NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

SPACE SHUTTLE MISSION STS-64

PRESS KIT
SEPTEMBER 1994

LIDAR IN-SPACE TECHNOLOGY EXPERIMENT (LITE)

STS-64 INSIGNIA

STS064-S-001 -- The STS-64 insignia depicts the space shuttle Discovery in a payload-bay-to-Earth attitude with its primary payload, Lidar In-Space Technology Experiment (LITE-1) operating in support of Mission to Planet Earth. LITE-1 is a lidar (light detection and ranging) system that uses a three-wavelength laser, symbolized by the three gold rays emanating from the star in the payload bay that form part of the astronaut symbol. The major objective of this first flight of LITE-1 is to validate its design and operating characteristics by gathering data about the Earth's troposphere and stratosphere, represented by the clouds and dual-colored Earth limb. A secondary payload on STS-64 is the free-flier SPARTAN-201 satellite shown on the Remote Manipulator System (RMS) arm post-retrieval. The objective of SPARTAN-201 is to investigate the physics of the solar wind and complement data being obtained from the ULYSSES satellite launched on STS-41. The RMS will also operate another secondary payload, Shuttle Plume Impingement Flight Experiment (SPIFEX), which will assess the plume effects from the Orbiter's Reaction Control System thrusters. Additionally, STS-64 will test a new extravehicular activity (EVA) maneuvering device, Simplified Aid for EVA Rescue (SAFER), represented symbolically by the two small nozzles on the backpacks of the two untethered EVA crew men. The names of the crew members encircle the insignia: astronauts Richard N. Richards, commander; L. Blaine Hammond Jr., pilot; Jerry M. Linenger, Susan J. Helms, Carl J. Meade and Mark C. Lee, all mission specialists. The gold or silver stars by each name represent that person's parent service.

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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LASER ATMOSPHERIC RESEARCH, ROBOTIC OPERATIONS AND UNTETHERED SPACEWALK HIGHLIGHT SHUTTLE MISSION STS- 64

NASA's fifth Shuttle flight of 1994 will include two firsts when the orbiter Discovery and her six-person crew perform atmospheric research using a laser and conduct robotic processing of semiconductor materials during Shuttle Mission STS-64. The mission also will see the deployment and retrieval of a free flying astronomical observer and the first untethered spacewalk by astronauts in over ten years.

Leading the STS-64 crew will be Mission Commander Richard (Dick) N. Richards who will be making his fourth flight. Pilot for the mission is L. Blaine Hammond Jr. who is making his second flight. The four mission specialists aboard Discovery are Jerry M. Linenger who will be making his first flight; Susan J. Helms who will be making her second flight; Carl J. Meade, who will be making his third flight; and Mark C. Lee, who will be making his third flight.

Launch of Discovery currently is scheduled for no earlier than September 9, 1994, at 4:30 p.m. EDT. The planned mission duration is 8 days, 20 hours, 11 minutes. An on-time launch on September 9 would produce a landing at 12:41 p.m. EDT on September 18, 1994 at the Kennedy Space Center's Shuttle Landing Facility.

The STS-64 mission will see the first flight of the Lidar In-Space Technology Experiment (LITE) payload. The LITE is primarily a technology test. Discovery will carry a laboratory laser into space, point it toward the Earth and beam narrow pulses of laser light through the atmosphere. The LITE will use a telescope to measure the laser's light as it is reflected from clouds, the suspended particles in the air and from the Earth's surface. This is the first time this type of laser system -- called a lidar -- has flown in space for atmospheric studies. Engineers will use information from LITE in the development of future remote-sensing instruments, including elements of NASA's Earth Observing System, a series of environmental satellites scheduled to begin launching in 1998.

The LITE will collect atmospheric data and will provide an opportunity to collect valuable information about the Earth's atmosphere -- crucial for a better understanding of our climate. Information gained from LITE can help explain the impact of human activity on the atmosphere as well as provide a new tool for improved measurements of clouds, particles in the atmosphere and the Earth's surface.

On the fifth day of the STS-64 mission, Helms will use the Shuttle's mechanical arm to deploy the Shuttle Pointed Autonomous Research Tool for Astronomy-201 (SPARTAN- 201) payload. For 40 hours, Spartan-201 will fly free of the Shuttle and study the acceleration and velocity of the solar wind and measure aspects of the Sun's corona. The corona is difficult to study because it is so dim relative to the rest of the Sun. On Flight Day seven, the Shuttle will rendezvous with SPARTAN-201 after which it will be retrieved and stowed in Discovery's cargo bay for return to Earth.

Discovery's cargo bay also will carry the Robot Operated Processing System (ROMPS) payload which is the first U.S. robotics system to be used in space. ROMPS will advance microgravity processing by using a robot to transport a variety of semiconductors from the storage racks to halogen lamp furnaces where their crystal structures are reformed in heating and cooling cycles. The purpose of ROMPS is to utilize the microgravity environment to develop commercially valuable methods of processing semiconductor materials. Another objective of the ROMPS program is to advance automation and robotics for material processing in ways that can lower the costs of developing and manufacturing semiconductors.

STS-64 crew members Mark Lee and Carl Meade will perform a six-and-a-half hour spacewalk on flight day eight of the mission to evaluate the Simplified Aid For EVA Rescue (SAFER); several spacewalking tools; and an Electronic Cuff Checklist developed to allow spacewalkers greater and easier access to information. SAFER is a small, self-contained, propulsive backpack device that can provide free-flying mobility for a spacewalker in an emergency. It is designed for self-rescue use by a spacewalker in the event the Shuttle is unable or unavailable to retrieve a detached, drifting crew member. Examples of such times may include a mission where the Shuttle is docked to the Russian Mir space station or to the International Space Station.

The STS-64 mission will see the continuation of NASA's Get Away Special (GAS) experiments program. The project gives an individual a chance to perform experiments in space on a Shuttle mission. On STS-64, U.S. universities and high schools and several foreign countries are flying experiments.

The Shuttle Plume Impingement Flight Experiment (SPIFEX) payload will study the characteristics and behavior of exhaust plumes from Discovery's Reaction Control System (RCS) thrusters during the mission. SPIFEX, when picked up by Discovery's mechanical arm, is a 33-foot long extension for the arm with a package of instruments that will measure the near-field, transition and far-field effects of thruster plumes. The plume information gathered by the experiment will assist planners in understanding the potential effects of thruster plumes on large space structures, such as the Russian Space Agency's Mir Space Station, and the International Space Station, during future Shuttle docking and rendezvous operations.

Research on the development and differentiation of a major food crop family that provides half of the world's calorie intake from plants, is the subject of the second Biological Research in Canisters (BRIC-2) experiment on STS-64. Microgravity research on orchard grass, which is part of the plant family that includes wheat, rice and corn, possibly will provide critical insights into the reproductive biology of the world's major food crops.

The Solid Surface Combustion Experiment (SSCE) being flown is a major study of how flames spread in a microgravity environment. Conducting the flame spreading experiment in microgravity removes buoyant air motion caused by gravity, commonly observed as "hot gases rising." Comparing microgravity results with test results obtained in normal gravity on Earth (1g) provides detailed information about how air motion affects flame spreading. The SSCE results will contribute to improvements in fire safety equipment and practices both on Earth and in spacecraft.

Three Department of Defense sponsored experiments will be flown during the STS-64 mission. The Air Force Maui Optical System (AMOS) is an electrical- optical facility on the Hawaiian island of Maui. The AMOS facility tracks the orbiter as it flies over the area and records signatures from thruster firings, water dumps or the phenomena of "Shuttle glow." The information obtained by AMOS is used to calibrate the infrared and optical sensors at the facility. The Military Applications of Ship Tracks (MAST) experiment on STS-64 is part of a five-year research program designed to characterize how effluents from ship stacks can affect cloud properties in the immediate vicinity. These effects are seen visually as a bright line in clouds corresponding to the track of the ship. The Radiation Monitoring Equipment-III (RME-III) measures ionizing radiation exposure to the crew within the orbiter cabin. RME-III measures gamma ray, electron, neutron and proton radiation and calculates in real time exposure in RADS-tissue equivalent. The hand-held instrument is stored in a middeck locker during flight except for when the crew activates it and replaces the memory module every two days.

The STS-64 crew will take on the role of teacher as they educate students in the United States and other countries about mission objectives. Using the Shuttle Amateur Radio Experiment-II (SAREX-II), astronauts aboard Discovery will discuss with students what it is like to live and work in space.

STS-64 will be the 19th flight of Space Shuttle Discovery and the 64th flight of the Space Shuttle System.

(END OF GENERAL RELEASE; BACKGROUND INFORMATION FOLLOWS.)

MEDIA SERVICES INFORMATION

NASA Television Transmission

NASA television is now available through a new satellite system. NASA programming can now be accessed on Spacenet-2, Transponder 5, located 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, Fla.; Marshall Space Flight Center, Huntsville, Ala.; Dryden Flight Research Center, Edwards, Calif.; Johnson Space Center, Houston and NASA Headquarters, Washington, D.C. 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 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 per day. The updated NASA television schedule will indicate when mission briefings are planned.

STS-64 QUICK LOOK

Launch Date/Site:	September 9, 1994/KSC Pad 39-B
Launch Time:	4:30 p.m. EDT
Orbiter:	Discovery (OV-103) - 19th Flight
Orbit/Inclination:	140 nautical miles/57 degrees
Mission Duration:	8 days, 20 hours, 11 minutes
Landing Time/Date:	12:41 p.m. EDT September 18, 1994
Primary Landing Site:	Kennedy Space Center, Fla.
Abort Landing Sites:	Return to Launch Site - KSC, Fla. Trans-Atlantic Abort Landing - Zaragoza, Spain Moron, Spain Ben Guerir, Morocco Abort Once Around - White Sands Space Harbor, N.M.
Crew:	Richard Richards, Commander (CDR) Blaine Hammond, Pilot (PLT) Jerry Linenger, Mission Specialist 1 (MS1) Susan Helms, Mission Specialist 2 (MS2) Carl Meade, Mission Specialist 3 (MS3) Mark Lee, Mission Specialist 4 (MS4)
Cargo Bay Payloads:	Lidar in Space Technology Experiment (LITE) Shuttle Pointed Autonomous Research Tool for Astronomy (SPARTAN 201) Robotic Operated Materials Processing System (ROMPS) Get Away Special Bridge Assembly (GBA) Shuttle Plume Impingement Flight Experiment (SPIFEX) Simplified Aid for Extravehicular Activity Rescue (SAFER)
Middeck Payloads:	Air Force Maui Optical Site (AMOS) Biological Research in Canisters (BRIC) Military Application of Ship Tracks (MAST) Radiation Monitoring Experiment-III (RME-III) Shuttle Amateur Radio Experiment-II (SAREX-II) Solid Surface Combustion Experiment (SSCE)

Development Test Objectives/Detailed Supplementary Objectives:

DTO 301D: Ascent Structural Capability Evaluation
DTO 305D: Ascent Compartment Venting Evaluation
DTO 306D: Descent Compartment Venting Evaluation
DTO 307D: Entry Structural Capability Evaluation
DTO 312: External Tank Thermal Protection System Performance
DTO 319D: Orbiter/Payload Acceleration and Acoustics Environment Data
DTO 414: Auxiliary Power Unit Shutdown Test
DTO 520: Edwards Lakebed Runway Bearing Strength and Rolling Friction
DTO 521: Orbiter Drag Chute System Test
DTO 524: Landing Gear Loads and Brake Stability Evaluation
DTO 659: Extended Duration Orbiter Treadmill Evaluation
DTO 664: Cabin Temperature Survey
DTO 671: EVA Hardware for Future Scheduled EVA Missions
DTO 672: EMU Electronic Cuff Checklist
DTO 673: Extended Duration Orbiter Ergometer Evaluation
DTO 674: Thermo-Electric Liquid Cooling System Evaluation
DTO 700-5: Payload Bay Mounted Rendezvous Laser
DTO 700-7: Orbiter Data for Real Time Navigation Evaluation
DTO 805: Crosswind Landing Performance
DTO 830: Shuttle Plume Impingement Flight Experiment
DSO 482: Cardiac Rhythm Disturbances During Extravehicular Activity
DSO 487: Immunological Assessment of Crewmembers
DSO 489: EVA Dosimetry Evaluation
DSO 491: Characterization of Microbial Transfer Among Crewmembers
DSO 603: Orthostatic Function During Entry, Landing and Egress
DSO 604: Visual-Vestibular Integration as a Function of Adaptation
DSO 610: In-Flight Assessment of Renal Stone Risk
DSO 612: Energy Utilization
DSO 614: The Effect of Prolonged Space Flight on Head and Gaze Stability During Locomotion
DSO 621: In-Flight Use of Florinef to Improve Orthostatic Intolerance Postflight
DSO 624: Pre and Postflight Measurement of Cardiorespiratory Responses to Submaximal Exercise
DSO 626: Cardiovascular and Cerebrovascular Responses to Standing Before and After Space Flight
DSO 901: Documentary Television
DSO 902: Documentary Motion Picture Photography
DSO 903: Documentary Still Photography

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 White Sands Space Harbor, N.M.

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

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

STS-64 contingency landing sites are the Kennedy Space Center, White Sands, Zaragoza, Moron and Ben Guerir.

