NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

SPACE SHUTTLE MISSION
STS-46

PRESS KIT
JULY 1992

TETHERED SATELLITE SYSTEM (TSS-1)

STS-46 INSIGNIA

STS046-S-001 -- Designed by the crewmembers assigned to the flight, the STS-46 crew insignia depicts the space shuttle Atlantis in orbit around Earth, accompanied by major payloads: the European Retrievable Carrier (EURECA) and the Tethered Satellite System (TSS-1). In the depiction, EURECA has been activated and released, its antennae and solar arrays deployed, and it is about to start its ten-month scientific mission. The Tethered Satellite is linked to the orbiter by a 20-km tether. The purple beam emanating from an electron generator in the payload by spirals around Earth's magnetic field. The TSS mission studied the dynamics and electrodynamics of tethered systems in space and the physics of Earth's ionosphere. Visible on Earth's surface are the United States of America and the thirteen member countries of the European Space Agency (ESA), in particular, Italy -- partner with the U.S. in the TSS program. The American and Italian flags, as well as the ESA logo, further serve to illustrate the international character of STS-46.

The NASA insignia design for space shuttle flights is reserved for use by the astronauts and for other official use as the NASA Administrator may authorize. Public availability has been approved only in the form of illustrations by the various news media. When and if there is any change in this policy, which we do not anticipate, it will be publicly announced.

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CONTENTS

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49th SHUTTLE FLIGHT TO DEPLOY TETHERED SATELLITE SYSTEM

Highlighting Shuttle mission STS-46 will be experiments involving a 12.5-mile-long tether connecting a satellite to the orbiter Atlantis, to demonstrate the feasibility of the technology for a variety of uses ranging from generating electrical power to researching the upper atmosphere.

During the mission the crew will also deploy the European Retrievable carrier (EURECA-1) platform, which contains a series of experiments dealing with materials sciences, life sciences and radiobiology. The platform will remain in orbit for about 9 months before being retrieved during a later Shuttle mission.

"First and foremost, this is a mission of discovery," Thomas Stuart, Tethered Satellite System Program Manager said.

"It's the first time we've ever deployed a satellite on a long tether in space. This system is at the leading edge of scientific discovery and will give us a glimpse of space technologies of the future," he said.

STS-46 is scheduled for launch in late July. It will be the 12th flight for Atlantis, and is scheduled to last 6 days, 22 hours and 11 minutes, with a planned landing at Kennedy Space Center, Fla.

TETHERED SATELLITE SYSTEM

The Tethered Satellite System-1 (TSS-1) -- a joint project of the United States and Italy under an agreement signed in 1984 -- consists of a satellite, a 1/10th inch diameter tether and a deployer in the Shuttle's cargo bay.

The 1,139 pound satellite was developed by the Italian Space Agency (ASI) and the tether and deployer system were developed by the U.S. The 12 main experiments were selected jointly by NASA and ASI.

"During this mission we're going to learn a great deal about how to safely operate a tether system," Stuart said. "We're going to demonstrate the feasibility of using a tether to generate electricity, as a propulsion system to power spacecraft and for studying the earth's magnetic field and ionosphere."

When the tether is fully extended to its 12.5 mile length, the combination of the orbiter, tether and satellite combined will be the longest structure ever flown in space.

EURECA

The crew will deploy the European Space Agency's (ESA) EURECA-1 which will then ascend to its operational orbit of 515 km using its own propulsion system. After 9 months it will be moved to a lower orbit for retrieval by another Shuttle in late April 1993. After its return to Earth it will be refurbished and equipped for its next mission.

Aboard EURECA-1 are 15 experiments devoted to researching the fields of material science, life sciences and radiobiology, all of which require a controlled microgravity environment. The experiments include:

- Protein crystallization
- Biological effects of space radiation
- Measurements of fluids' critical points in microgravity
- Measurements of solar irradiation
- Solar/terrestrial relationship in aeronomy and climatology
- electric propulsion in space.

Scientists participating in the investigations are from Belgium, Germany, Denmark, France, Italy, United Kingdom and The Netherlands.

EURECA-1 was built by the ESA and designed to be maintained during its long-term mission by ground controllers at ESA's Space Operations Centre (ESOC), Darmstadt, Germany.

ADDITIONAL PAYLOADS

Additional payloads carried in Atlantis' cargo bay include the:

Evaluation of Oxygen Interaction with Materials III (EOIM) experiment to study how oxygen molecules in low-earth orbit affect materials that will be used to construct Space Station Freedom;

Thermal Energy Management (TEMP 2A) experiment to test a new cooling method that may be used in future spacecraft;

Consortium for Material Development in Space Complex Autonomous Payload experiment to study materials processing;

Limited Duration Space Environment Candidate materials Exposure experiments will explore materials processing methods in weightlessness;

An IMAX camera will be in the payload bay to film various aspects of the mission for later IMAX productions.

Atlantis will be commanded by USAF Col. Loren Shriver, making his third Shuttle flight. Marine Corps Major Andy Allen will serve as Pilot, making his first flight. Mission specialists will include Claude Nicollier, a European Space Agency astronaut making his first Shuttle flight; Marsha Ivins, making her second Shuttle flight; Jeff Hoffman, making his third space flight; and Franklin Chang-Diaz, making his third space flight. Franco Malerba from the Italian Space Agency will be a payload specialist aboard Atlantis.

(END OF GENERAL RELEASE; BACKGROUND INFORMATION FOLLOWS.)

MEDIA SERVICES INFORMATION

NASA Select Television Transmission

NASA Select television is available on Satcom F-2R, Transponder 13, located at 72 degrees west longitude; frequency 3960.0 MHz, audio 6.8 MHz.

The schedule for television transmissions from the orbiter and for the mission briefings will be available during the mission at Kennedy Space Center, Fla.; Marshall Space Flight Center, Huntsville; Ames-Dryden Flight Research Facility, Edwards, Calif.; Johnson Space Center, Houston, and NASA Headquarters, Washington, DC. The television schedule will be updated to reflect changes dictated by mission operations.

Television schedules also may be obtained by calling COMSTOR 713/483-5817. COMSTOR is a computer data base service requiring the use of a telephone modem. A voice update of the television schedule is updated daily at noon Eastern time.

Status Reports

Status reports on countdown and mission progress, on-orbit activities and landing operations will be produced by the appropriate NASA news center.

Briefings

A mission press briefing schedule will be issued prior to launch. During the mission, change-of-shift briefings by the off-going flight director and the science team will occur at least once per day. The updated NASA Select television schedule will indicate when mission briefings are planned.

STS-46 QUICK LOOK (revised)

Launch Date/Site:	July 31, 1992 - Kennedy Space Center, FL, Pad 39B
Launch Time:	9:56 a.m. - 12:26 p.m. EDT
Orbiter:	Atlantis (OV-104)
Altitude:	230 n.m. x 230 n.m. (EURECA deploy) 160 n.m. x 160 n.m. (TSS operations) 128 n.m. x 128 n.m. (EOIM operations)
Inclination:	28.5 degrees
Landing Date:	August 7, 1992
Landing Time:	8:05 a.m. EDT
Primary Landing Site:	Kennedy Space Center, FL.
Return to Launch Site:	Return to Launch Site - Kennedy Space Center, Fla. Transoceanic Abort Landing **--** Banjul, The Gambia Alternates: Ben Guerir, Morocco; Moron, Spain Abort Once Around: Edwards Air Force Base, Calif.
Crew:	Loren Shriver, Commander Andy Allen, Pilot Claude Nicollier, Mission Specialist 1 Marsha Ivins, Mission Specialist 2 Jeff Hoffman, Mission Specialist 3 Franklin Chang-Diaz, Mission Specialist 4 Franco Malerba, Payload Specialist 1
Operational shifts:	Red team -- Ivins, Hoffman, Chang-Diaz Blue team -- Nicollier, Allen, Malerba
Cargo Bay Payloads:	TSS-1 (Tethered Satellite System-1) EURECA-1L (European Retrievable Carrier-1L) EOIM-III/TEMP 2A (Evaluation of Oxygen Integration with Materials/Thermal Management Processes) CONCAP II (Consortium for Materials Development in Space Complex Autonomous Payload CONCAP III ICBC (IMAX Cargo Bay Camera) LDCE (Limited Duration Space Environment Candidate Materials Exposure)
Middeck Payloads:	AMOS (Air Force Maui Optical Site) PHCF (Pituitary Growth Hormone Cell Function) UVPI (Ultraviolet Plume Instrument)

STS-46 SUMMARY OF MAJOR ACTIVITIES

Blue Team Flight Day One: **Red Team Flight Day One:**

Launch
Orbit insertion (230 x 230 n.m.)
TSS activation
RMS checkout
TSS deployer checkout
EOIM/TEMP-2A activation

Blue Flight Day Two: EURECA deploy EURECA stationkeeping checkout	**Red Flight Day Two:** TEMP-2A operations Tether Optical Phenomenon (TOP)
Blue Flight Day Three: TOP checkout Supply water dump nozzle DTO TEMP-2A operations OMS-3 burn OMS-4 burn (160 x 160 n.m.)	**Red Flight Day Three:** TSS checkout/in-bay operations
Blue Flight Day Four: TSS in-bay operations	**Red Flight Day Four:** TSS deploy TEMP-2A operations
Blue Flight Day Five: TSS on station 1 (12.5 miles)	**Red Flight Day Five:** TSS retrieval to 1.5 miles TSS final retrieval TSS dock
Blue Flight Day Six: TSS safing TSS in-bay operations OMS-5 burn OMS-6 burn (128 x 128 n.m.)	**Red Flight Day Six:** EOIM/TEMP-2A operations
Blue Flight Day Seven: TSS science deactivation EOIM/TEMP-2A operations	**Red Flight Day Seven:** EOIM/TEMP-2A operations Flight Control Systems checkout Reaction Control System hot-fire

Blue Flight Day Eight: **Red Flight Day Eight:**

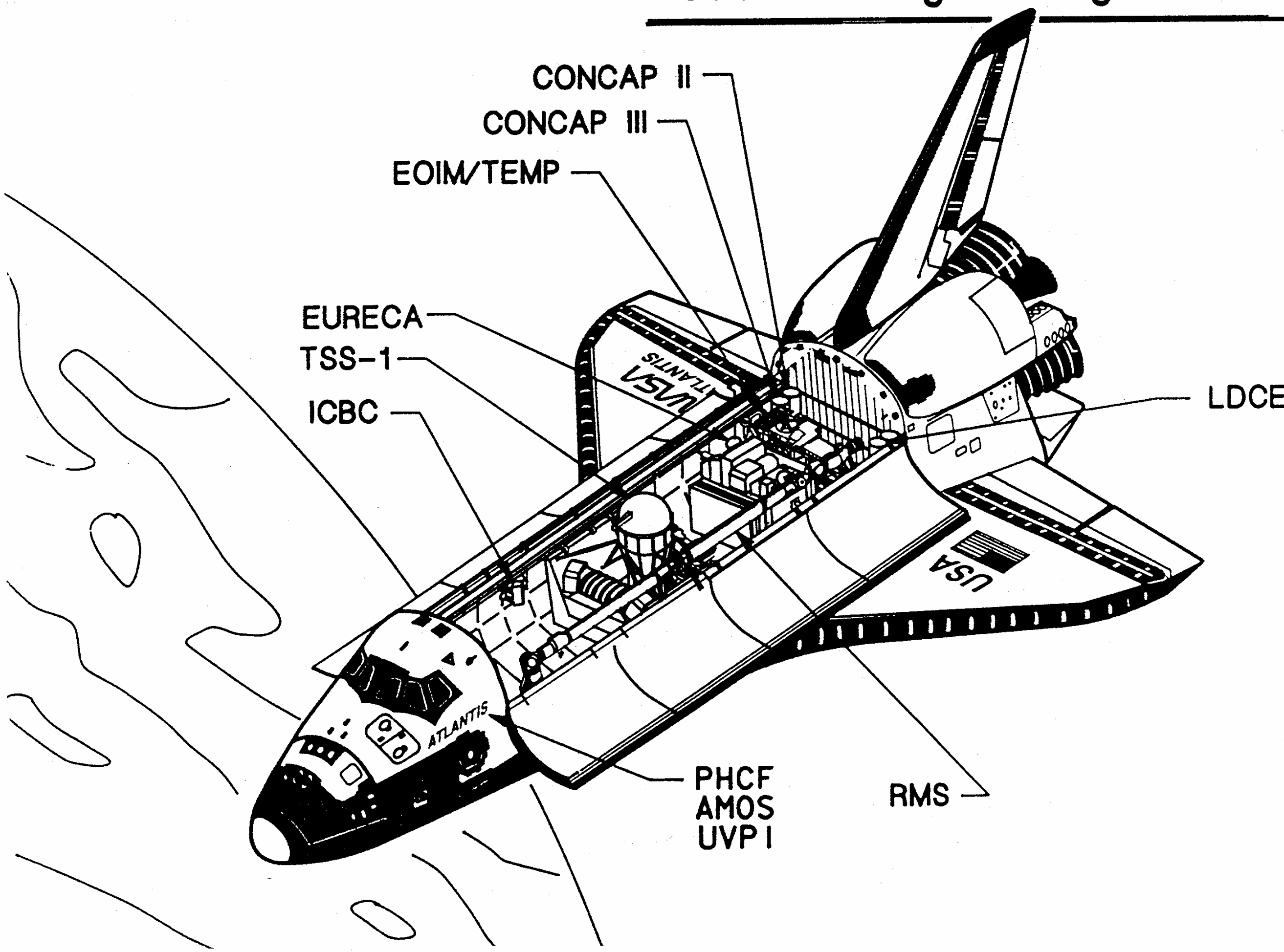
Cabin stow
Deorbit preparations
Entry and landing

VEHICLE AND PAYLOAD WEIGHTS

	Pounds
Orbiter (Atlantis) empty, and 3 SSMEs	151,377
Tethered Satellite -- pallet, support equipment	10,567
Tethered Satellite -- satellite, tether	1,476
European Retrievable Carrier	9,901
EURECA Support Equipment	414
Evaluation of Oxygen Interaction with Materials	2,485
CONCAP-II	590
CONCAP-III	368
LDCE	1,125
PHDF	69
Detailed Supplementary Objectives	56
Detailed Test Objectives	42
Total Vehicle at SRB Ignition	4,522,270
Orbiter Landing Weight	208,721

NASA

Space Shuttle Program
STS-46 Cargo Configuration



STS-46 TRAJECTORY SEQUENCE OF EVENTS

Event	MET (d/h:m:s	Relative Velocity (fps)	Mach	Altitude (ft)
Launch	00/00:00:00			
Begin Roll Maneuver	00/00:00:10	189	0.16	797
End Roll Maneuver	00/00:00:15	325	0.29	2,260
SSME Throttle Down to 80%	00/00:00:26	620	0.55	6,937
SSME Throttle Down to 67%	00/00:00:53	1,236	1.20	28,748
SSME Throttle Up to 104%	00/00:01:02	1,481	1.52	37,307
Maximum Dynamic Press.	00/00:01:04	1,548	1.61	41,635
SRB Separation	00/00:02:04	4,221	4.04	152,519
Main Engine Cutoff (MECO)	00/00:08:29	24,625	22.74	364,351
Zero Thrust	00/00:08:35	24,624	N/A	363,730
ET Separation	00/00:08:48			
OMS-2 Burn	00/00:41:24			
Landing	06/22:11:00			

Apogee, Perigee at MECO: 226 x 32 nautical miles
Apogee, Perigee post-OMS 2: 230 x 230 nautical miles

SPACE SHUTTLE ABORT MODES

Space Shuttle launch abort philosophy aims toward safe and intact recovery of the flight crew, orbiter and its payload. Abort modes include:

- Abort-To-Orbit (ATO) -- Partial loss of main engine thrust late enough to permit reaching a minimal 105-nautical mile orbit with orbital maneuvering system engines.

- Abort-Once-Around (AOA) -- Earlier main engine shutdown with the capability to allow one orbit around before landing at either Edwards Air Force Base, Calif., White Sands Space Harbor, NM, or the Shuttle Landing Facility (SLF) at the Kennedy Space Center, FL.

