Center
HAINS	high accuracy inertial navigation system
HRM	high-rate multiplexer
HUD	heads-up display
IFM	in-flight maintenance
IMU	inertial measurement unit
I/O	input/output
IR	infrared
IV	intravehicular
JSC	Johnson Space Center
KEAS	knots equivalent air speed
KSC	Kennedy Space Center
LBNP	lower body negative pressure
LCD	liquid crystal display
LES	launch escape system
LPS	launch processing system
LRU	line replaceable unit
MCC-H	Mission Control Center--Houston
MDM	multiplexer/demultiplexer
MECO	main engine cutoff
MET	mission elapsed time
MILA	Merritt Island
MLP	mobile launcher platform
MM	major mode

MPESS	mission-peculiar equipment support structure
MPM	manipulator positioning mechanism
MPS	main propulsion system
MS	mission specialist
MSFC	Marshall Space Flight Center
NCC	corrective combination maneuver
NH	differential height adjustment
NMI	nautical miles
NOR	Northrup Strip
NPC	plane change maneuver
NSR	coelliptic maneuver
O&C	operations and checkout
OAA	orbiter access arm
OCP	Office of Commercial Programs
OMS	orbital maneuvering system
OPF	orbiter processing facility
OTC	orbiter test conductor
PASS	primary avionics software system
PCMMU	pulse code modulation master unit
PCS	pressure control system
PGSC	payload and general support computer
PI	payload interrogator
PIC	pyro initiator controller
POCC	Payload Operations Control Center
PRD	payload retention device
PRLA	payload retention latch assembly
PRSD	power reactant storage and distribution
PS	payload specialist
PTI	preprogrammed test input
P/TV	photo/TV
RAAN	right ascension of the ascending node
RCRS	regenerable carbon dioxide removal system
RCS	reaction control system
RF	radio frequency
RGA	rate gyro assembly
RMS	remote manipulator system
ROEU	remotely operated electrical umbilical
RPM	revolutions per minute
RSLS	redundant-set launch sequencer
RSS	range safety system

RTLS	return to launch site
S&A	safe and arm
SA	solar array
SAF	Secretary of the Air Force
SAMS	space acceleration measurement system
SHF	superhigh frequency
SM	statute miles
SRB	solid rocket booster
SRM	solid rocket motor
SRSS	shuttle range safety system
SSME	space shuttle main engine
SSP	standard switch panel
SSPP	Shuttle Small Payload Project
SSPP	solar/stellar pointing platform
ST	star tracker
STA	structural test article
STS	Space Transportation System
SURS	standard umbilical retraction/retention system
TAEM	terminal area energy management
TAGS	text and graphics system
TAL	transatlantic landing
TDRS	tracking and data relay satellite
TDRSS	tracking and data relay satellite system
TFL	telemetry format load
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
VTR	videotape recorder
WCS	waste collection system