STS-64 SUMMARY TIMELINE

Flight Day 1
Ascent
OMS-2 burn (140 n.m. x 140 n.m.)
LITE activation
SPARTAN/ROMPS activation
RME activation
LITE operations
ROMPS operations
GAS activation

Flight Day 2
LITE operations
RMS checkout
SAREX activation
SPIFEX unberth/activation
SPIFEX operations

Flight Day 3
SPIFEX operations
LITE operations
ROMPS operations (overnight)

Flight Day 4
SPIFEX operations
SPIFEX berth
LITE operations
SSCE operations
LITE operations (overnight)

Flight Day 5
SPARTAN 201 deploy
ROMPS operations (overnight)
LITE operations (overnight)

Flight Day 6
EMU checkout
SAFER checkout
LITE operations

Flight Day 7
Depress cabin to 10.2 psi
SPARTAN 201 rendezvous
SPARTAN 201 retrieval
SPARTAN 201 berth
ROMPS operations (overnight)
LITE operations (overnight)

Flight Day 8
EVA preparation
EVA/SAFER operations
Repressurize cabin to 14.7 psi
LITE operations (overnight)
ROMPS operations overnight

Flight Day 9
SPIFEX unberth/activation
SPIFEX operations
SPIFEX berth
FCS checkout
ROMPS operations (overnight)

Flight Day 10
Payload deactivation
Cabin stow
Deorbit preparation
Entry
Landing

STS-64 VEHICLE AND PAYLOAD WEIGHTS

	Pounds
Orbiter (Discovery) empty and 3 SSMEs	173,852
Lidar in Space Technology Experiment	5,920
Robot Operated Materials Processing System	1,150
SPARTAN 201 (deployable)	2,840
SPARTAN 201 support equipment	2,409
Shuttle Plume Impingement Flight Experiment	772
Get-Away Specials and Bridge Assembly	5,000
Simplified Aid For EVA Rescue	269
Biological Research in Canisters	36
Military Applications of Ship Tracks	66
Radiation Monitoring Experiment	7
Shuttle Amateur Radio Experiment-II	35
Solid Surface Combustion Experiment	139
Detailed Supplementary/Test Objectives	184
Total Vehicle at SRB Ignition	4,503,199
Orbiter Landing Weight	210,916

STS-64 ORBITAL EVENTS SUMMARY

Event	Start Time (dd/hh:mm:ss)	Velocity Change (feet per second)	Orbit (n.m.)
OMS-2	00/00:38:00	209 fps	140 x 140
Trim Burn 1	00/04:03:00	TBD	139 x 141
Trim Burn 2	00/04:48:00	TBD	140 x 141
Trim Burn 3	01/04:15:00	TBD	140 x 141
Trim Burn 4	01/17:02:00	TBD	140 x 141
Trim Burn 5	03/16:51:00	TBD	140 x 141
Trim Burn 6	03/17:37:00	TBD	140 x 141
SP-201 Release	03/23:14:00	N/A	139 x141
Sep-1	03/23:20:00	1 fps	140 x140
Sep-2	03/23:42:00	2 fps	140 x140
Sep-3	04/00:04:00	3 fps	140 x140
NC-1	04:03:03:00	2.7 fps	140 x 140
NC-2	04/17:25:00	1.9 fps	140 x 140
NH-1	04/18:10:00	TBD	140 x 140
NC-3	05/02:29:00	TBD	140 x 140
NPC	05/16:04:00	2.1 fps	139 x 139
NC-4	05/17:26:00	5.7 fps	136 x 140
NH-2	05/18:11:00	TBD	136 x 140
NCC	05/19:29:00	TBD	138 x 140
TI	05/20:25:00	3.2 fps	138 x 140
MC-1	05/20:45:00	TBD	138 x 140
MC-2	05:21:13:00	TBD	139 x 140
MC-3	05/21:23:00	TBD	139 x 140
MC-4	05/21:33:00	TBD	139 x 140
Manual phase	05/21:38:00	TBD	139 x 140
SP-201 Grapple	05/22:28:00	N/A	139 x140
HITE	06:00:40:00	14.2 fps	131 x 139
CIRC	06/01:21:00	14.7 fps	131 x 132
Deorbit	08/19:14:00	229 fps	N/A
Touchdown	08/20:12:00	N/A	N/A

NOTES:

1. All maneuvers are recalculated in real time and the burn values are frequently updated during the mission. Also, some burns may not be needed and could be deleted in real time.

2. The trim burns are engine firings by Discovery to precisely set up observations by LITE.

3. From SP 201 release through grapple, the engine firings are for separation, station keeping and rendezvous with the SPARTAN. The final phase of rendezvous begins with the TI (Terminal Phase Initiation) burn and culminates in Commander Dick Richards manually flying Discovery to within 40 feet of SPARTAN for capture using the mechanical arm.

4. The HITE and CIRC burns are performed to circularize Discovery's orbit and improve landing opportunities.

STS-64 CREW RESPONSIBILITIES

Task/Payload	Primary	Backups/Others
LITE	Lee	Meade, Richards
ROMPS	Helms	Hammond
SPARTAN 201	Meade	Helms
GAS Cans	Linenger	Meade
SPIFEX	Helms	Lee, Hammond
SAFER/EVA	Lee (EV1), Meade (EV2)	Linenger (IV)
Middeck Payloads:		
SSCE	Meade	Hammond
BRIC	Helms	Meade
SAREX	Richards	Hammond, Linenger
RME-III	Hammond	Linenger
AMOS	Hammond	Richards
Detailed Supplementary/Test Objectives:		
DTO 659 (treadmill)	Linenger	Richards, Hammond
DTO 664 (cabin temp.)	Hammond	Helms
DTO 671 (EVA tools)	Meade	Lee
DTO 672 (EMU elec.)	Meade	Lee
DTO 673 (rower eval)	Hammond, Richards, Linenger, Helms	
DTO 674 (LES cooling)	Hammond	Richards
DSO 482 (EVA cardiac)	Lee	Meade
DSO 483 (back pain)	Hammond, Meade, Lee (Linenger-measurer)	
DSO 603C (orthostatic)	Meade	Helms, Linenger
DSO 624 (exercise)	Hammond	Richards, Linenger
Other:		
Photography/TV	Linenger	Hammond
In-Flight Maintenance	Hammond	Meade
Earth Observations	Hammond	Linenger
RMS	Helms, Meade	Lee
Medical	Linenger	Richards

LIDAR IN-SPACE TECHNOLOGY EXPERIMENT (LITE)

LITE Quick-Look Facts

- Experiment duration: Up to 46:15 hours of operation over nine-day mission;
- A technology test of first space-based lidar or "optical radar" for studying the atmosphere;
- Atmospheric measurements of clouds and airborne dust will be taken to demonstrate the LITE lidar system;
- International ground science team will take supporting measurements at approximately 50 ground sites in approximately 20 countries;
- Five international aircraft will fly underneath LITE making measurements over broad geographical regions, to include Europe, the Southwest United States, the Caribbean, South America and the South Atlantic;
- Technology goal: To test the ability of lidar technology to operate in space and to verify its usefulness in studying the Earth's atmosphere and climate change.

Summary

The LITE mission is primarily a technology test. The Space Shuttle will carry a laboratory laser into space, point it toward the Earth and beam narrow pulses of laser light through the atmosphere. LITE will use a telescope to measure the laser's light as it is reflected from clouds, suspended particles in the air and from the Earth's surface. Project engineers will closely monitor the performance and health of LITE's hardware. This is the first time this type of laser system -- called a lidar -- has flown in space for atmospheric studies. Engineers will use information from LITE in the development of future remote-sensing instruments, including elements of NASA's Earth Observing System (EOS), a series of environmental satellites scheduled to begin launching in 1998.

The LITE mission will collect atmospheric data. LITE will provide an opportunity to collect valuable information about the Earth's atmosphere, crucial for a better understanding of our climate. Having this first lidar in space allows for rapid, efficient and accurate global coverage. During the nine days of the mission, more than 46 hours of information will be gathered. Information gained from LITE can help explain the impact of human activity on the atmosphere as well as provide a new tool for improved measurements of clouds, particles in the atmosphere and the Earth's surface.

LITE will be supported by a worldwide science team. This team's measurements are an essential part of the LITE experiment because they will confirm the measurements taken from space. Information from the LITE flyovers will be verified by comparing it to results from similar measurements using airborne and ground-based instruments at more than 50 sites around the world. These instruments will measure very nearly the same vertical columns of air, clouds, and suspended particles that LITE will examine from space.

Background

Lidar is a remote sensing technique that can be used to study clouds and aerosols (suspended particles) in the atmosphere. By sending out short pulses of laser light and detecting the portion reflected back to the instrument by the atmosphere, the instrument can obtain very high vertical and horizontal resolution.

Researchers at NASA's Langley Research Center, in cooperation with NASA's offices of Advanced Concepts and Technologies and Mission to Planet Earth, have been developing lidar systems and techniques for more than two decades to address a wide variety of atmospheric remote sensing applications. This effort has resulted in the development and operation of a number of ground-based and airborne lidar systems.

NASA's Office of Advanced Concepts and Technology developed LITE as part of its initiative to explore applications of space-based lidar and to gain experience for future systems. NASA's Office of Mission to Planet Earth is supporting the data collection and development of the sensor as part of its exploration of new remote-sensing techniques for environmental studies.

The LITE mission is the first to use lasers in space for study of the Earth's atmospheric environment. Using the Space Shuttle as a platform, LITE will provide information to help us better understand our climate system. An important objective of the program is to validate the instrument design principles in such areas as laser performance, thermal control, and autonomous operations and to gain experience in commanding the instrument on orbit.

The LITE Mission

The LITE instrument will be mounted to a pallet inside the open payload bay of Discovery, which will orbit "upside- down" (with the bay pointed toward Earth). Discovery will fly at a relatively low altitude (about 160 miles or 260 kilometers), so that each downward-pointing lidar pulse is dispersed as little as possible on its way down through the atmosphere.

Over its nine-day mission, LITE will collect atmospheric information during ten 4-1/2 hour sessions, for a total of 45 hours. In addition, five 15-minute "snapshots" will be performed over specific target sites. LITE's observing targets include clouds, particles in the atmosphere, the planetary boundary layer (where the atmosphere meets the Earth's surface), density and temperature in the upper atmosphere and the Earth's surface.

During those periods, the returning lidar signals collected by LITE's telescope will be converted to digital data, which will be stored on tape and simultaneously transmitted down to investigators on the ground.

At one point during the mission, the Shuttle will execute roll and pitch maneuvers to change the angle at which the lidar reflects off its targets below. These tests will be useful to engineers designing future lidar instruments that can scan from side to side or front to back instead of holding to a fixed, downward-looking point of view.

Space Shuttle Discovery, orbiting at an inclination of 57 degrees to the equator, will pass over 25,000 miles of the Earth’s surface with each revolution. The LITE instrument will be able to collect data for a wide range of geographic and atmospheric settings, including remote areas like the open ocean, in a very short period of time.

Technological Focus

Because LITE is the first mission of its kind, the primary focus of the mission is to test the technological hardware. Scientists and engineers want to verify that the entire system works as planned in orbit, for example, that the laser and telescope remain aligned, that the built-in cooling system can handle the heat produced by a powerful lidar instrument and that the signals and noises are measured as expected. The Space Shuttle is an ideal "platform" for conducting this kind of technology test. It provides the opportunity to fly a heavy, multi-purpose instrument without building a dedicated satellite. Once the practical utility of lidar in space is demonstrated, the lessons learned during the LITE mission can be applied to designing future, operational systems that are lighter in weight, use less spacecraft power and are more capable.

How Lidar Works

Lidar, an acronym for "light detection and ranging," is similar to the radar commonly used to track everything from airplanes in flight to thunderstorms. It can be thought of as an "optical radar." Instead of bouncing radio waves off its target, lidar uses short pulses of laser light. Some of that light reflects off tiny particles in the atmosphere, called aerosols, then back to a telescope aligned with the laser. By precisely timing the lidar "echo," and by measuring how much laser light is received by the telescope, scientists can accurately determine the location, distribution and nature of the particles. The result is a revolutionary new tool for studying constituents in the atmosphere, from cloud droplets to industrial emissions, that are difficult to detect by other means.

How Lidar's Capabilities Will Be Improved From Space

Most remote-sensing satellites, including the ones used to produce our daily weather forecasts, rely on passive sensing. They simply measure the amount of solar radiation, visible light or other wavelengths, reflected, not emitted, back to the satellite from the atmosphere, clouds, oceans or solid land. Lidar, which uses a laser, is an active sensor. It provides better vertical resolution than passive sensors due to the short length of laser pulses and the use of more direct data-analysis methods.

A lidar also carries its own light source, allowing it to operate during orbital day or night. Passive instruments have restrictions on their sensing due to their reliance on an external source of light such as the Sun or Moon. Lidar can transmit light pulses continuously.

Lasers also produce a tight, coherent beam that spreads very little as it travels from its source, compared to ordinary light. From its orbital altitude, LITE's laser beam would spread to only about 975 feet (300 meters) wide at the surface -- almost the size of three football fields. This allows the LITE instrument to measure a very small, narrowly defined column of the atmosphere with each pulse. A space- based lidar offers another great advantage in its ability to penetrate thin or broken clouds to "see" through to the troposphere, the lower part of the atmosphere where weather systems form and where most satellite remote sensors have difficulty seeing.

From its vantage point above the atmosphere, LITE's extremely accurate laser will flash very short pulses of light directly downward, ten times every second. These pulses, lasting less than 30 billionths of a second each, will be in three wavelengths corresponding to ultraviolet, infrared and visible green light. Because the wavelengths are precisely known, and because LITE's telescope is designed to filter out other types of radiation, the signals returning to the Space Shuttle after reflecting off small airborne water or ice droplets and aerosols (suspended particles) are easy to identify. Timing the returned signal pinpoints the particle's altitude to within an accuracy of approximately 50 feet (15 meters).

Geographic Areas Studied

LITE's science mission takes in a variety of phenomena in widespread geographic areas. Targets include the organization of clouds in the western Pacific, cloud decks off the coasts of California and Peru, smoke plumes from biomass fires in South America and Africa and the transport of desert dust from the Sahara. The science team will study lower-atmosphere aerosols over the Amazon rain forest, gravity waves over the Andes Mountains in South America, and the reflection properties of desert surfaces in the United States, Africa and China.

Coordinating Ground Truth Data With LITE's Data Taken From the Shuttle

The LITE instrument will take up to five 15-minute "snapshots" over target areas selected for scientific interest or to support validation observations. Numerous airborne and ground-based lidars will make measurements at the same time under the path of the Shuttle. These "ground- truth" data provide a standard against which LITE data can be compared for accuracy.