- Transatlantic Abort Landing (TAL) -- Loss of one or more main engines midway through powered flight would force a landing at either Banjul, The Gambia; Ben Guerir, Morocco; or Moron, Spain.

- Return-To-Launch-Site (RTLS) -- Early shutdown of one or more engines, without enough energy to reach Ben Guerir, would result in a pitch around and thrust back toward KSC until within gliding distance of the SLF.

STS-46 contingency landing sites are Edwards Air Force Base, the Kennedy Space Center, White Sands Space Harbor, Banjul, Ben Guerir and Moron.

STS-46 PRE-LAUNCH PROCESSING

KSC's processing team began readying the orbiter Atlantis for its 12th flight into space following its STS-45 flight which ended with a landing at KSC on April 2. Atlantis was in the Orbiter Processing Facility from April 2 to June 4, undergoing post-flight inspections and pre-flight testing and inspections. While in the OPF, technicians installed the three main engines. Engine 2024 is in the No. 1 position, engine 2012 is in the No. 2 position and engine 2028 is in the No. 3 position.

The remote manipulator system was installed on Apr. 28. Members of the STS-46 flight crew participated in the Crew Equipment Interface Test on May 16.

Atlantis was towed from the Orbiter Processing Facility (OPF) on June 4 to the Vehicle Assembly Building where it was mated to its external tank and solid rocket boosters on the same day. Rollout to Launch Pad 39-B occurred on June 11, 1992. On June 15-16, the Terminal Countdown Demonstration Test with the STS-46 flight crew was conducted.

The Tethered Satellite System (TSS) was processed for flight in the Operations and Checkout Building high bay and the EURECA payload was processed at the commercial Astrotech facility in Titusville, FL. The two primary payloads were installed in the payload canister at the Vertical Processing Facility before they were transferred to the launch pad.

Payload installation into Atlantis' payload bay was scheduled for late June. Several interface verification tests were scheduled between the orbiter and the payload elements. A standard 43-hour launch countdown is scheduled to begin 3 days prior to launch. During the countdown, the orbiter's fuel cell storage tanks will be loaded with fuel and oxidizer and all orbiter systems will be prepared for flight.

About 9 hours before launch, the external tank will be filled with its flight load of a half million gallons of liquid oxygen and liquid hydrogen propellants. About 2 and one-half hours before liftoff, the flight crew will begin taking their assigned seats in the crew cabin.

Atlantis's end-of-mission landing is planned at Kennedy Space Center. Several hours after landing, the vehicle will be towed to the Vehicle Assembly Building for a few weeks until an OPF bay becomes available. Atlantis will be taken out of flight status for several months for a planned modification period. Atlantis' systems will be inspected and improved to bring the orbiter up to par with the rest of the Shuttle fleet.

Atlantis's next flight, STS-57, is planned next year with the first flight of the Spacehab payload and the retrieval of the EURECA payload deployed on the STS-46 mission.

TETHERED SATELLITE SYSTEM (TSS-1)

An exciting new capability for probing the space environment and conducting experiments will be demonstrated for the first time when the NASA/Italian Space Agency Tethered Satellite System (TSS-1) is deployed during the STS-46 Space Shuttle flight. The reusable Tethered Satellite System is made up of a satellite attached to the Shuttle orbiter by a super strong cord which will be reeled into space from the Shuttle's cargo bay. When the satellite on its cord, or tether, is deployed to about 12 miles above the orbiter, TSS-1 will be the longest structure ever flown in space.

Operating the tethered system is a bit like trolling for fish in a lake or the ocean. But the potential "catch" is valuable data that may yield scientific insights from the vast sea of space. For the TSS-1 mission, the tether -- which looks like a 12-mile-long white bootlace -- will have electrically-conducting metal strands in its core. The conducting tether will generate electrical currents at a high voltage by the same basic principle as a standard electrical generator -- by converting mechanical energy (the Shuttle's more than 17,000-mile-an-hour orbital motion) into electrical energy by passing a conductor through a magnetic field (the Earth's magnetic field lines).

TSS-1 scientific instruments, mounted in the Shuttle cargo bay, the middeck and on the satellite, will allow scientists to examine the electrodynamics of the conducting tether system, as well as clarify their understanding of physical processes in the ionized plasma of the near-Earth space environment.

Once the investigations are concluded, it is planned to reel the satellite back into the cargo bay and stow it until after the Shuttle lands.

The TSS-1 mission will be the first step toward several potential future uses for tethers in space now being evaluated by scientists and engineers. One possible application is using long conducting tethers to generate electrical power for Space Station Freedom or other orbiting bodies. Conversely, by expending electrical power to reverse the current flow into a tether, the system can be placed in an "electric motor" mode to generate thrust for orbit maintenance. Tethers also may be used to raise or lower spacecraft orbits. This could be achieved by releasing a tethered body from a primary spacecraft, thereby transferring momentum (and imparting motion) to the spacecraft. Another potential application is the creation of artificial gravity by rotating two or more masses on a tether, much like a set of bolas.

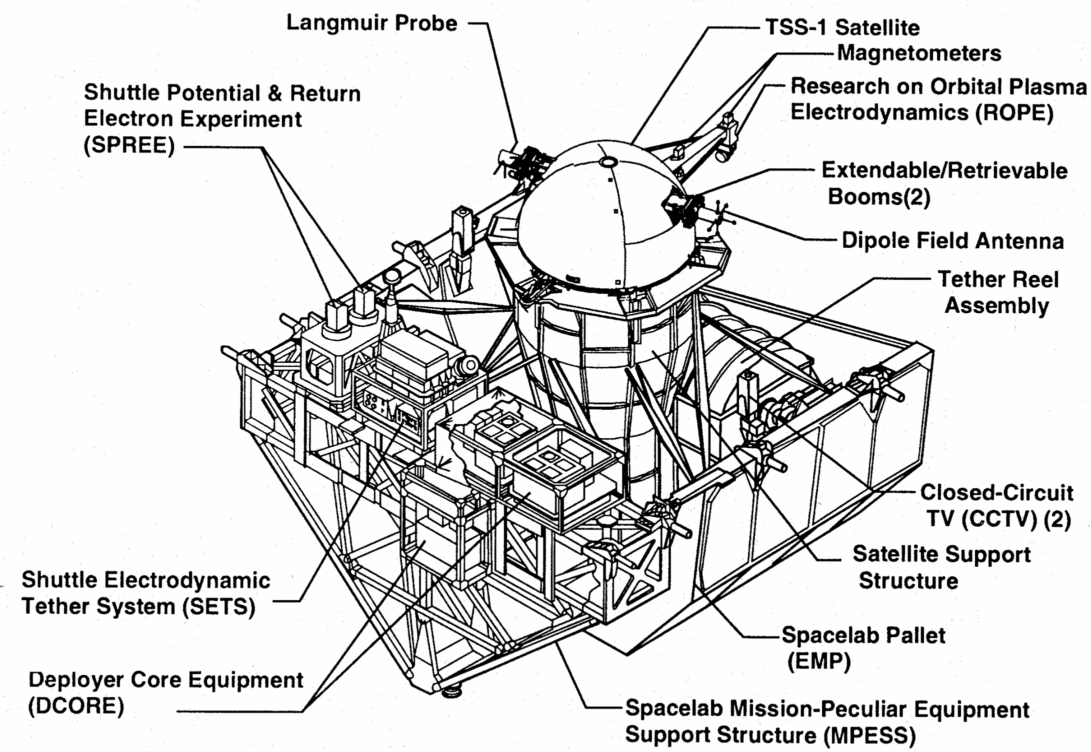
Downward deployment (toward Earth) could place a satellite in regions of the atmosphere that have been difficult to study because they lie above the range of high-altitude balloons and below the minimum altitude of free-flying satellites. Deploying a tethered satellite downward from the Shuttle also could make possible aerodynamic and wind tunnel type testing in the region 50 to 75 nautical miles above the Earth.

Mission Objectives

Space-based tethers have been studied theoretically since early in this century. More recently, the projected performance of such systems has been modeled extensively on computers. In 1984, the growing interest in tethered system experiments resulted in the signing of an agreement between NASA and the Italian Space Agency (Agenzia Spaziale Italiana - ASI) to jointly pursue the definition and development of a Tethered Satellite System to fly aboard the Space Shuttle. Scientific investigations (including hardware experiments) were selected in 1985 in response to a joint NASA/ASI announcement of opportunity.

The TSS-1 mission will be the first time such a large, electrodynamic tethered system has ever been flown. In many respects, the mission is like the first test flight of a new airplane: the lessons learned will improve both scientific theory and operations for future tether missions.

Shuttle Tethered Satellite System



The primary objectives of the first tethered satellite mission are to evaluate the capability to safely deploy, control and retrieve a tethered satellite, to validate predictions of the dynamic forces at work in a tethered satellite system and to conduct exploratory electrodynamic science investigations and demonstrate the capability of the system to serve as a facility for research in geophysical and space physics.

Since the dynamics of the Tethered Satellite System are complex and only can be tested fully in orbit, it is impossible to predict before the mission exactly how the system will perform in the space environment. Though tether system dynamics have been extensively tested and simulated, it could be that actual dynamics will differ somewhat from predictions. The complexity of a widely separated, multi-component system and the forces created by the flow of current through the system are other variables that will affect the system's performance.

Responsibilities

Responsibility for Tethered Satellite System activities within NASA is divided between the Marshall Space Flight Center, Huntsville, AL, and the Johnson Space Center, Houston. Marshall has the development and integration responsibility. Marshall also is responsible for developing and executing the TSS-1 science mission, and science teams for each of the 12 experiments work under that center's direction. During the mission, Johnson will be responsible for the operation of the TSS-1 payload. This includes deployment and retrieval of the satellite by the crew as well as controlling Spacelab pallet, the deployer and the satellite. Marshall will furnish real-time engineering support for the TSS-1 system components and tether dynamics. ASI is furnishing satellite engineering and management support. All remote commanding of science instruments aboard the satellite and deployer will be executed by a Marshall payload operations control cadre stationed at Johnson for the mission.

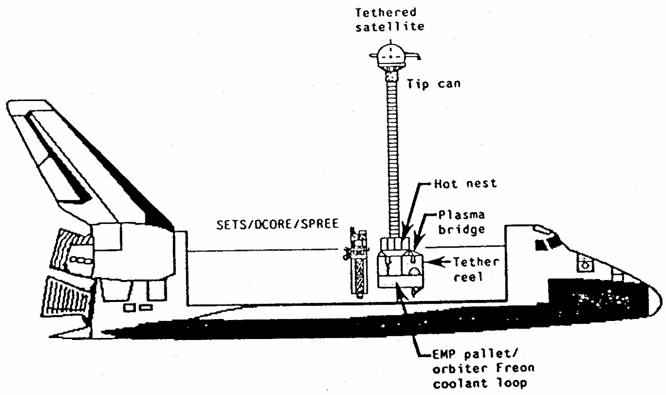
Tethered Satellite System Hardware

The Tethered Satellite System has five major components: the deployer system, the tether, the satellite, the carriers on which the system is mounted and the science instruments. Under the 1984 memorandum of understanding, the Italian Space Agency agreed to provide the satellite and NASA agreed to furnish the deployer system and tether. The carriers are specially adapted Spacelab equipment, and the science instruments were developed by various universities, government agencies and companies in the United States and Italy.

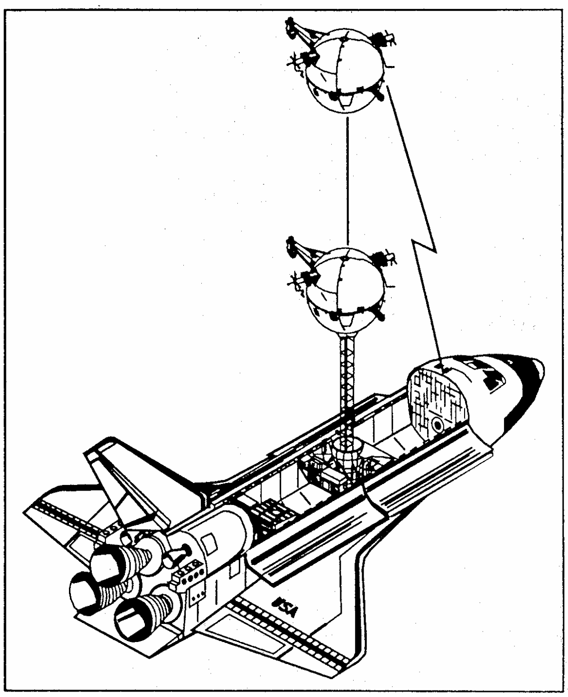
Carriers

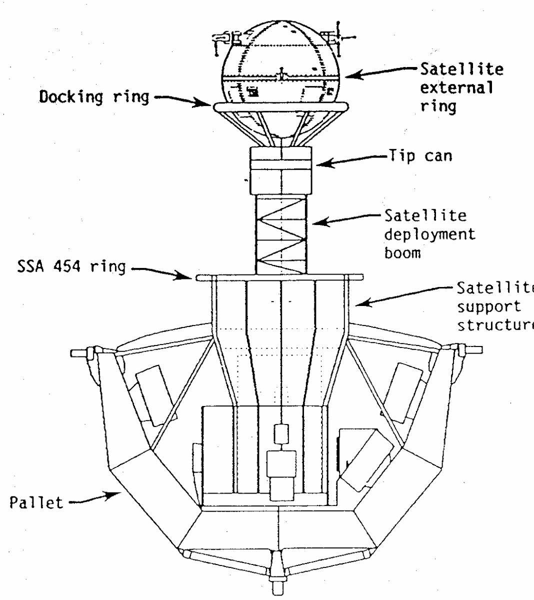
TSS-1 hardware rides on two carriers in the Shuttle cargo bay. The deployer is mounted on a Spacelab Enhanced Multiplexer-Demultiplexer pallet, a general-purpose unpressurized platform equipped to provide structural support to the deployer, as well as temperature control, power distribution and command and data transmission capabilities. The second carrier is the Mission Peculiar Equipment Support Structure, an inverted A-frame truss located immediately aft of the enhanced pallet. The support structure, also Spacelab-provided, holds science support equipment and two of the TSS-1 science experiments.

TSS



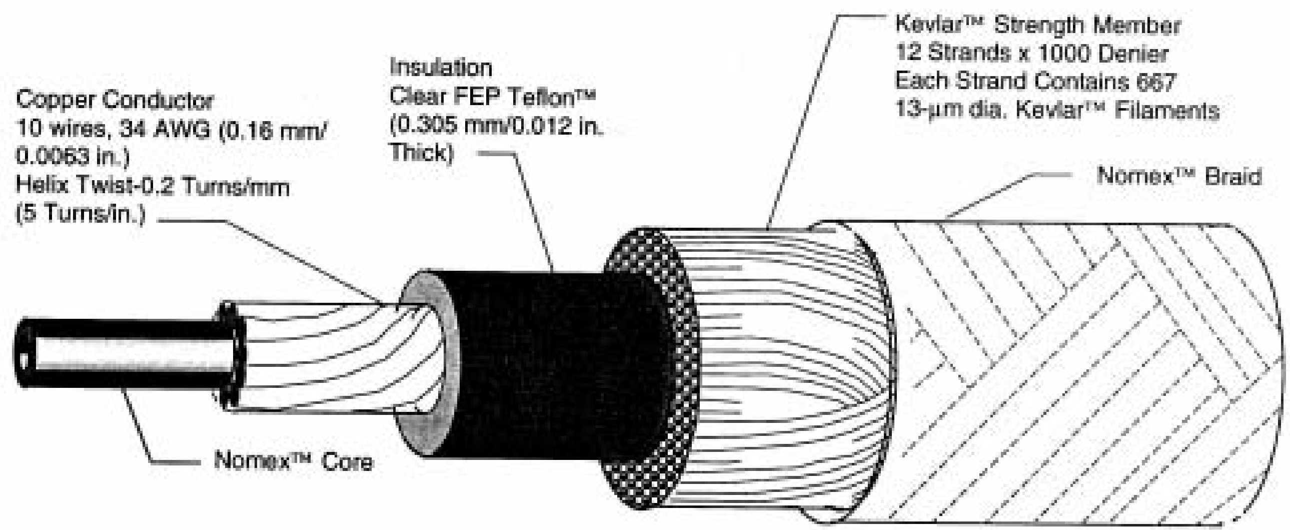
TSS predeploy configuration





Satellite/deployer interface

TSS-1 Electrically Conductive Tether



Diameter	**2.54 mm (0.1 in.)**
Max Mass	**8.2 kg/km (0.0055 lb/ft or 29.0 lb/mile)**
Breakstrength	**1780 N (400 lb)**
Temp Range	**-100°C to +125°C (-148°F to +257°F)**
Max Elongation	**5% at 1780 N**
Elec Breakdown Voltage	**10 kV (Specified), 15 kV (Qual)**
Elec Resistance	**0.12 Ω/m (Specified) 0.015 Ω/m (Actual at Room Temp)**
Leakage Current	**5 mA (Max) at 10 kVdc**

DEPLOYER

The deployer system includes the structure supporting the satellite, the deployment boom, which initially lifts the satellite away from the orbiter, the tether reel, a system that distributes power to the satellite before deployment and a data acquisition and control assembly.

