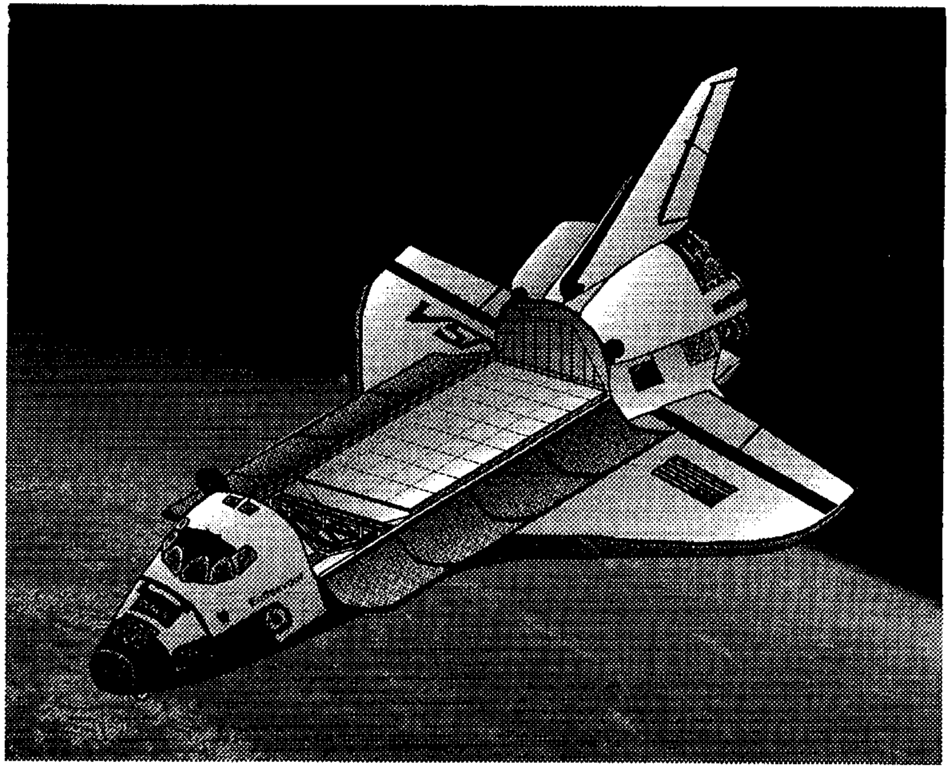

STS-59

PRESS INFORMATION AND MISSION TIME LINE

April 1994

Rockwell

Office of Media Relations
Space Systems Division

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CONTENTS

MISSION OVERVIEW

This is the 6th flight of Endeavour and the 62nd for the space shuttle.

The flight crew for the 9-day STS-59 mission is commander Sidney (Sid) M. Gutierrez, pilot Kevin P. Chilton, payload commander Linda M. Godwin, and mission specialists Jay Apt, Michael R. (Rich) Clifford, and Thomas (Tom) D. Jones. The crew will be divided into a blue team, consisting of Apt, Clifford, and Jones, and a red team made up of Gutierrez, Chilton, and Godwin. Each team will work 12-hour shifts so that operations continue around the clock.

STS-59 will be a landmark flight for scientific studies of Earth's changing environment. The mission's primary objective is the first of at least three planned flights of the Space Radar Laboratory (SRL-1), a complex and powerful radar system that will gather a variety of Earth images that will help improve man's understanding of our planet's carbon, water, and energy cycles and the effect humans have upon them. SRL will study vegetation, hydrology, tectonics, topography, and global carbon monoxide distribution. The data will be distributed to the international scientific community to assist people around the world in making informed decisions about protecting the environment. In addition to collecting valuable data, this first flight of SRL will serve to verify the performance of the radar system.

SRL comprises the Spaceborne Imaging Radar-C/X-Band Synthetic Aperture Radar (SIR-C/X-SAR) and the Measurement of Air Pollution from Satellites (MAPS). The German Space Agency (DARA) and the Italian Space Agency (ASI) are providing the X-SAR instrument. The SRL payload is installed on a standard Spacelab pallet and a multipurpose equipment support structure.

The SIR-C/X-SAR imaging radar instruments can make measurements over nearly any region in the world at any time and in any type of weather. The radar waves can penetrate clouds and, under certain conditions, "see" through vegetation, ice, and sand, allowing scientists to explore inaccessible regions of the Earth's surface.

SIR-C is the third generation of imaging radars flown on the shuttle. Its two antennas—C-band and L-band—can transmit and receive any combination of horizontally and vertically polarized L- and C-band signals.

X-SAR is a follow-up to the Microwave Remote Sensing Experiment (MRSE) flown as part of the Spacelab-1 mission (STS-9 aboard Columbia in November-December 1983). X-SAR consists of an X-band radar that transmits and receives vertically polarized signals.

Forty-nine science investigators and three associates from thirteen nations (Australia, Austria, Brazil, Canada, China, the United Kingdom, France, Germany, Italy, Japan, Mexico, Saudi Arabia, and the United States) will conduct the SIR-C/X-SAR experiments.

MAPS is a reflight of Earth photography and carbon monoxide sensing equipment flown on two earlier missions. MAPS will measure the global distribution of carbon monoxide in the Earth's troposphere, or lower atmosphere. Carbon monoxide is an important element in a number of chemical cycles. By measuring its levels, scientists can determine the ability of the Earth's atmosphere to clean itself of "greenhouse gases," chemicals that can increase the atmosphere's temperature. MAPS is installed on an MPESS with a tilted support structure to compensate for the rolled orbiter attitude (26 degrees). This orientation points the MAPS optical axis toward nadir.

Although the operation of SRL experiments does not require extensive crew involvement, the astronauts will record personal observations and take more than 6,000 photographs of the weather and environmental conditions at the sites for use in the postflight interpretation of the SIR-C/X-SAR and MAPS instrument data.

STS-59 secondary objectives include the Consortium for Materials Development in Space Complex Autonomous Payload (CONCAP) IV, three Getaway Special (GAS) payloads and one GAS ballast payload, Space Tissue Loss (STL), Visual Function Tester (VFT) 4, and the Shuttle Amateur Radio Experiment (SAREX) II. In addition, an improved thermal protection system tile known as Toughened Unipiece Fibrous Insulation (TUFI) will be tested.

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

NASA's GAS program, which has flown 101 payloads on 20 previous shuttle missions, allows individuals and organizations around the world access to space for scientific research. On STS-59, three GAS experiments from the United States, France, and Japan are manifested, plus the CONCAP IV payload and a GAS ballast payload. The GAS payload consists of various small, self-contained experiments integrated in a customer-provided standard canister. Each canister can be made up of one or multidisciplinary experiments, each with its own support system. They are controlled by the autonomous payload controller, a small hand-held keyboard used by a crew member in the aft flight deck. The GAS payloads are mounted on a bridge assembly that spans the full width of the payload bay and is installed with standard orbiter longeron and keel fittings.

The STS-59 GAS experiments are as follows:

- G-203 is a New Mexico State University experiment that will examine the freezing and crystallization process of water in space.
- G-300, sponsored by Matra Marconi Space of Paris, France, will explore thermal conductivity measurements on liquids (distilled water and two silicon oils) in microgravity.
- G-458, sponsored by the Society of Japanese Aerospace Companies, Inc., will determine whether small fruiting bodies (cellular slime molds) can be grown in microgravity.

The STS-59 STL experiment is a cooperative cell biology initiative between Walter Reed Army Institute of Research (WRAIR), Washington, D.C., and the National Institutes of Health (NIH). This special cell culture system, developed by WRAIR, will examine the effects of microgravity on muscle, bone, and endothelial cells to validate models of biochemical and functional loss induced by microgravity stress. STL will evaluate cytoskeleton, metabolism, membrane integrity, and protease activity in target cells in addition to testing tissue-loss pharmaceuticals for efficacy. Previous STL flights have shown that microgravity may affect growth rates for muscle, bone, and endothelial cells. This research will enhance understanding of astronaut bone loss and muscle deterioration during space flight, which can be applied to bone loss and muscle atrophy on Earth as well.

STL objectives require implementation of two independent and complementary analytical configurations to address the full spectrum of data. The STL-A module will address the micromolecular-level responses, and the STL-B module will study the macro-morphological alterations.

STL-B, an advanced cell culture device, will be tested for the first time on STS-59. This new system includes a video microscope that will permit scientists on Earth to see real-time video images of their experiments in space, opening up the possibility for scientists to monitor and control their space experiments from the ground. Fish eggs will be used to test the imaging capability of the system.

VFT-4 is an Air Force Armstrong Laboratory middeck experiment that will study the effects of weightlessness on human vision to determine if changes occur in space and, if so, whether the changes are clinically significant and how quickly the individual recovers. Once a day, the crew members will look into a hand-held, battery-powered device that measures the sensitivity of the eye to image contrast changes. Measurements will be taken of the near and far point of clear vision, as well as the ability to change focus within the range of clear vision. Data will be used to evaluate on-orbit refractive and accommodative changes in vision over time, derive a quantitative model of refractive changes in vision, and provide a database for microgravity effects on vision.

SAREX-II, sponsored by NASA, the American Radio Relay League/Amateur Radio Satellite Corporation, and the Johnson Space Center Amateur Radio Club, is a middeck payload that will establish two-way communication with amateur radio stations within the line of sight of the orbiter. Configuration C, planned for this mission, is capable of operating in the robot and voice modes. It consists of a suite of amateur radio equipment, including a hand-held transceiver, window antenna, headset assembly, interface module, spare battery set, packet module, and personal tape recorder. SAREX-II will be operated in the robot mode for most of the flight. Intermittent voice operations will be performed by crew members Linda Godwin and Jay Apt as time permits. Contacts with students in the United States, Finland, and Australia are planned. The crew members will educate students about STS-59 mission objectives and what it is like to live and work in space.

TUFI is a new thermal protection tile material being tested for the first time on STS-59. An advanced version of the material that protects space shuttles from the intense heat of atmospheric reentry, TUFI is designed to reduce damage from debris hits, resulting in faster and easier repairs and lower repair costs between missions. The material has been certified for testing on six shuttle flights. If the tests are successful, TUFI may be used to replace tiles in specific, limited areas of the orbiter susceptible to significant impact damage. The test TUFI tiles are located on Endeavour's base heat shield, between the three main engines. TUFI was developed at NASA's

Crew Insignia

Ames Research Center, Mountain View, Calif. The tiles were processed by Rockwell's Space Systems Division.

Endeavour will fly in a 57-degree inclination, 26-degree roll bias for all payload operations. It will be in a tail-forward attitude for all but 40 hours of the planned 9-day flight. The low orbital altitude of the mission (120 nautical miles) is required for SRL and secondary payload operations. More than 460 orbiter manevers—the most ever on a shuttle flight—will be performed to support SRL operations.

Sixteen development test objectives and 15 detailed supplementary objectives are scheduled for STS-59.

MISSION STATISTICS

Vehicle: Endeavour (OV-105), 6th flight

Launch Date/Time:

4/7/94	8:07 a.m. EDT (day) 7:07 a.m. CDT 5:07 a.m. PDT

Note: The launch team is protecting an option in the countdown time line that would allow Endeavour to launch one hour sooner at 7:07 a.m. EDT. By building flexibility into the launch time, NASA managers can evaluate predicted climatological and atmospheric conditions for the KSC area during the final part of the countdown and then select the optimum time for launch. A specific launch time will be decided no later than 24 hours before launch.

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

Launch Window: 2 hours, 30 minutes (crew-on-back constraint)

Mission Duration: 9 days, 5 hours, 7 minutes. An additional day is highly desirable and may be added if consumables (e.g., fuel, oxygen) allow. Planning will accommodate the longer duration whenever appropriate. Two days can be added for contingency operations and weather avoidance.

Landing: Nominal end-of-mission landing on orbit 150:

4/16/94	1:14 p.m. EDT (day) 12:14 p.m. CDT 10:14 a.m. PDT

Runway: Nominal end-of-mission landing on Runway 15, Kennedy Space Center (KSC), Fla., Alternatives are Edwards Air Force Base (EAFB), Calif., and Northrup Strip (NOR), White Sands, N. M.

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

Return to Launch Site: KSC

Abort Once Around: NOR; alternatives: EAFB, KSC

Inclination: 57 degrees

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

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

Altitude: 120 nautical miles (138 statute miles), circular orbit

Space Shuttle Main Engine Thrust Level During Ascent: 104 percent

Space Shuttle Main Engine Locations:

No. 1 position: Engine 2028
No. 2 position: Engine 2033

No. 3 position: Engine 2018

External Tank: ET-63

Solid Rocket Boosters: BI-065

Mobile Launcher Platform: 2

Cryo Tank Sets: 5 (fully loaded)

Software: OI-22 (7th flight)

Note: The following weight data are current as of March 21, 1994:

Total Lift-off Weight: Approximately 4,510,987 pounds

Orbiter Weight, Including Cargo, at Lift-off: Approximately 246,575 pounds

Orbiter (Endeavour) Empty and 3 SSMEs: Approximately 173,669 pounds

Payload Weight Up: Approximately 27,536 pounds

Payload Weight Down: Approximately 27,536 pounds

Orbiter Weight at Landing: Approximately 221,713 pounds

Payloads—Payload Bay (* denotes primary payload): Space Radar Laboratory (SRL) 1,* Consortium for Materials Development in Space Complex Autonomous Payload (CONCAP) IV, Getaway Special (GAS) bridge assembly with four GAS payloads (G-203, G-300, G-458, and one GAS ballast payload)

Payloads—Middeck: Space Tissue Loss (STL), Visual Function Tester (VFT) 4, Shuttle Amateur Radio Experiment (SAREX) II

Other Payloads and Activities: Toughened Unipiece Fibrous Insulation (TUFI)

Flight Crew Members (dual shift):

Red Shift:

Commander: Sidney (Sid) M. Gutierrez, second space shuttle flight
Pilot: Kevin P. Chilton, second space shuttle flight
Payload Commander (Mission Specialist 3): Linda M. Godwin, second space shuttle flight

Blue Shift:

Mission Specialist 1: Jerome (Jay) Apt, third space shuttle flight
Mission Specialist 2: Michael R. (Rich) Clifford, second space shuttle flight
Mission Specialist 4: Thomas (Tom) D. Jones, first space shuttle flight

Ascent and Entry Seating:

Ascent:

Flight deck, front left seat, commander Sidney (Sid) M. Gutierrez
Flight deck, front right seat, pilot Kevin P. Chilton
Flight deck, aft center seat, mission specialist Michael R. (Rich) Clifford
Flight deck, aft right seat, mission specialist Jerome (Jay) Apt
Middeck, payload commander Linda M. Godwin
Middeck, mission specialist Thomas (Tom) D. Jones

Entry:

Flight deck, front left seat, commander Sidney (Sid) M. Gutierrez
Flight deck, front right seat, pilot Kevin P. Chilton
Flight deck, aft center seat, mission specialist Michael R. (Rich) Clifford
Flight deck, aft right seat, mission specialist Thomas (Tom) D. Jones
Middeck, payload commander Linda M. Godwin
Middeck, mission specialist Jerome (Jay) Apt

Extravehicular Activity Crew Members, If Required:

Extravehicular (EV) astronaut 1: payload commander Linda M. Godwin
EV-2: mission specialist Thomas D. Jones

Intravehicular Astronaut: Kevin P. Chilton

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

Flight Directors:

Ascent/entry/Orbit 1: Rich Jackson
Orbit 2 and STS-59 lead: Al Pennington
Orbit 3: Bob Castle

Notes:

- The remote manipulator system is installed in Endeavour's payload bay for this mission
- The shuttle orbiter repackaged galley and middeck utility panel are installed in Endeavour's middeck
- NASA Select television is available through Spacenet 2, Transponder 5, located at 69 degrees west longitude with horizontal polarization. The frequency is 3880.0 MHz; audio is 6.8 MHz.

MISSION OBJECTIVES

- Primary objective
  - Space Radar Laboratory (SRL) 1 operations
- Secondary objectives
  - Payload bay
    - Consortium for Materials Development in Space Complex Autonomous Payload (CONCAP) IV
    - Four Getaway Special (GAS) payloads, including one GAS ballast payload
  - Middeck
    - Space Tissue Loss (STL)
    - Visual Function Tester (VFT) 4
    - Shuttle Amateur Radio Experiment (SAREX) II
  - Other
    - Toughened Unipiece Fibrous Insulation (TUFI)
- 16 development test objectives/15 detailed supplementary objectives

CREW ASSIGNMENTS

Commander: Sidney (Sid) M. Gutierrez

- Overall mission decisions
- Shift commander (red)
- Payload—VFT
- DTOs/DSOs—DTOs 653, 663, 664, and 665; DSOs 483, 487, 488, and 624
- Other—in-flight maintenance, medical

Pilot: Kevin P. Chilton

- Payload—CONCAP IV, GAS, STL
- DTOs/DSOs—DTOs 301D, 305D, 306D, 307D, 414, and 521; DSOs 326, 487, 604-1, 604-3, 608, 611, 626, 901,* 902,* and 903
- Other—in-flight maintenance (red), photo/TV,* IV

Payload Commander (Mission Specialist 3): Linda M. Godwin

- Payload—SRL-1, SAREX*
- DTOs/DSOs--DTO 656; DSOs 483, 487, 603B, 604-3, 621, and 626
- Other—EV-1, Earth observations (SRL)*

Mission Specialist 1: Jerome (Jay) Apt

- Shift commander (blue)
- Payload—CONCAP IV,* GAS,* SAREX, VFT*
- DTOs/DSOs—DTOs 312, 663,* 664,* and 665; DSOs 483, 487, 611, 624, 802, 901, 902, and 903
- Other—photo/TV, Earth observations (other), in-flight maintenance*

Mission Specialist 2: Michael R. (Rich) Clifford

- Payload—STL*
- DTOs/DSOs—DSOs 326, 483, 487, 488, 604-1, and 624
- Other—in-flight maintenance (blue), medical*

Mission Specialist 4: Thomas (Tom) D. Jones

- Payload—SRL-1
- DTOs/DSOs—DTOs 700-8 and 656*; DSOs 487 and 624
- Other—Earth observations (SRL), EV-2

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*Backup responsibility

NASA Photo

STS-59 crew members are (clockwise from top right) commander Sidney Gutierrez; mission specialists Rich Clifford, Jay Apt, and Tom Jones; payload commander Linda Godwin; and pilot Kevin Chilton.

FLIGHT ACTIVITIES OVERVIEW

Flight Day 1 (all)

Launch
OMS-2 burn (120 by 119 nmi)
Payload bay doors open
Unstow cabin
SRL-1 activation/operations
GAS activities
STL activation
VFT activation
CONCAP IV operations

Blue Flight Day 2

SRL operations
SAREX-II setup

Red Flight Day 2

SRL operations

Blue Flight Day 3

SRL operations
VFT-4 activities

Red Flight Day 3

SRL operations

Blue Flight Day 4

SRL operations
VFT activities
MS-4 off duty (half-day)

Red Flight Day 4

SRL operations
GAS activities

Blue Flight Day 5

SRL operations
STL activities
MS-2 off duty (half-day)

Red Flight Day 5

SRL operations
MS-3 off duty (half-day)
VFT activities

Blue Flight Day 6

SRL operations
MS-1 off duty (half-day)
VFT activities

Red Flight Day 6

SRL operations
VFT activities
PLT off duty (half-day)

Blue Flight Day 7

SRL operations

VFT activities

Red Flight Day 7

SRL operations
VFT activities
CDR off duty (half-day)

Blue Flight Day 8

SRL operations
VFT activities

Red Flight Day 8

SRL operations
VFT activities

Blue Flight Day 9

SRL operations
VFT activities

Red Flight Day 9

FCS checkout
RCS hot-fire
SRL operations
STL deactivation
GAS deactivation
SRL deactivation
SAREX deactivation
Cabin stow

Blue/Red Flight Day 10

Final payload deactivation
Cabin stow
Deorbit preparations
Deorbit
Entry
Landing

Note

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

DEVELOPMENT TEST OBJECTIVES/DETAILED SUPPLEMENTARY OBJECTIVES

DTOs

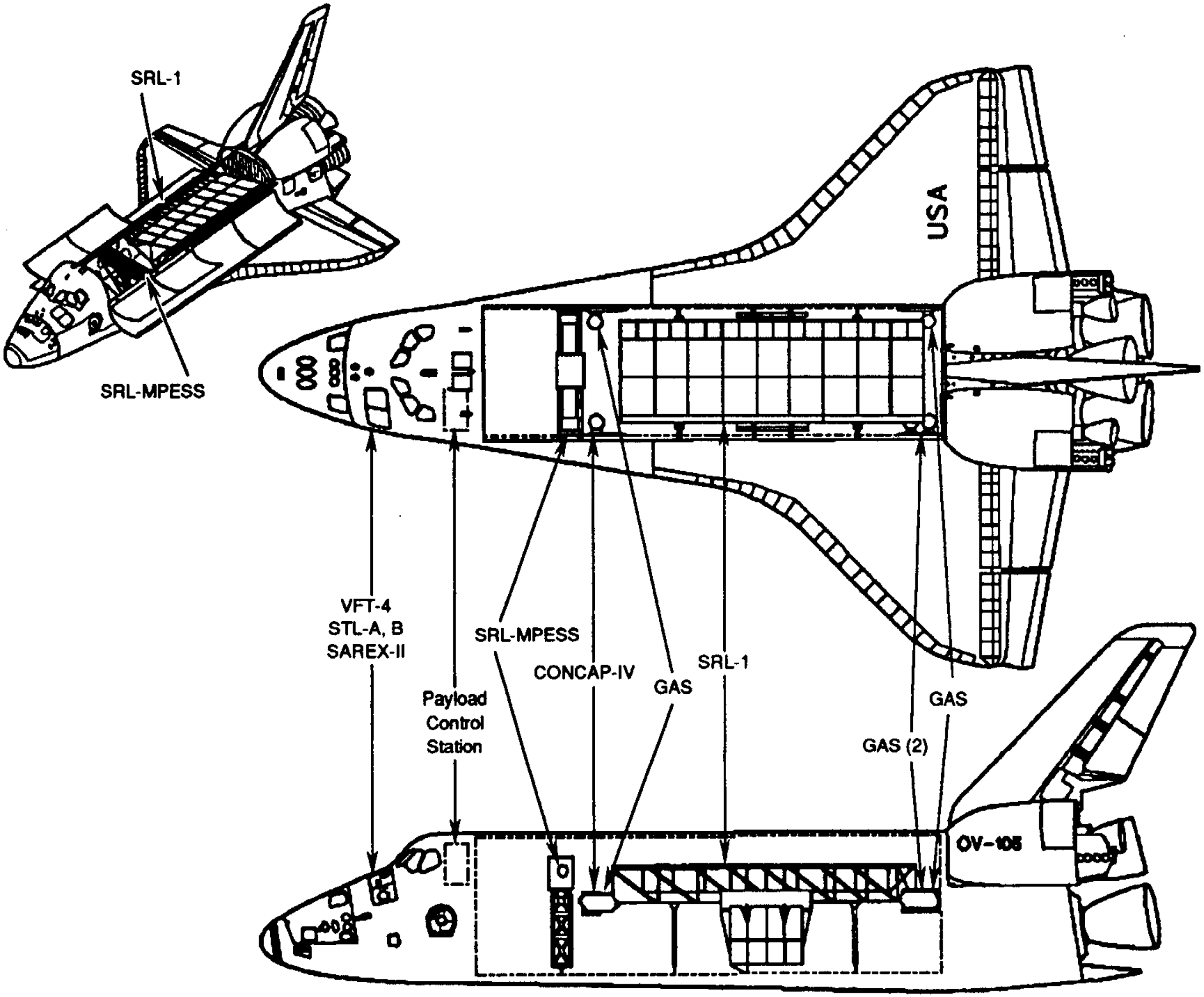
- Subsonic aerodynamic verification (DTO 254)
- Ascent structural capability evaluation (DTO 301D)
- Ascent compartment venting evaluation (DTO 305D)
- Descent compartment venting evaluation (DTO 306D)
- Entry structural capability evaluation (DTO 307D)
- ET TPS performance (method 1 and 3) (DTO 312)
- APU shutdown test, Sequence B (DTO 414)
- Orbiter drag chute system test (DTO 521)
- Evaluation of the MK-1 rowing machine (DTO 653)
- PGSC single-event-upset monitoring (DTO 656)
- Acoustical noise dosimeter data (sleep station data) (DTO 663)
- Cabin temperature survey (DTO 664)
- Acoustical noise sound-level data (sleep station data) (DTO 665)
- Thermoelectric liquid cooling system evaluation (DTO 674)
- Global positioning system development flight test (DTO 700-8)
- Crosswind landing performance (DTO 805)

DSOs

- Window impact observations (DSO 326)
- Back pain in microgravity (DSO 483)
- Immunological assessment of crew members (DSO 487)
- Measurement of formaldehyde using passive dosimetry (DSO 488)
- Orthostatic function during entry, landing, and egress (DSO 603B)*
- Visual-vestibular integration as a function of adaptation (DSO 604)*
- Effects of space flight on aerobic and anaerobic metabolism during exercise (DSO 608)*
- Air monitoring instrument evaluation and atmosphere characterization (microbial air sampler) (DSO 611)*
- In-flight use of florinef to improve orthostatic intolerance postflight (DSO 621)*
- Pre- and postflight measurement of cardiorespiratory responses to submaximal exercise (DSO 624)*

- Cardiovascular and cerebrovascular response to standing before and after space flight (DSO 626)*
- Educational activities (DSO 802)
- Documentary television (DSO 901)
- Documentary motion picture photography (DSO 902)
- Documentary still photography (DSO 903)

PAYLOAD CONFIGURATION



MTD 940322-4703

SPACE RADAR LABORATORY 1

The Space Radar Laboratory is the next step in NASA's continuing effort to increase our understanding of the Earth's environment and the effects of human activity on it. Part of NASA's Mission to the Planet Earth, SRL uses sophisticated imaging radar to probe how the Earth's environment is changing. The remote sensing systems will be able to observe, monitor, and assess large-scale processes, particularly climate changes, from space, and their data will help scientists differentiate between naturally occurring changes and those caused by human beings. The information will be shared with scientists throughout the world so that people everywhere can make informed decisions about how to protect the environment.