The ground-based and aircraft lidars will collect similar data to what the Shuttle is attempting but from a lower perspective. A lidar at the Langley Research Center in Hampton, Va., for example, will take upward-looking data at the exact time the Space Shuttle is passing overhead. Among the other "snapshot" targets are sites in Europe, Australia and the Sahara desert (to observe desert dust). This collection of ground-truth data will be performed jointly by five U.S., Canadian and European aircraft.

LITE's Potential Contribution to Atmospheric Science

Eventually, lidar instruments could be flown on permanently orbiting satellites to provide continuous global data. While LITE will collect data on a wide range of aerosols, from dust particles in the stratosphere to cloud droplets, future lidar instruments could be tailored to specific purposes. While one instrument studied clouds, another could track urban smog or desert dust storms.

Perhaps the greatest value of early space-based lidars is the unprecedented accuracy with which they can measure clouds on a global scale. Information on clouds is critical to improving computer models of global climate. Current remote-sensing satellites leave large gaps in our understanding of how clouds reflect and absorb solar energy, and how heat and moisture are exchanged between the air, ocean and land. Only by gathering more accurate information can scientists improve their models to the point where they can confidently predict the behavior of the real atmosphere, and tell how the environment is being affected by human activity.

Management

The LITE payload is the culmination of the cooperative efforts of NASA Headquarters, several NASA centers and their support contractors. Langley Research Center provided overall project management for the design and development of the LITE instrument; Marshall Space Flight Center, Huntsville, Ala., provided the Spacelab Enhanced MDM Pallet (EMP) and High Data Rate Recorder; Johnson Space Center, Houston, Texas, provided overall mission management as well as the OASIS-1 and the interface hardware between the EMP and the experiment; and Goddard Space Flight Center, Greenbelt, Md., and Kennedy Space Center, Cape Canaveral, Fla., provided test integration facilities and personnel.

Overall LITE program management and funding are provided by NASA Headquarters through the offices of Advanced Concepts and Technology, Life and Microgravity Sciences and Applications and Mission to Planet Earth.

LITE INSTRUMENT

The LITE payload was built at NASA's Langley Research Center, Hampton, Va. Langley has provided overall project management for the design and development of LITE's lidar instrument. Langley also will put the scientific data into usable form and make it available to scientists for their own studies.

Receiver Assembly

The receiver includes a one-meter telescope (approximately 3.25 feet) and an aft optics package. The telescope collects laser light reflected from the atmosphere and brings it to focus in the aft optics. The aft optics will separate the return signal into its three color components. The 532 nanometer (visible green) and 355 nanometer (ultraviolet) detectors are photomultiplier tubes, while the 1064 nanometer (infrared) detector is a silicon avalanche photodiode.

An existing NASA telescope, which was an engineering model of the Orbiting Astronomical Observatory from Goddard Space Flight Center that flew in 1968, will be used as the lidar receiver. The use of this existing hardware will save NASA an estimated $8 million.

Boresight Assembly

The boresight assembly consists of a two-axis motor-driven prism. Its purpose is to align the laser beam to the telescope field-of-view so that both point to the same column of atmosphere.

Laser Transmitter Module (LTM)

The LTM consists of two flash lamp-pumped, Q-switched Neodymium YAG lasers which emit simultaneously at the three harmonically related wavelengths of 1064 nanometers, 532 nanometers, and 355 nanometers. The two-laser system provides redundancy in case one laser fails. Only one laser operates at a time.

Support Instrumentation

OASIS-1 recorder

The OASIS-1 will measure and internally record accelerations, acoustic loads, strains temperatures, thermal flux and pressures during the launch, ascent, on orbit, descent, and landing phases of the LITE mission.

Camera Assembly

A special modified 35-mm camera will photograph daytime cloud cover and ground tracks every 20 seconds to help interpret the lidar data.

Experimental Platform

The LITE instrument is mounted on an orthogrid platform which is attached to the Spacelab pallet by 52 struts. The orthogrid is a support platform for the instrument subsystems and is designed to be immune to thermal deformations which could affect optical alignment.

Instrument Controller

The Instrument Controller handles all command and data interfaces of the LITE instrument. All subsystems can be commanded and controlled via the controller. Health and status of the LITE instrument are monitored and transferred to the Spacelab's Smart Flexible Multiplexer/Demultiplexer. The controller software consists of over 18 real-time tasks that perform all commands and data interfaces for the controller as well as independent operations.

Note to Amateur Astronomers

The LITE payload will transmit a laser beam directly from the Space Shuttle payload bay to the Earth's surface. Using criteria provided by the American National Standards Institute (ANSI) on the safe use of lasers, NASA calculated the amount of laser-generated energy that might reach the ground and compared it to ANSI-determined safe levels of exposures.

The study found that observers attempting to view the Shuttle with the naked eye are not at risk of eye injury, nor are observers using ordinary binoculars or small telescopes (up to approximately six inches in diameter). However, there is a remote possibility that telescopes larger than six inches in diameter could collect enough energy to expose the observer to levels higher than ANSI's Maximum Permissible Exposure for one of the laser's three wavelengths (532 nanometers). Therefore**, observers should not attempt to view the Shuttle through telescopes larger than six inches.**

Capturing images electronically does not present a hazard to the observer, but highly sensitive photo-electronic detectors could possibly be damaged.

SPARTAN-201

The Spartan program is designed to provide easy access to Earth orbit via the Space Shuttle for flying science experiments. Spartan uses proven technologies to provide a relatively inexpensive route to space for the scientific community. This is done by using a basic carrier which, with the addition of a science experiment, becomes a complete spacecraft capable of fulfilling the science objectives of each mission. Spartan missions can support stellar, solar, or Earth fine-pointing experiments, experiments requiring microgravity and experiments requiring space environments away from the Space Shuttle.

The Spartan project is managed by the Goddard Space Flight Center for the Office of Space Science, Washington, D.C. The Spartan Project Manager is Frank Collins; Goddard Space Flight Center Mission Manager is Craig Tooley; Goddard Principal Investigator is Dr. Richard Fisher and Dr. John Kohl is from the Smithsonian Astrophysical Observatory, Cambridge, Mass.

Spartan-201 will study the acceleration and velocity of the solar wind and measure aspects of the Sun's corona. Results should suggest solutions to the questions of coronal and solar wind physics with dramatic observations.

Spartan-201 is an orbiting spacecraft that is deployed by the Space Shuttle and retrieved on the same mission. After deployment, it is completely autonomous, providing its own battery power, pointing system and recorder for capturing data. While on orbit, Spartan executes a pre-programmed science mission.

The Spartan program has evolved using sounding rocket-class instruments to perform the scientific studies. This carrier system provides a significant increase in observing time compared to sounding rockets. The Spartan carriers are reusable and can accommodate a variety of scientific instruments on a low-cost per flight basis.

Spartan-201 Science

The Spartan-201 will look for evidence to explain how the solar wind is generated by the Sun. The solar atmosphere constantly ejects electrons, protons and heavy ions from the outer layer, continuously impacting the Earth. The solar wind fills interplanetary space and sweeps by the Earth at nearly one million miles per hour (1.6 million km/hour). The wind often gusts, transmitting disturbances from the Sun that frequently disrupt navigation, communications and electric power distribution systems on Earth.

The solar wind originates in the corona, the outermost atmosphere of the Sun. Spartan-201 carries two separate telescopes to study the corona. One telescope, the White Light Coronagraph (WLC), measures the density distribution of electrons making up the corona. The other telescope, the Ultraviolet Coronal Spectrometer (UVCS), investigates the temperatures and distributions of protons and hydrogen atoms through the same layers of the corona.

The corona is difficult to study in view of its relatively dim light in comparison to the Sun's total luminance. The white light corona can be viewed from Earth only during times of solar eclipse, which strongly reduces the brightness of the scattered sunlight. The ultraviolet radiation is never available to ground-based astronomers.

A comparison of the white light and ultraviolet data sets allows scientists to measure the electron and proton temperatures and densities in the solar corona and yields new evidence on bulk flows in the corona. These data sets also permit scientists to test specific theories on how the corona is heated to its million-degree temperature.

The scientific observations will be recorded on board Spartan-201 and analyzed by scientists and engineers after recovery on the ground. The Spartan carrier and instrument will be reflown on STS-72 in June 1995. This flight is timed to coincide with the Ulysses spacecraft passage over the north pole of the Sun.

The UVCS telescope was built by scientists from the Smithsonian Astrophysical Observatory, Cambridge, Mass. The WLC telescope was developed by the High Altitude Observatory of the National Center for Atmospheric Research in Boulder, Colo., and is maintained and managed by the Goddard Space Flight Center where the Spartan carrier structure was built. After the individual elements of the Spartan system are developed and completed by the respective investigator, the experiments are checked by engineers at Goddard. Finally, Goddard engineers integrate the payloads and perform system checks.

Deployment

The dual-telescope science payload is mounted aboard the Spartan carrier. When the Shuttle is on orbit and the payload bay doors are open, a crew member uses the robot arm to lift Spartan from the payload bay and release it over the side of the Shuttle. It is deployed from the Shuttle so that it can operate independently, turning and pointing at the Sun, while leaving the orbiter free for other activities. Additionally, because the Spartan and Shuttle become separated, the Spartan is able to view the Sun clear of any contamination which might be generated by Shuttle thruster firings.

Spartan is designed to self-operate as much as possible. The Shuttle crew has little interaction with the satellite other than releasing it and recapturing it.

For approximately 40 hours, Spartan-20l's instruments observe the Sun as the Space Shuttle paces it from behind. About four hours prior to the scheduled retrieval, the Shuttle performs engine firings allowing it to close on Spartan-201, eventually passing directly below it before a crew member manually flies the final few hundred feet (approximately 100 meters) to allow the satellite to be grasped by the robot arm. Once caught by the arm, Spartan- 201 is stowed back in the cargo bay to be returned to Earth.

History

The Spartan program was conceived in the mid-1970s and developed by the Special Payloads Division, Goddard Space Flight Center, and the U.S. Naval Research Laboratory, Washington, D.C., to extend the capabilities of sounding rocket-class science experiments by making use of the Space Shuttle.

The telescopes on Spartan-201 have flown three times previously on sounding rockets. In June 1985, a Spartan mission successfully carried an x-ray telescope aboard STS-51G. Another carrier, Spartan Halley, was on board Shuttle Mission STS-51L. In April 1993, Spartan-201 was flown aboard the Space Shuttle Discovery on mission STS-56.

Spartan-201 Statistics

Launch Vehicle: Space Shuttle Discovery
Deployment Altitude: 140 nautical miles
Inclination: 57 degrees
Spacecraft Weight: 2,840 lbs (1,288 kg)

ROMPS OVERVIEW

The purpose of NASA's Robot Operated Materials Processing System (ROMPS) is to improve the properties of materials by processing them in space. The performance, and consequently the commercial value, of most semiconductor materials is highly dependent on their crystalline structure. Gravity driven connection and sedimentation, which disturb crystal formation, can be eliminated in the microgravity environment of space.

ROMPS is the first U.S. robotics system to be used in space. ROMPS will advance microgravity processing by using a robot to transport each of a large variety of semiconductors from the storage racks to halogen lamp furnaces where their crystal structures are re-formed in heating and cooling cycles. ROMPS is contained in two Space Shuttle sidewall mounted Get Away Special (GAS) cans, one containing the robot, furnaces and samples; the other containing control electronics. The Hitchhiker avionics system provides ROMPS with power, ground commands and telemetry. The ROMPS samples will be analyzed on the ground after the Shuttle mission, and the results will be used to define materials and processing for planned reflights of ROMPS on future Shuttle missions.

ROMPS Mission Manager is Lloyd Purves, Goddard Space Flight Center; Principal Investigator is Dr. Tim Anderson, University of Florida; Principal Investigator is Dr. Eric Cole, George Mason University; Co-Principal Investigator is Kevin Jones, University of Florida. ROMPS is managed for NASA by the Goddard Space Flight Center, Greenbelt, Md.

ROMPS Summary

The purpose of ROMPS is to utilize the microgravity environment to develop commercially valuable methods of processing semiconductor materials. Microgravity processing can reduce semiconductor crystal irregularities caused by convection and sedimentation. Microgravity also can improve crystal structure by permitting containerless processing. Improved crystal structure will increase the performance of many types of semiconductors. A long-term ROMPS objective is to develop microgravity-processed semiconductor devices with sufficient performance advantages so that they can be competitively produced in space. There is also a more immediate objective of using microgravity processing to better understand the behavior of semiconductor crystal structures. This better understanding can improve the quality of ground processed semiconductors.

Another objective of the ROMPS program is to advance automation and robotics for material processing in ways that can lower the costs of developing and manufacturing semiconductors. The added cost of operations in space creates a need for in-space materials processing to have more advanced automation and robotics than are normally considered for ground operations. For example, an efficient long term space facility for materials processing not only needs to have robotic materials processing, but the assembly, servicing and upgrading of the facility also needs to be done by robotics. This higher level of automation and robotics needed for in-space materials processing can be applied to improve the operational efficiencies of ground based semiconductor laboratories and production facilities. The current robotic design of ROMPS permits it to address a variety of commercial objectives in materials processing and automation technology as summarized in Table 1.

Table 1 ROMPS Technology and Commercial Objectives

Exp. No.	Technology Area	Commercial Objective	Responsible Orgs./ Industry Partners
1	Closed Space Vapor Deposition of InAS Hall Generators	Improved noise immunity and repeatability of Hall Effect devices	UF/ F.W. Bell
2	RTA of Ion Implanted and In-situ Doped ZnS ACTFEL Devices	Enhanced color and reduced power consumption by EL devices	UF/ Planer Systems
3	Impurity Induced Disordering in GaAs/InP devices	Improved optoelectronic Superlatties	UF/ Kopin, Spire
4	Solid and Liquid Phase Epitaxial Regrowth of Six Gex on Silicon	Improved high speed transistors and LEDs	UF/Texas Instruments
5	Deposition and Solidification of Photovoltaic Materials	Higher performance and lower cost solar cells UF & GMU/ Photon Energy Astropower	
6	Robot and Furnace for Semiconductor Materials Processing	More advanced and commercially produced automation system for space and ground processing of semiconductor materials	GSFC & SpARC/ Zymark, Interface & Control Systems

Organization

ROMPS is sponsored by the NASA Office of Advanced Concepts and Technology (OACT) as part of its mission to develop commercially relevant techniques for in-space materials processing. The ROMPS project is being carried out by the Goddard Space Flight Center (GSFC) and two NASA sponsored Centers for the Commercial Development of Space (CCDSs). The CCDSs are the Consortium for Commercial Crystal Growth at Clarkson University in Potsdam, New York, and the Space Automation and Robotics Center (SpARC) in Ann Arbor, Michigan.

