

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

**SPACE SHUTTLE  
MISSION  
STS-75**

**PRESS KIT  
FEBRUARY 1996**



**TETHERED SATELLITE SYSTEM-1R (TSS-1R)  
UNITED STATES MICROGRAVITY PAYLOAD-3 (USMP-3)**

## **STS-75 INSIGNIA**

*STS075-S-001 -- The STS-75 insignia depicts the space shuttle Columbia and the Tethered Satellite connected by a 21 km electrically conduction tether. The Orbiter/satellite system is passing through the Earth's magnetic field which, like an electric generator, will produce thousands of volts of electricity. Columbia is carrying the United States Microgravity Pallet to conduct microgravity research in material science and thermodynamics. The tether is crossing the Earth's terminator signifying the dawn of a new era for space tether applications and in mankind's knowledge of the Earth's ionosphere, material science, and thermodynamics. The insignia was designed for the STS-75 crew by apace artist Mike Sanni.*

*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.*

*PHOTO CREDIT: NASA or National Aeronautics and Space Administration.*

## **NEWS MEDIA CONTACTS**

### **For Information on the Space Shuttle**

Ed Campion NASA Headquarters Washington, DC	Policy/Management	202/358-1778
Rob Navias Johnson Space Center Houston, TX	Mission Operations Astronauts	713/483-5111
Bruce Buckingham Kennedy Space Center, FL	Launch Processing KSC Landing Information	407/867-2468
June Malone Marshall Space Flight Center Huntsville, AL	External Tank Shuttle Propulsion	205/544-0034
Cam Martin Dryden Flight Research Center Edwards, CA	DFRC Landing Information	805/258-3448

### **For Information on STS-75 Experiments & Activities**

Jerry Berg Marshall Space Flight Center Huntsville, AL	TSS	205/544-0034
Mike Braukus NASA Headquarters Washington, DC	USMP	202/358-1979
Debbie Rahn Headquarters Washington, DC	International Cooperation	202/358-1639
Jim Cast NASA Headquarters Washington, DC	CPCG	202/358-1779

## CONTENTS

### **GENERAL BACKGROUND**

General News Release	5
Media Services Information	6
Quick-Look Facts	7
Shuttle Abort Modes	9
Mission Summary Timeline	10
Orbital Events Summary	11
Payload and Vehicle Weights	12
Crew Responsibilities	13

### **STS-75 PAYLOADS & ACTIVITIES**

Science Aboard STS-75	14
Tethered Satellite System-1R (TSS-1R)	15
Tethered Satellite System-1R Flight Operations	19
United States Microgravity Payload-3 (USMP-3)	22
Commercial Protein Crystal Growth (CPCG)	27

<b>STS-75 CREW BIOGRAPHIES</b>	<b>30</b>
--------------------------------	-----------

**RELEASE: 96-27**

## **REFLIGHT OF TETHERED SATELLITE HIGHLIGHTS STS-75**

NASA's second Shuttle mission of the year and the 75th in the history of the program will be highlighted by the flight of the Italian Tethered Satellite System designed to investigate new sources of spacecraft power and ways to study Earth's upper atmosphere. STS-75 also will see Columbia's seven-person crew work with the United States Microgravity Payload which continues research efforts into development of new materials and processes that could lead to a new generation of computers, electronics and metals.

The STS-75 crew will be commanded by Andrew Allen, who will be making his third Shuttle flight. Scott Horowitz will serve as pilot and will be making his first space flight. Jeff Hoffman will serve as Mission Specialist-1 and will be making his fifth flight. There will be two European Space Agency astronauts -- Maurizio Cheli and Claude Nicollier. Cheli will be serving as Mission Specialist 2, making his first flight, and Nicollier, serving as Mission Specialist-3, will be making his third flight. NASA astronaut Franklin Chang-Diaz, serving as Payload Commander and Mission Specialist-4, will be making his fifth flight. Also serving as Payload Specialist-1 for STS-75 is Umberto Guidoni, from the Italian Space Agency (ASI).

Launch of Columbia is currently targeted for February 22, 1996, at approximately 3:18 p.m. EST from Kennedy Space Center's Launch Complex 39-B. The STS-75 mission is scheduled to last 13 days, 16 hours, 14 minutes. An on-time launch on February 22 would produce a landing at Kennedy Space Center's Shuttle Landing Facility on March 7 at 7:32 a.m. EST.

The Tethered Satellite System's flight, designated TSS-1R ("R" for reflight), will be a scientific adventure aimed at understanding the possibilities for putting tether technology to work in space for a variety of applications. Tethered systems can be used to generate thrust to compensate for atmospheric drag on orbiting platforms such as the international Space Station. Deploying a tether towards Earth could place movable science platforms in hard-to-study atmospheric zones. Tethers also could be used as antennas to transmit extremely low frequency signals able to penetrate land and sea water, providing for communications not possible with standard radio. Non-electrical tethers can be used to generate artificial gravity and to boost payloads to higher orbits.

Computer-based communications traveling at the speed of light along the information superhighway have led to a revolution in the way we conduct business, and our lives. The third United States Microgravity Payload (USMP-3) continues a series of missions aimed at understanding the basic properties of materials in order to produce better semiconductors for complex computers and other high-tech electronics. USMP science also could help produce stronger metal alloys sought by the aircraft and automobile industries to improve their economic competitiveness. Millions of dollars are spent each year on ground-based studies in these areas, but on Earth, gravity overshadows or distorts many measurable results. The near-weightless environment aboard the Space Shuttle unmasks subtle physical processes, giving researchers a clearer look into the laws of nature, a perspective that cannot be seen in laboratories on Earth.

The STS-75 mission will be the 19th mission for Columbia and the 75th for the Space Shuttle system.

(END OF GENERAL RELEASE; BACKGROUND INFORMATION FOLLOWS.)

## **MEDIA SERVICES INFORMATION**

### **NASA Television Transmission**

NASA television is available through the Spacenet-2 satellite system. Spacenet-2 is located on Transponder 5, at 69 degrees West longitude, frequency 3880.0 MHz, audio 6.8 MHz.

The schedule for television transmissions from the orbiter and for mission briefings will be available during the mission at Kennedy Space Center, FL; Marshall Space Flight Center, Huntsville, AL; Dryden Flight Research Center, Edwards, CA; Johnson Space Center, Houston, TX; 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 at 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 provided 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 newscenter.

### **Briefings**

A mission press briefing schedule will be issued prior to launch. During the mission, status briefings by a flight director or mission operations representative and when appropriate, representatives from the payload team, will occur at least once each day. The updated NASA television schedule will indicate when mission briefings are planned.

### **Internet Information**

The NASA Headquarters Public Affairs Internet Home Page provides access to the STS-75 mission press kit and status reports. The address for the Headquarters Public Affairs Home Page is:

**[http://www.nasa.gov/hqpao/hqpao\\_home.html](http://www.nasa.gov/hqpao/hqpao_home.html)**

Informational materials, such as status reports and TV schedules, also are available from an anonymous FTP (File Transfer Protocol) server at **[ftp.hq.nasa.gov/pub/pao](ftp://ftp.hq.nasa.gov/pub/pao)**. Users should log on with the user name "anonymous" (no quotes), then enter their E-mail address as the password. Within the /pub/pao directory there will be a "readme.txt" file explaining the directory structure.

Pre-launch status reports from KSC are found under **[ftp.hq.nasa.gov/pub/pao/statrpt/ksc](ftp://ftp.hq.nasa.gov/pub/pao/statrpt/ksc)**, and mission status reports can be found under **[ftp.hq.nasa.gov/pub/pao/statrpt/jsc](ftp://ftp.hq.nasa.gov/pub/pao/statrpt/jsc)**. Daily TV schedules can be found under **[ftp.hq.nasa.gov/pub/pao/statrpt/jsc/tvsked](ftp://ftp.hq.nasa.gov/pub/pao/statrpt/jsc/tvsked)**.

### **Access by CompuServe**

Users with CompuServe accounts can access NASA press releases by typing "GO NASA" (no quotes) and making a selection from the categories offered.

## STS-75 QUICK LOOK FACTS

Launch Date/Site:	February 22, 1996/KSC Launch Pad 39-B
Launch Time:	3:18 PM EST
Launch Window:	2 hours, 30 minutes
Orbiter:	Columbia (OV-102), 19th flight
Orbit Altitude:	160 nautical miles
Orbit Inclination:	28.45 degrees
Mission Duration:	13 days, 16 hours, 14 minutes
Landing Date:	March 7, 1996
Landing Time:	7:32 AM EST
Primary Landing Site:	Kennedy Space Center, Florida
Abort Landing Sites:	Return to Launch Site - KSC Transoceanic Abort Sites - Ben Guerir, Morocco Moron, Spain Abort-Once Around - Edwards AFB, CA
Crew:	Andrew Allen, Commander (CDR) Scott Horowitz, Pilot (PLT) Jeff Hoffman, Mission Specialist 1 (MS 1) Maurizio Cheli, Mission Specialist 2 (MS 2) Claude Nicollier, Mission Specialist 3 (MS 3) Franklin Chang-Diaz, Mission Specialist 4 (MS 4) Umberto Guidoni, Payload Specialist 1 (PS 1)
Shifts:	Red Team: Horowitz, Cheli, Guidoni Blue Team: Nicollier, Chang-Diaz White Team: Allen, Hoffman (joins Blue team after TSS)
EVA Crew (if needed):	Franklin Chang-Diaz (EV 1), Claude Nicollier (EV 2)
Cargo Bay Payloads:	Tethered Satellite System USMP-3 OARE
In-Cabin Payloads:	Middeck Glovebox Commercial Protein Crystal Growth

## **Developmental Test Objectives/Detailed Supplementary Objectives**

DTO 301D: Ascent Structural Capability Evaluation  
DTO 307D: Entry Structural Capability  
DTO 312: External Tank Thermal Protection System Performance  
DTO 667: Portable In-Flight Landing Operations Trainer  
DTO 805: Crosswind Landing Performance  
DSO 331: Interaction of Shuttle Launch Entry Suits on Egress Locomotion  
DSO 487: Immunological Assessment of Crewmembers  
DSO 491: Characterization of Microbial Transfer Among Crewmembers  
DSO 492: In-Flight Evaluation of a Portable Clinical Blood Analyzer  
DSO 493: Monitoring Latent Virus Reactivation and Shedding in Astronauts  
DSO 802: Educational Activities  
DSO 901: Documentary Television  
DSO 902: Documentary Motion Picture Photography  
DSO 903: Documentary Still Photography

## **SHUTTLE ABORT MODES**

Space Shuttle launch abort philosophy aims toward safe and intact recovery of the flight crew, orbiter and its payload. Abort modes for STS-75 include:

- Abort-To-Orbit (ATO) -- Partial loss of main engine thrust late enough to permit reaching a minimal 105-nautical mile orbit with the orbital maneuvering system engines.
- Abort-Once-Around (AOA) -- Earlier main engine shutdown with the capability to allow one orbit of the Earth before landing at the Kennedy Space Center, FL.
- Transoceanic Abort Landing (TAL) -- Loss of one or more main engines midway through powered flight would force a landing at either Ben Guerir, Morocco; or Moron, Spain.
- Return-To-Launch-Site (RTL) -- Early shutdown of one or more engines, and without enough energy to reach a TAL site, would result in a pitch around and thrust back toward KSC until within gliding distance of the Shuttle Landing Facility.

