NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

SPACE SHUTTLE MISSION STS-50

PRESS KIT
JUNE 1992

USML-1 MISSION

STS-50INSIGNIA

STS050-S-001 - Designed by the flight crew, the insignia for STS-50, United States Microgravity Laboratory (USML-1), captures a space shuttle traveling above Earth while trailing the USML banner. The orbiter is oriented vertically in a typical attitude for microgravity science and in this position represents the numeral "1" in the mission's abbreviated title. This flight represents the first in a series of USML flights on which the primary objective is microgravity science, planned and executed through the combined efforts of America's government, industry and academia. Visible in the payload bay are the Spacelab module, and the extended duration orbiter "cryo" pallet which will be making its first flight. The small "g" and Greek letter "mu" on the Spacelab module symbolize the microgravity environment being used for research in the areas of materials science and fluid physics. The large block letter "U" extends outside the insignia perimeter, symbolizing the potential for the experiments on this flight to expand the current boundaries of knowledge in microgravity science. The Stars and Stripes of the USML block letters and the US land mass in the Earth scene below reflect the crew's pride in the US origin of all onboard experiments.

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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RELEASE: 92-81 **June 1992**

48TH SHUTTLE MISSION TO BE LONGEST, FOCUS ON WEIGHTLESSNESS

The longest flight ever for a Space Shuttle and around-the-clock investigations of the effects of weightlessness on plants, humans and materials will highlight Shuttle mission STS-50.

The 48th flight of a Space Shuttle and the 12th flight of Columbia, STS-50, carrying the U.S. Microgravity Laboratory-1 (USML-1), is planned for launching at 12:05 p.m. EDT on late June. The mission is scheduled to last 12 days, 20 hours and 28 minutes, with landing planned at Edwards Air Force Base, CA.

Richard N. Richards, 45, Capt., USN, will command STS-50, his third space flight. The pilot will be Kenneth D. Bowersox, 36, Lt. Cmdr., USN, making his first space flight. Mission specialists include Bonnie Dunbar, 43, who also will be Payload Commander and making her third flight; Ellen Baker, 39, making her second flight; and Carl Meade, 41, Col., USAF, making his second flight. Payload specialists include Lawrence J. DeLucas, 41, from the Center for Macromolecular Crystallography at the University of Alabama, making his first flight, and Eugene H. Trinh, 41, a research physicist on the Space Station Freedom experiments planning group, making his first flight.

USML-1 includes 31 experiments ranging from manufacturing crystals for possible semiconductor use to the behavior of weightless fluids. In addition, STS-50 will carry the Investigations into Polymer Membrane Processing experiment, an experiment in manufacturing polymers, used as filters in many terrestrial industries, and the Space Shuttle Amateur Radio Experiment-II, an experiment that allows crew members to contact ham radio operators worldwide and conduct question-and-answer sessions with various schools.

Columbia is currently the only Shuttle capable of a 13-day flight and will carry the necessary additional hydrogen and oxygen supplies on a pallet in the cargo bay. New systems for removing carbon dioxide from the crew cabin, for containing waste and for increased stowage of food and crew equipment also have been added.

The crew will perform several ongoing medical investigations during the flight as well, research that aims at counteracting the effects of prolonged exposure to weightlessness on the human physique.

(END OF GENERAL RELEASE; BACKGROUND INFORMATION FOLLOWS.)

STS-50 QUICK LOOK FACTS

Orbiter:	Columbia (OV-102)
Launch Date and Time:	Late June 1992
Launch Window:	3 hours, 8 min. (12:05 - 3:13 p.m. EDT)
Launch Site:	Kennedy Space Center, FL, Pad 39-A
Altitude	160 n.m. x 160 n.m.
Inclination:	28.5 degrees
Mission Duration:	12/20:28:00 MET
Primary Landing Site:	Edwards Air Force Base, CA
Abort Landing Sites:	Return to Launch Site - Kennedy Space Center, FL Transoceanic Abort Landing - Banjul, The Gambia Alternates - Ben Guerir, Morocco; Rota, Spain Abort Once Around - Edwards Air Force Base, CA
Crew:	Dick Richards, Commander Ken Bowersox, Pilot Bonnie Dunbar, Mission Specialist 1, Payload Commander Ellen Baker, Mission Specialist 2 Carl Meade, Mission Specialist 3 Larry DeLucas, Payload Specialist 1 Eugene Trinh, Payload Specialist 2
Cargo Bay Payloads:	U.S. Microgravity Laboratory-1 (USML-1) Crystal Growth Furnace (4 experiments) Drop Physics Module (3 experiments) Surface Tension Driven Convection Experiment Solid Surface Combustion Experiment Glovebox (16 experiments) Space Acceleration Measurement System (SAMS)
Middeck Payloads:	Astroculture-1 (ASC-1) Generic Bioprocessing Apparatus (GBA) Commercial Protein Crystal Growth (CPCG) Zeolite Crystal Growth (ZCG)
Secondary Payloads:	Extended Duration Orbiter Medical Project (EDOMP) Investigations into Polymer Membrane Processing (IPMP) Orbital Acceleration Research Experiment (OARE) Shuttle Amateur Radio Experiment-II (SAREX-II) Ultraviolet Plume Instrument (UVPI)

STS-50 VEHICLE AND PAYLOAD WEIGHTS

	Pounds
Orbiter (Columbia) empty, and 3 Space Shuttle Main Engines	181,344
U. S. Microgravity Laboratory	22,199
Protein Crystal Growth	229
Investigation of Polymer Membrane Processing	36
Shuttle Amateur Radio Experiment	52
Zeolite Crystal Growth	126
Generic Bioprocessing Apparatus	69
Detailed Supplementary Objectives	248
Detailed Test Objectives	122
Extended Duration Orbiter Pallet	3,597
Total Vehicle at Solid Rocket Booster Ignition	4,523,834
Orbiter Landing Weight	228,866

STS-50 TRAJECTORY SEQUENCE OF EVENTS

Event	MET (d/h:m:s)	Relative Velocity (fps)	Mach	Altitude (ft)
Launch	00/00:00:00			
Begin Roll Maneuver	00/00:00:10	189	0.17	800
End Roll Maneuver	00/00:00:14	301	0.27	1,968
SSME Throttle Down to 67%	00/00:00:35	842	0.77	12,795
Maximum Dynamic Pressure	00/00:00:51	1,178	1.13	27,314
SSME Throttle Up to 104%	00/00:01:02	1,464	1.49	39,895
SRB Separation	00/00:02:04	4,167	3.95	55,799
Main Engine Cutoff (MECO)	00/00:08:31	24,572	22.73	63,636
Zero Thrust	00/00:08:37	24,509	N/A	62,770
External Tank Separation	00/00:08:50			
OMS 2 Burn	00/00:34:55			
Landing	12/20:28:00			

Apogee, Perigee at MECO: 156 x 35 nautical miles
Apogee, Perigee post-OMS 2: 162 x 160 nautical miles

SPACE SHUTTLE ABORT MODES

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

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

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

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

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

STS-50 contingency landing sites are Edwards Air Force Base, the Kennedy Space Center, White Sands Space Harbor, Banjul, Ben Guerir and Rota.

THE U.S. MICROGRAVITY LABORATORY-1 MISSION

The U. S. Microgravity Laboratory (USML) -1 and subsequent missions will bring together representatives from academia, industry and the government to study basic scientific questions and gain new knowledge in materials science, biotechnology, combustion science, the physics of fluids and the way energy and mass are transported within them. The U.S. Microgravity Laboratory series will help the United States maintain world leadership in microgravity research and development.

As Space Station Freedom development proceeds, the USML missions will continue development and testing of experimental flight equipment and will be laying the scientific foundation for microgravity research conducted over extended time periods. In addition, USML experiments will be conducted on nutrient and water transport for growing food in space, on the behavior of fire in low-gravity and on the effects of long-term space travel on humans.

In June 1992, the USML-1 Spacelab mission -- designated STS-50 -- will be launched into a 160-nautical-mile orbit aboard the Space Shuttle Columbia. It will be a 13-day mission to perform scientific investigations using some of the latest high-technology research equipment. Because of the great number of experiments planned for the mission and to fully utilize the time in microgravity, the crew will be split into two teams. Each team will work a 12-hour shift to maintain around-the-clock operations.

The Laboratory

Spacelab is a modular research laboratory flown within the Shuttle orbiter's cargo bay. It includes interchangeable elements, including open U-shaped platforms, called pallets (for equipment such as telescopes that require direct exposure to space), and short and long laboratory modules. The laboratory modules are pressurized so researchers can work in a laboratory environment in their shirt sleeves rather than bulky spacesuits. These elements are arranged in the Shuttle cargo bay to meet the unique needs of each mission.

For USML-1, the long pressurized module will be used. This 23-foot-long laboratory workshop will contain a series of standard racks that will hold furnaces for growing crystals, facilities for studying the behavior of fluids and doing combustion research, computers and other equipment needed for the various experiments.

During USML-1, as with all NASA Spacelab missions, flight controllers and experiment scientists direct science activities from the Spacelab Mission Operations Control Center in Huntsville, AL. They have a direct voice communication link with the orbiting Spacelab crew, and on-board video cameras make it possible for them to view crew and experiment activities. Scientists and controllers on the ground can receive information from Spacelab experiments and send commands via computer links. With this communications access, scientists on the ground and in orbit can work together, sharing information about experiments, monitoring data, solving problems and revising experiment plans.

Extended Mission

Shuttle missions usually have been less than 10 days. At 13 days, USML-1 will be the longest Shuttle mission to date. This will be made possible by the first use of the new Extended Duration Orbiter kit, which includes equipment and fuel for extra energy production, additional nitrogen tanks for cabin air and a regeneration system to remove carbon dioxide. The kit eventually may permit Shuttle missions up to 30 days long.

What Is Microgravity?

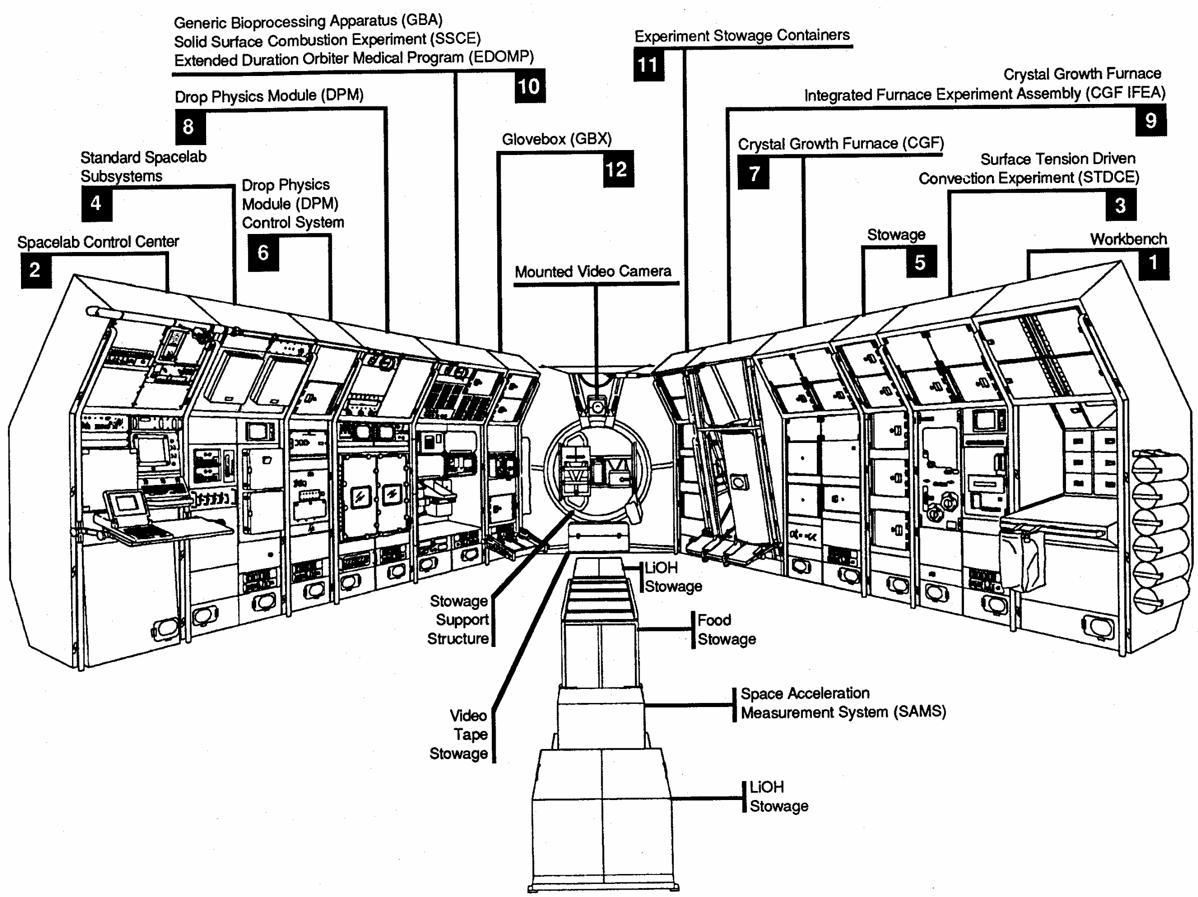
Microgravity literally means a state of very small or minute gravity. Earth's gravitational field extends far into space. It is the Shuttle's balance between that gravity, which pulls it down, and centrifugal force, created as the Shuttle flies along a circular path, that causes space travelers and anything in the Shuttle that is not secured to "float" in space as they fall free in Earth's gravitational field. Though microgravity is a relatively new term, it could become a household word in the next century as the potential benefits of space-based research are realized.