GSFC is providing its experience with autonomous space flight technology, space robotics and the HH/GAS system. GSFC also is managing the project and developing the ROMPS mechanisms. The two CCDSs are supported by OACT and are contributing the technical expertise and commercial linkages they have in their respective areas of responsibility. SpARC is developing the ROMPS control system, and the Clarkson CCDS is leading the materials processing work. The bulk of the Clarkson CCDS work is being done by its University of Florida (UF) member. The George Mason University (GMU), Fairfax, Va., is a co-Principal Investigator with UF.

Industry interest in ROMPS is shown by nine industry partners identified in Table 1 teaming with the two CCDSs and GMU. Industry involvement with regard to materials being processed includes donation of samples and substrates, analyzing results, developing returned samples into commercial products and funding. SpARC is collaborating with two companies whose automation products are being used for ROMPS.

Design

The ROMPS flight hardware will be contained in a pair of GAS Cans mounted on the HH-G Carrier. One GAS Can is designated the Processing Can and consists of a full size GAS Can with a five inch extension. This GAS Can will house the samples, sample storage racks, robot, two furnaces, and some electronics. A second, smaller GAS Can is called the System Controller Can and will house the control electronics and Hitchhiker interface. Each GAS can will be pressurized to one atmosphere using dry nitrogen.

The HH system will provide the ROMPS GAS Cans with power and ground links for telemetry and commands. The HH configuration allows ground monitoring and control of in- space processing, return of the samples to ground and reflight of the ROMPS system with new samples and modified processing capabilities.

The ROMPS furnaces have tungsten halogen lamps and elliptical reflectors. There are two identical furnaces to provide lamp redundancy, and they are mounted to the GAS Can lid. This configuration will conductively couple to the radiator to reject the furnace power of potentially 250 watts. Each furnace is about 6.5 in. diameter x 8.0 in. long and weighs less than 5 lbs. The furnaces also provide a mechanical and electrical interface to the sample pallets. This mechanical interface, consisting of two tapered pins, serves to align a pallet with respect to the lamp focus. The electrical interface is for the calibration pallets which are equipped with sensors to measure lamp output.

Each sample pallet has a sample holder which is sealed so that samples can be heated to a vapor phase without causing contamination. Sample materials, substrates, environments inside sealed sample holders, processing times and temperatures can be varied for each sample, thus allowing a wide range of materials research to be conducted using the same equipment.

The ROMPS robot will transfer each of approximately 150 sample pallets from its storage location to a processing furnace and back to its storage location. The robot has three degrees of freedom and a gripper. The robot's three positional axes (elevation, azimuth, radial) and the gripper will be position-controlled and force limited. Each robot axis incorporates a brushless DC motor drive, incremental position encoder, brake, gearing, and end-of-travel monitors. The gripper is activated like the robot axes except that it does not have a brake because it is not back- drivable and its position is monitored using sensors. Only one motor at a time is powered during operation. Transfer time for each sample between the storage rack and furnace is less than two minutes. The robot will be unpowered and braked during heating cycles so as not to disturb the sample being processed.

The accuracy of the three positioning axes at the tool tip is 10.020 in. ROMPS can accommodate robot positioning inaccuracies of up to about 10.200 in., using a compliance device on the robot, guides and tapers on pallets and objects that the pallets contact. The robot will grip a support to provide extra stiffness during launch and descent. When in this position the robot harnessing also will be held taut for minimum vibration.

The robot support structure attaches to the GAS Can lid. The robot assembly lower plate, on which is mounted the majority of the GAS Can electronics, will be snubbed to the canister side walls. For heat transfer, the robot will conductively couple to the upper radiator lid and radiatively couple to the lid and GAS Can interior.

The processor GAS Can also contains electronics for power control, motor power and furnace control. The Power Controller interfaces with the Hitchhiker and the ROMPS subsystems. The Power Controller provides the first level of Hitchhiker to ROMPS power-line filters, the fusing for safety power distribution to ROMPS subsystems, and the power distribution for safety interlocks and experiment operation. The motor control provides the power for the servo motor and switching to direct this power to whichever one of the four motors is selected by the System Controller. The furnace controller provides the power going to the furnace lamps and controls this power to a level specified by a digital input signal from the ROMPS System Controller.

The ROMPS System Controller in a separate half height GAS can interfaces with the HH avionics and controls all experiment operations. Control functions include robot servo control, furnace profile control, and command and telemetry formatting and control. The Systems Controller also monitors the sensors and the conditions of other subsystems, and it formats telemetry to provide housekeeping data to the ground station.

ROMPS will be commanded from the ground. The System Controller contains a predetermined program for autonomous experiment operation once initiated by the proper ground commands. The first part of this predetermined program is a power up sequence to test the experiment subsystems. Upon successful testing, the experiment will execute the preprogrammed sequence of experiment samples. The gripper will be positioned to take the appropriate sample from the storage rack and position it in the furnace. After the annealing process, the sample is returned to its position in the rack and the next sample will be processed.

To get the lowest possible microgravity levels, the samples will be processed during crew rest periods when Shuttle vibrations will be at a minimum. Because of the number of samples and the possibility of lengthy heating times for certain samples, it is expected that processing will extend over more than one crew rest period. Thus the stored processing sequence will have automatic shutdowns scheduled for the end of each crew rest period. Ground command will restart the processing at the beginning of the next crew rest period. This occurs until all samples have been processed.

Thus, the processing will be basically autonomous with ground control used to monitor progress and intervene if unexpected situations develop. The System Controller will monitor outputs from temperature, position, force, and current sensors, as well as telemeter them to the ground station. The System Controller will stop the experiment if it detects problems or receives a command from the ground operator. If anomalies occur, the ground crew will diagnose the problem, develop alternate procedures, send up new command sequences, and reinitiate processing.

GET AWAY SPECIALS

NASA's Get Away Special (GAS) program is managed by the Goddard Space Flight Center, Greenbelt, Md. Charlie Knapp is NASA Technical Manager for all GAS payloads on this mission. Clarke Prouty is GAS Mission Manager.

GAS remains a viable avenue for individuals and organizations to conduct experiments in space. Prior to this flight, GAS has flown 107 payloads. On STS-64, U.S. universities and high schools and several foreign countries are flying experiments. Following is a brief description of each:

G-178
Customer: Sierra College, Rocklin, Calif.
Customer: Dr. Kevin Ramirez
Payload Manager: Mike Dobeck

G-178 is from Sierra College. The objective of this experiment is to take ozone measurements of the Earth's upper atmosphere in the ultraviolet (UV) 200 nanometer to 400 nanometer spectral range using a Charge Coupled Device (CCD)-based spectrometer. A CCD photographic camera also will fly as part of the experiment and provide target verification for the spectrometer.

G-254
Customer: The Kinkaid School, Houston, Texas and Utah State University, Logan, Utah
Customer: Glen A. Ballard
Payload Manager: Tumkur Raghuram

Since it flew the world's first ten Get Away Special (GAS) experiments in the first GAS payload aboard Columbia in 1982, Utah State University (USU) has maintained an academic program designed to allow many individual students and other educational organizations to participate in a GAS space engineering and microgravity science program. Under this program, the university has flown 22 student GAS experiments to date in canisters G-001, G-004, G-008, G-010 and G-518.

On the present mission, the four experiments described below are being flown in their own individual spacepaks, one of which is of a new aluminum Isogrid construction. In addition, the payload will contain popcorn kernels and radish seeds in separate Ziploc bags as an experiment by Edith Bowen Elementary School located on the USU campus. After the flight, the students will pop and taste the popcorn. The radishes will be grown and compared with a similar sample maintained in 1 g. The purpose of this experiment is to foster interest in the space sciences among a younger generation.

Spacepak 1: Distillation Experiment. The objective of this experiment, which is a joint endeavor between the Kinkaid School and USU, is to separate a mixture of two common organic liquids, trichlorotrifluoroethane and chloroform, in microgravity by distillation. These liquids have boiling points of 47 degrees C (116 degrees F) and 61.2 degrees C (140 degrees F) respectively. An aluminum chamber containing the liquids will be heated to 53 degrees C (127 degrees F) after a solenoid opens a ball valve connecting the chamber to another aluminum collection chamber. A temperature sensitive switch will be used to maintain the distillation temperature. Results of the spaceborne experiment likely will not be identical to those from a 1 g reference run, and the reasons for the differences will be explored.

Spacepak 2: Float Zone Instability Experiment (FZIE). FZIE is an experiment investigating convective instabilities in float zone geometries. The primary goal of the experiment is to verify the Plateau Instability Limit, which theorizes that in zero gravity a fluid cylinder is unstable when the ratio of length to radius exceeds two degrees. This will be accomplished by melting four independent liquid wax bridges with varying lengths and radii. These bridges are initially held between two copper supports, and the wax is melted by heating one of the copper supports. In addition, by allowing the liquid wax to resolidify under "non-quiescent" conditions, a sensitive test of background g-levels can be qualitatively measured by the common distortions in the resolidified float zones.

Spacepak 3: This spacepak contains all the batteries needed to power the individual experiment spacepaks.

Spacepak 4: Pachamama. The objective of this experiment is to study the effects of microgravity on the photosynthetic ability of the plant lichen. An aluminum air-tight chamber will hold the lichen. The control system will heat the water reservoir to 10 degrees C (50 degrees F), and then each sample will be rehydrated. Temperatures within the measuring chamber will be varied with Peltier heating/cooling chips. Four incandescent light bulbs used for growth lighting then will be turned on to start photosynthesis. The data acquisition will begin after a suitable time for rehydration and will be done through a pair of photometric sensors. Measurements will be made at five different temperatures to characterize the temperature response of the organism.

Spacepak 5: Bubble Interferometer Experiment. The objectives of this experiment are to: a) observe the formation of bubbles in a microgravity environment, b) look for evidence of drainage in the bubble after it has been formed, c) look for interference bands due to bubble wall thickness gradients and, d) observe surface tension induced motions on the bubble surface. Bubbles will be formed from a mixture of Dow Corning 704 diffusion pump oil and FC-430 surfactant. The critical bubble blowing sequences will be recorded by an 8 mm camera, while ancillary data, i.e. temperatures, will be stored digitally in an EPROM (an erasable programmable read-only memory chip).

Bubbles will be blown with the help of two linear actuators and an air pump. The camera will record the bubble blowing sequence. A fluorescent lamp is used to provide lighting during the filming sequence. A small incandescent lamp is used to heat the bubble surface. The heating is not uniform and causes a gradient in the surface tension. This induced surface tension gradient will cause movement of the material on the bubble surface.

G-325
Customer: Norfolk Public Schools, Norfolk, Va.
Customer: Dr. Gene Carter
Payload Manager: Joy Young

This experiment is intended to record visually how sound affects dust particles in near-zero gravity, hopefully contributing to a better understanding of acoustics.

The NORSTAR (Norfolk Public Schools Science and Technology Advanced Research) consists of high school students from Norfolk Public Schools. The program was designed to provide a learning experience for high school students while building a working experiment to fly on the Space Shuttle. The NORSTAR experiment is unique because it remains a student-designed, student-run experiment. Education is the main program objective.

The G-325 acoustical experiments will be conducted in a 5- cubic-foot GAS canister. Two 21-inch clear acrylic tubes will be suspended from a box containing two titanium tweeters (high frequency speakers). A separate function generator will be connected to each tweeter to supply the sound and an amplifier will amplify the sound. Inside each test chamber there will be approximately five grams of cork dust as a medium to visualize the modal patterns created by acoustic standing waves at resonances of the test chambers. Different patterns will be formed as the frequency range from 6000 to 7499 Hz runs through Test Chamber 1. A frequency range from 7500 to 9000 Hz will be run through Test Chamber 2. In the microgravity environment of space, the cork particles will be free to move without the constraints of gravity and will form floating discs at the nodes of the standing waves. The three-dimensional modal patterns at different frequencies will be videotaped.

Although the primary object of the NORSTAR GAS-325 project is to study acoustical standing wave modal patterns on a space available basis, there also will be 60 small passive benign experiments placed in a sealed container in the GAS canister. These have been contributed by middle and elementary school classes to more widely share the excitement of space experimentation. The passive experiments will fall primarily into the physical sciences category and will seek to discover and/or measure the effects of space and microgravity on prepared samples.

G-417
Customer: Beijing Institute of Environmental Testing, Beijing, China
Payload Manager: Ke Shouquan

Three experiments submitted by three different students will be carried out on G-417. One of the student experiments was organized and sponsored by the American Association for the Promotion of Science in China and the Chinese Society of Astronautics. The Beijing Institute of Satellite Environmental Engineering designed and developed the payload.

Experiment #1, the Reproduction of Parameciums, will study the effects of microgravity on the reproduction of insects. Experiment #2 will study contact between oil and water droplets for investigating the effect of microgravity on surface interaction of different kinds of liquids. Experiment #3 involves conducting a general survey of surface interaction of solids and liquids under microgravity conditions.

G-453
Customer: The Society of Japanese Aerospace Companies, Inc. (SJAC), Tokyo, Japan
Customer: N. Tateyama
Payload Manager: Takemasa Koreki

This experiment will investigate the formation of superconducting material and the boiling phenomenon under microgravity and the absence of convection. There will be two experiments carried out:

1. Formation of Silicon-Lead (Si-Pb) Alloy: To investigate the formation of superconducting alloy (not mixable on the ground). Each sample, in a platinum crucible located inside a quartz ampoule (small glass container), will be heated in a furnace up to 1450 degrees C (2640 degrees F) for 25 minutes.