## MISSION SUMMARY TIMELINE

### **Flight Day 1**

Launch/Ascent  
TSS Checkout and Activation  
USMP-3 Activation.

### **Flight Day 2**

TSS Pre-Deploy Checkout  
USMP-3 Operations.

### **Flight Day 3**

TSS Flyaway  
USMP-3 Operations.

### **Flight Day 4**

TSS Science Operations and Retrieval  
USMP-3 Operations.

### **Flight Day 5**

TSS Retrieval and Docking  
TSS Post- Retrieval Safing  
USMP-3 Operations.

### **Flight Day 6**

Middeck Glovebox Setup.

### **Flight Day 7-12**

USMP-3 Operations.

### **Flight Day 13**

USMP-3 Operations  
Crew News Conference.

### **Flight Day 14**

Flight Control System Checkout  
Reaction Control System Hot-Fire  
USMP-3 Deactivation  
Cabin Stow.

### **Flight Day 15**

Deorbit Prep  
Deorbit Burn  
Entry  
KSC Landing.

## STS-75 ORBITAL EVENTS SUMMARY

(Based on a Feb. 22, 1996 Launch)

<b>Event</b>	<b>MET</b>	<b>Time of Day (EST)</b>
Launch	0/00:00	3:18 PM, Feb. 22
OMS-2	0/00:42	4:00 PM, Feb. 22
TSS Flyaway	2/00:19	3:37 PM, Feb. 24
TSS On-Station	2/06:00	9:18 PM, Feb. 24
TSS Retrieve-1	3/03:30	6:48 PM, Feb. 25
TSS Docking	3/22:27	1:45 PM, Feb. 26
Crew News Conference	11/16:00	7:18 AM, March 5
Deorbit Burn	13/15:17	6:35 AM, March 7
KSC Landing	13/16:14	7:32 AM, March 7

## **PAYLOAD AND VEHICLE WEIGHTS**

	<b><u>Pounds</u></b>
Orbiter (Columbia) empty and 3 SSMEs	160,328
Tethered Satellite System	1,486
TSS Support Equipment	10,653
USMP-3 Experiments and Support Equipment	5,351
Commercial Protein Crystal Growth	57
Middeck Glovebox Experiment	395
Detailed Test/Supplementary Objectives	129
Shuttle System at SRB Ignition	4,523,663
Orbiter Weight at Landing	229,031

## CREW RESPONSIBILITIES

<b>Payloads</b>	<b>Prime</b>	<b>Backup</b>
Tethered Satellite System	Hoffman, Guidoni	Chang-Diaz, Nicollier
TSS Science	Chang-Diaz	Guidoni, Hoffman Nicollier
USMP-3 Systems	Cheli	Chang-Diaz
Middeck Glovebox	Horowitz	Chang-Diaz
Earth Observations	Nicollier	Horowitz
EVA (if needed)	Chang-Diaz (EV 1)	Nicollier (EV 2)
Intravehicular Crewmember	Hoffman	-----
TSS Rendezvous/Proximity Ops	Allen	Horowitz, Nicollier

## **SCIENCE ABOARD STS-75**

Science aboard STS-75 comes in two parts: developing and understanding the basic dynamic and electrodynamic processes governing tethered systems. The flight also will focus on improving our basic knowledge on materials under microgravity conditions.

The TSS-1R flight will explore ideas and test concepts which may be applied to spacecraft of the future. It also will lead to an increased understanding of physical processes in the near-Earth space environment. USMP-3 is a pathfinder for 21st century technologies needed to spur development of a new generation of computers, electronics and metals.

During the first two days in space, the crew will activate and perform health checks on the Tethered Satellite System and the USMP equipment. On the third flight day, the astronauts will unreel the Tethered Satellite spaceward into Earth's electrically charged upper atmosphere, known as the ionosphere, to begin a series of studies about how the two interact. The major portion of TSS investigations will be conducted on flight days two through five, although data collection will continue throughout the mission.

Also on flight day two, crew members will activate major USMP experiments. Once microgravity experiments are running, most will be remotely controlled, a mode of operation known as telepresence. Flight days five through 12 will be devoted mainly to conducting USMP investigations while the crew carries out combustion experiments in a device known as the glovebox, located in the middeck. During this time, Columbia's position will be adjusted periodically to give USMP experiments the best possible conditions based on measurement of microgravity disturbances by on-board sensors.

## **TETHERED SATELLITE SYSTEM REFLIGHT (TSS-1R)**

NASA and ASI long have planned the TSS reflight but a formal commitment awaited U.S. congressional approval for NASA to spend funds on the project. TSS originally was flown on the Space Shuttle STS-46 mission launched in July 1992. TSS deployment was curtailed when mechanical interference in the deployer reel assembly prevented full deployment of the satellite. The TSS reflight will focus on science objectives not accomplished on the STS-46 mission.

The TSS flight will be a scientific adventure aimed at understanding the possibilities for putting tether technology to work in space for many uses. TSS-1R will take advantage of the knowledge gained about tether dynamics during the first TSS mission. This mission will gather more crucial information needed to test theories for a variety of future tether applications.

For example, by reversing the direction of the current in the tether, the force caused by its interaction with Earth's magnetic field could put an object in motion, serving to boost a spacecraft's orbit without using precious fuel. Also, a satellite could be moved up and down in orbit by releasing a tethered body from a primary spacecraft to position it into a desired location. Deploying a tether downwards towards Earth could place movable science platforms in hard-to-study atmospheric zones, such as the ozone region over the South Pole.

Tethers also may be used as antennas to transmit extremely low frequency signals to Earth. Such low frequency waves can penetrate land and sea water providing for communications not possible with standard radio. Tethers could place instrumented experimental aircraft models in the region 60 to 90 miles (100 to 150 kilometers) above Earth to gain a more accurate evaluation than is possible in wind tunnels, which only partially simulate flight conditions. It may one day be possible to create artificial gravity for long-duration missions, such as the first human trip to Mars, by using tethered systems.

TSS-1R experiments support seven mission objectives:

1. Determine the amount of electrical current collected and voltage produced by the Tethered Satellite-Shuttle system as it interacts with Earth's ionospheric environment of charged gas (plasma) and its magnetic and electric fields.
2. Understand how a tethered satellite makes contact with the ionospheric plasma and how an electrical current is extracted.
3. Demonstrate electrical power generation, as a product of current and voltage, to determine how such a system could be used as a space-based power source.
4. Verify tether control and dynamics from short (1.2 mile/2 kilometer) to long (12.8 mile/20.7 kilometer) deployment ranges.
5. Demonstrate how neutral gas affects the satellite's plasma sheath and current collection, possibly enhancing tether-produced current.
6. Determine how electrical current is conducted through the near-Earth plasma by measuring waves broadcast as the tethered satellite passes over a series of ground-based receiving stations, as well as how the tether acts as a low-frequency-band antenna.
7. Learn to control tether motion by collecting data about how current flow produces force.

## **Earth's Charged-Particle Environment and the Tethered Satellite System**

TSS-1R will make use of Earth's magnetic field and electrically charged atmosphere for a variety of experiments. Just as a bar magnet produces invisible lines of force known as "field lines," so does Earth. The Sun is a ball of electrically charged, or ionized, gas known as plasma. Plasma from the Sun, the solar wind, continually rushes past Earth; most is deflected around the planet, but some penetrates Earth's upper atmosphere, creating electric fields. Lightning is a commonly seen form of plasma. More than 99 percent of matter in the universe exists in the plasma state.

Speeding through the magnetized ionospheric plasma at almost five miles per second, the Tethered Satellite should create a variety of very interesting plasma-electrodynamic phenomena. These are expected to provide unique experimental opportunities, including the ability to collect an electrical charge and drive a large-current system, generate high voltages (around 5,000 volts) across the tether, 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. While ground-based scientists are limited to small-scale experiments, Earth's ionosphere offers TSS-1R scientists a vast laboratory for space plasma experiments that cannot be conducted any other way.

The tether system consists of a five-foot (1.6-meter) diameter battery-powered satellite secured by a strong, electrically conducting cord, or tether, to the satellite support structure attached to the Shuttle orbiter. Data-gathering instruments are mounted in the Shuttle's cargo bay and middeck area, and on the satellite. During the second day on orbit, the STS-75 crew will reel the satellite out on its tether -- which looks like a long white shoelace - to about 12.5 miles (20.7 kilometers) away from the Shuttle, into the ionosphere. TSS-1R scientific instruments will allow scientists to examine the electrodynamics of the conducting tether system, as well as clarify the physical processes of the near-Earth space environment and, by extension, throughout the Solar System.

The conducting tether's generator mode will produce electrical current at a high voltage, using the same basic principle as a standard electrical generator. A small portion of the mechanical energy of the Shuttle's more than 17,500-mile-an-hour orbital motion will be converted into electrical energy as the electrically conducting metal strands in the tether's core pass through Earth's magnetic field lines.