USML-1 Experiments

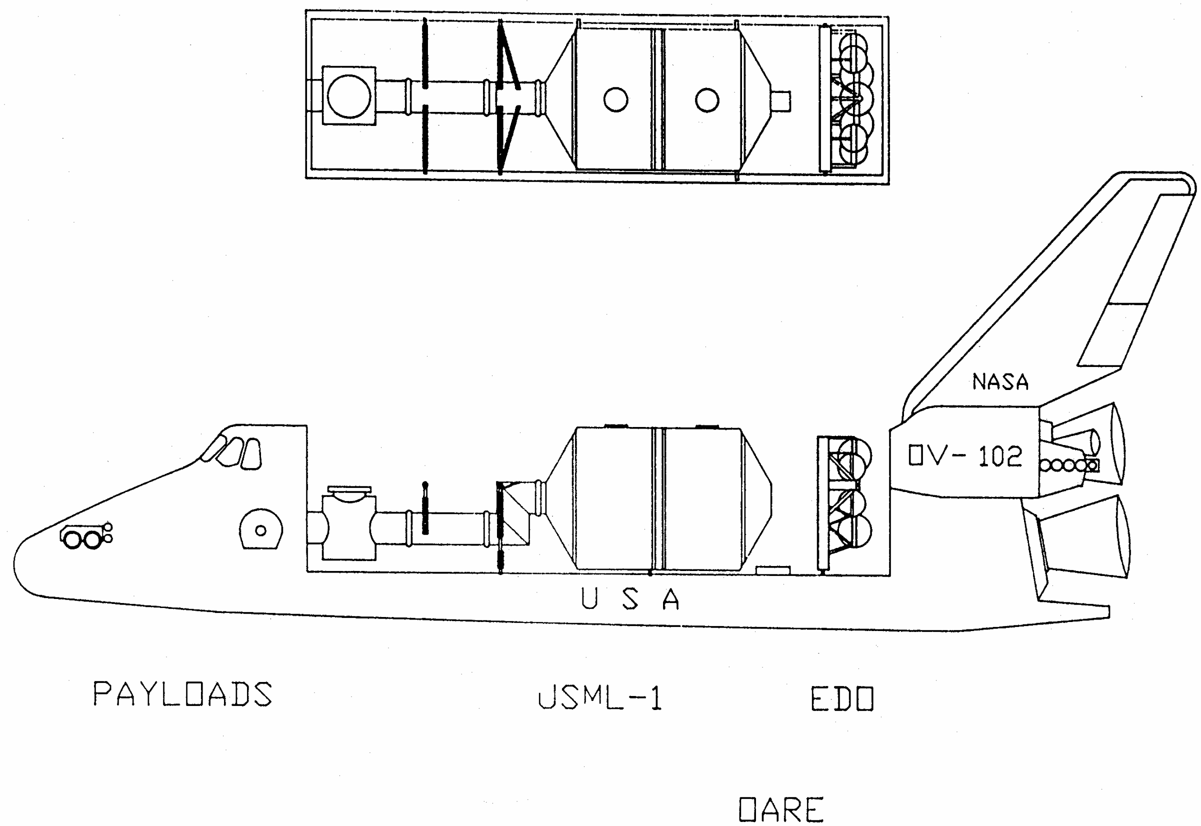
Equipment used and data obtained during earlier Shuttle missions provide a basis on which many of the USML-1 investigations will build. During the USML-1 mission, 31 experiments will be conducted in four broad areas -- materials science, fluid physics, combustion science and biotechnology -- in addition to the study of accelerations in the Shuttle and the complementary glovebox experiments.

Laboratory hardware includes new equipment, such as the Crystal Growth Furnace, and some equipment that has flown previously, such as the Solid Surface Combustion Experiment.

FIRST UNITED STATES MICROGRAVITY LAB (USML-1)



STS-50 Cargo Configuration



MATERIALS SCIENCE

While in space, materials can be formed in ways not possible on Earth. Research performed in the microgravity environment of Spacelab has greatly reduced gravitational effects, such as settling and separation of components and convection.

The Crystal Growth Furnace is new equipment developed specifically to study directional solidification of materials (primarily semi-conductors), which form the basis of electronic devices. Over the past few decades, semiconductor technology has revolutionized our lifestyle through consumer goods such as smaller, faster computers, more precise timepieces and a wide variety of audio/video and other communication equipment that just a few years ago were found only in science fiction.

The Crystal Growth Furnace is one of the first U.S. furnaces developed for spaceflight that processes samples at temperatures above 2,300 degrees Fahrenheit (approximately 1,300 degrees Centigrade). This reusable equipment will help scientists investigate the different factors affecting crystal growth and explore the best methods to produce better crystals.

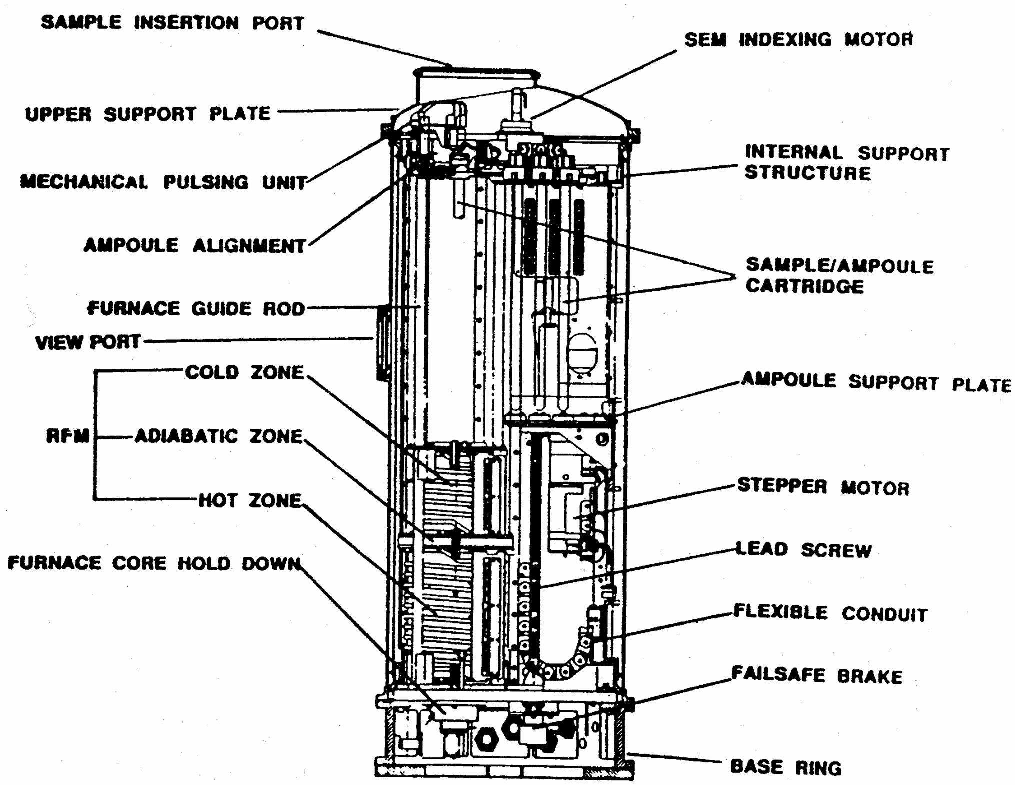
Four experiments to be conducted in the Crystal Growth Furnace will result in crystals grown from different materials: cadmium telluride, mercury zinc telluride, gallium arsenide and mercury cadmium telluride. These crystals are used in infrared detectors found in certain medical equipment, night-vision goggles and sensors used in some telescopes.

In the orbiter crew cabin mid-deck area, zeolite crystals will be grown. Zeolite crystals act as sponges or filters. They are called molecular sieves because they strain out specific molecules from a compound. High-quality zeolites may one day allow gasoline, oil and other petroleum products to be refined less expensively.

Protein crystal growth experiments -- also conducted in the mid-deck -- will study the growth of crystals in a low-gravity environment. Proteins are large, complex compounds made of a very specific arrangement of amino acids present in all life forms. Like the minerals named above, proteins also can have a crystalline structure.

The function of a certain type of protein is determined by its molecular arrangement. By understanding how a protein is structured, scientists may be better able to develop foods that have improved nutritional value. Also, medicines that act in a specific way with fewer side effects or new medicines to treat diseases may be designed.

CGF



CGF INTEGRATED FURNACE EXPERIMENT ASSEMBLY (IFEA)

CRYSTAL GROWTH FURNACE EXPERIMENTS

On USML-1, four principal investigators (PIs) will use the Crystal Growth Furnace (CGF) to study the effect of gravity on the growth of a variety of materials having electronic and electro-optical properties. Gravity contributes to the formation of defects during the production of crystals of these materials through convection, sedimentation and buoyancy effects. These gravity-induced complications result in problems ranging from structural imperfections to chemical inhomogeneity. By conducting crystal growth research in microgravity, scientists can investigate the different factors affecting crystal growth and determine the best methods to produce various types of crystals.

The CGF is the first space furnace capable of processing multiple large samples at temperatures up to 1800!F (1350!C). The CGF consists of three major subsystems: the Integrated Furnace Experiment Assembly (IFEA), the Avionics Subsystem and the Environmental Control System (ECS). The IFEA houses a Reconfigurable Furnace Module (RFM) -- a modified Bridgman-Stockbarger furnace with five controlled heating zones -- a Sample Exchange Mechanism capable of holding and positioning up to six samples for processing and a Furnace Translation System which moves the furnace over each sample. Sample material is contained in quartz ampoules mounted in containment cartridges. Thermocouples mounted in each cartridge provide temperature data. The Avionics Subsystem monitors and controls the CGF experiments and provides the interface with the Spacelab data system. The ECS maintains and controls the argon processing atmosphere inside the IFEA and provides cooling to the outer shell of the furnace through connections to Spacelab Mission Peculiar Equipment (MPE) fluid loop.

Once on orbit, a crew member will open the IFEA and load six experiment samples into the Sample Exchange Mechanism. The samples are processed under computer control. PIs can change experiment parameters via command uplinking. A flexible glovebox is used to provide crew access to the interior of the IFEA should an ampoule/cartridge fail on orbit.

Orbital Processing Of High-Quality CDTE Compound Semiconductors
Principal Investigator:
Dr. David J. Larson Jr.
Grumman Corporation Research Center

Cadmium Zinc Telluride (CdZnTe) crystals are used as lattice-matched substrates in a variety of mercury cadmium telluride (HgCdTe) infrared detectors. Reducing defects in the CdZnTe substrate minimizes the propagation of defects into the active HgCdTe layer during its growth. The purpose of the experiment is to quantitatively evaluate the influences of gravitationally-dependent phenomena (convection and hydrostatic pressure) on the chemical homogeneity and defect density of CdZnTe.

Processing the CdZnTe crystals in microgravity could significantly improve the chemical homogeneity of the substrates, minimizing interface strain and reducing the defects that result from gravitationally dependent phenomena. This improvement in substrate quality should enhance the quality and performance of the HgCdTe active detector. An improved understanding of gravitationally-dependent thermosolutal convection on the structural and chemical quality of alloyed compound semiconductors may help improve modeling of the semiconductor growth process which, in turn, would result in improving the chemical homogeneity and defect densities of the material, as well as increasing the primary yield of high quality material for infrared applications.

The sample on USML-1 ($Cd_{0.96}Zn_{0.04}Te$) will be processed using the seeded Bridgman-Stockbarger method of crystal growth. Bridgman-Stockbarger crystal growth is accomplished by establishing isothermal hot-zone and cold-zone temperatures with a uniform temperature gradient between. The thermal gradient spans the melting point of the material (1,095 degrees C. After sample insertion, the furnace's hot and cold zones are ramped to temperature (1,175 degrees C and 980 degrees C respectively) establishing a thermal gradient of 25 degrees C/cm and melting the bulk of the sample. The furnace is then programmed to move farther back on the sample, causing the bulk melt to come into contact with the high-quality seed crystal, thus "seeding" the melt. The seed crystal prescribes the growth orientation of the crystal grown. Having seeded the melt, the furnace translation is reversed and the sample is directionally solidified at a uniform velocity of 1.6 mm/h by moving the furnace and the thermal gradient over the stationary sample.

The USML-1 sample will be examined post-flight using infrared and optical microscopy, microchemical analysis, X-ray precision lattice parameter mapping and synchrotron topography, infrared transmission, optical reflectance, photoconductance and photoluminescence spectroscopy. These characterization techniques will quantitatively map the chemical, physical, mechanical and electrical properties of the CGF flight crystal for comparison with identically processed CGF ground samples. These results will be compared quantitatively with the best results accomplished terrestrially using the same growth method. Thermal, compositional and stress models will be quantitatively compared to the experimental 1-g and microgravity results.

Crystal Growth Of Selected II-VI Semiconducting Alloys By Directional Solidification
Principal Investigator:
Dr. Sandor L. Lehoczky
NASA Marshall Space Flight Center
Huntsville, AL

The purpose of the experiment is to determine how the structural, electrical and optical properties of selected II-VI semiconducting crystals are affected by growth in a low-gravity environment. On USML-1, the PI will investigate mercury zinc telluride (HgZnTe), with particular emphasis on compositions appropriate for infrared radiation detection and imaging in the 8- to 12-micrometer wavelength region. Infrared detection and imaging systems at those wavelengths have the potential for use in applications ranging from resource detection and management on Earth to deep-space imaging systems. On Earth, gravity-induced fluid flows and compositional segregation make it nearly impossible to produce homogeneous, high-quality bulk crystals of the alloy.

The PI will attempt to evaluate the effect of gravitationally driven fluid flows on crystal composition and microstructure and determine the potential role of irregular fluid flows and hydrostatic pressure effects in causing crystal defects. The flight experiment should produce a sufficient quantity of crystal to allow the PI to perform bulk property characterizations and fabricate detectors to establish ultimate material performance limits.

The sample on USML-1 (Hg0.84Zn0.16Te) will be processed using the directional solidification crystal growth method. The hot zone of the CGF furnace will be 800!C for melting, and the cold zone will be 350!C. A portion of the sample will be melted in the hot zone, and crystal growth will occur in the resulting temperature gradient. The furnace and thus, the temperature gradient, will be moved slowly across the sample at a rate of approximately 3.5 mm per 24 hrs. The slow rate is required to prevent constitutional supercooling ahead of the solidification interface.

The sample produced on USML-1 will be examined after the mission for chemical homogeneity and microstructural perfection by using a wide array of characterization techniques, including optical and electron microscopy, X-ray diffraction, X-ray topography and X-ray energy dispersion, infrared transmission spectroscopy and galvanomagnetic measurements as a function of temperature and magnetic field. Selected slices from the crystal will be used to fabricate device structures (detectors) for further evaluation.