Cables woven through the structure provide power and data links to the satellite until it is readied for release. When the cables are disconnected after checkout, the satellite operates on its internal battery power. If the safety of the orbiter becomes a concern, the tether can be cut and the satellite released or the satellite and boom jettisoned.

The boom, with the satellite resting atop it, is housed in a canister in the lower section of the satellite support structure. As deployment begins, the boom will unfold and extend slowly out of the turning canister, like a bolt being forced upward by a rotating nut. As the upward part of the canister rotates, horizontal cross members (fiberglass battens similar to those that give strength to sails) are unfolded from their bent-in-half positions to hold the vertical members (longerons) erect. Additional strength is provided by diagonal tension cables. The process is reversed for retrieval. When it is fully extended, the 40-foot boom resembles a short broadcasting tower.

The tether reel mechanism regulates the tether's length, tension and rate of deployment -- critical factors for tether control. Designed to hold up to 68 miles of tether, the reel is 3.3 feet in diameter and 3.9 feet long. The reel is equipped with a "level-wind" mechanism to assure uniform winding on the reel, a brake assembly for control of the tether and a drive motor. The mechanism is capable of letting out the tether at up to about 10 miles per hour. However, for the TSS-1 mission, the tether will be released at a much slower rate, about 2.5 miles per hour.

Tether

The tether's length and electrical properties affect all aspects of tethered operations. For the TSS-1 mission, the tether will be reeled out to an altitude about 12 miles above the Shuttle, making the TSS-1/orbiter combination 100 times longer than any previous spacecraft. It will create a large current system in the ionosphere, similar to natural currents in the Earth's polar regions associated with the aurora borealis. When the tether's current is pulsed by electron accelerators, it becomes the longest and lowest frequency antenna ever placed in orbit. Also, for the first time, scientists can measure the level of charge or electric potential acquired by a spacecraft as a result of its motion through the Earth's magnetic field lines. All these capabilities are directly related to the structure of the bootlace-thick tether, a conducting cord designed to anchor a satellite miles above the orbiter.

The TSS-1 tether is 13.6 miles long. When deployed, it is expected to develop a 5,000-volt electrical potential and carry a maximum current of 1 ampere. At its center is the conductor, a 10-strand copper bundle wrapped around a Nomex (nylon fiber) core. The wire is insulated with a layer of Teflon, then strength is provided with a layer of braided Kevlar -- a tough, light synthetic fiber also used for making bulletproof vests. An outer braid of Nomex protects the tether from atomic oxygen. The cable is about 0.1 inch in diameter.

Satellite

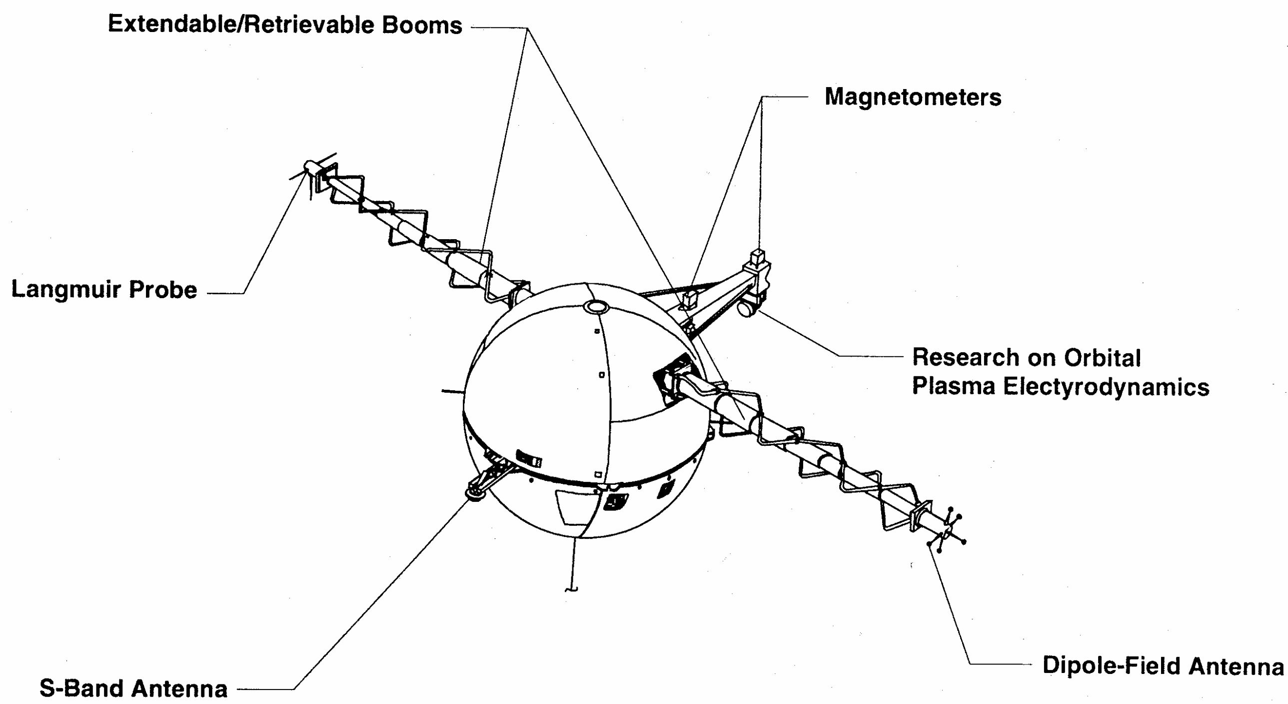
Developed by the Italian Space Agency, the spherical satellite is a little more than 5 feet in diameter and is latched atop the deployer's satellite support structure. The six latches are released when boom extension is initiated. After the satellite is extended some 40 feet above the orbiter atop the boom, tether unreeling will begin.

The satellite is divided into two hemispheres. The payload module (the upper half of the sphere opposite the tether) houses satellite-based science instruments. Support systems for power distribution, data handling, telemetry and navigational equipment are housed in the service module or lower half. Eight aluminum-alloy panels, covered with electrically conductive paint, developed at the Marshall Space Flight Center, form the outer skin of the satellite. Doors in the panels provide access for servicing batteries; windows for sun, Earth and charged-particle sensors; and connectors for cables from the deployer.

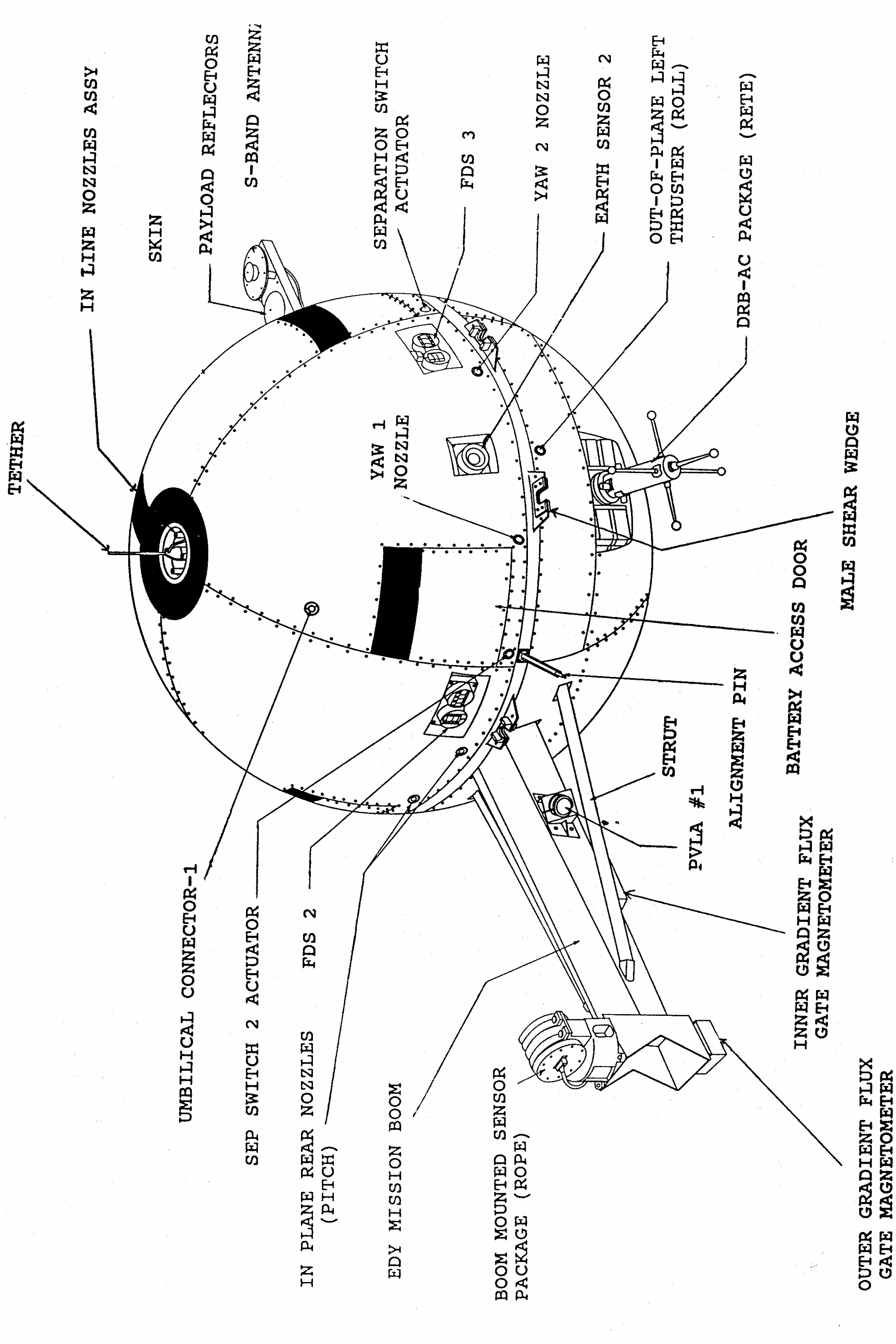
A fixed boom for mounting science instruments extends some 39 inches from the equator of the satellite sphere. A short mast opposite the boom carries an S-band antenna for sending data and receiving commands. For the TSS-1 mission, the satellite is outfitted with two additional instrument-mounting booms on opposite sides of the sphere. The booms may be extended up to 8 feet from the body of the satellite, allowing instruments to sample the surrounding environment, then be pulled back inside before the satellite is reeled back to the Shuttle.

Motion of the tethered satellite is controlled by its auxiliary propulsion module, in conjunction with the deployer's tether reel and motor. The module also initiates, maintains and controls satellite spin at up to 0.7 revolution per minute on command from the Shuttle. One set of thrusters near the tether attachment can provide extra tension on the tether, another can be used to reduce or eliminate pendulum-type motions in the satellite, and a third will be used to spin and de-spin the satellite. A pressurized tank containing gaseous nitrogen for the thrusters is located in the center of the sphere.

TSS-1 Satellite



TSS


TETHER
IN LINE NOZZLES ASSY
SKIN
PAYLOAD REFLECTORS
S-BAND ANTENN
SEPARATION SWITCH ACTUATOR
FDS 3
YAW 2 NOZZLE
EARTH SENSOR 2
OUT-OF-PLANE LEFT THRUSTER (ROLL)
DRB-AC PACKAGE (RETE)
YAW 1 NOZZLE
MALE SHEAR WEDGE
BATTERY ACCESS DOOR
ALIGNMENT PIN
STRUT
PVLA #1
INNER GRADIENT FLUX GATE MAGNETOMETER
OUTER GRADIENT FLUX GATE MAGNETOMETER
BOOM MOUNTED SENSOR PACKAGE (ROPE)
EDY MISSION BOOM
IN PLANE REAR NOZZLES (PITCH)
FDS 2
SEP SWITCH 2 ACTUATOR
UMBILICAL CONNECTOR-1

TETHERED SATELLITE SYSTEM-1 FLIGHT OPERATIONS

The responsibility for flying the tethered satellite, controlling the stability of the satellite, tether and Atlantis, lies with the flight controllers in the Mission Control Center at the Johnson Space Center, Houston.

The primary flight control positions contributing to the flight of the Tethered Satellite System (TSS) are the Guidance and Procedures (GPO) area and the Payloads area. GPO officers will oversee the dynamic phases of deployment and retrieval of the satellite and are responsible for determining the correct course of action to manage any tether dynamics. To compute corrective actions, the GPO officers will combine data from their workstations with inputs from several investigative teams.

The Payloads area will oversee control of the satellite systems, the operation of the tether deployer and all other TSS systems. Payloads also serves as the liaison between Mission Control Center and the science investigators, sending all real-time commands for science operations to the satellite. Atlantis' crew will control the deployer reel and the satellite thrusters from onboard the spacecraft.

Deploy Operations

The satellite will be deployed from Atlantis when the cargo bay is facing away from Earth, with the tail slanted upward and nose pitched down. A 39-foot long boom, with the satellite at its end, is raised out of the cargo bay to provide clearance between the satellite and Shuttle during deploy and retrieval operations. The orientation of the payload bay will result in the tethered satellite initially deployed upward but at an angle of about 40 degrees behind Atlantis' path.

Using the tether reel's electric motors to unwind the tether, an electric motor at the end of the boom to pull the tether off of the reel and a thruster on the satellite that pushes the satellite away from Atlantis, the satellite will be moved away from the Shuttle. The deploy will begin extremely slowly, with the satellite, after 1 hour has elapsed since the tether was first unwound, moving away from Atlantis at about one-half mile per hour. The initial movement of the satellite away from the boom will be at less than two-hundredths of 1 mile per hour. The speed of deploy will continue to increase, peaking after 1 and a half hours from the initial movement to almost 4 miles per hour.

At this point, when the satellite is slightly less than 1 mile from Atlantis, the rate of deployment will begin slowing briefly, a maneuver that is planned to reduce the 40-degree angle to 5 degrees and put the satellite in the same plane almost directly overhead of Atlantis by the time that about 3 miles of tether has been unwound.

When the satellite is 3.7 miles from Atlantis, 2 and one-half hours after the start of deployment, a one-quarter of a revolution-per-minute spin will be imparted to it via its attitude control system thrusters. The slight spin is needed for science operations with the satellite.

After this, the speed of deployment will again be increased gradually, climbing to a peak separation from Atlantis of almost 5 mph about 4 hours into the deployment when the satellite is about 9 miles distant. From this point, the speed with which the tether is fed out will gradually decrease through the rest of the procedure, coming to a stop almost 5 and half hours after the initial movement, when the satellite is almost 12.5 miles from Atlantis. Just prior to the satellite arriving on station at 12.5 miles distant, the quarter-revolution spin will be stopped briefly to measure tether dynamics and then, a seven-tenths of a revolution-per-minute spin will be imparted to it. At full deploy, the tension on the tether or the pull from the satellite is predicted to be equivalent to about 10 pounds of force.

The tether, in total, is 13.7 miles long, allowing an extra 1.2 miles of spare tether that is not planned to be unwound during the mission.

Dynamics Functional Objectives

During the deploy of TSS, several tests will be conducted to explore control and dynamics of a tethered satellite. Models of deployment have shown that the longer the tether becomes, the more stable the system becomes. The dynamics and control tests to be conducted during deploy also will aid in preparing for retrieval of the satellite and serve to verify the ability to control the satellite during that operation. During retrieval, it is expected that the stability of the system will decrease as the tether is shortened, just opposite the way stability increased as the tether was lengthened during deploy.