The conductive outer skin of the Tethered Satellite will collect free electrons from the space plasma, and the resulting voltage will cause the electrons to flow down the conductive tether to the Shuttle. An electron accelerator, also called an electron gun, will then eject them back into space. Scientists expect the electrons to travel through the ionosphere to complete the loop required to close the circuit, just as a wire must close the circuit between the positive and negative poles of a car battery before current will flow. They will use a series of interdependent experiments -- conducted with 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. This also will shed light on the processes by which the circuit is completed at the satellite and the Shuttle.

### **Scientific Investigations**

Of the TSS-1R mission's 12 scientific investigations, NASA will provide six, ASI will provide five and the U.S. Air Force Phillips Laboratory will contribute one. Seven experiments include equipment that either stimulates or monitors the tether system and its environment, two will use ground-based instruments to measure electromagnetic emissions from the TSS, two will use satellite and orbiter-mounted instruments to study tether dynamics and one will provide theoretical support in the area of electrodynamics.

Only a complete set of data on plasma and field conditions can give an accurate understanding of the space environment and its interaction with the tethered system. TSS-1R science investigations are complementary

- while some instruments will measure magnetic fields, others will record particle energies and densities, and still others will map electric fields.

The Tethered Satellite System Deployer Core Equipment and Satellite Core Equipment, by Dr. Carlo Bonifazi of the ASI, Rome, will control the electrical current flowing through the tether between the satellite and the Shuttle, as well as make a number of basic electrical and physical measurements of the system.

The Research on Orbital Plasma Electrodynamics experiment, by Dr. Nobie Stone of Marshall, will study the behavior of charged particles in the ionosphere and ionized particles around the satellite under a variety of conditions. The Research on Electrodynamic Tether Effects experiment, by Dr. Marino Dobrowolny of the Italian National Research Council, Rome, will measure the electrical potential in the plasma sheath around the satellite and identify waves excited by the satellite and tether system. The goal of the Magnetic Field Experiment for TSS Missions investigation, by Prof. Franco Mariani of the Second University of Rome, will be to map the levels and fluctuations in magnetic fields around the satellite.

The Shuttle Electrodynamic Tether System investigation, by Dr. Brian Gilchrist of the University of Michigan, Ann Arbor, will study the ability of the Tethered Satellite to collect electrons by determining the current and voltage of the tethered system and measuring the resistance to current flow in the tether itself. The Shuttle Potential and Return Electron Experiment, by Dr. David Hardy of the U.S. Air Force Phillips Laboratory, Bedford, MA, will measure the charged particles around the Shuttle.

How well the Tethered Satellite -- the longest antenna ever placed in orbit -- broadcasts radio signals from space is the main goal of the Investigation of Electromagnetic Emissions for Electrodynamic Tether, by Dr. Robert Estes of the Smithsonian Astrophysical Observatory, Cambridge, MA, and the Observations at the Earth's Surface of Electromagnetic Emissions, by Dr. Giorgio Tacconi of the University of Genoa. The Tether Optical Phenomena experiment, by Dr. Stephen Mende of Lockheed Martin's Palo Alto Research Laboratory, CA, will use a hand-held low-light-level television camera operated by the crew, to provide visual data to help scientists answer questions about tether dynamics and optical effects generated by the Tethered Satellite.

The Investigation and Measurement of Dynamic Noise in the TSS, by Dr. Gordon Gullahorn of the Smithsonian Astrophysical Observatory, Cambridge, MA, and the Theoretical and Experimental Investigation of TSS Dynamics, by Prof. Silvio Bergamaschi of the Institute of Applied Mechanics, Padua University, Italy, will analyze data from a variety of instruments to examine TSS oscillations over a wide range of frequencies. The Theory and Modeling in Support of Tethered Satellite Applications, by Dr. Adam Drobot of the Science Applications International Corp., McLean, VA, will provide theoretical electrodynamic support for the mission.

## **TSS-1R Responsibilities**

TSS-1R mission responsibilities are shared between the Marshall and Johnson Centers, with ASI support at each location. Marshall provides project management, as well as system development, testing and integration. Science teams work under Marshall direction. Marshall will furnish real-time engineering support for the TSS-1R system components and tether dynamics. All remote commanding of science instruments aboard the satellite deployer and the Tethered Satellite will be executed by the Marshall Payload Operations Control team. Because of the unique interaction between the payload and the Shuttle, Mission Control in Houston is responsible for the crew's deployment and retrieval of the satellite. Mission Control also will manage the satellite in orbit and monitor the state of the instrument pallet, the deployer and the satellite. ASI will provide equipment engineering support during the mission.

## **TSS-1R Mission Management**

TSS-1R is directed by Program Manager Tom Stuart, Office of Space Flight, and Science Payload Program Manager Mike Calabrese, Office of Space Science, NASA Headquarters, Washington, DC. Responsible for project management at Marshall are Mission Manager Robert McBrayer and Mission Scientist Dr. Nobie Stone, who also serves as project scientist and co-chairman of the Investigator Working Group. The chief engineer is Tony Lavoie.

At the Italian Space Agency, Rome, Italy's TSS-1R contribution is directed by ASI Program Manager Dr. Carlo Bonifazi, also the ASI Science Program Manager. Responsible for the Project Management of the satellite and the Core Equipment are, respectively, Raffaele Battaglia and Francesco Svelto. Dr. Marino Dobrowolny is ASI Mission Scientist, with his assistant Dr. Jean Sabbagh.

## **TETHERED SATELLITE FLIGHT OPERATIONS**

The Tethered Satellite's primary scientific data will be taken during a planned 22-hour period when the satellite is extended to the maximum distance from the Shuttle and throughout the 7- to 10-hour period after the satellite has been reeled back to within approximately 1.2 miles (3.2 kilometers) of the Shuttle. Secondary science measurements will be taken before and during the 5.5-hour deployment and retrieval operations, and throughout the period when the satellite is within approximately 1.5 miles of the Shuttle.

Most activities not carried out by the crew will be controlled by command sequences stored in an onboard computer. To make the mission more flexible, however, modifications to these sequences may be uplinked, or commands may be sent in real-time to the instruments aboard the Shuttle. During the mission, teams of scientists will be stationed in the Science Operations Area at Marshall's Spacelab Mission Operations Control Center.

The responsibility for flying the Tethered Satellite, controlling the stability of the satellite, tether and Columbia, lies with the flight controllers in Mission Control at the Johnson Space Center in Houston. The primary flight control positions that will contribute to the flight of the Tethered Satellite System are the Rendezvous Guidance and Procedures (RGPO, commonly called Rendezvous) area and the Payloads area.

Rendezvous officers will oversee the dynamic phases of the 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 Rendezvous 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 and the science investigators at Marshall, where all real-time commands for science operations will originate. Columbia's crew will control the deployer reel and the satellite thrusters from onboard the Shuttle.

### **Deploy Operations**

The satellite will be deployed from Columbia 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 the deploy and retrieval operations. The orbital dynamics will result in the Tethered Satellite initially being deployed upward but at an angle of about 40 degrees behind Columbia's path.

As an electric motor at the end of the boom pulls tether off of the reel and a nitrogen gas thruster on the satellite pushes the satellite away from Columbia, the satellite will begin its journey. The deploy will begin very slowly, with the satellite eventually moving away from Columbia 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 one mile per hour. The speed of deploy will continue to increase, peaking after one and a half hours from the initial movement to about one mile per hour. At this point, when the satellite is slightly less than one mile from Columbia, the rate of deployment will be slowed briefly, a maneuver that will reduce the 40-degree angle of the satellite to the Shuttle to five degrees and will put the satellite almost directly overhead of Columbia, by the time about three miles of tether has been unwound.

When the satellite is almost 2,000 feet, or 600 meters, from Columbia, it will be allowed to begin a very slow rotation. Once the satellite reaches about 3.7 miles from the Shuttle, about two and a half hours after the start of deployment, the rotation rate will be increased by the satellite's attitude control system thrusters to a one-quarter-of-a-revolution-per-minute spin. 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 Columbia of almost 5 mph about four hours into the deployment, when the satellite is

about nine miles away. 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 five and a half hours after the initial movement, when the satellite is a little more than 12.8 miles, or 20.7 kilometers, from Columbia.

Just prior to the satellite's arrival at its most distant point, the quarter-revolution spin will be stopped briefly to measure tether dynamics. Then, a seven-tenths-of-a-revolution-per-minute spin will be imparted. At full deploy, the tension on the tether, or the pull from the satellite, is predicted to be equivalent to about 12 pounds of force.

The tether is 13.7 miles, or 22 kilometers, long, allowing an extra mile, or 1.3 kilometers, 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 will be. The dynamics and control tests that will be conducted during deploy also will aid in preparing for retrieval of the satellite and will 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, 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.

The 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; an oscillation of the tether, called a libration, resulting in a pendulum-like movement of tether and satellite; a pendulous motion of the satellite, rolling and pitching motion of 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. Some disturbances will be intentionally induced. The first test objective will be performed when the satellite is 250 yards from Columbia, and will involve small firings of the satellite's steering jets to test the response of the satellite's automatic rate damping system.

Other methods of controlling the satellite and tether motion can be performed by the crew when needed. Those methods include using visual contact with the satellite or telemetry information from it to manually stabilize TSS from aboard the Shuttle by remotely firing the satellite's attitude thrusters.

Another test will be performed when the satellite is about 2.5 miles from Columbia. Columbia's autopilot will be adjusted to allow the Shuttle to drift by as much as 10 degrees in any direction before steering jets automatically fire to maintain Columbia's 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 Columbia. The standard deadband, or degree of allowable drift, set in the Shuttle's digital autopilot for Tethered Satellite operations is two degrees of drift. Tests using the wider deadband will allow the crew and flight controllers to monitor the amount of motion the satellite and tether impart to Columbia.

