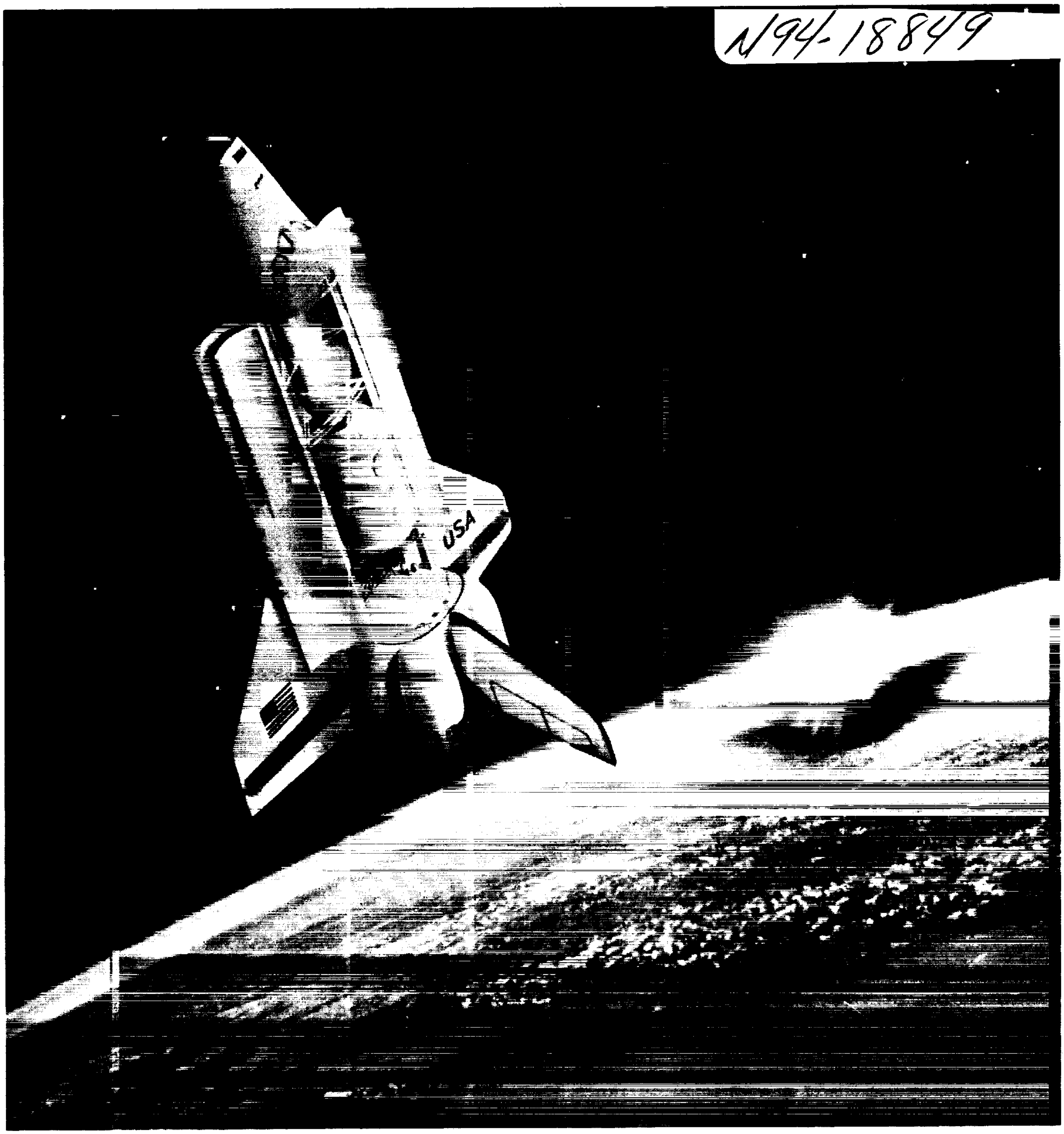
# SPACELAB 3





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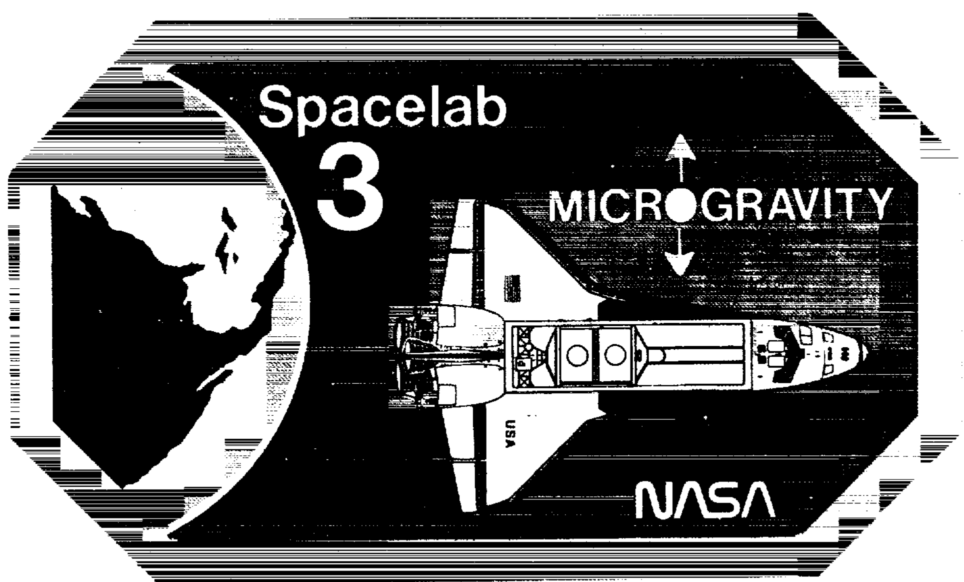


NASA

National Aeronautics and
Space Administration

**Marshall Space Flight Center**

M484

*"Instruments continue to be indispensable in the exploration of space. But man has proven himself irreplaceable.... Even in 1984, it remains for the brain of man to correlate unexpected observations, to perceive solutions to novel situations and to take independent action in the light of new data collected by his instruments."*

**Dr. Wernher von Braun,**
former Director of the Marshall Space Flight Center, commenting in 1964 on the future role of man in space.

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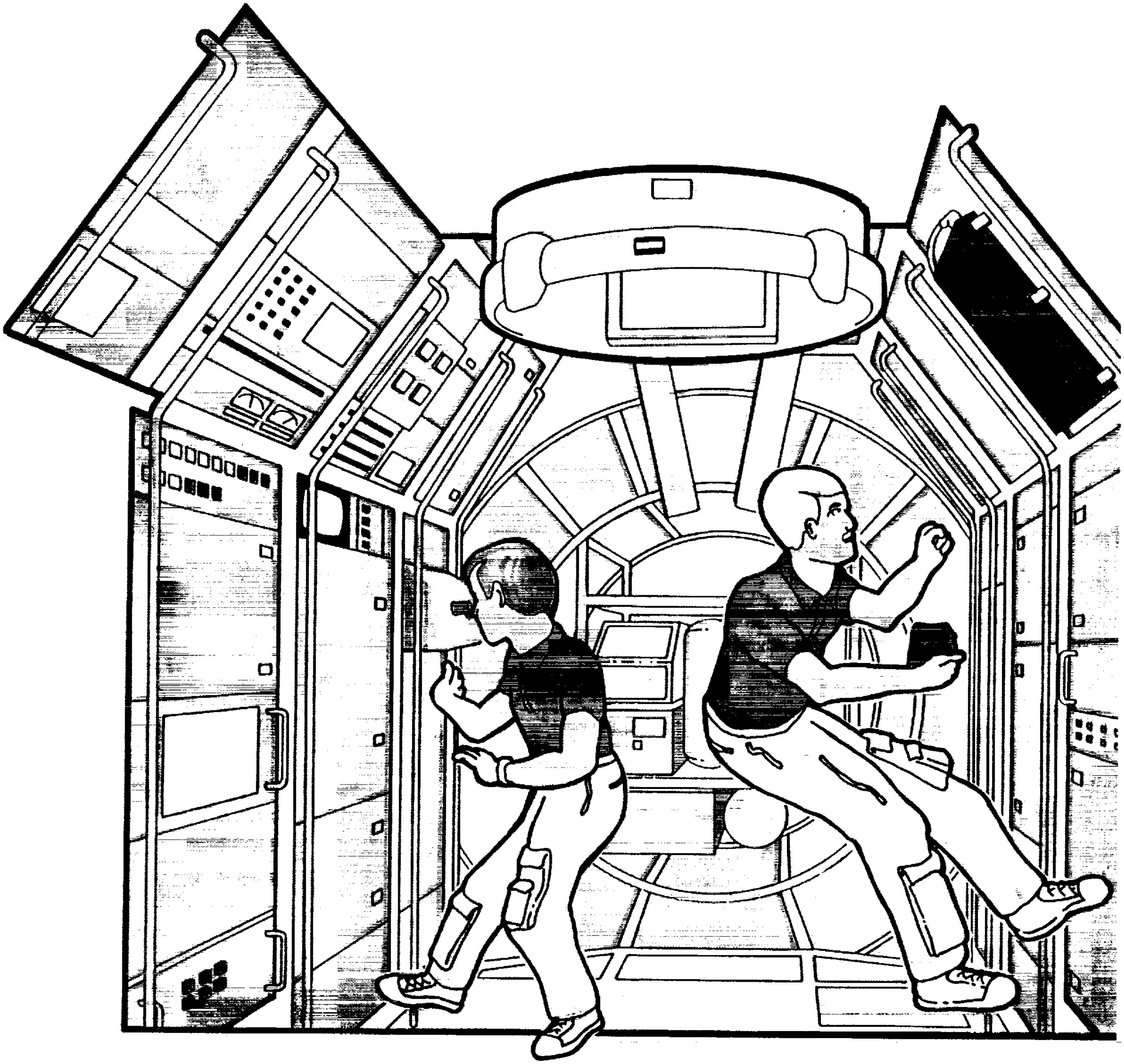


# SPACELAB IN SERVICE

Peering through a microscope, a scientist concentrates on a tiny, ruby-red crystal growing inside a special furnace. Another scientist intently watches the same crystal on a television screen. Together, these researchers are performing a very delicate experiment in an attempt to produce a perfect crystal.

As the experiment progresses, the two colleagues discuss what they see and how they want to proceed. The television observer asks for information from the laboratory and suggests a course of action. The scientist in the lab responds quickly or suggests another approach.

For the next hour or so, both scientists pay close attention to the experiment. Their dialogue continues as if they were working side-by-side. In this case, however, one scientist is busy in Spacelab, a unique research center orbiting Earth in the Space Shuttle. The other is watching and consulting with his colleague from a control center on the ground.

During the Spacelab 3 mission, five specialists will spend a week in this orbital laboratory doing their own research and experiments for dozens of scientists on Earth. While one is engaged in crystal growth operations, another will be monitoring the behavior of rats and monkeys in small cages nearby. A third scientist will be busy at a window in the Shuttle cabin, focusing cameras on the spectacular atmospheric light show – the aurora – below. Meanwhile, the other two will be asleep or preparing to come on duty at shift change.

The primary purpose of the Spacelab 3 mission is to conduct materials science experiments in a stable low-gravity environment. In addition, the crew will do research in life sciences, fluid mechanics, atmospheric science, and astronomy. Fifteen investigations in five research fields are scheduled.

For this mission, Spacelab is equipped with several new mini-labs, special facilities that will be used repeatedly on future flights. Two elaborate crystal growth furnaces, a life support and housing facility for small animals, and two types of apparatus for the study of fluids are being evaluated on their inaugural flight. Most of the experiment equipment is contained inside the laboratory, but instruments requiring direct exposure to space are mounted outside in the open payload bay of the Shuttle.

An earlier mission successfully demonstrated that scientists from vastly different disciplines can share Spacelab for important research that cannot be done on the ground. On Spacelab 3, they expect to produce high-quality materials for potential technological uses on Earth, examine physiological responses to weightlessness, test theories that cannot be confirmed under the influence of Earth's gravity, and go beyond the atmosphere to observe the Earth and sky more clearly.

Spacelab represents the merger of science and manned spaceflight. It opens remarkable opportunities to push the frontiers of knowledge beyond the limits of research on Earth. Now scientists in space can do experiments in close collaboration with their colleagues on the ground. This interaction enhances the success of research through quick response to problems and to surprising results.

On the Spacelab 3 mission, managed by Marshall Space Flight Center, this versatile laboratory enters routine operational service. For the rest of the century, scientists will be exploiting the many capabilities of Spacelab to do research that will extend knowledge and produce benefits for life on Earth. ■

# MISSION SCENARIO

Spacelab 3 is scheduled for flight aboard the orbiter Challenger in late 1984 or early 1985. The Shuttle will be launched from Kennedy Space Center in Florida into an orbit 350 kilometers (218 miles/190 nautical miles) above Earth at a 57° inclination to the equator. To meet the objectives of an atmospheric science experiment at this time of year, a night launch is planned.

A few hours after launch, crew members will enter Spacelab and begin an ambitious schedule of around-the-clock research activities. After a busy seven days in space, the Shuttle will land at Kennedy Space Center. Instruments will be returned to their respective sponsors, and experiment data will be handed over to the scientists. Spacelab will be removed from the Shuttle and recycled for another mission.

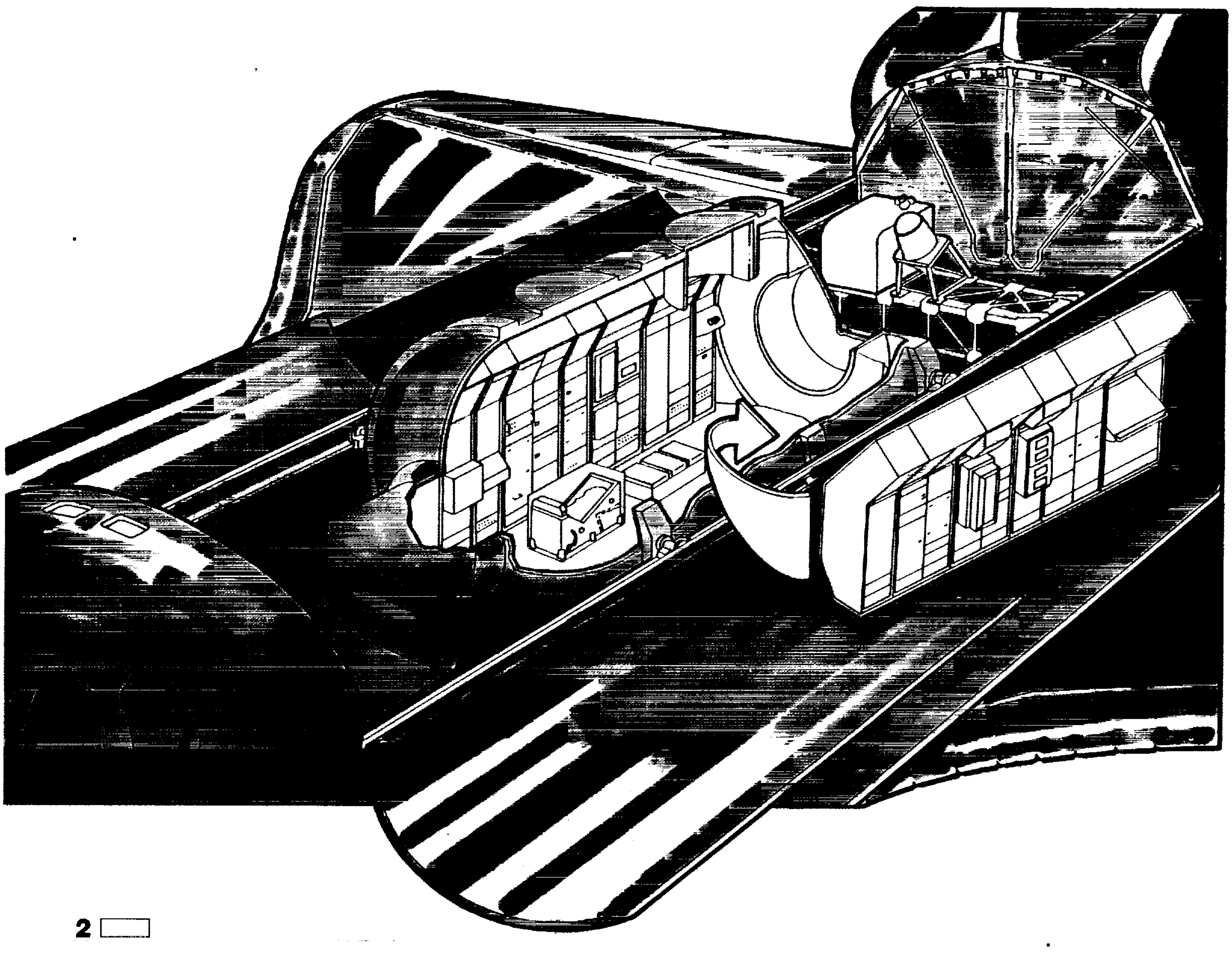
## Inside Spacelab 3

In orbit, the Spacelab 3 scientists leave the Shuttle cabin and pass through a pressurized tunnel to the cylindrical laboratory module nestled in the payload bay. They float through the open circular entry hatch into their workplace for the mission, a well-equipped laboratory about the size of a bus.