2. Boiling Experiment: To observe the bubble formation when an organic solvent (Freon 113) is boiling under microgravity and the absence of convection. The organic solvent in a small sealed vessel is heated and boiled. The behavior of bubbles formed while boiling is observed and recorded using a video system.

This payload was flown on board STS-57 in June 1993. Some of the experiments at that time were not continued until the final sequence because of inadequate battery capacity. Scientists are eager to pursue the space experiments which were not completed on the STS-57 flight.

G-454
Customer: The Society of Japanese Aerospace Companies, Inc. (SJAC), Tokyo, Japan
Customer: N. Tateyama
Payload Manager: Takemasa Koreki

This experiment will investigate the crystallization or the formation of materials under microgravity and the absence of convection. Two kinds of experiments will be carried out:

1. Crystal growth of 3-Selenic-Niobium ($NbSe_3$) from the vapor phase. To investigate the process of the crystal growth from the vapor phase of the one-dimensional electric conducting material, each sample in a quartz ampoule will be heated in a temperature gradient furnace up to 900 degrees C (1650 degrees F) for 20 minutes. At the high temperature end of the furnace, $NbSe_3$ will be vaporized and crystallized at the other (lower temperature) end of the furnace.

2. Crystal growth of the optoelectronic crystal by the diffusion method. To investigate the diffusion process of the optoelectronic crystal growth from the saturated solution. Two organic solvents (potassium-hydrogen-phosphate KH_2PO_4 and ethanol C_2H_5OH) are separated into two chambers by a partition wall. In space, when the partition wall is removed, the optoelectronic crystal will be grown. The process of the crystal growth will be observed for 24 hours using a video system intermittently.

G-456
Customer: The Society of Japanese Aerospace Companies, Inc.
(SJAC), Tokyo, Japan
Customer: N. Tateyama
Payload Manager: Takemasa Koreki

An electrophoresis (the movement of suspended particles through a fluid or gel under the action of an electromotive force applied to electrodes in contact with the suspension) has a number of important advantages for the separation and isolation of cells or biologically active materials. Therefore, the electrophoresis is being studied, particularly in the area of drug manufacturing for biological/biotechnological products.

In microgravity, the effects of sedimentation, buoyancy and thermal convection, all of which involve differences in density, will decrease. In this experiment, a mixture of the samples will be separated by free-flow electrophoresis in a microgravity environment. Free-flow electrophoresis is a continuous electrophoretic separation method, using a carrier solution which is flowing as a thin liquid film under laminar conditions through the separation chamber. The direction of the flow of the carrier solution (linear flow velocity) is perpendicular to the direction of an electrical field. The samples are separated by this electrical field according to their different electrophoretic mobility or their different isoelectric point and are migrating in the form of narrow zones to the end of the separation chamber. The phenomena of this separation are observed by a video camera above the separation chamber and recorded by video cassette recorders. Results of this separation will be compared to results obtained on the Earth's surface.

G-485
Customer: European Space Agency/ESTEC FTD, The Netherlands
Customer: Manfred Trischberger
Payload Manager: Andre Robelet

G-485 was developed by Crisa (Spain) under the auspices of the In-Orbit Technology Demonstration Program of the European Space Agency. The payload is designed to test the feasibility of depositing different materials in a microgravity and vacuum environment. To do this, the payload is being flown in a GAS canister with a Motorized Door Assembly (MDA).

Inside the GAS canister, the payload is divided into two sections: The lower volume which contains the battery and electronics (under 1 atmosphere of pressure) and the experiment chamber, which has the evaporation sources and the target substrates that will be exposed to vacuum when the MDA is opened in orbit. The experiment chamber contains the ceramic effusion cells (crucibles) for processing aluminum and silicon and molybdenum filament for evaporating gold. Each evaporation source is located within a separate compartment in the experiment chamber. In each compartment, mounted opposite the evaporation source, is a target substrate panel. These panels are composed of six different materials (glass, silicon, alumina, sapphire, gallium arsenide and transmission electron microscopy grids).

Once in orbit, the MDA is opened, the vacuum gauge measures the chamber environment and the experiment sequence starts. The evaporation sources are operated sequentially and, upon completion, the MDA is closed, and the experiment chamber kept under vacuum until de-integration to protect the substrates from contamination.

G-506
Customer: Goddard Space Flight Center, Greenbelt, Md.
Customer: Lawrence R. Thomas
Payload Manager: James Houston

The Orbiter Stability Experiment (OSE) was designed originally to evaluate the Space Shuttle as a platform for imaging the Sun in x-rays and extreme ultraviolet light. Although the Spacelab instrument that was being planned at that time was never funded for development, the OSE in its two previous flights has provided valuable information on the performance of the orbiter's high-frequency stability, that is, the steadiness with which it is oriented in space. Steadiness is measured by observing the position of the Sun with high precision optical sensors mounted rigidly on the top of a GAS canister. The measurements are made 60 times a second, and the location of the Sun is determined relative to the Orbiter to a small fraction of an arc second.

These data tell about the angular vibration produced by small thruster firings and human activity in the Orbiter cabin. Additional information has been obtained on the accuracy with which a GAS canister can be installed and aligned relative to the orbiter's structure. Such information is useful to other experimenters who are planning to fly instruments requiring accurate pointing by the Shuttle.

The OSE was designed and built by Goddard's Laboratory for Astronomy and Solar Physics, Code 680, using funds provided by the Director's Discretionary Fund and with several major flight components lent by the Engineering Directorate, Code 700, and the Suborbital Projects and Operations Directorate, Code 800. The instrument manager is James Houston, and principal electronics technician is Thomas B. Plummer. Werner M. Neupert is principal investigator.

This will be the third flight of the instrument, previously flown on STS-40 and STS-60. As a GAS payload, the experiment is not able to request solar pointing by the Shuttle, but in two previous flights, experimenters were able to take advantage of solar pointing carried out as part of the Shuttle's timeline for engineering tests.

In addition to the vibration measurements that are planned, the OSE also carries a passive experiment to evaluate the effects of radiation on photographic film. That experiment was developed and provided by Dr. Ernest Hammond of Morgan State University. The GAS container also carries seeds provided by students in the NASA Scientific Knowledge for Indian Learning and Leadership (SKILL) program for 9th through 12th grade high school students. The seeds will be used to study the effects of radiation and zero gravity on germination and growth. This program is administered by the South Dakota School of Mines and Technology, collaborators in this NASA-funded program.

G-562
Customer: Canadian Space Agency, Ontario, Canada
Customer and Payload Manager: R.D. Hendry

The Get Away Special payload QUESTS-2 is a materials science payload funded by the Canadian Space Agency and is a re- flight of G-521 flown in September 1992.

The QUESTS payload consists of 15 furnaces, a computer control system, a data acquisition system and batteries. There are two types of furnaces: temperature-gradient (for directional crystal growth studies) and constant-temperature (for metal diffusion studies).

There are three experiments on QUESTS-2. Following is a description of each:

Experiment #1 - Queen's University

The Queen's University experiment involves eight samples: Two are eutectics (alloy composition having lowest melting point), and six are for Ostwald ripening (how the size distribution of droplets of one metal changes with time).

In the original QUESTS project, the two Queen's University eutectic specimens produced startling results, namely, the spacing between the "rods" of one material was found to be unaltered in zero-gravity, despite claims to the contrary of other workers in the U.S. and Europe. The antimony- magnesium specimens to be flown on QUESTS-2 will provide data on the growth behavior of roddy-type eutectics. Scientists hope that this data will be used to develop models to predict the microstructure of eutectics likely to be present when processing eutectic materials in space vehicles such as the International Space Station and Mir.

An immiscible alloy is one in which two components do not mix in the molten state, and droplets of one metal are formed in the melt of the other metal. In Ostwald ripening, the distribution of size of the droplets changes - the smaller droplets will become smaller over time, while the larger droplets become larger (i.e. the distribution "ripens"). On Earth, two mechanisms are responsible: Marangoni (surface-tension driven) convection and diffusion, in which the smaller droplets start to become smaller over time as they slowly dissolve and the material diffuses, while the larger droplets become larger as the dissolved material comes out of the large droplets.

The QUESTS-2 experiment is designed to develop a better understanding of droplet growth in liquid-liquid systems by adding particles of a third material to constrain the motion due to surface tension forces, while the microgravity will eliminate gravity-driven settling. Aluminum-indium and aluminum-bismuth are the two alloys to be studied.

Experiment #2 - University of Manitoba

Metal-matrix composites offer excellent mechanical properties which, when combined with light weight and stiffness, make them a suitable material for applications demanding high performance. Most metal-matrix composites are reinforced with randomly-oriented, high-strength fibers, which are either mechanically mixed in the metal powder or in the molten alloy.

The strength of these meta-matrix composites can be improved further by aligning the fibers in the same direction, accomplished by directional solidification (from one end) alloys such as aluminum-nickel, which produce strong fibers of $NiAl_3$ in a matrix of aluminum. However, composites produced on Earth contain many defects, and depending on the growth rate, the shape of the fibers can be round or long. Scientists believe that the gravity-driven flow of the melt on Earth may be responsible for these phenomena. Composite material grown in zero-gravity should be more uniform than that grown on Earth.

Experiment #3 - Ceramics Kingston Ceramique

This company currently is developing a range of new materials for use in the next generation of high performance, fuel-efficient aircraft. High-strength fibers or particles of one material are added to the melt of a second, lighter weight metal. Because the densities of the two components are quite different, one component settles to the bottom because of gravity, and the mixing is uneven. In addition, further unevenness in the mixing can occur from thermally-induced flow in the melt. This uneven mixing leads to degraded material properties.

The Shuttle tests allow the separation of the gravitational and non-gravitational effects. Using the Shuttle, "ideal" samples of materials can be made in the microgravity environment. These materials will be used as benchmarks to compare with materials produced on Earth and to gain an understanding of the various phenomena which can degrade product quality and their respective importance.

In the QUESTS-2 experiments, aluminum is used as a model system. Samples of aluminum reinforced with various materials are to be melted then solidified, both on Earth and on the Shuttle. The distribution of the reinforcing material is to be compared to gain an understanding of the process and the relative importance of the various phenomena influencing the properties.

SIMPLIFIED AID FOR EXTRAVEHICULAR ACTIVITY RESCUE (DTO 661)

STS-64 crew members Mark Lee (EV1) and Carl Meade (EV2) will perform a six-and-a-half hour spacewalk on flight day eight of the mission to evaluate the Simplified Aid For EVA Rescue (SAFER); several spacewalking tools; and an Electronic Cuff Checklist developed to allow spacewalkers greater and easier access to information. During the spacewalk, STS-64 crew member Jerry Linenger will serve as the Intravehicular Crewmember (IV), assisting the spacewalkers with their work from within Discovery's crew cabin.

SAFER, designed and developed by the Johnson Space Center in a team project led by the Automation and Robotics Division, is a small, self-contained, propulsive backpack device that can provide free-flying mobility for a spacewalker in an emergency. It is designed for self-rescue use by a spacewalker in the event the Shuttle is unable or unavailable to retrieve a detached, drifting crew member. Examples of such times may include a mission where the Shuttle is docked to the Russian Mir Space Station or to the International Space Station.

SAFER is attached to the spacesuit's Portable Life Support System backpack, and is, in essence, a scaled-down, miniature version of the Manned Maneuvering Unit propulsion backpack flown aboard Shuttle missions in 1984. It is designed for emergency use only, but without built- in backup systems. SAFER's propulsion is provided by 24 fixed- position thrusters that expel nitrogen gas and have a thrust of .8 lbs. each. Stowed in the crew cabin for launch and landing, SAFER's nitrogen supply can be recharged in orbit from the Shuttle's nitrogen system. SAFER's three-pound supply of nitrogen can provide a ten-foot-per-second change in velocity for the operator before it is exhausted. Its attitude control system includes an automatic attitude hold and six degrees of freedom. A 28-volt battery pack for SAFER can be replaced in orbit.

For STS-64, first Lee, and then Meade, will evaluate SAFER through four test sequences: A SAFER familiarization, a system engineering evaluation, a rescue demonstration, and a flight qualities evaluation. The SAFER flight operations will be conducted without a tether attached to the Shuttle. The familiarization will have the SAFER spacewalker perform several short single-axis translation and then rotation commands. They will be performed first with the unit's automatic attitude hold "on" and again with the attitude hold "off". Next, the spacewalker will fly a square trajectory within the Shuttle payload bay, recording the percent of nitrogen used both before and after the maneuver to compare the actual use with what had been predicted.

For the engineering evaluation, the spacewalker will fly several short translation commands, for example, a one- second thrust forward, five seconds of coasting, and a one- second braking thrust. The same type of command will be done for rotations as well, and a data recorder in the SAFER will retain all measurements of the unit's performance for study on the ground after the mission.

The self-rescue demonstration will have one spacewalker-- standing in a foot restraint at the end of Discovery's mechanical arm--impart a series of rotations to the SAFER spacewalker. The SAFER spacewalker will then activate the unit's automatic attitude hold system to stop the rotation and fly back to the end of the arm, which will have slowly been backed away. The rotations will not exceed a speed of 30 degrees per second, a rate well below the design capability of SAFER.

The flight qualities evaluation will have the spacewalker fly a precision trajectory that will follow the Shuttle's bent mechanical arm. Next, he will fly a precision approach from the elbow of the arm to the aft flight deck windows of the Shuttle, establishing a hover one foot away from the windows.

Between each test sequence, SAFER will be recharged with nitrogen from the Shuttle's nitrogen supply via a SAFER Recharge Station mounted in the forward portion of the cargo bay. In addition, before the unit is switched from Lee to Meade, the SAFER battery will be changed.

DTO 671: EVA Hardware for Future Scheduled EVA Missions

Throughout the spacewalk, Lee and Meade will evaluate several new and some improved spacewalking tools. These include quick-release tether hooks and wrist tethers, push- button portable foot restraints, a rigid tether, modified handrails and an articulating portable foot restraint. Except for the articulating portable foot restraint, which will have specific time scheduled for its evaluation, these tools will be evaluated by the spacewalkers as they use them to work on the SAFER tests.