When the satellite is fully deployed and on station at 12.8 miles, Columbia will perform jet firings to judge disturbances imparted to the tether and satellite at that distance. The satellite is planned to remain at that distance, called On Station-1 (OST-1), for about 22 hours. Damping of any motion which is expected to occur in the tether and satellite while at 12.8 miles and during the early portion of retrieval will be accomplished using electrical current flow through the tether. During the later stages of retrieval, damping will be accomplished using a combination of the Shuttle's steering jets, a built-in damping system at the end of the deploy boom and the satellite's steering jets.

## **Retrieval Operations**

Retrieval operations of the satellite will occur more slowly than deployment. The rate of retrieval of the tether, the closing rate between Columbia and the satellite, will build after five hours since its initial movement to a peak rate of about three miles per hour. At that point, when the satellite is about four and a half miles from Columbia, the rate of retrieval will gradually decrease, coming to a halt about five and a half hours after the start of retrieval operations when the satellite is approximately 1.5 miles from Columbia. The satellite will remain at 1.5 miles from Columbia for seven to nine hours of science operations before the final retrieval begins.

The final phase of retrieval is expected to take about two hours. A peak closing rate of closing between Columbia and the satellite of about 1.5 miles per hour will be attained just after the final retrieval begins, and the closing rate will gradually decrease 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 one mile per hour.

## UNITED STATES MICROGRAVITY PAYLOAD-3 (USMP-3)

### USMP-3 Science

Once on orbit, crew members will activate the USMP-3 experiment hardware, while science teams in the Science Operations Area of Marshall's Spacelab Mission Operations Control watch preliminary data, awaiting their turn as primary payload following TSS operations. Science teams will monitor and adjust experiments as necessary, based on data downlinked from Columbia.

#### Cargo Bay Experiments

##### **Advanced Automated Directional Solidification Furnace (AADSf)**

Principal Investigator: Dr. Archibald L. Fripp,  
NASA Langley Research Center, Langley, VA

**Objective.** The speed and the amount of information that can be stored and sent by computers and high-tech electronics, using sophisticated semiconductor materials, may be increased by better control of how the semiconductor's structure forms. Millions of dollars are invested each year in ground-based research to reach this goal. The Advanced Automated Directional Solidification Furnace (AADSf) will fly again on USMP-3 to expand upon findings from USMP-2 to help researchers develop processes and materials that perform better and cost less to produce.

A semiconductor's usefulness is determined by how atoms are ordered within the crystals underlying three-dimensional structure. These materials, when produced under the influence of gravity, often suffer structural damage that limits the crystal's usefulness. A warm fluid is less dense than a cooler sample of the same fluid, and on Earth, gravity causes the cooler, denser material to sink while the warmer fluid rises. Flows caused by this process, known as buoyancy-induced convection, as well as another undesirable phenomenon sedimentation are greatly reduced in the Shuttle's orbiting microgravity laboratory. The effects of gravity on the orbiting spacecraft are roughly a million times less than experienced on the ground.

**Procedure.** During USMP-3, the AADSf will be used to grow a crystal of lead-tin-telluride (PbSnTe), a material used to make infrared radiation detectors and lasers. This will be done by the technique known as directional solidification. This method involves cooling a molten material, causing a solid to form at one end of the sample. The solidification region grows at the point where the solid and liquid meet, known as the solid/liquid interface. This interface is moved from one end of the sample to the other at a controlled rate, resulting in a high degree of crystalline perfection.

The facility has multiple temperature zones, ranging from extremely hot above the melting point of the material (about 1600 degrees Fahrenheit/870 Celsius) to cooler zones below the melting point (about 650 degrees Fahrenheit/340 Celsius). Once a region of the crystal is melted, the sample is slowly moved and directional solidification takes place.

The solid/liquid interface is where the flows in the molten material influence the final composition and structure of the crystal sample. After the mission, scientists will analyze the solidified sample to determine the density of defects and the distribution of elements in the crystal.

### **Critical Fluid Light Scattering Experiment (Zeno)**

Principal Investigator: Dr. Robert Gammon, Institute for Physical Science and Technology,  
University of Maryland, College Park, MD

**Objective.** The Zeno investigation, named for the Greek philosopher, will explore an unusual state of matter by measuring the density of the element xenon at its critical point, a unique set of conditions when it is literally on the edge of simultaneously being in a gaseous phase and a liquid phase. More precisely, the material rapidly changes back and forth from one state to the other so that one is unable to determine the state of a given volume of material.

Scientists are interested in what happens at the critical point because these phase change phenomena are common to many different materials. Understanding how matter behaves at the critical point can provide insight into a variety of physics problems, ranging from state changes in fluids (gas to liquid) to alterations in the magnetic properties of solids. This knowledge will be valuable in a wide variety of fields, including liquid crystals, superconductors and even matter fluctuations in the early formation of the universe.

**Procedure.** Aboard the Shuttle, Zeno will measure properties of xenon a hundred times closer to its critical point than is possible on Earth. USMP-3 will use a refined procedure for approaching the critical point temperature more slowly, gradually scanning from one temperature to the next, taking advantage of the Zeno instrument's sensitivity to minute variations in fluid density that arise in microgravity. This will be done by shining laser light on a xenon sample and analyzing the resulting light scattering. At controlled temperatures extremely near the critical temperature, the fluid will be a billion times more compressible than water but will have similar density. It will change from a vapor clear as glass to a milky white fluid with a large capacity for absorbing heat, but will transport heat very slowly. Accurate measurements of a fluid's physical properties when very close to the critical point cannot be made on Earth because gravity causes the fluid to layer, with respect to density, (vapor on top, liquid below) severely at the temperatures of most significance. The orbital environment will permit measurements to be made within a few millionths of a degree of the critical temperature.

The Zeno instrument is contained within two flight modules to isolate electrical noise sources and thermal loads from the most sensitive optical and electronic subsystems in the light-scattering instrument. A precision, high-pressure sample cell will hold the xenon sample with a 100-micron- thick fluid layer for the light-scattering experiment. This cell and a compact, high-performance thermostat are the key elements in making precision measurements. The main components of the light-scattering system are housed on an optics bench.

### **Isothermal Dendritic Growth Experiment (IDGE)**

Principal Investigator: Dr. Martin Glicksman,  
Rensselaer Polytechnic Institute, Troy, NY

**Objective.** Metals manufacturing for many industrial and consumer products involves the process of solidification. Industrial materials research traditionally has tried many different things instead of developing a clear understanding of the fundamental processes involved. Microgravity research such as this will lead to manufacturing improvements in metals and alloys that display dendrite formation.

As most molten materials solidify, they form tiny pine tree-shaped crystals called dendrites, from the ancient Greek for "tree." The size, shape and direction of these crystals dictate the final properties of the resulting solid material, such as its hardness, its ability to bend without breaking and its electrical properties. On USMP-2, dendrite researchers were able to observe dendrites in the absence of convection at extremely small temperature differences below the freezing point, a phenomenon never seen on Earth. During USMP-3, the experiment will continue to build upon that foundation.

**Procedure.** The Isothermal Dendritic Growth Experiment apparatus consists of a thermostat that contains the dendrite growth chamber. The growth chamber will be filled with ultra pure succinonitrile (SCN), a substance that mimics the behavior of metals, but is transparent, thus allowing the dendrites to be easily

photographed. Dendrite growth begins by cooling a tube, known as a stinger, which is filled with the liquid and extends into the growth chamber. This causes the SCN to solidify, with a solidification front moving down the tube to the tip of the stinger and emerging into the SCN volume as an individual dendrite.

Two television cameras will allow scientists to watch for dendrites to emerge. The images of dendrites growing in space will be viewed in near-real-time by scientists on the ground. When the experiment computer detects dendrites, it will trigger two 35-millimeter cameras to photograph the samples. Researchers will compare photographs of the space- grown dendrites to evaluate growth rate and dendrite shape.

### **Materials for the Study of Interesting Phenomena of Solidification on Earth and in Orbit (MEPHISTO)**

Principal Investigator: Dr. J. J. Favier,  
Center for Nuclear Study, Grenoble, France

**Objective.** The investigation known as MEPHISTO is a cooperative program between NASA, the French Space Agency and the French Atomic Energy Commission, with the goal of understanding how gravity-driven convection affects the production of metals, alloys and electronic materials. MEPHISTO flew on both previous USMP missions. Analyses of samples produced on orbit are being conducted by science and technical teams to improve processes for making products ranging from alloys for airplane turbine blades to electronic materials. This third flight of MEPHISTO will continue the investigation into how material solidifies in microgravity. Ultimately, the MEPHISTO experiments may bring dramatic improvements in materials production.

Researchers want to know what happens at the boundary between solid and liquid the solid/liquid interface during solidification of a molten material, to better control this process on Earth. Temperature differences at this boundary can cause fluid movements that affect the structure and properties of the solidified product through convection and sedimentation. In microgravity, sedimentation and buoyancy-induced convection are greatly reduced, so researchers can explore underlying processes that normally are masked by gravity.

**Procedure.** The MEPHISTO furnace aboard USMP-3 will repeatedly process three samples of a tin-bismuth alloy using directional solidification, a common method for growing crystalline materials such as metals and semiconductors. As the solidified region grows, the boundary between the solid and liquid material will move from one end of the sample toward the other. Electrical measurements will gauge temperature variations in the solidification front. These temperature variations are indicative of the stability of the interface which is very important in controlling the properties of the material in its solid state. The shape of the front will be marked in the growing crystal by subjecting the sample to electric-current pulses.

Researchers will compare results produced on orbit with those produced on the ground to better understand and expand theories of materials, materials processing and the potential that the microgravity environment offers for research in areas with down-to-Earth applications.

## Measuring the Microgravity Environment of the Orbiting Shuttle

### Space Acceleration Measurement Systems (SAMS)

Project Scientist: Richard DeLombard,  
NASA Lewis Research Center, Cleveland, OH

**Objective.** When the Space Shuttle is in orbit, the effects of gravity are reduced by close to one million times. However, disturbances happen when crew members move about and equipment is operated, as well as when the Shuttle maneuvers by firing thrusters and even when it experiences subtle atmospheric drag. USMP-3 scientists will depend on measurements of minute changes in the orbital environment to tweak their experiments and improve scientific data collection, as well as to determine how such vibrations or accelerations influence experiment results. Future mission designs also will benefit from Space Acceleration Measurement System data.