The life support system for the lab provides the crew with a comfortable shirt-sleeve environment where they can use equipment normally found in laboratories on the ground. Spacelab is furnished with computers, cameras, tape recorders, a workbench, tools, and much of the usual laboratory paraphernalia. Spacelab 3 also contains some sophisticated new equipment that has been tested on the ground but never used in space. Instruments for experiments are mounted in standard floor-to-ceiling racks along each side wall. An airlock in the ceiling can be used to extend an instrument into space, operate it outside, and then return it to the laboratory.

The laboratory design has been adapted for working in weightlessness. Handrails and foot restraints are within easy reach to help the scientists stabilize themselves as they do experiments.

Unlike a laboratory on the ground, Spacelab 3 is actually several compact labs in one room. An area dedicated to materials science and fluid mechanics occupies one end of the module. Here the crew uses elaborate furnaces, optical devices, and fluid systems to study diverse physical problems in crystal



growth and fluid behavior. In the center of the module is a life sciences area dominated by an animal habitat. Here crew members observe animal behavior in weightlessness while performing an engineering evaluation of the new housing facility. Other areas of Spacelab 3 serve as an observatory for astronomical photography, investigations of Earth's atmosphere, and cosmic ray measurements. Nowhere on Earth do these different science disciplines rub shoulders in the same laboratory.

From the rear window of the module, crew members can see two instrument packages on a small platform in the payload bay. Instruments requiring direct exposure to the space environment or relatively unobstructed viewing of Earth and space are mounted on this experiment support structure.

Many of the Spacelab 3 experiments are controlled and monitored through a master computer, the electronic brain and nerve center for science operations. The computer system occupies a double rack at the forward end of the module. Both automatic and crew-controlled experiment operations are scheduled. Some experiments will be controlled during the mission by scientists located in the Payload Operations Control Center at Johnson Space Center in Houston, Texas. Cameras and tape recorders are available for recording crew activity and experiment data, which can be transmitted to the ground control center or stored on board for postflight evaluation.

Because Spacelab is a modular system, the standard components may be selected and arranged inside the Shuttle to meet different mission needs. Several different combinations of these elements are possible. For Spacelab 3, the configuration is a long laboratory module with the optional airlock, a long tunnel, and a small experiment support structure. For other missions, a shorter module and tunnel and larger platforms called pallets are available. This design flexibility permits Spacelab to be "customized" to satisfy many different users in the course of many missions.

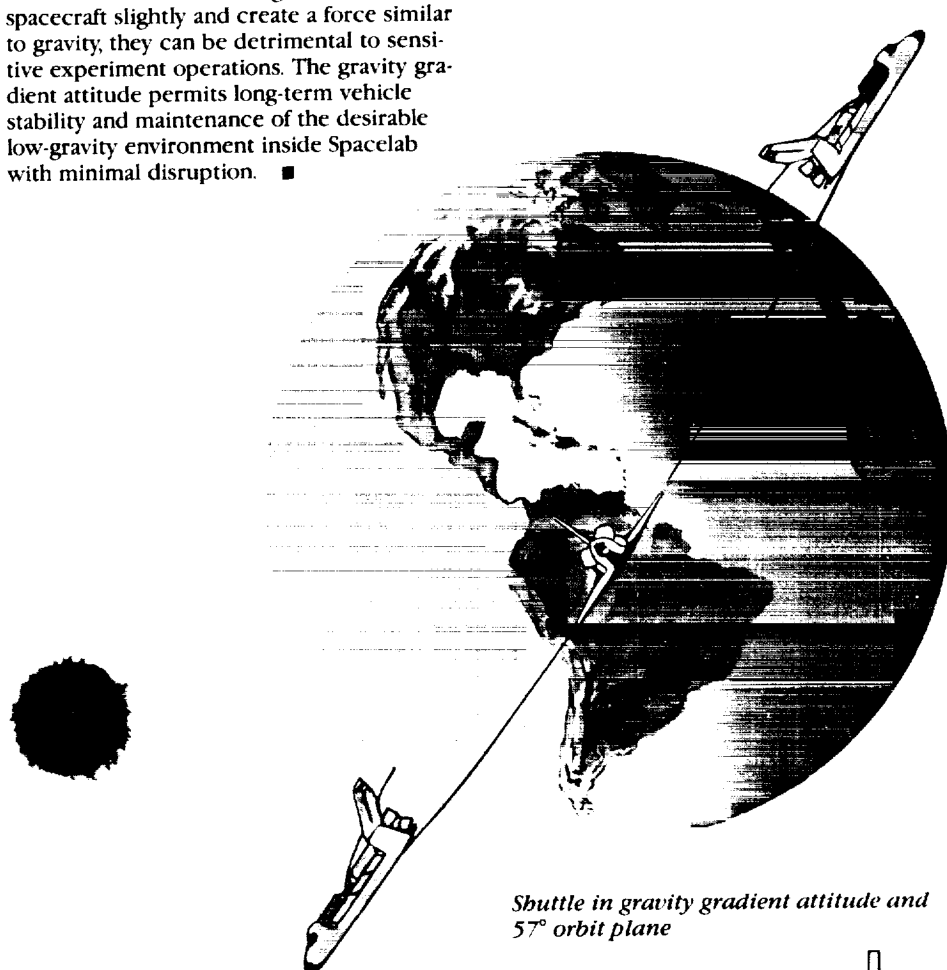
## A Smooth Ride

The Spacelab 3 payload consists of a compatible set of investigations, most of which require a low-gravity environment and a very smooth, undisturbed ride through space. Five of the fifteen investigations involve very delicate crystal growth and fluid dynamics experiments that can be disrupted or ruined by excessive motion of the orbiter. The mission has been carefully designed to accommodate these sensitive investigations.

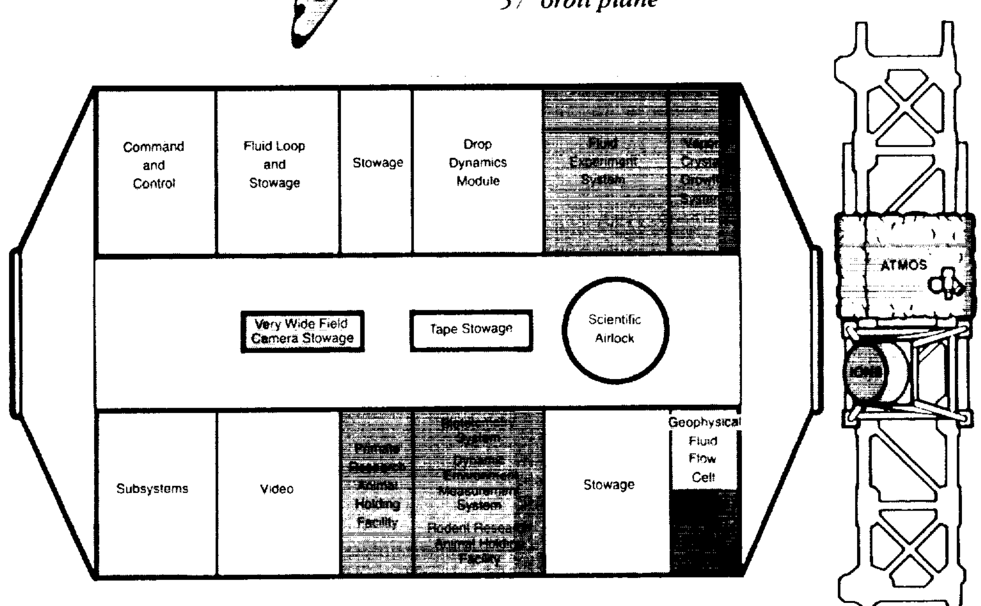
To minimize disturbances, major vehicle maneuvers will be virtually eliminated. Early in the mission, the Shuttle will be pointed for night-time astronomical observations by a wide field-of-view camera mounted in the airlock. Seventeen hours into the mission, however, the Shuttle will move into a fixed attitude until experiment operations end a week later. The orbiter will not turn and roll frequently as it has done on other flights.

The best way to maintain a stable drift through space is to keep the nose or tail of the Shuttle pointed toward Earth. This position is called a gravity gradient attitude. For the Spacelab 3 mission, the tail of the orbiter is pointed down, in alignment with the center of the Earth, and the port (left) wing is pointed into the direction of travel. The Shuttle nose is pitched slightly above the orbital plane for stability.

The advantage of this orientation is that vehicle attitude is maintained primarily by natural forces, thereby reducing the need for attitude control by firing the orbiter's thrusters. Because thruster firings accelerate the spacecraft slightly and create a force similar to gravity, they can be detrimental to sensitive experiment operations. The gravity gradient attitude permits long-term vehicle stability and maintenance of the desirable low-gravity environment inside Spacelab with minimal disruption. ■



*Shuttle in gravity gradient attitude and 57° orbit plane*




*Spacelab 3 configuration and floor plan*

# MISSION DEVELOPMENT AND MANAGEMENT


*Before and during the mission, Marshall Center scientists, engineers, and management teams work together to ensure mission success.*

Years before launch, managers and engineers are busy planning and organizing activities to flow smoothly during a Spacelab mission. By launch day, everyone involved in the Spacelab 3 mission will be working together as a team with one common goal: a successful mission with maximum scientific return for each investigation.

The Marshall Space Flight Center in Huntsville, Alabama, is responsible for planning and directing the Spacelab 3 mission. The center's mission manager and the Spacelab Payload Project Office coordinate all preparations for the mission. The mission management team works to ensure that the payload of scientific instruments satisfies the needs of the user scientists, utilizes Shuttle-Spacelab resources efficiently, and operates well during flight. This team works closely with other NASA organizations involved in preparing the Shuttle and Spacelab for launch and conducting flight operations.

The mission management team also conducts crew training in payload operations and prepares the science teams for their role in the Payload Operations Control Center during the mission. The same mission management team is in charge of all science activities during the mission, resolving problems and rescheduling payload operations as necessary.

## Choosing Experiments

Spacelab 3 investigations were selected by a peer review process and were judged on the basis of their intrinsic scientific merit and suitability for flight on the Shuttle. Proposals for experiments came through several channels, including NASA Announcements of Opportunity that solicited research ideas from the worldwide scientific community.

NASA then selected investigations that were compatible with one another and with Spacelab's capabilities. The Spacelab 3 payload was carefully selected to meet the primary flight requirement–maintenance of an undisturbed microgravity environment through a long period in a stable vehicle attitude. Of the 15 selected investigations, 12 are sponsored by scientists in the United States, 2 by French scientists, and 1 by scientists in India.

## Planning for Science

After experiments were selected, an Investigator Working Group convened to guide the scientific planning of the Spacelab 3 mission. This committee includes the principal investigator, or chief scientist, for each experiment chosen for flight. The mission scientist from Marshall Space Flight Center is chairman of the group, which meets periodically before and during the mission.

The Investigator Working Group guides the incorporation of the various experiments into a single payload, coordinating the needs of user scientists and communicating them to the mission manager. This group also selects the payload specialists for the mission.

## Training the Mission Team

Although the payload specialists and mission specialists for Spacelab 3 are professional scientists or astronauts, they must train for the mission to ensure the success of each investigation. The major part of crew training is conducted by the principal investigators in their own laboratories. There, they instruct the crew members in the theory, hardware, and operation of their experiments.

Training for overall experiment operations occurs at the Marshall Space Flight Center. In-flight operations involving the Spacelab computer system are realistically simulated in the Spacelab 3 mockup in the Payload Crew Training Complex there.

Part of the crew's training involves the basic skills necessary for living and working safely on board the Shuttle and Spacelab. Medical, emergency, and survival skills as well as the normal routines of living in a spacecraft are practiced in training programs at the Johnson and Kennedy Space Centers.

In addition to the crew, the principal investigators and the entire mission management team undergo training for their activities. Everyone involved in the mission participates in simulations to practice planned operations, communications, and problem solving. It is the mission manager's responsibility to coordinate all training exercises and to ensure that the entire mission team is well-prepared.

## Planning the Mission

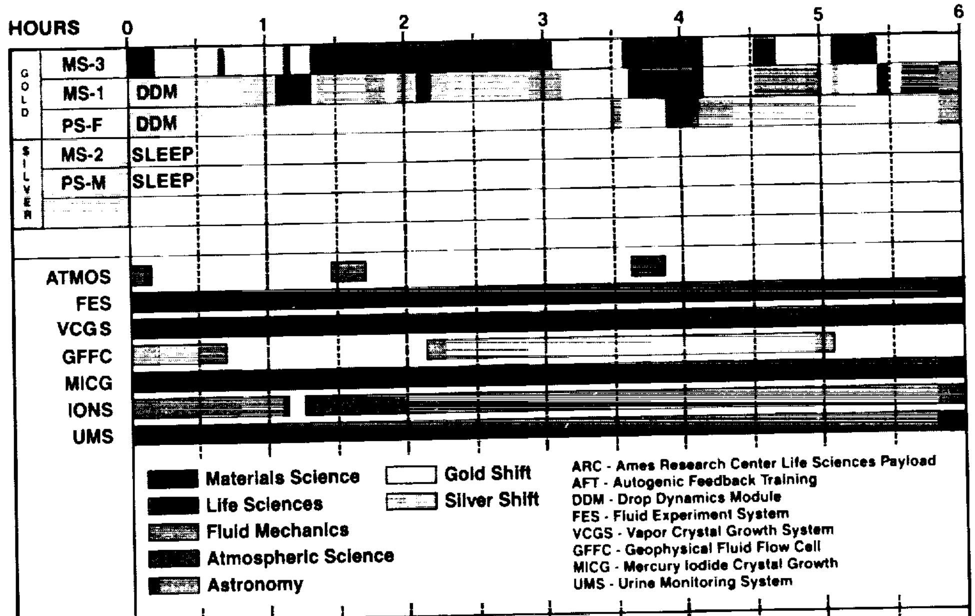
Long before launch day, Spacelab 3 mission planners begin to prepare the mission timeline, an around-the-clock schedule of events during the flight. This is a complex task that involves the merger of all crew activities, experiment requirements, Spacelab resources, and Shuttle maneuvers into an efficient operating plan. Each experiment is assigned time slots during which it receives the necessary power, crew time, and computer support for operation. Mission planning produces a very precisely coordinated sequence of operations for maximum efficiency.