The dynamics tests involve maintaining a constant tension on the tether and correcting any of several possible disturbances to it. Possible disturbances include: a bobbing motion, also called a plumb bob, where the satellite bounces slightly on the tether causing it to alternately slacken and tighten; a vibration of the tether, called a libration, resulting in a clock-pendulum type movement of tether and satellite; a pendulous motion of the satellite or a rolling and pitching action by the satellite at the end of the tether; and a lateral string mode disturbance, a motion where the satellite and Shuttle are stable, but the tether is moving back and forth in a "skip rope" motion. All of these disturbances may occur naturally and are not unexpected. However, some disturbances will be induced intentionally.

The first test objectives will be performed before the satellite reaches 200 yards from Atlantis and will involve small firings of Atlantis' steering jets to test the disturbances these may impart to the tether and satellite. The crew will test three different methods of damping the libration (clock pendulum) motion expected to be created in the tether and the pendulous (rolling and pitching) motion expected in the satellite. First, using visual contact with the satellite, to manually stabilize it from onboard the Shuttle by remotely firing TSS's attitude thrusters. Second, using the telemetry information from the satellite to manually fire the satellite's attitude thrusters. Third, using an automatic attitude control system for the satellite via the Shuttle's flight control computers to automatically fire the TSS thrusters and stabilize the system.

Another test will be performed when the satellite is about 2.5 miles from Atlantis. Atlantis' autopilot will be adjusted to allow the Shuttle to wobble by as much as 10 degrees in any direction before steering jets automatically fire to maintain Atlantis' orientation. The 10-degree deadband will be used to judge any disturbances that may be imparted to the satellite if a looser attitude control is maintained by Atlantis. The standard deadband, or degree of wobble, set in Shuttle autopilot for the tethered satellite operations is 2 degrees of wobble. Tests using the wider deadband will allow the crew and flight controllers to measure the amount of motion the satellite and tether impart to Atlantis.

When the satellite is fully deployed and on station at 12.5 miles, Atlantis will perform jet firings to judge disturbances imparted to the tether and satellite at that distance.

Dampening of the various motions expected to occur in the tether and satellite will be accomplished while at 12.5 miles using electrical current flow through the tether. During retrieval, test objectives will be met using a combination of the Shuttle's steering jets, a built-in dampening system at the end of the deploy boom and the satellite's steering jets.

Tether Retrieval Operations

Satellite retrieval will occur more slowly than deployment. The rate of tether retrieval, the closing rate between Atlantis and the satellite, will build after 5 hours since first movement to a peak rate of about 3 miles per hour. At that point, when the satellite is about 4 and a half miles from Atlantis, the rate of retrieval will gradually decrease, coming to a halt 10 hours after start of retrieval operations when the satellite is 1.5 miles from Atlantis.

The satellite will remain at 1.5 miles from Atlantis for about 5 hours of science operations before the final retrieval begins. Final retrieval of the satellite is expected to take about 2 hours. A peak rate of closing between Atlantis and the satellite of about 1.5 miles per hour will be attained just after the final retrieval begins, and the closing rate will decrease gradually through the remainder of the operation. The closing rate at the time the satellite is docked to the cradle at the end of the deployer boom is planned to be less than one-tenth of 1 mile per hour.

If the safety of the orbiter becomes a concern, the tether will be cut and the satellite released or the satellite and boom jettisoned.

TSS-1 SCIENCE OPERATIONS

Speeding through the magnetized ionospheric plasma at almost 5 miles per second, a 12-mile-long conducting tethered system should create a variety of very interesting plasma-electrodynamic phenomena. These are expected to provide unique experimental capabilities, including the ability to collect an electrical charge and drive a large current system within the ionosphere; generate high voltages (on the order of 5 kilovolts) across the tether at full deployment; control the satellite's electrical potential and its plasma sheath (the layer of charged particles created around the satellite); and generate low-frequency electrostatic and electromagnetic waves. It is believed that these capabilities can be used to conduct controlled experimental studies of phenomena and processes that occur naturally in plasmas throughout the solar system, including Earth's magnetosphere.

A necessary first step toward these studies -- and the primary science goal of the TSS-1 mission -- is to characterize the electrodynamic behavior of the satellite-tether-orbiter system. Of particular interest is the interaction of the system with the charged particles and electric and magnetic fields in the ionosphere.

A circuit must be closed to produce an electrical current. For example, in a simple circuit involving a battery and a light bulb, current travels down one wire from the battery to the bulb, through the bulb and back to the battery via another wire completing the circuit. Only when the circuit is complete will the bulb illuminate. The conductive outer skin of the satellite collects free electrons from the space plasma, and the induced voltage causes the electrons to flow down the conductive tether to the Shuttle. Then, they will be ejected back into space with electron guns.

Scientists expect the electrons to travel along magnetic field lines in the ionosphere to complete the loop. TSS-1 investigators will use a series of interdependent experiments conducted with the electron guns and tether current-control hardware, along with a set of diagnostic instruments, to assess the nature of the external current loop within the ionosphere and the processes by which current closure occurs at the satellite and the orbiter.

Science Operations

The TSS-1 mission is comprised of 11 scientific investigations selected jointly by NASA and the Italian Space Agency. In addition, the U.S. Air Force's Phillips Laboratory, by agreement, is providing an experimental investigation. Seven investigations provide equipment that either stimulates or monitors the tether system and its environment. Two investigations will use ground-based instruments to measure electromagnetic emissions from the Tethered Satellite System as it passes overhead, and three investigations were selected to provide theoretical support in the areas of dynamics and electrodynamics.

Most of the TSS-1 experiments require measurements of essentially the same set of physical parameters, with instrumentation from each investigation providing different parts of the total set. While some instruments measure magnetic fields, others record particle energies and densities, and still others map electric fields. A complete set of data on plasma and field conditions is required to provide an accurate understanding of the space environment and its interaction with the tether system. TSS-1 science investigations, therefore, are interdependent. They must share information and operations to achieve their objectives. In fact, these investigations may be considered to be different parts of a single complex experiment.

The TSS-1 principal and associate investigators and their support teams will be located in a special Science Operations Center at the Mission Control Center in Houston. During the tethered satellite portion of the STS-46 flight, all 12 team leaders will be positioned at a conference table in the operations center. Science data will be available to the entire group, giving them an integrated "picture" of conditions observed by all the instruments. Together, they will assess performance of the experiment objectives. Commands to change any instrument mode that affects the overall data set must be approved by the group, because such a change could impact the overall science return from the mission. Requests for adjustments will be relayed by the mission scientist, the group's leader, to the science operations director for implementation.

The primary scientific data will be taken during the approximately 10.5-hour phase (called "on-station 1") when the satellite is extended to the maximum distance above the Shuttle. Secondary science measurements will be taken prior to and during deployment, during "on-station 1," and as the satellite is reeled back to the orbiter. However, during the latter phase, satellite recovery has a higher priority than continued science data gathering.

Science activities during the TSS-1 mission will be directed by the science principal investigator team and implemented by a payload cadre made up primarily of Marshall Space Flight Center employees and their contractors. Science support teams for each of the 12 experiments will monitor the science hardware status. From the Science Operations Center at Mission Control, the principal investigator team will be able to evaluate the quality of data obtained, replan science activities as needed and direct adjustments to the instruments. The cadre will be led by a science operations director, who will work closely with the mission scientist, the mission manager and Mission Control's payloads officer to coordinate science activities.

During the mission, most activities not carried out by the crew will be controlled by command sequences, or timeline files, written prior to the mission and stored in an onboard computer. For maximum flexibility, however, during all TSS phases, modifications to these timeline files may be uplinked, or commands may be sent in real-time from the Science Operations Center to the on-board instruments.

SCIENCE INVESTIGATIONS

TSS Deployer Core Equipment and Satellite Core Equipment (DCORE/SCORE)
Principal Investigator:
Dr. Carlo Bonifazi
Italian Space Agency, Rome, Italy

The Tethered Satellite System Core Equipment controls the electrical current flowing between the satellite and the orbiter. It also makes a number of basic electrical and physical measurements of the system.

Mounted on the aft support structure in the Shuttle cargo bay, the Deployer Core Equipment features an electron accelerator with two electron beam emitters that can each eject up to 500 milli-amperes (one-half amp) of current from the system. A master switch, power distribution and electronic control unit, and command and data interfaces also are included in the deployer core package. A voltmeter measures tether potential with respect to the orbiter structure, and a vacuum gauge measures ambient gas pressure to prevent operations if pressure conditions might cause electrical arcing.

Core equipment located on the satellite itself includes an accelerometer to measure satellite movements and an ammeter to measure tether current collected on the skin of the TSS-1 satellite.

Research on Orbital Plasma Electrodynamics (ROPE)
Principal Investigator:
Dr. Nobie Stone
NASA Marshall Space Flight Center, Huntsville, AL

This experiment studies behavior of ambient charged particles in the ionosphere and ionized neutral particles around the satellite under a variety of conditions. Comparisons of readings from its instruments should allow scientists to determine where the particles come from that make up the tether current as well as the distribution and flow of charged particles in the space immediately surrounding the satellite.

The Differential Ion Flux Probe, mounted on the end of the satellite's fixed boom, measures the energy, temperature, density and direction of ambient ions that flow around the satellite as well as neutral particles that have been ionized in its plasma sheath and accelerated outward by the sheath's electric field.

The Soft Particle Energy Spectrometer is actually five electrostatic analyzers -- three mounted at different locations on the surface of the satellite itself, and the other two mounted with the Differential Ion Flux Probe on the boom. Taken together, measurements from the two boom-mounted sensors can be used to determine the electrical potential of the sheath of ionized plasma surrounding the satellite. The three satellite-mounted sensors will measure geometric distribution of the current to the satellite's surface.

Research on Electrodynamic Tether Effects (RETE)
Principal Investigator:
Dr. Marino Dobrowolny
Italian National Research Council, Rome, Italy

This experiment measures the electrical potential in the plasma sheath around the satellite and identifies waves excited by the satellite and tether system. The instruments are located in two canisters at the end of the satellite's extendible booms. As the satellite spins, the booms are extended, and the sensors sweep the plasma around the entire circumference of the spacecraft. To produce a profile of the plasma sheath, measurements of direct-current potential and electron currents are made both while the boom is fully extended and as it is being extended or retracted. The same measurements, taken at a fixed distance from the spinning satellite, produce a map of the angular structure of the sheath.

Magnetic Field Experiment for TSS Missions (TEMAG)
Principal Investigator:
Prof. Franco Mariani
Second University of Rome, Italy

The primary goal of this investigation is to map the levels and fluctuations in magnetic fields around the satellite. Two magnetometers -- very accurate devices for measuring such fields -- are located on the fixed boom of the satellite, one at its end and the other at its midpoint. Comparing measurements from the two magnetometers allows real-time estimates to be made of unwanted disturbances to the magnetic fields produced by the presence of satellite batteries, power systems, gyros, motors, relays and other magnetic material. After the mission, the variable effects of switching satellite subsystems on and off, of thruster firings and of other operations that introduce magnetic disturbances will be modeled on the ground, so these satellite effects can be subtracted from measurements of the ambient magnetic fields in space.

Shuttle Electrodynamic Tether System (SETS)
Principal Investigator:
Dr. Peter Banks
University of Michigan, Ann Arbor

This investigation studies the ability of the tethered satellite to collect electrons by determining current and voltage of the tethered system and measuring the resistance to current flow in the tether itself. It also explores how tether current can be controlled by the emission of electrons at the orbiter end of the system and characterizes the charge the orbiter acquires as the tether system produces power, broadcasts low-frequency radio waves and creates instabilities in the surrounding plasma.

The hardware is located on the support structure in the orbiter cargo bay. In addition to three instruments to characterize the orbiter's charge, the experiment includes a fast-pulse electron accelerator used to help neutralize the orbiter's charge. It is located close to the core electron gun and aligned so beams from both are parallel. The fast-pulse accelerator acts as a current modulator, emitting electron beams in recognizable patterns to stimulate wave activity over a wide range of frequencies. The beams can be pulsed with on/off times on the order of 100 nanoseconds.

Shuttle Potential and Return Electron Experiment (SPREE)
Associate Investigators:
Dr. Dave Hardy and Capt. Marilyn Oberhardt
Dept. of the Air Force, Phillips Laboratory, Bedford, Mass.

Also located on the support structure, this experiment will measure populations of charged particles around the orbiter. Measurements will be made prior to deployment to assess ambient space conditions as well as during active TSS-1 operations. The measurements will determine the level of orbiter charging with respect to the ambient space plasma, characterize the particles returning to the orbiter as a result of TSS-1 electron beam ejections and investigate local wave-particle interactions produced by TSS-1 operations. Such information is important in determining how the Tethered Satellite System current is generated, and how it is affected by return currents to the orbiter. The experiment uses two sets of two nested electrostatic analyzers each, which rotate at approximately 1 revolution per minute, sampling the electrons and ions in and around the Shuttle's cargo bay.

Tether Optical Phenomena Experiment (TOP)
Associate Investigator:
Dr. Stephen Mende
Lockheed, Palo Alto Research Laboratory, Palo Alto, Calif.

This experiment uses a hand-held, low-light-level TV camera system operated by the crew, to provide visual data to allow scientists to answer a variety of questions about tether dynamics and optical effects generated by TSS-1. The imaging system will operate in four configurations: filtered, interferometer, spectrographic and filtered with a telephoto lens. In particular, the experiment will image the high voltage plasma sheath surrounding the satellite when it is reeled back toward the orbiter near the end of the retrieval stage of the mission.

Investigation of Electromagnetic Emissions for Electrodynamic Tether (EMET)
Principal Investigator:
Dr. Robert Estes
Smithsonian Astrophysical Observatory, Cambridge, Mass.

Observations at the Earth's Surface of Electromagnetic Emission by TSS (OESEE)
Principal Investigator:
Dr. Giorgio Tacconi
University of Genoa, Italy

The main goal of these experiments is to determine how well the Tethered Satellite System can broadcast from space. Ground-based radio transmissions, especially below 15 kilohertz, are inefficient since most of the power supplied to the antenna -- large portions of which are buried -- is absorbed by the ground. Since the Tethered Satellite System operates in the ionosphere, it should radiate waves more efficiently. Magnetometers at several locations in a chain of worldwide geomagnetic observatories and extremely low-frequency receivers at the Arecibo Radio Telescope facility, Puerto Rico, and other sites around the world, will try to measure the emissions produced and track direction of the waves when electron accelerators pulse tether current over specific land reference points. An Italian ocean surface and ocean bottom observational facility also provides remote measurements for TSS-1 emissions.

The Investigation and Measurement of Dynamic Noise in the TSS (IMDN)
Principal Investigator:
Dr. Gordon Gullahorn
Smithsonian Astrophysical Observatory, Cambridge, Mass.

Theoretical and Experimental Investigation of TSS Dynamics (TEID)
Principal Investigator:
Prof. Silvio Bergamaschi
Institute of Applied Mechanics, Padua University, Padua, Italy

These two investigations will analyze data from a variety of instruments to examine Tethered Satellite System dynamics or oscillations over a wide range of frequencies. Primary instruments will be accelerometers and gyros on board the satellite, but tether tension and length measurements and magnetic field measurements also will be used. The dynamics will be observed in real-time at the Science Operations Center and later, subjected to detailed post-flight analysis. Basic theoretical models and simulations of tether movement will be verified, extended or corrected as required. Then they can be used confidently in the design of future systems.

Theory and Modeling in Support of Tethered Satellite Applications (TMST)
Principal Investigator:
Dr. Adam Drobot
Science Applications International Corp., McLean, VA

This investigation provides theoretical electro-dynamic support for the mission. Numerical models were developed of anticipated current and voltage characteristics, plasma sheaths around the satellite and the orbiter and of the system's response to the operation of the electron accelerators. These models tell investigators monitoring the experiments from the ground what patterns they should expect to see in the data.