Study Of Dopant Segregation Behavior During Growth Of GaAs In Microgravity
Principal Investigator:
Dr. David H. Matthiesen
GTE Laboratories Incorporated

Typically, semiconductors have a very small amount of impurity added to them to precisely engineer their material properties. These impurities, called dopants, are usually added at a level of 10 parts per million. Because of convection in the melt on Earth, it is very difficult to precisely control dopant distribution. Inhomogeneity in dopant distribution leads to widely varying material properties throughout the crystal. This experiment investigates techniques for obtaining complete axial and radial dopant uniformity during crystal growth of selenium-doped gallium arsenide (GaAs). GaAs is a technologically important semiconductor used in a variety of applications, such as high-speed digital integrated circuits, optoelectronic integrated circuits and solid-state lasers.

This experiment will use GaAs doped with selenium to investigate the potential of the microgravity environment to achieve uniform dispersal of the dopant during crystal growth. The hot zone (1,260!C) and the cold zone (1,230!C) temperatures are chosen to locate the 1,238!C melting point of GaAs in the center of the gradient zone.

The PI will analyze the USML-1 sample post-flight using a variety of techniques, including electrical measurements by Hall effect and capacitance-voltage techniques, chemical measurements by glow discharge mass spectroscopy and optical measurements by advanced quantitative infrared microscopy and Fourier transform infrared spectroscopy. These data will be compared to current analytical and computer model based theories.

Vapor Transport Crystal Growth Of HgCdTe In Microgravity
Principal Investigator:
Dr. Herbert Wiedemeier
Rensselaer Polytechnic Institute, NY

This experiment will investigate the relationship between convective flow, mass flux and morphology in mercury cadmium telluride (HgCdTe) crystals. HgCdTe crystals are useful as infrared detectors for a variety of defense, space medical and industrial applications. Crystals free of large structural defects and with a more even dispersion of the constituent elements may improve detector performance. To better understand the factors that influence HgCdTe crystal growth, this experiment will examine phenomena ranging from temperature profiles to how the aspect ratio (shape) of the sample ampoule affects mass transport and crystal growth.

The USML-1 sample (Hg0.8Cd0.2Te) will be processed using the vapor transport crystal growth technique. The sample material, sealed in one end of a quartz ampoule will be heated to 625!C. The vapors driven off will deposit as a crystal in the cold zone (455!C).

After the mission, the flight crystal will be examined using X-ray diffraction, optical microscopy, scanning electron microscope/wavelength dispersive spectroscopy, chemical etching, Hall measurement and other techniques for evaluation of morphology, structural perfection and properties of the crystals. The flight crystal may be used to fabricate an infrared detector for further examination of its device performance. The PI will evaluate the temperature profile and the geometry of the condensation region of the flight sample to determine how these factors affect mass fluxes and crystal morphology. In addition, the PI will study how the aspect ratio of the ampoule affects mass transport and crystal growth properties.

Zeolite Crystal Growth
Principal Investigator:
Dr. Albert Sacco
Worcester Polytechnic Institute

NASA's Office of Commercial Programs (OCP) is sponsoring the Zeolite Crystal Growth payload, developed by the Battelle Advanced Materials Center, a NASA Center for the Commercial Development of Space (CCDS) based in Columbus, Ohio, and the Clarkson Center for Commercial Crystal Growth in Space, a CCDS based in Potsdam, NY.

The ZCG payload is designed to process multiple samples of zeolite crystals, providing scientists with data on the most efficient procedures and equipment for producing high-quality zeolite crystals in space.

Zeolite crystals are complex arrangements of silica and alumina which occur both naturally and synthetically. An open, three-dimensional, crystalline structure enables the crystals to selectively absorb elements or compounds. As a result, the crystals are often used as molecular sieves, making the crystals highly useful as catalysts, filters, absorbents and ion exchange materials.

Zeolite crystals produced in space are expected to be larger and more perfect than their ground-produced counterparts, providing tremendous industrial potential for space-produced crystals. Ground-produced crystals are small in size, causing severe disadvantages in absorption/separation and ion exchange processes. Knowledge gained through space-based processing of large zeolites will provide a better understanding of how zeolites act as catalysts, which could result in the development of new ground-based catalysts.

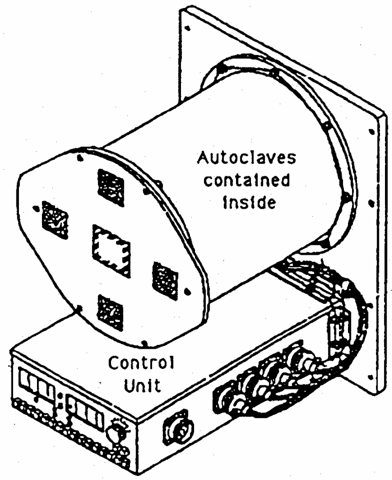
Current technology produces zeolite crystals using chemical additives, however, if large zeolite crystals can be produced without the need for additives, then the crystals could be used effectively in membrane technology. Such membranes could result in major advantages over current separation techniques and have potential for numerous commercial applications. In an attempt to grow such crystals and to investigate optimal growth conditions, the ZCG experiments on this mission will be processed in the middeck and the Glovebox Module, an enclosed compartment that minimizes risks to the experiments and the Spacelab environment.

The ZCG experiment will be contained in a cylindrical ZCG furnace assembly which fits into the space of two middeck lockers and uses another locker for storage. The furnace consists of 19 heater tubes surrounded by insulation and an outer shell. Multiple samples will be processed in the furnace using three independently-controlled temperature zones of 175 degrees C, 105 degrees C and 95 degrees C.

The nucleus of the experiment will consist of 38 individually-controlled, metal autoclaves, each containing two chambers and a screw assembly. To activate the experiment, a crew member will turn the screw assembly with a powered screwdriver, pressurizing the solution in one chamber and forcing it into the other. Turning the screw assembly in the opposite direction will pull the fluid back into the emptied chamber. By repeating this process several times, proper mixing of the two solutions can be obtained (several different mixing aids and nozzle designs are to be used on this mission).

Other experiments conducted in the Glovebox Module will use clear autoclaves to determine the proper number of times the fluids should be worked to ensure proper mixing for each design. Once all of the autoclaves are activated and loaded into the furnace assembly, a cover will be secured over the front of the assembly and the furnace activated. Once the experiment is complete, the autoclaves will be removed and stored for landing. After the mission, scientists will examine the crystals to determine which growth conditions were optimum.

ZCG



ZCG Payload

Payload Ops:

- Accessing and operating payload
- Mixing and loading of samples
- Periodic observation of experiment status
- Video recording and downlink required
- Processed samples moved into middeck for descent and landing

FLUID PHYSICS EXPERIMENTS

Drop Physics Module (DPM)
NASA Jet Propulsion Laboratory
Pasadena, CA

The DPM is a major microgravity instrument supporting various experiments on the dynamics of fluids freed from the influences of gravity and the walls of a container.

Three Earth-based investigators will conduct experiments using this system in USML-1: Dr. Robert Apfel, Yale University; Dr. Taylor Wang, Vanderbilt University and Dr. Michael Weinberg, University of Arizona. Serving as Payload Specialist in USML-1 and co-investigator to the three university scientists, Dr. Eugene Trinh will be the principal operator of the DPM.

The scientists will conduct pure-science studies to investigate the internal and surface properties of liquids, seeking to verify certain fluid-dynamics theories. To get the best match with theory, the scientists need to minimize the influence of gravity which distorts the liquid's surfaces and separates the material into layers of different density.

Container walls also will distort the surfaces, whether the liquid wets them or not, and introduce chemical contamination. The DPM uses computer-controlled sound waves in a carefully-designed chamber, allowing the investigator to position fluid drops free of the chamber walls, moving them, spinning them and making them separate and flow together while their dynamic properties are observed and recorded on videotape and film.

Scientific objectives of the DPM investigations include testing and verifying theories describing the behavior of vibrating drops stimulated by sound waves, measuring physical properties of drop surfaces and studying the shapes of rotating drops and their behavior as they split into double drops. Other objectives involve understanding the dynamics of coalescence, when two free drops merge. Compound drops -- with a drop of one type of liquid inside the main drop of another -- and air-filled liquid shells also will be studied for multiple surface-tension effects and for spin dynamics.

Science And Technology Of Surface-Controlled Phenomena
Principal Investigator:
Dr. Robert E. Apfel
Yale University

Surface active materials (surfactants) play an important role in industrial processes, from the production of cosmetics to the dissolution of proteins in synthetic drug production to enhanced oil recovery. The PI will use the DPM to conduct two sets of experiments to understand the effect of surfactants on fluid behavior.

The first experiment will investigate the surface properties of single liquid drops in the presence of surfactants. Water drops will be positioned stably by the acoustic field of the Drop Physics Module. The drop will be squeezed acoustically and then released, exciting it so that it oscillates in a quadruple shape. The frequency and damping of the resulting free oscillations will be measured. The process will be repeated both for varying surfactant concentrations and for different surfactants. These results will be analyzed to determine the static and dynamic rheological properties of the surface of liquid drops (e.g., surface viscosity, elasticity). This set of experiments, coupled with the current theoretical work of the science team, should give a better understanding of the molecular-level forces acting in the surface layer of simple water drops.

In the second group of experiments, two water drops containing varying concentrations of surfactants first will be positioned stably at separate nodes of the Drop Physics Module acoustic field. They then will be brought slowly into contact by carefully mixing acoustic modes to force the drops toward each other. If the drops do not coalesce spontaneously (which will be the case as surfactant concentrations increase), a combination of static squeezing and then forced oscillation will be applied to the contacting drops with increasing strength, inducing them to combine. Both the parameters of the induction techniques and the interface between the drops will be measured during this process in an attempt to characterize critical parameters that force the drops to rupture and coalesce. The PI will use the dual-drop coalescence experiment to gain insight into the role of surfactants as "barriers" to coalescence. These experiments also may yield practical knowledge by determining an energy-efficient approach to enhancing drop coalescence.

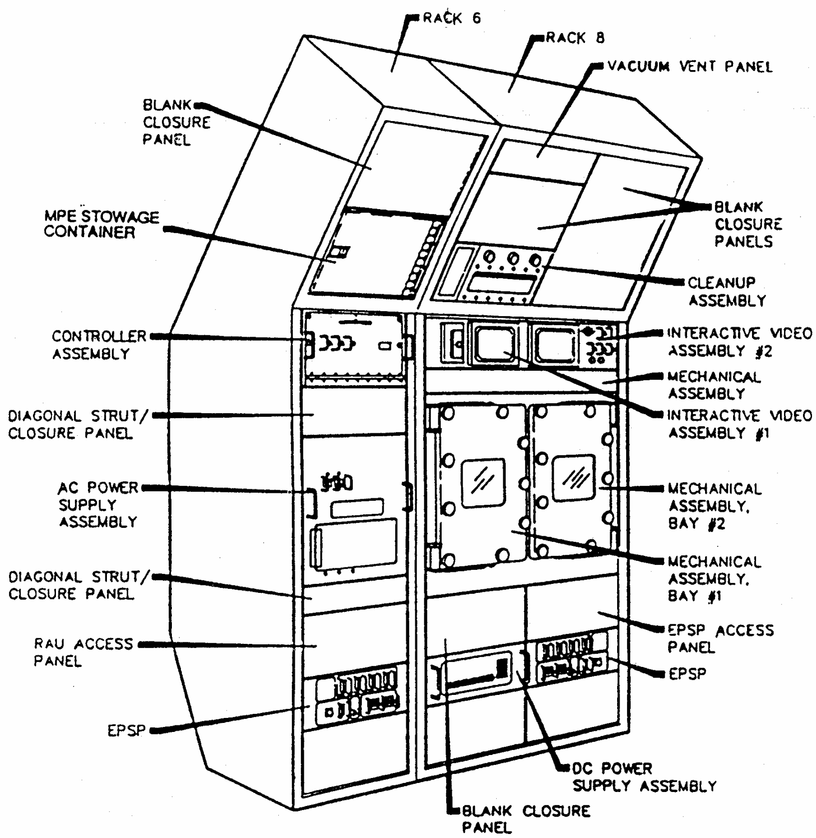
Drop Dynamics Investigation
Principal Investigator:
Dr. Taylor G. Wang
Vanderbilt University

Preliminary experiments using acoustic levitation to suspend liquid drops were first completed in the Drop Dynamics Module flown on the Spacelab-3 mission in 1985. These experiments not only confirmed some theories about drop behavior but also provided unexpected results. For example, the bifurcation point -- when a spinning drop takes a dog-bone shape to hold itself together -- came earlier than predicted under certain circumstances. On USML-1, the PI team will attempt to resolve the differences between experiment and theory using the more advanced capabilities of the Drop Physics Module. The PI also will use the DPM to study large-amplitude oscillations in drop shape and the process of drop fission.

Liquid drops (water, glycerin and silicone oil) between 0.5 to 2.7 cm in diameter will be deployed individually or in groups in the experiment chamber at ambient temperatures and pressures. Sound waves directed at the drops will be varied in frequency and intensity as drops are rotated, fused and made to oscillate. The equilibrium shapes of both charged and uncharged liquids undergoing solid body and differential rotation will be experimentally determined. To determine the equilibrium shapes of rotating drops, the relative phase between the orthogonal acoustic waves used to position each drop will be shifted by 90 degrees. This phase shift will create an acoustic rotational torque on the drop.

The shape oscillation spectra of drops also will be experimentally studied. To determine the shape oscillation frequency of both simple and compound drops, the acoustic field will undergo carrier modulation to stimulate drop shape oscillation. The amplitude of the oscillation as a function of the modulation frequency will be studied to determine the non-linear behavior of the drop. These data will allow the equilibrium shapes and frequency spectrum of both simple and compound liquid drops, undergoing different types of rotation and oscillation, to be determined.

Finally, the PI will use the DPM to conduct encapsulation studies using sodium alginate and calcium chloride to determine methods for centering one component of a compound drop. In this experiment, sodium alginate droplets will be injected into a calcium chloride drop. The resulting compound drop will be subjected to various acoustic conditions to try to determine an optimal method of forming uniform concentric spherical membranes.