**Procedure.** The system accurately measures the orbital environment via five sensors, called "accelerometers," placed throughout the Shuttle. Microgravity profiles are transmitted to the ground through the Shuttle's communications system. These data also are recorded on optical disks for post-flight analysis.

### Orbital Acceleration Research Experiment (OARE)

Project Scientist: Richard DeLombard,  
NASA Lewis Research Center, Cleveland, OH

**Objective.** In the past, the Orbital Acceleration Research Experiment has helped scientists obtain data to make the best possible use of the low-gravity environment. While the orbiting Shuttle offers a remarkably stable ride for space-based experiments, it does experience some low-level disturbances from the Shuttle's orientation, atmospheric drag and venting of liquids or gases, among others. USMP-3 experiments will use this acceleration data to complement the data provided by the Space Acceleration Measurement System and improve research results.

**Procedure.** The heart of the OARE instrument is a miniature electrostatic accelerometer that accurately measures low-frequency on-orbit acceleration disturbances. The Shuttle's flight attitude can be changed to satisfy the needs of any particular experiment based on information measured, processed, stored and downlinked in near real-time.

### Middeck Glovebox Facility (MGBX) Combustion Investigations

MGBX Project Scientist: Dr. Donald Reiss,  
NASA Marshall Space Flight Center, Huntsville, AL

Three combustion investigations will be conducted in the Middeck Glovebox Facility. The glovebox facility is a contained space where potentially hazardous materials can be handled and crew members can perform operations that are impractical in the open cabin environment. This glovebox was developed to provide such capabilities in the Shuttle middeck and for future use on the international Space Station. The facility provides power, air and particle filtration, light, data collection, real-time monitoring, and sensors for gas, temperature, air pressure and humidity. For each experiment, a crew member will remove the experiment kit from stowage and place it through the glovebox door, then tightly seal the opening. Using gloves that project into the facility, a crew member will set up the experiment and conduct it in this safe enclosure.

### **Forced-Flow Flamespreading Test (FFFT)**

Investigator: Kurt R. Sacksteder,  
NASA Lewis Research Center, Cleveland, OH

**Objective.** On Earth, gravity causes air motion known as buoyant convection the rising of hot air and falling of cool air. Scientists who study combustion want to know the details of how air motion affects flame spreading, to be able to better control fires that may occur on orbit. When a fire starts on Earth, flames spread due to the movement of air around and through the flames. Air motion provides oxygen for the chemical reactions in the flame, removes combustion products (some toxic), and controls how the heat released in the flame is distributed.

**Procedure.** A crew member will place small solid fuel samples (flat paper and cellulose cylinders) into the test module; seal the module in the Middeck Glovebox; establish air flow; heat, then ignite the fuel sample; and record the results on video and film for later study. Gas samples will be extracted from the combustion products. Researchers on the ground will watch downlinked video of the flame and temperature displays to analyze early results and possibly change subsequent test runs.

### **Radiative Ignition and Transition to Spread Investigation (RITSI)**

Investigator: Dr. Takashi Kashiwagi,  
National Institute for Standards and Testing, Gaithersburg, MD

**Objective.** Fires in spacecraft pose a significant threat. A short-circuit in an electrical system or overheated electrical components could ignite flammable material. Toxic gases can quickly poison the air, and fire extinguishers can damage critical equipment. To prevent and control fires on orbit, the conditions that lead up to ignition must be understood.

**Procedure.** The experiment apparatus consists of a flow duct with screens at both ends and a fan that pulls air through the duct. The clear lid of the duct opens for access to the sample holder to change out samples of ashless filter paper. A high-intensity lamp will be focused on the sample to preheat and then ignite it. The crew member will use a small control box attached to the outside of the glovebox to perform the experiment. During operations, Dr. Kashiwagi's team will monitor the experiment. Between tests, downlinked data will be analyzed to recommend conditions for subsequent tests.

### **Comparative Soot Diagnostics (CSD)**

Investigator: Dr. David L. Urban,  
NASA Lewis Research Center, Cleveland, OH

**Objective.** An understanding of soot processes in flames produced in microgravity will contribute to our ability to predict fire behavior on Earth. However, no soot measurements have been made of quasi-steady, microgravity flames. The Comparative Soot Diagnostics experiment will provide the first such measurements and will provide data useful for understanding soot processes on Earth. Since fire detector systems currently flown on the Shuttle and scheduled for use on the international Space Station have not been tested for quasi-steady, low-gravity sources of minute particles, this data will be studied for its applicability to the design and operation of future spacecraft smoke detection systems.

**Procedure.** The experiment will examine particle formation from a variety of sources, including a candle and four overheated materials paper, silicone rubber, and wires coated with Teflon and Kapton. These materials are found in crew cabins, and silicone rubber is an industrial product. The apparatus consists of two modules, one installed inside the glovebox and the other attached to the outside of the glovebox. After running a self-diagnostic procedure on the smoke detectors in the internal module, the crew member performing this experiment will activate a video camera and turn on an igniter. A probe will sample the soot when flames are well developed.

## COMMERCIAL PROTEIN CRYSTAL GROWTH (CPCG)

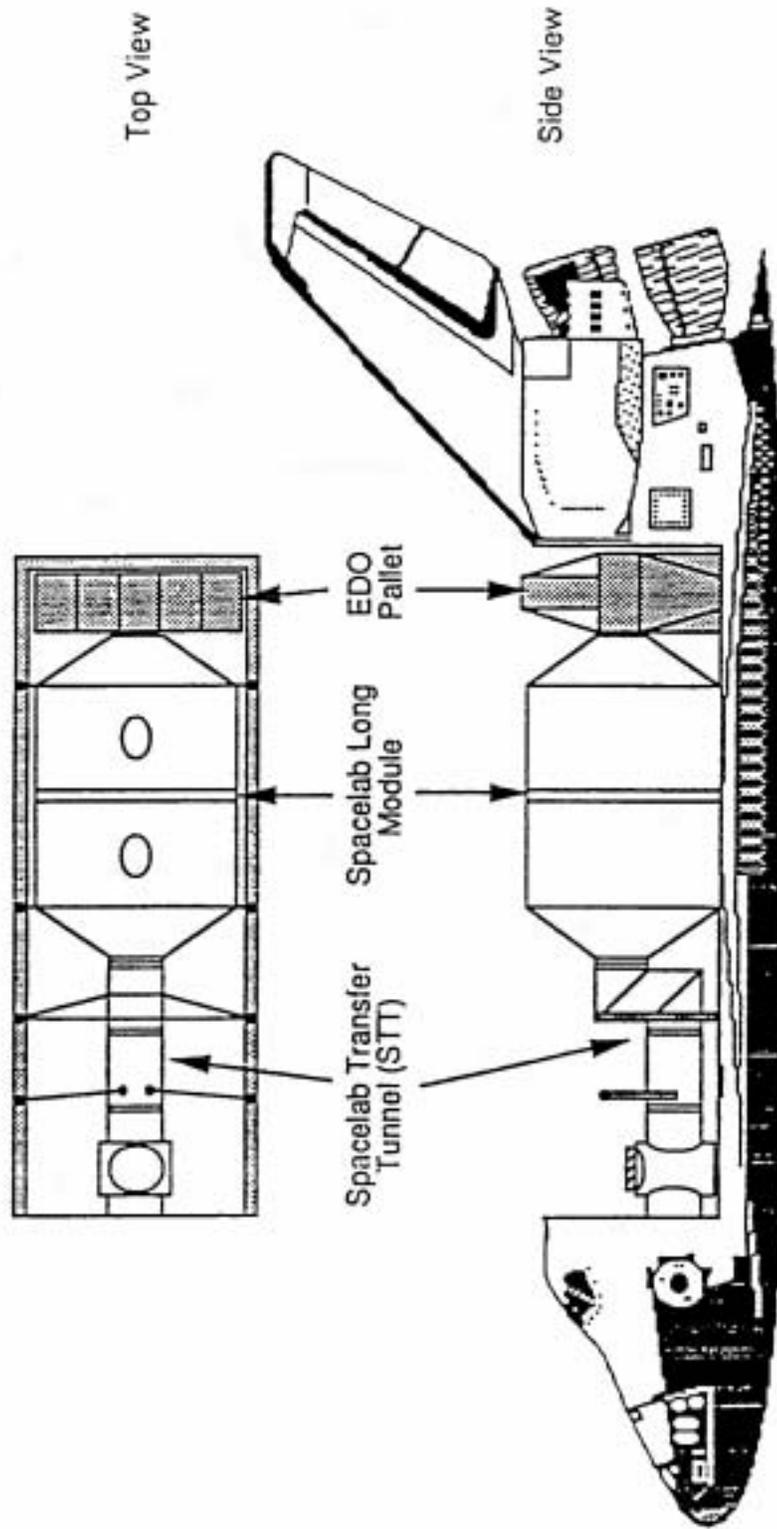
STS-75 includes a flight of the Commercial Protein Crystal Growth systems identified as CPCG-09. This payload will process nine different proteins seeking the development of new therapeutic treatments for infections, human cancers, diseases caused from hormone disorders, and Chagas disease.

Columbia will carry into space the first joint U.S.- Latin American experiment in protein crystal growth. The project, conceived in March 1993, brings together a small team of investigators from Costa Rica, Chile and the United States. It involves the crystallization in microgravity of ultrapure samples of Tripanothione Reductase, a DNA-grown protein expressing key features of the *Tripanosoma Cruzi*, the parasite that causes Chagas Disease. The experiment will seek to determine the structure of this protein through crystallographic studies of the crystals obtained in space. The high resolution resulting from the space grown crystals could pave the way for the development of effective pharmaceuticals to combat this debilitating disease and lead, some day, to an effective vaccine.