Later, during flight, the timeline is revised in response to unexpected difficulties or opportunities. Replanning occurs throughout the mission, but the guiding philosophy is to adhere as closely as possible to the master schedule.

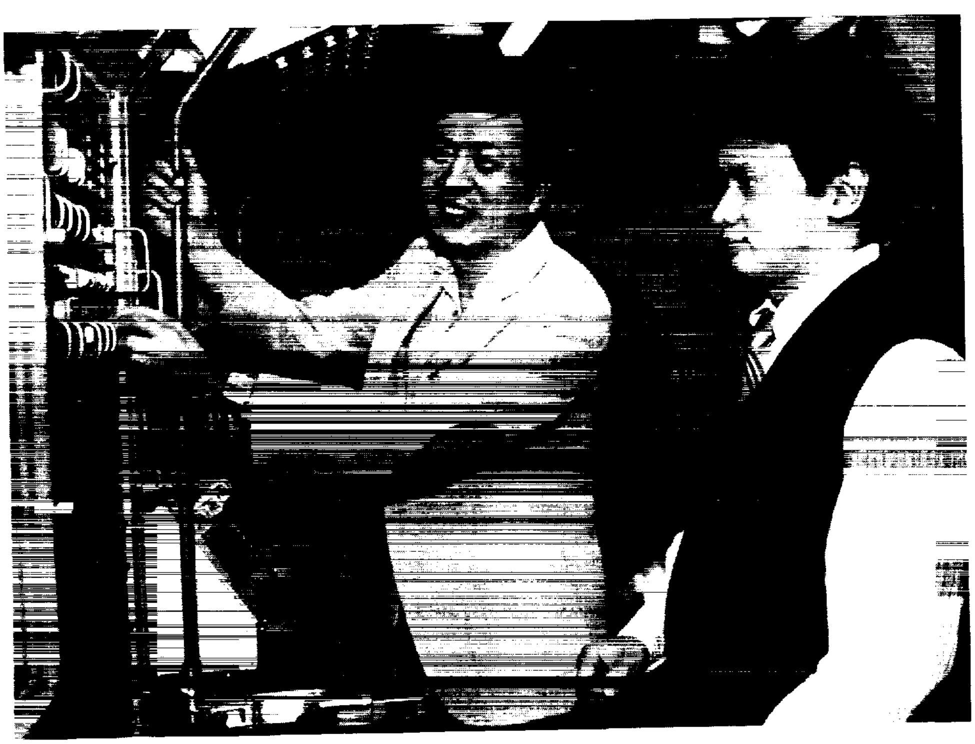
## Developing Experiment Hardware

Experiment hardware is developed by investigators in collaboration with NASA and private industry. The apparatus are designed not only to fulfill their research purpose but also to fit with other experiments into the size, weight, and power supply capabilities of Spacelab. For the sake of economy, existing equipment is used as much as possible, and some of the hardware is designed for reuse

*Investigators meet to discuss Spacelab 3 experiments and mission plans.*




*Sample Spacelab 3 timeline, showing crew activities and experiment operations*



*Payload specialists train intensively in the Spacelab 3 simulator at the Marshall Space Flight Center.*

on future missions. The principal investigators and the mission manager stay in close communication to ensure that instruments and related support hardware are well-coordinated and are compatible with the Shuttle and Spacelab.

In addition to individual instruments, NASA project offices have developed several large instrument complements that occupy an entire experiment rack or double rack. These facilities can be used repeatedly by many scientists on different missions; they may remain assembled between missions for ready reflight. With the addition of new specimens, the same equipment can be used for a variety of different investigations.

Five such facilities are being introduced on the Spacelab 3 mission: the Vapor Crystal Growth System and the Fluid Experiment System for materials science investigations; the Drop Dynamics Module and the Geophysical Fluid Flow Cell for research in fluid mechanics; and the Research Animal Holding Facility for life sciences research. These facilities are in effect mini-laboratories, each a self-contained unit for concentrated research in a particular discipline.

## Putting the Payload Together

For a successful mission, all Spacelab systems and all experiments must be assembled so they work properly. This process, called payload integration, occurs in several phases during the life of the mission. Initially, the requirements (such as space, electricity, computer time, and crew time) of each experiment are evaluated and a layout is designed. This blueprint assures that all users can share Spacelab's accommodations compatibly. Cables connecting instruments to Spacelab's power supply, computer, and data system are also laid out on paper.

Later, instruments are shipped to the launch site for assembly of the total payload and installation into Spacelab according to the developed blueprint. Components are attached to experiment racks and the experiment support structure, and all circuits and connections are tested. The mission management team schedules and coordinates all payload integration activities performed by NASA and contractor personnel.

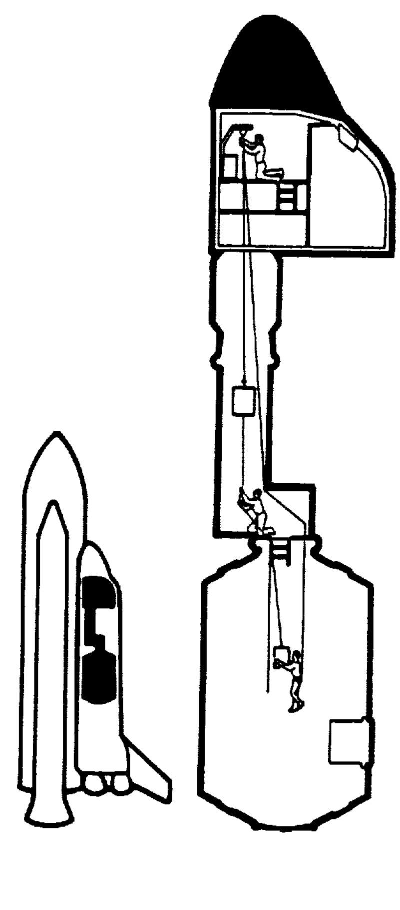
About a month before launch, Spacelab is placed inside the Shuttle orbiter and all connections are checked. Then the loaded orbiter is moved to the Vehicle Assembly Building to be attached to the external tanks and solid rocket boosters. Finally, the fully assembled Shuttle-Spacelab is moved to the launch pad.

A few hours before the launch of this mission, technicians will enter the Shuttle and use a specially designed module vertical access kit to load animals for a life science investigation into Spacelab. Hoisting personnel and equipment into and out of Spacelab on the launch pad is an elaborate procedure that has been carefully planned and rehearsed for first use on the Spacelab 3 mission.

## Making it Happen

During a Spacelab flight, the hub of activity is the Payload Operations Control Center in Houston. The Marshall Center's mission management staff monitors and manages all Spacelab 3 payload operations from this site. Like the Mission Control Center, this area contains banks of television monitors, computers, and communications consoles. The Payload Operations Control Center becomes

*Technicians install experiment hardware in racks that fit inside the Spacelab module.*



*Using special equipment, 3 technicians will enter the Shuttle on the launch pad about 18 hours before lift-off to place animals into their Spacelab habitats.*

home to the management and science teams who work around the clock to guide and support the mission. All the months of preparation come to a focus here as personnel on the ground work in concert with the crew in space to make the mission happen as planned.

For the mission, all Spacelab 3 principal investigators and their teams of scientists and engineers set up work areas in the Payload Operations Control Center. They bring whatever they need to participate in the flight operation of their experiments. Through computers, they can send commands to their instruments and receive and analyze experiment data. Instantaneous video and audio communications make it possible for scientists on the ground to follow the progress of their research almost as if they were in space with the crew.

This "real-time" interaction between investigators and crew is probably the most exciting of Spacelab's many capabilities. As principal investigators talk to the payload specialists during the mission, they consult on experiment operations, make decisions, and share in the thrill of gaining new knowledge.

While the investigators monitor their own experiments, the mission scientist and other key members of the mission management team are also busy in the control center overseeing the full range of Spacelab operations. Supported by a payload flight operations cadre, these people assess and respond to up-to-the-minute information, replan as necessary, advise the crew of changes in the schedule, and work together to resolve problems and keep the mission flowing smoothly.

## Collecting Data

Information pertinent to the in-flight operation of Spacelab 3 investigations is received through the data management system in the Payload Operations Control Center. The data flow during a Spacelab mission is tremendous.

To handle the steady flood of scientific and engineering data, a special Spacelab Data Processing Facility was established at Goddard Space Flight Center in Greenbelt, Maryland. This facility separates and organizes the mass of incoming data by experiment and sends it out to investigators after the mission. In addition to the data received in Houston during the mission, scientists may obtain from Goddard computer tapes, voice recordings, and video tapes that contain more detailed information about their experiments.

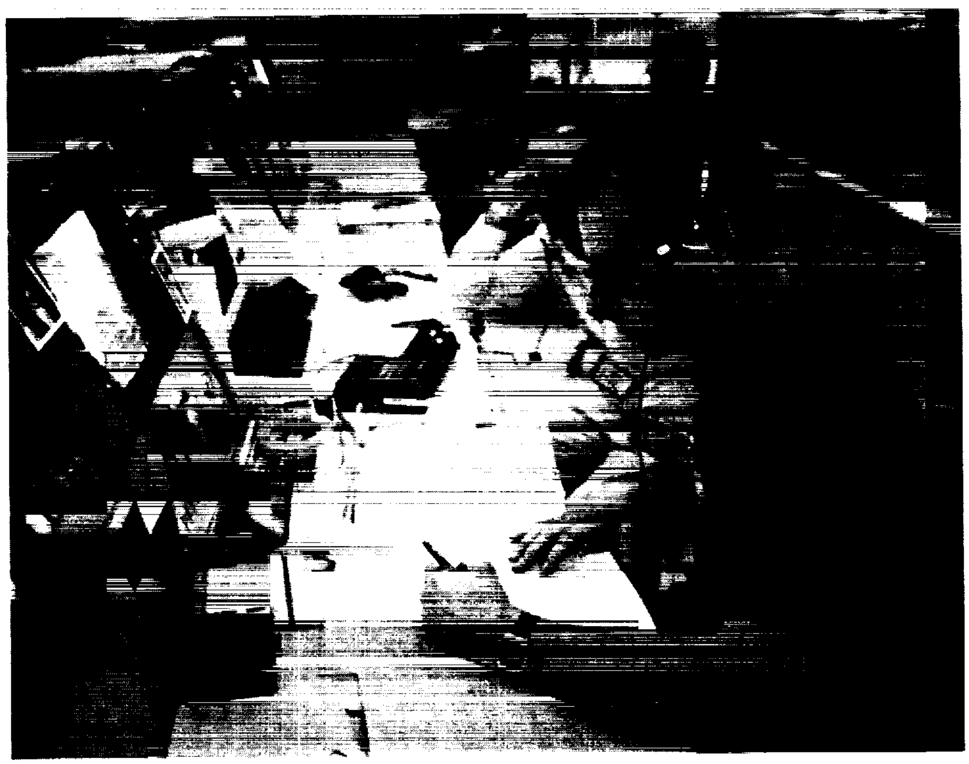
Animals, film, tapes, crystals, experiment samples, and other such data and specimens are removed promptly after the Shuttle lands for postflight evaluation. Later, experiment equipment is returned to the principal investigators, and experiment facilities are returned to NASA for reuse.

The Spacelab 3 mission undoubtedly will produce immediate discoveries, but full analysis of all returned data may take several years. Within this mass of data, the potential exists for quantum leaps in our knowledge and practical benefits on Earth.

## Recycling Equipment

A unique advantage of Spacelab is that the laboratory, the experiment facilities, and many of the individual instruments are designed to be reused on other missions. The module and its subsystems, airlock, video recorders, and other equipment for this mission were previously used on Spacelab 1. Two scientific instruments from Spacelab 1 are being flown again on this mission, and the experiment facilities being introduced on Spacelab 3 will be recycled for future flights.

After this mission, the Spacelab hardware will be dismantled, inspected and, if necessary, repaired or modified. Some components may be required immediately for other Spacelab missions; others will be placed in inventory for future use. ■



*Scientists in the Payload Operations Control Center monitor their experiments and talk to the crew as experiments are performed in space.*

*The mission management team works in the Payload Operations Control Center during the mission.*

# SPACELAB 3 CREW

The seven-member Spacelab 3 crew is the largest group ever to fly on a NASA mission. While working together as a flight team, the crew members have different roles and responsibilities.

The operation of the Shuttle is the primary responsibility of the commander and pilot, who are members of the astronaut corps. ROBERT OVERMYER is commander of the Spacelab 3 mission. A veteran Air Force pilot, Overmyer has 15 years of astronaut experience and served as pilot for the fifth Shuttle mission. The commander is responsible for overseeing the entire mission and returning the crew safely home. FREDERICK GREGORY, on his first space mission, is the pilot. He alternates duty with Overmyer in 12-hour shifts. Gregory has served as a NASA test pilot for eight years and has six years of astronaut experience.

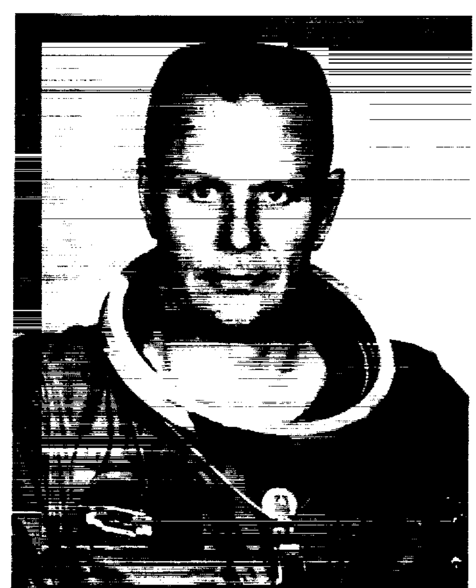
Five members of the Spacelab 3 crew have scientific assignments. Of these, two payload specialists are professional scientists on temporary leave from their own laboratories to operate experiments in space. Three mission specialists are career astronauts with scientific expertise who are trained to work as engineers on Shuttle and Spacelab systems or to work as scientists performing experiments.

These science crew members were chosen for their diverse backgrounds. The payload specialists for this mission were specifically selected for their expertise in materials science and fluid mechanics. The mission specialists were selected both for their engineering skills and their scientific backgrounds in the fields of life sciences and physics.

To shorten training time, the payload specialists and mission specialists are not fully cross-trained to do all the scheduled scientific investigations. Instead, the members of the science crew have primary and secondary assignments. Each person is fully trained to conduct some investigations but is merely "oriented" to the operations of others. Responsibility for each experiment is delegated to a prime crew member and a backup. Each scientist is fully trained to do every investigation in his or her own field of expertise.

## Payload Specialists

Payload specialists conduct the major share of investigations scheduled for a particular mission. After the mission, they return to their positions in laboratories elsewhere to



*Robert Overmyer, Commander*

resume their own research. Since the Spacelab 3 payload specialists were chosen for their unique qualifications in materials science and fluid mechanics, they are already familiar with some of the experiments. They have a shorter training period and spend less time away from their usual work than previous Spacelab payload specialists.

Four scientists are trained to be Spacelab 3 payload specialists. One of them is a principal investigator and two are co-investigators for experiments. All have conducted experiments related to the Spacelab 3 experiments in ground-based laboratories and on NASA's research aircraft, a plane that achieves the effect of zero-gravity for 15 to 20 second intervals during parabolic, roller coaster flight patterns. They also have tested equipment concepts and automated experiments aboard small rockets, which spend approximately five minutes in low-gravity before returning to Earth.