DROP PHYSICS MODULE

DPM

Measurement Of Liquid-Liquid Interfacial Tension And The Role Of Gravity In Phase Separation Kinetics Of Fluid Glassmelts

Principal Investigator:
Dr. Michael C. Weinberg
University of Arizona

The experiment explores a unique method for measuring an important surface parameter -- the tension between interfaces of drops and other materials.

There are many liquid solutions that tend to separate into several liquid phases when held in an appropriate temperature range. This same process occurs in many glass systems, where it is referred to as glass-in-glass or liquid- liquid phase separation, or amorphous immiscibility. In both liquids and glasses, the rates at which these phase separation processes occur depend upon several factors, such as the temperature and the characteristics of the surface at the boundary between phases. The measurement of the liquid-liquid interfacial tension will provide one of the key quantities that governs the rate of such a process.

The experiment consists of measuring the liquid-liquid surface tension of a compound drop consisting of two liquids that do not mix. A drop containing tracer particles is deployed and then injected with an inner drop. This compound drop will be rotated in the Drop Physics Module at specified angular velocities, and the shapes of both the inner and outer drops will be distorted. After equilibration of drop shape and rotation rate, film images will be taken from two orthogonal views to record the drops' new geometries. Eight drop sets will be examined (four liquid pairs, two drop radii ratios each). The photographs will be analyzed to determine the drop distortions and will use theoretical models to calculate the liquid-liquid surface tension between the substances that make up each drop.

ASTROCULTURE™

Principal Investigator:
Dr. Theodore W. Tibbitts
Wisconsin Center for the Commercial Development of Space
Madison, WI

NASA's Office of Commercial Programs is sponsoring the Astroculture payload, developed by the Wisconsin Center for Space Automation and Robotics (WCSAR), a NASA Center for the Commercial Development of Space (CCDS) based at the University of Wisconsin in Madison.

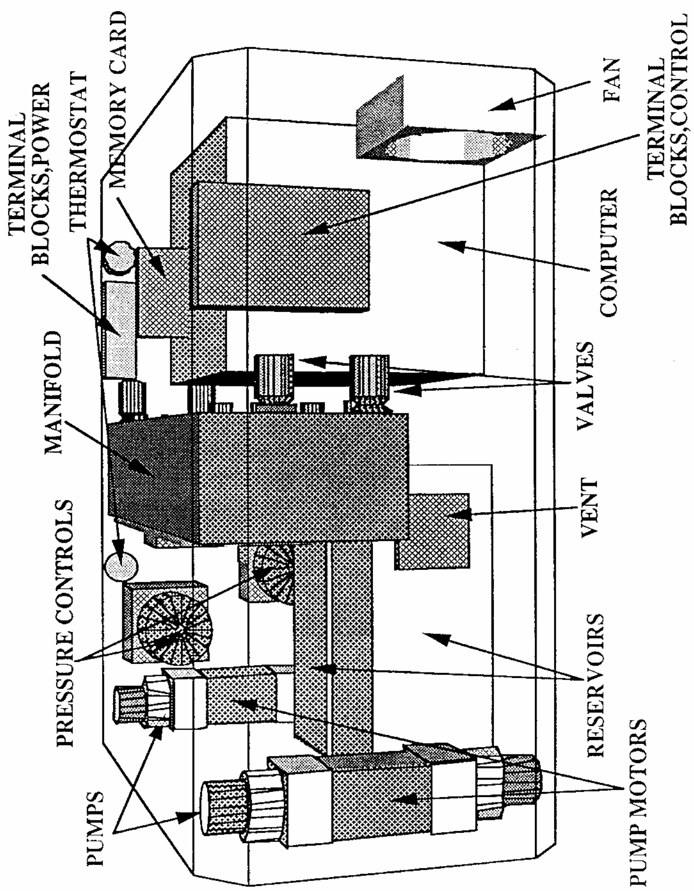
Currently, no satisfactory plant growth unit is available for support of long-term plant growth in space. Increases in the duration of Space Shuttle missions have made it necessary to develop plant growth technology that minimizes the costs of life support while in space. Plants can reduce the costs of providing food, oxygen and pure water and also lower the costs of removing carbon dioxide in human space habitats.

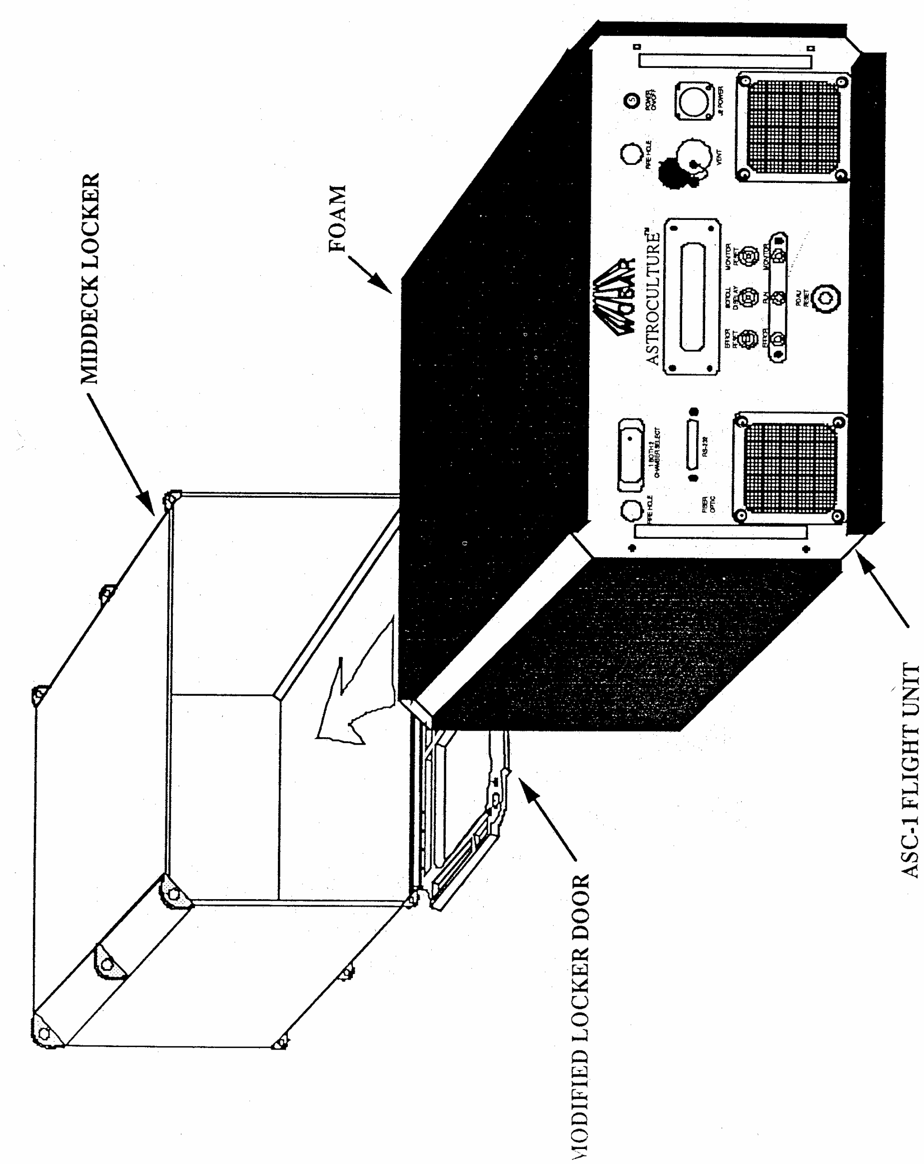
Before plants can be grown in the Astroculture unit, however, a series of experiments will have to be conducted on the Space Shuttle to evaluate the critical subsystems (water and nutrient delivery, lighting and humidity control) needed to construct a reliable plant growth unit. Water and nutrient delivery will be tested and evaluated on STS-50, with additional experiments added to future missions for evaluation of the other two subsystems.

The flight hardware for the STS-50 mission is self-contained in a middeck locker and weighs approximately 70 pounds. The Astroculture unit consists of a covered cavity with two growth chambers containing inert material (having particle size of 20 to 40 mesh) that serve as the root matrix; a water supply system consisting of a porous stainless steel tube embedded into the matrix, a water reservoir, a pump, and appropriate valves for controlling the pressure flow of water through the stainless steel tube; a water recovery system consisting of the same components as the water supply system; and a microprocessor system for control and data acquisition functions.

In orbit, the water supply and recovery systems will be activated to initiate circulation of a nutrient solution through the porous tubes. Subsequently, the solution will move through the wall of each porous tube into the matrix by capillary forces. In the matrix, the small pores will be filled with the solution and the large pores with air, thereby providing a non-saturated state. The recovery system will operate at several pressure levels to determine the rate at which the solution will move through the matrix and the capacity of the supply system to provide the solution to the matrix.

A computer system will monitor the amount of solution pumped from the supply reservoir to the recovery reservoir. Data collected by the computer will indicate the supply system's overall capacity for replacing water and nutrients removed by plants growing in microgravity.




MIDDECK LOCKER
FOAM
ASTROCULTURE™
WCSAR
MODIFIED LOCKER DOOR
ASC-1 FLIGHT UNIT

SURFACE TENSION DRIVEN CONVECTION EXPERIMENT (STDCE)
Principal Investigator:
Dr. Simon Ostrach
Case Western Reserve University, Ohio

On Earth, buoyancy-driven flows and convection impede attempts to grow better crystals and solidify new metals and alloys. Ground-based and preliminary space experiments have shown that variations in surface tension, caused by temperature differences along a liquid's free surface, generate thermocapillary fluid flows. Although thermocapillary flows exist on Earth, they are masked by stronger buoyancy-driven flows. In low-gravity, buoyancy-driven flows are reduced, making it easier to examine thermocapillary flows. Earth's gravity also alters the liquid free surface shape and damping characteristics of any fluid. The microgravity environment allows researchers to study the impact of a variety of curved free surface geometries on thermocapillary fluid flows.

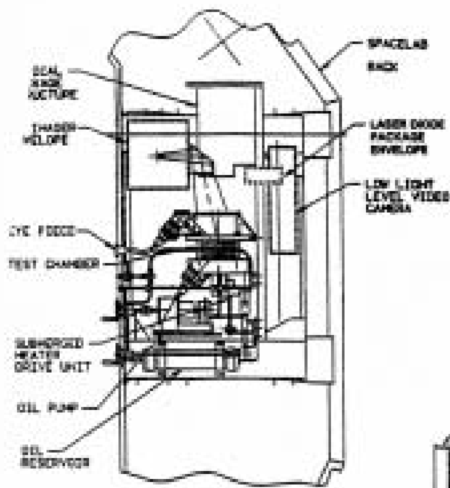
The USML-1 Surface Tension Driven Convection Experiment (STDCE) will obtain quantitative data on thermocapillary flows over a wide range of parameters in experiments that vary the imposed surface temperature distributions (thermal signatures) and the configuration of the liquid's free surface. For USML-1, both steady flows (those that do not change over time) and transient flows (those that do change over time) will be studied. A variety of conditions and experiment configurations will be used, and an attempt will be made to identify the conditions for the onset of oscillations.

The experiments will be conducted in the Surface Tension Driven Convection Experiment Apparatus, which consists of an experiment package and an electronics package located in a double Spacelab rack. The experiments are carried out in a cylindrical container (10 cm in diameter and 5 cm high). A lightweight silicone oil is used as the test fluid because it is not susceptible to surface contamination, which can ruin surface tension experiments. The experiment package contains the test chamber, made of copper to assure good thermal conductivity along the walls, and the silicone oil system, consisting of a storage reservoir and a fluid management system for filling and emptying the test chamber.

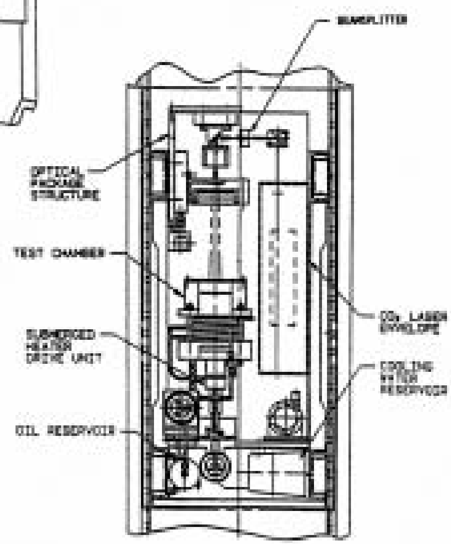
Two heating systems, which provide the different thermal signatures, are part of the test chamber. A submerged cartridge heater system will be used to study thermocapillary flows over a range of imposed temperature differences. A surface heating system will be used to investigate fluid flows generated by various heat fluxes distributed across the surface of the liquid. This heating system consists of a CO\s\do2(2) laser and optical elements that direct the laser beam to the test chamber and vary the imposed heat flux and its distribution.

To visualize the fluid flows in the test chamber, a laser diode and associated optical elements will illuminate aluminum oxide particles suspended in the silicone oil, and a video camera, attached to a chamber view port, will record the particle motion. A scanning infrared imaging system records oil surface temperature. Thermistors inside the test chamber measure bulk oil temperatures. The crew can use a Spacelab camera mounted to the front of the chamber to monitor oil filling and draining, submerged heater positions and oil surface shapes and motions. These data will be downlinked to the Spacelab Payload Operations Control Center at the Marshall Space Flight Center. Based on the analysis of the data, a new set of test parameters for the next series of experiments will be uplinked to the experiment computer in the Spacelab. From the data obtained, the PI will correlate velocity and temperature distributions with imposed thermal conditions to complete mathematical models of thermocapillary flow.