This is the first of at least three flights of the SRL payload. SRL-2 is scheduled for August 18, which would be the fastest turnaround of a payload in the shuttle program's history.

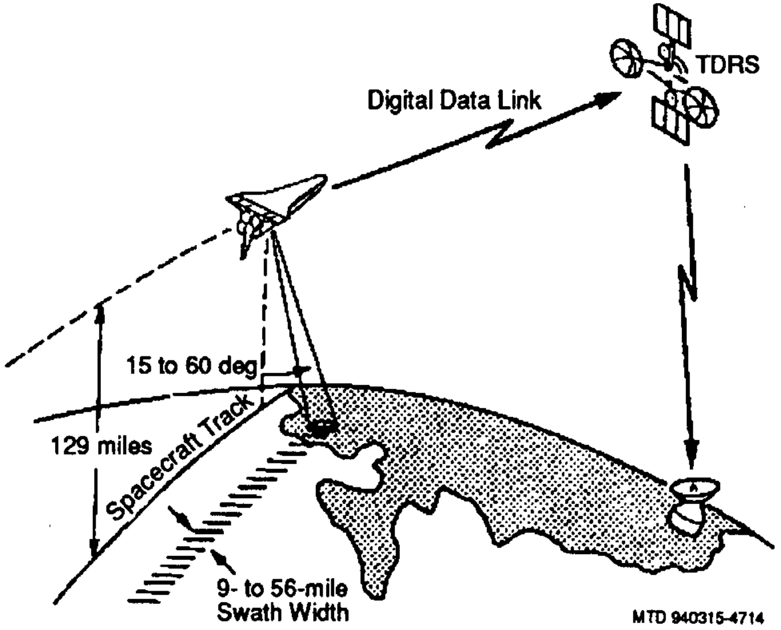
The main components of the SRL-1 payload are the Spaceborne Imaging Radar C (SIR-C) and the X-Band Synthetic Aperture Radar (X-SAR). SIR-C/X-SAR is a cooperative effort of NASA and the German and Italian space agencies.

The payload complement also includes an atmospheric sensor called Measurement of Air Pollution From Satellites (MAPS) and the Applied Physics Laboratory. The SRL payload occupies most of the shuttle's cargo bay.

Mission plans call for the two radars to collect 50 hours of data, which is roughly equivalent to radar coverage of 18 million square miles of the Earth's surface. Tape recorders on board Endeavour will record the 320 trillion bits of data gathered by the radars on 180 digital tape cartridges. The amount of data to be returned is the equivalent of a 20,000-volume encyclopedia.

Part of the data will be relayed to Earth through NASA's Tracking and Data Relay Satellite system. Mission personnel at the Jet Propulsion Laboratory in Pasadena, Calif., will process some images during the flight for release to the news media.

SIR-C and X-SAR scientists will process the raw data into images with supermini-class computers that can do the job in less time than before. However, it will be 14 months before detailed processing is complete.



The SIR-C/X-SAR Mission

The data will also be used to develop and validate algorithms for a free-flying space radar that will make continuous measurements of the Earth over 15 years.

Four hundred sites have been selected for radar imaging during the mission. Nineteen of these sites, called supersites, are of extreme interest to scientists and will be monitored continuously. If anything happens during the flight to drastically reduce the researchers' data-gathering ability, the supersites will be given priority. Future SRL missions will be flown at different times of the year so that investigators can obtain comparative measurements of the supersites.

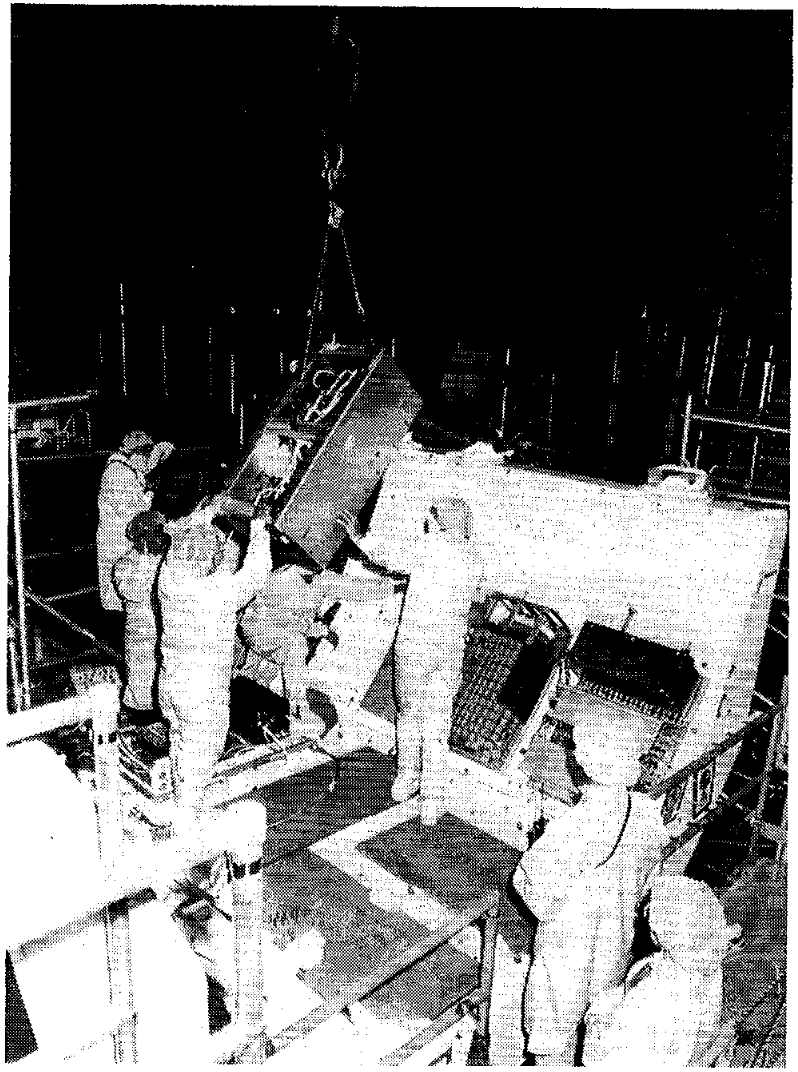
An international team of 49 scientists and three associates will conduct the SRL experiments. The science team members are from Australia, Austria, Brazil, Canada, China, England, France, Germany, Italy, Japan, Saudi Arabia, and the United States.

Dr. Diane Evans of the JPL is the U.S. project scientist. The German project scientist is Dr. Herwig Ottl, and Prof. Mario Calamia is the Italian project scientist.

Developed in 1951, radar imaging was initially put to military use only and was classified until 1964. The first nonmilitary radar mapping project, to image a Central American province constantly covered by clouds, took place in 1968.

NASA has been using imaging radar to study the Earth and other planets since the late 70s because it can collect data over almost any region, particularly otherwise inaccessible areas, in any weather or light condition. It can see through clouds and, under certain conditions, can penetrate vegetation, snow, ice, and even arid sand.

NASA launched its first Earth-observing synthetic aperture radar on Seasat in 1978. SIR-A followed in 1981 and SIR-B in 1984, each an improvement on its predecessor. X-SAR is a follow-on to



NASA Photo MTD 940315-4690

McDonnell Douglas and NASA workers install the deploy/stow control unit on the pallet for the Space Radar Laboratory. The DSCU will control movement of the X-SAR and provide power to the transmitters on the SIR-C.

the Microwave Remote Sensing Experiment, a German payload that was flown on the first shuttle Spacelab mission in 1983.

One of the most astonishing results of the SIR-A mission was the discovery of ancient river beds under the sands of the Sahara Desert in North Africa, and SIR-B enabled explorers to find the Lost City of Ubar in Oman. The Magellan mission to Venus was equipped with an imaging radar that gave mankind its first look at the entire surface of that cloud-shrouded planet.

SRL SCIENCE APPLICATIONS

SIR-C/X-SAR will provide scientists with more information about some of the global systems that make this planet livable—processes that control the movement of land, water, carbon, and heat.

Researchers will use the radars to study the geologic record to determine how geologic activity altered climate in the past so they can improve their computer climate models. The radars will peer beneath desert sands at ancient river patterns and observe volcanic and tectonic processes, erosion, and glaciation.

Radar images will be used to study the interaction of the sea and air as they exchange heat, motion, and gases through such processes as evaporation, precipitation, and circulation.

SIR-C/X-SAR will also measure the structure and regrowth of vegetation and monitor the effects on vegetation of natural and human disturbances. Vegetation plays an important role in the exchange of carbon among the Earth's atmosphere, oceans, and terrestrial life.

SIR-C/X-SAR data will be used to better understand the processes involved in the circulation of water on a large scale. Besides sustaining life, water helps to redistribute the Earth's heat and shapes the Earth's surface. The radar data will enable scientists to estimate the amount of moisture in the soil and evaporation rates for many different types of terrain. Flying the SRL payload at different times of the year will allow researchers to develop a database of seasonal changes in wetlands, snow and ice, and glaciers.

Ground teams will take simultaneous measurements of vegetation, soil moisture, sea state, snow, and weather conditions during the SRL operations, and their data will be supplemented with data collected by airplanes and ships to ensure the SRL data is interpreted accurately. Although operation of the SRL experiments does not require extensive crew involvement, the astronauts will record personal observations and take 6,000 photographs of the weather and environmental conditions at the sites for use in the postflight interpretation of the SIR-C/X-SAR and MAPS instrument data.

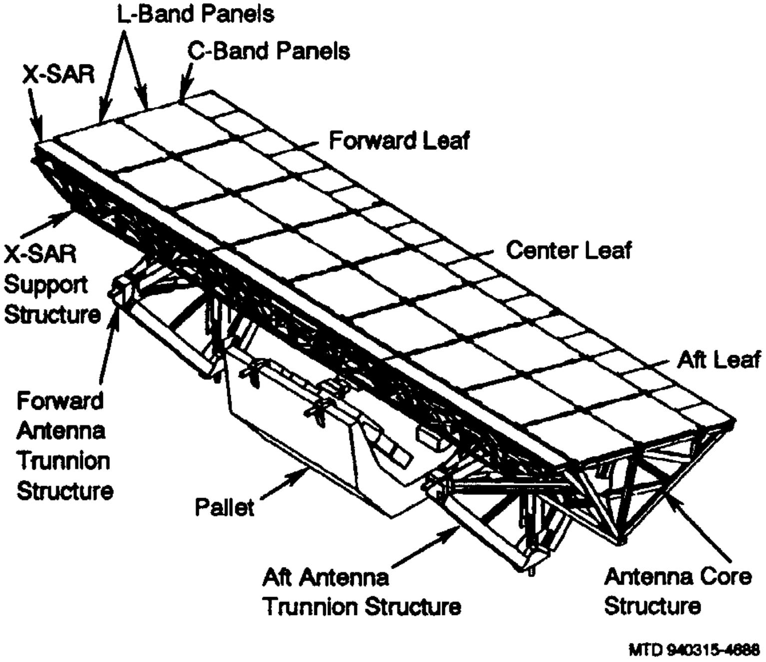
Radar images can be produced in two basic ways. For real array radar, the simpler method, a rectangular or dish antenna is mounted on an aircraft or spacecraft. The dimensions of the antenna determine the aperture and resolution, which is also constrained by target range, frequency, and radar pulse duration.

Synthetic aperture radar directs pulses of microwave energy at a target and measures the strength of the energy that returns to the radar antenna and the amount of time it takes the energy to return. Processors analyze the Doppler shift of the radar echoes. The motion of the radar carrier, in this case the shuttle Endeavour, "synthesizes" an antenna (or aperture) that is longer than the actual antenna, which produces a finer resolution. Thus, resolution does not depend on the size of the antenna; velocity (and resulting Doppler shift), range, frequency, and pulse length determine resolution and aperture size, which can be increased by grouping SAR antennas into a phased array.

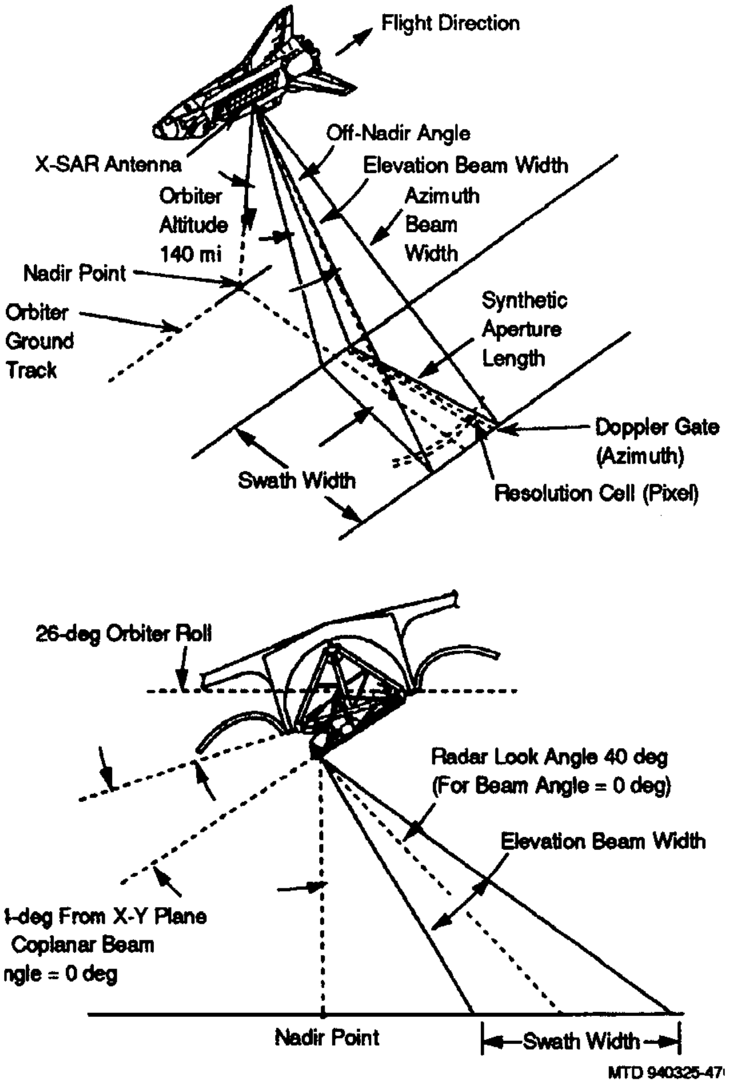
SIR-C and X-SAR can operate independently or together and can cover a swath 9 to 56 miles wide, depending on the orientation of their radar beams. Selectable resolutions range from 33 to 656 feet.

SIR-C's images will contain more information about the Earth's surface than images collected by single-frequency, single-polarization radars like SIR-A and SIR-B because SIR-C has been designed to transmit and receive horizontally and vertically polarized radar waves in the 23-centimeter wavelength (L-band) and 6-centimeter wavelength (C-band) simultaneously. Polarization refers to the way radar waves travel in space—either in a horizontal or vertical plane. SIR-C can transmit and receive waves in the horizontal plane (referred to as HH polarization) or in the vertical plane (VV polarization) or in combinations (HV and VH polarization).

SIR-C's radar beam is formed by hundreds of tiny transmitters that are embedded in the surface of the antenna. The energy they emit can be adjusted precisely to electronically steer the radar beam



SIR-C/X-SAR Antenna Subsystem



X-SAR Data Take Geometry

without moving the antenna itself. Electronic beam steering and shuttle roll and yaw maneuvers will allow the radar to acquire data at angles of incidence of 15 to 55 degrees.

SIR-C was built by NASA's Jet Propulsion Laboratory in Pasadena, Calif., and Ball Communications Systems Division. The most massive piece of space hardware ever built at JPL, SIR-C weighs 23,100 pounds and at 39.4 feet long and 13 feet wide just about fills Endeavour's payload bay.

X-SAR is a single-polarization (VV) radar and the first synthetic aperture radar that operates in the 3-centimeter wavelength (X-band). Its slotted-waveguide antenna produces a pencil-thin radar beam. The antenna can be tilted mechanically so that its beam can be aligned with SIR-C's L-band and C-band beams. Like all microwave sensors, X-SAR can take measurements regardless of weather and lighting.

During the mission, the radar antenna will radiate toward a swath of Earth and map it continuously as the shuttle travels its orbital path. Since the target will stay in the radar beam for quite a while, the radar can observe it from many locations along the flight line and collect echoes that form a Doppler history (which is summarized by ground processing). Thus, a synthetic antenna is created whose synthetic aperture length equals the distance the shuttle travels during the summation period.

X-SAR was built by Dornier and Alenia Spazio for the German and Italian space agencies.

SUPERSITES

The 19 supersites and their backups are representative environments that will be the focus of scientific study by the disciplines of ecology, hydrology, oceanography, geology, and calibration. These activities complement other national and international measurement programs: ERS-1/JERS-1 and Landsat/SPOT in space, and various vehicles in the air, on land, and sea.

Ecology

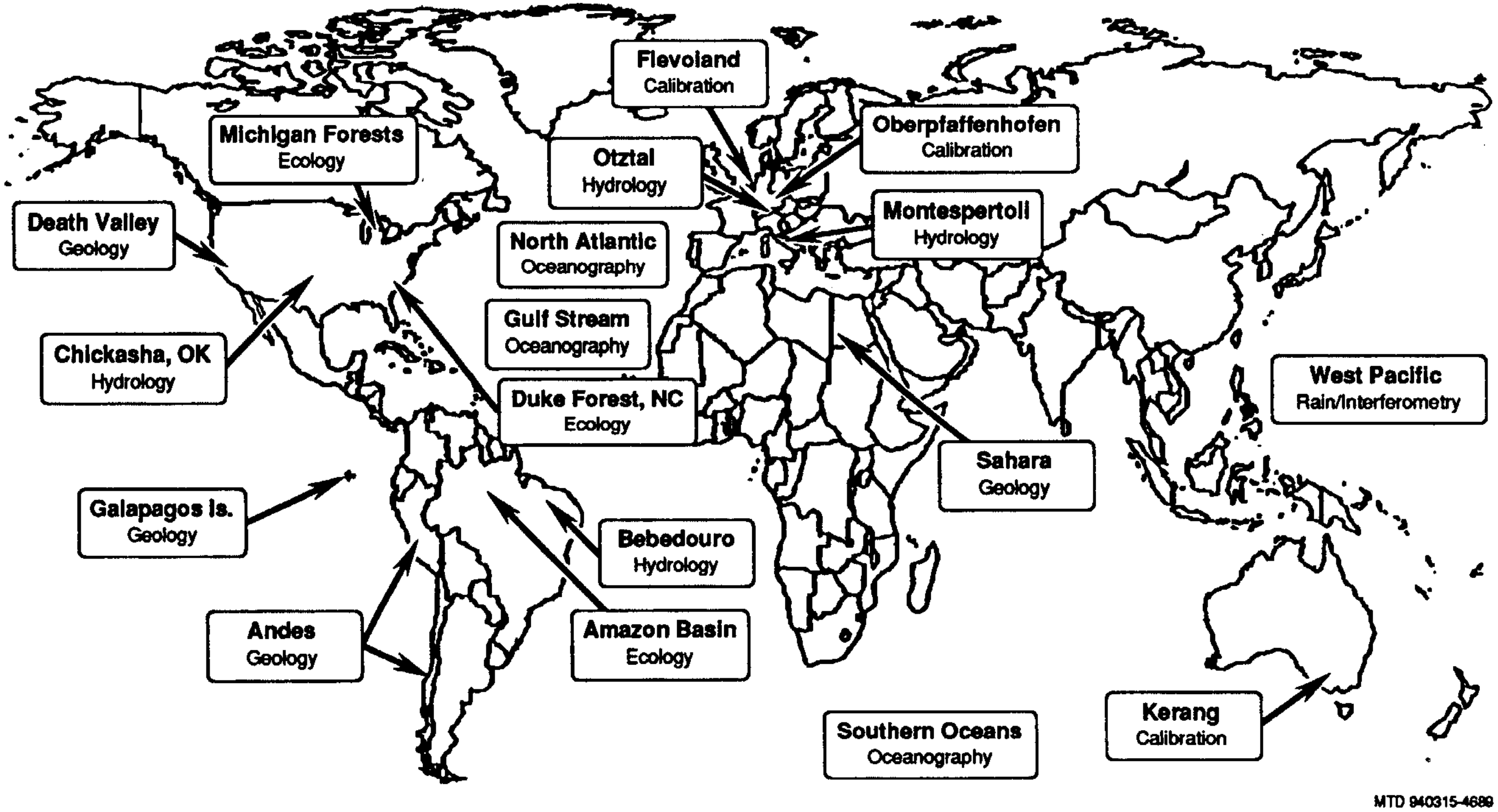
Ecologists will use SIR-C/X-SAR images to study land use; the volume, types, and extent of vegetation; and the effects of fires, floods, and clear cutting of trees in the rain forests of South America and in the temperate forests of North America and Central Europe. The supersites for the ecology studies are Manaus, Brazil; Raco, Mich.; and Duke Forest, N.C.

The researchers will investigate both short-term and long-term changes in the forests in the hope of discovering how changes in environmental conditions and land use affect the forests and global climate.

The data collected by the radars will give the scientists a more complete understanding of terrestrial conditions. Some of the data will also enable researchers to update their computer models on the species of trees, types of crops, and amount of soil moisture in certain areas. The ecologists will use data gathered on the ground and the SIR-C/X-SAR data to study the effects of deforestation on local plants and animals.

Hydrology

Hydrologists will focus their investigation of soil moisture patterns on four sites—Chickasha, Okla.; Otztal, Austria; Montespertoli, Italy; and Bebedouro, Brazil. This so-called hidden water is an important factor in determining whether a region is wet or dry and also influences how energy is distributed around the Earth. The data on soil moisture is expected to help scientists predict a region's water cycle. Continuous radar monitoring of water resources may one day help farmers decide what to plant, when to plant it, and where to plant it.



SIR-C/X-SAR Supersites

SIR-C/X-SAR will also take radar images of snow cover at Mammoth Lakes, Calif.; the Austrian Alps; and southern Chile, where the largest glaciers and ice fields in South America are located. Radar is the only way information about snow cover can be gathered. The information can be used to estimate how much runoff will be available for human use.

The hydrological studies will also include wetlands, which are attractive places to live but whose delicate ecosystems are very vulnerable. The extremely sensitive radar will allow hydrologists to determine the limits of the wetlands, and repeated flights of the radar will enable them to chart changing conditions.