THE TSS-1 TEAM

Within NASA, the Tethered Satellite System program is directed by the Office of Space Flight and the Office of Space Science and Applications. The Space Systems Projects Office at the Marshall Space Flight Center, Huntsville, AL, has responsibility for project management and overall systems engineering. Experiment hardware systems were designed and developed by the U.S. and Italy. Responsibility for integration of all hardware, including experiment systems, is assigned to the project manager at the Marshall center. The Kennedy Space Center, Florida, is responsible for launch-processing and launch of the TSS-1 payload. The Johnson Space Center, Houston, has responsibility for TSS-1/STS integration and mission operations.

R. J. Howard of the Office of Space Science and Applications, NASA Headquarters, Washington, DC, is the TSS-1 Science Payload Program Manager. The TSS Program Manager is Tom Stuart of the Office of Space Flight, NASA Headquarters. Billy Nunley is NASA Project Manager and TSS-1 Mission Manager at the Marshall Space Flight Center. Dr. Nobie Stone, also of Marshall, is the NASA TSS-1 Mission Scientist, the TSS Project Scientist and Co-chairman of the Investigator Working Group.

For the Italian Space Agency, Dr. Gianfranco Manarini is Program Manager for TSS-1, while the Program Scientist is Dr. F. Mariani. Dr. Marino Dobrowolny is the Project Scientist for the Italian Space Agency, and Co-chairman of the investigator group. Dr. Maurizio Candidi is the Mission Scientist for the Italian Space Agency.

Martin Marietta, Denver, Colo., developed the tether and control system deployer for NASA. Alenia in Turin, Italy, developed the satellite for the Italian Space Agency.

TSS-1 SCIENCE INVESTIGATIONS

Title	Institution (Nation)
Research on Electrodynamic Tether Effects	CNR or Italian National Research Council (Italy)
Research on Orbital Plasma Electrodynamics	NASA/MSFC (U.S.)
Shuttle Electrodynamic Tether System	University of Michigan (U.S.)
Magnetic Field Experiments for TSS Missions	Second University of Rome (Italy)
Theoretical & Experimental Investigations of TSS Dynamics	Univ. of Padua (Italy)
Theory & Modeling in Support of Tethered Satellite	SAIC (U.S.)
Investigation of Electromagnetic Emissions for Electrodynamic Tether	Smithsonian Astrophysical Observatory (U.S.)
Investigation and Measurement of Dynamic Noise of TSS Smithsonian Astrophysical Observatory (U.S.)	
Observation on Earth's Surface of Electromagnetic Emissions by TSS	Univ. of Genoa (Italy)
Deployer Core Equipment and Satellite Core Equipment	ASI (Italy)
Tether Optical Phenomena Experiment	Lockheed (U.S.)
Shuttle Potential & Return	Dept. of the Air Force
Electron Experiment	Phillips Laboratory (U.S.)

EUROPEAN RETRIEVABLE CARRIER (EURECA)

The European Space Agency's (ESA) EURECA will be launched by the Space Shuttle and deployed at an altitude of 425 km. It will ascend, using its own propulsion, to its operational orbit of 515 km. After 6 to 9 months in orbit, it will descend to the lower orbit where it will be retrieved by another orbiter and brought back to Earth. It will refurbished and equipped for the next mission.

The first mission (EURECA-1) primarily will be devoted to research in the fields of material and life sciences and radiobiology, all of which require a controlled microgravity environment. The selected microgravity experiments will be carried out in seven facilities. The remaining payload comprises space science and technology.

During the first mission, EURECA's residual carrier accelerations will not exceed 10-5g. The platform's altitude and orbit control system makes use of magnetic torquers augmented by cold gas thrusters to keep disturbance levels below 0.3 Nm during the operational phase.

Physical characteristics

Launch mass	4491 kg
Electrical power solar array	5000w
Continuous power to EURECA experiments	1000w
Launch configuration	dia: 4.5m, length: 2.54m
Volume	40.3m
Solar array extended	20m x 3.5

User friendly

Considerable efforts have been made during the design and development phases to ensure that EURECA is a "user friendly" system. As is the case for Spacelab, EURECA has standardized structural attachments, power and data interfaces. Unlike Spacelab, however, EURECA has a decentralized payload control concept. Most of the onboard facilities have their own data handling device so that investigators can control the internal operations of their equipment directly. This approach provides more flexibility as well as economical advantages.

Operations

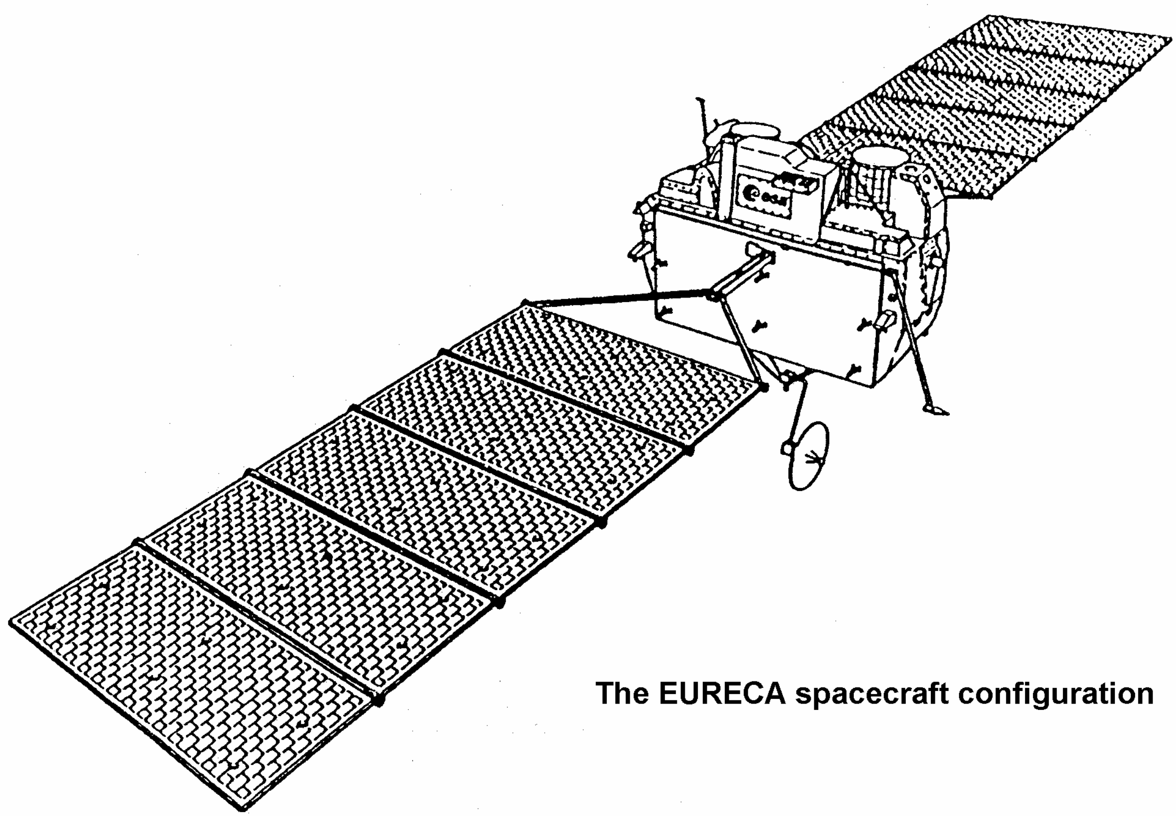
EURECA is directly attached to the Shuttle cargo bay by means of a three-point latching system. The spacecraft has been designed with a minimum length and a close-to-optimum length-to-mass ratio, thus helping to keep down launch and retrieval costs.

All EURECA operations will be controlled by ESA's Space Operations Centre (ESOC) in Darmstadt, Germany. During the deployment and retrieval operations, ESOC will function as a Remote Payload Operations Control Centre to NASA's Mission Control Center, Houston, and the orbiter will be used as a relay station for all the commands. In case of unexpected communication gaps during this period, the orbiter crew has a back-up command capability for essential functions.

Throughout the operational phase, ESOC will control EURECA through two ground stations at Maspalomas and Kourou. EURECA will be in contact with its ground stations for a relatively short period each day. When it is out of contact, or "invisible", its systems operate with a high degree of autonomy, performing failure detection, isolation and recovery activities to safeguard ongoing experimental processes.

An experimental advanced data relay system, the Inter-orbit Communication package, is included in the first payload. This package will communicate with the European Olympus Communication Satellite to demonstrate the possible improvements for future communications with data relay satellites. As such a system will significantly enhance real-time data coverage, it is planned for use on subsequent EURECA missions to provide an operational service via future European data relay satellites.

EURECA-1L



The EURECA spacecraft configuration

Structure

The EURECA structure is made of high strength carbon-fiber struts and titanium nodal points joined together to form a framework of cubic elements. This provides relatively low thermal distortions, allows high alignment accuracy and simple analytical verification, and is easy to assemble and maintain. Larger assemblies are attached to the nodal points. Instruments weighing less than 100 kg are assembled on standard equipment support panels similar to those on a Spacelab pallet.

Thermal Control

Thermal control for EURECA combines active and passive heat transfer and radiation systems. Active transfer, required for payload facilities which generated more heat, is achieve by means of a Freon cooling loop which dissipates the thermal load through two radiators into space. The passive system makes use of multi-layer insulation blankets combined with electrical heaters. During nominal operations, the thermal control subsystem rejects a maximum heat load of about 2300 w.

Electrical Power

The electrical power subsystem generates, stores, conditions and distributes power to all the spacecraft subsystems and to the payload. The deployable and retractable solar arrays, with a combined raw power output of some 5000 w together with four 40 amp-hour (Ah) nickel-cadmium batteries, provide the payload with a continuous power of 1000 w, nominally at 28 volts, with peak power capabilities of up to 1500 w for several minutes. While EURECA is in the cargo bay, electric power is provided by the Shuttle to ensure that mission critical equipment is maintained within its temperature limits.

Attitude and Orbit Control

A modular attitude and orbit control subsystem (AOCS) is used for attitude determination and spacecraft orientation and stabilization during all flight operations and orbit control maneuvers. The AOCS has been designed for maximum autonomy. It will ensure that all mission requirements are met even in case of severe on-board failures, including non-availability of the on-board data handling subsystem for up to 48 hours.

An orbit transfer assembly, consisting of two redundant sets of four thrusters, is used to boost EURECA to its operation attitude at 515 km and to return it to its retrieval orbit at about 300 km. The amount of onboard propellant hydrazine is sufficient for the spacecraft to fly different mission profiles depending on its nominal mission duration which may be anywhere between 6 and 9 months.

EURECA is three-axis stabilized by means of a magnetic torque assembly together with a nitrogen reaction control assembly (RCA). This specific combination of actuators was selected because its' control accelerations are well below the microgravity constraints of the spacecraft. The RCA cold gas system can be used during deployment and retrieval operations without creating any hazards for the Shuttle.

Communications and Data Handling

EURECA remote control and autonomous operations are carried out by means of the data handling subsystem (DHS) supported by the telemetry and telecommand subsystems which provide the link to and from the ground segment. Through the DHS, instructions are stored and executed, telemetry data is stored and transmitted, and the spacecraft and its payload are controlled when EURECA is no longer "visible" from the ground station.

EURECA SCIENCE

Solution Growth Facility (SGF)
Principal Investigator:
J. C. Legros
Universite Libre de Bruxelles, Brussels, Belgium

The Solution Growth Facility (SGF) is a multi-user facility dedicated to the growth of monocrystals from solution, consisting of a set of four reactors and their associated control system.

Three of the reactors will be used for the solution growth of crystals. These reactors have a central buffer chamber containing solvent and two reservoirs containing reactant solutions. The reservoirs are connected to the buffer chamber by valves which allow the solutions to diffuse into the solvent and hence, to crystallize.

The fourth reactor is divided into twenty individual sample tubes which contain different samples of binary organic mixtures and aqueous electrolyte solutions. This reactor is devoted to the measurement of the Soret coefficient, that is, the ratio of thermal to isothermal diffusion coefficient.

The SGF has been developed under ESA contract by Laben and their subcontractors Contraves and Terma.

Protein Crystallization Facility (PCF)
Principal Investigator:
W. Littke
Chemisches Laboratorium, Universitat Freiburg, Freiburg, Germany

The Protein Crystallization Facility (PCF) is a multi-user solution growth facility for protein crystallization in space. The object of the experiments is the growth of single, defect-free protein crystals of high purity and of a size sufficient to determine their molecular structure by x-ray diffraction.
This typically requires crystal sizes in the order of a few tenths of a millimeter.

The PCF contains twelve reactor vessels, one for each experiment. Each reactor, which is provided with an individually controlled temperature environment, has four chambers -- one containing the protein, one containing a buffer solution and two filled with salt solutions. When the reactors have reached their operating temperatures, one of the salt solution chambers, the protein chamber and the buffer solution chamber are opened. Salt molecules diffuse into the buffer chamber causing the protein solution to crystallize. At the end of the mission the second salt solution chamber is activated to increase the salt concentration. This stabilizes the crystals and prevents them from dissolving when individual temperature control for the experiments ceases and the reactors are maintained at a common storage temperature.

One particular feature of the PCF is that the crystallization process can be observed from the ground by means of a video system.

The PCF has been developed under ESA contract by MBB Deutsche Aerospace and their subcontractors Officine Galileo and Reusser.

Exobiology And Radiation Assembly (ERA)
Principal Investigator:
H. Bucker
Institut fur Flugmedizin Abt. Biophysik, DLR, Cologne, Germany

The Exobiology and Radiation Assembly (ERA) is a multi-user life science facility for experiments on the biological effects of space radiation. Our knowledge of the interaction of cosmic ray particles with biological matter, the synergism of space vacuum and solar UV, and the spectral effectiveness of solar UV on viability should be improved as a result of experiments carried out in the ERA.

The ERA consists of deployable and fixed experiment trays and a number of cylindrical stacks, known as Biostacks, containing biological objects such as spores, seeds or eggs alternated with radiation and track detectors. An electronic service module also is included in the facility. The deployable trays carry biological specimens which are exposed to the different components of the space radiation environment for predetermined periods of time. The duration of exposure is controlled by means of shutters and the type of radiation is selected by the use of optical bandpass filters.

The ERA has been developed under ESA contract by Sira Ltd.

Multi-Furnace Assembly (MFA)
Principal Investigator:
A. Passerone
Ist. di Chimica Fisica Applicata dei Materiali, National Research Council (CNR), Genova, Italy

The Multi-Furnace Assembly (MFA) is a multi-user facility dedicated to material science experiments. It is a modular facility with a set of common system interfaces which incorporates twelve furnaces of three different types, giving temperatures of up to 1400 degrees C. Some of the furnaces are provided by the investigators on the basis of design recommendations made by ESA. The remainder are derived from furnaces flown on other missions, including some from sounding rocket flights. These are being used on EURECA after the necessary modifications and additional qualification. The experiments are performed sequentially with only one furnace operating at any one time.

The MFA has been developed under ESA contract by Deutsche Aerospace, ERNO Raumfahrttechnik and their subcontractors SAAB, Aeritalia, INTA and Bell Telephone.

Automatic Mirror Furnace (AMF)
Principal Investigator:
K. W. Benz
Kristallographisches Institut, Universitat Freiburg, Freiburg, Germany

The Automatic Mirror Furnace (AMF) is an optical radiation furnace designed for the growth of single, uniform crystals from the liquid or vapor phases, using the traveling heater or Bridgman methods.

The principal component of the furnace is an ellipsoidal mirror. The experimental material is placed at the lower ring focus of the mirror and heated by radiation from a 300 w halogen lamp positioned at the upper focus. Temperatures of up to 1200 degrees C can be achieved, depending on the requirements of individual samples. Seven lamps are available and up to 23 samples can be processed in the furnace.

As the crystal grows, the sample holder is withdrawn from the mirror assembly at crystallization speed, typically 2 mm/day, to keep the growth site aligned with the furnace focus. The sample also is rotated while in the furnace.

The AMF is the first of a new generation of crystal growth facilities equipped with sample and lamp exchange mechanisms. Fully automatic operations can be conducted in space during long microgravity missions on free flying carriers. During a 6 month mission, about 20 different crystal growth experiments can be performed.

The AMF has been developed under ESA contract by Dornier Deutsche Aerospace and their subcontractors Laben, ORS and SEP.