Spacelab offers these scientists a quiet, stable environment where they can continue their research over a period of days instead of minutes. They have a unique opportunity to do experiments in space where they can observe details of crystal growth or fluid behavior, interpret small changes, and take action if necessary. After years of experience on Earth, spaceflight is the next logical step in their careers. They also perform experiments developed and supplied by other scientists, the principal investigators for the mission.

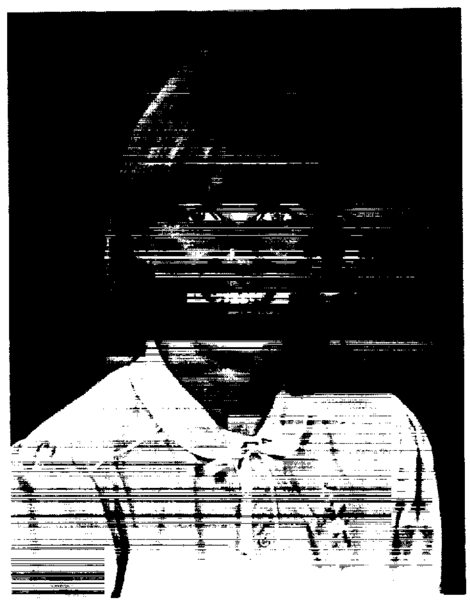
Before launch, the principal investigators will select one materials science payload specialist and one fluid mechanics payload specialist to fly aboard Spacelab 3. The other two payload specialists serve as alternates if a member of the flight crew is unable to fly for some reason. During the mission, the alternate payload specialists work in the Payload Operations Control Center in Houston, where they communicate with the flight crew and provide essential support to the mission management and science teams on the ground.

***Frederick Gregory, Pilot***

## Materials Science Payload Specialists

DR. MARY HELEN JOHNSTON is one of two materials science experts training for the position of Spacelab 3 payload specialist. She earned a Ph.D. in metallurgical engineering from the University of Florida and for almost 20 years has worked in the Materials and Processes Laboratory at the Marshall Space Flight Center, where she is responsible for research in crystal growth and metal alloys for the Materials Processing in Space program and the Space Shuttle program. Dr. Johnston conducted a comprehensive body of research on single crystal growth using a new technique that she developed in ground-based laboratories and in the low-gravity environment attained by small rockets and research aircraft. She has logged approximately 25 hours in low-gravity aboard NASA's research aircraft. She also participated in a five-day simulated space mission to test materials science hardware concepts for Spacelab missions.

DR. LODEWIJK VAN DEN BERG is an authority on the vapor growth technique for producing mercuric iodide crystals. He earned a Ph.D. in applied science from the University of Delaware and is currently employed by EG&G Energy Measurements, Inc. in Goleta, California, where he is responsible for a 20-furnace crystal growth facility similar to the Vapor Crystal Growth System on Spacelab 3. Dr. van den Berg is a co-investigator for the Vapor Crystal Growth System experiment, and he has participated in design and science reviews for both this system and the Fluid Experiment System to be introduced during the Spacelab 3 mission. Dr. van den Berg also has participated in low-gravity tests of Spacelab 3 experiments aboard NASA's research aircraft.



***Dr. Mary Helen Johnston, Payload Specialist***

***Dr. Lodewijk van den Berg, Payload Specialist***

## Fluid Mechanics Payload Specialists

DR. TAYLOR WANG is both a principal investigator for a Spacelab 3 experiment and a payload specialist. He invented the acoustic levitation and manipulation chamber in the Drop Dynamics Module for investigation of fluid behavior in space. Dr. Wang has a Ph.D. in physics from the University of California and currently manages materials processing in space programs at the NASA-Jet Propulsion Laboratory, where he is responsible for the development of containerless processing. Since 1976, Dr. Wang has successfully tested containerless processing technology and drop dynamics research in a series of rocket flights. He has logged approximately 30 hours in weightlessness aboard NASA's research aircraft to define the experimental parameters and procedures for the Spacelab 3 drop dynamics investigation.

DR. EUGENE H. TRINH is a research scientist at the NASA-Jet Propulsion Laboratory, where he is involved in both experimental and theoretical studies in fluid mechanics and acoustics. He is a co-investigator for the Drop Dynamics Module investigation, and he has performed many fluid mechanics experiments in ground-based laboratories and in low-gravity aboard NASA's research aircraft. Dr. Trinh has effectively used acoustical levitation to study the behavior of free drops, and he holds three patents on levitation devices. His Ph.D. in applied physics is from Yale University, where he used acoustical levitation techniques to examine the physics of liquids.

*Dr. Taylor Wang, Payload Specialist*

*Dr. Eugene Trinh, Payload Specialist*

## Mission Specialists

Mission specialists fill two roles on a Spacelab mission. As career astronauts, they are qualified to operate some Shuttle systems and are responsible for operating and servicing Spacelab systems. As specialists in a scientific field, they also collaborate with payload specialists and principal investigators to conduct experiments.

Three mission specialists, one with expertise in space physics and two in biomedical science, are participating in the Spacelab 3 mission. The physicist alternates 12-hour shifts with the materials science payload specialist to ensure that delicate crystal growth experiments are monitored, and he is in charge of an auroral investigation that he helped develop. The two medical doctors alternate 12-hour shifts to monitor the Ames Research Center Life Sciences Payload, which consists of a Research Animal Holding Facility that accommodates and electronically monitors monkeys and rats. All three mission specialists share responsibility for the other experiments with the rest of the crew.

DR. DON LIND has a broad background in space physics and received a Ph.D. in high-energy physics from the University of California, Berkeley. Before his selection as an astronaut, he worked at NASA's Goddard Space Flight Center as a space physicist. He has 20 years of NASA experience and helped develop science payloads for early Shuttle missions. A co-investigator for the Auroral Imaging experiment, Dr. Lind gained considerable first-hand experience in observing auroras during a year-long residence in Alaska.


*Dr. Don Lind, Mission Specialist*

DR. NORMAN THAGARD has an M.S. in engineering science from Florida State University and an M.D. from the University of Texas Southwestern Medical School. He has six years of NASA experience as a scientist, airplane pilot, and engineer, and he has designed and developed several biomedical instruments. Dr. Thagard served as a mission specialist on the seventh Shuttle mission, collecting data on physiological changes associated with human adaptation to space.

DR. WILLIAM THORNTON has a B.S. in physics and an M.D. from the University of North Carolina. He has approximately 20 years of NASA experience as a scientist, airplane pilot, and engineer, and he has been a principal investigator for life science experiments on previous Shuttle and Skylab missions. Responsible for maintenance of crew condition during Shuttle flights, Dr. Thornton developed the Shuttle treadmill for in-flight exercises. Holding 50 patents, he has designed and developed several biomedical instruments. As a mission specialist on the eighth Shuttle mission, he monitored the crew's physiological adaptation to weightlessness. ■


***Dr. Norman Thagard, Mission Specialist***

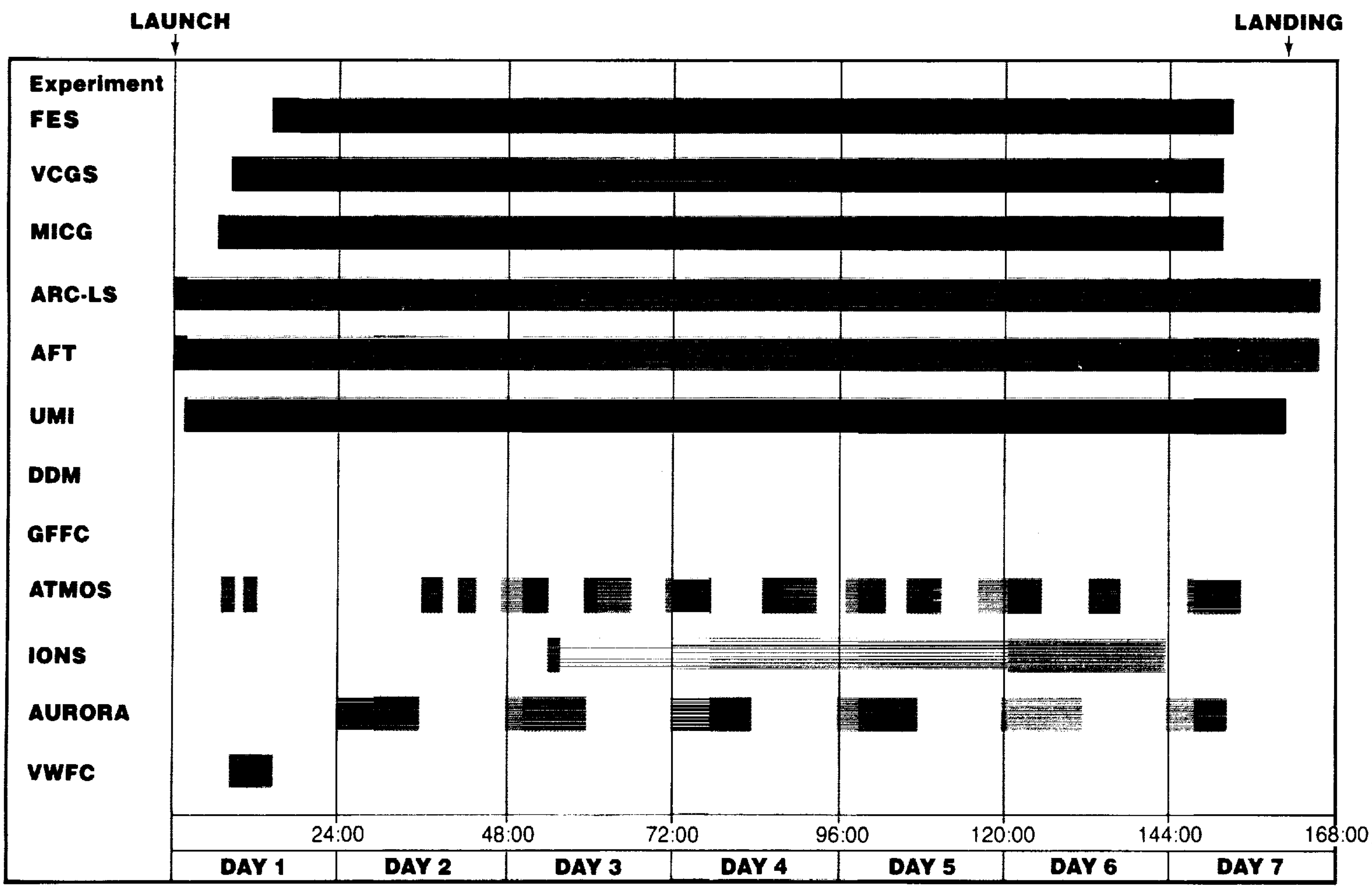

***Dr. William Thornton, Mission Specialist***

# SCIENTIFIC INVESTIGATIONS

Spacelab 3 is a laboratory and observatory for 15 investigations in 5 scientific disciplines: materials science, life sciences, fluid mechanics, atmospheric science, and astronomy. On this mission several major new facilities will be introduced for verification and initial experimental use. Over the next decade, routine use of this remarkable laboratory will greatly expand the capability to do science in space.

Various specific results are expected from individual scientific investigations. The following summaries include the purpose, importance, and method for each Spacelab 3 investigation (some of which involve several experiments). The official investigation name, the principal investigator's name and affiliation, and the co-investigators' names and affiliations are given for each investigation.

Two of the investigations, one in materials science and one in astronomy, have already flown aboard Spacelab 1. Many of the Spacelab 3 investigations are scheduled to be modified and reflown on later missions to further explore the discoveries of this mission.



# Materials Science

The history and progress of civilization go hand-in-hand with advances in materials science and technology. The intrinsic purpose of materials science is to understand the structure and properties of materials, with a view toward practical applications of this knowledge. Then, processing techniques can be controlled to produce improved crystals, alloys, glass, plastics, and other materials. As better materials become available, unforeseen new applications spur growth in high technology. The communications and information industries, for example, continue to leap ahead with advances in solid-state electronics and miniaturization. Better understanding of materials expands the limits of their performance to meet our changing needs.

Spacelab offers unique advantages for materials science research. Primarily, it serves as a microgravity facility where processes can be studied and materials produced without the interference of gravity. It is not possible to sustain a comparable microgravity environment on Earth.

Normally, gravity dominates the behavior of fluids, with undesirable effects on the quality of materials. For example, imperfections result from convection, or circulation, of fluid solutions from which industrial crystals are formed. These defects impair the performance of the crystals as radiation sensors or electronic components. Because convection and buoyancy effects are essentially eliminated in space, it should be possible to produce more nearly perfect materials there. If so, improved products with properties currently unattainable on Earth may someday be manufactured in space.

It should also be possible to study subtle effects, such as diffusion, that are normally masked by gravity during materials processing on Earth. Some crystals produced by diffusion processes are so weak at their growth temperatures that, on Earth, they deform under the strain of their own weight. In space, such gravity-induced stress is negligible, so structural defects in crystals produced there should be minimal.

Spacelab also offers the advantage of a manned laboratory in which delicate operations can be performed by experienced, professional scientists. Although materials processing is to some extent automated, a skilled, participating eye-witness is invaluable. This specialist can watch an experiment closely to control the variables, fine tune operations, record and interpret data, make decisions, and coax the maximum scientific yield from an investigation. Moreover, the spaceborne scientist may observe phenomena never before seen and capitalize on these exciting opportunities for discovery.

Materials science is a major thrust of the Spacelab 3 mission. Three investigations are scheduled to be performed by the payload specialist whose expertise is in crystal growth. Two special facilities, the Fluid Experiment System and the Vapor Crystal Growth System, have been developed specifically for these investigations. These systems are designed to be multi-user facilities capable of supporting different experiments on other Spacelab missions. The third investigation, Mercury Iodide Crystal Growth, is a reflight of a Spacelab 1 experiment with modified hardware and procedures.