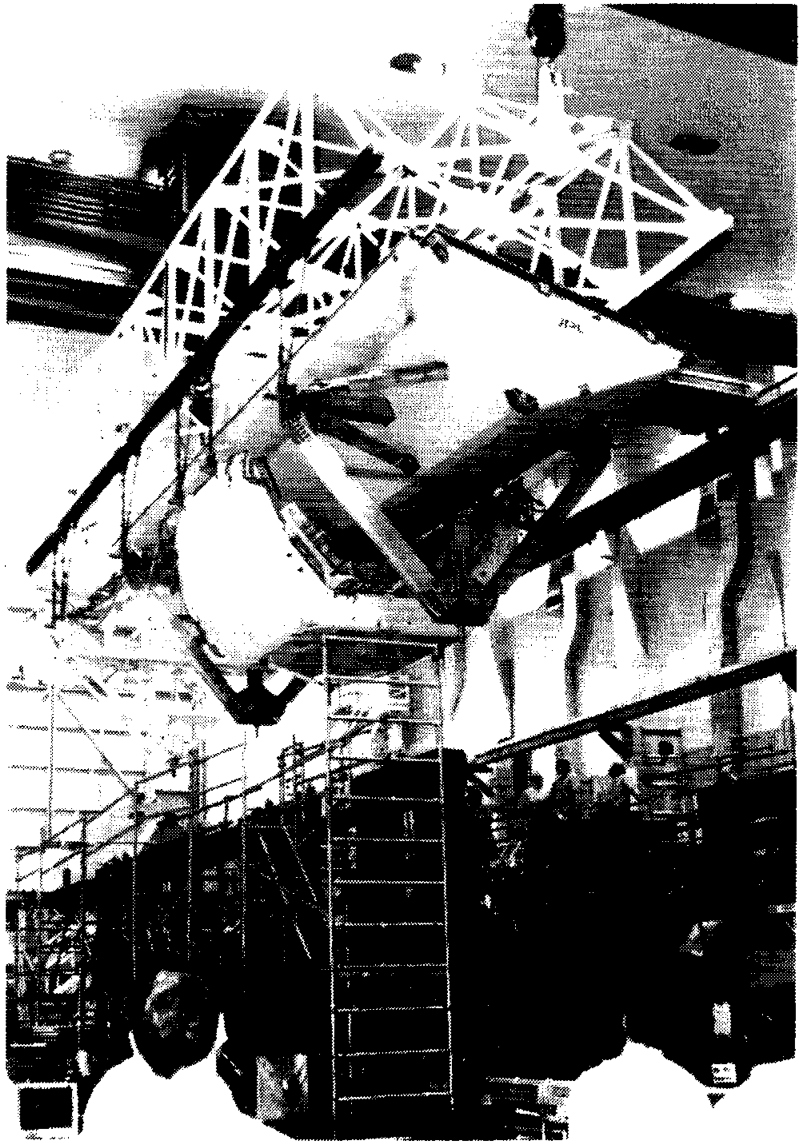
Oceanography

Oceanographers will use radar images to study the motion of surface and internal waves, wind motion at the ocean surface, and ocean currents at three sites—the mid-Atlantic region of the Gulf Stream, the East and North Atlantic, and the southern ocean. This data will contribute to scientists' understanding of how the ocean moderates Earth's climate through the movement of heat and energy and interaction with the air.

Geology

SIR-C/X-SAR will map geologic structures over large areas and areas of volcanic activity and erosion in Death Valley, Calif.; the Galapagos Islands; the Sahara Desert; and the Andes Mountains in Chile. Images of ancient river channels buried beneath the Sahara and of areas of past tectonic activity will help geologists predict climate changes.

Radar images will also be taken of Mt. Pinatubo in the Philippines and the volcanoes on the Galapagos Islands off the west coast of South America. Scientists are hoping to image an erupting volcano so they can get a better understanding of the evolution of volcanoes.



NASA Photo MTD 940315-4692

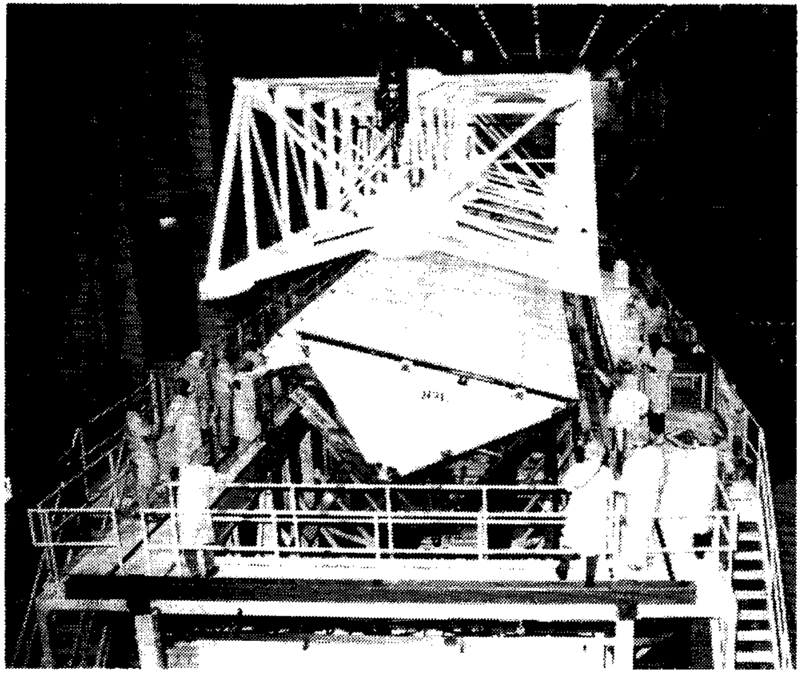
Space Radar Laboratory is hoisted from workstand in Operations and Checkout Building at KSC.

Calibration

Four of the supersites—Flevoland, Netherlands; Kerang, Australia; Oberphaffenhofen, Germany; and the western Pacific Ocean—have been equipped with devices that will measure the energy radiated by the radars. Scientists will use this information during postflight processing to calibrate the radar data.

Rain Experiment

Two SIR-C/X-SAR experiments will image rain over the western Pacific Ocean, which has more rain than any other place on Earth. These experiments will help researchers understand how rain can change conditions on the ground, which would affect radar images.



NASA Photo MTD 940315-4691

Workers in the Operations and Checkout Building at KSC move the Space Radar Laboratory into the cargo integration test equipment stand for temporary storage.

MEASUREMENT OF AIR POLLUTION FROM SATELLITES

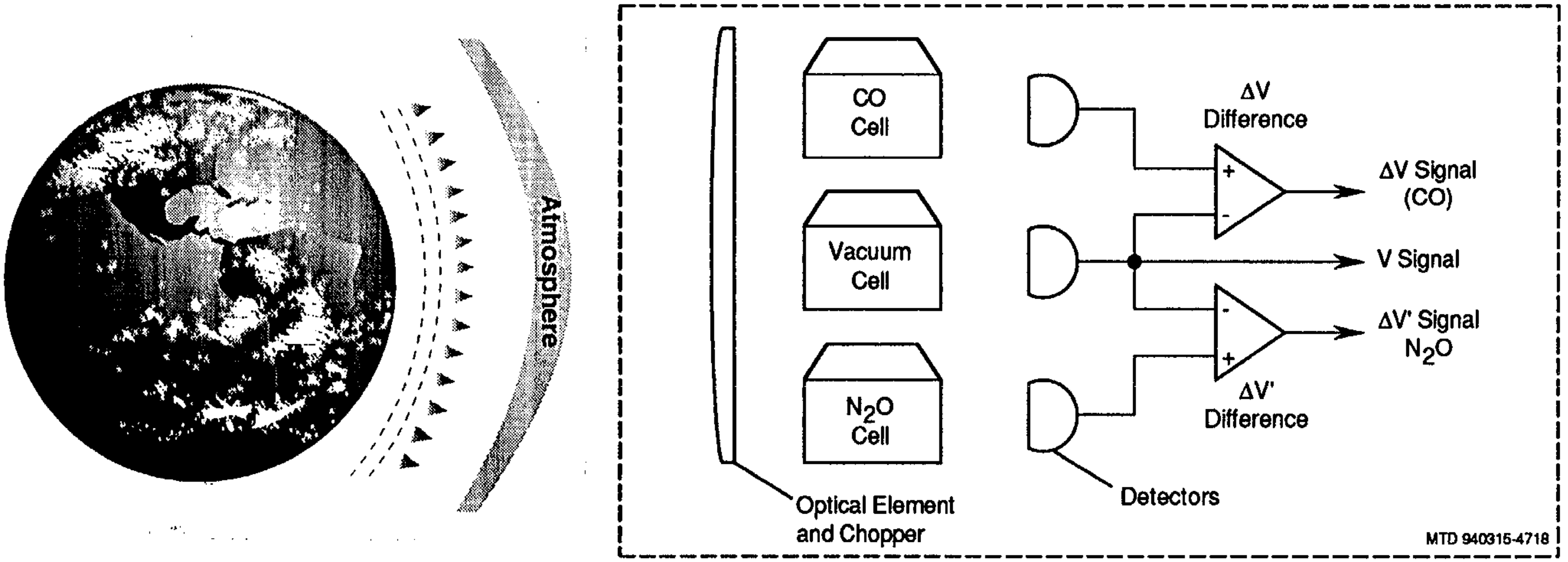
The MAPS payload, which is mounted on a support structure in the forward part of the payload bay, will measure the concentration and distribution of carbon monoxide in the lower atmosphere (as well as seasonal changes), trace the movement of carbon monoxide between the Northern and Southern hemispheres, determine the sources of the gas, and separate the natural and manmade sources, if possible. This correlative measurement program will produce the first intercalibrated, multilayer, near-global carbon monoxide data set.

Higher-than-normal levels of carbon monoxide can contribute to climate change. The presence of carbon monoxide indicates that the ability of the atmosphere to cleanse itself of trace gases through oxidation is declining and that pollution is increasing in clean-air areas.

Both natural and human actions produce carbon monoxide. Scientists think that oxidation of methane and other hydrocarbons is the main source of natural carbon monoxide. Man's major contributions to carbon monoxide come from high-technology activities (located primarily in the Northern Hemisphere) and biomass burning (primarily in the tropics).

On a previous mission, MAPS discovered higher-than-expected concentrations of carbon monoxide in the Southern Hemisphere. In 1984, high carbon monoxide concentrations over the southeast coast of Africa were traced to the burning of the savannah in that region.

MAPS, which has flown twice before, was initiated in 1976 by NASA to learn more about the effect of carbon monoxide on global tropospheric chemistry. The global distribution and sources of carbon monoxide cannot be determined from the ground, but shuttle



Measurement of Air Pollution From Satellites (MAPS)

flights have gathered valuable data to define these areas and point out significant correlations as well.

Activated and deactivated by the crew, MAPS operates continuously while the shuttle is in orbit, commanded mainly from the Mission Control Center on the ground. The MAPS team at JSC receives downlinked telemetry for near-real-time evaluation of performance and fulfillment of mission objectives.

The MAPS instrument, originally developed for the Nimbus G program, views the Earth's nadir and measures the global distribution of middle tropospheric carbon monoxide. It uses gas filter correlation and high spectral resolution to detect and measure carbon monoxide. Radiation gathered by the optical system is directed by beam splitters through three gas-filled cells onto detectors for three optical channels. These channels output signals correlating the spectrum of gas in the cells to the spectrum of the collected radiation.

Other MAPS subassemblies include an electronics unit housing signal processing and control, data handling, balance and calibration, mode sequencing and control, and power conditioning circuits; a flight magnetic tape recorder; and a flight camera that takes photographs of correlative cloud cover during the daylight portions of the flight.

APPLIED PHYSICS LABORATORY

The APL will receive ocean wave data from the SIR-C antenna, and its data processing assembly will transform the data into a two-dimensional spectrum. The transformed data, which will be recorded on board the shuttle, will be used to validate and improve ocean wave models. Real-time remote sensing of wave phenomena would be particularly useful, especially in the southern oceans, where some of the planet's most intense storms originate. The performance of the APL could lead to the development of a small satellite with similar capabilities.

CONSORTIUM FOR MATERIALS DEVELOPMENT IN SPACE COMPLEX AUTONOMOUS PAYLOAD IV

The complex autonomous payload (CAP) manifested on STS-59 is a nonstandard secondary payload in NASA's CAP program. These use the small self-contained payload standard carrier system hardware (getaway special hardware) and are sponsored by NASA's Goddard Space Flight Center Shuttle Small Payload Project (SSPP).

The payloads are controlled through the autonomous payload control system (APCS), which includes the small, hand-held command encoder known as the autonomous payload controller (APC), the auxiliary input/output (I/O) data line, GAS control decoders (GCDs), and payload power contactors (PPCs).

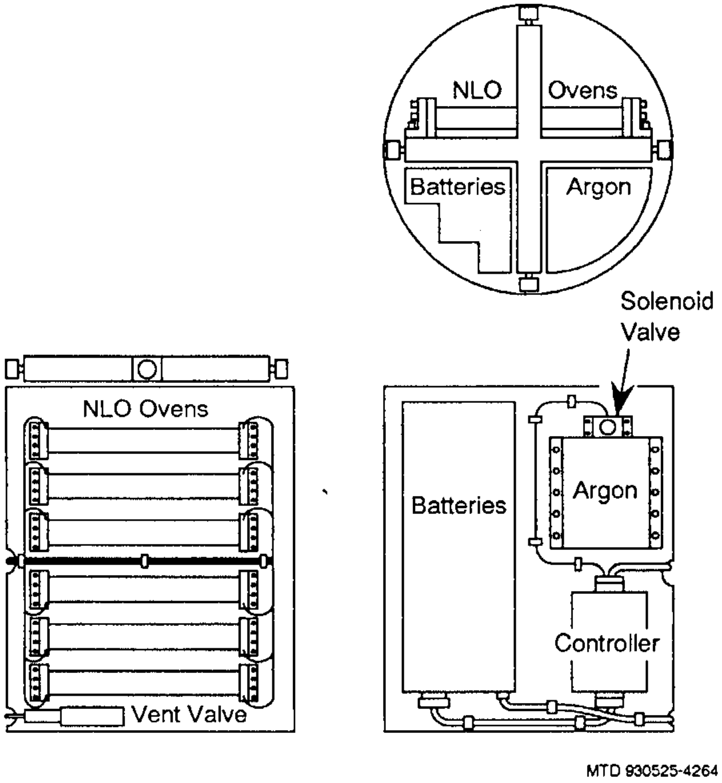
The CAPs are integrated into standard 5-cubic-foot GAS cylindrical canisters. CONCAP IV is mounted on the forward port GAS bridge assembly (GBA). Connecting cables provide communication to the experiment via the APC.

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

CONCAP IV will be activated during ascent by a baroswitch and deactivated by the crew as late as possible to allow a long crystal-growing period. It is scheduled in the flight plan as part of the GAS Group A, D, and E activities.

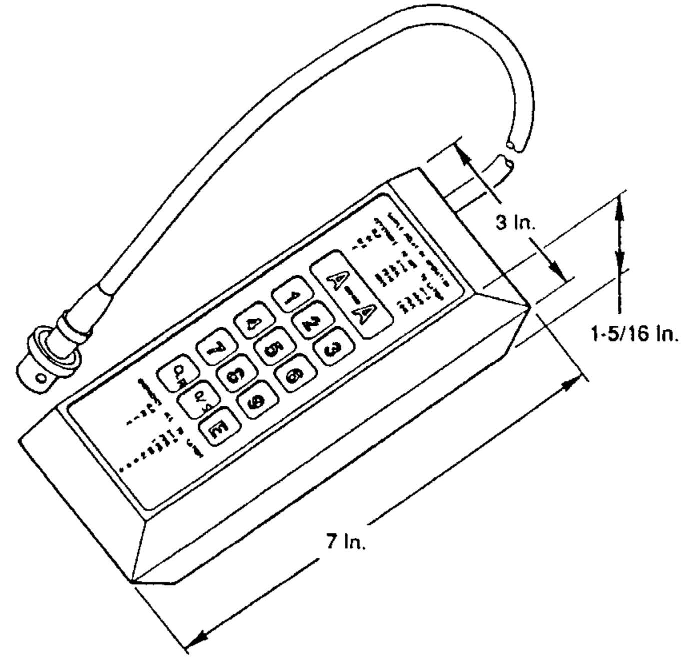
The experiment operation involves heating up a chamber containing the material to produce the crystal but keeping one spot on the chamber walls cooler than the rest of the chamber walls. This method causes the vapor of the material to condense onto the cold spot so that the crystal grows there.

Within CONCAP IV there are six NLO "ovens," each containing two glass growth cells. Each cell is wrapped in a heater. The



CONCAP IV Configuration

ovens are constructed from two aluminum cylinders, one inside the other, the area between them vented to space to form an insulating vacuum that reduces heat loss. The high and low temperatures in each chamber are controlled by a mini-computer designed and built specially for this purpose.



Autonomous Payload Controller

The materials from which the crystals will be grown are composed of organic molecules that have been uniquely designed through molecular engineering. This method creates materials with precisely the physical and optical properties required for a specific application. With these techniques, it is no longer necessary to make one type of nonlinear optical material fit all applications. Each application can be examined separately and molecules designed for that particular application.

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

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

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

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

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

GETAWAY SPECIAL PROGRAM

STS-59 will mark the 21st shuttle mission to participate in NASA's Getaway Special (GAS) program, officially known as the Small, Self-Contained Payloads program. The program offers interested individuals or groups the opportunity to fly small experiments in space. It enhances education by making opportunities for hands-on space research available and generates new activities unique to space. Customers also are able to inexpensively test ideas that could later grow into major space experiments.

To assure that diverse groups have access to space, NASA rotates payload assignments among three major categories of users: educational, foreign and commercial, and U.S. government. Since the program was first announced in the fall of 1976, 101 GAS payloads have been reserved and flown by foreign governments and individuals; U.S. industrialists, foundations, high schools, colleges and universities; professional societies; service clubs; and many others. Three more are manifested on STS-59. Although persons and groups involved in space research have obtained many of the reservations, a large number of spaces have been reserved by persons and organizations outside the space community.

The GAS program began in 1982 and is managed by the Goddard Space Flight Center, Greenbelt, Md.

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

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

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

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

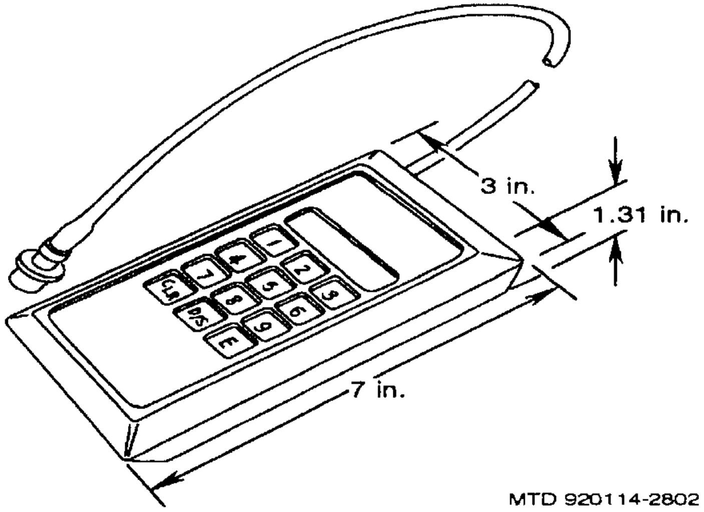
The cost of this unique service depends on the size and weight of the experiment. Getaway specials of 200 pounds and 5 cubic feet cost $10,000; 100 pounds and 2.5 cubic feet, $5,000; and 60 pounds and 2.5 cubic feet, $3,000. The weight of the GAS container, experiment mounting plate and its attachment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

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

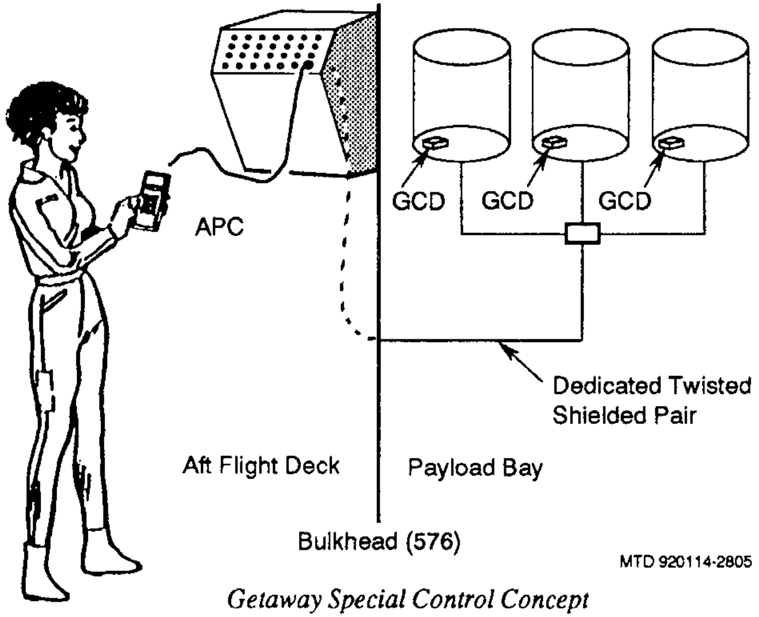
The GAS container is made of aluminum, and the circular end plates are 0.625-inch-thick aluminum. The bottom 3 inches of the container are reserved for NASA interface equipment, such as command decoders and pressure regulating systems. The container is a pressure vessel that can be evacuated before or during launch or on orbit and can be repressurized during reentry or on orbit, as required by the experimenter.

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

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



GAS Autonomous Payload Controller



Getaway Special Control Concept

STS-59 GETAWAY SPECIAL PAYLOADS

On STS-59, three GAS experiments from the United States, France, and Japan are manifested, plus the CONCAP IV payload (see CONCAP IV section) and a GAS ballast payload. The lids of the STS-59 GAS canisters do not require raising and involve no deployments, power usage, or attitude restrictions.

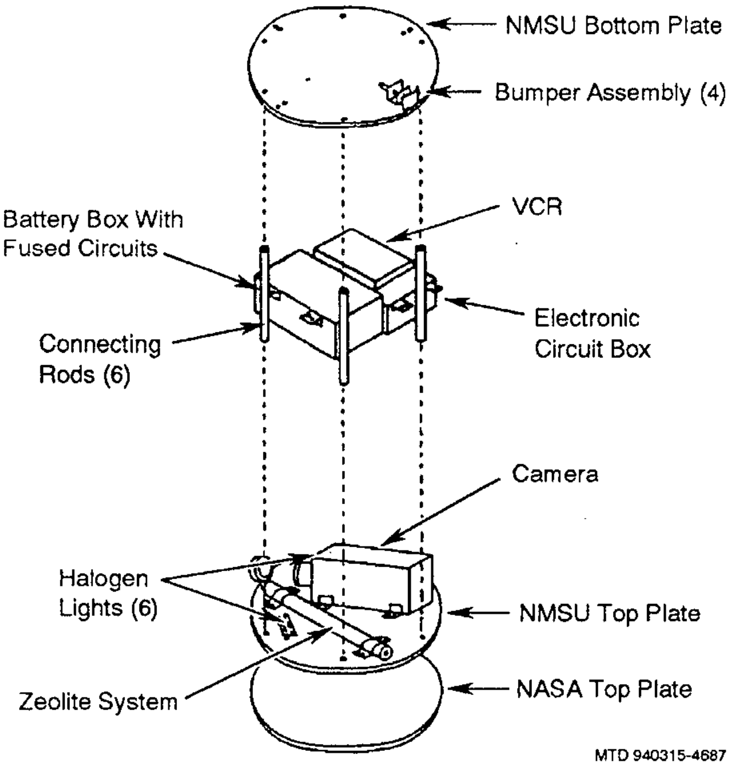
The STS-59 GAS payloads are as follows:

G-203

Customer: Dr. Harold Daw, New Mexico State University, Las Cruces, N.M.
NASA Technical Manager: Charlie Knapp

G-203 will examine the freezing and crystallization process of water in space flight. While other water-freezing experiments have flown on previous shuttle flights, this experiment is unique in its freezing technique and is predicted to produce very different ice-crystal-growth patterns. Experimenters will study growth patterns of the ice crystals and record them on video.

A crew member will activate G-203 by throwing a switch from "latent" to "hot." This will open a vapor valve, allowing water vapor in a chamber to be adsorbed rapidly (the adhesion of extremely thin layers of molecules to the surface of solid bodies or liquids with which they are in contact) into the pores of dry zeolite contained in the chamber. The rapid adsorption of the water vapor causes the water temperature to drop to the point of freezing. Activation and deactivation are controlled by an encoder stored in an aft flight deck locker. Activation will occur at the start of a low-gravity period and will last for at least 1-1/2 hours.



Gas Experiment G-203

G-300

Customer: Daniel Kaplan, MATRA/Laboratoire de Genie Electrique de Paris, Paris, France
NASA Technical Manager: Rick Scott

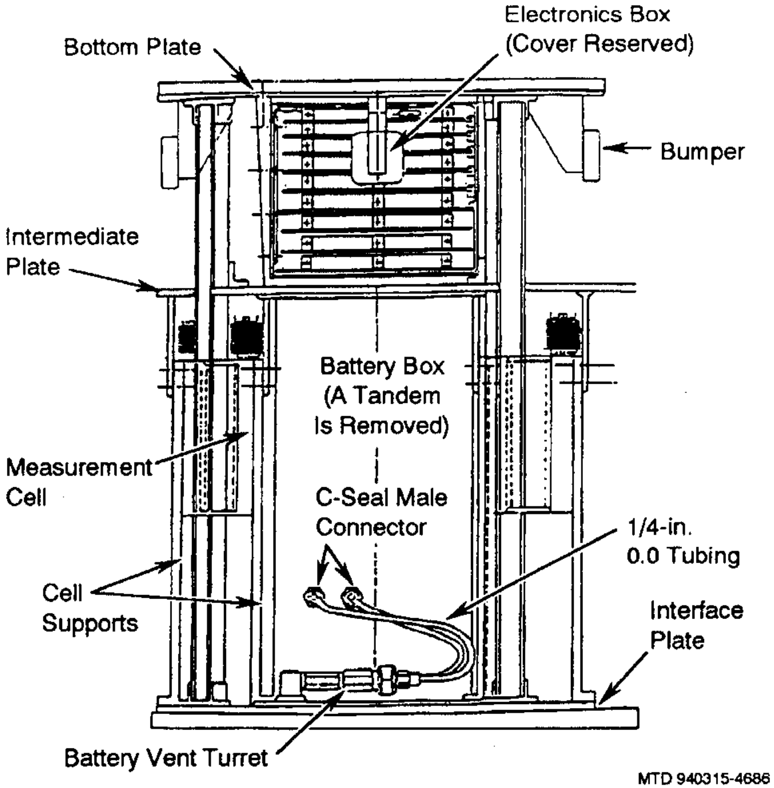
G-300, the first GAS payload from France, flew previously on STS-47 but an unforeseen event caused the experiment to be turned on before flight.