Surface Forces Adhesion Instrument (SFA)
Principal Investigator:
G. Poletti
Universita di Milano, Milan, Italy

The Surface Forces Adhesion instrument (SFA) has been designed to study the dependence of surface forces and interface energies on physical and chemical-physical parameters such as surface topography, surface cleanliness, temperature and the deformation properties of the contacting bodies.
The SFA experiment aims at refining current understanding of adhesion-related phenomena, such as friction and wear, cold welding techniques in a microgravity environment and solid body positioning by means of adhesion.

Very high vacuum dynamic measurements must be performed in microgravity conditions because of the extreme difficulty experienced on Earth in controlling the physical parameters involved. As a typical example, the interface energy of a metallic sphere of 1 g mass contacting a pane target would be of the order of 10-3 erg. corresponding to a potential gravitational energy related to a displacement of 10-5 mm. In the same experiment performed on the EURECA platform, in a 10 to 100,000 times lower gravity environment, this energy corresponds to a displacement of 1 mm, thus considerably improving measurements and reducing error margins.

The SFA instrument has been funded by the Scientific Committee of the Italian Space Agency (ASI) and developed by the University of Milan and their subcontractors Centrotechnica, Control Systems and Rial.

High Precision Thermostat Instrument (HPT)
Principal Investigator:
G. Findenegg
Ruhr Universitat Bochum, Bochum, Germany

Basic physics phenomena around the critical point of fluids are not, as yet, fully understood. Measurements in a microgravity environment, made during the German mission D-1, seem to be at variance with the expected results. Further investigations of critical phenomena under microgravity conditions are of very high scientific value.

The High Precision Thermostat (HPT) is an instrument designed for long term experiments requiring microgravity conditions and high precision temperature measurement and control. Typical experiments are "caloric", "critical point" or "phase transition" experiments, such as the "Adsorption" experiment designed for the EURECA mission.

This experiment will study the adsorption of Sulphur Hexafluoride (SF6), close to its critical point (Tc=45.55 degrees C, pc=0.737 g/cm3) on graphitized carbon. A new volumetric technique will be used for the measurements of the adsorption coefficient at various temperatures along the critical isochore starting from the reference temperature in the one-phase region (60x) and approaching the critical temperature. The results will be compared with 1g measurements and theoretical predictions.

The HPT has been developed under DLR contract by Deutsche Aerospace ERNO Raumfahrttechnik and their subcontractor Kayser-Threde GmbH.

Solar Constant And Variability Instrument (SOVA)
Principal Investigator:
D. Crommelynck IRMB
Brussels, Belgium

The Solar Constant and Variability Instrument (SOVA) is designed to investigate the solar constant, its variability and its spectral distribution, and measure:

- fluctuations of the total and spectral solar irradiance within periods of a few minutes up to several hours and with a resolution of 10-6 to determine the pressure and gravity modes of the solar oscillations which carry information on the internal structure of the sun;

- short term variations of the total and spectral solar irradiance within time scales ranging from hours to few months and with a resolution of 10-5 for the study of energy redistribution in the solar convection zone. These variations appear to be associated with solar activities (sun spots);

- long term variations of the solar luminosity in the time scale of years (solar cycles) by measuring the absolute solar irradiance with an accuracy of better than 0.1 percent and by comparing it with previous and future measurements on board Spacelab and other space vehicles. This is of importance for the understanding of solar cycles and is a basic reference for climatic research.

The SOVA instrument has been developed by the Institut Royal Meteorologique de Belgique of Brussels, by the Physikalisch-Meteorologishces Observatorium World Radiation Center (PMOD/WRC) Davos and by the Space Science Department (SSD) of the European Space Agency (ESA-ESTEC), Noordwijk.

Solar Spectrum Instrument (SOSP)
Principal Investigator:
G. Thuillier
Service d'Aeronomie du CNRS, Verrieres le Buisson, France

The Solar Spectrum Instrument (SOSP) has been designed for the study of solar physics and the solar-terrestrial relationship in aeronomy and climatology. It measures the absolute solar irradiance and its variations in the spectral range from 170 to 3200 n.m., with an expected accuracy of 1 percent in the visible and infrared ranges and 5 percent in the ultraviolet range.

Changes in the solar irradiance mainly relate to the short-term solar variations that have been observed since 1981 by the Solar Maximum spacecraft, the variations related to the 27-day solar rotation period and the long-term variations related to the 11-year sun cycles. While the short term variations can be measured during one single EURECA flight mission, two or three missions are needed to assess the long term variations.

SOSP has been developed by the Service d'Aeronomie of the Centre National de Recherche Scientifique (CNRS), the Institut d'Aeronomie Spatiale de Belgique (IASB), the Landassternwarte Koenigstuhl and the Hamburger Sternwarte.

Occultation Radiometer Instrument (ORA)
Principal Investigator:
E. Arijs
Belgisch Instituut voor Ruimte Aeronomie (BIRA), Brussels, Belgium

The Occultation Radiometer instrument (ORA) is designed to measure aerosols and trace gas densities in the Earth's mesosphere and stratosphere. The attenuation of the various spectral components of the solar radiation as it passes through the Earth's atmosphere enables vertical abundance profiles for ozone, nitrogen dioxide, water vapor, carbon dioxide and background and volcanic aerosols to be determined for altitudes between 20 and 100 km.

The ORA instrument has been developed by the Institut d'Aeronomie Spatiale, and the Clarendon Laboratory of the University of Oxford.

Wide Angle Telescope (WATCH)
Principal Investigator:
N. Lund
Danish Space Research Institute, Lyngby, Denmark

The Wide Angle Telescope (WATCH) is designed to detect celestial gamma and x-ray sources with photon energies in the range 5 to 200 keV and determine the position of the source.

The major objective of WATCH is the detection and localization of gamma-ray bursts and hard x-ray transients. Persistent x-ray sources also can be observed.

Cosmic gamma-ray bursts are one of the most extreme examples of the variability of the appearance of the x-ray sky. They rise and decay within seconds, but during their life they outshine the combined flux from all other sources of celestial x-and gamma rays by factors of up to a thousand.

Less conspicuous, but more predictable are the x-ray novae which flare regularly, typically with intervals of a few years. In the extragalactic sky, the "active galactic nuclei" show apparently are random fluctuations in their x-ray luminosity over periods of days or weeks.

WATCH will detect and locate these events. The data from the experiment can be used to provide light curves and energy for the sources. The data also may be searched for regularities in the time variations related to orbital movement or rotation or for spectral features that yield information about the source. Additionally, other, more powerful sky observation instruments can be alerted to the presence of objects that WATCH has detected as being in an unusual state of activity.

WATCH has been developed by the Danish Space Research Institute.

Timeband Capture Cell Experiment (TICCE)
Principal Investigator:
J. A. M. McDonnell
Unit for Space Science, Physics Laboratory University of Kent, Great Britain

The Timeband Capture Cell Experiment (TICCE) is an instrument designed for the study of the microparticle population in near-Earth space -- typically Earth debris, meteoroids and cometary dust. The TICCE will capture micron dimensioned particles with velocities in excess of 3 km/s and store the debris for retrieval and post-mission analysis.

Particles detected by the instrument pass through a front foil and into a debris collection substrate positioned 100 n.m. behind the foil. Each perforation in the foil will have a corresponding debris site on the substrate. The foil will be moved in 50 discrete steps during the six month mission, and the phase shift between the debris site and the perforation will enable the arrival timeband of the particle to be determined. Between 200 and 300 particles are expected to impact the instrument during the mission. Ambiguities in the correlation of foil perforations and debris sites will probably occur for only a few of the impacts.

Elemental analysis of the impact sites will be performed, using dispersive x-ray techniques, once the instrument has returned to Earth.

TICCE has been developed by the University of Kent. Its structural support has been sponsored by ESA and subcontracted to SABCA under a Deutsche Aerospace ERNO Raumfahrttechnik contract.

Radio Frequency Ionization Thruster Assembly (RITA)
Principal Investigator:
H. Bassner
MBB Deutsche Aerospace, Munich, Germany

The Radio Frequency Ionization Thruster Assembly (RITA) is designed to evaluate the use of electric propulsion in space and to gain operational experience before endorsing its use for advanced spacecraft technologies.

The space missions now being planned - which are both more complex and of longer duration - call for increased amounts of propellant for their propulsion systems which, in turn, leads to an increase in the overall spacecraft mass to the detriment of the scientific or applications payload. Considerable savings can be made in this respect by the use of ion propulsion systems, wherein a gas is ionized and the positive ions are them accelerated by an electric field. In order to avoid spacecraft charging, the resulting ion beam is then neutralized by an electron emitting device, the neutralizer. The exhaust velocities obtained in this way are about an order of magnitude higher than those of chemical propulsion systems.

RITA has been developed under ESA and BMFT contract by Deutsche Aerospace ERNO Raumfahrttechnik.

Inter-Orbit Communication (IOC)
R. Tribes
CNES Project Manager, CNES-IOC Toulouse, France

N. Neale
ESA Project Manager, ESTEC-CD Noordwijk, The Netherlands

The Inter-Orbit Communication (IOC) instrument is a technological experiment designed to provide a pre-operational inflight test and demonstration of the main functions, services and equipment typical of those required for a data relay system, namely:

- bi-directional, end-to-end data transmission between the user spacecraft and a dedicated ground station via a relay satellite in the 20/30 GHz frequency band;
- tracking of a data relay satellite;
- tracking of a user spacecraft;
- ranging services for orbit determination of a user spacecraft via a relay satellite.

In this case, the EURECA platform is the user spacecraft and the ESA communications satellite Olympus the relay satellite. One of the Olympus steerable spot beam antennas will be pointed towards the IOC on EURECA and the other towards the IOC ground station. The IOC instrument is provided with a mobile directional antenna to track Olympus.

The IOC has been developed under ESA contract by CNES and their subcontractors Alocatel Espace, Marconi Space Systems, Laben, Matra Espace, Sener, Alcatel Bel, AEG-Telefunken, ETCA, TEX, MDS and COMDEV.

Advanced Solar Gallium Arsenide Array (ASGA)
Principal Investigator:
C. Flores
CISE SPA, Segrate, Italy

The Advanced Solar Gallium Arsenide Array (ASGA) will provide valuable information on the performance of gallium arsenide (GaAs) solar arrays and on the effects of the low Earth orbit environment on their components. These solar cells, already being used in a trial form to power the Soviet MIR space station, are expected to form the backbone of the next generation of compact, high power-to-weight ratio European solar energy generators.

The most significant environmental hazards encountered arise from isotopic proton bombardment in the South Atlantic Anomaly, high frequency thermal cycling fatigue of solar cell interconnections and the recently discovered atomic oxygen erosion of solar array materials. Although a certain amount of knowledge may be gained from laboratory experiments, the crucial confirmation of the fidelity of the GaAs solar array designs awaits the results of flight experiments.

The project has been sponsored by the Italian Space Agency (ASI) and developed by CISE with its subcontractor, Carlo Gavazzi Space. The planar solar module has been assembled by FIAR. The miniature Cassegranian concentrator components have been developed in collaboration with the Royal Aircraft Establishments and Pilkington Space Technology.

EURECA has been developed under ESA contract by Deutsche Aerospace, ERNO Raumfahrttechnik, (Germany), and their subcontractors Sener, (England), AIT, (Italy), SABCA, (Belgium), AEG, (Germany), Fokker, (The Netherlands), Matra, (France), Deutsche Aerospace, ERNO Raumfahrttechnik, (Germany), SNIA-BPD, (Italy), BTM, (Belgium), and Laben, (Italy). F. Schwan - Industrial Project Manager Deutsche Aerospace, ERNO Raumfahrttechnik, Bremen, Germany W. Nellessen - ESA Project Manager ESTEC MR, Noordwijk, The Netherlands

EVALUATION OF OXYGEN INTERACTION WITH MATERIALS/ TWO PHASE MOUNTING PLATE EXPERIMENT (EOIM-III/TEMP 2A-3)

EOIM

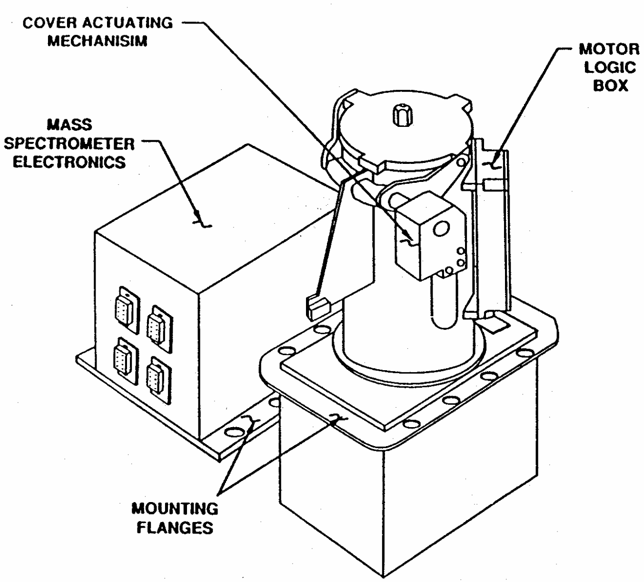
The Evaluation of Atomic Oxygen Interactions with Materials (EOIM) payload will obtain accurate reaction rate measurements of the interaction of space station materials with atomic oxygen. It also will measure the local Space Shuttle environment, ambient atmosphere and interactions between the two. This will improve the understanding of the effect of the Shuttle environment on Shuttle and payload operations and will update current models of atmospheric composition. EOIM also will assess the effects of environmental and material parameters on reaction rates.

To make these measurements, EOIM will use an ion-neutral mass spectrometer to obtain aeronomy measurements and to study atom-surface interaction products. The package also provides a mass spectrometer rotating carousel system containing "modeled" polymers for mechanistic studies. EOIM also will study the effects of mechanical stress on erosion rates of advanced composites and the effects of temperature on reaction rates of disk specimens and thin films. Energy accommodations on surfaces and surface-atom emission characteristics concerning surface recession will be measured using passive scatterometers. The payload also will assess solar ultraviolet radiation reaction rates.

The environment monitor package will be activated pre-launch, while the remainder of the payload will be activated after payload bay door opening. Experiment measurements will be made throughout the flight, and the package will be powered down during de-orbit preparations.

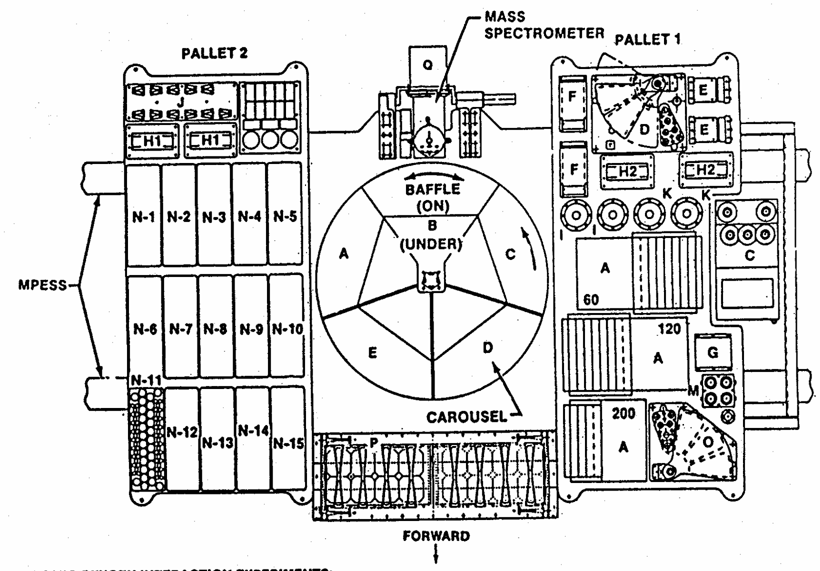
TEMP

The Two Phase Mounting Plate Experiment (TEMP 2A-3) has two-phase mounting plates, an ammonia reservoir, mechanical pumps, a flowmeter, radiator and valves, and avionics subsystems. The TEMP is a two-phase thermal control system that utilizes vaporization to transport large amounts of heat over large distances. The technology being tested by TEMP is needed to meet the increased thermal control requirements of space station. The TEMP experiment will be the first demonstration of a mechanically pumped two-phase ammonia thermal control system in microgravity. It also will evaluate a propulsion-type fluid management reservoir in a two-phase ammonia system, measure pressure drops in a two-phase fluid line, evaluate the performance of a two-phase cold plate design and measure heat transfer coefficients in a two-phase boiler experiment. EOIM-III/TEMP 2A-3 are integrated together on a MPESS payload carrier in the payload bay.