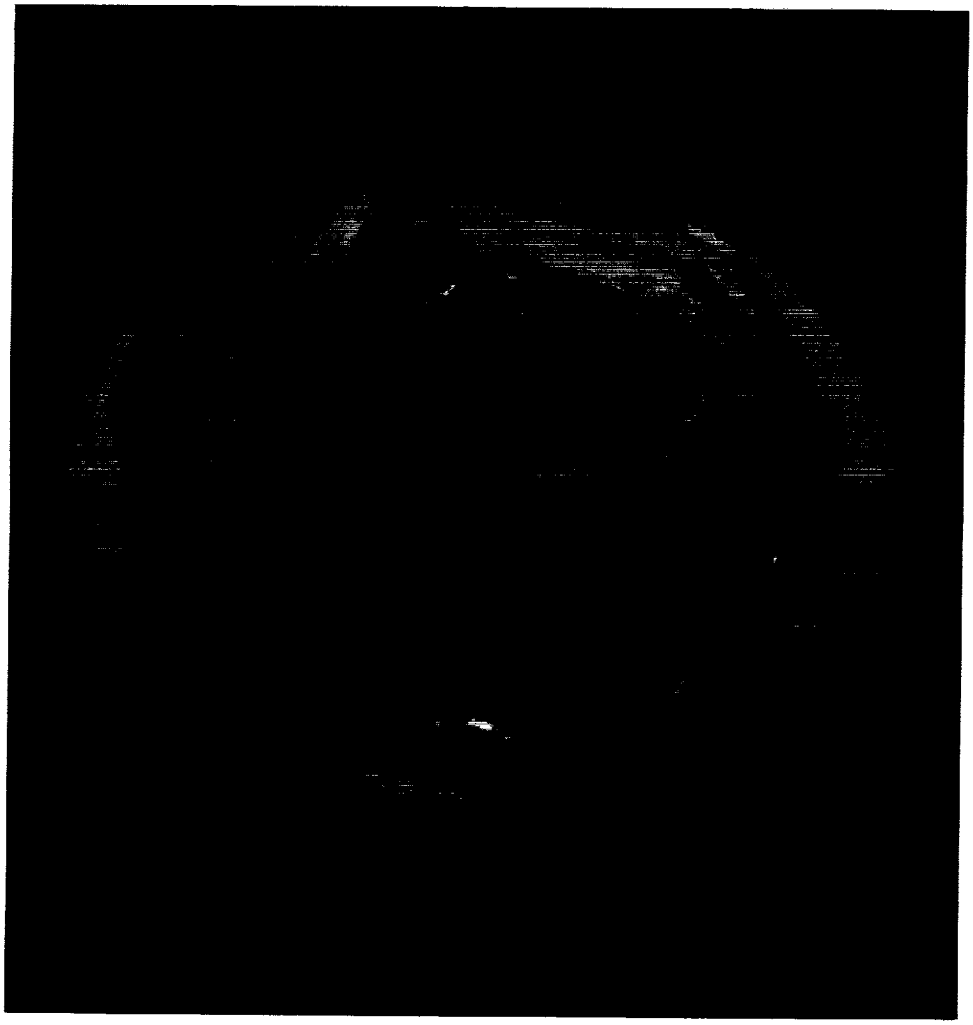
*Crystals grown in microgravity during the Spacelab 3 mission will be compared to similar crystals grown on Earth. This mercuric iodide crystal was produced during a ground test of the Vapor Crystal Growth System.*

# Solution Growth of Crystals in Zero-Gravity

## Fluid Experiment System

**Dr. Ravindra B. Lal**
**Department of Physics and Applied Physics**
**Alabama A&M University**
**Huntsville, Alabama**

***Purpose:*** In this investigation, triglycine sulfate crystals are produced from a liquid by a low-temperature solution growth technique. The goals of the investigation are to develop a technique for solution crystal growth in space, to define the orbital environment and its influence on crystal growth, and to evaluate the properties of the resultant crystal.



*Triglycine sulfate crystal produced during a ground test of the Fluid Experiment System*

***Importance:*** Triglycine sulfate is an important infrared detector material with theoretically predicted high performance. Unlike most other high-performance detectors which require very low operating temperatures (hence, cooling systems), detectors made of triglycine sulfate can operate at ambient temperatures. This property is an advantage for the cost-effective design and use of infrared detection devices. There are many uses for improved infrared detectors in military systems, astronomical telescopes, Earth observation cameras, and environmental analysis monitors.

To date, the actual performance of triglycine sulfate has not met expectations, probably because the processing technique does not produce crystals of sufficiently good quality. On Earth, gravity causes convective flows in the liquid in which crystals are formed. The resultant crystals often have microscopic defects that affect their electrical and optical performance. Various laboratories in the United States and abroad are working to improve the quality of triglycine sulfate crystals.

It may be possible to produce more nearly perfect crystals in space without the interference of gravity-induced convection. If these crystals perform better, the technological impact will be significant, not only for infrared detectors but also for the production of other materials by the same technique.

***Method:*** Single crystals of triglycine sulfate will be grown in specially designed cells in the Fluid Experiment System, a facility mounted in a double rack inside the Spacelab module. The system includes growth cells, an elaborate optical monitoring assembly, a control panel, and associated electrical hardware.

Before launch, the growth cells will be filled with about one liter of high-purity crystal growth solution. A small disc-shaped seed crystal of triglycine sulfate attached to a sting, a heat extraction device sometimes called a "cold finger," will be stored in the cell. Each seed crystal is 1 to 1.5 centimeters (about one-half inch) in diameter. The seed crystal temperature will be maintained below 45°C (113°F), and there will be no contact between the seed and the growth fluid. These cells will be stowed until Spacelab experiment operations begin on orbit.

To form a crystal from solution, the growth solution is heated and then allowed to cool to a desired temperature. Heat is removed from the seed crystal in a carefully controlled manner to initiate growth as the solution solidifies on the seed. The slow but very uniform growth in thickness (about 1 millimeter per day) should result in a high degree of crystal perfection.

Three runs are scheduled; two last 24

hours and should produce about a 2 millimeter thick (0.08 inch) crystal; one lasts 48 hours to produce a crystal about 4 millimeters (0.16 inch) thick. Each run will follow essentially the same procedure but parameters such as the temperature and concentration of the solution, or the size and orientation of the seed crystal, will differ.

As a crystal grows, the process will be recorded by a holographic (three-dimensional imaging) laser optical system that reveals variations in the density and temperature of the transparent triglycine sulfate solution. When the three-dimensional images are reconstructed and photographed after the mission, analysts can determine more precisely what happens at a given time in the course of crystal growth. In-flight video recordings will permit scientists in Spacelab and on the ground to watch and record, for the first time, the crystal growth sequence in space.

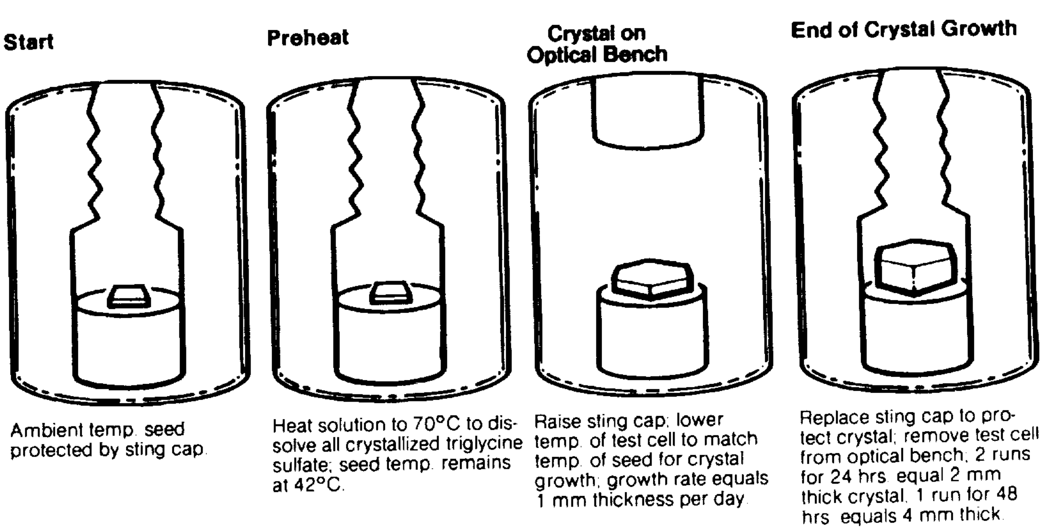
The payload specialist will be in voice contact with investigators on the ground periodically during the operation to report observations and make adjustments as necessary. The specialist is responsible for setting up, activating and monitoring the experiment, aligning the optical system, changing film, stowing samples, and deactivating the experiment. A stable vehicle attitude that minimizes fluid motion around the crystal must be maintained for the duration of crystal growth operations.

After the mission, the specimen crystals will be returned to the investigators' laboratories for extensive analysis of crystalline structure and properties, including their capability for infrared detection. The space-grown crystals will be compared with crystals grown by the same technique on the ground and with commercially available triglycine sulfate crystals. Flight data will be evaluated to assess the effectiveness of this crystal growth technique and of the Fluid Experiment System before they are used again on future missions.

Dr. Roger L. Kroes of the Space Science Laboratory at NASA-Marshall Space Flight Center is a co-investigator for this experiment.

*This image is reconstructed from a hologram made inside the Fluid Experiment System during ground tests. The wavy lines around the crystal are convective currents that indicate variations in the density and temperature of the growth solution.*

*Principal investigator Dr. Ravindra Lal (right) and co-investigator Dr. Roger Kroes (left) examine the Fluid Experiment System.*




*Crystal growth process in the Fluid Experiment System*

# Mercuric Iodide Growth
## Vapor Crystal Growth System

**Wayne F. Schnepple**
**EG&G Energy Measurements, Inc.**
**Goleta, California**

***Purpose:*** The aims of this investigation are to grow more nearly perfect single crystals of mercuric iodide and to gain improved understanding of crystal growth by a vapor process.

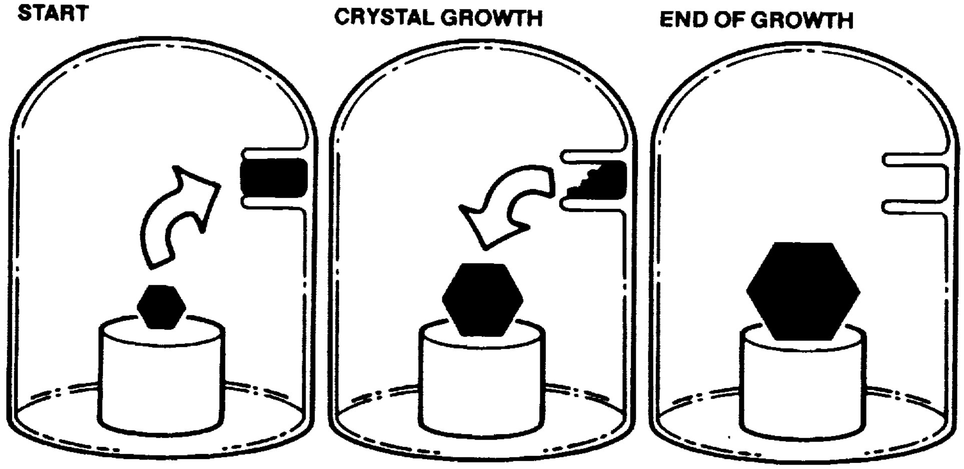
*Principal investigator Wayne Schnepple watches as Dr. Lodewijk van den Berg, payload specialist and co-investigator, looks through a microscope into the Vapor Crystal Growth System furnace.*

***Importance:*** Mercuric iodide crystals have practical use as sensitive X-ray and gamma-ray detectors. In addition to their high-performance electronic properties, these crystals can operate well at room temperature rather than at the extremely low temperature usually required by other materials. Because a bulky cryogenic cooling system is unnecessary, mercuric iodide crystals could be useful in portable detector devices for nuclear power plant monitoring, natural resource prospecting, biomedical applications in both diagnosis and therapy, and in astronomical instruments.

Although mercuric iodide seems to have greater potential performance than existing technology, its actual performance does not yet meet expectations. It is suspected that problems in the growth process cause defects in the crystals. Unstable convective flow in the vapor, for example, may cause a crystal to grow unevenly. Furthermore, mercuric iodide has a fragile structure that can be deformed during growth by the stress of the crystal's own weight.

Scientists believe that it will be possible to control the crystal growth process better in microgravity and produce large single crystals with few defects. When gravity-related convection is minimized, variations in the vapor transport should be reduced. Movement of the vapor will then occur mainly by diffusion or by Stefan Flow (a regular displacement caused by evaporation at the source and condensation at the seed crystal). Strain deformities caused by the crystal's own weight also should be minimized in microgravity. Improvements in the crystals should result in higher yield and more feasible applications for detector devices.

***Method:*** The technique to be used is crystal growth by solidification from a vapor. Source material and a seed crystal are enclosed in a sealed container, called an ampoule, inside a furnace. When the ampoule is heated, the material sublimes and spreads through the chamber. The seed crystal is maintained at a




*Crystal growth process in the Vapor Crystal Growth System* lower temperature, so the vapor condenses onto the seed. The condensing vapor molecules follow the structure of the 2 to 3 millimeter (0.08 to 0.12 inch) seed to produce a larger, uniform crystal.

A special Vapor Crystal Growth System was designed for use on Spacelab 3 and subsequent missions. It introduces several refinements of the vapor growth process to minimize the causes of crystalline defects. The ampoule is evenly heated to 100 to 110 °C (212 to 230 °F) by a helical coil wound symmetrically around it. The seed crystal is thermally coupled to a sting, a device that conducts heat away. The sting is maintained at a desired cooler temperature of 40°C (104°F).

Crew members can control seed crystal growth by adjusting the temperature of the sting. If they see undesirable growths forming on the surface of the main crystal, the crew members can eliminate them by raising the sting temperature. Normal crystal growth resumes when the sting temperature is lowered. Scientists hope to grow a single crystal with a volume of about 1 cubic centimeter (0.06 cubic inches) by this technique. Careful monitoring and delicate adjustments are essential to the success of this operation.

The vapor crystal growth sequence of heat-up, growth, and cool-down is controlled by a microprocessor. The payload specialist is responsible for making periodic observations of the sample, checking process variables, adjusting operations as required, measuring crystal growth rates, and properly stowing the crystal for landing. The specialist can view the growing crystal through a microscope mounted on the front panel of the furnace assembly and can discuss operations with the principal investigator on the ground. Engineering data are downlinked, and experiment data are tape recorded on board for postflight analysis on the ground. Real-time television downlink is scheduled for critical periods in the long growth process. The heat-up phase requires 4 hours, and cool-down requires about 10 hours; the crystal growth period lasts 110 hours (4½ days). Such slow growth is conducive to the production of large single crystals.

After landing, the space-grown crystal will be compared to the best sample crystals grown by identical techniques on the ground. Scientists will be interested in the comparative structural imperfections, electronic properties, and detector response of the crystals. They will also glean valuable information about the vapor growth process and apparatus. The technique being tried on Spacelab 3 is innovative; evaluation of the method and the hardware may lead to further refinements for subsequent crystal growth experiments in space and on the ground. If space-grown crystals prove to be of significantly better quality than crystals produced on the ground, the next step may be a production facility in space.

Co-investigators for this experiment from EG&G, Inc. in Goleta, California, are payload specialist Dr. Lodewijk van den Berg and Dr. Michael M. Schieber.

## Mercury Iodide Crystal Growth

**Robert Cadoret**
**Laboratoire de Cristallographie et de Physique**
**Les Cezeaux, France**

***Purpose:*** In this investigation nearly perfect single crystals of mercury iodide will be grown at different pressures to analyze the effects of weightlessness on vapor transport.

***Importance:*** High-quality mercury iodide crystals are very sensitive X-ray and gamma ray detectors that operate well at room temperature. Since comparable high-performance detector materials require extremely low operating temperatures, mercury iodide is an attractive material for a variety of uses in science and industry.

A standard technique for producing these crystals is by solidification from a vapor under carefully controlled growth conditions. In a closed container, vapor from a heated source material moves by slow convection and condenses upon a cooler seed crystal to produce a larger crystal. Crystal quality depends on constant temperature, growth rate, and vapor transport conditions.

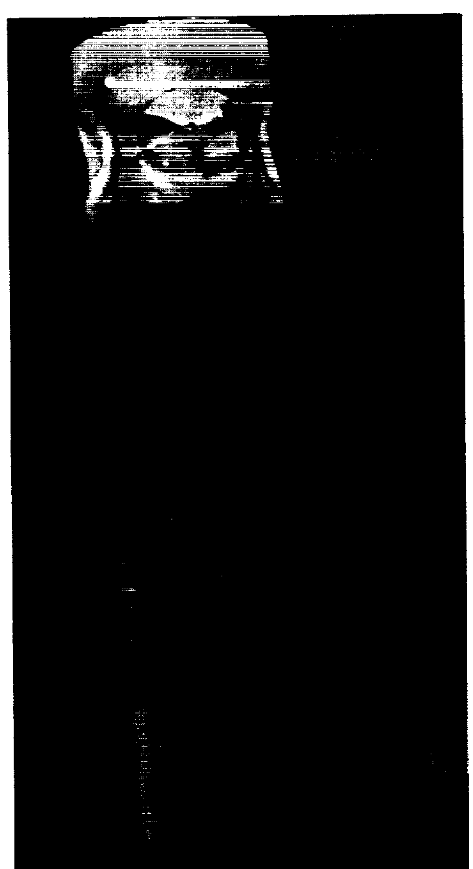
It is difficult to produce sufficiently high-quality crystals on Earth because small variations in pressure during the growth process create defects that impair the electronic performance of the crystals. These variations may be induced by gravity. Scientists are interested in understanding the effects of gravity on vapor transport so they can learn to control crystal growth conditions and thus control crystal quality. The practical result of this knowledge will be the production of improved materials for use as radiation detectors.