The objective of this reflight is to explore thermal conductivity measurements on liquids in microgravity. The three modes of heat transfer in liquids (conduction, radiation, and convection) are inherently linked in a 1-g environment and are empirically difficult to stage because of thermal motions induced by convection. In orbit, assuming near-zero gravity, convection, caused by buoyancy, disappears and the accuracy of the thermal conductivity data is improved, especially with low-viscosity liquids. Furthermore, convection effects can be determined by comparing results from space and Earth. Convective motions are expected to be strongly reduced in orbit unless large gravitational variations occur.

Three liquids will be measured: distilled water and two silicone oils of different viscosities. The experimental cells are assembled in three sets comprising two cells per set. In each set, the two cells are filled with the same liquid but of different thicknesses.

Each cell consists of a heating element and data acquisition sensors. By supplying power to one cell's heater at a constant rate, supplying power to the other cell's heater at a variable rate, and monitoring power distribution and temperature between the cells, the thermal conductivity of the liquid within the cells can be calculated. The experimenters will use a modified "hot plate" method with a simplified guard ring to reduce heat losses.

During ascent, a crew member will throw a GAS baroswitch to activate a timer. Approximately four hours later, the timer will activate G-300. Power will then be applied to the heaters of one set of cells, and a zero temperature gradient between the cells will be maintained for two hours. Various data will be collected and stored. The timer will then remove power from a cell set and the temperature of the surrounding structure will be allowed to stabilize. Then the next set of cells will be activated and the above sequence will be repeated until a total of 75 hours since experiment activation have elapsed. The timer will then halt experiment execution and data acquisition. At the end of this time period, a crew member will remove power from the payload by using the autonomous payload control system.

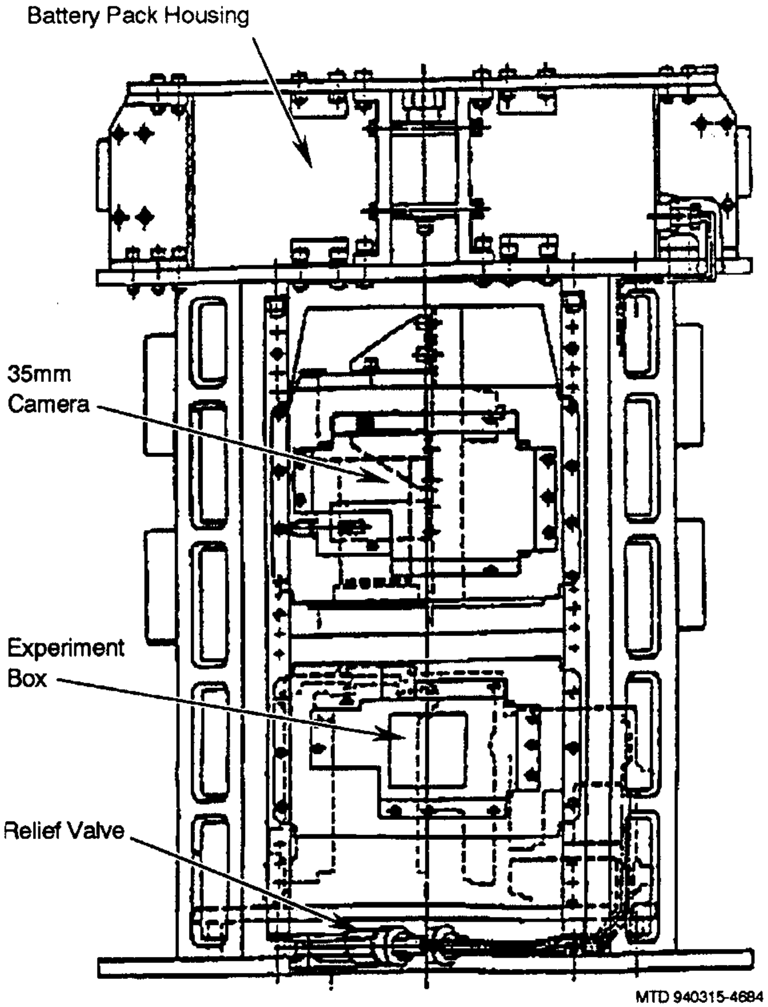


Gas Experiment G-300

G-458

Customer: Dr. S. Hosaka, The Society of Japanese Aerospace Companies, Inc., Tokyo, Japan
NASA Technical Manager: Charles Knapp

The objective of this experiment is to determine whether small fruiting bodies can be obtained in microgravity. The information



Gas Experiment G-458

will be obtained by taking a culture of Dictysotelium Discoideum (cellular slime mold) in microgravity and observing its growth.

The cellular slime mold is a small organism, several millimeters long, that is resistant to a wide variety of environmental conditions. It has unusual characteristics in that it assumes unicellular, multicellular, plant-like, and animal-like properties during its life cycle. Still, it is a very simple organism composed of just two kinds of cells, even when fully developed. Because of this, its response to altered gravity can be regarded as representative of the graviresponse of all organisms.

Ground experiments have demonstrated that the height of fruiting bodies of Dictysotelium Discoideum is gravity-dependent: the height decreases as gravity decreases. This contradicts the prediction that microgravity favors the growth of organisms and results in greater height. This experiment is expected to conclude that, in some cases, more gravity is favorable and microgravity is unfavorable for vertical growth.

G-458 is activated by a baroswitch during ascent. The experiments, which are automatically sequenced, start 3 hours after payload activation and run for a minimum of 120 hours. Bacteria solution will be observed intermittently. Cells will then be chemically fixed and recovered after the flight for further observation of their intracellular structure. The payload will be deactivated by a baroswitch during descent.

GBP No. 1

GAS ballast payload No. 1 is a contingency payload used in the event that the manifested GAS payload cannot be successfully integrated into the GAS canister at the launch site in time for installation into the shuttle. The GBP consists of an accelerometer unit and a 54-pound basic structure that can accommodate up to sixteen 10-pound steel plates. It weighs 189 pounds.

SPACE TISSUE LOSS

When gravity is reduced or eliminated, as it is in space travel, life systems degrade at a remarkable rate. The Space Tissue Loss (STL) life sciences payload studies cell growth during space flight, specifically the response of muscle, bone, and endothelial and white blood cells to microgravity, by evaluating various parameters, including shape, cytoskeleton, membrane integrity and metabolism, activity of enzymes that inactivate proteins, and the effects or change of response to various stimulants, hormones, and drugs on these parameters.

STL will help scientists understand more about how white cells respond to antigens from infectious agents and tumors. It will also show how space flight can cause a tremendous loss of calcium and minerals from bones and find ways to prevent or minimize bone failure in space and on Earth. Findings from tests of muscle disintegration could yield more information about similar muscle failure that occurs in forms of muscular dystrophy and the loss of muscle mass after severe injury, prolonged bed rest, and aging.

Findings from this and other studies will be used to develop pharmaceutical products and physical treatment regimens to limit the extent of muscle tissue loss after fractures/cast immobilization and surgery. Anticipated benefits include savings from reducing the need for physical therapy and more rapid return to activity following injury.

On this mission, researchers will attempt to reproduce and verify the changes in the function of cells that were seen when the STL experiment was flown on STS-45, STS-53, and STS-56. They will study the cells after the flight for an extended period of time and will determine the validity and applicability of their cellular model by comparing the results of the STL experiment with changes noted in animals exposed to microgravity.

On the three previous flights of the STL experiment, researchers found evidence that microgravity causes the metabolism of bone-forming cells to change and impairs the mineralization of bone fibers, leading to a decrease in bone strength. After this nine-day mission, the investigators will determine the amount and type of bone products in the cells that were exposed to the space environment and will determine whether changes induced by space flight can be reversed.

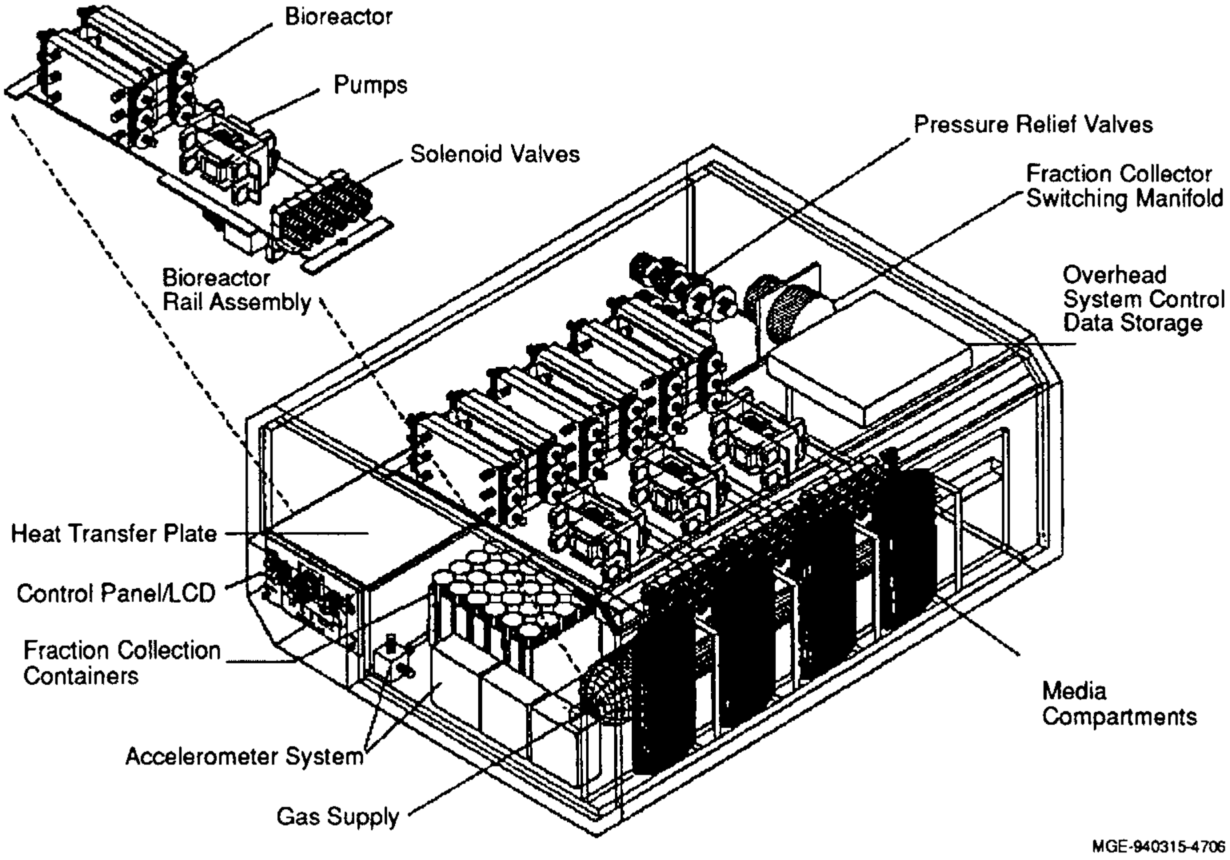
The bone products found in the cell culture will also be compared to data obtained in previous shuttle experiments involving live rats to see if the bones in the rats undergo changes like those in the bone cell cultures. Researchers hope that analyzing changes in the cells will help them determine whether the cellular changes trigger changes in the strength of bones.

The study of alterations in muscle cells during space flight will look into the previously noted inability of precursor cells exposed to microgravity to fuse to form muscle fibers. Although cells failed to fuse for 35 days after space flight, most of the changes in their function lasted hours or days in normal gravity conditions. Researchers believe that they may be able to speed up the recovery of muscle mass and strength in astronauts after space flight if these cells are fully functional during the repair process.

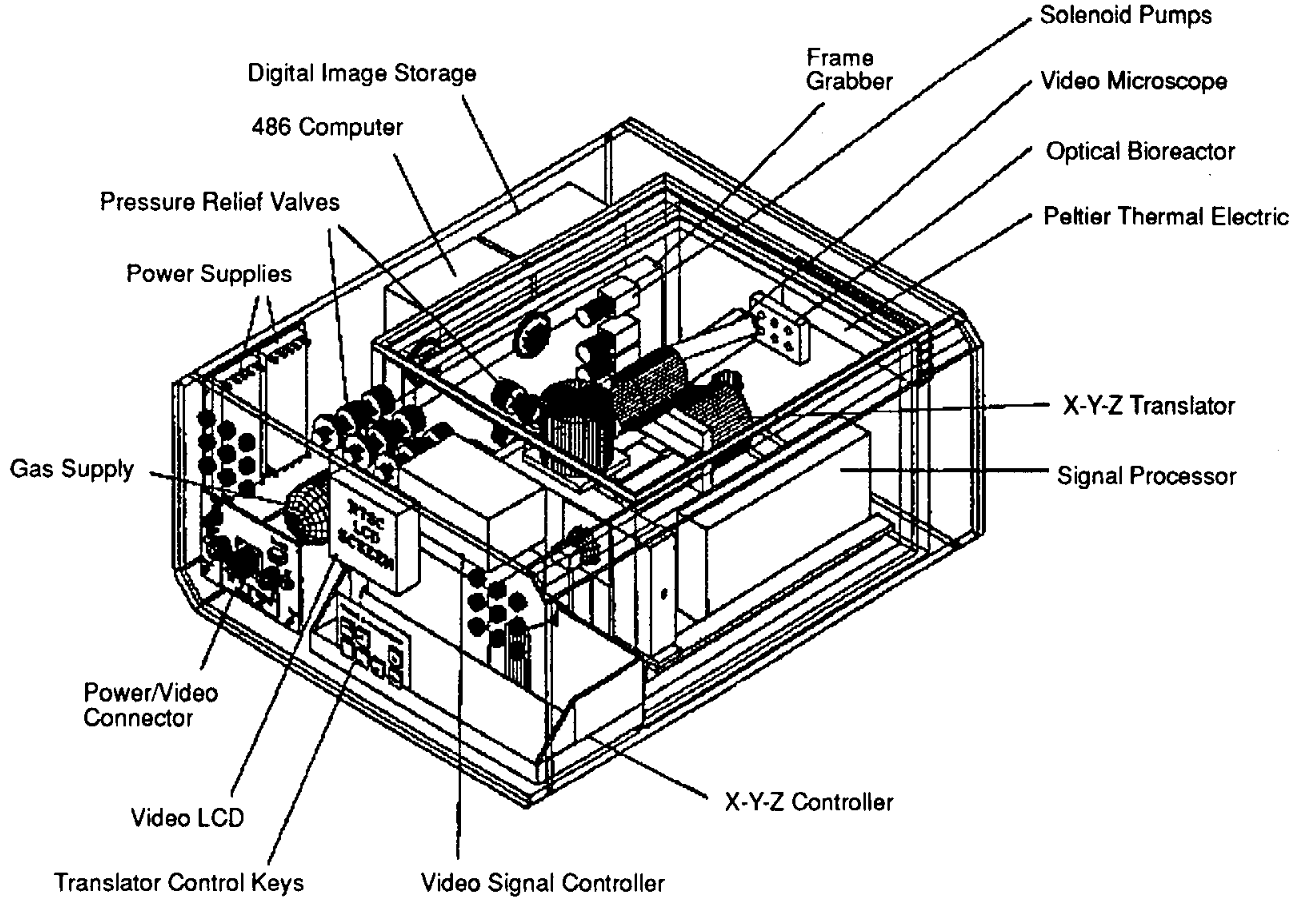
The STL research may also have application in the treatment of disorders that affect muscle tissue, such as muscular dystrophy. Blocking the natural fusion of muscle cells may allow satellite cells that contain desirable genetic properties to be produced for use as gene transplants in sufferers of Duchenne muscular dystrophy.

Two independent and complementary STL units will be flown for STS-59. The STL-A module will address the micromolecular-level responses and the STL-B module will study the macromorphological alterations.

STL-A is a cooperative initiative with the National Institutes of Health (NIH). The STL-A payload is a cell culture device that replaces a standard locker double tray inside one standard middeck locker and has a large tray assembly that can be refurbished and replaced. The STL-A analysis module consists of a triply contained, hermetically sealed fluid path assembly that holds the cells under study, all media for sustained growth, and automated drug delivery provisions for testing candidate pharmaceuticals. A self-contained computer system is preprogrammed for medium and gas delivery to the cells, environmental monitoring of temperature and other important parameters, timed collection of medium and/or cells, and cell fixation. The payload requires 28 volts of orbiter power. A power/electronics assembly supplies backup battery power to STL when



STL-A Module



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STL-B Module

orbiter power is interrupted. It also supplies fusing for STL protection and visual experiment status output for crew use. The STL-A experiments are being managed by NASA's Ames Research Center, Mountain View, Calif.

Three science investigations will be performed with STL-A. *Effect of Gravity on Bone Matrix Production and Mineralization* has four objectives:

- Measure osteoblast cell growth rates (by glucose and lactate analysis of collected media).
- Determine collagen gene expression, collagen accumulation, and collagen fibril and matrix assembly (by biochemical, molecular biology, and microscopic means).
- Determine noncollagenous proteins (osteopontin, alkaline phosphatase, bone sialoprotein, osteocalcin, and others) in culture matrices.
- Examine temporal (preflight and postflight) and spatial events of matrix mineralization (by EM, electron diffraction, and electron probe X-ray microanalysis combined with novel three-dimensional graphic image reconstruction methods) during space flight as compared with ground controls.

Primary chicken embryo calvarial osteoblasts will be used. The principal investigator is Dr. William J. Landis of the Children's Hospital and Harvard Medical School, Boston. Dr. Louis Gerstenfeld is the co-investigator.

Molecular and Cellular Analysis of Space-Flown Myoblasts has four objectives:

- Evaluate the roll of microgravity in regulating the differentiation program of skeletal muscle myoblasts.
- Extend the cellular analysis of space-flown L8 myoblast cells with respect to specific proliferation/differentiation steps that are affected by microgravity.
- Determine whether any of the observed phenotypic changes is a direct result of space-flight-induced, modulated gene expression.
- Analyze the mechanism(s) by which space flight may affect the genetic expression pattern of cultured myoblasts specifically and other cells generally.

The cell type used is the L8 C cell line purchased from American Type Culture Collection. L8 is a nontumorigenic myogenic (muscle) cell line originally isolated by the selective serial passage of myoblasts isolated from primary rat skeletal muscle cell cultures prepared from newborn non-inbred Wistar rats. No carcinogen was used to establish the L8 cell line.

The principal investigator is Dr. David A. Kulesh and the co-investigators are Dr. George Kearney, Major Loraine H. Anderson, and Dr. William J. Mehm, all from the Air Force Institute of Pathology in Washington, D.C.

Effects of Hypogravity on Osteoblast Differentiation has two objectives:

- Determine if space flight alters mineralization of the extracellular matrix (by light and electron microscopy, electron diffraction, and X-ray microanalysis).
- Determine if space flight delays osteoblastic maturation by assessing changes in markers characteristic of progressive differentiation (MRNA of Type I collagen, alkaline phosphatase, and osteocalcin, with glyceraldehyde-3 phosphate dehydrogenase MRNA to normalize sample loading).

Primary rat fetal calvarial osteoblasts will be used. The principal investigator is Dr. Ruth K. Globus of the University of California, San Francisco. The co-investigator is Dr. Steven B. Doty of the Hospital of Special Surgery, New York City.

An advanced cell culture device, STL-B, will be flown for the first time on STS-59. The new system includes a video microscope that will allow scientists on the ground to see real-time video images of their experiments in space. Designed to be controlled from either space or Earth, it opens up the possibility for scientists to monitor and control their space experiments from the ground. STS-59 will test the operation of the equipment. Fish eggs will be used to test the imaging capability of the system. Fluid levels and cell numbers in the STL-B are lower than those in STL-A.

Like STL-A, STL-B fits into a single standard middeck locker that has a modified locker door with its panels removed and consists of two major subassemblies: a power/electronics module and an analysis module. STL-B, however, also features a video outlet to interface the video signal with the orbiter closed-circuit television system. STL-B has a 3- by 3-inch video graphics array screen on its front panel for viewing the video microscope image and system status information. A keypad/control cluster is used to operate the video imaging system.

STL functions continuously from prelaunch through postlanding, and requires late installation into the orbiter middeck before launch. Before operations begin, the crew will enter a reference time tag using a push-button input on the front panels of the payloads. The flight crew will also be required to activate the STL-B video imaging system, enable its XYZ translator, and perform an illumination and focus check. Throughout the remainder of the flight, the crew will periodically check the equipment and perform video downlink. The samples will be analyzed immediately after the landing.

The STL experiment is sponsored by the Department of Space Biosciences at the Walter Reed Army Institute of Research, Washington, D.C., in conjunction with NASA's Office of Life and Microgravity Sciences and Applications Small Payloads program. It is being integrated with and flown on the shuttle under the direction of the DOD's Space Test Program.

Dr. George Kearney, research scientist at Walter Reed Army Institute of Research, is the principal investigator. Col. Bill Wiesmann, M.D., director of the Division of Surgery at WRAIR, is the program manager. Tom Cannon, of the WRAIR Department of Space Biosciences, is the project manager. The three are supported by collaborative partners at WRAIR, the Armed Forces Institute of Pathology, NASA's Ames Research Center, the University of Louisville Medical School, and a DOD Space Test Program team of personnel from the Air Force, Aerospace Corporation, and Rockwell.

VISUAL FUNCTION TESTER 4

The Visual Function Tester (VFT) 4 experiment will examine whether any change in human vision occurs in space and, if so, will determine whether the changes are clinically significant and how quickly recovery occurs.

There is a range of distances from ourselves within which we see objects clearly. In young and middle-aged people, the extent of this range of clear vision is determined primarily by visual accommodation: our ability to change the optical power of our eyes, allowing us to focus on objects located at different distances.

The far and near points (of clear vision) are the farthest and closest points within the range of clear vision. The range of accommodation is the linear distance between the far and near points. The amplitude of accommodation is the difference between the far- and near-point distances when these distances are represented in terms of diopters (reciprocal meters). In the case of hyperopia (far-sightedness), the far point is located beyond optical infinity. In the case of myopia (near-sightedness), the far point is located closer than optical infinity. Accommodative facility describes how fast the focus of the eye shifts between two objects that are located at different distances within the range of best vision.

Unfortunately, amplitude of accommodation decreases with age, causing the near point to recede from us. Accommodative amplitude becomes insufficient for people in their 50s to see clearly at normal reading distances. This condition is known clinically as presbyopia, which is corrected by bifocal or reading glasses. Once people reach their 60s, the amplitude of accommodation approaches zero, causing the range of clear vision to be very small.

Since the Gemini program, astronauts have suggested that space flight exacerbates presbyopia. These reports include presbyopes needing stronger reading glasses and incipient presbyopes needing to wear their reading spectacles more often while in space than on the ground. Currently, approximately 30 percent of astronauts report some near-vision degradation in orbit.

The Duntley Studies (Gemini) and, more recently, Vision Function Tester 1 have confirmed reports that far vision is unaffected in orbit. This suggests that the integrity of the visual system remains intact, which limits possible causes of degraded near vision to accommodative control and vegetative properties (e.g., microgravity causing a change in eyeball shape). Possible causes of these reports include decreased accommodative amplitude, decreased accommodative facility, and increased hyperopia.

VFT-4 was designed to investigate the above-listed possible causes of near-vision problems by determining the far and near points of clear vision and evaluating accommodative facility. The role of these three possible causes can be determined by making space-ground comparisons. If, in space, the near point recedes but the far point is unchanged, then a decrease in accommodative amplitude is indicated. If both the far and near points recede, then a hyperopic shift is indicated. Accommodative facility problems are indicated by a decrease in facility performance.