DTO 672: Extravehicular Mobility Unit Electronic Cuff Checklist

One new piece of spacewalking equipment to be worn and evaluated by both Lee and Meade is called the Electronic Cuff Checklist (ECC).

The Electronic Cuff Checklist, developed by the Johnson Space Center's Crew and Thermal Systems Division, attaches to the lower arm of a spacesuit and can hold more than 500 pages of information, including graphics and even photographs, to display on a 3-by-4-inch screen. Roughly the same size as the current printed checklist, the two-and- a-half-pound, battery-powered unit is an inch deep at its thickest point.

The standard checklist currently worn by spacewalkers is a printed notebook, usually 25-50 pages long, worn on the cuff of the spacesuit during a spacewalk. It normally contains only a small amount of critical information, such as emergency spacesuit operations. The Electronic Cuff Checklist would allow spacewalkers to have quick, easy access to much more information that will be useful as work in space becomes more complex, such as during the Hubble Space Telescope servicing spacewalks.

The Electronic Cuff Checklist also has the capability to be altered during a flight. Information can be loaded into the checklist on orbit from a laptop computer carried on the Shuttle.

The unit's flat screen has a resolution roughly equivalent to that of a standard television set -- 320 by 240 pixels -- that may give it the ability to display graphics and photographs. The screen is divided into six different touch-sensitive buttons that allow instant access to various categories of information. It is designed for easy operation when wearing bulky spacesuit gloves. A touch and hold feature built into the checklist allows ready access to special functions, including an emergency page. The checklist also includes a mission elapsed time clock and a spacewalk elapsed time clock.

The checklist has about two megabytes of memory, is powered by standard AA batteries and can operate up to 12 hours on one battery pack.

On STS-64, Lee and Meade each will wear the Electronic Cuff Checklist on the left arm of his spacesuit and a standard, printed checklist on the right arm. The electronic checklist will include the information on the printed checklist plus additional information, including the spacewalk timeline and complete SAFER evaluation procedures. The electronic checklist will be evaluated in parallel with the other spacewalk operations on its size, weight, viewability, accessibility of information, attachment to the suit and general operation. In addition, after the spacewalk is completed, new pages of information will be transferred to the unit from the laptop computer aboard Discovery to test that capability.

SHUTTLE PLUME IMPINGEMENT FLIGHT EXPERIMENT

The Shuttle Plume Impingement Flight Experiment (SPIFEX), designed and built by a team of Johnson Space Center scientists and engineers, will study the characteristics and behavior of exhaust plumes from Discovery's Reaction Control System (RCS) thrusters during STS-64.

SPIFEX, when picked up by Discovery's mechanical arm, is a 33-foot long extension for the arm with a package of instruments that will measure the near-field, transition and far-field effects of thruster plumes. The plume information gathered by the experiment will assist planners in understanding the potential effects of thruster plumes on large space structures, such as the Russian Space Agency's Mir Space Station and the International Space Station, during future Shuttle docking and rendezvous operations.

During STS-64, SPIFEX will be moved by a series of complex mechanical arm maneuvers to take measurements of 86 separate test firings of the Shuttle's RCS thrusters at 60 different locations. The majority of locations will have SPIFEX either above the nose of Discovery, in front of the nose, or at the rear of the spacecraft near the left Orbital Maneuvering System pod. Operations of the experiment are scheduled on four different flight days of the mission and are planned to gather a total of 12 to 14 hours of data during the flight.

In addition to the thruster plume data, a Get-Away Special canister in Discovery's cargo bay will contain cold gas that will be released during the SPIFEX operations to fine-tune the experiment's instruments. Most of the SPIFEX data will be recorded aboard Discovery on a laptop computer for analysis after landing. Some data, however, may be transmitted immediately to ground scientists.

The SPIFEX instruments are comprised of three basic systems: A Load Measurement System; a Plume Impingement Characterization System; and a Position and Orientation Verification System. The load measurements will obtain information on the pressures that might be imparted by the jet plumes to delicate structures such as solar arrays, while the characterization measurements will detail the concentrations of contaminants from exhaust plumes. All of the operations will be done at a variety of distances from and orientations to the Shuttle steering jets. The primary crew member for SPIFEX mechanical arm operations will be Susan Helms, although the experiment will require two additional crewmembers during each data take -- one to operate the laptop computer and another to perform the jet firings.

SOLID SURFACE COMBUSTION EXPERIMENT (SSCE)

The Solid Surface Combustion Experiment (SSCE) is a major study of how flames spread in a microgravity environment (10-6g). Conducting the flame spreading experiment in microgravity removes buoyant air motion caused by gravity, commonly observed as "hot gases rising." Comparing microgravity results with test results obtained in normal gravity on Earth (1 g) provides detailed information about how air motion affects flame spreading. The SSCE results will contribute to improvements in fire safety equipment and practices both on Earth and in spacecraft.

This is the seventh of eight Space Shuttle flights planned for the SSCE. During the STS-64 mission, a small sample of PMMA, or Plexiglas, will be burned in a mixture of 50 percent oxygen and 50 percent nitrogen at twice normal atmospheric pressure.

After the mission, comparisons of burning behavior in microgravity and normal gravity will be made by engineers and scientists at NASA's Lewis Research Center, Cleveland, Ohio, and by Principal Investigator, Professor Altenkirch and his team at Mississippi State University. In addition, Professor Altenkirch will compare the test results with a complex computer simulation of flame spreading, which he and his students have developed from over a decade of research in this field.

The results of earlier flights of the SSCE have been published in scientific literature. Those data resulted in the modification of the theoretical flame spreading simulation, particularly in the description of how the fuel is vaporized by the flame before burning.

The SSCE experiment is sponsored by NASA's Office of Life and Microgravity Sciences and Applications and is managed by the Lewis Research Center.

BIOLOGICAL RESEARCH IN CANISTERS (BRIC-2)

Research on the development and differentiation of a major food crop family that provides half of the world's calorie intake from plants, is the subject of the second Biological Research in Canisters (BRIC-2) experiment on STS-64. Microgravity research on orchard grass, which is part of the plant family that includes wheat, rice and corn, possibly will provide critical insights into the reproductive biology of the world's major food crops.

Orchard grass, the subject of BRIC-2, provides an ideal subject for studying and understanding food crops as part of an environmental system of food production and waste recycling for long duration space missions, the International Space Station and as part of the ecology of Earth.

On STS-64, for the first time, basic microgravity research on a member of the grass family will be performed. Leaf cultures will be grown in a fixed nutrient "soil" as opposed to having to be placed in suspension. Leaf sections will be split providing for excellent research controls and statistical analysis. Finally, a fixed number of the seeds will develop fully and will be germinated and grown to full plants for further research. All portions of the orchard grass, such as leaf, veins, etc., will be analyzed to understand the development and life cycle of the plant.

The principal scientist for this experiment is Dr. Robert Conger, Department of Plant and Soil Science from the University of Tennessee in Knoxville. For Dr. Conger's research, orchard grass leaf segments will be placed in a special nutrient broth in petri dishes in a BRIC 100 canister. The experiment will be sealed and housed in the mid-deck of the Space Shuttle. The experiment is passive and requires no in-flight manipulation. It does require immediate removal from the Shuttle after landing to assess the effects of microgravity on the reproductive and regeneration systems of the plants before the effects of full gravity are reestablished.

BRIC experiments are sponsored by NASA's Office of Life and Microgravity Sciences and Applications (OLMSA) Small Payloads Program, and are designed to examine the effects of microgravity on a wide range of physiological processes in higher order plants and arthropod animals, such as insects, spiders, centipedes and crustaceans.

SHUTTLE AMATEUR RADIO EXPERIMENT (SAREX)

Students in the U.S. and New Zealand will have a chance to speak via amateur radio with astronauts aboard the Space Shuttle Discovery during STS-64. Ground-based amateur radio operators ("hams") also will be able to contact the Shuttle through automated computer-to-computer amateur (packet) radio links. There also will be voice contacts with the general ham community as time permits.

Shuttle Commander Dick Richards (KB5SIW), pilot Blaine Hammond Jr., (KC5HBS) and mission specialist Jerry Linenger (KC5HBR) will talk with students in 10 schools in the U.S. and New Zealand using "ham radio."

Students in the following schools will have the opportunity to talk directly to orbiting astronauts for approximately 4 to 8 minutes:

- Grizzly Hill School, North San Juan, Calif. (N6NYY)
- The Branson School, Ross, Calif. (KC6VIM)
- Crystal Lake South Elementary, Crystal Lake, Ill. (N9NJF)
- Morocco Elementary School, Morocco, Ind. (N9GBM)
- Dwight D. Eisenhower Middle School, Laurel, Md. (N3MJA)
- Springfield Plains Elementary, Clarkston, Mich. (K8ZZU)
- Francis Howell North H.S., St. Charles, MO (KO0Z)
- Central Square Middle School, Central Square, N.Y. (N2STK)
- STEP/Star Schools-Young Astronauts, Spokane, Wash. (WB7NNF)
- Middleton Grange School, Christchurch, New Zealand (ZL3JG)

The radio contacts are part of the SAREX (Shuttle Amateur Radio EXperiment) project, a joint effort by NASA, the American Radio Relay League (ARRL), and the Radio Amateur Satellite Corporation (AMSAT).

The project, which has flown on 14 previous Shuttle missions, is designed to encourage public participation in the space program and to support the conduct of educational initiatives through a program to demonstrate the effectiveness of communications between the Shuttle and low- cost ground stations using amateur radio voice and digital techniques.

Information about orbital elements, contact times, frequencies and crew operating schedules will be available during the mission from NASA, ARRL (Steve Mansfield, 203/666-1541) and AMSAT (Frank Bauer, 301/ 286-8496). AMSAT will provide information bulletins for interested parties on Internet and amateur packet radio. The ARRL bulletin board system (BBS) number is (203) 688-0578.

The ARRL ham radio station (W1AW) will include SAREX information in its regular voice and teletype bulletins.

Mission information will be available online from the Johnson Space Center computer bulletin board (8 N 1 1200 baud): dial (713) 244-5625. BBS information is available from the Goddard Space Flight Center amateur radio club via Internet. The address is: wa3nan.gsfc.nasa.gov.

The amateur radio station at the Goddard Space Flight Center, (WA3NAN), will operate during the mission, providing SAREX information, retransmitting live Shuttle air-to-ground audio, and retransmitting some of the SAREX school group contacts.

STS-64 SAREX Frequencies

Routine SAREX transmissions from the Space Shuttle may be monitored on a
worldwide downlink frequency of 145.55 MHz.

The voice uplink frequencies are (except Europe):
144.91 MHz 144.93
144.95 144.97
144.99

The voice uplink frequencies for Europe only are:
144.70 144.75
144.80

Note: The astronauts will not favor any one of the above frequencies. Therefore, the ability to talk with an astronaut depends on selecting one of the above frequencies chosen by the astronaut.

The worldwide amateur packet frequencies are:

Packet downlink 145.55 MHz
Packet uplink 144.49 MHz

The Goddard Space Flight Center amateur radio club planned HF operating frequencies are:

3.860 MHz	14.295	28.650	7.185	21.395

RADIATION MONITORING EQUIPMENT-III

The Radiation Monitoring Equipment-III (RME-III) measures ionizing radiation exposure to the crew within the orbiter cabin. RME-III measures gamma ray, electron, neutron and proton radiation and calculates in real time exposure in RADS-tissue equivalent. The information is stored in a memory module for post-flight analysis.

The hand-held instrument is stored in a mid-deck locker during flight except for when the crew activates it and replaces the memory module every two days. RME-III will be activated by the crew as soon as possible after they achieve orbit, and it will operate throughout the mission. A crew member will enter the correct mission elapsed time upon activation. RME-III is sponsored by the Department of Defense in cooperation with NASA.

MILITARY APPLICATIONS OF SHIP TRACKS

The Office of Naval Research (ONR) is sponsoring the Military Applications of Ship Tracks (MAST) experiment on STS-64. MAST is part of a five-year research program developed by ONR to examine the effects of ships on surrounding clouds and aerosols. The Naval Postgraduate School, Monterey, Calif., will conduct the experiment at the Johnson Space Center during the mission. The objective of MAST is to determine how effluents generated by ships modify the reflective properties of clouds. Ship tracks are observed in satellite imagery as long, narrow, curvilinear cloud features that have greater brightness than the surrounding clouds. The STS-64 crew will photograph ship tracks using handheld cameras. These high-resolution photographs will provide insight into the processes of ship track production on a global scale. MAST is a Department of Defense payload and is being flown under the direction of the DOD Space Test Program.

STS-64 CREWMEMBERS

STS064-S-002 **--** *The crewmembers assigned to the STS-64 mission include: astronaut Richard N. Richards (center front), mission commander; L. Blaine Hammond Jr., (front left) pilot and Susan J. Helms (front right) mission specialists. On the back row, from left to right are: Mark C. Lee, Jerry M. Linenger and Carl J. Meade, all mission specialists. All but Lee and Meade are wearing launch and entry suits. Lee and Meade are wearing extravehicular activity units (EMU).*

PHOTO CREDIT: NASA or National Aeronautics and Space Administration.

BIOGRAPHICAL DATA

RICHARD (DICK) N. RICHARDS, 48, Capt., USN, will command STS-64. Selected as an astronaut in 1980, Richards considers St. Louis, Mo., his hometown and will be making his fourth space flight.

Richards graduated from Riverview Gardens High School, St. Louis, in 1964. He received a bachelor's degree in chemical engineering from the University of Missouri in 1969 and received a master's degree in aeronautical systems from the University of West Florida in 1970. Richards graduated from the Naval Test Pilot School, Patuxent River, Md., in 1976.

After joining NASA, Richards first Shuttle flight was as pilot of STS-28, a Department of Defense-dedicated mission in August 1989. He next flew as commander of STS-41, a mission that deployed the Ulysses probe to study the Sun's polar regions, in October 1990. His third flight was as commander of STS-50, the first flight of the United States Microgravity Payload.

Richards has logged more than 22 days and 22 hours in space, and more than 5,100 hours flying time in over 16 different types of aircraft.