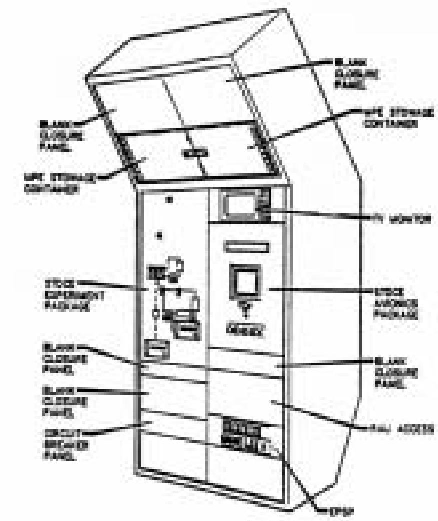
STDCE



STDCE PACKAGE (SIDE VIEW)



STDCE PACKAGE (FRONT VIEW)



STDCE DOUBLE RACK 3 CONFIGURATION

COMBUSTION SCIENCE EXPERIMENT

SOLID SURFACE COMBUSTION EXPERIMENT (SSCE)
Principal Investigator:
Robert A. Altenkirch, Mississippi State University

The Solid Surface Combustion Experiment (SSCE) is a major study of how flames spread in microgravity. Comparing data on how flames spread in microgravity with knowledge of how flames spread on Earth may contribute to improvements in all types of fire safety and control equipment. This will be the fifth time SSCE has flown aboard the Shuttle. Ultimately, plans call for SSCE to fly a total of eight times, testing the combustion of different materials under different atmospheric conditions.

In the SSCE planned for USML-1, scientists will test how flames spread along a sample of Plexiglas in an artificial atmosphere containing oxygen mixed with nitrogen.

During the other four missions on which this experiment was flown, samples of a special filter paper were burned in atmospheres with different levels of oxygen and pressure. The special filter paper and Plexiglas were chosen as test materials because extensive databases already exist on the combustion of these materials in Earth's gravity. Thus, combustion processed on Earth and in space can be readily compared.

Scientists will use computer image enhancement techniques to analyze the film record of the Solid Surface Combustion Experiment. They then will compare the enhanced images and recorded temperature and pressure data with a computer simulation of the flame spreading process. Reconciling the two sets of data is expected to provide new insights into the basic process of combustion.

BIOTECHNOLOGY EXPERIMENTS

PROTEIN CRYSTAL GROWTH (PCG)
Principal Investigator:
Dr. Charles E. Bugg, University of Alabama at Birmingham

NASA's Office of Commercial Programs (OCP) is sponsoring the Protein Crystal Growth (PCG) payload, developed by the Center for Macromolecular Crystallography (CMC), a NASA Center for the Commercial Development of Space (CCDS) based at the University of Alabama at Birmingham.

The objective of the PCG experiments is to produce large, well-ordered crystals of various proteins. These crystals will be used in ground-based studies to determine the three-dimensional structures of the proteins and to investigate the kinetics of crystal growth and the impact of fluid disturbances on crystal growth.

Since proteins play an important role in everyday life -- from providing nourishment to fighting disease -- research in this area is quickly becoming a viable commercial industry. Scientists need large, well-ordered crystals to study the structure of a protein and to learn how a protein's structure determines its functions.

The technique most-widely used to determine a protein's three-dimensional structure is X-ray crystallography, which requires large, well-ordered crystals for analysis. Crystals produced on Earth often are large enough to study, but usually they have numerous gravity-induced flaws. However, space-produced crystals tend to be purer and have more highly-ordered structures which significantly facilitates X-ray diffraction studies of the crystallized proteins.

Studies of such crystals not only can provide information on basic biological processes, but they could lead to the development of food with higher protein content, highly resistant crops and more effective drugs. By studying the growth rates of crystals under different conditions, scientists can find ways to improve crystal growth in microgravity, thus providing higher-quality crystals for study and the ability to produce large crystals made of hard-to-grow proteins. For these reasons, PCG activities have been conducted on 14 Shuttle missions counting STS-49.

On STS-50, the flight hardware will include two Refrigerator/Incubator Module (R/IM) thermal enclosures and one newly-designed thermal enclosure, called the Commercial R/IM (CRIM). The CRIM allows for a pre-programmed temperature profile and a feedback loop that monitors CRIM temperatures during flight.

To optimize protein crystal growth conditions, some of the PCG experiments will be conducted in the Glovebox Module, an enclosed compartment that minimizes risk to the experiments and the Spacelab environment. Prior to being activated, the experiments will be stowed in a R/IM set at 22 degrees C. The experiments will be conducted using modular crystal growth hardware and will include as many as 21 different proteins. Experiment parameters will be altered in response to crew observation of the crystal growth process. New experiments will be initiated throughout the mission to take advantage of lessons learned from early experiment runs. As the PCG activities in the Glovebox are completed, the experiments will be returned to the 22-degree R/IM.

Other PCG experiments will be stowed in the other R/IM, also set at 22 degrees C, and the CRIM, set at 4 degrees C. Each will contain three vapor diffusion apparatus (VDA) trays with 20 individual growth chambers. One side of each tray holds 20 double-barreled syringes, while the other side holds plugs that cap the tips of the syringes. Protein solution will be stored in one barrel of each syringe, and the other will house precipitant solution. A reservoir of concentrated precipitant solution surrounds each syringe inside the crystal growth chamber.

To activate the experiment, a crew member will attach a handwheel to a ganging mechanism on the plug side of each VDA and turn it to retract the plugs from the syringe tips. The handwheel then will be moved to the ganging mechanism on the syringe side of the tray, where it will be turned to extrude the protein and precipitant solutions to form a drop on the tip of each syringe. The difference in concentration of the precipitant in the reservoir and the drop causes water molecules to migrate from the drop through the vapor phase into the reservoir solution. As the concentration of protein and precipitant increase in the drop, crystal growth will begin.

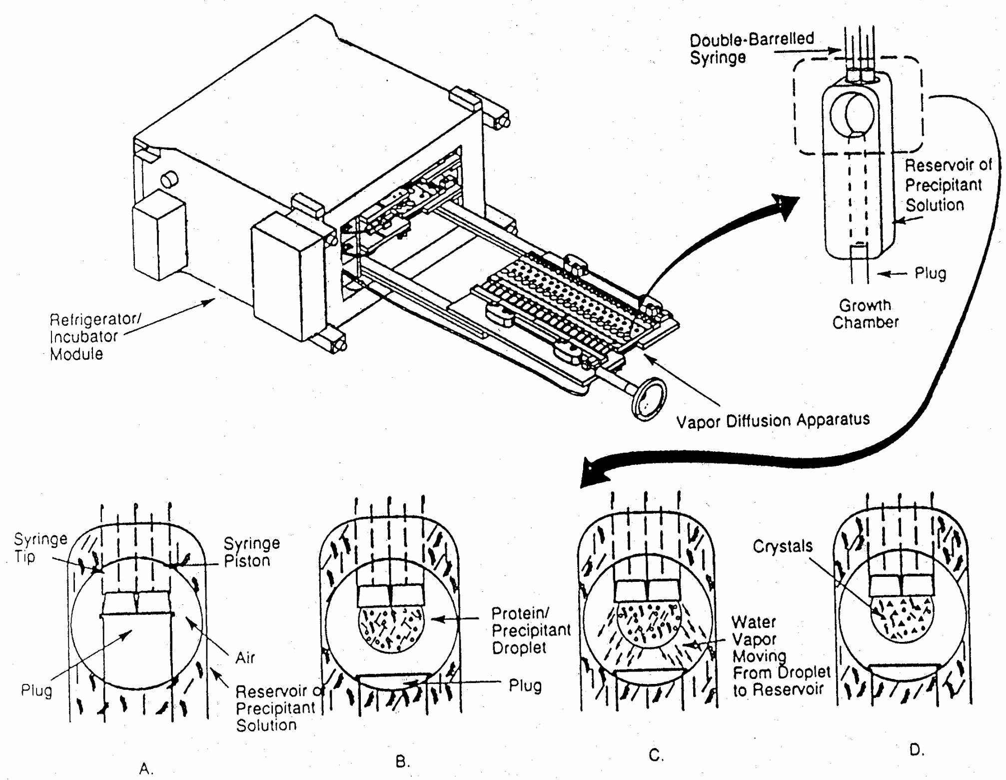
Twenty of the growth chambers are designed to accommodate crystal seeding. During the second flight day, a crew member will open a port on 10 of the seeding chambers in the VDA R/IM and inject each protein drop with a few microliters of solution containing Earth-grown "seed" crystals. The operation will be repeated on the third flight day with the remaining 10 seeding chambers. Inserting seed crystals into the protein droplets is expected to initiate immediate growth of protein crystals.

At the end of the mission, the experiments will be deactivated. Due to each protein's short lifetime and the crystals' resulting instability, the PCG payload will be retrieved from the Shuttle within 3 hours of landing and returned to the CMC CCDS for post-flight analyses.

Of the 34 proteins selected to fly on this mission, 60 percent have flown on previous flights. Nine of the proteins are OCP-sponsored and have commercial co-investigators that are affiliates of the CMC CCDS. Many have potential commercial application in the pharmaceutical industry. Structural information gained from these experiments may provide better understanding of the immune system, the function of individual genes and treatment of disease, and many ultimately aid in the design of a specific, effective and safe treatment of viral infections.

Dr. Lawrence J. DeLucas, Associate Director for PCG at the CMC CCDS, is a co-investigator and a payload specialist on the STS-50 mission, providing on-site scientific management of the PCG experiments.

PCG HARDWARE



A double-barrelled syringe holds protein crystal growth materials separate before the experiment begins (A). A crew member turns one handwheel to withdraw the plug and another to activate pistons that push the two solutions out of the syringe and into an air space, where they form a hanging drop (B). During the mission, water vapor moves out of the drop and into a reservoir lining the growth chamber (C), thus increasing the concentration of precipitating solution in the droplet and stimulating protein crystal growth.

GENERIC BIOPROCESSING APPARATUS

Principal Investigator:
Dr. Michael C. Robinson, BioServe Space Technologies
University of Colorado in Boulder

NASA's Office of Commercial Programs is sponsoring the Generic Bioprocessing Apparatus (GBA) payload, developed by BioServe Space Technologies, a NASA Center for the Commercial Development of Space (CCDS) based at the University of Colorado in Boulder.

The GBA is a multi-purpose payload that supports mixing of fluids and solids in up to 500 individual sample containment devices, called Fluids Processing Apparatuses (FPAs), in microgravity. On STS-50, 23 different experiments will be conducted in 132 FPAs.

Some of the experiments will be stowed in a middeck Refrigerator/Incubator Module (R/IM), while others will be stowed in an ambient temperature stowage locker in the Spacelab module. Of the 23 experiments, one (called Directed Orientation of Polymerizing Collagen Fibers) will be processed in the Glovebox Module, an enclosed compartment that allows sample manipulation with minimal risks to the experiments and the Spacelab environment.

A crew member will activate a batch of 12 FPAs by mixing sample materials and inserting them into the GBA for incubation. A computer will automatically terminate incubation after a preprogrammed duration. A crew member then will remove the samples from the GBA, restow them in either the R/IM or Spacelab stowage locker and load another batch of samples for incubation.

For a number of samples, on-orbit video recordings will be obtained to document sample behavior and morphology. The GBA will monitor and control its own temperature, and it will monitor optical density to provide information on processing rates and cell growth.

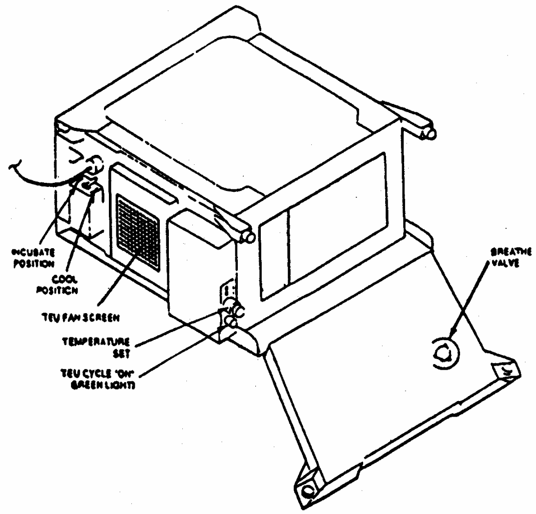
The GBA will allow scientists to study an array of biological processes, with samples ranging from molecules to small organisms. Some of the many commercial experiments currently scheduled to fly in the GBA include:

Artificial Collagen Synthesis -- the ability to artificially synthesize collagen fibers in microgravity could result in materials that have the strength and properties of natural collagen. Synthesized collagen could be used more effectively as artificial skin, blood vessels, and other parts of the body.

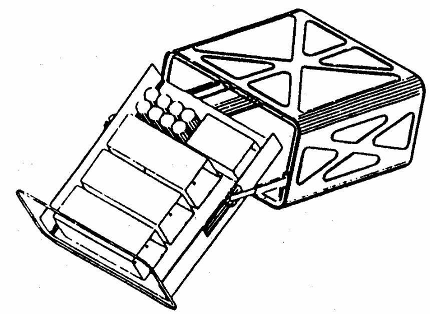
Assembly of Liposomes and Virus Capsid (two types of spherical structures that could be used to encapsulate pharmaceuticals) -- the ability to properly assemble liposomes and virus capsid in microgravity could result in using them to navigate drugs to specific body tissues, such as tumors. Development of Brine Shrimp and Miniature Wasps in Microgravity -- could shed light on the importance of gravity in human development and aging and potential components of a Controlled Ecological Life Support System (CELSS).

Seed Germination and Development -- could help develop technology for growing plants in space and provide knowledge for use in agriculture on Earth.

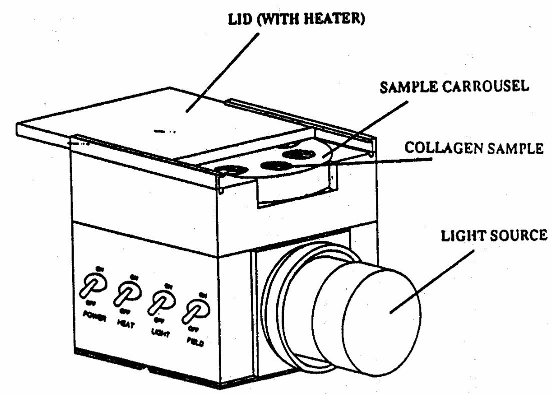
The ability to process such a large quantity of different samples truly exemplifies the GBA as a multi-purpose facility, helping to answer important questions about the relationship between gravity and biology. The GBA will be instrumental in evaluating the commercial potential of space-based biomaterials processes and products.