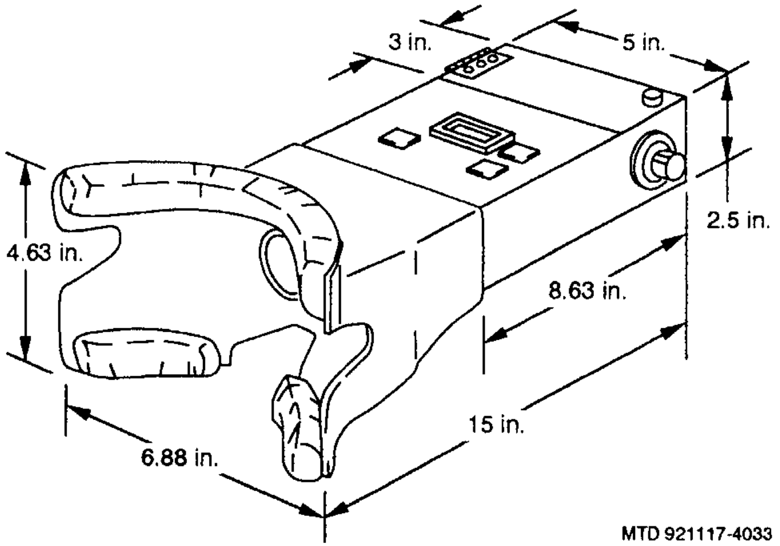
The accommodative facility test involves a timed accommodative-dactyl task (manipulate thumbswitch). Since decreased-facility test performance in space may be partly due to decreased dactyl performance, two other tests will be performed to factor out space-ground dactyl performance differences.

VFT-4 payload hardware consists of the experiment unit (a hand-held, battery-powered device with a binocular eyepiece that uses controlled illumination to present three types of visual targets), a cable connecting VFT-4 to a computer serial port, two self-booting floppy disks containing a software program and serving as a data storage medium, a payload and general support computer with power and data cables, and a standard 28-volt power cable. The experiment occupies one middeck locker and is restowed between sessions.

Two STS-59 crew members will be tested two weeks and one week before the flight, as close to launch as possible, every day during the flight, after the landing, on the day of landing, and two and seven days after the landing. Testing will be performed at the same time in the morning, when the subjects' eyes are rested. The procedure takes about 30 minutes and may be performed anywhere in the crew cabin during the mission. Crew members look into the device and follow prescribed operational procedures.

Test data are read on device displays and recorded on data sheets. The data will be used to evaluate refractive and accommodative changes in vision over a period of several days to provide a database for microgravity effects on vision and to assist in deriving a quantitative model of visual refractive changes.

VFT-4 has been flown previously on six shuttle missions.



Visual Function Tester Configuration

The VFT is a DOD Space Test Program secondary experiment and is sponsored by the Armstrong Laboratory at Wright-Patterson Air Force Base, Ohio. Dr. Lee Task, research physicist, and Dr. (Lt. Col.) Mel O'Neal, research optometrist, of the Human Engineering Division, are the principal investigators. They are assisted by Air Force and Rockwell personnel located at NASA's Johnson Space Center, Houston, Texas.

VFT-4 Far-Point Test Operating Procedures

Operational objective: to determine the far point of clear vision.

Step	Operation	Control	Comments
1	Look into the center of the eyepiece with the right eye.		
2	Press the left thumbswitch to begin the test when the green light is visible inside the viewing area.	Green LEDs on top of the unit and inside the viewing area. The left momentary push-button located on the left handle.	The first of a series of E's will be presented.
3	Initially, each E should be readable. If not, move the E closer by pressing the right thumbswitch downward until the E becomes clear.	Four-position toggle switch on the right handle of the unit.	
4	Move the E farther away by pressing the right thumbswitch upward until the E is too blurred to read.	Four-position toggle switch.	
5	Move the E closer by pressing the right thumbswitch downward until you are just able to recognize the E with fair certainty.	Four-position toggle switch.	
6	Press the left button to proceed to the next E.	Momentary push-button on the left handle of the unit.	When the series is finished, a red and green light will become visible in the viewing area.
7	Repeat steps 3 through 6 for all E's presented.		

VFT-4-T1

VFT-4 Far-Reaction Test Operating Procedures

Operational objective: to determine how fast the subject can accurately determine the direction of the E's presented optically far away.

Step	Operation	Control	Comments
1	Look into the center of the eyepiece with the right eye		
2	When the green light is visible, press the left button.	Green LEDs on top of the unit and inside the viewing area. The left momentary push-button located on the left handle.	A series of E's is presented. All E's are located far away.
3	Quickly and accurately, toggle the right thumb-switch toward the same direction that each E points.		This timed test begins with the first response. Accuracy is scored. Test must be repeated if accuracy is less than 90 percent.
4	When the series is finished, a red and green light becomes visible.		

VFT-4-T2

VFT-4 Accommodative-Facility Test Operating Procedures

Operational objective: to determine how fast the subject can accurately determine the direction of the E's alternating between optically far away and near.

Step	Operation	Control	Comments
1	Look into the center of the eyepiece with the right eye		
2	When the green light is visible, press the left button.	Green LEDs on top of the unit and inside the viewing area. The left momentary push-button located on the left handle.	A series of E's is presented, alternating between far away and near.
3	Quickly and accurately, toggle the right thumb-switch toward the same direction that each E points.		This timed test begins with the first response. Accuracy is scored. Test must be repeated if accuracy is less than 90 percent.
4	When the series is finished, a red and green light becomes visible.		

VFT-4-T3

VFT-4 Near-Point Test Operating Procedures

Operational objective: to determine the near point of clear vision.

Step	Operation	Control	Comments
1	Look into the center of the eyepiece with the right eye		
2	Press the left thumbswitch to begin the test when the green light is visible inside the viewing area.	Green LEDs on top of the unit and inside the viewing area. The left momentary push-button located on the left handle.	At this point, the first of a series of E's will be presented.
3	Initially, each E should be readable. If not, move the E farther away by pressing the right thumbswitch upward until the E becomes clear.	Four-position toggle switch on the right handle of the unit.	
4	Move the E closer by pressing the right thumbswitch downward until the E is too blurred to read.	Four-position toggle switch.	
5	Move the E farther away by pressing the right thumbswitch upward until you are just able to recognize the E with fair certainty.	Four-position toggle switch.	
6	Press the left button to proceed to the next E.	Momentary push-button on the left handle of the unit.	When the series is finished, a red and green light will become visible in the viewing area.
7	Repeat steps 3 through 6 for all E's presented.		

VFT-4-T4

VFT-4 Near-Reaction Test Operating Procedures

Operational objective: to determine how fast the subject can accurately determine the direction of the E's presented optically near.

Step	Operation	Control	Comments
1	Look into the center of the eyepiece with the right eye		
2	When the green light is visible, press the left button.	Green LEDs on top of the unit and inside the viewing area. The left momentary push-button located on the left handle.	A series of E's is presented. All E's are located close to the eye.
3	Quickly and accurately, toggle the right thumb-switch toward the same direction that each E points.		This timed test begins with the first response. Accuracy is scored. Test must be repeated if accuracy is less than 90 percent.
4	When the series is finished, all lights are extinguished.		Test series completed. Perform ENDING TEST SEQUENCE before introducing new test subject.

VFT-4-T5

SHUTTLE AMATEUR RADIO EXPERIMENT II

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

SAREX has been flown on missions STS-9, -51F, -35, -37, -45, -50, -47, -56, -55, -57, -58, and -60 in five different configurations. Configuration C will be flown on STS-59. It consists of a hand-held transceiver and interface module, spare batteries, headset, 2-meter antenna, a crew recorder, and a packet module, which contains a power supply and a packet terminal node controller. Configuration C is the SAREX-II configuration most often flown because its operation is not limited by battery life; it can operate in the unattended robot packet operations mode, and it is a reasonably simple configuration with small stowage and power requirements. The hardware in this configuration receives orbiter power through a power supply in the packet module. The equipment complement is stowed in one and one-half middeck lockers.

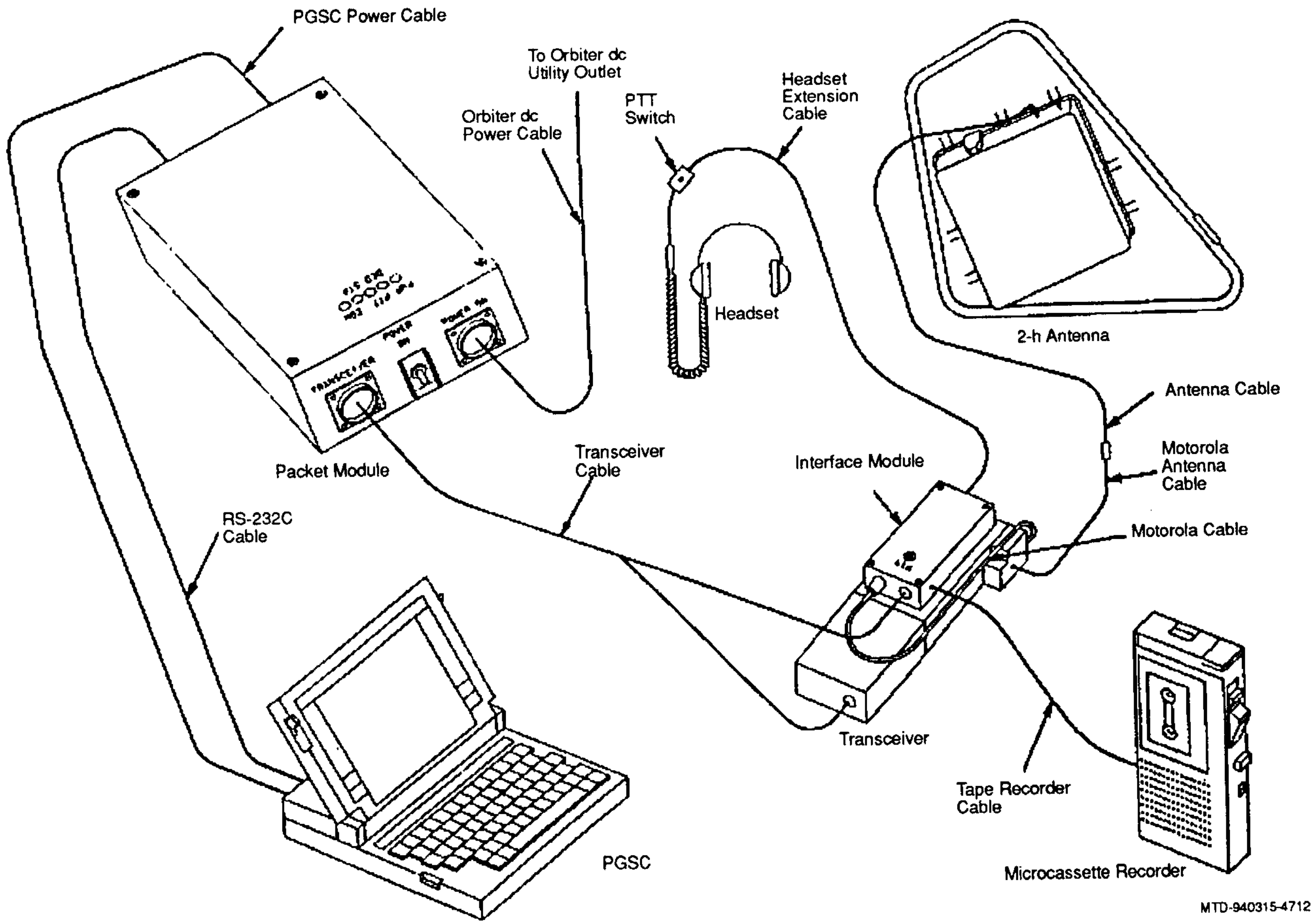
SAREX Configuration C communicates with amateur stations within Endeavour's line of sight in one of two transmission modes: voice or data (messages entered on a computer keyboard can be transmitted to and displayed on another computer via ham radio signals). The voice transmissions are operated in the attended mode, while the data transmissions can be operated in either the attended or unattended mode.

During the mission, SAREX-II will be operated at the discretion of crew members who are licensed amateur radio operators. Mission specialists Linda Godwin (call sign N5RAX) and Jay Apt (N5QWL) will talk with students in nine schools in the U.S., Finland, and Australia on ham radio. Unlicensed crew members can operate SAREX-II in the presence of a licensed crew member.

Students in the following schools will have the opportunity to talk directly with orbiting astronauts for approximately four to eight minutes:

- Ealy Elementary School, West Bloomfield, Mich. (W8JXU)
- Kanawha Elementary School, Davisville, W.V. (KD8YY)
- Alcatel Amateur Radio Associates and Circle Ten Council, BSA, Richardson, Texas (K2BSA/5)
- Anthony Elementary School, Anthony, Kan. (KB0HH)
- St. Bernard High School, Playa Del Rey, Calif. (AB6UI)
- Country Club School, San Ramon, Calif. (KE6YD)
- Deep Creek Middle School, Baltimore, Md. (WA3Z)
- Paltamo Senior High School, Paltamo, Finland (OH8AK)
- Ogilvie School, Western Australia (VK6IU)

SAREX-II will be operated in the robot mode for the majority of the flight. Nonscheduled intermittent voice operations will be performed by the crew during periods when the crew members are not scheduled for orbiter or other payload activities. The antenna's window location (window 1 or 6) does not affect communications and therefore does not require a specific orbiter attitude for operations. When possible, SAREX-II will be operated on passes over the



SAREX-II Configuration C

continental U.S., home of the heaviest concentration of ham radio operators.

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

The primary frequencies intended for use during the mission are 145.55 MHz for downlink from Endeavour and 144.91, 144.93, 144.95, 144.97, and 144.99 MHz for uplink (except Europe). The voice uplink frequencies for Europe only are 144.70, 144.75, and 144.80. The astronauts will not favor any one of these frequencies. Therefore, to talk to an astronaut, ham operators will have to select one of the frequencies chosen by the astronaut. A spacing of 600 kHz was deliberately chosen for this primary pair to accommodate those whose split-frequency capability is limited to the customary repeater offset. Digital packet will operate on 145.55 MHz for downlink transmission and 144.49 MHz for uplink transmission.

The voice operations mode works as follows: The transceiver receives uplinked signals picked up by the antenna and sends them through the interface (I/F) module to the headset for crew monitoring and to the microcassette recorder (MCR) for recording. When the crew member keys the push-to-talk button on the I/F module or headset extension cable and speaks into the microphone on the headset, his/her voice is recorded on the MCR and transmitted by the transceiver through the antenna to the ground.

The packet operations mode works as follows: SAREX-II packet radio operations use a payload and general support computer (PGSC) as the data terminal for two-way communications with similarly equipped ground stations. Packet radio can be operated in either active (seldom used) or robot mode. In the active or manual mode, the transceiver receives signals from the antenna and sends the data through the I/F module to the terminal node controller (TNC) located inside the packet module (Configuration C). The TNC converts the uplinked data for display on the PGSC. For downlinking packet data, the crew types a message on the PGSC and strikes the ENTER key. This sends the ASCII data to the TNC, where it is converted to a format that can be transmitted in the 1-meter bandwidth. The TNC automatically keys the transceiver, which transmits the signal to the ground stations.

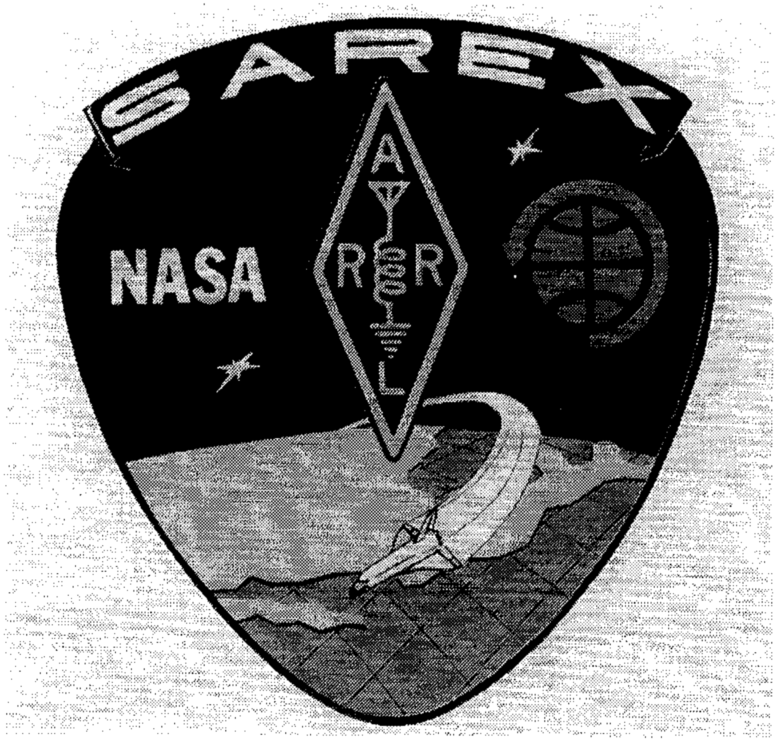
The PGSC is required to initiate robot packet operations; however, if necessary, it may be disconnected for other uses once SAREX-II is operating in the robot packet mode. This is not the desired operating scenario because some data will be lost. The TNC distinguishes between two types of robot packet contacts. When the TNC hears a call from a ground operator, it sends confirmation back to that ground station and the contact is logged as a heard call. The operator's call sign and the time of the contact are logged in the TNC's memory. If possible, several more exchanges take place between the two stations after this first exchange. If all of these exchanges are successful, the contact is logged by the TNC as a worked call. There are areas in the TNC's internal memory for both the heard and worked calls. Heard calls are much easier to process and much more numerous than worked calls. There is enough room in the TNC's memory to store all of the worked calls that occur on a mission. Memory space for heard calls is limited to the last 40 contacts, the earlier calls scrolling off as additional contacts are made. If the PGSC remains connected to SAREX-II, the log of heard calls is written to a floppy disk in the PGSC every time the buffer becomes full. When the PGSC is disconnected, the majority of heard calls are lost because several thousand such calls are typically logged throughout the course of a mission.

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

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

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

The amateur radio station at the Goddard Space Flight Center (WA3NAN) will operate around the clock during the mission, providing information and retransmitting live shuttle air-to-ground audio. Planned HF operating frequencies are 3.860, 7.185, 14.295, 21.395, and 28.650 MHz.



SAREX Insignia

TOUGHENED UNIPIECE FIBROUS INSULATION

An improved thermal protection system tile will be tested for the first time on STS-59. The new material, known as toughened unipiece fibrous insulation (TUFI), is being evaluated as a possible replacement for tiles in specific, limited areas of the orbiter that are susceptible to significant damage from debris impacts during launch and landing. These areas include the base heat shield between the shuttle's three main engines, the area near the landing gear doors, and the area near the orbital maneuvering system thrusters. Use of TUFI would result in quicker and easier tile maintenance between missions and overall reduced repair costs.

The space shuttle's thermal protection system (TPS) consists of various materials applied externally to the aluminum and graphite-epoxy outer structural skin of the orbiter to maintain the skin within acceptable temperatures, primarily during the atmospheric entry phase of the mission.

The TPS is a passive system of materials selected for stability at high temperatures and weight efficiency. It consists of several types of materials: reinforced carbon-carbon (RCC), high-temperature reusable surface insulation (HRSI) tiles, fibrous refractory composite insulation (FRCI) tiles, low-temperature reusable surface insulation (LRSI) tiles, Nomex felt resuable surface insulation (FRSI), advanced flexible reusable surface insulation (AFRSI) blankets, and additional materials in other special areas.

The approximately 20,550 HRSI and 2,950 more technologically advanced FRCI tiles are made of a ceramic-fiber material. They are used in areas on the orbiter's upper forward fuselage, especially around the windows; the entire underside of the vehicle where RCC is not used; portions of the orbital maneuvering system and reaction control system pods; the leading and trailing edges of the vertical stabilizer; wing glove areas; elevon trailing edges; the upper wing surface adjacent to the RCC; the base heat shield; the interface with wing-leading-edge RCC; and the upper body flap surface. The HRSI and FRCI tiles work very efficiently as thermal protectors, insulating the orbiter's aluminum substructure from reentry temperatures that exceed 2,200°F.

The tiles are covered with a thin, dense, black coating called reaction-cured glass (RCG). While RCG functions effectively in its designed role, its relatively thin, brittle, eggshell-like surface is easily cracked or chipped by debris impacts; and the affected tiles must be repaired or replaced.

To alleviate this concern, in the late 1980s, NASA's Ames Research Center, Mountain View, Calif., developed toughened unipiece fibrous insulation—an effective, tough, easily produced tile coating that is compatible with and may be applied to FRCI-12 tiles. TUFI has three constituents: glass frit, molybdenum disilicide, and silicon hexaboride. Each is individually ball-milled in an ethanol mix to achieve a specific particle size distribution. The constituents are then combined in a slurry and sprayed directly on the tile (which was previously machined to the desired shape from a rigid block of fibrous insulation). The slurry mix permeates the pores near the surface of the insulation material, penetrating the tile's surface to a depth of approximately 0.1 inch and adding reinforcement to the composite surface (the current tile coating remains on the tile surface and is only 0.013 inch thick). The coated tiles are then sintered in a furnace for 90 minutes at 2,200°F.

TUFI is at least ten times more durable than the baseline RCG. TUFI's porous surface also stops cracks from spreading, which limits tile damage.

Until now, TUFI has been available only on a laboratory scale. Rockwell's Space Systems Division (SSD), Downey, Calif., is presently bringing the process "in house" through a technology transfer agreement and has produced several test and demonstration articles.

Six TUFI-coated FRCI-12 tiles are to be flown on STS-59. They will be between the three main engines on the base heat shield, an area that has historically been susceptible to significant impact damage from launch pad debris. The TUFI tiles are certified for six flights, involving all four orbiters. Rockwell SSD's facility processed the tiles.

After the mission, NASA and Rockwell engineers will examine the tiles and compare the damage with RCG damage from previous missions.

DEVELOPMENT TEST OBJECTIVES

Subsonic aerodynamic verification (DTO 254). This DTO will perform a series of flight test maneuvers during the approach and landing phase of the mission to obtain aerodynamic response data. The data will be used to evaluate the effectiveness of the orbiter's rudder surface for crosswind landings. It will also be used to evaluate the handling characteristics of the orbiter during approach.

Ascent wing structural capability evaluation (DTO 301D). The purpose of this DTO is to verify that the orbiter wing structure is at or near its design condition during lift-off and ascent with near-maximum-weight payloads. The DTO will determine flight loads and structural capability and whether any unacceptable dynamic effects exist. This is a data-collection-only test and requires no specific activity other than recording and returning specified data.

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

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

Entry structural capability evaluation (DTO 307D). This DTO will collect structure load data for different payload weights and configurations to expand the data base of flight loads during entry, approach, and landing to verify the adequacy of the structure at or near design conditions and to demonstrate structural system operational capability, determine flight loads, and verify the stress/temperature response of critical structural components. This is a data-collection-only test and requires no specific activity other than recording and returning specified data.

ET TPS performance, Methods 1 and 3 (DTO 312). This DTO will obtain photographs of the external tank after separation to determine TPS charring patterns, identify regions of TPS material spallation, evaluate overall TPS performance, and identify TPS or other problems that may be a debris concern to the orbiter. The cameras are located in the orbiter umbilical well and in the flight deck. Method 1 will not have the standard +x translation burn, while Method 3 requires a +pitch maneuver.

APU shutdown test, Sequence B (DTO 414). This DTO will explore the hypothesis that delays between shutting down individual auxiliary power units on ascent can lead to "back-driving" of the nonoperational hydraulic system's speed-brake hydraulic motor. Reviews of mission data have shown that when an individual APU is shut down prematurely on ascent while the remaining APUs continue operating, there is the possibility of extended hydraulic supply pressure (i.e., the hydraulic pressure of the shut-down system remains at an elevated level for a significant period of time). The explanation for this behavior is that the operational hydraulic systems are back-driving the speed-brake hydraulic motor of the system that has been shut down. Performing this DTO during flight will produce the most representative data for this behavior. This DTO will be flown on multiple missions to create a representative database. The pilot will wait at least five seconds between each APU shutdown.

Orbiter drag chute system test (DTO 521). This DTO will evaluate the orbiter drag chute system performance through a series of landings with increasing deployment speeds. The DTO will be performed on vehicles equipped to measure drag forces imposed by the drag chute system. This DTO has two phases. Phase I consisted of two flights: the first drag chute deployment was at nose-gear touchdown (STS-49), and the second deployment was at initiation of derotation. Now that Phase I testing is complete, the drag chute is cleared for deployment under the same conditions for subsequent missions. Phase II consists of seven additional flights, each flight gradually increasing in speed from initiation at derotation of 185 knots equivalent airspeed (KEAS) to 205 KEAS. Concrete runways will be used whenever possible. On STS-59, deployment will occur at 185 KEAS.

Evaluation of the MK-1 rowing machine (DTO 653). This DTO will evaluate the ease of setup, stowage, comfort, and effectiveness of foot restraints and hand grip of the MK-1 rowing machine as an alternative to the shuttle treadmill. The MK-1 is expected to produce significantly less noise and vibration than the treadmill. Additionally, in-flight simulated rowing is expected to provide total body exercise, including aerobic and anaerobic conditioning. Heart rate will be recorded to determine the effectiveness of changes in the resistive settings of the device.