L. BLAINE HAMMOND Jr., 42, Col., USAF, will serve as pilot. Selected as an astronaut in 1984, Hammond considers St. Louis, Mo., his hometown and will be making his second space flight.

Hammond graduated from Kirkwood High School, Kirkwood, Mo., in 1969. He received a bachelor's degree in engineering science and mathematics from the Air Force Academy in 1973 and a master's degree in engineering science and mathematics from the Georgia Institute of Technology in 1974.

Hammond, as an Air Force pilot and instructor pilot, attended the Empire Test Pilot School, Boscombe Down, England, in 1981. He later served as a test pilot at Edwards Air Force Base, Calif., before being assigned as an instructor at the Air Force Test Pilot School, where he was serving when selected by NASA.

Hammond's first Shuttle flight was as pilot of STS-39 in May 1991, the first unclassified Department of Defense-dedicated mission that collected data on atmospheric infrared and ultraviolet phenomena as well as in support of the Strategic Defense Initiative Office.

Hammond has logged more than 199 hours in space and more than 4,200 hours flying time in 15 different types of U.S. aircraft and 10 types of British aircraft.

J. M. (JERRY) LINENGER, 39, M.D., Ph.D., Cdr., Medical Corps, USN, will serve as Mission Specialist 1 (MS1). Selected as an astronaut in 1992, Linenger considers Eastpointe, Mich., and Coronado, Calif., his hometowns and will be making his first space flight.

Linenger graduated from East Detroit High School, Eastpointe, Mich., in 1973; received a bachelor's degree in bioscience from the Naval Academy in 1977; received a doctorate in medicine from Wayne State University in 1981; received a master's degree in systems management from the University of Southern California in 1988; received a master of public health degree in health policy from the University of North Carolina in 1989; and received a doctorate in epidemiology from the University of North Carolina in 1989.

Linenger completed his surgical internship at Balboa Naval Hospital, San Diego, Calif., and aerospace medicine training at the Naval Aerospace Medical Institute, Pensacola, Fla. He first served as a Naval flight surgeon at Cubi Point, Republic of the Philippines, and was later assigned as medical advisor to the commander, Naval Air Forces, U.S. Pacific Fleet, in San Diego. After receiving a doctorate in epidemiology, he served as a research principal investigator at the Naval Health Research Center, where he was assigned when selected by NASA.

BIOGRAPHICAL DATA

SUSAN J. HELMS, 36, Lt. Col., USAF, will serve as Mission Specialist 2 (MS2). Selected as an astronaut in 1990, Helms considers Portland, Or., her hometown and will be making her second space flight.

Helms graduated from Parkrose Senior High School, Portland, Or., in 1976; received a bachelor's degree in aeronautical engineering from the Air Force Academy in 1980; and received a master's degree in aeronautics and astronautics from Stanford University in 1985.

Prior to her selection by NASA, Helms' work in the Air Force included lead engineer for F-15 weapons separation at the Air Force Armament Laboratory, Eglin Air Force Base, Fla.; assistant professor of aeronautics at the Air Force Academy; graduate of the Air Force Test Pilot School as a flight test engineer in 1988; and service as a flight test engineer and Air Force Exchange Officer with the Aerospace Engineering Test Establishment, Canadian Armed Forces Base, Cold Lake, Alberta, Canada. At the time of her selection, Helms was managing the development of a CF-18 Flight Control System Simulation for the Canadian Armed Forces.

Helms' first flight was as a mission specialist on STS-54 in January 1993, a mission that deployed a NASA Tracking and Data Relay Satellite and operated the Diffuse X-Ray Spectrometer, gathering X-ray astronomy data to explore the origins of the Milky Way galaxy.

Helms has logged more than 143 hours in space and has flown in more than 30 different types of aircraft as a flight test engineer.

CARL J. MEADE, 43, Col., USAF, will serve as Mission Specialist 3 (MS3). Selected as an astronaut in 1985, Meade will be making his third space flight.

Meade graduated from Randolph High School, Randolph Air Force Base, Texas, in 1968; received a bachelor's degree with honors in electronics engineering from the University of Texas in 1973; and received a master's degree in electronics engineering from the California Institute of Technology in 1975.

Meade was a distinguished graduate of undergraduate pilot training at Laughlin Air Force Base, Texas, and later graduated from the Air Force Test Pilot School, receiving the Lichen-Tittle Award as the Outstanding Test Pilot of the class. He was then assigned to the 6510th Test Wing, Edwards Air Force Base, Calif., serving in a variety of research, development and test programs. In 1985, he was assigned as a test pilot instructor at the Air Force Test Pilot School, where he was serving at the time of his selection by NASA.

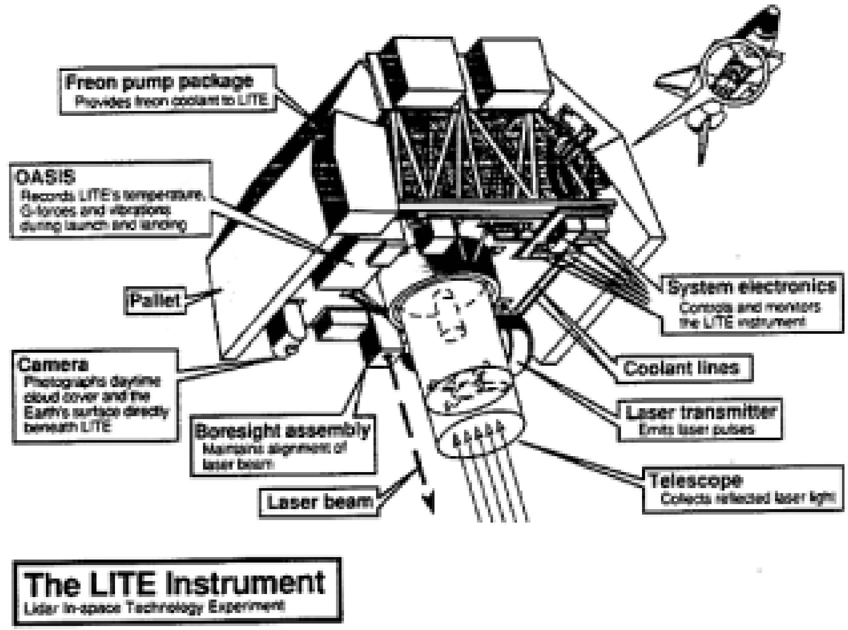
Meade's first space flight was as a mission specialist on STS-38 in November 1990, a Department of Defense-dedicated mission. He next flew as a mission specialist on STS-50 in June 1992, a mission that carried the first United States Microgravity Laboratory.

Meade has logged more than 449 hours in space and more than 4,300 hours flying time in 27 different types of aircraft.

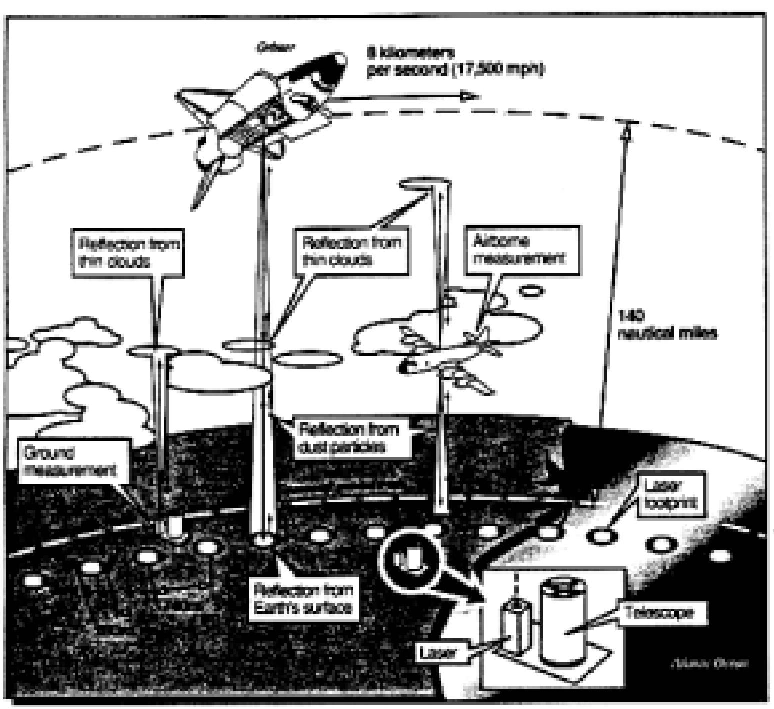
MARK C. LEE, 42, Col., USAF, will serve as Mission Specialist 4 (MS4). Selected as an astronaut in May 1984, Lee considers Viroqua, Wisc., his hometown and will be making his third space flight.
Lee graduated from Viroqua High School in 1970; received a bachelor's degree in civil engineering from the Air Force Academy in 1974; and received a master's degree in mechanical engineering from the Massachusetts Institute of Technology in 1980.

Lee completed Air Force pilot training at Laughlin Air Force Base, Texas, and served at Okinawa Air Base, Japan, flying F-4s. Later, he served as the operations support manager in the Airborne Warning and Control System at Hanscom Air Force Base, Mass. In 1982, he upgraded to fly the F-16, assigned as executive officer for the 388th Tactical Fighter Wing Commander for Operations at Hill Air Force Base, Utah.

Lee's first space flight was as a mission specialist on STS- 30 in May 1989, a mission that launched the Magellan planetary probe to map Venus. Lee next flew as the payload commander and a mission specialist on STS-47 in September 1992, a cooperative Spacelab mission between the U.S. and Japan. Lee has logged more than 288 hours in orbit and more than 3,500 hours flying time in various aircraft.

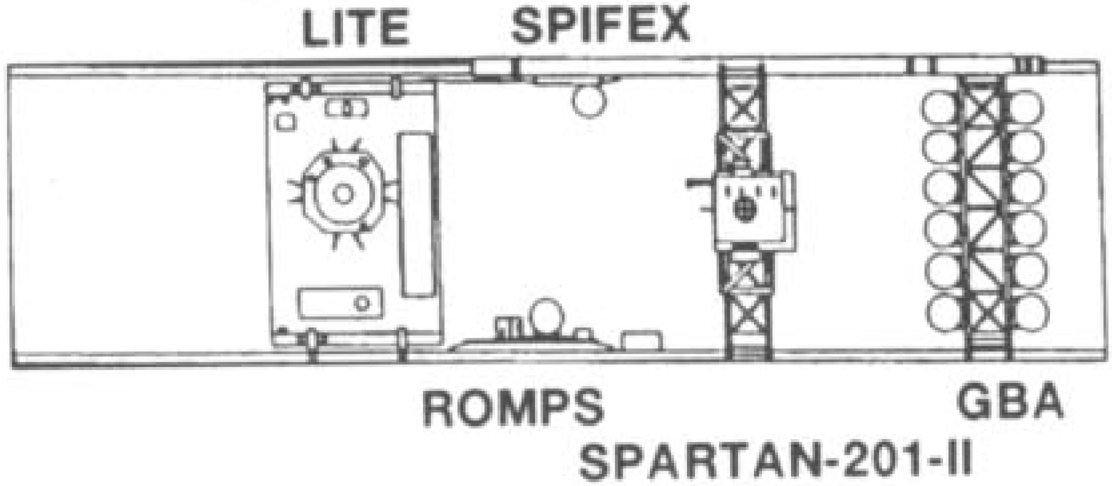


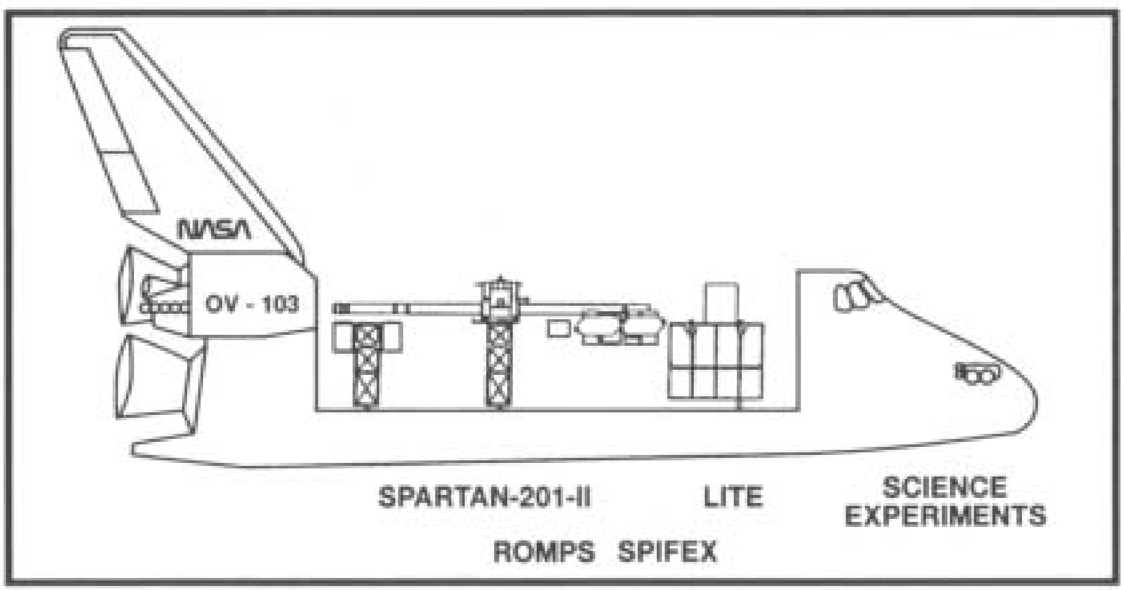
Laser light, directed toward Earth, will bounce off of thin clouds, dust particles and the surface of the Earth -- LITE's telescope receiver will "catch" that reflected light.



Laser light from the shuttle contacts thin clouds, dust particles and the Earth's surface, and a reflection is bounced back to LITE's telescope.