GBA REFRIGERATOR/INCUBATION MODULE



GBA PROCESSING UNIT



DPA MODULE

GBA

GLOVEBOX

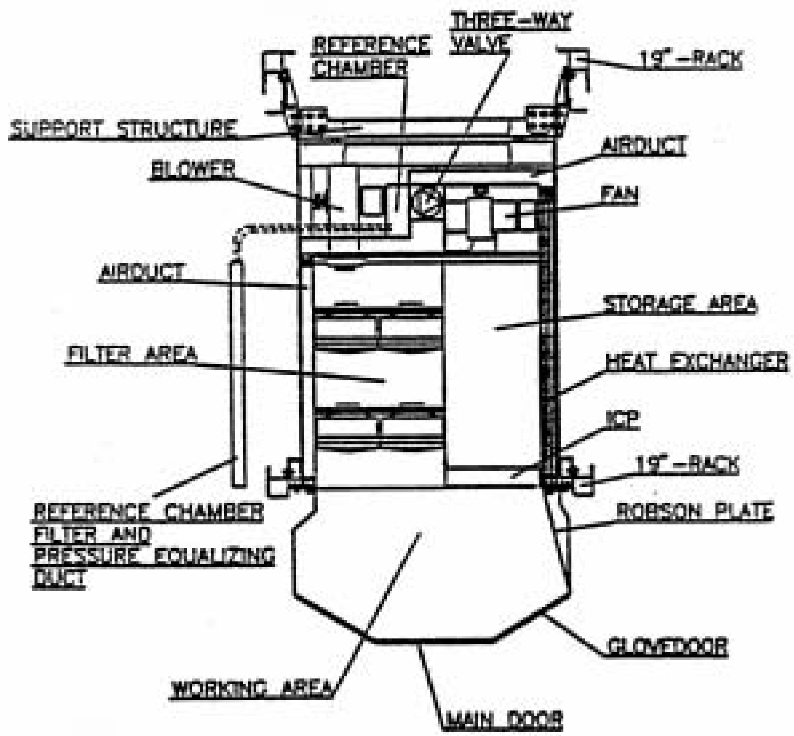
The USML-1 Glovebox (GBX), provided by the European Space Agency, is a multi-user facility supporting 16 experiments in fluid dynamics, combustion science, crystal growth and technology demonstration. Some of the experiments will provide information that other USML-1 investigations will use immediately during the mission to refine their experiment operations. Others will provide data that may be used to define future microgravity science investigations.

The GBX has an enclosed working space that minimizes the contamination risks to both Spacelab and experiment samples. The GBX working volume provides two types of containment: physical isolation from the Spacelab and negative air pressure differential between the enclosure and the Spacelab ambient environment. An air-filtering system also protects the crew from harmful experiment products. The crew manipulates experiment equipment through three doors: a central port through which experiments are placed in the working volume and two glove doors. When an airtight seal is required, the crew inserts their hands into rugged gloves attached to the glove doors. If an experiment requires more sensitive handling, the crew may don surgical gloves and insert their arms through a set of adjustable cuffs.

Most of the GBX experiment modules have magnetic bases that hold them to the steel floor of the enclosure. Others attach to a laboratory jack that can position the equipment at a chosen height above the cabinet floor. Equipment also may be bolted to the left wall of the working volume or attached outside the GBX with Velcro(TM).

The GBX supports four charge-coupled device (CCD) cameras, two of which can be operated simultaneously. Three black-and-white and three color camera CCD heads are available. Operations can be viewed through three view-ports or through a large window at the top of the working volume. The GBX also has a backlight panel, a 35 mm camera and a stereomicroscope that offers high-magnification viewing of experiment samples. Video data can be downlinked in real-time. The GBX also provides electrical power for experiment hardware, a time-temperature display and cleaning supplies.

GBX



GLOVEBOX COMPONENTS

Passive Accelerometer System (PAS)
Dr. J. Iwan D. Alexander, The University of Alabama in Huntsville

The objective of PAS is to test a simple system to measure residual acceleration caused by atmospheric drag effects and the gravity gradient from the spacecraft's center of mass. Because many microgravity experiments and processes are sensitive to accelerations, it is important to measure these accelerations to improve the design of future experiments and facilities. A proof mass (steel ball) will be placed in a glass tube full of water. This tube is contained in a Lexan sleeve and will be mounted parallel to the flight direction. An astronaut tracks its position manually every 1-2 minutes, using a ruler and protractor, repositioning the tube if the angular deviation of the proof mass exceeds 10!. Stokes' law will be used to indirectly calculate the residual acceleration from the ball's trajectory and speed. Each run will take approximately 20 minutes. This experiment will be repeated 5-10 times during the mission, at several different locations in middeck and the Spacelab.

Interface Configuration Experiment (ICE)
Dr. Paul Concus, University of California at Berkeley and Lawrence Berkeley Laboratory

ICE will explore the behavior of liquid-vapor interfaces that has been predicted mathematically for certain irregularly shaped "exotic" containers in a low-gravity environment. By demonstrating the ability to mathematically predict the shape and location of liquids in exotic containers, the researchers hope to build confidence in the ability to predict fluid configurations in containers of all shapes.

ICE has been designed to observe:

- The location and relative stability of surface shapes in mathematically designed containers
- The effects of container surface conditions on fluid behavior
- The effects of fluid properties on fluid behavior

Protein Crystal Growth Glovebox (PCGG)
Dr. Lawrence J. DeLucas
The University of Alabama at Birmingham

This experiment will be flown by the Center for Macromolecular Crystallography, a NASA Center for the Commercial Development of Space (CCDS) based at the University of Alabama at Birmingham (UAB). Individual protein crystal growth experiments are jointly sponsored by the Office of Commercial Programs and the Microgravity Science and Applications Division, Office of Space Science and Applications.

The objectives are to identify optimal conditions for nucleating and growing protein crystals in space and to investigate ways of manipulating protein crystals in microgravity. By determining the structure of protein crystals, scientists may be able to develop dramatically improved medical and agricultural products. More information is needed about optimum mixing times, solutions concentrations and other growth parameters for future microgravity protein crystal growth experiments.

The PCGG investigator, Dr. Lawrence J. DeLucas, is a USML-1 payload specialist. He and other crew members will conduct 720 interactive experiments using modular crystal growth hardware and including as many as 21 different proteins. Sample materials will be stored in a middeck R/IM for launch. Protein crystals will be grown by vapor diffusion and free interface diffusion methods. Graduated syringes with dispensing devices will be used to extrude precise amounts of proteins, buffers or precipitates. Seed crystals will be injected into equilibrated protein/precipitant solutions using micro-manipulators. The GBX microscope and a PCGG light table will be used to inspect growing crystals. Experiment parameters will be altered in response to crew observations of the crystal growth process. New experiments will be initiated throughout the mission to take advantage of lessons learned from early experiment runs. Crew members also will study ways to manipulate protein crystals and mount them in capillaries.

Solid Surface Wetting Experiment (SSW)
Dr. Eugene H. Trinh
NASA Jet Propulsion Laboratory
Pasadena, CA

The objective is to determine the most reliable injector tip geometry and coating for droplet deployment for Drop Physics Module (DPM) experiments. Fluids experiments in the DPM depend on efficient and accurate deployment of droplets of the proper volume and shape. Different combinations of fluids and injector nozzles will be used to deploy droplets inside the GBX working area. A micrometer drive will provide calibrated volume control of the manual injection syringe. The crew will test three different compositions of water-glycerol mixtures, as well as a variety of silicon oils. A coaxial injector will be used to inject air bubbles into some drops, so shells can be studied. Video data of droplet deployment will be recorded for post flight analysis. The crew also will measure droplet volume and wetting angles during the tests.

Marangoni Convection In Closed Containers (MCCC)
Dr. Robert J. Naumann
The University of Alabama in Huntsville

The objective is to determine under what conditions (if any) surface tension driven convection can occur in closed containers. A liquid in space may not conform to the shape of its container. It may be possible for Marangoni convection to occur along all free surfaces of a liquid. If so, models of Marangoni convection effects on heat transfer and fluid motion in space must be refined. Two glass ampoules will be tested, one with water and one with silicone oil, both containing glass tracer beads. Each ampoule has a set of heaters and thermistors. The crew will record the onset of Marangoni convection during heating with video and the 35 mm camera.

Smoldering Combustion In Microgravity (SCM)
Dr. A. Carlos Fernandez-Pello
University of California at Berkeley

The SCM experiment will study the smoldering characteristics of a polyurethane foam in environments with and without air flows. Specifically, the experiment will:

- Measure how different air flows and igniter geometries affect the smolder propagation rates and the smolder temperatures.

- Measure the ignition energy required in low gravity as compared to Earth's gravity.

- Observe the potential transition from smoldering to flaming, the transition from smoldering to extinction and conditions leading to the transition.

Data gathered from the experiment will help scientists develop computer models of smoldering combustion processes and explore ways to control smoldering combustion in low gravity. Ultimately, this experiment will improve methods of fire prevention, detection and extinguishment aboard spacecraft and possibly on Earth.

Wire Insulation Flammability Experiment (WIF)
Paul Greenberg
NASA Lewis Research Center
Cleveland, Ohio

The WIF experiment is designed to determine the offgassing, flammability and flame spread characteristics of overheated wire in a low gravity environment.

Extensive studies of the relationship between the electrical current passed through a wire and the heating of the wire have led to the development of building codes and insulation materials that minimize the number and severity of wiring-related fires. To support the development of similar "building codes" for future space-based structures, the WIF will study the warming of electrical wire in microgravity.

Candle Flames In Microgravity
Dr. Howard Ross
NASA Lewis Research Center
Cleveland, Ohio

This experiment is expected to provide new insights into the combustion process. Specifically, this experiment is designed to:

- Determine if candle flames can be sustained in a purely diffusive, very still environment or in the presence of air flows smaller than those caused by buoyancy on Earth.

- Determine how the absence of buoyant convection affects the burning rate, flame shape and color of candle flames.

- Study the interactions between two closely spaced candles in microgravity.

- Determine if candle flames spontaneously oscillate before they go out in the absence of buoyancy-induced flows.

For the first test, the crew member will remove a candle and igniter from the candle parts box and install them inside the glovebox. After making and verifying the electrical connections, the crew member will set up video cameras at the top and one side of the glovebox to focus on the area around the candle tip and the displays of thermocouple data.

After starting the camera and instruments, the crew member will activate the igniter which will light the candle. Photography and temperature measurements will continue until the flame burns out or until a fixed period of time passes. The crew member then will turn on the glovebox fan to cool the candle box and replenish the glovebox with air. After about 1 minute, the next test can proceed. There will be a total of four tests conducted.

Fiber Pulling In Microgravity (FPM)
Dr. Robert J. Naumann
The University of Alabama in Huntsville

The objective is to test a variety of techniques to pull fibers in microgravity. On Earth, gravity drainage and Rayleigh-Taylor instabilities cause thin columns of low-viscosity liquids to break apart or form beads. In space, it should be possible to determine which of the two influences is the limiting factor in fiber pulling and whether certain low-viscosity materials could be more efficiently processed in microgravity. Simulated glass melts of different viscosities will be extruded from syringes to simulate the drawing of a fiber. The time for the breakage of the fibers will be determined. There are six syringe sets with decreasing ratios of viscosity to surface tension. One video camera will observe the apparatus, while the other camera will use a high resolution macro lens to focus on the pulled fibers.

Nucleation Of Crystals From Solutions In A Low-G Environment (NCS)
Dr. Roger L. Kroes
NASA Marshall Space Flight Center
Huntsville, AL

The objective is to test a new technique for initiating and controlling the nucleation of crystals from solution in reduced gravity. Improvements in the ability to control the location and time of the onset of nucleation of crystals in a solution have the potential to increase the flexibility of all space experiments involving solution crystal growth. A mildly supersaturated solution will be injected with a fixed amount of warmer solution in a crystal growth test cell. The injected solution will be more concentrated than the host solution and will initiate nucleation. The nucleation process will be recorded on the GBX video system. Solutions of triglycine sulfate, L-Arginine phosphate and potassium aluminum sulfate will be tested. At the conclusion of each test, any crystals produced will be removed and stored for post-flight analysis.

Oscillatory Dynamics Of Single Bubbles And Agglomeration In An Ultrasonic Sound Field In Microgravity (ODBA)
Dr. Philip L. Marston
Washington State University

The objective is to explore how large and small bubbles behave in space in response to an ultrasound stimulus. By understanding how the shape and behavior of bubbles in a liquid change in response to ultrasound, it may be possible to develop techniques that eliminate or counteract the complications that small bubbles cause during materials processing on earth. A variety of bubble configurations will be tested in a sealed water chamber. An ultrasonic transducer will be attached to the chamber to establish an ultrasonic standing wave. The wave will drive the bubbles into shape oscillations. Bubbles will be brought into contact by either the ultrasonic field or direct mechanical manipulation. The coalescence and resulting decay of large amplitude shape oscillations will be recorded on video. The response of bubbles to a surfactant solution -- sodium dodecyl sulfate -- also will be tested.

Stability Of A Double Float Zone (DFZ)
Dr. Robert J. Naumann
The University of Alabama in Huntsville

The objective is to determine if a solid cylinder can be supported by two liquid columns and remain stable in microgravity. It may be possible to increase the purity and efficiency of glass materials with a newly patented technique that relies on a solid column of material supported by two liquid columns of its own melt. If this arrangement can be maintained in microgravity, space may be a suitable laboratory for such processing. A variety of double float zone configurations will be tested using Lexan rods of different sizes and with different end geometries. A center rod will be supported between two other rods by a float zone made of dyed water. The oscillations and breakup of the fluid as the two outer rods are moved will be recorded on video.

Oscillatory Thermocapillary Flow Experiment (OTFE)
Dr. Simon Ostrach
Case Western Reserve University

The objective is to determine the conditions for the onset of oscillations in thermocapillary flows in silicone oils. Temperature variations along a free surface generate thermocapillary flows in the bulk liquid. On Earth, the flows become oscillatory under certain conditions. By determining the conditions present when oscillations begin in microgravity and comparing them to oscillatory onset conditions on Earth, scientists will gain insight into the cause of the oscillations. Four cell/reservoir modules will be tested (two different sizes, using two different viscosities of silicone oil). Micron-sized aluminum oxide tracer particles will be mixed with the fluid in the reservoir. The fluid will then be transferred to the test cell. The crew member manipulates the cell to obtain a fluid free surface. The fluid then is heated by a wire heating element in the center of the test cell. Three thermocouples measure the temperature at the wall, heater and in the fluid. Three video cameras will record the free surface behavior and the thermocouple readings.