PGSC single-event-upset monitoring (DTO 656). This DTO will evaluate the susceptibility of two payload and general-support computers, including the new candidate 486 IBM Think Pad, to single-event upset caused by cosmic radiation. This information could lead to improved procedures, hardware, or software to reduce radiation effects. This DTO will run continuously once initiated on the PGSC and will be interrupted only if the crew needs to use the PGSC for PADM operations. Data will be collected for a minimum of four crew sleep periods. This DTO requires a minimum of eight flights, of which at least three should be high-altitude flights.

Acoustical noise dosimeter data (sleep station data) (DTO 663). This DTO wil 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, manned laboratory data, the three- or four-tier sleep station, and 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. Crewmembers will complete a questionnaire during the flight regarding noise levels.

Cabin temperature survey (DTO 664). The purpose of this DTO is to compile a temperature profile of the crew cabin in a variety of orbiter attitudes and configurations and to correlate the cabin temperature sensor reading with the cabin temperature profile during on-orbit operations. The goal is to reevaluate the optimum location for the cabin temperature sensor due to changes in avionics power and heat loads since STS-2 and STS-3. A crew member will record temperatures at various test points twice a day using a digital thermometer from the IFM tool kit.

Acoustical noise sound-level data (sleep station data) (DTO 665). This DTO will use the GFE sound-level meter to obtain baseline data of octave-band acoustical noise levels for the middeck and flight deck, exercise equipment, inside the four-tier sleep station, the new RCRS, the new galley, the new WCS, and manned laboratory data when labs are flown.

Thermoelectric liquid cooling system evaluation (DTO 674). The purpose of this DTO is to perform an in-flight evaluation of a thermoelectric liquid cooling system that will increase crew thermal comfort. The LCS is intended to replace the existing personal suit ventilation system in function, mounting location, and stowage location.

Global positioning system development flight test (DTO 700-8). This DTO will demonstrate the performance and operation of the global positioning system (GPS) with a modified GPS receiver-processor and the existing orbiter GPS antennas. The GPS will estimate the orbiter's position, velocity, measurement discretes, and attitude during ascent, on-orbit, entry, and landing phases. The GPS receiver output data will be recorded on the modular auxiliary data system recorder.

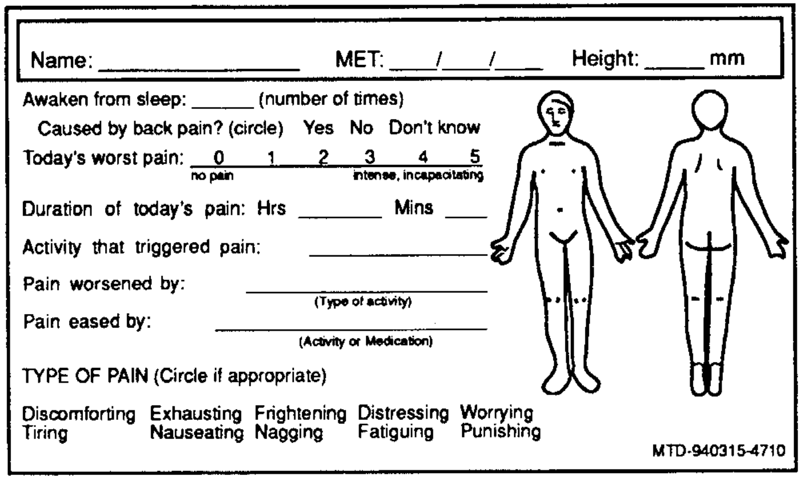
Crosswind landing performance (DTO 805). This DTO will continue to gather data for manually controlling landing in a crosswind.

Window impact observations (target of opportunity) (DSO 326). This DSO will visually document window abrasions made by orbital debris. It is designed to link window damage found during orbiter turnaround processing to mission time, attitude, and altitude. This data will aid significantly in the analysis of shuttle window impacts, in the effort to identify the sources of damage. The data will be useful in determining whether most of the damage occurs during ascent, orbit, or entry. Furthermore, if on-orbit impacts occur, this data will be useful in determining what particular attitudes and/or altitudes are more damaging. The crew will check the windows every morning and evening for new abrasions and will record their findings in a log. This DSO is a target of opportunity.

Back pain in microgravity (DSO 483). This study will collect information about the back pain pattern and height changes experienced by astronauts during flight. Crew members participating in this DSO are required to record height measurements and log back pain symptoms daily. The DSO will gather data from 30 astronauts in flight during missions of at least 8 days in duration.

Immunological assessment of crew members (DSO 487). This DSO will examine the mechanisms of space-flight-induced alterations in human immune function. As shuttle mission duration increases, the potential for development of infectious illness in crew members during flight also increases. This investigation will assess the immune system function by using the immune cells from the standard flight medicine blood draw. No on-orbit crew activities are associated with this DSO.

Measurement of formaldehyde using passive dosimetry (DSO 488). DSO 488 consists of personal and area samples that will be used to measure formaldehyde levels aboard the shuttle, establish baseline levels, and evaluate potential risks to crew health and safety from exposure to this chemical. Formaldehyde air samplers will be placed throughout the middeck and will be worn by crew members. Area samples will be collected in the middeck on an early, mid, and late flight day. In addition, personal samples will be collected from crew members for 12-hour intervals on an early, mid, and late flight day.



Name: ______________ MET: ___/___/___ Height: _____ mm

Awaken from sleep: _____ (number of times)

Caused by back pain? (circle) Yes No Don't know

Today's worst pain: 0 1 2 3 4 5
no pain intense, incapacitating

Duration of today's pain: Hrs _______ Mins ____

Activity that triggered pain: ______________

Pain worsened by: ______________
(Type of activity)

Pain eased by: ______________
(Activity or Medication)

TYPE OF PAIN (Circle if appropriate)

Discomforting Exhausting Frightening Distressing Worrying
Tiring Nauseating Nagging Fatiguing Punishing

MTD-940315-4710

Daily Pain Questionnaire

Orthostatic function during entry, landing, and egress (DSO 603B).* This DSO documents the relationship between mission duration and changes in orthostatic function of crew members during the actual stresses of landing and egress from the seat and crew cabin. The heart rate and rhythm, blood pressure, cardiac output, and peripheral resistance of crew members will be monitored to develop and assess countermeasures for improving orthostatic tolerance upon return to Earth. This data will be used to determine whether precautions and countermeasures other than (or perhaps instead of) operational saline are needed to protect crew members if they have to leave the orbiter in an emergency. It will also be used to determine the effectiveness of proposed in-flight countermeasures. Crew members will don equipment before they put on the LES during deorbit preparations. Equipment consists of a blood pressure

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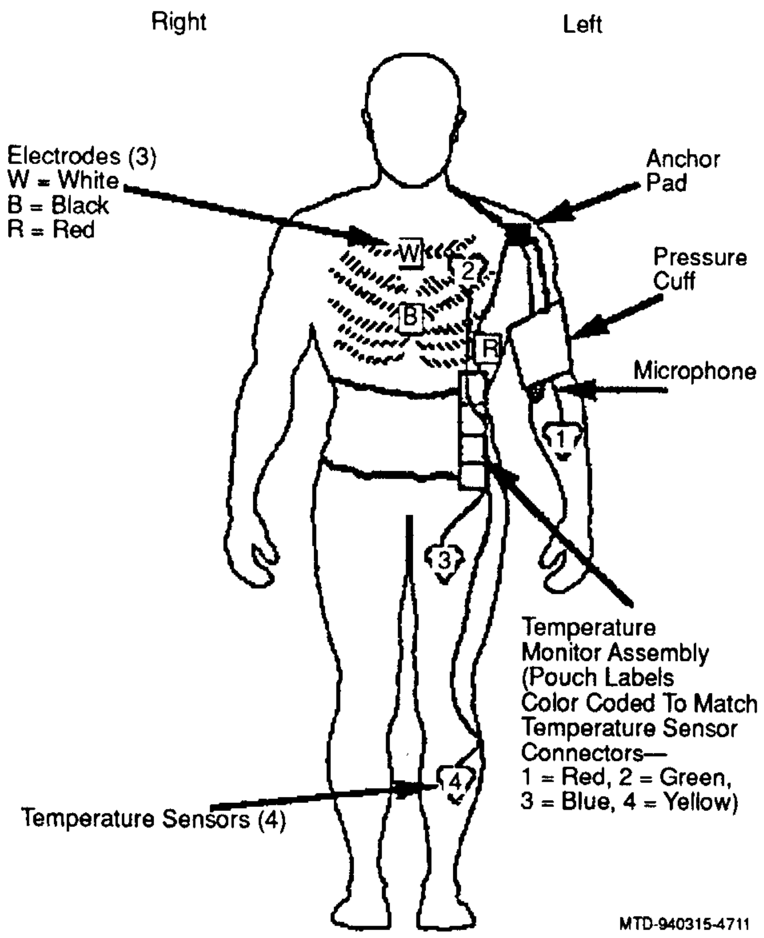
*EDO buildup—medical evaluation DSO

monitor, accelerometers, an impedance cardiograph, and transcranial Doppler hardware. The crew members wear the equipment and record verbal comments throughout entry. This will be flown as a DSO of opportunity.

Visual-vestibular integration as a function of adaptation (DSO 604).* The objective of this DSO is to investigate visual-vestibular and perceptual adaptive responses (changes in vision and sense of balance) to the readaptation to gravity by crewmembers as a function of mission duration. The operational impact of these responses on the crew members' ability to conduct entry, landing, and egress procedures will also be investigated. These data will be used to develop training and/or countermeasures to assure the safety and success of extended missions by promoting optimal neurosensory function needed for entry, landing, and possible emergency egress. Subjects will make specific head movements while looking at a visual target on a locker in front of their seats and recording sensations on a tape recorder.

Effects of space flight on aerobic and anaerobic metabolism during exercise (DSO 608).* Energy is supplied in the human body via aerobic and anaerobic metabolism. Postflight energy metabolism and pulmonary responses during exercise differ from preflight values in that most of the energy pool is obtained anaerobically. Therefore, the pupose of this DSO is to quantify changes in aerobic and anaerobic metabolism during exercise and to relate them to alterations in total body water, dry lean tissue, fat mass, and fluid volume intake. Changes in energy metabolism, shifts in fuel utilization, and decreases in muscle mass after extended-duration space flight may limit a crew member's ability to do physical work, both in flight and after flight. Participating crew members will drink one quart of fluid after each exercise session and keep a daily log of their fluid intake. After the flight, oxygen intake and body hydration will be measured during a series of treadmill sessions, and total lean body mass will be determined.



Electrode and Temperature Sensor Placement for DSO 603B

Air monitoring instrument evaluation and atmosphere characterization (microbial air sampler) (DSO 611).* This DSO is designed to evaluate and verify air monitoring equipment to ensure its proper function and operation during flight. Data collected on contaminant levels during missions of varying durations will be used to establish baseline levels and to evaluate potential risks to crew health and safety. Contaminants being detected include thermodegradation products, volatile organics, toxic compounds, airborne particulates, and airborne micro-organisms. The microbial air sampler configuration will be flown on STS-59. The MAS will evaluate the effect of the regenerable carbon dioxide removal system on air quality. Air samples from the middeck and flight deck will be collected on an early, mid, and late flight day.

In-flight use of florinef to improve orthostatic intolerance postflight (DSO 621).* The purpose of this DSO is to evaluate the efficacy of florinef on postflight orthostatic tolerance by measuring heart rate, blood pressure, stroke volume, and other cardiovascular responses to orthostatic stress. A cardiovascular profile will be determined before and after flight for crew members participating in this investigation. Crew members will ingest a florinef tablet and a potassium supplement tablet at 12-hour intervals and drink two quarts of fluid with meals for the last two days of flight.

Pre- and postflight measurement of cardiorespiratory responses to submaximal exercise (DSO 624).* For this DSO, the crew members will wear heart watches during exercise and log exercise to help evaluate the changes in aerobic capacity before, during, and after flight. These evaluations will help develop optimal exercise protocols to prevent decrements in nominal cardiorespiratory response.

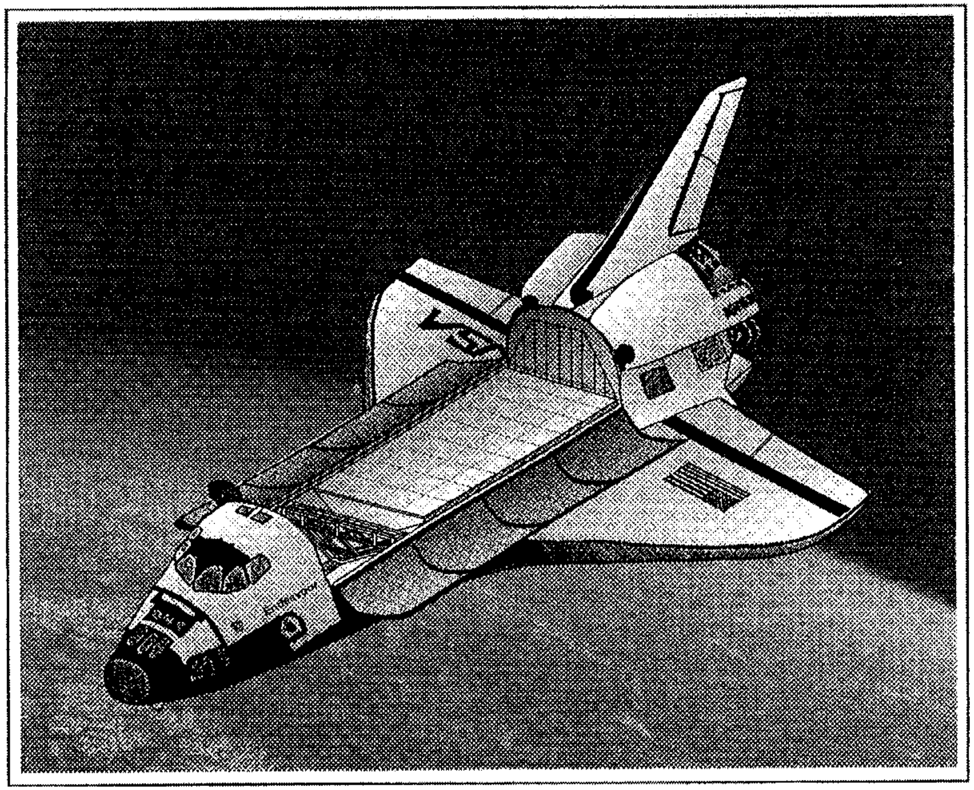
Cardiovascular and cerebrovascular response to standing before and after space flight (DSO 626).* This DSO will characterize the integrated response of the arterial pressure control system to standing before and after space flight. This test includes the measurement of blood volume.

Educational activities (DSO 802). The purpose of this DSO is to use the attraction of space flight to capture the interest of students and motivate them toward careers in science, engineering, and mathematics. Objective 1 is to produce educational products that will capture the interest of students and motivate them toward careers in science, engineering, and mathematics. These products include video lessons of approximately 20 minutes in length with scenes recorded both in orbit and on the ground. The on-orbit video will represent approximately one-third of the finished video product. This DSO will support the videotaping of on-orbit educational activities performed by the flight crew as well as other educational activities that are deemed appropriate by the Educational Working Group and the flight crew. Objective 2 is to support the live TV downlink of educational activities performed by the flight crew. Typically, these activities will be limited to one or two 30-minute live downlinks. On STS-59, Objective 1 will be performed.

Documentary television (DSO 901). The purpose of DSO 901 is to provide live television transmission or VTR dumps of the following crew activities and spacecraft functions: payload bay views, STS and payload crew activities, VTR downlink of crew activities, in-flight crew press conference, orbiter operations, payload deployment/retrieval and operations, Earth views, rendezvous and proximity operations, and unscheduled TV activities. Telecasts are planned for communication periods with seven or more minutes of uninterrupted viewing time. The broadcast will use operational air-to-ground and/or operational intercom audio. VTR recording may be used when live television is not possible.

Documentary motion picture photography (DSO 902). This DSO requires documentary and public affairs motion picture photography of significant activities that best depict the basic capabilities of the space shuttle and key flight objectives. This DSO includes photography of payload bay activities, flight deck activities, middeck activities, and any unscheduled motion picture photography. This photography provides a historical record of the flight as well as material for release to the news media, independent publishers, and film producers.

Documentary still photography (DSO 903). This DSO requires still photography of crew activities in the orbiter and payload bay, and mission-related scenes of general public and historical interest. Still photography uses 70mm format for exterior shots and 35mm format for interior shots.



STS-59

MISSION TIME LINE

April 1994

Rockwell

Office of Media Relations
Space Systems Division

PUB 3546-V Rev 4-94

CONTENTS

STS-59 PRELAUNCH COUNTDOWN TIME LINE

T - (MINUS) HR:MIN:SEC	EVENT
06:00:00	Verification of the launch commit criteria is complete at this time. The liquid oxygen and liquid hydrogen systems chill-down commences in order to condition the ground line and valves as well as the external tank (ET) for cryo loading. Orbiter fuel cell power plant activation is performed.
05:50:00	The space shuttle main engine (SSME) liquid hydrogen chill-down sequence is initiated by the launch processing system (LPS). The liquid hydrogen recirculation valves are opened and start the liquid hydrogen recirculation pumps. As part of the chill-down sequence, the liquid hydrogen prevalves are closed and remain closed until T minus 9.5 seconds.
05:30:00	Liquid oxygen chill-down is complete. The liquid oxygen loading begins. The liquid oxygen loading starts with a "slow fill" in order to acclimate the ET. Slow fill continues until the tank is 2-percent full.
05:15:00	The liquid oxygen and liquid hydrogen slow fill is complete and the fast fill begins. The liquid oxygen and liquid hydrogen fast fill will continue until that tank is 98-percent full.
05:00:00	The calibration of the inertial measurement units (IMUs) starts. The three IMUs are used by the orbiter navigation systems to determine the position of the orbiter in flight.
04:30:00	The orbiter fuel cell power plant activation is complete.
04:00:00	The Merritt Island (MILA) antenna, which transmits and receives communications, telemetry and ranging information, alignment verification begins.
03:45:00	The liquid hydrogen fast fill to 98 percent is complete, and a slow topping-off process is begun and stabilized to 100 percent.
03:30:00	The liquid oxygen fast fill is complete to 98 percent.
03:20:00	The main propulsion system (MPS) helium tanks begin filling from 2,000 psi to their full pressure of 4,500 psi.
03:15:00	Liquid hydrogen stable replenishment begins and continues until just minutes prior to T minus zero.
03:10:00	Liquid oxygen stable replenishment begins and continues until just minutes prior to T minus zero.
03:00:00	The MILA antenna alignment is completed.

T - (MINUS) HR:MIN:SEC	EVENT
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	Postingress software reconfiguration occurs.
02:00:00	Checking of the launch commit criteria starts at this time.
02:00:00	The ground launch sequencer (GLS) software is initialized.
01:50:00	The solid rocket boosters' (SRBs') hydraulic pumping units' gas generator heaters are turned on and the SRBs' aft skirt gaseous nitrogen purge starts.
01:50:00	The SRB rate gyro assemblies (RGAs) are turned on. The RGAs are used by the orbiter's navigation system to determine rates of motion of the SRBs during first-stage flight.
01:35:00	The orbiter accelerometer assemblies (AAs) are powered up.
01:35:00	The orbiter reaction control system (RCS) control drivers are powered up.
01:35:00	The flight crew starts the communications checks.
01:25:00	The SRB RGA torque test begins.
01:20:00	Orbiter side hatch is closed.
01:10:00	Orbiter side hatch seal and cabin leak checks are performed.
01:01:00	IMU preflight align begins. Flight crew functions from this point on will be initiated by a call from the orbiter test conductor (OTC) to proceed. The flight crew will report back to the OTC after completion.
01:00:00	The orbiter RGAs and AAs are tested.
00:50:00	The flight crew starts the orbiter hydraulic auxiliary power units' (APUs') water boilers preactivation.
00:45:00	Cabin vent redundancy check is performed.
00:45:00	The GLS mainline activation is performed.
00:40:00	The eastern test range (ETR) shuttle range safety system (SRSS) terminal count closed-loop test is accomplished.

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

T - (MINUS) HR:MIN:SEC	EVENT
	All test support team members verify they are "go for launch."
00:12:00	Emergency aircraft and personnel are verified on station.
00:10:00	All orbiter aerosurfaces and actuators are verified to be in the proper configuration for hydraulic pressure application. The NASA test director gets a "go for launch" verification from the launch team.
00:09:00	A planned 10-minute hold starts.
Hold 10 Minutes	NASA and contractor project managers will be formally polled by the deputy director of NASA, Space Shuttle Operations, on the Space Shuttle Program Office communications loop during the T-minus-9-minute hold. A positive "go for launch" statement will be required from each NASA and contractor project element prior to resuming the launch countdown. The loop will be recorded and maintained in the launch decision records.
	All test support team members verify that they are "go for launch."
	Final GLS configuration is complete.
00:09:00 Counting	The GLS auto sequence starts and the terminal countdown begins.
	From this point, the GLSs in the integration and backup consoles are the primary control until T-0 in conjunction with the on-board orbiter PASS redundant-set computers.
00:09:00	Operations recorders are on. MCC-H, Johnson Space Center, sends a command to turn these recorders on. They record shuttle system performance during ascent and are dumped to the ground once orbit is achieved.
00:08:00	Payload and stored prelaunch commands proceed.
00:07:30	The orbiter access arm (OAA) connecting the access tower and the orbiter side hatch is retracted. If an emergency arises requiring flight crew activation, the arm can be extended either manually or by GLS computer control in approximately 30 seconds or less.
00:06:00	APU prestart occurs.
00:05:00	Orbiter APUs start. The orbiter APUs provide pressure to the three orbiter hydraulic systems. These systems are used to move the SSME engine nozzles and aerosurfaces.
00:05:00	ET/SRB range safety system (RSS) is armed. At this point, the firing circuit for SRB ignition and destruct devices is mechanically enabled by a

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

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

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

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

STS-59 MISSION HIGHLIGHTS TIME LINE

T + (PLUS) DAY/ HR:MIN:SEC	EVENT
	DAY ZERO
0/00:00:07	Tower is cleared (SRBs above lightning-rod tower).
0/00:00:10	180-degree positive roll maneuver (right-clockwise) is started. Pitch profile is heads down, wings level.
0/00:00:19	Roll maneuver ends.
0/00:00:28	All three SSMEs throttle down from 104 to 67 percent for maximum aerodynamic load (max q).
0/00:00:57	Max q occurs.
0/00:01:01	All three SSMEs throttle to 104 percent.
0/00:02:05	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.
	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.
0/00:07:23	Single-engine press to main engine cutoff (MECO).
0/00:07:31	All three SSMEs throttle down to 67 percent for MECO.
0/00:08:34	MECO occurs at approximate velocity 25,777 feet per second, 29 by 117 nautical miles (33 by 135 statute miles).

Editor's Note: This time line lists selected highlights only. For full detail, please refer to the NASA Mission Operations Directorate STS-59 Flight Plan, Ascent Checklist, Postinsertion Checklist, Deorbit Prep Checklist, and Entry Checklist.

On every shuttle mission, some day-to-day replanning takes place to adjust crew and event time lines according to unforeseen developments or simply to optimize the use of time in orbit. Each day's replanning effort will produce an execute plan defining the approach for the next day's activities in space and on the ground.

Although STS-59 is planned to be a nine-day mission, an additional flight day is highly desirable and may be added if consumables (e.g., fuel, oxygen) allow.

T + (PLUS) DAY/ HR:MIN:SEC	EVENT
0/00:08:41	Zero thrust.
0/00:08:53	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.
	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.

T + (PLUS) DAY/ HR:MIN:SEC	EVENT
	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.
0/00:37	OMS-2 thrusting maneuver is performed, approximately 1 minutes, 42 seconds in duration, at 164 fps, 120 by 121 nautical miles.
0/00:51	Commander closes all current breakers, panel L4.
0/00:53	Mission specialist (MS), payload specialist seat egress.
0/00:54	Commander and pilot configure GPCs for OPS-2.
0/00:57	MS configures preliminary middeck.
0/00:59	MS configures aft flight station.
0/01:02	MS unstows, sets up, and activates PGSC.
0/01:03	MS configures for payload bay door operations.
0/01:05	Pilot activates payload bus (panel R1).
0/01:07	Commander activates star tracker and opens door.