***Method:*** Evaporation and condensation will occur within ampoule cartridges in a two-zone furnace having different temperatures at each end. The experiment apparatus includes two heat pipe furnaces, each holding three cartridges, and six ampoule cartridges enclosing mercury iodide seed crystals and source material.

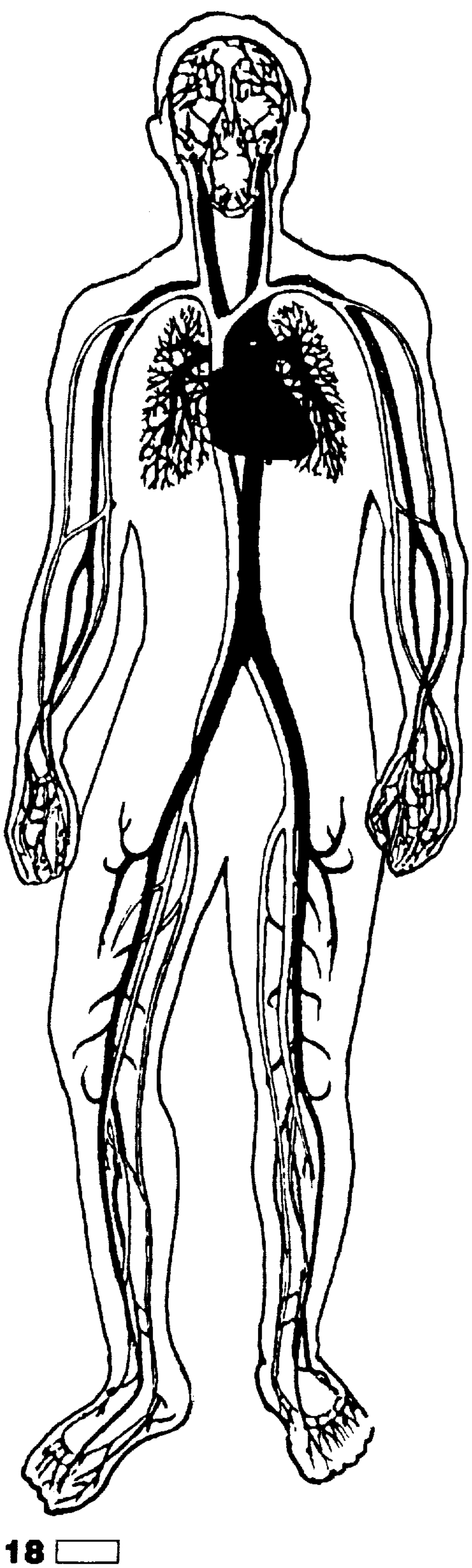
The normal sequence of this experiment is controlled by the Spacelab experiment computer. Crew members change cartridges and reprogram the experiment as necessary. During the two 70-hour operations, the computer monitors the power supply status and the temperature difference between the two zones of the oven. Signals alert the crew to intervene if either parameter is out-of-limits.

A similar experiment developed by the same principal investigator was accomplished during the Spacelab 1 mission. For Spacelab 3, the samples will be subjected to different temperatures and growth conditions, for comparison with the crystals previously grown. Reflight of the investigation demonstrates the capability of changing and repeating experiments on successive Spacelab missions. In this way, scientists can respond fairly rapidly to experimental results from research in space.

The co-investigator for this experiment is Dr. Pierre Brisson of the Laboratoire de Cristallographie et de Physique.



*These mercury iodide crystals were grown during the Spacelab 1 mission. A modified version of this experiment will be performed during the Spacelab 3 mission.*



# Life Sciences

As people live and work in orbit, their bodies respond in various ways to the space environment. Understanding the physiological changes during human adaptation to weightlessness is a major challenge in the biomedical sciences.

The common goal of the medical and biological investigations aboard Spacelab 3 is to gain knowledge about the functioning of basic life processes. Spacelab is a workshop where humans and animals can be studied under conditions that cannot be simulated on Earth. Investigations here may result in new information that will extend our basic knowledge of biology and also ensure the health, safety and optimal performance of humans in space.

Spacelab 3 carries a contingent of animals living in new housing facilities designed by the NASA Ames Research Center. Engineering tests of the Research Animal Holding Facility are scheduled, as well as continuous monitoring of the animals' physiological and behavioral reactions to the space environment.

In two other investigations, the crew serves as experimental subjects. One investigation, Autogenic Feedback Training, explores the ability of crew members to control space sickness by using biofeedback techniques. Another, the Urine Monitoring Investigation, uses a new system to collect and measure crew urine samples, which can be analyzed to determine changes in human body fluids during weightlessness.

The Spacelab 3 results will contribute to the extensive life sciences studies planned for Spacelab 4, the first mission dedicated to one discipline. Results of verification tests performed on the Research Animal Holding Facility will be useful in preparing it for further animal studies on future Spacelab missions. The Spacelab 3 life science investigations will provide practical information about using the orbital environment to advance knowledge in medicine and biology.

## Ames Research Center Life Sciences Payload

**Dr. Paul X. Callahan**
**Dr. John W. Tremor**
**NASA-Ames Research Center**
**Moffett Field, California**

The need for suitable animal housing to support research in space led to the development of the Research Animal Holding Facility at the Ames Research Center. The major life science objective of this mission is to perform engineering tests on two new facilities: the rodent animal holding facility and the primate animal holding facility. In addition, scientists will observe the animals to obtain first-hand knowledge of the effects of launch and reentry stresses and weightlessness on animal physiology and behavior. Two other electronic systems in the Ames Research Center Payload will also be tested; the Biotelemetry System for measuring the physiological functions of the animals, and the Dynamic Environment Measurement System for monitoring noise, vibration, and acceleration in the immediate vicinity of the animal holding facility during ascent and reentry.

### Research Animal Holding Facility Verification Test

***Purpose:*** The objectives of the Ames life sciences investigations are to perform engineering tests to ensure that the Research Animal Holding Facility is a safe and adequate facility for housing and studying animals in the space environment; to observe the animals' reactions to the space environment; and to evaluate the operations and procedures for in-flight animal care.

***Importance:*** Scientists often study animals to find clues to human physiology and behavior. Rats, insects, and microorganisms have already been studied aboard the Shuttle on previous missions. On Spacelab 3 scientists will have a chance to observe a large number of animals living in space in a specially designed and independently controlled housing facility.

Several ground tests of the facility have been performed, but it is impossible to simulate the stress of launch and reentry or the condition of orbital weightlessness. During the Spacelab 3 mission, scientists and engineers will be able to study the facility under actual flight conditions to determine whether there are any peculiarities of spaceflight operations that affect its capability to accommodate animal specimens. This engineering evaluation will give investigators time to change the operating procedures, if necessary, before more extensive experiments are conducted on future missions.

While evaluating the new facility, the scientists can also study, in a preliminary but controlled manner, the animals' reactions to the space environment. Humans typically experience some mild physical problems, such as space sickness, mineral loss, and redistribution of body fluids, during adaptation to space. By electronically monitoring and observing the physical characteristics of the Spacelab 3 animals, scientists may be able to determine if animals, like humans, experience some of these adaptation problems. Monkeys and rats are commonly used as laboratory animals, and their behavior and physical condition in space can be compared to their behavior and physical condition on Earth. Data collected during this spaceflight may suggest useful scientific areas to probe on future missions and may aid in the design of future experiments and flight equipment.

***Method:*** Housing in modular, removable cages is available for animals ranging in size from rodents to small primates. For the Spacelab 3 mission, 4 squirrel monkeys will be housed in individual cages in a primate Research Animal Holding Facility and 24 rats will be housed in individual cages in a rodent Research Animal Holding Facility. Food and water will be dispensed automatically on animal demand, and waste will be directed by air flow into absorbent trays beneath the cages. Periodically, crew members will replace food in the dispensers and remove the easily accessible waste trays, replacing them with clean ones. These procedures will be recorded on video tape. Using the Spacelab computer, the crew will monitor food and water consumption to ensure that the animals are well-nourished. Caution and warning indicators on the control panel will inform the crew of any malfunctions, such as a water leak in a cage.

There are no plans for the crew to handle the animals. However, both Thornton and Thagard, who are medical doctors, have received veterinary training and will be able to care for the animals, particularly the monkeys, in the event of illness or injury. A veterinarian kit to support the Ames payload will be carried in a stowage locker. Through windows on the front of the cages, the crew will routinely observe each rat and monkey and will describe any abnormalities in their activity, posture, coat, skin or breathing patterns to a veterinarian on the ground. All descriptions will be recorded in a log book for later reference. The animals will be observed before, during, and after the mission for comparative analysis.

The crew also will evaluate the use of a soft jacket to be worn by two of the squirrel monkeys. The jacket helps the monkey maintain orientation in the cage and supplies a comfortable restraint during weightlessness. Side loops on the jacket ride on vertical rails in the cage, allowing the monkey some free movement but preventing it from floating about in the weightless environment. The other two monkeys can be temporarily restrained, if necessary, by a back wall that can be moved forward by a crew member to position the animal in the front of the cage. These techniques may be used in later missions to gain access to the animals without removing them from their cages.

In addition to the crew's observations, electronic systems will monitor the holding facility and the animals. Cage temperature, humidity, water pressure, and other housekeeping parameters will be measured continuously. As the animals move, they will break a light beam, and special photocell sensors in the cage walls will record their daily movement patterns. Four rats will be photographed intermittently by a 16 millimeter camera-mirror system to record their responses to launch, weightlessness, and reentry; video tapes of the monkeys will be made at various times.

A Biotelemetry System, which monitors the output of sensors surgically implanted in some of the animals before flight, will measure basic physiological functions, such as heart rate, muscle activity and body temperature. Four of the rats and the four monkeys will have these wireless sensors, which permit normal movement and behavior. Data will be sent via a dedicated computer directly to scientists on the ground who monitor the animals' well being.

A Dynamic Environment Measurement System will measure noise, vibration and acceleration in the immediate vicinity of the Research Animal Holding Facility during launch and reentry. This information is useful for experiments in which external environmental factors must be taken into account in experiment design and interpretation of data. Environmental measurements will be recorded on magnetic tapes. The data will be analyzed after the mission to interpret animal response to spaceflight and to evaluate the performance of the new flight hardware.

*Ames Research Center project scientist Dr. John W. Tremor (left) and project manager Dr. Paul X. Callahan (right) examine a feeder device used in the Research Animal Holding Facility.*

*The Research Animal Holding Facility: rodent facility (left), primate facility (right)*

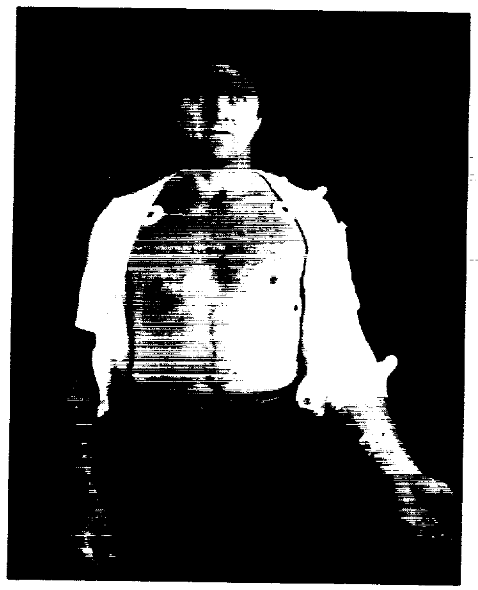
# Autogenic Feedback Training

**Dr. Pat Cowings**
**NASA-Ames Research Center**
**Moffett Field, California**

***Purpose:*** This investigation tests a treatment for space adaptation syndrome (space motion sickness) and a technique for training people to control bodily processes voluntarily.

***Importance:*** About half of all spaceflight crew members experience some discomfort while adapting to the space environment. Symptoms of space adaptation syndrome range from mild discomfort, such as sweating or pallor, to nausea. The symptoms usually appear early in a mission and gradually disappear in two to four days; meanwhile, the ability of a crew member to carry out scheduled tasks may be affected.

Many experiments have been performed on previous missions to determine the causes of discomfort during adaptation to space. This experiment ignores the causes and examines the physical responses to adaptation. Autogenic feedback training, a form of biofeedback, has been used in laboratory testing on the ground and has proven successful in helping people control motion sickness. If astronauts can learn to control the symptoms of motion sickness in preflight training sessions on Earth, they may be able to apply this training to control discomfort in space.



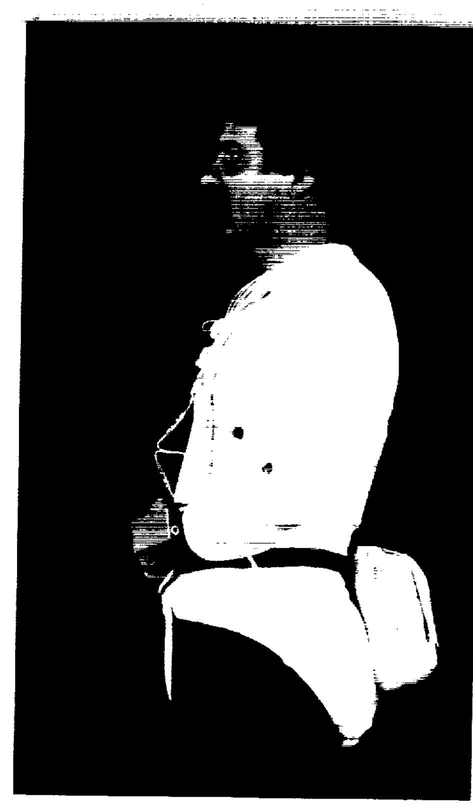
*The Autogenic Feedback Training electrodes, beltpack recorder, and wrist display unit will help crew members monitor body functions.*

In 10 years of laboratory research by the principal investigator, 75 percent of the test subjects have learned to control Earth motion sickness in 6 hours of training; the other 25 percent learned after a slightly longer training period. The Spacelab 3 crew will receive five hours of training, in half-hour periods, over several weeks. In addition to formal training sessions in a laboratory, the crew members will practice on their own.

***Method:*** This investigation consists of two major activities: preflight training in recognizing and controlling the symptoms of Earth motion sickness and in-flight attempts to control the symptoms of space motion sickness. Both payload specialists and one mission specialist will participate in the experiment as the treatment group and will have preflight training. The two other mission specialists will serve as a control group. They will not receive preflight training but will wear monitors during flight so their physical responses can be compared to those of the treatment group.

During training, electronic monitors display the body's reactions as the crew member is exposed to motion sickness stimuli. The trainee first learns to recognize physical responses to motion sickness and then tries to control them by biofeedback techniques. For example, if a display indicates hyperventilation, the trainee takes slow, deep breaths to alleviate the symptoms. Eventually, the crew member should learn to perceive body sensations and automatically control them without interrupting work.

During flight, an undergarment with elec-



trodes that attach to the chest, arm, and finger will be worn to measure heart rate, respiration rate and volume, basal skin response (sweat), and blood volume pulse. These physiological data will be displayed on a small monitor worn on the wrist; the data will be recorded on a medical cassette recorder worn on a belt outside the crew member's clothing. A tiny accelerometer worn on the head will measure head and body movement, which seems to be associated with space motion sickness discomfort.