Mass spectrometer system

EOIM-III/TEMP 2A



ATOMIC OXYGEN INTERACTION EXPERIMENTS:

- A - HEATED PLATE (JSC), 3 EA
- B - ATOM SCATTERING EXPERIMENT (UAH), 1 EA
- C - ENVIRONMENT MONITOR PACKAGE (GSFC), 1 EA
- D - SOLAR UV EXPERIMENT (JSC), 1 EA
- E - STATIC STRESS FIXTURE (MSFC), 2 EA
- F - UNIFORMN STRESS FIXTURE (MSFC), 2 EA
- G - ATOMIC OXYGEN MONITOR (MSFC), 1 EA
- H1 - COMPOSITE STRESS FIXTURE (LaRC), 2 EA
- H2 - COMPOSITE STRESS FIXTURE (JSC), 2 EA
- I - SCATTEROMETER (JPL), 2 EA
- J - MECHANICAL STRESS FIXTURE (LeRC), 11 EA
- K - REFLECTORMETER (LeRC), 2 EA
- L - PIN-HOLE CAMERA (LeRC), 1 EA
- M - SCATTEROMETER (AEROSPACE CORP.), 1 EA
- N - SAMPLE CARRIERS, 15 EA
- O - VARIABLE EXPOSURE TRAY, 1 EA
- P - FREEDOM ARRAY MATERIALS EXPOSURE EXPERIMENT (LeRC), 1 EA
- Q - MASS SPECTROMETER (AFGL), 1 EA

CONSORTIUM FOR MATERIALS DEVELOPMENT IN SPACE COMPLEX AUTONOMOUS PAYLOAD (CONCAP)

The Consortium for Materials Development in Space Complex Autonomous Payload (CONCAP) is sponsored by NASA's Office of Commercial Programs (OCP). On STS-46, two CONCAP payloads (CONCAP-II and -III) will be flown in 5-foot cylindrical GAS (Get Away Special) canisters.

CONCAP-II is designed to study the changes that materials undergo in low-Earth orbit. This payload involves two types of experiments to study the surface reactions resulting from exposing materials to the atomic oxygen flow experienced by the Space Shuttle in orbit. The atomic oxygen flux level also will be measured and recorded. The first experiment will expose different types of high temperature superconducting thin films to the 5 electron volt atomic oxygen flux to achieve improved properties. Additional novel aspects of this experiment are that a subset of the materials samples will be heated to 320 degrees Celsius (the highest temperature used in space), and that the material resistance change of 24 samples will be measured on-orbit.

For the second CONCAP-II experiment, the surface of different passive materials will be exposed (at ambient and elevated temperatures) to hyperthermal oxygen flow. This experiment will enable enhanced prediction of materials degradation on spacecraft and solar power systems. In addition, this experiment will test oxidation-resistant coatings and the production of surfaces for commercial use, development of new materials based on energetic molecular beam processing and development of an accurate data base on materials reaction rates in orbit.

CONCAP-III is designed to measure and record absolute accelerations (microgravity levels) in one experiment and to electroplate pure nickel metal and record the conditions (temperature, voltage and current) during this process in another experiment. Items inside the orbiter experience changes in acceleration when various forces are applied to the orbiter, including thruster firing, crew motion and for STS-46, tethered satellite operations. By measuring absolute accelerations, CONCAP-III can compare the measured force that the orbiter undergoes during satellite operations with theoretical calculations. Also, during accelerations measurements, CONCAP-III can gather accurate acceleration data during the electroplating experiments.

The second CONCAP-III experiment is an electroplating experiment using pure nickel metal. This experiment will obtain samples for analysis as part of a study of microgravity effects on electroplating. Materials electroplated in low gravity tend to have different structures than materials electroplated on Earth. Electroplating will be performed before and during the tethered satellite deployment to study the differences that occur for different levels of accelerations.

The CONCAP-II and -III experiments are managed and developed by the Consortium for Materials Development in Space, a NASA Center for the Commercial Development of Space at the University of Alabama in Huntsville (UAH). Payload integration and flight hardware management is handled by NASA's Goddard Space Flight Center, Greenbelt, MD.

Dr. John C. Gregory and Jan A. Bijvoet of UAH are Principal investigator and payload manager, respectively, for CONCAP-II. For CONCAP-III, principal investigator for the acceleration experiment is Bijvoet, principal investigator for the electrodeposition (electroplating) is Dr. Clyde Riley, also of UAH, and payload manager is George W. Maybee of McDonnell Douglas Space Systems Co., Huntsville, AL.

LIMITED DURATION SPACE ENVIRONMENT CANDIDATE MATERIALS EXPOSURE (LDCE)

The first of the Limited Duration Space Environment Candidate Materials Exposure (LDCE) payload series is sponsored by NASA's Office of Commercial Programs (OCP). The LDCE project on STS-46 represents an opportunity to evaluate candidate space structure materials in low-Earth orbit.

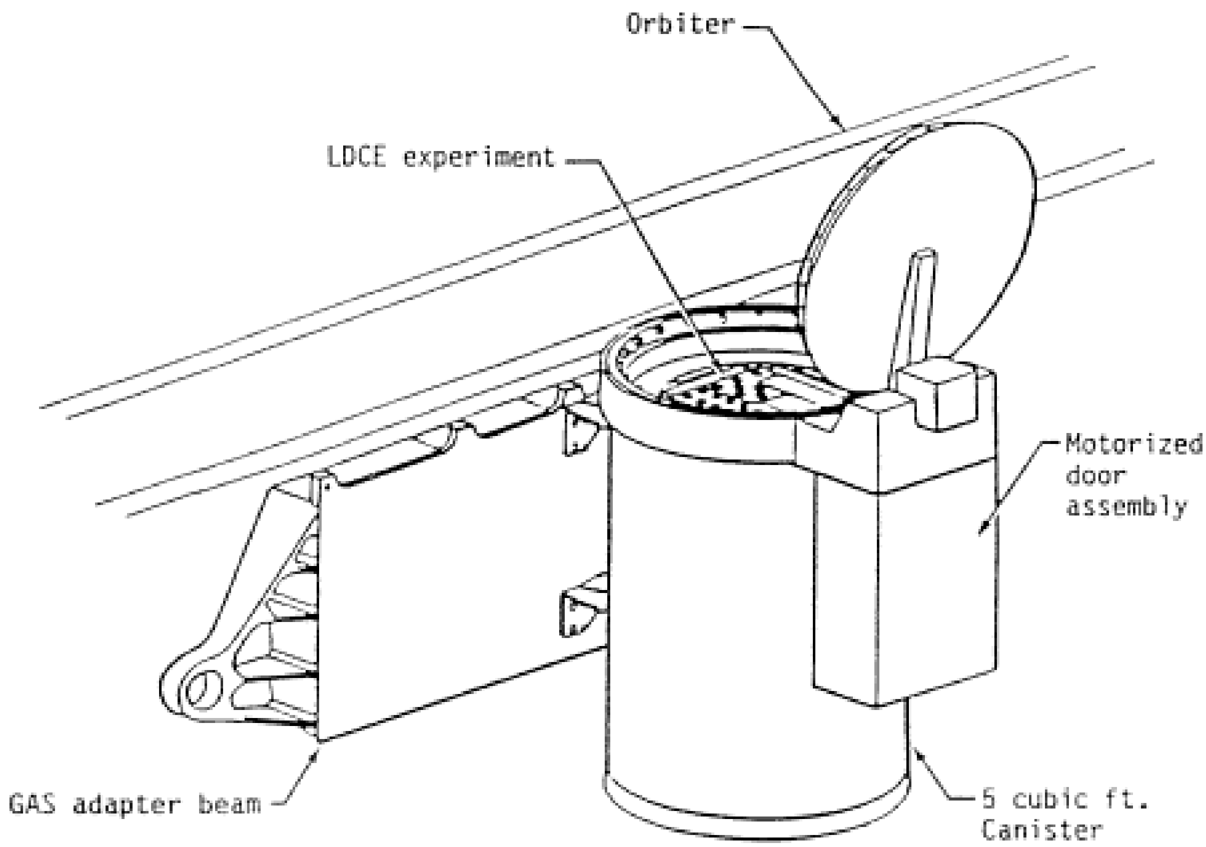
The objective of the project is to provide engineering and scientific information to those involved in materials selection and development for space systems and structures. By exposing such materials to representative space environments, an analytical model of the performance of these materials in a space environment can be obtained.

The LDCE payload consists of three separate experiments, LDCE-1, -2 and -3, which will examine the reaction of 356 candidate materials to at least 40 hours exposure in low-Earth orbit. LDCE-1 and -2 will be housed in GAS (Get Away Special) canisters with motorized door assemblies. LDCE-3 will be located on the top of the GAS canister used for CONCAP-III. Each experiment has a 19.65-inch diameter support disc with a 15.34-inch diameter section which contains the candidate materials. The support disc for LDCE-3 will be continually exposed during the mission, whereas LDCE-1 and -2 will be exposed only when the GAS canisters' doors are opened by a crew member. Other than opening and closing the doors, LDCE payload operations are completely passive. The doors will be open once the Shuttle achieves orbit and will be closed periodically during Shuttle operations, such as water dumps, jet firings and changes in attitude.

Two primary commercial goals of the flight project are to identify environmentally-stable structural materials to support continued humanization and commercialization of the space frontier and to establish a technology base to service growing interest in space materials environmental stability.

The LDCE payload is managed and developed by the Center for Materials on Space Structures, a NASA Center for the Commercial Development of Space at Case Western Reserve University (CWRU) in Cleveland. Dr. John F. Wallace, Director of Space Flight Programs at CWRU, is lead Investigator. Dawn Davis, also of CWRU, is program manager.

Limited Duration Space Environment Candidate
Materials Exposure (LDCE) Flight Configuration



BEAM MOUNTED CONFIGURATION

PITUITARY GROWTH HORMONE CELL FUNCTION (PHCF)

Principal Investigator:
Dr. W. C. Hymer
The Pennsylvania State University, University Park, Pa.

The Pituitary Growth Hormone Cell Function (PHCF) experiment is a middeck-locker rodent cell culture experiment. It continues the study of the influence of microgravity on growth hormone secreted by cells isolated from the brain's anterior pituitary gland.

PHCF is designed to study whether the growth hormone-producing cells of the pituitary gland have an internal gravity sensor responsible for the decreased hormone release observed following space flight. This hormone plays an important role in muscle metabolism and immune-cell function as well as in the growth of children. Growth hormone production decreases with age. The decline is thought to play an important role in the aging process.

The decreased production of biologically active growth hormone seen during space flight could be a factor in the loss of muscle and bone strength and the decreased immune response observed in astronauts following space flight. If the two are linked, PHCF might identify mechanisms for providing countermeasures for astronauts on long space missions. It also may lead to increased understanding of the processes underlying human muscle degeneration as people age on Earth.

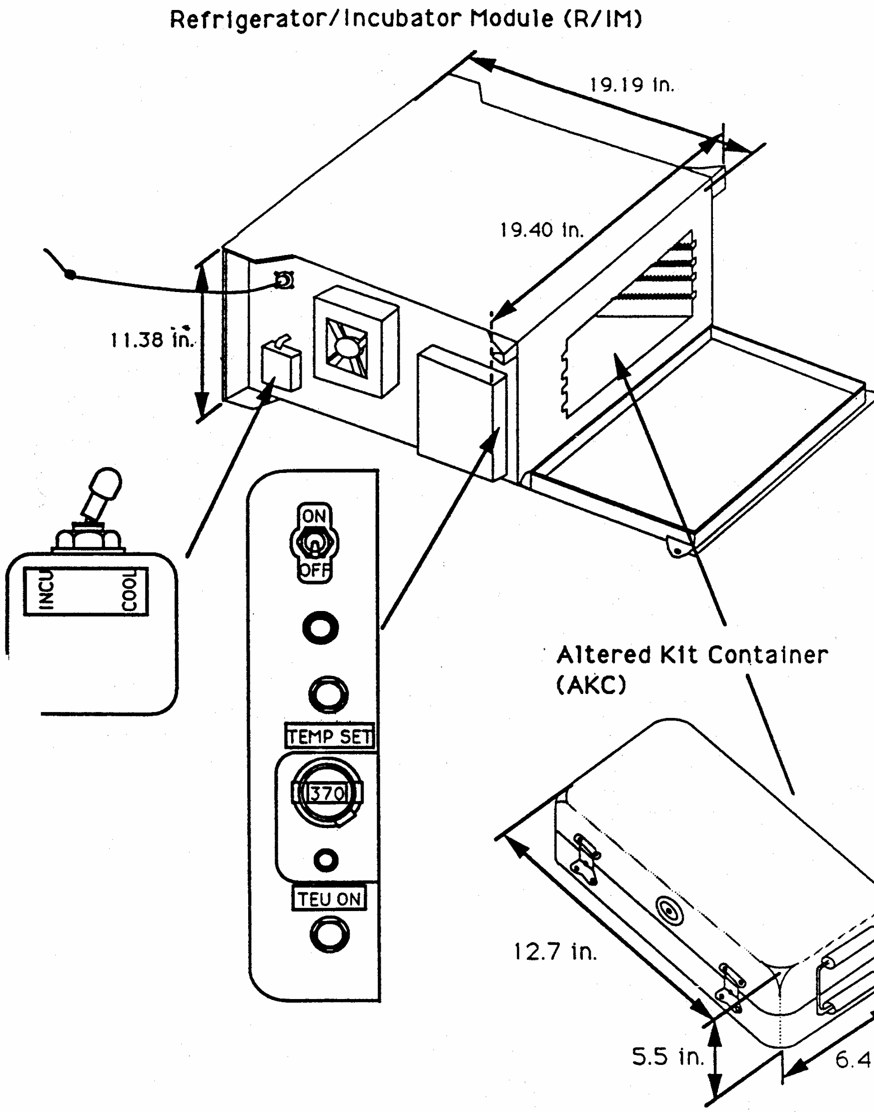
The PHCF experiment uses cultures of living rat pituitary cells. These preparations will be placed in 165 culture vials carried on the Shuttle's middeck in an incubator. After the flight, the cells will be cultured and their growth hormone output assayed.

IMAX CARGO BAY CAMERA (ICBC)

The IMAX Cargo Bay Camera (ICBC) is aboard STS-46 as part of NASA's continuing collaboration with the Smithsonian Institution in the production of films using the IMAX system. This system, developed by IMAX Corp., Toronto, Canada, uses specially-designed 70 mm film cameras and projectors to produce very high definition motion picture images which, accompanied by six channel high fidelity sound, are displayed on screens up to ten times the size used in conventional motion picture theaters.

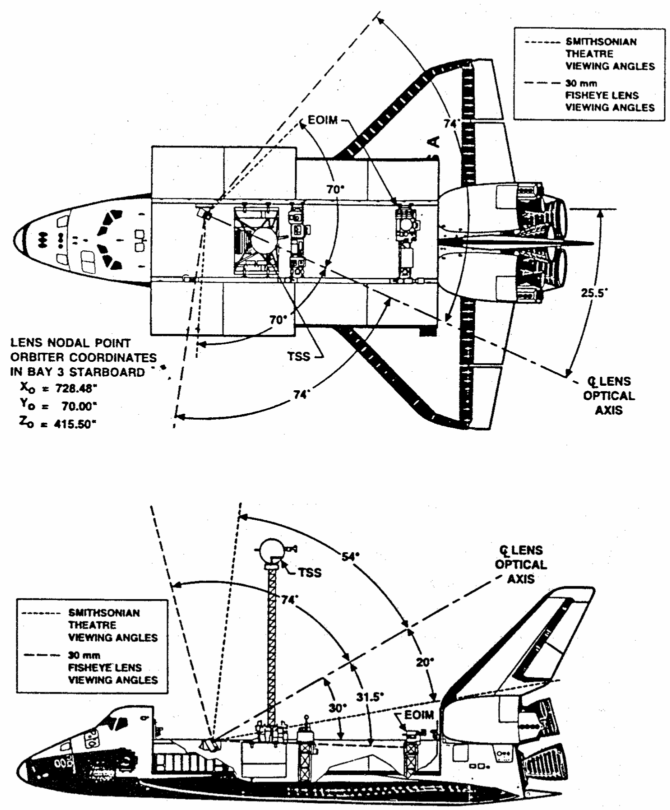
"The Dream is Alive" and "Blue Planet," earlier products of this collaboration, have been enjoyed by millions of people around the world. On this flight, the camera will be used primarily to cover the EURECA and Tether Satellite operations, plus Earth scenes as circumstances permit. The footage will be used in a new film dealing with our use of space to gain new knowledge of the universe and the future of mankind in space. Production of these films is sponsored by the Lockheed Corporation.