Particle Dispersion Experiment (PDE)
Dr. John R. Marshall
NASA Ames Research Center
Mountain View, CA

The PDE will determine the efficiency of air injection as a means of dispersing fine particles in a microgravity environment. The experiment will serve as a simple trial run for particle dispersion experiments in the Space Station Gas-Grain Simulation Facility. The dispersion particles also will be studied for their tendency to electrostatically aggregate into large clusters.

Electrostatic aggregation is an important process for cleansing planetary atmospheres after major dust storms, volcanic eruptions and meteorite/comet impact. Major biological/geological events such as the extinction of the dinosaurs have been attributed to the occlusion of sunlight by dust in the atmosphere after a meteorite impact. This climate effect depends on the time the dust stays aloft, which in turn depends upon the rate and mode of dust aggregation; hence the importance of understanding the nature of the aggregation process.

The PDE consists of a pump unit for generating compressed air and eight small experiment modules. An experiment involves connecting a module to the pump, pressurizing the pump by operation of a hand crank and sudden release of the compressed air into the module which forcefully injects a stream of small particles into the 2 x 2 x 2 inch cubic experiment volume of the module. The injection force disaggregates the particles and disperses them throughout the complete module volume. This process is filmed on video through one of two windows in the module. After this dispersion technique is tested, the particles will be monitored as they float freely in the experiment chamber and eventually aggregate into large clusters. The rapidity of aggregation and the mode of aggregation (sphere or chain formation) are of prime interest. This process is repeated for all modules. The eight modules allow for eight different tests that vary particle size and particle mass.

Directed Polymerization Apparatus (DPA): Directed Orientation Of Polymerizing Collagen Fibers

Dr. Louis S. Stodieck
Center for BioServe Space Technologies
Colorado University, Boulder

This experiment is provided by the Center for BioServe Space Technologies, a NASA Center for the Commercial Development of Space (CCDS) based at the University of Colorado, Boulder. The objective is to demonstrate that the orientation of collagen fiber polymers can be directed in microgravity in the absence of fluid mixing effects. Collagen fibers have potential uses as synthetic implant materials. The orientation of collagen fiber polymers is critical to their functions, and gravity-driven mixing on Earth interferes with the ability to direct the orientation of these fibers. Collagen samples will be processed using a Directed Polymerization Apparatus. Eight samples will be activated on orbit in the GBX. Four will be subjected to weak electric currents to direct the orientation of the collagen fibers during assembly. Four samples will not be exposed to the current and will act as controls. After processing, the samples will be stored in a Refrigerator/Incubator Module.

Zeolite Glovebox Experiment (ZGE)

Dr. Albert Sacco
Worcester Polytechnic Institute

The Zeolite Crystal Growth experiment will be provided by the Battelle Advanced Materials Center, Columbus, Ohio, and the Clarkson Center for Commercial Crystal Growth in Space, Potsdam, New York, both of which are NASA Centers for the Commercial Development of Space (CCDS). The objective is to examine and evaluate mixing procedures and nozzle designs that will enhance the middeck Zeolite Crystal Growth experiment. Twelve self-contained, cylindrical, Plexiglas/Teflon(TM) autoclaves will be used to test three different mixer (nozzle) designs and four mixing protocols. Each autoclave is a sealed container containing silicate and aluminum solutions in separate volumes. The fluids are mixed by using a screwdriver to drive a piston into one volume, forcing the fluid through an opening to mix with the fluid in the second volume. Operations with the twelve autoclaves will be recorded on video.

SPACE ACCELERATION MEASUREMENT (SAMS)

Principal Investigator:
Charles Baugher
NASA Lewis Research Center
Cleveland, Ohio

The Space Acceleration Measurement System (SAMS) is designed to measure and record low-level acceleration that the Spacelab experiences during typical on-orbit activities. The three SAMS sensor heads are mounted on or near experiments to measure the acceleration environment experienced by the research package. The signals from these sensors are amplified, filtered and converted to digital data before being stored on optical disks.

For the first USML-1 mission, the main unit of the Space Acceleration Measurement System will be mounted in the center aisle of the Spacelab module, near the aft end of the module. Its three remote sensor heads will be mounted on the Crystal Growth Furnace experiment, Surface Tension Driven Convection Experiment and the Glovebox Experiment Module.

SAMS flight hardware was designed and developed in-house by the NASA Lewis Research Center.

EXTENDED DURATION ORBITER MEDICAL PROJECT (EDOMP)

Project Manager:
J. Travis Brown
NASA Johnson Space Center
Houston, Texas

A series of medical investigations are included in the STS-50 flight plan to assist in the continuing development of countermeasures to combat adverse effects of space flight.

The upward shift of body fluids and slight muscle atrophy that occurs in space causes no problems while astronauts are in space. Researchers are concerned, however, that the readaptative processes occurring immediately upon return to Earth's gravity could hinder the crew in an emergency escape situation.

The Extended Duration Orbiter Medical Project, sponsored by the Johnson Space Center's Medical Science Division, will validate countermeasures for longer duration flights. EDOMP will have middeck investigations and pre- and post-flight investigations to assess the medical status of the crew following 13 days of exposure to microgravity. Three experiments selected for Spacelab use will involve Lower Body Negative Pressure, Variability of Heart Rate and Blood Pressure and a Microbial Air Sampler.

Lower Body Negative Pressure (LBNP)

During early phases of a mission, observers notice that crew members' faces become puffy due to fluid shifting from the lower body toward the head and chest in the absence of gravity. While it is not a problem on orbit, the fluid shift and resultant fluid loss, although appropriate for microgravity, can pose potential problems upon return to Earth. Crew members may experience reduced blood flow to the brain when standing up. This could lead to fainting or dizziness. The investigators hypothesize that redistributing body fluids through exposure to Lower Body Negative Pressure in conjunction with fluid loading and salt tablets will improve this situation and help prevent fainting. The benefit is believed to remain in the body for 24 hours after the last treatment.

The LBNP experiment uses an inflatable cylinder which seals around the waist. The device is tethered to the floor of the Spacelab and stands 4 feet tall. A vent to the Spacelab vacuum is used to apply negative pressure to the device after the crew member is inside. The pressure is gradually decreased, drawing fluids to the lower body and somewhat offsetting the upward fluid shift that occurs upon entry to microgravity. A controller is used to automatically reduce and increase the pressure according to a preset protocol. Measurements of heart dimensions and function, heart rate and blood pressure will be recorded. Leg volume measurements will be performed before and after each protocol using the LBNP device. The data collected will be analyzed to determine the physiological changes in the crew members and the effectiveness of the treatment. The result of the procedure is expected to be an increased tolerance of orthostasis -- or standing upright -- upon return to Earth's gravity.

LBNP has been used a number of times in the U. S. space program, first during the Skylab missions. STS-50 will be the fourth flight of the current collapsible unit. Researchers are refining the LBNP protocol which will be used operationally on future 13- through 16-day missions.

Variable Heart Rate And Blood Pressure

On Earth, many factors affect our heart rate and blood pressure. These include job stress, specific activity and diet. There are changes between our sleeping and waking states, known as diurnal variation. While emotions and normal body cycles cause a majority of these fluctuations, gravity plays a role. This study will determine if blood pressure and heart rate exhibit more or less variability in microgravity than on Earth. The study also will determine whether a change, if any, correlates with the reduction in sensitivity of baroreceptors in the carotid artery located in the neck. Baroreceptors are one of the body's blood pressure sensors used to regulate blood pressure and heart rate.

Crew members will wear portable equipment including an Automatic Blood Pressure Monitor and a Holter Recorder system that continuously records ECG while periodically monitoring blood pressure in the arm. The data collected are analyzed after the mission.

Microbial Air Sample

Although all materials that go into the Shuttle are as clean as possible, bacteria and fungi growth have been detected in missions of 6-10 days duration. The growths were minimal and posed no health risk to the crew.

The microbial air sampler is a small device that will be placed in several areas of the Spacelab for air sampling. Agar strips will be inserted into the device for collection of microbes. Postflight analysis of the agar strips will quantify the fungal and bacterial growth from this 13-day mission.

Isolated/Stabilized Exercise Platform

One of the major challenges faced in the STS-50/USML mission is the incompatibility of astronauts who need to perform vigorous exercise to maintain their health while at the same time sensitive microgravity experiments which need to be in an environment free from disturbances. The solution to this problem is a device called the Isolated/Stabilized Exercise Platform (ISEM) which supports the use of exercise equipment yet cancels out the inherent vibrations.

Lockheed designed the first ISEP for use with an ergometer, a stationary-cycle device built by the European Space Agency. Future designs will accommodate a treadmill and a rowing machine.

The ISEP consists of four rectangular stabilizers attached vertically to a frame, which rests on shock absorbers called isolators. The ergometer attaches to the frame. The stabilizers hold each corner of the frame stationary. A motor inside each stabilizer uses inertial stabilization to counteract the disturbances caused by exercise.

Without stabilizers, a crew member peddling a stationary bike can produce as much as 100 pounds of force, which far exceeds the allowable microgravity disturbance limits set by NASA. With the ISEP system, the exercise is expected to cause less than 1 pound of disturbance force on the Shuttle middeck.

INVESTIGATIONS INTO POLYMER MEMBRANE PROCESSING

Principal Investigator:
Dr. Vince McGinness
Battelle Advanced Materials Center
Columbus, Ohio

The Investigations into Polymer Membrane Processing (IPMP), a middeck payload, will make its seventh Space Shuttle flight for the Columbus, Ohio-based Battelle Advanced Materials Center, a NASA Center for the Commercial Development of Space, sponsored in part by the Office of Commercial Programs.

The objective of IPMP is to investigate the physical and chemical processes that occur during the formation of polymer membranes in microgravity such that the improved knowledge base can be applied to commercial membrane processing techniques. Supporting the overall program objective, the STS-50 mission will provide additional data on the polymer precipitation process.

Polymer membranes have been used by industry in separation processes for many years. Typical applications include enriching the oxygen content of air, desalination of water and kidney dialysis.

Polymer membranes frequently are made using a two-step process. A sample mixture of polymer and solvents is applied to a casting surface. The first step involves the evaporation of solvents from the mixture. In the second step, the remaining sample is immersed in a fluid (typically water) bath to precipitate the membrane, form the solution and complete the process.

On STS-50, a crew member will activate the IPMP experiment by sliding the stowage tray which contains two IPMP units to the edge of the locker. By turning each unit's valve to an initial position, the evaporation process is initiated. The evaporation process will last 5 minutes for one unit and 1 hour for the other. Subsequently, the units' valves will be turned to a second position, initiating a 15-minute precipitation process which includes quenching the membrane with water. Once the precipitation process is complete, the stowage tray will be slid back into the locker for the flight's duration.

Following the flight, the samples will be retrieved and returned to Battelle for testing. Portions of the samples will be sent to the CCDS's industry partners for quantitative evaluation consisting of comparisons of the membranes' permeability and selectivity characteristics with those of laboratory-produced membranes.

ORBITAL ACCELERATION RESEARCH EXPERIMENT (OARE)

Principal Investigator:
Robert C. Blanchard
NASA Langley Research Center
Hampton, VA.

The Orbital Acceleration Research Experiment (OARE) provides measurements of orbiter aerodynamic data within the thin atmosphere of extreme altitudes. Aerodynamic data is acquired on-orbit and during the high-altitude portion of atmospheric entry. The OARE instrument comprises a three-axis set of extremely sensitive linear accelerometers, which measure the vehicle's response to aerodynamic forces. These accelerometers are capable of measuring acceleration levels as small as one part per billion of Earth's gravity.

Because of their extreme measurement sensitivity, the OARE sensors cannot be adequately calibrated on the ground, in the presence of Earth's gravity. Consequently, the sensors are mounted on a rotary calibration table which enables an accurate instrument calibration to be performed on-orbit.

The OARE instrument is installed for flight at the bottom of the orbiter's payload bay on a special carrier plate attached to the orbiter's keel. OARE data are recorded both on the mission payload recorder and within the OARE's own solid-state memory for analysis after the flight.

SHUTTLE AMATEUR RADIO EXPERIMENT

The Shuttle Amateur Radio Experiment (SAREX) is designed to demonstrate the feasibility of amateur short-wave radio contacts between the Space Shuttle and ground amateur radio operators, often called ham radio operators. SAREX also serves as an educational opportunity for schools around the world to learn about space first hand by speaking directly to astronauts aboard the Shuttle via ham radio. Contacts with certain schools are included in planning the mission.

Ham operators may communicate with the Shuttle using VHF FM voice transmissions, slow scan television and digital packet. Several selected ground stations also will be able to send standard television to the crew via SAREX. The television uplink will be used to send video of the crew's families and of the launch.

The primary voice frequencies to be used during STS-50 are 145.55 MHz for transmissions from the spacecraft to the ground and 144.95 MHz for transmissions from the ground to the spacecraft. Digital packet and slow scan television will operate on the same frequencies, while the television uplink will be limited to the UHF ham band at 450 MHz.

Equipment aboard Columbia will include a low-power, hand-held FM transceiver, spare batteries, headset, an antenna custom designed by NASA to fit in an orbiter window, interface module and an equipment cabinet.

SAREX has flown previously on Shuttle missions STS-9, STS-51F, STS-35, STS-37 and STS-45. SAREX is a joint effort by NASA, the American Radio Relay League (ARRL), the Amateur Radio Satellite Corp. and the Johnson Space Center Amateur Radio Club. Information about orbital elements, contact times, frequencies and crew operating times will be available from these groups during the mission and from amateur radio clubs at other NASA centers.

Ham operators from the JSC club will be operating on HF frequencies and the AARL (W1AW) will include SAREX information in its regular HF voice and teletype bulletins. The Goddard Space Flight Center Amateur Radio Club, Greenbelt, MD, will operate 24 hours a day during the mission, providing information on SAREX and retransmitting live Shuttle air-to-ground communications. In addition, the NASA Public Affairs Office at the Johnson Space Center will have a SAREX information desk during the mission.