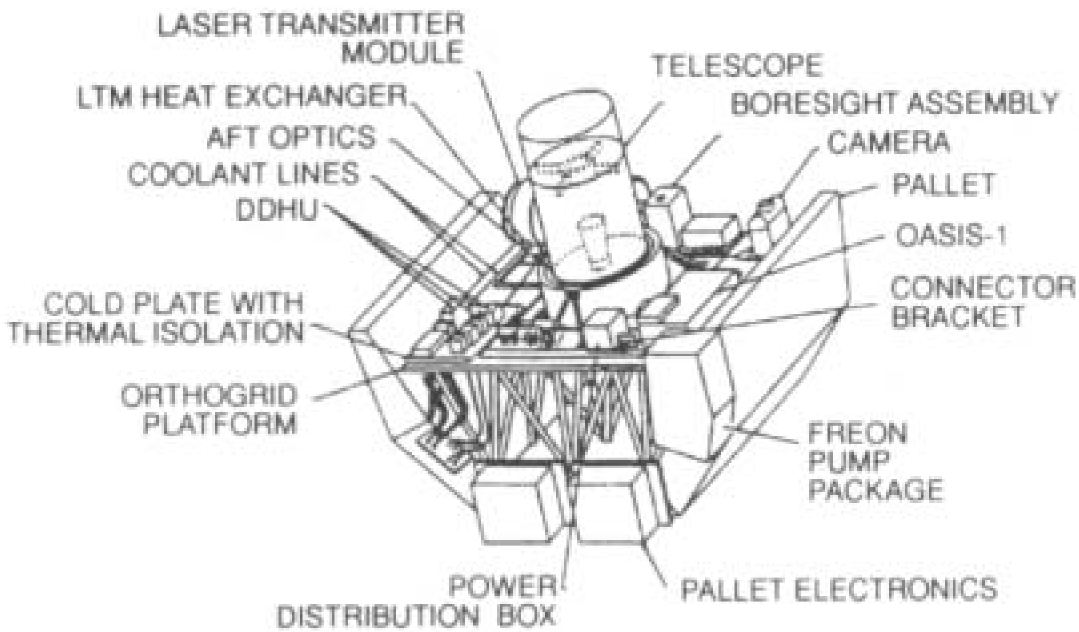
STS-64 FACT SHEET



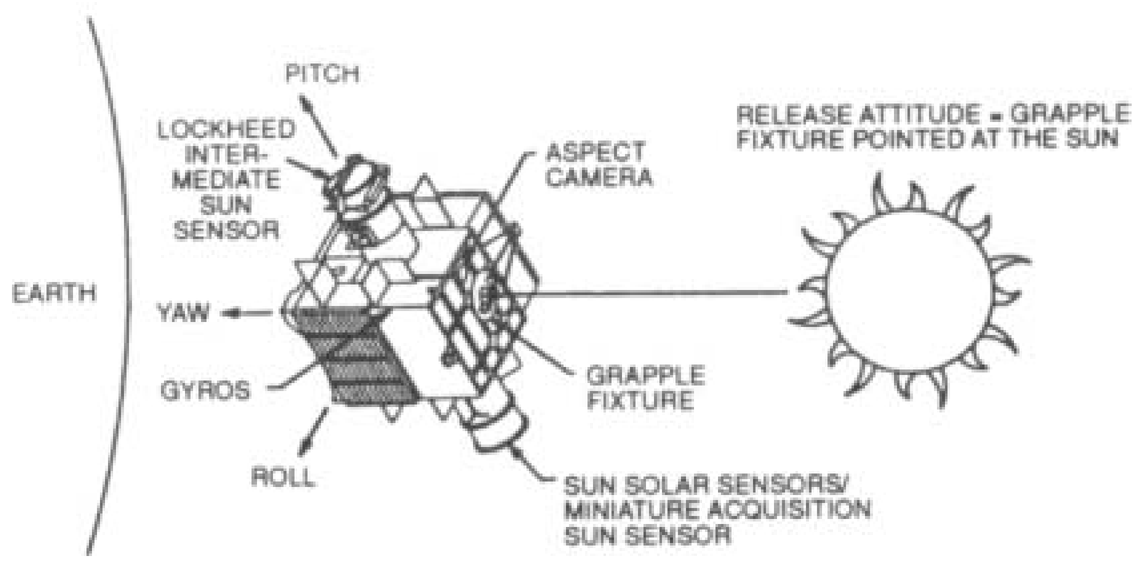


STS-64 PAYLOADS IN ORBITER BAY

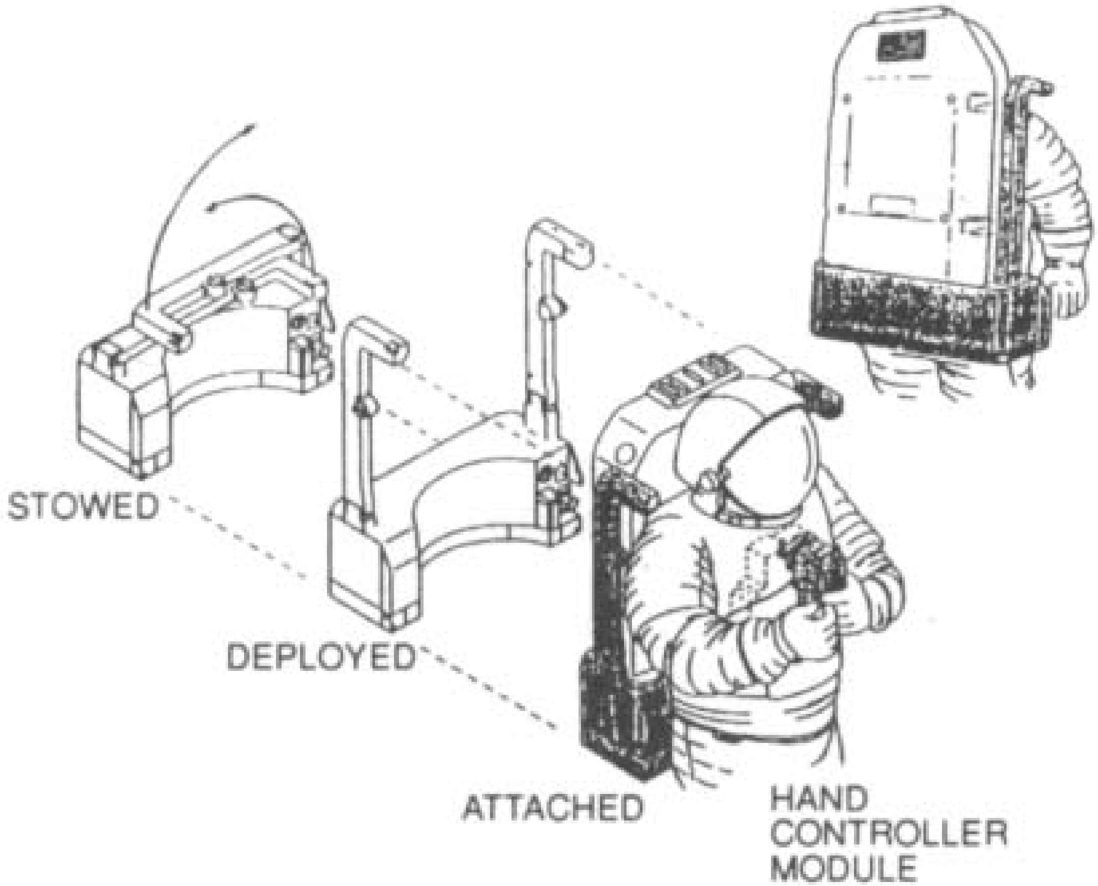
LITE PAYLOAD CONFIGURATION



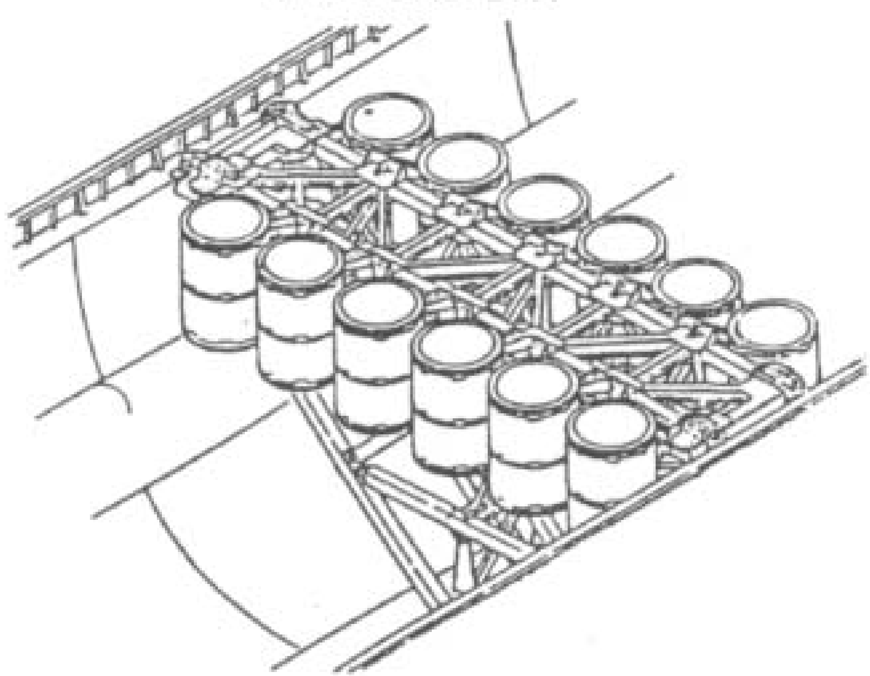
SPARTAN 201-II



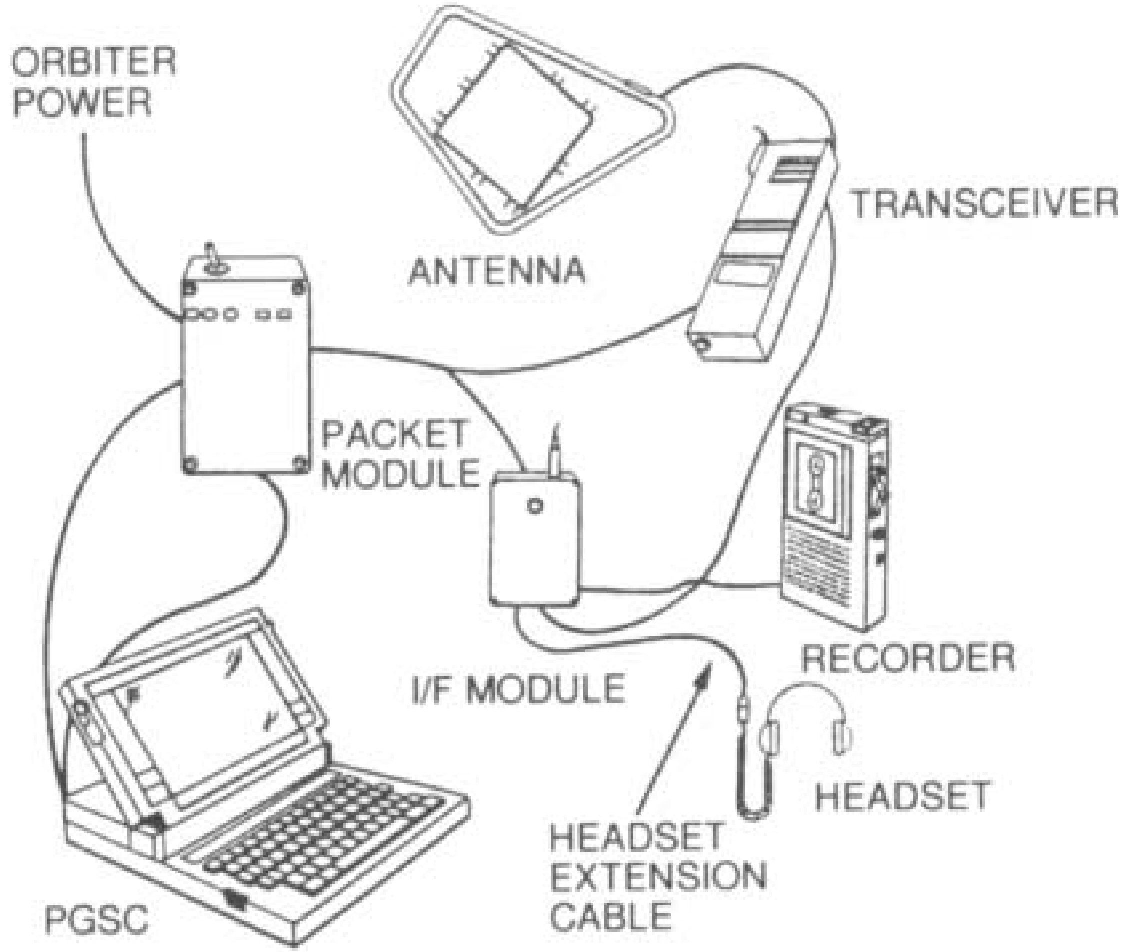
SIMPLIFIED AID FOR EVA RESCUE



GAS BRIDGE ASSEMBLY IN THE PAYLOAD BAY



SAREX-II CONFIGURATION C



SHUTTLE FLIGHTS AS OF SEPTEMMBER 1994

63 TOTAL FLIGHTS OF THE SHUTTLE SYSTEM -- 38 SINCE RETURN TO FLIGHT

		STS-60 02/03/94 - -2/11/94		
STS-65 07/08/94 0 07/23/94		STS-51 09/12/93 - 09/22/93		
STS-62 03/04/94 - 03/18/94		STS-56 04/08/83 - 04/17/93		
STS-58 10/18/93 - 11/01/93		STS-53 12/02/92 - 12/09/92		
STS-55 04/26/93 - 05/06/93		STS-42 01/22/92 - 01/30/92		
STS-52 10/22/92 - 11/01/92		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-46 07/31/92 - 08/08/92	
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-59 04/09/94 - 04/20/94
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-61 12/02/93 - 12/13/93
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-57 06/21/93 - 07/01/93
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-54 01/13/93 - 01/19/93
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-47 09/12/92 - 09/20/92
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 (17 flights)	**OV-099 Challenger (10 flights)**	**OV-103 Discovery (18 flights)**	**OV-104 Atlantis (12 flights)**	**OV-105 Endeavour (6 flights)**