Upon waking, participating crew members will don the equipment and check their physiological responses. This is all the control group will do, but the treatment group will go one step further. On a checklist, they will rate nine symptoms, such as pallor, stomach awareness and nausea, from mild to moderate to severe. This checklist can be compared to the physiological data to correlate specific symptoms with specific body functions.

If any discomfort should occur, the crew member will record the symptoms and try to control them mentally. The subject's physiological functions will be recorded continuously during each 12-hour work shift. All equipment except the chest electrodes will be removed before sleep.

This experiment may be reflown to gain larger treatment and control groups for comparative analysis. Co-investigators in this research are Dr. Joe Kamiya and Mr. William Toscano of the University of California at San Fransisco; Dr. Neal Miller of the Rockefeller University; and Dr. Joe Sharp of the NASA-Ames Research Center.

## Urine Monitoring Investigation


### Dr. Howard Schneider
### NASA-Johnson Space Center
### Houston, Texas

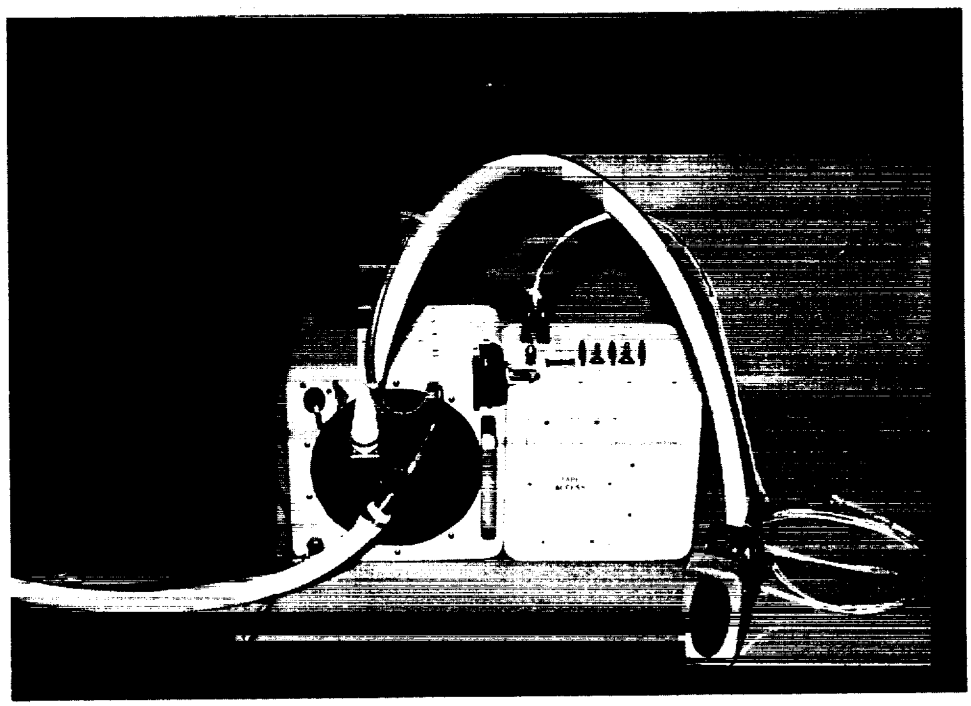

***Purpose:*** The goals of this investigation are to verify that the Urine Monitoring System works correctly; to test a system for preparing urine samples for postflight analysis; and to develop a procedure for monitoring crew water intake.

***Importance:*** Scientists and physicians regularly analyze urine samples to determine the chemical content of the human body and reach certain conclusions about the body's physiological condition. Urine samples collected in space can be analyzed on Earth to study changes in the human body during spaceflight. Urinalysis is a useful technique for determining electrolyte, protein, mineral, and hormone levels of crew members.

It has been observed that the distribution of body fluid changes as astronauts adapt to the weightless environment of space. Crew members often experience fluid and weight loss during the early days of a mission. By performing urine collection continuously throughout the flight and simultaneously monitoring the crew's water intake, investigators can understand the crew members' body fluid responses to weightlessness. Future missions probably will incorporate a number of experiments focused on the volume disturbances resulting from low-gravity exposure.

***Method:*** The Urine Monitoring System is a new piece of equipment designed to collect and measure urine samples for all crew members. After launch, the Urine Monitoring System will be installed in the middeck near the Shuttle's waste collection system for automatic measurements of urine volume. The urine volume measurements will be compared to the fluid consumption recorded by each crew member.

Urine samples for two designated crew members will be collected, stored, and returned for analysis to determine if and how their body chemistry changed during the mission.

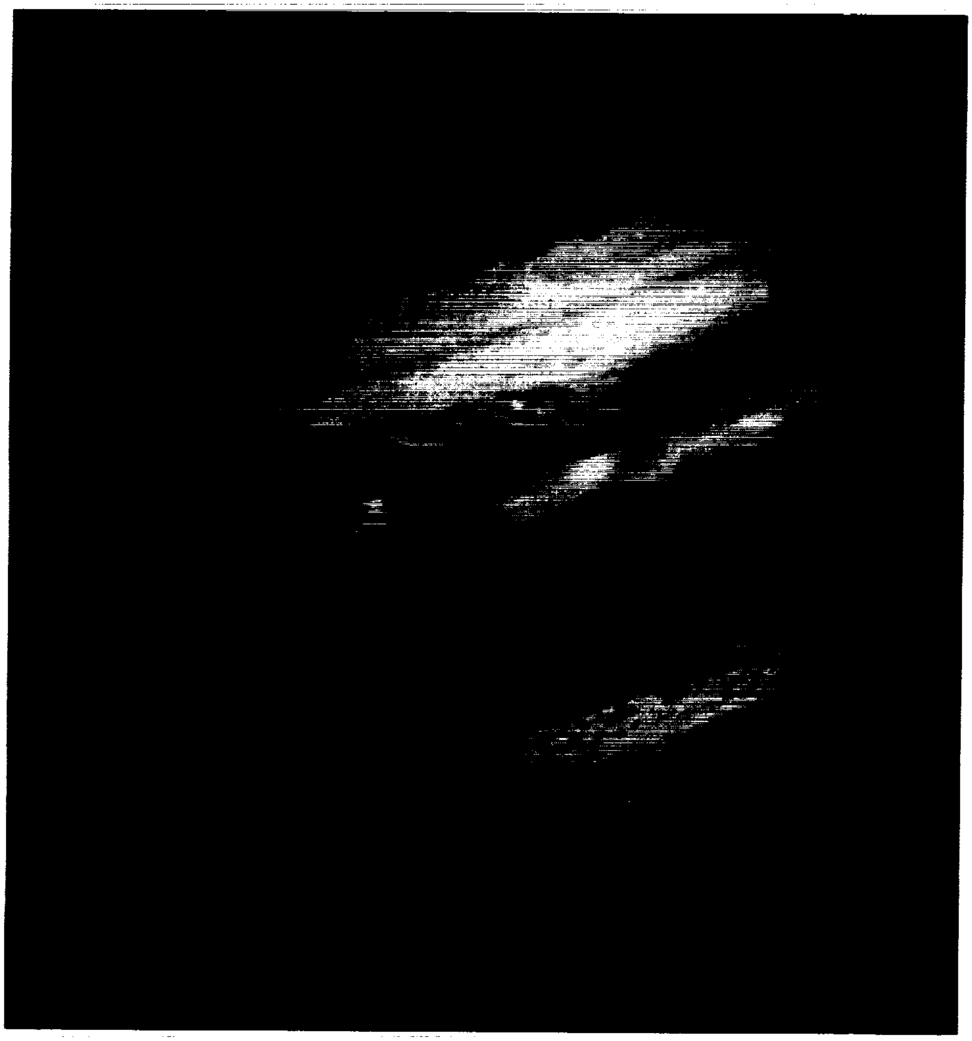


*Urine Monitoring Investigation hardware*

# Fluid Mechanics

Fluid mechanics is the study of the behavior of fluids in response to applied forces. The force of gravity on Earth plays an important role in fluid behavior. In the weightless environment of space, however, gravity is usually not a significant factor in governing fluids; other forces are more pronounced.

On Earth, it is difficult to study subtle effects because the force required to overcome gravity is so strong that it overwhelms them. For example, acoustical levitation, the use of sound waves to hold uncontained fluid specimens in position, is difficult on Earth because high-intensity sound waves tend to cause the fluid to deform and become unstable. In space, weak sound waves can be used to position and manipulate weightless specimens. This method is being investigated because sound waves can be used in "containerless processing," a method for processing materials while they are suspended without touching anything; contact with containers sometimes causes imperfections in processed materials.



Studying fluids in a gravity-free environment can help scientists understand the largest and smallest objects in the universe, from stars to raindrops to atomic nuclei. The dynamic behavior of raindrops has been studied to gain insight into the processes that govern the formation, growth, and fracturing of water droplets in clouds.

Stars and planetary atmospheres also can be understood by studying the way fluids form and move. Because stars and planets are distant and satellite measurements are few, scientists must study them indirectly, by developing models based on mathematics and experiments. Fluid processes in experiments on Earth may be similar to the intricate processes that take place in a planetary atmosphere or the interior of a star. Thus, Sir Isaac Newton, who formulated many of the basic laws of motion, studied the shapes of rotating fluids in an attempt to determine the shape of Earth.

Scientists in terrestrial laboratories have completed many studies and are still postulating theories that describe the way fluids behave. The Spacelab 3 crew will study fluids in two new facilities, the Drop Dynamics Module and the Geophysical Fluid Flow Cell. Studying the behavior of fluids in the microgravity environment of space may answer existing questions about fluid behavior on Earth and lead to new and improved theories. These theories can then be applied to processing more nearly perfect materials on Earth or in space. They also can be used to better understand the atmospheres of the sun, Earth and other planets, and the formation of stars.

# Dynamics of Rotating and Oscillating Free Drops
## Drop Dynamics Module

**Dr. Taylor G. Wang**
**NASA-Jet Propulsion Laboratory**
**Pasadena, California**

***Purpose:*** Fundamental experiments will be performed in the Drop Dynamics Module to verify that the sophisticated new facility can acoustically manipulate drops, to test theoretical predictions of drop behavior, and perhaps to observe new phenomena.

***Importance:*** Dynamics is the study of the motion of material bodies under the action of forces. Surface tension and gravity are two competing forces that influence the shape and movement of drops on Earth. In space, the more subtle force – surface tension – is dominant.

The formation and movement of drops on Earth, under the dominant influence of gravity, have been described by scientists, but many questions about drop behavior remain unanswered. To confirm theoretical predictions of fluid behavior undisturbed by gravity, scientists today are still repeating an experiment devised over 100 years ago by the Belgian scientist, J. Plateau, who suspended one fluid in another fluid of equal density. However, the interactions of the two fluids produce extraneous forces that mask the phenomena being investigated.

Recently, scientists have also tried to suspend drops with sound waves in the moments of weightlessness aboard NASA's research aircraft and small rockets. These brief experiments have given them some insight into how drops would behave in zero-gravity, but they have not been detailed enough to confirm theories formulated during the last century. The Spacelab 3 drop investigation is a significant experimental advance that may lead to new ideas for continued research on Earth and in space.

The Drop Dynamics Module gives scientists the capability to extend their studies in microgravity to longer periods of time aboard Spacelab. These studies are necessary for experimental confirmation of theoretical predictions. Scientists may then be able to apply the drop dynamics theory to practical matters, such as the development of containerless processing techniques or improved industrial processes in metallurgy and chemical engineering.

The study of drops also has astrophysical and geophysical applications. Scientists may gain new understanding of stellar interiors and star formation in molecular clouds by studying the formation and movement of drops, which resemble astrophysical processes. This research is also pertinent to the study of raindrops, clouds, and atmospheric processes. Improved understanding of drop dynamics could lead to advances in the disparate fields of materials science, astrophysics, cloud physics, and nuclear physics.

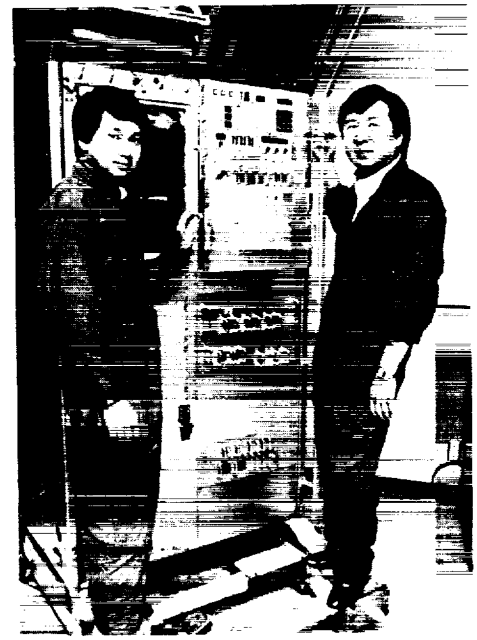
***Method:*** A number of experiments, lasting a total of 30 hours, will be conducted in the Drop Dynamics Module. The module consists of an acoustical chamber with three sources that generate, in three different directions, sound waves of variable frequency and amplitude. The sound waves will be used to rotate and oscillate water and silicone drops and to position the drops in a field of view. In space, it should be possible to position and manipulate a free drop with small acoustic forces that will not interfere with the physical processes being studied.

A syringe will automatically inject liquid between two probes that will retract to leave a drop of predetermined size free-floating inside the acoustic chamber. Sound waves of varying frequencies will rotate or oscillate the drop in the field-of-view of a camera that records the experiment. As drops rotate or oscillate, their shapes change in response to the associated forces.

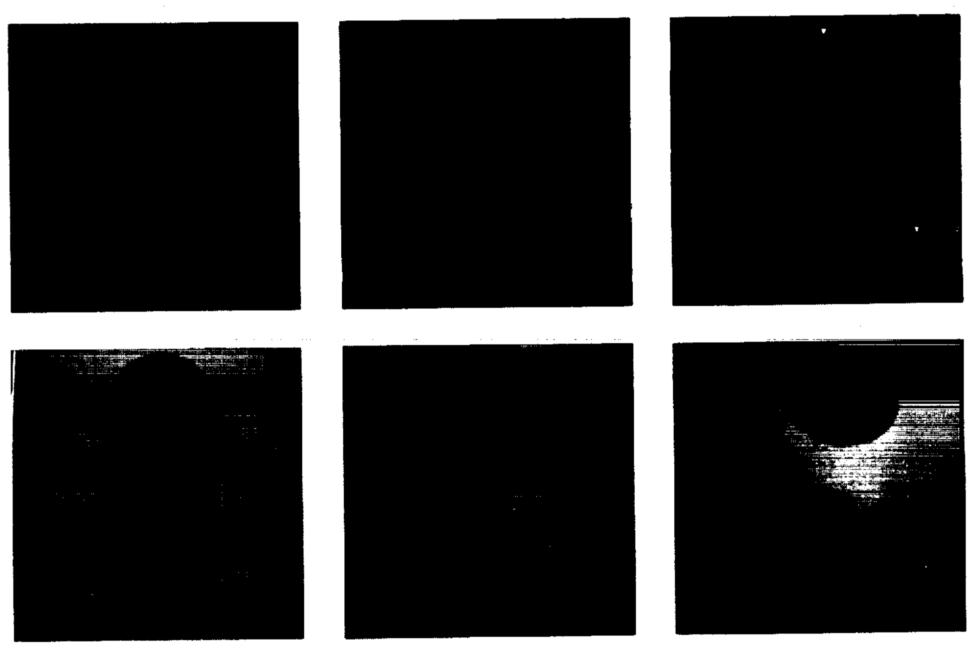
The fluid mechanics payload specialist, who has worked extensively in developing this investigation, will observe the drops and try to distinguish minute variations in their motion and shape. Colored particles in the liquid will enable scientists to observe the fluid flow inside the drop as well as details on the surface. The dynamic behavior of the rotating and oscillating drops will be observed, interpreted and described in the context of available theoretical predictions. The payload specialist will watch the experiment carefully to make necessary adjustments, fine tune the acoustic parameters, and observe subtle drop dynamics phenomena. If unusual patterns are observed, the crew member can vary experiment parameters to investigate them.