T + (PLUS) DAY/ HR:MIN:SEC	EVENT
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.
0/01:28	MS opens payload bay doors.
0/01:31	MS sets up photo/TV camera 01, if time is available.
0/01:36	Mission Control Center (MCC), Houston (H), informs crew to "go for orbit operations."
0/01:37	Commander performs IMU alignment using star tracker.
0/01:41	Pilot maneuvers to tail-forward attitude, biased negative Z local vertical, negative X velocity vector attitude.
0/01:45	Commander and pilot seat egress.
0/01:48	Commander and pilot clothing configuration.
0/01:49	MS/PS clothing configuration.
0/01:52	Commander begins post-payload-bay-door operations and radiator configuration.
0/01:54	MS/PS remove and stow seats.
0/01:56	Commander starts ST self-test and opens door.
0/01:56	MS configures and activates WCS.
0/01:57	MS activates switch configuration/galley.
0/01:58	MS stows escape pole.
0/02:00	Blue team begins presleep activities.
0/02:01	Pilot activates auxiliary power unit steam vent heater, panel R2, boiler controller/heater, 3 to A, power, 3 to ON.
0/02:04	MS performs on-orbit initialization.
0/02:05	Commander configures vernier controls.
0/02:09	MS deploys Ku-band antenna.
0/02:10	Commander, pilot configure controls for on-orbit.
0/02:15	MS activates SRL MPESS pallet.
0/02:18	MS activates Ku-band antenna.
0/02:19	Pilot enables hydraulic thermal conditioning.
0/02:24	MS resets caution/warning (C/W).
0/02:28	Pilot plots fuel cell performance.
0/02:30	SRL MAPS activation steps 1-7.
0/02:45	SRL SIR-C/X-SAR activation begins.
0/03:00	SRL MAPS activation, step 8.

T + (PLUS) DAY/ HR:MIN:SEC	EVENT
0/03:20	SRL MAPS activation, step 9.
0/03:30	Blue team begins sleep period.
0/04:00	SRL on-orbit checkout (ground commanded).
0/04:14	On-orbit +X RCS burn (orbit adjustment).
0/04:55	Priority Group B powerdown.
0/04:59	On-orbit +X RCS burn (orbit circularization).
0/06:05	SRL on-orbit checkout (ground commanded).
0/06:20	Group A GAS experiments.
0/07:15	STL-A initiation.
0/07:25	STL-B initiation.
0/08:05	Group B GAS experiments.
0/08:45	Red team begins presleep activities.
0/09:30	DSO 483.
0/09:35	Blue team begins postsleep activities.
0/10:15	Red team handover to blue team.
0/11:00	Red team begins sleep period.
0/11:40	SRL orbiter maneuver.
0/11:40	DSO 488 personal and area sampler deployment.

T + (PLUS) DAY/ HR:MIN:SEC	EVENT
0/12:10	DTO 656.
0/12:15	VFT tests.
0/12:45	DTO 656.
0/13:00	DTO 663 airlock setup.
0/13:10	SRL orbiter maneuver.
0/13:25	SRL Earth observations.
0/13:35	SRL Earth observations.
0/13:55	SRL Earth observations.
0/14:05	SAREX setup.
0/14:25	SAREX packet/robot operations.
0/14:40	SRL orbiter maneuver.
0/14:45	SRL Earth observations.
0/15:10	SRL Earth observations.
0/15:25	SRL Earth observations.
0/15:40	DSO 611.
0/16:10	SRL orbiter maneuver.
0/16:20	SRL Earth observations—Safsaf, Egypt/Sudan supersite.
0/16:25	SRL Earth observations.

T + (PLUS) DAY/ HR:MIN:SEC	EVENT
0/17:40	SRL orbiter maneuver.
0/17:45	SRL Earth observations.
0/18:10	SRL Earth observations.
0/18:25	SRL Earth observations.
0/19:00	DSO 483.
0/19:05	SRL orbiter maneuver.
0/19:05	Red team begins postsleep activities.
0/19:05	SRL Earth observations.
0/19:20	SRL Earth observations.
0/19:25	SRL Earth observations—Otztal, Austrian Alps supersite.
0/19:30	SRL Earth observations.
0/19:40	SRL Earth observations.
0/19:55	SRL Earth observations.
0/20:00	SRL Earth observations.
0/20:35	SRL orbiter maneuver.
0/20:45	DTO 656.
0/20:50	VFT tests.

T + (PLUS) DAY/ HR:MIN:SEC	EVENT
0/20:50	SRL Earth observations.
0/20:55	SRL Earth observations—Flevoland, Netherlands supersite.
0/21:00	SRL Earth observations.
0/21:10	SRL Earth observations.
0/21:20	DTO 656.
0/21:40	POCC payload update.
0/21:45	DSO 488 stow.
0/22:00	Ergometer setup.
0/22:10	SRL orbiter maneuver.
0/22:20	SAREX voice contact—Surrey, England test.
0/22:25	SRL Earth observations.
0/22:35	Blue team handover to red team.
0/22:45	DSO 488 deployment.
0/22:45	MK-1 rower setup.
0/23:00	DSO 624.
0/23:35	SAREX voice check—Houston, Texas.
0/23:40	SRL Earth observations.
0/23:45	SRL Earth observations—Duke Forest, N. Carolina supersite.

T + (PLUS) DAY/ HR:MIN:SEC	EVENT
0/23:50	SRL Earth observations.
0/23:55	SRL Earth observations.
	MET DAY ONE
1/00:00	Blue team begins presleep activities.
1/00:00	SRL Earth observations.
1/00:00	DSO 624.
1/00:15	SRL Earth observations.
1/00:20	SRL orbiter maneuver.
1/00:59	Multi-axis RCS burn.
1/01:05	SRL orbiter maneuver.
1/01:20	DTO 664.
1/01:25	SRL Earth observations.
1/01:30	SRL Earth observations—Otztal, Austrian Alps supersite.
1/01:30	DSO 326 window impact observations.
1/01:35	SRL Earth observations.
1/01:40	SRL Earth observations.
1/02:00	Blue team begins sleep period.
1/02:15	DTO 663 data take—airlock.

T + (PLUS) DAY/ HR:MIN:SEC	EVENT
1/02:30	SRL orbiter maneuver.
1/02:30	SRL Earth observations.
1/02:35	SAREX voice contact—Playa del Rey, California.
1/02:45	SRL Earth observations—Stovepipe Wells Fan, Calif. supersite.
1/02:50	SRL Earth observations.
1/03:00	SRL Earth observations.
1/03:05	SRL Earth observations.
1/03:10	SRL Earth observations.
1/04:00	SRL orbiter maneuver.
1/04:10	SRL Earth observations.
1/04:20	SRL Earth observations.
1/04:35	SRL Earth observations.
1/05:30	SRL orbiter maneuver.
1/05:45	DSO 608.
1/05:50	SRL Earth observations.
1/06:00	SRL Earth observations.
1/06:55	SRL orbiter maneuver.
1/07:25	SRL Earth observations.

T + (PLUS) DAY/ HR:MIN:SEC	EVENT
1/07:25	SAREX voice contact—Davisville, West Virginia.
1/07:30	SRL Earth observations—Raco, Michigan supersite.
1/07:35	SRL Earth observations.
1/07:40	SRL Earth observations—Gulf Stream supersite.
1/07:45	SRL Earth observations—Bebedouro, Brazil supersite.
1/08:55	SRL orbiter maneuver.
1/08:55	SAREX voice contact—Anthony, Kansas.
1/09:00	SRL Earth observations.
1/09:05	SRL Earth observations.
1/09:10	SRL Earth observations.
1/09:15	Radiator deploy.
1/09:15	SRL Earth observations.
1/09:20	SRL Earth observations.
1/09:25	DSO 488 stow.
1/09:50	Red team begins presleep activities.
1/09:55	SRL orbiter maneuver.
1/10:00	DSO 483.
1/10:05	Blue team begins postsleep activities.
1/11:00	Red team handover to blue team.
1/11:25	SRL orbiter maneuver.
1/12:00	Red team begins sleep period.
1/12:05	DTO 656.
1/12:10	VFT tests.
1/12:10	SRL Earth observations.
1/12:35	DSO 488 stow.
1/12:40	DTO 656.
1/12:55	SRL orbiter maneuver.
1/13:05	DSO 624.
1/13:05	SRL Earth observations.
1/13:15	SRL Earth observations.
1/13:20	SRL Earth observations.
1/13:25	SAREX voice contact—personal contact.
1/13:35	SRL Earth observations.
1/14:05	DSO 624.
1/14:15	SRL orbiter maneuver.
1/14:30	SRL Earth observations.

T + (PLUS) DAY/ HR:MIN:SEC	EVENT
1/14:50	SRL Earth observations.
1/15:00	SAREX robot operations.
1/15:05	SRL Earth observations.
1/15:30	DTO 663 data take—airlock.
1/15:50	SRL orbiter maneuver.
1/15:55	SRL Earth observations.
1/16:05	SRL Earth observations.
1/16:20	SRL Earth observations.
1/17:20	SRL orbiter maneuver.
1/17:30	SRL Earth observations.
1/17:35	SRL Earth observations.
1/17:55	SRL Earth observations.
1/18:55	SRL orbiter maneuver.
1/19:05	SRL Earth observations—Oberpfaffenhofen, Germany supersite.
1/19:10	SRL Earth observations.
1/19:20	SRL Earth observations.
1/19:40	SRL Earth observations.
1/20:00	DSO 483.
1/20:00	Red team begins postsleep activities.
1/20:15	SRL orbiter maneuver.
1/20:30	SRL Earth observations.
1/20:35	SRL Earth observations.
1/20:40	SRL Earth observations.
1/20:45	SRL Earth observations.
1/20:50	SRL Earth observations.
1/21:10	SRL Earth observations.
1/21:30	DSO 624.
1/21:40	DTO 656.
1/21:45	SRL orbiter maneuver.
1/21:45	VFT tests.
1/22:10	SRL Earth observations.
1/22:15	DTO 656.
1/22:40	PAO opportunity.
1/23:00	Blue team handover to red team.
1/23:15	POCC payload update.
1/23:15	DTO 664.
1/23:15	DTO 665.

T + (PLUS) DAY/ HR:MIN:SEC	EVENT
1/23:15	SRL orbiter maneuver.
1/23:20	SAREX voice contact—Baltimore, Maryland.
1/23:25	SRL Earth observations—Duke Forest, N. Carolina supersite.
1/23:30	SRL Earth observations.
1/23:35	SRL Earth observations.
1/23:40	SRL Earth observations.
1/23:45	SRL Earth observations.
1/23:45	DTO 663 sleep station setup.
1/23:55	SRL Earth observations.

MET DAY TWO

T + (PLUS) DAY/ HR:MIN:SEC	EVENT
2/00:00	Blue team begins presleep activities.
2/00:37	Multi-axis RCS burn.
2/00:40	SRL orbiter maneuver.
2/00:55	SRL Earth observations—Chickasha, Okla. supersite.
2/01:10	SRL Earth observations.
2/01:15	SRL Earth observations—Otztal, Austrian Alps supersite.
2/01:20	SRL Earth observations.
2/01:25	SRL Earth observations.
2/02:00	Blue team begins sleep period.
2/02:00	DSO 608.
2/02:10	SRL orbiter maneuver.
2/02:25	SRL Earth observations—Stovepipe Wells Fan, Calif. supersite.
2/02:30	SRL Earth observations.
2/02:45	SRL Earth observations.
2/02:50	DSO 624.
2/03:40	SRL orbiter maneuver.
2/04:05	SRL Earth observations.
2/04:20	SRL Earth observations.
2/04:25	SRL Earth observations.
2/05:10	SRL orbiter maneuver.
2/05:30	SRL Earth observations.
2/05:45	SRL Earth observations.
2/06:40	SRL orbiter maneuver.
2/07:00	SRL Earth observations.
2/07:05	SRL Earth observations.

T + (PLUS) DAY/ HR:MIN:SEC	EVENT
2/07:05	SAREX voice contact—W. Bloomfield, Michigan.
2/07:10	SRL Earth observations.
2/07:15	SRL Earth observations—Gulf Stream supersite.
2/07:25	SRL orbiter maneuver.
2/08:35	SAREX voice contact—Richardson, Texas.
2/08:35	SRL Earth observations.
2/08:40	SRL Earth observations.
2/08:45	SRL Earth observations.
2/08:55	SRL Earth observations.
2/08:55	SRL orbiter maneuver.
2/09:00	SRL Earth observations.
2/09:35	SRL Earth observations—Western Pacific supersite.
2/09:50	SRL Earth observations.
2/09:55	DSO 326 window impact observations.
2/10:00	DSO 483.
2/10:00	SRL orbiter maneuver.
2/10:05	SAREX voice contact—San Ramon, California.

T + (PLUS) DAY/ HR:MIN:SEC	EVENT
2/10:05	Blue team begins postsleep activities.
2/10:10	SRL Earth observations.
2/10:20	SRL Earth observations—Galapagos Islands supersite.
2/10:30	DTO 663 data take—sleep station.
2/10:45	Red team begins presleep activities.
2/11:05	SRL orbiter maneuver.
2/11:45	Red team handover to blue team.
2/12:00	DTO 656.
2/12:05	VFT tests.
2/12:10	DSO 488 deployment.
2/12:30	DTO 656.
2/12:35	DSO 624.
2/12:35	SRL orbiter maneuver.
2/12:40	SRL Earth observations.
2/12:45	SRL Earth observations.
2/13:00	Red team begins sleep period.
2/13:00	SRL Earth observations.
2/13:20	SRL Earth observations.

T + (PLUS) DAY/ HR:MIN:SEC	EVENT
2/14:00	SRL orbiter maneuver.
2/14:10	SRL Earth observations.
2/14:15	SRL Earth observations.
2/14:30	SRL Earth observations.
2/14:45	SRL Earth observations.
2/15:15	SAREX robot operations.
2/15:15	DSO 624.
2/15:30	SRL orbiter maneuver.
2/15:45	SRL Earth observations.
2/16:05	SRL Earth observations.
2/16:30	SRL orbiter maneuver.
2/17:05	SRL Earth observations.
2/17:40	SRL Earth observations.
2/17:45	SRL Earth observations—Western Pacific supersite.
2/18:05	DSO 611.
2/18:30	SRL orbiter maneuver.
2/18:40	MS4 off duty/exercise.

T + (PLUS) DAY/ HR:MIN:SEC	EVENT
2/18:45	SRL Earth observations—Otztal, Austrian Alps supersite.
2/18:50	SRL Earth observations.
2/19:00	SRL Earth observations.
2/19:20	SRL Earth observations.
2/19:55	SRL orbiter maneuver.
2/20:15	SAREX voice contact—Paltamo, Finland.
2/20:20	SRL Earth observations.
2/20:25	SRL Earth observations.
2/20:30	SRL Earth observations.
2/21:00	DSO 483.
2/21:00	Red team begins postsleep activities.
2/21:50	SRL orbiter maneuver.
2/21:50	SRL Earth observations.
2/22:00	SRL Earth observations.
2/22:05	SRL Earth observations.
2/22:15	SAREX voice contact—Northampton, Australia.
2/22:40	DTO 656.
2/22:45	VFT tests.

T + (PLUS) DAY/ HR:MIN:SEC	EVENT
2/22:45	POCC payload update.
2/22:55	SRL orbiter maneuver.
2/23:00	SAREX voice contact—Eastern U.S. backup.
2/23:00	SRL Earth observations.
2/23:05	SRL Earth observations.
2/23:10	SRL Earth observations—Duke Forest, N. Carolina supersite.
2/23:15	SRL Earth observations.
2/23:15	DTO 656.
2/23:35	DTO 663 data take—sleep station/stow.
2/23:35	DSO 488 stow.
2/23:45	Blue team handover to red team.

MET DAY THREE

T + (PLUS) DAY/ HR:MIN:SEC	EVENT
3/00:25	Multi-axis RCS burn.
3/00:30	SRL orbiter maneuver.
3/00:30	Blue team begins presleep activities.
3/00:35	SRL Earth observations—Chickasha, Okla. supersite.
3/00:55	SRL Earth observations—Montespertoli, Italy supersite.

T + (PLUS) DAY/ HR:MIN:SEC	EVENT
3/01:00	SRL Earth observations.
3/01:00	DSO 488 deployment.
3/01:50	DSO 608.
3/01:50	SRL orbiter maneuver.
3/02:00	DTO 664.
3/02:05	SRL Earth observations.
3/02:10	SRL Earth observations.
3/02:25	SRL Earth observations.
3/02:30	Blue team begins sleep period.
3/02:30	SRL Earth observations.
3/02:35	DSO 624.
3/03:20	SRL orbiter maneuver.
3/03:30	SRL Earth observations.
3/03:45	SRL Earth observations.
3/03:50	SRL Earth observations.
3/03:55	SRL Earth observations.
3/04:05	SRL Earth observations.
3/04:05	PAO opportunity.
3/04:50	SRL orbiter maneuver.

T + (PLUS) DAY/ HR:MIN:SEC	EVENT
3/05:15	SRL Earth observations.
3/05:25	SRL Earth observations.
3/06:20	SRL orbiter maneuver.
3/06:40	SRL Earth observations.
3/06:45	SRL Earth observations.
3/06:55	SRL Earth observations—Gulf Stream supersite.
3/07:00	SRL Earth observations.
3/07:05	SRL Earth observations.
3/07:15	Group C GAS experiments.
3/07:35	SAREX voice contact—Northampton, Australia backup.
3/07:55	SRL Earth observations—Western Pacific supersite.
3/08:10	SRL orbiter maneuver.
3/08:20	SRL Earth observations.
3/08:20	SAREX voice contact—Central U.S. backup.
3/08:25	SRL Earth observations.
3/08:30	SRL Earth observations—Chickasha, Okla. supersite.
3/08:35	SRL Earth observations.

T + (PLUS) DAY/ HR:MIN:SEC	EVENT
3/08:40	SRL Earth observations.
3/09:15	SRL orbiter maneuver.
3/09:35	SRL Earth observations.
3/09:45	SAREX voice contact—Western U.S. backup.
3/09:55	SRL Earth observations.
3/10:00	SRL Earth observations.
3/10:30	DSO 483.
3/10:35	Blue team begins postsleep activities.
3/10:50	SRL orbiter maneuver.
3/11:05	SRL Earth observations.
3/11:15	DSO 326 window impact observations.
3/11:25	DSO 488 stow.
3/11:30	SRL Earth observations.
3/11:40	SRL orbiter maneuver.
3/12:15	Red team handover to blue team.
3/12:30	Red team begins presleep activities.
3/12:30	SRL Earth observations.
3/12:55	VFT tests.
3/13:00	SRL Earth observations.

T + (PLUS) DAY/ HR:MIN:SEC	EVENT
3/13:25	DTO 656.
3/13:35	DSO 488 stow.
3/13:45	SRL orbiter maneuver.
3/13:55	DSO 624.
3/13:55	SRL Earth observations.
3/14:00	Red team begins sleep period.
3/14:10	SRL Earth observations.
3/14:25	SRL Earth observations.
3/14:50	STL-B TV downlink.
3/14:55	DSO 624.
3/15:10	SRL orbiter maneuver.
3/15:30	SRL Earth observations.
3/15:45	SRL Earth observations.
3/16:40	SRL orbiter maneuver.
3/16:55	SRL Earth observations.
3/17:15	SRL Earth observations.
3/17:45	SRL orbiter maneuver.
3/18:25	SRL Earth observations—Oberpfaffenhofen, Germany supersite.

T + (PLUS) DAY/ HR:MIN:SEC	EVENT
3/18:30	SRL Earth observations.
3/18:35	SRL Earth observations.
3/18:40	SRL Earth observations.
3/18:50	MS2 off duty/exercise.
3/19:05	SRL Earth observations.
3/19:15	SAREX robot operations.
3/19:40	SRL orbiter maneuver.
3/19:55	SRL Earth observations.
3/19:55	SAREX voice contact—Paltamo, Finland backup.
3/20:00	SRL Earth observations.
3/20:15	SRL Earth observations.
3/21:10	SRL orbiter maneuver.
3/21:25	SRL Earth observations.
3/21:45	SRL Earth observations.
3/22:00	Red team begins postsleep activities.
3/22:05	DSO 483.
3/22:45	SRL Earth observations.
3/22:50	SRL Earth observations.

T + (PLUS) DAY/ HR:MIN:SEC	EVENT
3/23:05	SRL Earth observations.
3/23:10	SRL orbiter maneuver.
3/23:15	SRL Earth observations.
3/23:35	DTO 664.
3/23:55	POCC payload update.
	MET DAY FOUR
4/00:00	SRL Earth observations.
4/00:00	DTO 664.
4/00:05	SRL orbiter maneuver.
4/00:10	Blue team handover to red team.
4/00:25	SRL Earth observations—Chickasha, Okla. supersite.
4/00:35	SRL Earth observations—Montespertoli, Italy supersite.
4/00:40	SRL Earth observations.
4/01:00	Blue team begins presleep activities.
4/01:10	DTO 656.
4/01:15	VFT tests.
4/01:35	SRL orbiter maneuver.

T + (PLUS) DAY/ HR:MIN:SEC	EVENT
4/01:45	DTO 656.
4/01:45	SRL Earth observations.
4/02:10	SRL Earth observations.
4/02:25	SRL Earth observations.
4/02:34	Multi-axis RCS burn.
4/02:40	SRL orbiter maneuver.
4/02:55	DSO 624.
4/03:00	Blue team begins sleep period.
4/03:00	SRL orbiter maneuver.
4/03:10	SRL Earth observations.
4/03:20	SRL Earth observations.
4/03:25	SRL Earth observations.
4/03:30	SRL Earth observations.
4/03:30	DSO 608.
4/03:40	SRL Earth observations.
4/03:45	SRL Earth observations.
4/04:00	SRL Earth observations.
4/04:30	SRL orbiter maneuver.
4/04:55	SRL Earth observations.

T + (PLUS) DAY/ HR:MIN:SEC	EVENT
4/05:10	SRL Earth observations.
4/06:00	MS3 off duty/exercise.
4/06:25	SRL Earth observations.
4/06:30	SRL Earth observations—Gulf Stream supersite.
4/06:55	SRL Earth observations—Bebedouro, Brazil supersite.
4/07:30	SRL orbiter maneuver.
4/07:55	SRL Earth observations.
4/08:00	SAREX voice contact—personal contact.
4/08:00	SRL Earth observations.
4/08:05	SRL Earth observations—Chickasha, Okla. supersite.
4/08:10	SRL Earth observations.
4/08:15	SRL Earth observations.
4/09:00	SRL orbiter maneuver.
4/09:15	SRL Earth observations.
4/09:35	SRL Earth observations.
4/09:45	SRL Earth observations—Galapagos Islands supersite.
4/10:05	PAO opportunity.

T + (PLUS) DAY/ HR:MIN:SEC	EVENT
4/11:00	DSO 483.
4/11:00	DSO 326 window impact observations.
4/11:05	Blue team begins postsleep activities.
4/12:05	SRL Earth observations.
4/12:10	SRL Earth observations.
4/12:20	SRL Earth observations.
4/12:45	Red team handover to blue team.
4/13:00	Red team begins presleep activities.
4/13:00	DTO 656.
4/13:05	VFT tests.
4/13:25	SRL orbiter maneuver.
4/13:30	DTO 656.
4/13:30	MS1 off duty/exercise.
4/13:35	SRL Earth observations.
4/14:10	SRL Earth observations.
4/14:15	PAO opportunity.
4/14:55	SRL orbiter maneuver.
4/15:00	Red team begins sleep period.
4/15:10	SRL Earth observations.

T + (PLUS) DAY/ HR:MIN:SEC	EVENT
4/15:25	SRL Earth observations.
4/16:25	SRL orbiter maneuver.
4/16:30	SRL Earth observations.
4/16:35	DSO 624.
4/16:45	SRL Earth observations.
4/16:55	SRL Earth observations.
4/17:50	SRL orbiter maneuver.
4/18:05	SRL Earth observations—Otztal, Austrian Alps supersite.
4/18:10	SRL Earth observations.
4/18:15	SRL Earth observations.
4/18:20	SRL Earth observations.
4/18:30	SRL Earth observations.
4/18:45	SRL Earth observations.
4/19:20	SRL orbiter maneuver.
4/19:35	SRL Earth observations.
4/19:40	SRL Earth observations.
4/19:45	SRL Earth observations.

T + (PLUS) DAY/ HR:MIN:SEC	EVENT
4/19:50	SRL Earth observations.
4/19:55	SRL Earth observations.
4/20:20	SRL Earth observations.
4/20:45	SRL orbiter maneuver.
4/21:00	SAREX robot operations.
4/21:05	SRL Earth observations.
4/21:10	SRL Earth observations.
4/21:25	SRL Earth observations.
4/22:00	DSO 624.
4/22:15	SRL orbiter maneuver.
4/22:25	SRL Earth observations.
4/22:30	SRL Earth observations—Gulf Stream supersite.
4/22:35	SRL Earth observations.
4/22:45	SRL Earth observations—Flevoland, Netherlands supersite.
4/23:00	Red team begins postsleep activities.
4/23:00	DSO 483.
4/23:45	SRL orbiter maneuver.
4/23:55	SRL Earth observations—Chickasha, Okla. supersite.