STS-45 SAREX Operating Frequencies

Location	Shuttle Transmission (MHz)	Shuttle Reception (MHz)
U.S./Africa	145.55	144.95
South America	145.55	144.97
and Asia	145.55	144.91
Europe	145.55	144.95
	145.55	144.75
	145.55	144.70

Goddard Amateur Radio Club Operations
(SAREX information and Shuttle audio broadcasts)

3.860	7.185
14.295	21.395
28.395	

SAREX information also may be obtained from the Johnson Space Center computer bulletin board (JSC BBS), 8 N 1 1200 baud, at 713/483-2500 and then type 62511. The same information may be obtained from NASA Spacelink, 8 N 1 300-9600 baud at 205/895-0028 or 128.158.13.250 via Internet.

STS-50 PRELAUNCH PROCESSING

Columbia arrived at KSC on Feb. 9, after a 6-month modification period at Rockwell International in Palmdale, CA. Some of the major changes incorporated into the flagship orbiter will allow for extended duration missions up to 16 days.

Changes made to equip the orbiter for extended flights include adding an extended duration orbiter (EDO) pallet to meet additional power and water requirements, increasing the capacity of the waste collection system, installing the regenerative carbon dioxide removal system for removing carbon dioxide from the crew cabin atmosphere, installing two additional nitrogen tanks for the crew cabin atmosphere and augmenting the stowage space with extra middeck lockers.

Other systems on board Columbia now feature design changes or updates as part of continued improvements to the Space Shuttle. The upgrades include several improved or redesigned avionics systems, the drag chute and new beefed-up main gear tires that use a synthetic rubber tread instead of the natural rubber previously used.

While in the Orbiter Processing Facility (OPF), flight technicians installed the three main engines. Engine 2019 is in the No. 1 position, engine 2031 is in the No. 2 position and engine 2011 is in the No. 3 position.

After being readied for its 12th flight, Columbia was transferred out of the OPF on May 29th and towed several hundred yards to the Vehicle Assembly Building (VAB) and connected to its external tank and solid rocket boosters on the same day.

In the VAB technicians connected the 100-ton space plane to its already stacked solid rocket boosters and external tank. Columbia was scheduled to be transferred to pad 39-A the week of June 1.

The primary STS-50 payload, the U.S. Microgravity Laboratory-1, was installed in the OPF on April 13. An interface verification test between the orbiter and laboratory was completed.

In addition to the routine operations at the launch pad, a test is scheduled in which the orbiter's fuel cell storage tanks and extended duration orbiter pallet tanks will be loaded with liquid oxygen and liquid hydrogen reactants. This test will validate procedures and establish timelines to tank and detank the EDO pallet.

Also planned is the Terminal Countdown Demonstration Test with the STS-50 flight crew during the week of June 8.

A standard 43-hour launch countdown is scheduled to begin 3 days prior to launch. During the countdown, the orbiter's fuel cell storage tanks and extended duration orbiter pallet tanks will be loaded with fuel and oxidizer and all orbiter systems will be prepared for flight. The hold time will be extended to allow extra time for loading the EDO pallet with cryogenic propellants.

About 9 hours before launch, the external tank will be filled with its flight load of a half million gallons of liquid oxygen and liquid hydrogen propellants. About 2 1/2 hours before liftoff, the flight crew will begin taking their assigned seats in the crew cabin.

Columbia's end-of-mission landing is planned for Edwards Air Force Base, CA. Columbia's landing will feature the drag chute. KSC's landing and recovery teams will be on hand to prepare the vehicle for the cross-country ferry flight back to Florida. Columbia's next flight, STS-52, is planned this fall with the LAGEOS II payload.

STS-50CREWMEMBERS

STS050-S-002 -- STS-50 United States Microgravity Laboratory 1 (USML-1) crewmembers pose for their official portrait in front of Columbia, Orbiter Vehicle (OV) 102, at Rockwell International (RI), Palmdale, California. The crew was at the Rockwell facility for OV-102's extended duration orbiter (EDO) modifications rollout. Left to right, wearing navy blue flight suits, are Mission Specialist (MS) Ellen S. Baker, Pilot Kenneth D. Bowersox, MS and Payload Commander (PLC) Bonnie J. Dunbar, Commander Richard N. Richards, MS Carl J. Meade, Payload Specialist Eugene H. Trinh, and Payload Specialist Lawrence J. DeLucas. Portrait was made by NASA JSC contract photographer Scott A. Wickes.

BIOGRAPHICAL DATA

RICHARD N. RICHARDS, 45, Capt., USN, will serve as Commander of STS-50. Selected as an astronaut in May 1980, Richards considers St. Louis, MO, his hometown and will be making his third space flight.

Richards graduated from Riverview Gardens High School, St. Louis, in 1964; received a bachelor's in chemical engineering from the University of Missouri in 1969; and received a master's in aeronautical systems from the University of West Florida in 1970.

Richards first flew as pilot of Shuttle mission STS-28, a Department of Defense-dedicated mission in August 1989. His next flight was as commander of STS-41, a mission that deployed the Ulysses solar probe in October 1990. He has logged more than 219 hours in space.

KENNETH D. BOWERSOX, 36, Lt. Cmdr, USN, will serve as pilot. Selected as an astronaut in June 1987, Bowersox considers Bedford, IN, to be his hometown and will be making his first space flight.

Bowersox graduated from Bedford High School, Bedford, IN; received a bachelor's in aerospace engineering from the Naval Academy in 1978; and received a master's in mechanical engineering from Columbia University in 1979.

He was designated a naval aviator in 1981 and was assigned aboard the USS Enterprise, where he completed more than 300 carrier landings. In 1985, he graduated from the Air Force Test Pilot School and was assigned as the A-7E and F/A-18 test pilot at the Naval Weapon Center when selected by NASA. Bowersox has logged more than 2,000 hours flying time.

BONNIE J. DUNBAR, 43, will serve as mission specialist 1 (MS1) and as payload commander. Selected as an astronaut in August 1981, she considers Sunnyside, WA, to be her hometown and will be making her third space flight.

Dunbar graduated from Sunnyside High School, Sunnyside, WA; received a bachelor's and a master's in ceramic engineering from the University of Washington; and received a doctorate in biomedical engineering from the University of Houston.

Dunbar first flew on STS-61A, the Spacelab D-1 mission, in November 1985. Her next flight was on STS-32, the mission to retrieve the Long Duration Exposure Facility in January 1990. She has logged 430 hours in space.

ELLEN BAKER, 39, will serve as mission specialist 2 (MS2). Selected as an astronaut in May 1984, Baker considers New York, NY, to be her hometown and will be making her second space flight.

Baker graduated from Bayside High School in New York City; received a bachelor's degree in geology from the State University of New York; and received a doctorate of medicine from Cornell University.

Baker first flew on STS-34, a mission that deployed the Galileo probe to Jupiter in October 1989. She joined NASA in 1981 and served as a physician in the Flight Medicine Clinic until her selection as an astronaut. Baker has logged more than 119 hours in space.

BIOGRAPHICAL DATA

CARL J. MEADE, 41, Col., USAF, will serve as mission specialist 3 (MS3). Selected as an astronaut in June 1985, Meade considers Universal City, TX, his hometown and will be making his second space flight.

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

Meade first flew on STS-38 in November 1990, a Department of Defense-dedicated Shuttle mission. He has logged more than 117 hours in space.

LAWRENCE J. DELUCAS, 41, will serve as payload specialist 1 (PS1). DeLucas was born in Syracuse, NY, and will be making his first space flight.

DeLucas received a bachelor's and master's in chemistry from the University of Alabama at Birmingham; received a bachelor's in physiological optics from the University of Alabama at Birmingham; and received doctorates of optometry and biochemistry from the University of Alabama at Birmingham.

He has served as associate director of the Center for Macromolecular Crystallography at the University of Alabama since 1986; has been a member of the NASA Science Advisory Committee for Advanced Protein Crystal Growth since 1987; and is a professor in the University of Alabama's Department of Optometry. He also is a member of the graduate faculty at the University of Alabama.

EUGENE H. TRINH, 41, will serve as payload specialist 2 (PS2). Trinh is a resident of Culver City, CA, and will be making his first space flight. Trinh was born in Saigon, Vietnam, and was raised in Paris, France, since age 2. He has lived in the United States since 1968.

Trinh graduated from Lycee Michelet, Paris, with a baccalaureate degree; received a bachelor's in mechanical engineering-applied physics from Columbia University in 1972; received a master's in applied physics from Yale University; and received a doctorate in applied physics from Yale.

Trinh's research work has focused on physical acoustics, fluid dynamics and containerless materials processing. He served as an alternate payload specialist for NASA for the Spacelab 3 mission in May 1985 and has developed several Shuttle flight experiments. He also is a member of the NASA Space Station Freedom Experiments planning group for Microgravity Science.

STS-50 MISSION MANAGEMENT

NASA HEADQUARTERS, WASHINGTON, DC

Office of Space Flight

Jeremiah Pearson	Associate Administrator
Thomas E. Utsman	Deputy Associate Administrator
Bryan O'Connor	Deputy Associate Administrator (Programs)
Leonard Nicholson	Director, Space Shuttle

Office of Space Science and Applications

Dr. Lennard A. Fisk	Associate Administrator
Alphonso V. Diaz	Deputy Associate Administrator
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Dr. Roger Crouch	USML-1 Program Scientist
Robert H. Benson	Director, Flight Systems Division
James McGuire	USML-1 Program Manager

Office of Commercial Programs

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Richard H. Ott	Director, Commercial Development Division
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James R. Phelps	Chief, Space Support Office

KENNEDY SPACE CENTER, FL

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J. Robert Lang	Director, Vehicle Engineering
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P. Thomas Breakfield	Director, Shuttle Payload Operations
Joanne H. Morgan	Director, Payload Project Management
Russell D. Lunnen	STS-50 Payload Processing Manager

MARSHALL SPACE FLIGHT CENTER, HUNTSVILLE, AL

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Dr. J. Wayne Littles	Deputy Director
Harry G. Craft	Manager, Payload Projects Office
Charles E. Sprinkle	USML Mission Manager
Dr. Donald O. Frazier	USML Mission Scientist
Alexander A. McCool	Manager, Shuttle Projects Office
Dr. George McDonough	Director, Science and Engineering
James H. Ehl	Director, Safety and Mission Assurance
Otto Goetz	Manager, Space Shuttle Main Engine Project
Victor Keith Henson	Manager, Redesigned Solid Rocket Motor Project
Cary H. Rutland	Manager, Solid Rocket Booster Project
Gerald C. Ladner	Manager, External Tank Project

JOHNSON SPACE CENTER, HOUSTON, TX

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

STENNIS SPACE CENTER, BAY ST. LOUIS, MS

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

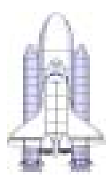
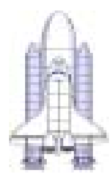
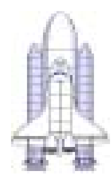
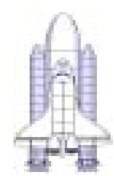
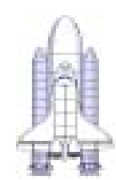
COLUMBIA'S TWELFTH MISSION -- USML-1 -- STS-50 LAUNCH WINDOW

Launch Date	Launch Window Opens			Launch Window Closes			Duration
	GMT	EST	CST	GMT	EST	CST	
06/22/92	16:05	12:05 p.m.	11:05 a.m.	18:35	02:35 p.m.	01:35 p.m.	2 hrs 30 min
06/23/92	16:06	12:06 p.m.	11:06 a.m.	18:36	02:36 p.m.	01:36 p.m.	2 hrs 30 min
06/24/92	16:07	12:07 p.m.	11:07 a.m.	18:37	02:37 p.m.	01:37 p.m.	2 hrs 30 min
06/25/92	16:07	12:07 p.m.	11:07 a.m.	18:37	02:37 p.m.	01:37 p.m.	2 hrs 30 min
06/26/92	16:08	12:08 p.m.	11:08 a.m.	18:38	02:38 p.m.	01:38 p.m.	2 hrs 30 min
06/27/92	16:08	12:08 p.m.	11:08 a.m.	18:38	02:38 p.m.	01:38 p.m.	2 hrs 30 min
06/28/92	16:09	12:09 p.m.	11:09 a.m.	18:39	02:39 p.m.	01:39 p.m.	2 hrs 30 min
06/29/92	16:09	12:09 p.m.	11:09 a.m.	18:39	02:39 p.m.	01:39 p.m.	2 hrs 30 min
06/30/92	16:10	12:10 p.m.	11:10 a.m.	18:40	02:40 p.m.	01:40 p.m.	2 hrs 30 min
07/01/92	16:11	12:11 p.m.	11:11 a.m.	18:41	02:41 p.m.	01:41 p.m.	2 hrs 30 min
07/02/92	16:11	12:11 p.m.	11:11 a.m.	18:41	02:41 p.m.	01:41 p.m.	2 hrs 30 min
07/03/92	16:12	12:12 p.m.	11:12 a.m.	18:42	02:42 p.m.	01:42 p.m.	2 hrs 30 min
07/04/92	16:13	12:13 p.m.	11:13 a.m.	18:43	02:43 p.m.	01:43 p.m.	2 hrs 30 min
07/05/92	16:13	12:13 p.m.	11:13 a.m.	18:43	02:43 p.m.	01:43 p.m.	2 hrs 30 min
07/06/92	16:14	12:14 p.m.	11:14 a.m.	18:44	02:44 p.m.	01:44 p.m.	2 hrs 30 min
07/07/92	16:15	12:15 p. m.	11:15 a.m.	18:45	02:45 p.m.	01:45 p.m.	2 hrs 30 min
07/08/92	16:15	12:15 p.m.	11:15 a.m.	18:45	02:45 p.m.	01:45 p.m.	2 hrs 30 min
07/09/92	16:16	12:16 p.m.	11:16 a.m.	18:46	02:46 p.m.	01:46 p.m.	2 hrs 30 min

Note: Mission duration is 12/20:28

SHUTTLE FLIGHTS AS OF JUNE 1992

47 TOTAL FLIGHTS OF THE SHUTTLE SYSTEM -- 22 SINCE RETURN TO FLIGHT

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