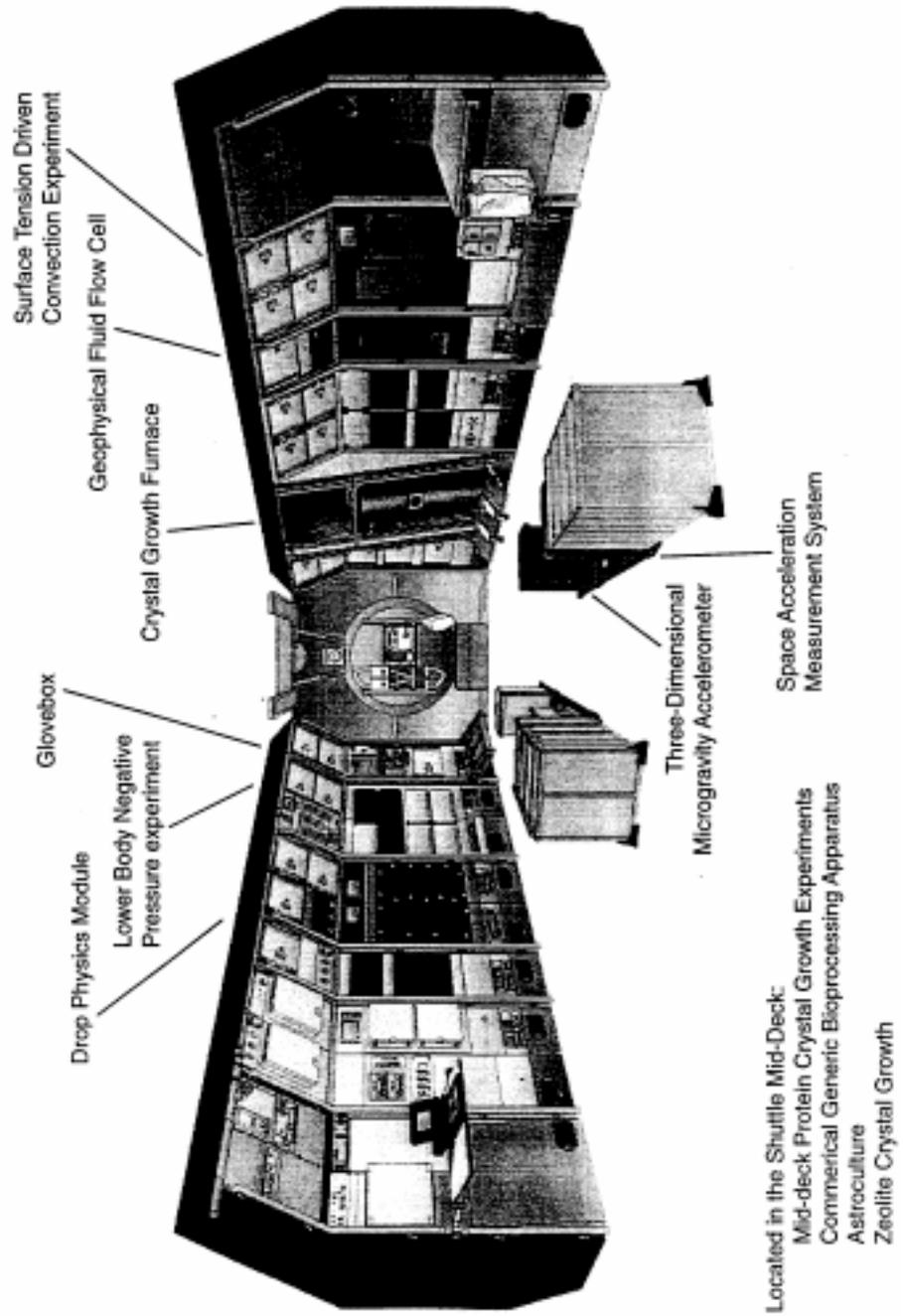
The CPCG-09 payload was developed by the CMC, which was formed in 1985 as a NASA Center for the Commercial Development of Space. The CMC's objective is to form partnerships with industrial groups and other government agencies who are pursuing commercial applications of macromolecular crystallography relating to structure-based drug design. This is a drug discovery methodology based on inhibiting or enhancing the biological activity of macromolecules, or proteins, responsible for various diseases. Protein crystallography, using X-ray diffraction, is the lead technique whereby the three-dimensional molecular structure of a protein disease target is established. Protein structural information leads to the discovery and synthesis of complementary compounds that can become potent drugs specifically directed against the disease target. Structure-based drug design is a productive and cost-effective targeted drug development strategy.

CPCG-09 will be the CMC's 29th space flight, and will use the CMC's newly developed Commercial Vapor Diffusion Apparatus (CVDA). Analysis of the results of previous CMC missions has shown that techniques have produced proteins crystals of significantly higher quality than ever grown on Earth before. The CMC has developed over ten pieces of flight hardware specifically for the support of microgravity investigations in protein crystal growth. These systems use vapor diffusion, temperature induction, and batch mixing techniques and certain pieces of hardware have been augmented with instrumentation for localized temperature, light scattering, and video monitoring. The newest addition to the crystal growth hardware inventory, the Commercial Vapor Diffusion Apparatus (CVDA), was designed, developed, and manufactured by the CMC. The CVDA can accommodate 128 protein samples. The flight of CPCG-09 is sponsored by the Space Processing Division of the Office of Space Access and Technology, as part of NASA's commercial development of space program.

# USML-2 PAYLOAD CONFIGURATION



## USML-2 Spacelab Rack Assignments



## STS-75 CREWMEMBERS



*STS075-S-002 -- With their major payload as the backdrop, members of the STS-75 crew pose for the traditional crew portrait. The crew will deploy and work with the Tethered Satellite System (TSS-1 R). Seated at center are astronauts Scott J. Horowitz (left), pilot; and Andrew M. Allen, commander. Astronaut Franklin R. Chang-Diaz (front right) is payload commander. In the rear are (left to right) European Space Agency (ESA) astronaut Maurizio Cheli, mission specialist; payload specialist Umberto Guidoni of the Italian Space Agency (ASI); Jeffrey A. Hoffman and ESA astronaut Claude Nicollier, mission specialists.*

*No copyright is asserted for this photograph. If a recognizable person appears in the photo, use for commercial purposes may infringe a right of privacy or publicity. It may not be used to state or imply the endorsement by NASA or by any NASA employee of a commercial product, process or service, or used in any other manner that might mislead. Accordingly, it is requested that if this photograph is used in advertising and other commercial promotion, layout and copy be submitted to NASA prior to release.*

*PHOTO CREDIT: NASA or National Aeronautics and Space Administration.*

## **BIOGRAPHICAL DATA**

### **Andrew M. Allen (Lieutenant Colonel, USMC) NASA Astronaut**

**BIRTHPLACE AND DATE:** Born August 4, 1955, in Philadelphia, PA. His father, Charles A. Allen, resides in Richboro, PA. His mother, Loretta T. Allen, is deceased.

**EDUCATION:** Graduated from Archbishop Wood High School, Warminster, PA, in 1973; received a bachelor of science degree in mechanical engineering from Villanova University in 1977.

**CHILDREN:** Jessica Marie, July 19, 1985; Meredith Frances, January 9, 1990.

**SPECIAL HONORS:** Recipient of the Defense Superior Service Medal, the Single Mission Air Medal, the NASA Exceptional Service Medal, the NASA Space Flight Medal, and an honorary Doctorate of Public Service from Bucks County Community College (PA) in 1993.

**EXPERIENCE:** Allen was a member of the Navy ROTC unit and received his commission in the United States Marine Corps at Villanova University in 1977. Following graduation from flight school, he flew F-4 Phantoms from 1980 to 1983 with VMFA-312 at Marine Corps Air Station (MCAS) Beaufort, SC, and was assigned as the Aircraft Maintenance Officer. He was selected by Headquarters Marine Corps for fleet introduction of the F/A-18 Hornet, and was assigned to VMFA-531 in MCAS El Toro, California, from 1983 to 1986. During his stay in VMFA-531, he was assigned as the squadron Operations Officer, and also attended and graduated from the Marine Weapons & Tactics Instructor Course, and the Naval Fighter Weapons School (Top Gun). A 1987 graduate of the United States Navy Test Pilot School at Patuxent River, MD, he was a test pilot under instruction when advised of his selection to the astronaut program.

He has logged over 4,500 flight hours in more than 30 different aircraft.

**NASA EXPERIENCE:** Selected by NASA in June 1987, Allen became an astronaut in August 1988. His technical assignments have included: Astronaut Office representative for all Space Shuttle issues related to landing sites, landing and deceleration hardware, including improvements to nosewheel steering, brakes and tires, and drag chute design; Shuttle Avionics Integration Laboratory (SAIL), which oversees, checks, and verifies all Shuttle flight control software and avionics programs; served as Technical Assistant to the Flight Crew Operations Director who is responsible for and manages all flight crew operations and support; was the lead of the Astronaut Support Personnel team which oversee Shuttle test, checkout, and preparation at Kennedy Space Center; served as Special Assistant to the Director of the Johnson Space Center in Houston, Texas; was lead of a Functional Workforce Review at the Kennedy Space Center, Florida, to determine minimal workforce and management structure requirements which allow maximum budget reductions while safely continuing Shuttle Flight Operations. A veteran of two space flights, Allen has logged over 526 hours in space. He was the pilot on STS-46 in 1992, and STS-62 in 1994. Allen is assigned to command the STS-75 mission, a 13-day flight scheduled for launch in early 1996.

## BIOGRAPHICAL DATA

### **Scott J. "Doc" Horowitz, Ph.D. (Lieutenant Colonel, USAF) NASA Astronaut**

**BIRTHPLACE AND DATE:** Born March 24, 1957, in Philadelphia, PA, but considers Thousand Oaks, CA, to be his hometown. His father, Seymour B. Horowitz, resides in Thousand Oaks, CA. His mother, Iris D. Chester, resides in Santa Monica, CA.

**EDUCATION:** Graduated from Newbury Park High School, Newbury Park, CA, in 1974; received a bachelor of science degree in engineering from California State University at Northridge in 1978; a master of science degree in aerospace engineering from Georgia Institute of Technology in 1979; and a doctorate in aerospace engineering from Georgia Institute of Technology in 1982.