T + (PLUS) DAY/ HR:MIN:SEC	EVENT
	MET DAY FIVE
5/00:00	SRL Earth observations—Raco, Michigan supersite.
5/00:15	SRL Earth observations.
5/00:25	SRL Earth observations—Safsaf, Egypt/Sudan supersite.
5/01:00	Blue team handover to red team.
5/01:15	POCC payload update.
5/01:15	SRL orbiter maneuver.
5/01:25	DTO 656.
5/01:30	VFT tests.
5/01:40	SRL Earth observations.
5/01:45	SRL Earth observations.
5/01:45	DSO 326 window impact observations.
5/01:55	SRL Earth observations.
5/01:55	DTO 656.
5/02:00	Blue team begins presleep activities.
5/02:05	SRL Earth observations.
5/02:41	Multi-axis RCS burn.

T + (PLUS) DAY/ HR:MIN:SEC	EVENT
5/02:45	SRL orbiter maneuver.
5/03:05	SRL Earth observations.
5/03:10	SRL Earth observations.
5/03:20	SRL Earth observations.
5/03:25	SRL Earth observations.
5/03:40	SRL Earth observations.
5/04:00	Blue team begins sleep period.
5/04:05	DSO 611.
5/04:10	SRL orbiter maneuver.
5/04:30	SRL Earth observations.
5/04:45	SRL Earth observations.
5/06:00	SRL Earth observations.
5/06:10	SRL Earth observations—Raco, Michigan supersite.
5/06:15	SRL Earth observations—Gulf Stream supersite.
5/06:30	SRL Earth observations—Bebedouro, Brazil supersite.
5/07:30	Pilot off duty/exercise.
5/07:30	SRL Earth observations.
5/07:45	SRL Earth observations—Chickasha, Okla. supersite.

T + (PLUS) DAY/ HR:MIN:SEC	EVENT
5/07:55	SRL Earth observations.
5/08:55	SRL Earth observations.
5/09:05	SRL Earth observations.
5/09:15	SRL Earth observations—Stovepipe Wells Fan, Calif. supersite.
5/09:25	SRL Earth observations—Galapagos Islands supersite.
5/09:35	SRL Earth observations.
5/10:05	SRL orbiter maneuver.
5/10:15	DSO 624.
5/10:30	SRL Earth observations.
5/10:50	SRL Earth observations.
5/12:00	DSO 483.
5/12:05	Blue team begins postsleep activities.
5/13:05	SRL orbiter maneuver.
5/13:15	DTO 664.
5/13:15	SRL Earth observations.
5/13:45	Red team handover to blue team.
5/14:00	Red team begins presleep activities.

T + (PLUS) DAY/ HR:MIN:SEC	EVENT
5/14:00	DTO 656.
5/14:05	VFT tests.
5/14:30	DTO 656.
5/14:35	SRL orbiter maneuver.
5/14:50	SRL Earth observations.
5/15:00	SRL Earth observations.
5/15:05	SRL Earth observations.
5/16:00	Red team begins sleep period.
5/16:00	DSO 624.
5/16:00	SRL orbiter maneuver.
5/16:15	SRL Earth observations.
5/16:45	SRL Earth observations—Western Pacific supersite.
5/17:30	SRL orbiter maneuver.
5/17:40	DSO 624.
5/17:45	SRL Earth observations—Oberpfaffenhofen, Germany supersite.
5/17:55	SRL Earth observations.
5/18:00	SRL Earth observations.
5/18:10	SRL Earth observations.

T + (PLUS) DAY/ HR:MIN:SEC	EVENT
5/18:40	DSO 624.
5/19:00	SRL orbiter maneuver.
5/19:15	SRL Earth observations.
5/19:20	SRL Earth observations.
5/19:25	SRL Earth observations.
5/19:30	SRL Earth observations.
5/19:35	SRL Earth observations.
5/19:45	SRL Earth observations—Western Pacific supersite.
5/20:30	SRL orbiter maneuver.
5/20:45	SRL Earth observations.
5/21:05	SRL Earth observations.
5/21:50	PAO opportunity.
5/21:55	SRL orbiter maneuver.
5/22:10	SRL Earth observations.
5/22:15	SRL Earth observations.
5/22:25	SRL Earth observations—Flevoland, Netherlands supersite.
5/22:30	SRL Earth observations.

T + (PLUS) DAY/ HR:MIN:SEC	EVENT
5/23:10	SAREX robot operations.
5/23:25	SRL orbiter maneuver.
5/23:40	SRL Earth observations—Chickasha, Okla. and Raco, Michigan supersites.
5/23:55	SRL Earth observations.
	MET DAY SIX
6/00:00	Red team begins postsleep activities.
6/00:00	DSO 483.
6/00:05	SRL Earth observations—Safsaf, Egypt/Sudan supersite.
6/00:55	SRL orbiter maneuver.
6/01:05	SRL Earth observations.
6/01:25	SRL Earth observations.
6/01:30	SRL Earth observations.
6/01:45	Blue team handover to red team.
6/02:00	DTO 656.
6/02:05	VFT tests.
6/02:10	POCC payload update.
6/02:25	SAREX voice contact—personal contact.
6/02:25	SRL orbiter maneuver.

T + (PLUS) DAY/ HR:MIN:SEC	EVENT
6/02:30	DTO 656.
6/02:40	SRL Earth observations.
6/02:45	SRL Earth observations.
6/02:50	SRL Earth observations.
6/03:00	Blue team begins presleep activities.
6/03:05	SRL Earth observations.
6/03:20	SRL Earth observations.
6/03:21	Multi-axis RCS burn.
6/03:25	SRL orbiter maneuver.
6/03:45	DSO 608.
6/03:45	DTO 664.
6/04:10	SRL Earth observations.
6/04:20	SRL Earth observations.
6/04:25	SRL Earth observations.
6/05:00	Blue team begins sleep period.
6/05:15	SRL orbiter maneuver.
6/05:40	SRL Earth observations.
6/05:50	SRL Earth observations—Raco, Michigan supersite.

T + (PLUS) DAY/ HR:MIN:SEC	EVENT
6/05:55	SRL Earth observations.
6/06:05	SRL Earth observations—Bebedouro, Brazil supersite.
6/06:50	SRL orbiter maneuver.
6/07:05	Commander off duty/exercise.
6/07:15	SRL Earth observations.
6/07:25	SRL Earth observations—Chickasha, Okla. supersite.
6/07:30	SRL Earth observations.
6/07:40	SRL Earth observations.
6/08:35	SRL Earth observations.
6/08:40	SRL orbiter maneuver.
6/08:50	SRL Earth observations—Stovepipe Wells Fan, Calif. supersite.
6/09:05	SRL Earth observations—Galapagos Islands supersite.
6/09:15	SRL Earth observations.
6/09:30	PAO opportunity.
6/10:00	SRL Earth observations.
6/10:05	SRL orbiter maneuver.
6/10:25	DSO 326 window impact observations.

T + (PLUS) DAY/ HR:MIN:SEC	EVENT
6/10:30	SRL Earth observations.
6/11:15	SRL orbiter maneuver.
6/11:25	SRL Earth observations.
6/11:30	SRL Earth observations.
6/11:35	SRL Earth observations.
6/11:40	SRL Earth observations.
6/11:45	SAREX voice contact—personal contact.
6/12:00	SRL Earth observations.
6/12:50	SRL orbiter maneuver.
6/12:55	SRL Earth observations.
6/13:00	DSO 483.
6/13:05	Blue team begins postsleep activities.
6/13:10	SRL Earth observations.
6/13:45	Red team begins presleep activities.
6/14:10	SRL orbiter maneuver.
6/14:45	Red team handover to blue team.
6/15:00	DTO 656.
6/15:05	VFT tests.

T + (PLUS) DAY/ HR:MIN:SEC	EVENT
6/15:35	DTO 656.
6/15:40	SRL orbiter maneuver.
6/15:50	DSO 624.
6/16:00	Red team begins sleep period.
6/16:05	SRL Earth observations.
6/16:15	SRL Earth observations.
6/16:55	DSO 624.
6/17:10	SRL orbiter maneuver.
6/17:20	SAREX voice contact—personal contact.
6/17:30	SRL Earth observations—Oberpfaffenhofen, Germany supersite.
6/17:35	SRL Earth observations.
6/17:40	SRL Earth observations.
6/17:50	SRL Earth observations—Western Pacific supersite.
6/18:00	DSO 624.
6/18:10	SRL orbiter maneuver.
6/18:30	SAREX robot operations.
6/18:55	SRL Earth observations.
6/19:00	SRL Earth observations.

T + (PLUS) DAY/ HR:MIN:SEC	EVENT
6/19:05	SRL Earth observations.
6/19:10	SRL Earth observations.
6/19:15	SRL Earth observations.
6/19:20	SRL orbiter maneuver.
6/20:20	SRL Earth observations.
6/20:25	SRL Earth observations.
6/20:50	SRL orbiter maneuver.
6/21:15	SRL Earth observations.
6/21:50	SRL Earth observations—Duke Forest, N. Carolina supersite.
6/21:55	SRL Earth observations.
6/22:05	SRL Earth observations—Flevoland, Netherlands supersite.
6/22:10	SRL Earth observations.
6/22:20	SRL orbiter maneuver.
6/23:20	SRL Earth observations—Raco, Michigan supersite.
6/23:35	SRL Earth observations.
6/23:40	SRL Earth observations—Montespertoli, Italy supersite.
6/23:45	SRL Earth observations—Safsaf, Egypt/Sudan supersite.
6/23:55	SRL Earth observations.

MET DAY SEVEN

T + (PLUS) DAY/ HR:MIN:SEC	EVENT
7/00:00	Red team begins postsleep activities.
7/00:05	DSO 483.
7/00:35	SRL orbiter maneuver.
7/00:50	SRL Earth observations.
7/01:00	SRL Earth observations.
7/01:10	SRL Earth observations.
7/01:25	SRL Earth observations.
7/01:40	DTO 656.
7/01:45	VFT tests.
7/01:55	POCC payload update.
7/02:00	SRL orbiter maneuver.
7/02:10	DTO 656.
7/02:15	Blue team handover to red team.
7/02:30	SRL Earth observations.
7/02:45	SRL Earth observations.

T + (PLUS) DAY/ HR:MIN:SEC	EVENT
7/03:00	SRL Earth observations.
7/03:11	Multi-axis RCS burn.
7/03:15	SRL orbiter maneuver.
7/03:20	SRL orbiter maneuver.
7/03:55	SRL Earth observations.
7/04:00	Blue team begins presleep activities.
7/04:00	SRL Earth observations.
7/04:05	SRL Earth observations.
7/04:05	DSO 326 window impact observations.
7/04:20	SRL orbiter maneuver.
7/04:30	SRL Earth observations—Southern Ocean supersite.
7/04:40	DTO 664.
7/05:20	SRL Earth observations.
7/05:25	SRL Earth observations—Raco, Michigan supersite.
7/05:35	SRL Earth observations—Gulf Stream supersite.
7/05:40	SRL Earth observations.
7/05:45	SRL orbiter maneuver.
7/06:00	Blue team begins sleep period.
7/06:20	DSO 611.
7/06:40	SRL Earth observations.
7/07:00	SRL Earth observations.
7/07:05	SRL Earth observations—Chickasha, Okla. supersite.
7/07:10	SRL Earth observations.
7/07:15	SRL Earth observations.
7/08:15	SRL Earth observations.
7/08:25	SRL Earth observations.
7/08:35	SRL Earth observations—Stovepipe Wells Fan, Calif. supersite.
7/08:45	SRL Earth observations—Galapagos Islands supersite.
7/08:55	SRL Earth observations.
7/09:05	PAO opportunity.
7/09:25	SRL orbiter maneuver.
7/09:50	SRL Earth observations.
7/10:10	SRL Earth observations.
7/10:15	DSO 608.

T + (PLUS) DAY/ HR:MIN:SEC	EVENT
7/10:55	SRL orbiter maneuver.
7/11:10	DTO 653.
7/11:10	SRL Earth observations.
7/11:35	SRL Earth observations.
7/11:40	SRL Earth observations.
7/12:20	SRL orbiter maneuver.
7/13:05	SRL Earth observations.
7/13:50	SRL orbiter maneuver.
7/14:00	Red team begins presleep activities.
7/14:00	DSO 483.
7/14:05	Blue team begins postsleep activities.
7/15:05	Red team handover to blue team.
7/15:20	SRL orbiter maneuver.
7/16:00	Red team begins sleep period.
7/16:00	DSO 488 deployment.
7/16:10	DTO 656.
7/16:15	VFT tests.
7/16:40	DTO 656.
7/16:50	SRL orbiter maneuver.
7/17:00	SAREX voice contact—personal contact backup.
7/17:00	SRL Earth observations.
7/17:05	SRL Earth observations—Oberpfaffenhofen, Germany supersite.
7/17:15	DSO 624.
7/17:30	SRL Earth observations—Western Pacific supersite.
7/18:05	SAREX robot operations.
7/18:20	SRL orbiter maneuver.
7/18:30	DSO 624.
7/18:35	SRL Earth observations—Southern Ocean supersite.
7/18:40	SRL Earth observations.
7/18:45	SRL Earth observations.
7/18:50	SRL Earth observations.
7/18:55	SRL Earth observations.
7/19:00	SRL Earth observations.
7/19:05	DSO 624.
7/19:45	SRL orbiter maneuver.

T + (PLUS) DAY/ HR:MIN:SEC	EVENT
7/20:00	SRL Earth observations.
7/20:05	SRL Earth observations.
7/20:15	SRL Earth observations.
7/21:20	SRL orbiter maneuver.
7/21:30	SRL Earth observations—Duke Forest, N. Carolina supersite.
7/21:45	SRL Earth observations—Flevoland, Netherlands supersite.
7/21:55	SRL Earth observations.
7/22:45	SRL orbiter maneuver.
7/23:10	SRL Earth observations.
7/23:15	SRL Earth observations—Montespertoli, Italy supersite.
7/23:25	SRL Earth observations—Safsaf, Egypt/Sudan supersite.
7/23:35	SRL Earth observations.

MET DAY EIGHT

T + (PLUS) DAY/ HR:MIN:SEC	EVENT
8/00:00	DSO 483.
8/00:00	Red team begins postsleep activities.
8/00:25	SRL Earth observations.
8/00:30	SRL Earth observations.
8/00:40	SRL Earth observations—Southern Ocean supersite.
8/00:50	SRL Earth observations.
8/01:35	DSO 488 stow.
8/01:45	Crew press conference.
8/02:15	Blue team handover to red team.
8/02:30	POCC payload update.
8/02:30	FCS checkout.
8/03:30	SRL Earth observations.
8/03:35	DSO 488 deployment.
8/03:40	SRL Earth observations.
8/03:45	SRL Earth observations.
8/03:50	RCS hot fire.
8/04:40	SRL orbiter maneuver.
8/04:45	Deorbit preparation briefing.
8/05:05	SRL Earth observations—Raco, Michigan supersite.
8/05:15	SRL Earth observations—Gulf Stream supersite.
8/05:15	DTO 663 questionnaire.

T + (PLUS) DAY/ HR:MIN:SEC	EVENT
8/05:15	Blue team begins presleep activities.
8/05:20	SRL Earth observations.
8/06:06	Multi-axis RCS burn.
8/06:10	SRL orbiter maneuver.
8/06:35	DTO 656.
8/06:40	VFT tests.
8/06:40	SRL Earth observations—Chickasha, Okla. supersite.
8/06:50	SRL Earth observations.
8/06:55	SRL orbiter maneuver.
8/07:00	DTO 656.
8/07:15	Blue team begins sleep period.
8/08:20	DTO 664.
8/08:20	SRL Earth observations—Galapagos Islands supersite.
8/08:50	Begin cabin stow.
8/08:50	STL-A entry preparation.
8/09:00	STL-B entry preparation.
8/09:05	SRL orbiter maneuver.

T + (PLUS) DAY/ HR:MIN:SEC	EVENT
8/09:15	DSO 624.
8/09:25	SRL Earth observations.
8/09:30	Group D GAS experiments.
8/09:50	DSO 326 window impact observations.
8/09:50	SRL Earth observations.
8/10:05	SRL Earth observations—Puerto Aisen, Chile supersite.
8/10:35	SRL orbiter maneuver.
8/10:35	Group E GAS experiments.
8/11:00	SRL Earth observations.
8/11:00	DSO 608.
8/11:20	SRL Earth observations.
8/12:00	DSO 608.
8/12:55	DSO 488 stow.
8/13:00	Radiator stow.
8/13:15	SIR-C/X-SAR deactivation, steps 1-5.
8/13:25	SRL orbiter maneuver.
8/13:35	Ku-band antenna stow.
8/13:50	Red team begins presleep activities.

T + (PLUS) DAY/ HR:MIN:SEC	EVENT
8/15:00	SRL orbiter maneuver.
8/15:15	Blue team begins postsleep activities.
8/15:30	Red team handover to blue team.
8/16:00	Red team begins sleep period.
8/16:25	SRL orbiter maneuver.
8/17:15	DTO 656.
8/17:20	VFT tests.
8/17:45	SAREX stow.
8/18:55	SIR-C/X-SAR deactivation, steps 6-11.
8/19:10	MAPS deactivation.
8/19:15	MPESS pallet deactivation.
8/19:35	Priority Group B powerup.
8/19:45	Final cabin stow.
8/22:30	DSO 483.
8/22:30	Red team begins postsleep activities.
8/22:30	Ergometer stow.
8/22:45	Rower stow.

T + (PLUS) DAY/ HR:MIN:SEC	EVENT
	MET DAY NINE
9/00:12	Crew begins deorbit preparation.
9/00:12	CRT timer setup.
9/00:15	Commander initiates coldsoak.
9/00:24	Stow radiators, if required.
9/00:42	Commander configures DPS for deorbit preparation.
9/00:45	Mission Control Center updates IMU star pad, if required.
9/00:54	MS configures for payload bay door closure.
9/01:05	MCC-H gives "go/no-go" command for payload bay door closure.
9/01:15	Maneuver vehicle to IMU alignment attitude.
9/01:30	IMU alignment/payload bay door operations.
9/01:47	MCC gives the crew the go for OPS 3.
9/01:54	Pilot starts repressurization of SSME systems.
9/01:58	Commander and pilot perform DPS entry configuration.
9/02:07	MS deactivates ST and closes ST doors.
9/02:09	All crew members verify entry payload switch list.

T + (PLUS) DAY/ HR:MIN:SEC	EVENT
9/02:24	All crew members perform entry review.
9/02:26	Crew begins fluid loading, 32 fluid ounces of water with salt over next 1.5 hours (2 salt tablets per 8 ounces).
9/02:41	Commander and pilot configure clothing.
9/02:56	MS/PS configure clothing.
9/03:07	Commander and pilot seat ingress.
9/03:09	Commander and pilot set up heads-up display (HUD).
9/03:11	Commander and pilot adjust seat, exercise brake pedals.
9/03:19	Final entry deorbit update/uplink.
9/03:25	OMS thrust vector control gimbal check is performed.
9/03:26	APU prestart.
9/03:41	Close vent doors.
9/03:45	MCC-H gives "go" for deorbit burn period.
9/03:51	Maneuver vehicle to deorbit burn attitude.
9/03:54	MS/PS ingress seats.
9/04:01	First APU is activated.
9/04:07	Deorbit burn.

T + (PLUS) DAY/ HR:MIN:SEC	EVENT
9/04:10	Initiate post-deorbit-burn-period attitude.
9/04:14	Terminate post-deorbit-burn attitude.
9/04:22	Dump forward RCS, if required.
9/04:30	Activate remaining APUs.
9/04:35	Entry interface, 400,000 feet altitude.
9/04:40	Automatically deactivate RCS roll thrusters.
9/04:47	Automatically deactivate RCS pitch thrusters.
9/04:52	Initiate first roll reversal.
9/04:56	Initiate second roll reversal.
9/04:56	TACAN acquisition.
9/04:58	Initiate air data system (ADS) probe deploy.
9/04:59	Initiate third roll reversal.
9/05:00	Begin entry/terminal area energy management (TAEM).
9/05:00	Initiate payload bay venting.
9/05:02	Automatically deactivate RCS yaw thrusters.
9/05:05	TAEM/approach and landing interface.
9/05:06	Initiate landing gear deployment.
9/05:07	Vehicle has weight on main landing gear.

T + (PLUS) DAY/ HR:MIN:SEC	EVENT	T + (PLUS) DAY/ HR:MIN:SEC	EVENT
9/05:07	Vehicle has weight on nose landing gear.		
9/05:07	Initiate main landing gear braking.		
9/05:08	Wheel stop.		

GLOSSARY

A/G	air-to-ground
AA	accelerometer assembly
ACS	active cooling system
ADACS	attitude determination and control system
ADS	air data system
AFB	Air Force base
AFD	aft flight deck
AG	airglow
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
ASI	Italian Space Agency
BFS	backup flight control system
BHPS	boiling heater power supply
CCD	charge-coupled device
CCTV	closed-circuit television
CDMS	command and data management subsystem
COAS	crewman optical alignment sight
CONCAP	Consortium for Materials Development in Space Complex Autonomous Payload
CP	condenser profile
CR/IM	commercial refrigerator/incubator module
CRT	cathode ray tube
C/W	caution/warning
DACA	data acquisition and control assembly
DA	detector assembly
DACS	data acquisition and control system
DAP	digital autopilot
DARA	German Space Agency
DC	detector controller
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
EPS	electrical power subsystem
ESA	European Space Agency
ESS	equipment support section
ET	external tank
ETR	Eastern Test Range
EV	extravehicular
EVA	extravehicular activity
FC	fuel cell
FCP	fuel cell power plant
FCS	flight control system
FDF	flight data file
FES	flash evaporator system
FF	flight forward
FPA	fluid processing apparatus

FPS	feet per second
FRCS	forward reaction control system
FSTV	fast-scan TV
FTS	force torque sensor
GAS	getaway special experiment
GBA	getaway special bridge assembly
GLS	ground launch sequencer
GN&C	guidance, navigation, and control
GPC	general-purpose computer
GPS	global positioning system
GSE	ground support equipment
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
IUS	inertial upper stage
IV	intravehicular
JPL	Jet Propulsion Laboratory
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
MAPS	measurement of air pollution from satellite (SRL)
MCC-H	Mission Control Center—Houston
MCP	microchannel plate
MDM	multiplexer/demultiplexer
MECO	main engine cutoff
MEE	magnetic end effector
MET	mission elapsed time
MILA	Merritt Island
MLP	mobile launcher platform
MM	major mode
MOD	Mission Operations Directorate
MPESS	multi-purpose experiment support structure
MPM	manipulator positioning mechanism
MPS	main propulsion system
MS	mission specialist
MSFC	Marshall Space Flight Center
MRSE	microwave remote sensing experiment
NASA	National Aeronautics and Space Administration
NCC	corrective combination maneuver
NH	differential height adjustment that adjusts the altitude of orbiter's orbit
NIH	National Institutes of Health
NLO	non-linear optical
nm	nanometer
NMI	nautical miles
NOR	Northrup Strip
NSR	coelliptic maneuver that circularizes orbiter's orbit
O&C	operations and checkout
OAA	orbiter access arm
OAST	Office of Aeronautics and Space Technology
OCP	Office of Commercial Programs
OG	orbiter glow
OMS	orbital maneuvering system

OPF	orbiter processing facility
OTC	orbiter test conductor
PAO	public affairs officer
PASS	primary avionics software system
PC	proportional counter
PCIS	passive cycle isolation system
PCMMU	pulse code modulation master unit
PCS	pressure control system
PCU	power control unit
PDI	payload data interleaver
PDU	playback/downlink unit
PGSC	payload and general support computer
PI	payload interrogator
PIC	pyro initiator controller
PLBD	payload bay door
PMCU	payload measurement and control unit
POCC	Payload Operations Control Center
PRCS	primary reaction control system
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
RAM	random access memory
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
RSS	range safety system

RTLS	return to launch site
S&A	safe and arm
SA	solar array
SAF	Secretary of the Air Force
SAREX	shuttle amateur radio experiment
SDA	sealed door assembly
SHF	superhigh frequency
SIR-C	spaceborne imaging radar-C (SRL)
SM	statute miles
SPASP	small payload accommodations switch panel
SRB	solid rocket booster
SRL	space radar laboratory
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
SSTV	slow scan TV
ST	star tracker
STA	structural test article
STL	space tissue loss
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
TEPC	tissue equivalent proportional counter
TFL	telemetry format load
TI	thermal phase initiation burn
TIG	time of ignition
TIPS	thermal impulse printer system

TPS	thermal protection system
TRAC	targeting and reflective alignment concept
TSM	tail service mast
TT&C	telemetry, tracking, and communications
TUFI	toughened unipiece fibrous insulation
TV	television
TVC	thrust vector control
UHF	ultrahigh frequency
VBAR	along the velocity vector
VFT	visual function tester
VRCS	vernier reaction control system
VTR	videotape recorder
WCCS	wireless crew communication system
WCS	waste collection system
X-SAR	X-band synthetic aperture radar