PHCF



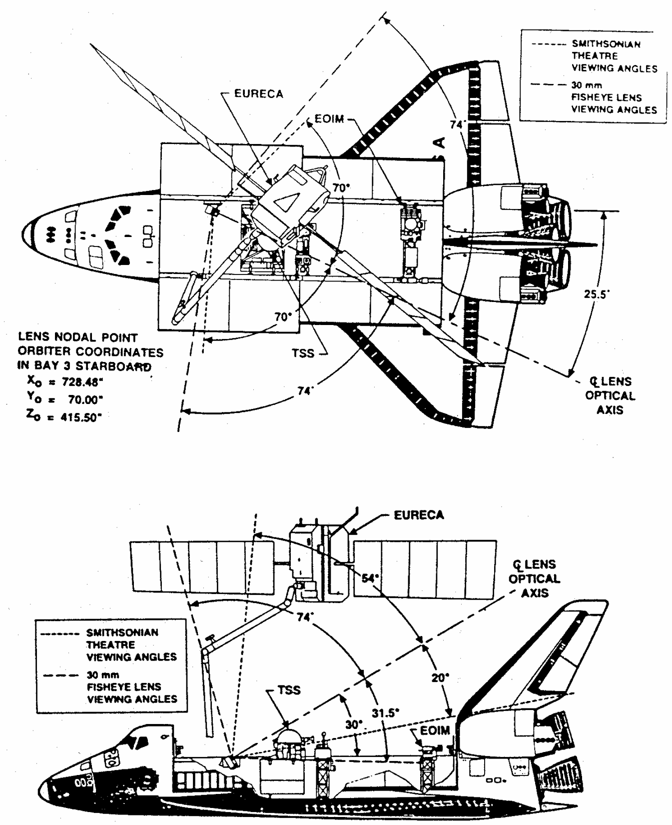
PHCF configuration

ICBC



TSS deploy/retrieve

ICBC viewing angles for STS-46 for 30mm lens
and Smithsonian Theater



EURECA deployment

AIR FORCE MAUI OPTICAL SYSTEM (AMOS)

The Air Force Maui Optical System (AMOS) is an electrical-optical facility located on the Hawaiian island of Maui. The facility tracks the orbiter as it flies over the area and records signatures from thruster firings, water dumps or the phenomena of shuttle glow, a well-documented glowing effect around the shuttle caused by the interaction of atomic oxygen with the spacecraft.

The information obtained is used to calibrate the infrared and optical sensors at the facility. No hardware onboard the shuttle is needed for the system.

ULTRAVIOLET PLUME EXPERIMENT

The Ultraviolet Plume Experiment (UVPI) is an instrument on the Low-Power Atmospheric Compensation Experiment (LACE) satellite launched by the Strategic Defense Initiative Organization in February 1990. LACE is in a 43-degree inclination orbit of 290 n.m. Imagery of Columbia's engine firings or attitude control system firings will be taken on a non-interference basis by the UVPI whenever an opportunity is available during the STS-46 mission.

STS-46 CREWMEMBERS

STS046-S-002 -- The crewmembers assigned to NASA's STS-46 mission pose with seven flags that represent participation on the flight. Mission commander Loren J. Shriver (right), holding launch and entry helmet (LEH), and pilot Andrew M. Allen (left), also holding LEH, are seated in the front. Standing behind them and wearing launch and entry suits (LESs) are (left to right) mission specialists(MS) Marsha S. Ivins, Claude Nicollier (representing the European Space Agency (ESA)), mission specialist and payload commander Jeffrey A. Hoffman, mission specialist Franklin R. Chang-Diaz, and payload specialist Franco Malerba (flying for the Italian Space Agency (ASI)). The flags (left to right) represent the United States of America (USA), Costa Rica (Chang-Diaz's native country), Italy, Switzerland (Nicollier's homeland), NASA, ESA, and ASI. Portrait made by NASA JSC photographer Robert L. Walck.

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PHOTO CREDIT: NASA or National Aeronautics and Space Administration.

BIOGRAPHICAL DATA

LOREN J. SHRIVER, 47, Col., USAF, will serve as commander of STS-46. Selected as an astronaut in January 1978, Shriver considers Paton, IA, his hometown and will be making his third space flight.

Shriver graduated from Paton Consolidated High School, received a bachelor's in aeronautical engineering from the Air Force Academy and received a master's in aeronautical engineering from Purdue University.

Shriver was pilot of STS-51C in January 1985, a Department of Defense-dedicated shuttle flight. He next flew as commander of STS-31 in April 1990, the mission that deployed the Hubble Space Telescope. Shriver has logged more than 194 hours in space.

ANDREW M. ALLEN, 36, Major, USMC, will serve as pilot. Selected as an astronaut in June 1987, Allen was born in Philadelphia, PA, and will be making his first space flight.

Allen graduated from Archbishop Wood High School in Warminster, PA, in 1973 and received a bachelor's in mechanical engineering from Villanova University in 1977.

Allen was commissioned in the Marine Corps in 1977. Following flight school, he was assigned to fly the F-4 Phantom at the Marine Corps Air Station in Beaufort, SC. He graduated from the Navy Test Pilot School in 1987 and was a test pilot under instruction at the time of his selection by NASA. He has logged more than 3,000 flying hours in more than 30 different types of aircraft.

CLAUDE NICOLLIER, 47, will be Mission Specialist 1 (MS1). Under an agreement between the European Space Agency and NASA, he was selected as an astronaut in 1980. Nicollier was born in Vevey, Switzerland, and will be making his first space flight.

Nicollier graduated from Gymnase de Lausanne, Lausanne, Switzerland, received a bachelor's in physics from the University of Lausanne and received a master's in astrophysics from the University of Geneva.

In 1976, he accepted a fellowship at ESA's Space Science Dept., working as a research scientist in various airborne infrared astronomy programs. In 1978, he was selected by ESA as one of three payload specialist candidates for the Spacelab-1 shuttle mission, training at NASA for 2 years as an alternate. In 1980, he began mission specialist training. Nicollier graduated from the Empire Test Pilot School, Boscombe Down, England, in 1988, and holds a commission as Captain in the Swiss Air Force. He has logged more than 4,300 hours flying time, 2,700 in jet aircraft.

MARSHA S. IVINS, 41, will be Mission Specialist 2 (MS2). Selected as an astronaut in 1984, Ivins was born in Baltimore, MD, and will be making her second space flight.

Ivins graduated from Nether Providence High School, Wallingford, PA, and received a bachelor's in aerospace engineering from the University of Colorado.

Ivins joined NASA shortly after graduation and was employed at the Johnson Space Center as an engineer in the Crew Station Design Branch until 1980. she was assigned as a flight simulation engineer aboard the Shuttle Training Aircraft and served as co-pilot of the NASA administrative aircraft.

She first flew on STS-32 in January 1990, a mission that retrieved the Long Duration Exposure Facility (LDEF). She has logged more than 261 hours in space.

BIOGRAPHICAL DATA

JEFFREY A. HOFFMAN, 47, will be Mission Specialist 3 (MS3) and serve as Payload Commander. Selected as an astronaut in January 1978, Hoffman considers Scarsdale, NY, his hometown and will be making his third space flight.

Hoffman graduated from Scarsdale High School, received a bachelor's in astronomy from Amherst College, received a doctorate in astrophysics from Harvard University and received a master's in materials science from Rice University.

Hoffman first flew on STS-51D in April 1985, a mission during which he performed a spacewalk in an attempt to rescue a malfunctioning satellite. He next flew on STS-35 in December 1990, a mission carrying the ASTRO-1 astronomy laboratory.

FRANKLIN R. CHANG-DIAZ will be Mission Specialist 4 (MS4). Selected as an astronaut in May 1980, Chang-Diaz was born in San Jose, Costa Rica, and will be making his third space flight.

Chang-Diaz graduated from Colegio De La Salle in San Jose and from Hartford High School, Hartford, CT; received a bachelor's in mechanical engineering from the University of Connecticut and received a doctorate in applied physics from the Massachusetts Institute of Technology.

Chang-Diaz first flew on STS-61C in January 1986, a mission that deployed the SATCOM KU satellite. He next flew on STS-34 in October 1989, the mission that deployed the Galileo spacecraft to explore Jupiter. Chang-Diaz has logged more than 265 hours in space.

FRANCO MALERBA, 46, will serve as Payload Specialist 1 (PS1). An Italian Space Agency payload specialist candidate, Malerba was born in Genova, Italy, and will be making his first space flight.

Malerba graduated from Maturita classica in 1965, received a bachelor's degree in electrical engineering from the University of Genova in 1970 and received a doctorate in physics from the University of Genova in 1974.

From 1978-1980, he was a staff member of the ESA Space Science Dept., working on the development and testing of an experiment in space plasma physics carried aboard the first shuttle Spacelab flight. From 1980-1989, he has held various technical and management positions with Digital Equipment Corp. in Europe, most recently as senior telecommunications consultant at the European Technical Center in France. Malerba is a founding member of the Italian Space Society.

MISSION MANAGEMENT FOR STS-46

NASA HEADQUARTERS, WASHINGTON, DC

Office of Space Flight

Jeremiah W. Pearson III	Associate Administrator
Brian O'Connor	Deputy Associate Administrator
Tom Utsman	Director, Space Shuttle

Office of Space Science

Dr. Lennard A. Fisk	Associate Administrator, Office of Space Science and Applications
Alphonso V. Diaz	Deputy Associate Administrator, Office of Space Science and Applications
George Withbroe	Director, Space Physics Division
R. J. Howard	TSS-1 Science Payload Program Manager

Office of Commercial Programs

John G. Mannix	Assistant Administrator
Richard H. Ott	Director - Commercial Development Division
Garland C. Misener	Chief, Flight Requirements and Accommodations
Ana M. Villamil	Program Manager, Centers for the Commercial Development of Space

Office of Safety and Mission Quality

Col. Federick Gregory	Associate Administrator
Dr. Charles Pellerin Jr.	Deputy Associate Administrator
Richard Perry	Director, Programs Assurance

KENNEDY SPACE CENTER, FL

Robert L. Crippen	Director
James A. "Gene" Thomas	Deputy Director
Jay F. Honeycutt	Director, Shuttle Management and Operations
Robert B. Sieck	Launch Director
Conrad G. Nagel	Atlantis Flow Director
J. Robert Lang	Director, Vehicle Engineering
Al J. Parrish	Director of Safety Reliability and Quality Assurance
John T. Conway	Director, Payload Management and Operations
P. Thomas Breakfield	Director, Shuttle Payload Operations
Joanne H. Morgan	Director, Payload Project Management
Robert W. Webster	STS-46 Payload Processing Manager

MARSHALL SPACE FLIGHT CENTER, HUNTSVILLE, AL

Thomas J. Lee	Director
Dr. J. Wayne Littles	Deputy Director
Harry G. Craft	Manager, Payload Projects Office
Billy Nunley	TSS-1 Mission Manager
Dr. Nobie Stone	TSS-1 Mission Scientist
Alexander A. McCool	Manager, Shuttle Projects Office
Dr. George McDonough	Director, Science and Engineering
James H. Ehl	Director, Safety and Mission Assurance
Otto Goetz	Manager, Space Shuttle Main Engine Project
Victor Keith Henson	Manager, Solid Rocket Booster Project
Gerald C. Ladner	Manager, External Tank Project

JOHNSON SPACE CENTER, HOUSTON, TX

Paul J. Weitz	Director (Acting)
Paul J. Weitz	Deputy Director
Daniel Germany	Manager, Orbiter and GFE Projects
Donald R. Puddy	Director, Flight Crew Operations
Eugene F. Kranz	Director, Mission Operations
Henry O. Pohl	Director, Engineering
Charles S. Harlan	Director, Safety, Reliability and Quality Assurance

STENNIS SPACE CENTER, BAY ST. LOUIS, MS

Roy S. Estess	Director
Gerald Smith	Deputy Director
J. Harry Guin	Director, Propulsion Test Operations

AMES-DRYDEN FLIGHT RESEARCH FACILITY, EDWARDS, CA

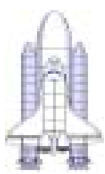
Kenneth J. Szalai	Director
T. G. Ayers	Deputy Director
James R. Phelps	Chief, Space Support Office

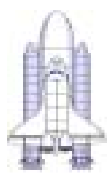
AMES RESEARCH CENTER, MOUNTAIN VIEW, CA

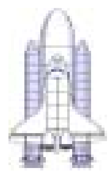
Dr. Dale L. Compton	Director
Victor L. Peterson	Deputy Director
Dr. Steven A. Hawley	Associate Director
Dr. Joseph C. Sharp	Director, Space Research

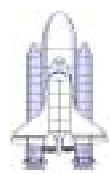
SHUTTLE FLIGHTS AS OF JUNE 1992

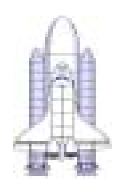
48 TOTAL FLIGHTS OF THE SHUTTLE SYSTEM -- 23 SINCE RETURN TO FLIGHT











		STS-42 01/22/92 - 01/30/92		
		STS-48 09/12/91 - 09/18/91		
STS-50 06/25/92 - 07/09/92		STS-39 04/28/91 - 05/06/91		
STS-40 06/05/91 - 06/14/91		STS-41 10/06/90 - 10/10/90	STS-45 03/24/92 - 04/02/92	
STS-35 12/02/90 - 12/10/90	STS-51L 01/28/86	STS-31 04/24/90 - 04/29/90	STS-44 11/24/91 - 12/01/91	
STS-32 01/09/90 - 01/20/90	STS-61A 10/30/85 - 11/06/85	STS-33 11/22/89 - 11/27/89	STS-43 08/02/91 - 08/11/91	
STS-28 08/08/89 - 08/13/89	STS-51F 07/29/85 - 08/06/85	STS-29 03/13/89 - 03/18/89	STS-37 04/05/91 - 04/11/91	
STS-61C 01/12/86 - 01/18/86	STS-51B 04/29/85 - 05/06/85	STS-26 09/29/88 - 10/03/88	STS-38 11/15/90 - 11/20/90	
STS-9 11/28/83 - 12/08/83	STS-41G 10/05/84 - 10/13/84	STS-51-I 08/27/85 - 09/03/85	STS-36 02/28/90 - 03/04/90	
STS-5 11/11/82 - 11/16/82	STS-41C 04/06/84 - 04/13/84	STS-51G 06/17/85 - 06/24/85	STS-34 10/18/89 - 10/23/89	
STS-4 06/27/82 - 07/04/82	STS-41B 02/03/84 - 02/11/84	STS-51D 04/12/85 - 04/19/85	STS-30 05/04/89 - 05/08/89	
STS-3 03/22/82 - 03/30/82	STS-8 08/30/83 - 09/05/83	STS-51C 01/24/85 - 01/27/85	STS-27 12/02/88 - 12/06/88	
STS-2 11/12/81 - 11/14/81	STS-7 06/18/83 - 06/24/83	STS-51A 11/08/84 - 11/16/84	STS-61B 11/26/85 - 12/03/85	
STS-1 04/12/81 - 04/14/81	STS-6 04/04/83 - 04/09/83	STS-41D 08/30/84 - 09/05/84	STS-51J 10/03/85 - 10/07/85	STS-49 05/07/92 - 05/16/92
OV-102 Columbia (12 flights)	**OV-099 Challenger (10 flights)**	**OV-103 Discovery (14 flights)**	**OV-104 Atlantis (11 flights)**	**OV-105 Endeavour (1 flight)**