**MARITAL STATUS:** Married to the former Lisa Marie Kern. Her parents, Frank and Joan Ecker, reside in Briarwood, NY.

**SPECIAL HONORS:** USAF Test Pilot School Class 90A Distinguished Graduate (1990); Combat Readiness Medal (1989); Air Force Commendation Medals (1987, 1989); F-15 Pilot, 22TFS, Hughes Trophy (1988); F-15 Pilot, 22TFS, CINCUSAFE Trophy; Mission Ready in the F-15 Eagle at Bitburg Air Base (1987); Systems Command Quarterly Scientific & Engineering Technical Achievement Award (1986); Master T-38 Instructor Pilot (1986); Daedalean (1986); 82nd Flying Training Wing Rated Officer of the Quarter (1986); Outstanding Young Men In America (1985); Outstanding T-38 Instructor Pilot (1985); Outstanding Doctoral Research Award for 1981-82 (1982); Sigma Xi Scientific Research Society (1980); Tau Beta Pi Engineering Honor Society (1978); 1st Place ASME Design Competition.

**EXPERIENCE:** Following graduation from Georgia Tech in 1982, Scott worked as an associate scientist for the Lockheed-Georgia Company, Marietta, GA, where he performed background studies and analyses for experiments related to aerospace technology to validate advanced scientific concepts. In 1983, he graduated from Undergraduate Pilot Training at Williams Air Force Base, AZ. From 1984 to 1987, he flew as a T-38 instructor pilot and performed research and development for the Human Resources Laboratory at Williams Air Force Base. The following two years were spent as an operational F-15 Eagle Fighter Pilot in the 22nd Tactical Fighter Squadron stationed at Bitburg Air Base in Germany. In 1990, Scott attended the United States Air Force Test Pilot School at Edwards Air Force Base, CA, and was subsequently assigned as a test pilot flying A-7s and T-38s for the 6512th Test Squadron at Edwards. Additionally, from 1985 to 1989, Scott served as an adjunct professor at Embry Riddle University where he conducted graduate level courses in aircraft design, aircraft propulsion and rocket propulsion. In 1991, as a professor for California State University, Fresno, he conducted graduate level courses in mechanical engineering including advanced stability and control.

**NASA EXPERIENCE:** Selected by NASA in March 1992, Scott reported to the Johnson Space Center in August 1992. He completed one year of training and is qualified for selection as a pilot on Space Shuttle flight crews. Scott is currently working technical issues for the Operations Development Branch of the Astronaut Office.

## BIOGRAPHICAL DATA

### **Jeffrey A. Hoffman (Ph.D.) NASA Astronaut**

**BIRTHPLACE AND DATE:** Born November 2, 1944, in Brooklyn, New York, but considers Scarsdale, New York, to be his hometown. His parents, Dr. and Mrs. Burton P. Hoffman, are residents of White Plains, New York.

**EDUCATION:** Graduated from Scarsdale High School, Scarsdale, New York, in 1962; received a bachelor of arts degree in astronomy (graduated summa cum laude) from Amherst College in 1966, a doctor of philosophy in astrophysics from Harvard University in 1971, and a masters degree in materials science from Rice University in 1988.

**MARITAL STATUS:** Married to the former Barbara Catherine Attridge of Greenwich, London, England. Her father, Mr. Frederick J. C. Attridge, resides in Kidbrooke, London, England.

**CHILDREN:** Samuel L., May 3, 1975; Orin P. F., April 30, 1979.

**SPECIAL HONORS:** Awarded the Amherst College 1963 Porter Prize in Astronomy, 1964 Second Walker Prize in Mathematics, 1965 John Summer Runnells Scholarship Prize, and 1966 Stanley V. and Charles B. Travis Prize and Woods Prize for Scholarship. Elected to Phi Beta Kappa in 1965 and Sigma Xi in 1966. Also received a Woodrow Wilson Foundation Pre- Doctoral Fellowship, 1966-67; a National Science Foundation Pre-Doctoral Fellowship, 1966-71; a National Academy of Sciences Post-Doctoral Visiting Fellowship, 1971-72; a Harvard University Sheldon International Fellowship, 1972-73; and a NATO Post-Doctoral Fellowship, 1973-74. Dr. Hoffman was awarded NASA Space Flight Medals in 1985, 1991, 1992 and 1994, NASA Exceptional Service Medals in 1988 and 1992, and the NASA Distinguished Service Medal in 1994.

**EXPERIENCE:** Dr. Hoffman's original research interests were in high-energy astrophysics, specifically cosmic gamma ray and x-ray astronomy. His doctoral work at Harvard was the design, construction, testing, and flight of a balloon-borne, low-energy, gamma ray telescope.

From 1972 to 1975, during 3 years of post-doctoral work at Leicester University, he worked on three rocket payloads, two for the observation of lunar occultations of x-ray sources and one for an observation of the Crab Nebula with a solid state detector and concentrating x-ray mirror. He designed and supervised the construction and testing of the lunar occultation payloads and designed test equipment for use in an x-ray beam facility which he used to measure the scattering and reflectivity properties of the concentrating mirror. During his last year at Leicester, he was project scientist for the medium-energy x-ray experiment on the European Space Agency's EXOSAT satellite and played a leading role in the proposal and design studies for this project.

He worked in the Center for Space Research at the Massachusetts Institute of Technology (MIT) from 1975 to 1978 as project scientist in charge of the orbiting HEAO-1 A4 hard x-ray and gamma ray experiment, launched in August 1977. His involvement included pre-launch design of the data analysis system, supervising its operation post-launch, and directing the MIT team undertaking the scientific analysis of flight data being returned. He was also involved extensively in analysis of x-ray data from the SAS-3 satellite being operated by MIT, performing research on the study of x-ray bursts. Dr. Hoffman has authored or co-authored more than 20 papers on this subject since bursts were first discovered in 1976.

**NASA EXPERIENCE:** Selected by NASA in January 1978, Dr. Hoffman became an astronaut in August 1979. During preparations for the Shuttle Orbital Flight Tests, Dr. Hoffman worked in the Flight Simulation Laboratory at Downey, California, testing guidance, navigation and flight control systems. He has worked with the orbital maneuvering and reaction control systems, with Shuttle navigation, with crew

training, and with the development of satellite deployment procedures. Dr. Hoffman served as a support crew member for STS-5 and as a CAPCOM (spacecraft communicator) for STS-8. Dr. Hoffman has been the Astronaut Office Payload Safety Representative. He has also worked on EVA, including the development of a high-pressure spacesuit for use on the Space Station. Dr. Hoffman is a member of the Astronaut Office Science Support Group.

Dr. Hoffman made his first space flight as a mission specialist on STS 51-D, April 12-19, 1985, on the Shuttle Discovery. On this mission, he made the first STS contingency space walk, in an attempted rescue of a malfunctioning satellite.

Dr. Hoffman made his second space flight as a mission specialist on STS-35, December 2-10, 1990, on the Shuttle Columbia. This Spacelab mission featured the ASTRO-1 ultraviolet astronomy laboratory, a project on which Dr. Hoffman had worked since 1982.

Dr. Hoffman made his third space flight as payload commander and mission specialist on STS-46, July 31-August 8, 1992, on the Shuttle Atlantis. On this mission, the crew deployed the European Retrievable Carrier (EURECA), an ESA- sponsored free-flying science platform, and carried out the first test flight of the Tethered Satellite System (TSS), a joint project between NASA and the Italian Space Agency. Dr. Hoffman had worked on the Tethered Satellite project since 1987.

Dr. Hoffman made his fourth flight as an EVA crew member on STS-61, December 2-13, 1993, on the Shuttle Endeavour. During this flight, the Hubble Space Telescope (HST) was captured, serviced, and restored to full capacity through a record five space walks by four astronauts.

With the completion of his fourth space flight, Dr. Hoffman has logged more than 834 hours and 15 million miles in space.

## **BIOGRAPHICAL DATA**

### **Maurizio Cheli ESA Astronaut**

**BIRTHPLACE AND DATE:** Born May 4, 1959, in Modena, Italy. His parents, Araldo and Eulalia Cheli, reside in Zocca (Modena), Italy.

**EDUCATION:** Graduated from the Italian Air Force Academy in 1982. Studied geophysics at University of Rome in 1989. He received a master of science in Aerospace Engineering from the University of Houston.

**MARITAL STATUS:** Married to the former Marianne Merchez. Her parents, Marcel and Annie Merchez, reside in Brussels, Belgium.

**SPECIAL HONORS:** Top graduate, Italian Air Force War College (1987); top graduate, Empire Test Pilot School, Boscombe Down, United Kingdom (1988).

**EXPERIENCE:** After graduation from the Italian Air Force Academy, Cheli underwent pilot training at Vance Air Force Base, Oklahoma, in 1982-1983. Following fighter lead-in training at Holloman Air Force Base, New Mexico and initial training in the F-104G in Italy, he joined the 28th Squadron, 3rd Recce Wing in 1984. In 1987, he attended the Italian Air Force War College and in 1988 he graduated from the Empire Test Pilot's School, Boscombe Down, United Kingdom. While assigned to the Italian Air Force Flight Test Center in Pratica di Mare, Rome, he served as a Tornado and B-707 Tanker project pilot on a variety of test programs. His flight experience includes over 3,000 flying hours in over 50 different types of fixed wing aircraft and helicopters. In June 1992, he was selected by the European Space Agency for astronaut training.

Cheli holds a commission as Lieutenant Colonel in the Italian Air Force.

**NASA EXPERIENCE:** Cheli reported to the Johnson Space Center in August 1992 and completed one year of training in August 1993. He is qualified for assignment as a mission specialist on future Space Shuttle flight crews. His technical assignments to date include: flight software verification in the Shuttle Avionics Integration Laboratory (SAIL); remote manipulator system/robotics; crew equipment.

## **BIOGRAPHICAL DATA**

### **Claude Nicollier ESA Astronaut**

**BIRTHPLACE AND DATE:** Born September 2, 1944, in Vevey, Switzerland. His father, Mr. Georges Nicollier, resides in La Tour de Peilz, Switzerland.

**EDUCATION:** Graduated from Gymnase de Lausanne (high school), Lausanne, Switzerland, in 1962; received a bachelor of science in physics from the University of Lausanne in 1970 and a master of science degree in astrophysics from the University of Geneva in 1975. Also graduated as a Swiss Air Force pilot in 1966, an airline pilot in 1974, and a test pilot in 1988.

**MARITAL STATUS:** Married to the former Susana Perez of Monterrey, Mexico. Her parents, Mr. and Mrs. Jose L. Perez, reside in Guadalajara, Mexico.

**CHILDREN:** Maya, July 19, 1974; and Marina, June 15, 1978.

**SPECIAL HONORS:** Two NASA Space Flight Medals (1992 & 1993), Prix d'honneur de la Fondation Pro Aero, Switzerland (1992), Yuri Gagarin Gold Medal from the International Aeronautical Federation (1994), Silver Medal from the Academie Nationale de l'Air et de l'Espace, France (1994), Collier Trophy (awarded to the crew of STS-61) from the National Aeronautics Association (1994), Prix de l'Universite de Lausanne (1994), honorary doctorates from the Swiss Federal Institute of Technology, Lausanne, and the Geneva University (both in 1994). Appointed professor at the Swiss Federal Institute of Technology, Lausanne, in November 1994.

**EXPERIENCE:** From 1970 to 1973, Claude worked as a graduate scientist with the Institute of Astronomy at Lausanne University and at the Geneva Observatory. He then joined the Swiss Air Transport School in Zurich and was assigned as a DC-9 pilot for Swissair, concurrently participating part-time in research activities of the Geneva Observatory. At the end of 1976 he accepted a Fellowship at the European Space Agency's (ESA) Space Science Department at Noordwijk, Netherlands, where he worked as a research scientist in various airborne infrared astronomy programs. In July 1978 he was selected by ESA as a member of the first group of European astronauts. Under agreement between ESA and NASA he joined the NASA astronaut candidates selected in May 1980 for astronaut training as a mission specialist.

His technical assignments in the Astronaut Office have included flight software verification in the Shuttle Avionics Integration Laboratory (SAIL), participation in the development of retrieval techniques for the Tethered Satellite System (TSS), Remote Manipulator System(RMS), and International Space Station (ISS) robotics support. During 1988 he attended the Empire Test Pilot School in Boscombe Down, England, from where he graduated as a test pilot in December 1988.

Claude holds a commission as captain in the Swiss Air Force and, during leave periods in Switzerland, maintains proficiency in the Northrop F-5E aircraft. He has logged 5,300 hours flying time--including 3,700 hours in jet aircraft.

A veteran of two space flights, Claude has logged more than 451 hours in space. He flew on STS-46 in 1992, and STS- 61 in 1993.

## BIOGRAPHICAL DATA

### **Franklin R. Chang-Diaz (Ph.D.)**

#### **NASA Astronaut**

**BIRTHPLACE AND DATE:** Born April 5, 1950, in San Jose, Costa Rica, to the late Mr. Ramon A. Chang-Morales and Mrs. Maria Eugenia Diaz De Chang. His mother resides in Costa Rica.

**EDUCATION:** Graduated from Colegio De La Salle in San Jose, Costa Rica, in November 1967, and from Hartford High School in Hartford, CT, in 1969; received a bachelor of science degree in mechanical engineering from the University of Connecticut in 1973 and a doctorate in applied plasma physics from the Massachusetts Institute of Technology (MIT) in 1977.

**MARITAL STATUS:** Married to the former Peggy Marguerite Doncaster of Alexandria, LA.

**CHILDREN:** Jean E., December 22, 1973; Sonia R., March 31, 1978; Lidia A., March 1, 1988; and Miranda K., July 9, 1995.

**SPECIAL HONORS:** Recipient of the University of Connecticut's Outstanding Alumni Award (1980); NASA Space Flight Medal (1986); the Liberty Medal from President Ronald Reagan at the Statue of Liberty Centennial Celebration in New York City (1986); the Medal of Excellence from the Congressional Hispanic Caucus (1987); NASA Exceptional Service Medals (1988, 1990, 1993); American Astronautical Society Flight Achievement Award (1989); NASA Space Flight Medals (1986, 1989, 1992, 1994). Outstanding Technical Contribution Award, Hispanic Engineer National Achievement Awards Conference (1993). Awarded the Cross of the Venezuelan Air Force by President Jaime Lusinchi during the 68th Anniversary of the Venezuelan Air Force in Caracas, Venezuela (1988). Recipient of three Honoris Causa Doctorates: Doctor of Science from the Universidad Nacional de Costa Rica; Doctor of Science from the University of Connecticut and Doctor of Law from Babson College. Also Honorary faculty from the College of Engineering of the University of Costa Rica. Honorary Citizenship from the government of Costa Rica (April 1995). This is the highest honor Costa Rica confers to a foreign citizen, making him the first such honoree who was actually born there.

**EXPERIENCE:** While attending the University of Connecticut, he also worked as a research assistant in the Physics Department and participated in the design and construction of high energy atomic collision experiments. Following graduation in 1973, he entered graduate school at MIT, becoming heavily involved in the United States' controlled fusion program and doing intensive research in the design and operation of fusion reactors. He obtained his doctorate in the field of applied plasma physics and fusion technology and, in that same year, joined the technical staff of the Charles Stark Draper Laboratory. His work at Draper was geared strongly toward the design and integration of control systems for fusion reactor concepts and experimental devices, in both inertial and magnetic confinement fusion. In 1979, he developed a novel concept to guide and target fuel pellets in an inertial fusion reactor chamber. More recently he has been engaged in the design of a new concept in rocket propulsion based on magnetically confined high temperature plasmas. As a visiting scientist with the M.I.T. Plasma Fusion Center from October 1983 to December 1993, he led the plasma propulsion program there to develop this technology for future human missions to Mars. In December 1993, Dr. Chang-Diaz was appointed Director of the Advanced Space Propulsion Laboratory at the Johnson Space Center where he continues his research on plasma rockets. He is an Adjunct Professor of Physics at the University of Houston and has presented numerous papers at technical conferences and in scientific journals.

In addition to his main fields of science and engineering, he worked for 2-1/2 years as a house manager in an experimental community residence for de-institutionalizing chronic mental patients, and was heavily involved as an instructor/advisor with a rehabilitation program for Hispanic drug abusers in Massachusetts.

**NASA EXPERIENCE:** Selected by NASA in May 1980, Dr. Chang- Diaz became an astronaut in August 1981. While undergoing astronaut training he was also involved in flight software checkout at the Shuttle Avionics Integration Laboratory (SAIL), and participated in the early Space Station design studies. In late 1982 he was designated as support crew for the first Spacelab mission and, in November 1983, served as on orbit capsule communicator (CAPCOM) during that flight. From October 1984 to August 1985 he was leader of the astronaut support team at the Kennedy Space Center. His duties included astronaut support during the processing of the various vehicles and payloads, as well as flight crew support during the final phases of the launch countdown. He has logged over 1,800 hours of flight time, including 1,500 hours in jet aircraft.

Dr. Chang-Diaz was instrumental in implementing closer ties between the astronaut corps and the scientific community. In January 1987, he started the Astronaut Science Colloquium Program and later helped form the Astronaut Science Support Group, which he directed until January 1989.

**SPACE FLIGHT EXPERIENCE:** A veteran of four space flights, Dr. Chang-Diaz has logged over 656 hours in space. He was a crew member on STS 61-C in 1986, STS-34 in 1989, STS-46 in 1992, and STS-60 in 1994.

## BIOGRAPHICAL DATA

### **Umberto Guidoni (Ph.D.) Italian Space Agency (ASI) Astronaut, (Payload Specialist)**

**BIRTHPLACE AND DATE:** Born August 18, 1954, in Rome, Italy. His parents, Mr. Pietro Guidoni and Giuseppina Cocco-Guidoni, reside in Rome, Italy.

**EDUCATION:** Graduated from Classic Liceum "Gaio Lucilio" in Rome, Italy, in 1973; received his BS degree in physics and Ph.D. in Astrophysics (Summa Cum Laude) from University of Rome in 1978.

**MARITAL STATUS:** Married to Mariarita Bartolacci of Milan, Italy.

**CHILDREN:** Luca, February 21, 1992.

**ORGANIZATION:** Member of the Italian Space Society (ISS).

**MILITARY STATUS:** Reserve Officer of the Italian Air Force.

**EXPERIENCE:** In 1983, as a staff scientist in the Solar Energy Division of the National Committee for Renewable Energy (ENEA), he was responsible for developing new techniques to characterize solar panels.

In 1984, he became a permanent researcher of the Space Physics Institute (IFSI-CNR) and was involved as co-investigator in the Research on Electrodynamical Tether Effects (RETE) experiment, one of the payloads selected for the Tethered Satellite System (TSS-1). From 1985 to 1988 he designed the Ground Support Equipment (GSE) and supervised the design and testing of the Data Processing Unit (DPU) for the RETE experiment. He also collaborated to the realization of a plasma chamber at IFSI, for laboratory simulations of electrodynamic tether phenomena and for characterization of plasma contactors in ionospheric environment. In 1988, Dr. Guidoni was appointed Project Scientist of RETE. In this capacity he was responsible for the integration of the experiment with the Tethered Satellite System.

In 1989, he was selected by the Italian Space Agency (ASI) to be one of the two Italian scientists to be trained as payload specialists for the TSS-1 mission and joined ASI as a member of the Astronaut Office. In 1991 he was relocated to the NASA Johnson Space Center to follow the training for STS-46/TSS-1 flight.

In 1992, completing his training as Alternate Payload Specialist (APS), Dr. Guidoni supported the STS-46/TSS-1 mission by assisting the Science Team for on-orbit operations at the Payload Operations Control Center (POCC) at the Johnson Space Center for the duration of the mission.

Dr. Guidoni is currently assigned as payload specialist on the STS-75, Tethered Satellite System Reflight (TSS-1R) mission, scheduled for launch in February of 1996 aboard Space Shuttle Columbia.