The payload specialist will make a trial run of a preprogrammed sequence and record it on videotape for downlink to the Payload Operations Control Center. A Spacelab video camera can be mounted to the module window for this operation. If satisfied with the operation, he will start the film camera positioned underneath the module and make a recording for postflight analysis. Live data by television and voice link will be received on the ground for most of the experiments in this facility.

Co-investigators for this experiment are Dr. Eugene H. Trinh, who is a payload specialist, and Dr. Daniel D. Elleman. Both scientists are associated with the NASA-Jet Propulsion Laboratory.



*The Drop Dynamics Module was designed and developed by principal investigator-payload specialist, Dr. Taylor Wang (right), and co-investigator-payload specialist, Dr. Eugene Trinh (left).*

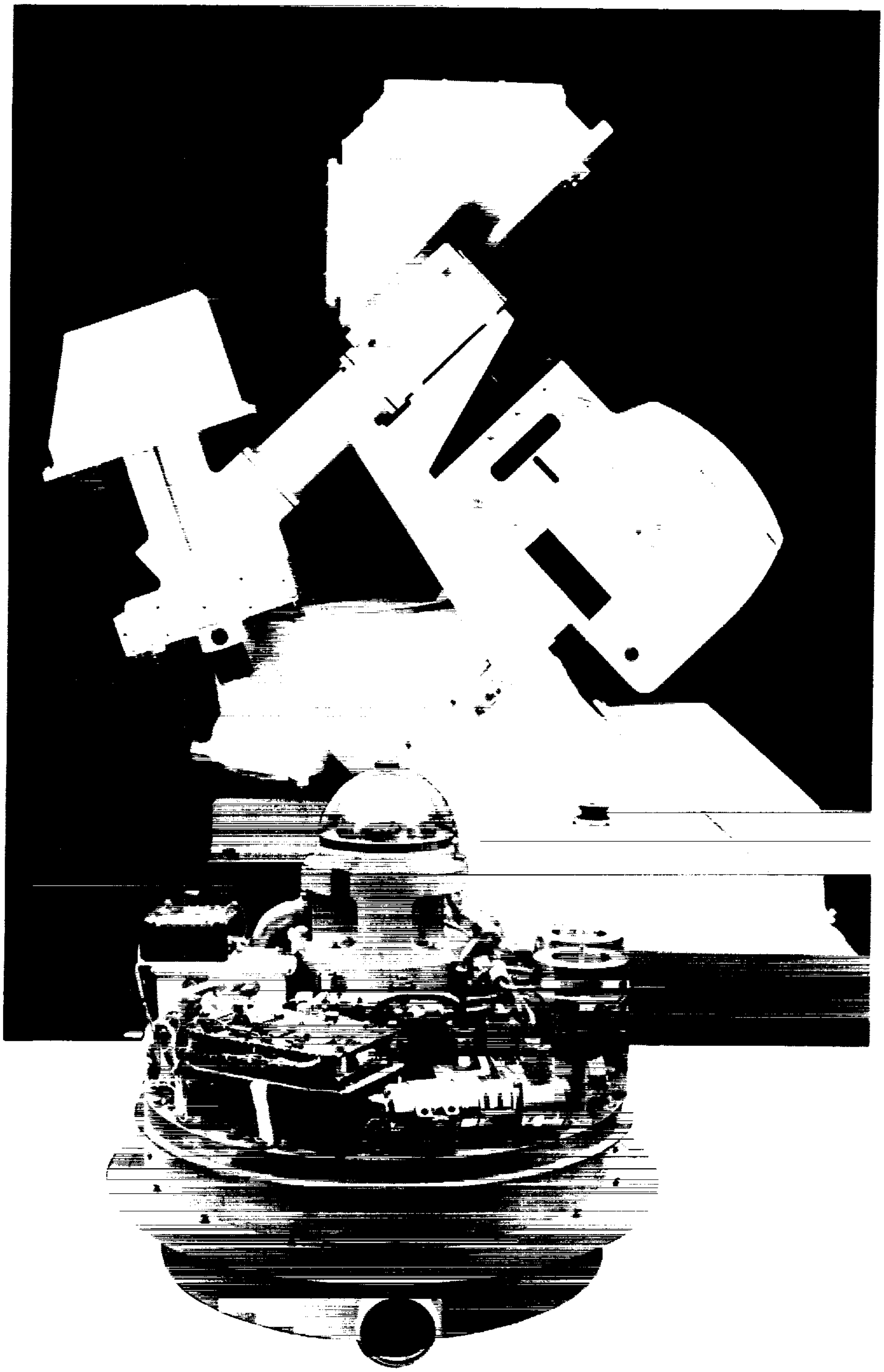


*Scientists will study how drops change in shape and break apart as they are rotated or oscillated.*

## Geophysical Fluid Flow Cell Experiment

**Dr. John Hart**
**University of Colorado**
**Boulder, Colorado**

***Purpose:*** In this investigation, scientists study fluid motions in microgravity as a means of understanding fluid flow in oceans, atmospheres, and stars, and they test an elaborate new facility for laboratory experiments on these geophysical flows.



***Importance:*** Meteorologists and astrophysicists are interested in the large-scale circulations of fluids under the influence of rotation, gravity, and heating. Such circulations occur in planetary atmospheres, oceans, and stars.

The thermally-driven motion of a fluid in a spherical experiment is similar to that in a thermally-driven, rotating, shallow atmosphere or in a deep ocean on a spherical planet. It is very difficult to do controlled experiments with rotating, spherical models in a ground-based laboratory because terrestrial gravity distorts the flow patterns in ways that do not correspond to actual planetary flows. In the microgravity environment of an orbiting laboratory, the interference of normal gravity will be eliminated, and it should be possible to obtain useful information pertinent to convective flows in atmospheres and oceans.

Although the Geophysical Fluid Flow Cell has been tested on the ground, Spacelab 3 is the first flight of an experiment of this type. Thermal convection, the transfer of heat by the circulation of fluid, will be observed inside a spherical, rotating liquid shell. Photographs of the liquid during the experiment will contain data that can be used to deduce temperature and velocity fields. From these photos, scientists can gain new insight into the fundamental fluid mechanics processes that govern Earth's atmosphere and oceans, planetary atmospheres, and the sun.

Scientists are particularly interested in the atmosphere of Jupiter, which is composed primarily of hydrogen and helium, like the sun and many stars. Jupiter radiates more

*The top of the Geophysical Fluid Flow Cell is a camera and monitoring system that measures and records fluid flow between the two spheres (inset).*

heat than it receives from the sun, which leads to speculation that the planet may have an internal heat source. By experimentation with temperature differences in this model, scientists hope to understand better the processes that produce the distinct cloud patterns on Jupiter. Ultimately this knowledge might be applied to understanding large-scale atmospheric circulations around other planets.

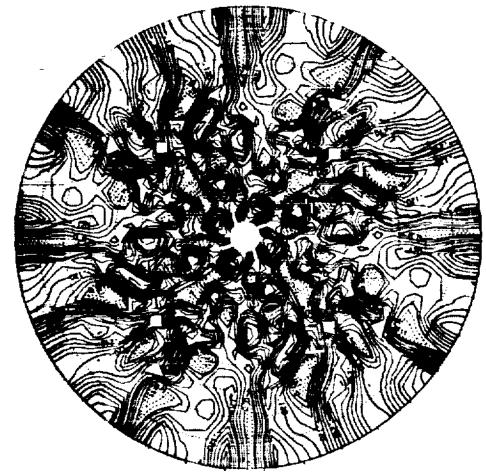
***Method:*** The experiment hardware assembly will be installed in a rack near the center of mass of the Shuttle, where gravity effects aboard the spacecraft are minimized. The instrument consists of a stainless steel hemisphere, the size of a baseball, surrounded by a sapphire hemisphere. A space between the two hemispheres contains silicone oil. Sapphire conducts heat well and is transparent; these properties allow good thermal control of the experiment and photography of the movement of fluid between the two hemispheres. The hemispheres are mounted on a turntable equipped with heating and cooling systems. When an electric voltage is applied between the hemispheres, it imparts to the fluid a buoyancy force that is identical to buoyant forces in planetary atmospheres and stars.

A photochromic chemical dissolved in the oil forms blue dye lines when activated by ultraviolet light. By tracking the movement of the lines, scientists can measure the fluid movement and velocity. Temperature measurements will be obtained by using a Schlieren optical system that senses density variations in the fluid.

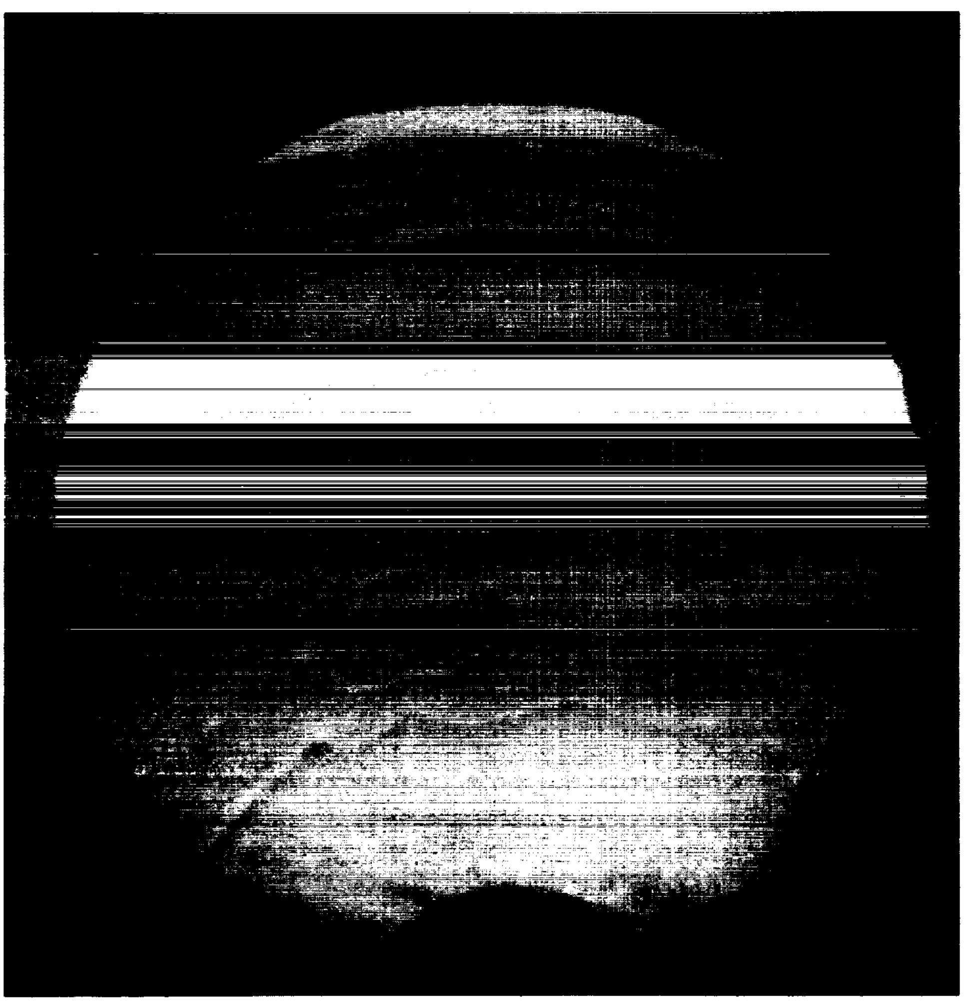
By varying rotation rate, temperature, and voltage, scientists will be able to create fluid flows relevant to the study of oceans, planetary atmospheres, and stars. These experiments will test existing theoretical models and help scientists answer many questions about fluid mechanics in the universe. What flow patterns cause the bands that run across Jupiter's atmosphere? Why does the solar equator rotate faster than the rest of the sun? What causes certain very deep currents in our oceans?

About 85 hours of experimentation in the Geophysical Fluid Flow Cell facility are planned. Each 3-hour or 6-hour experiment will explore a particular aspect of convection on a rotating sphere. The pre-programmed experiments will be monitored by a crew member and by investigators in the Payload Operations Control Center. Data will be recorded on 16 millimeter film for later analysis by the investigators.

Co-investigators are Dr. Juri Toomre of the University of Colorado; Dr. Peter Gilman of the National Center for Atmospheric Research; and Dr. Fred W. Leslie, Dr. George H. Fichtl and Dr. William Fowlis of the NASA-Marshall Space Flight Center.



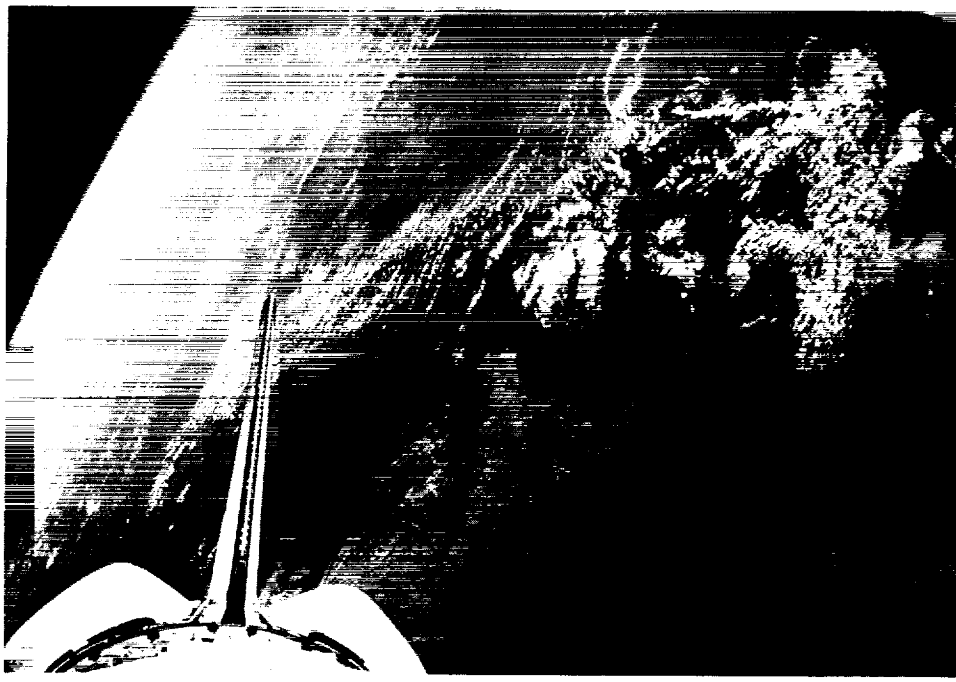
*These temperature patterns associated with convection on a rotating sphere were calculated by a computer. The changing convection patterns from the pole (center of the figure) to the equator (perimeter of the figure) are caused by rotation of the sphere in a gravitational field.*



*In an image made during tests of the Geophysical Fluid Flow Cell, the lines represent convective flows. In normal gravity, hot fluids rise; therefore, most of the lines are at the top of the hemisphere.*

# Atmospheric and Astronomical Observations

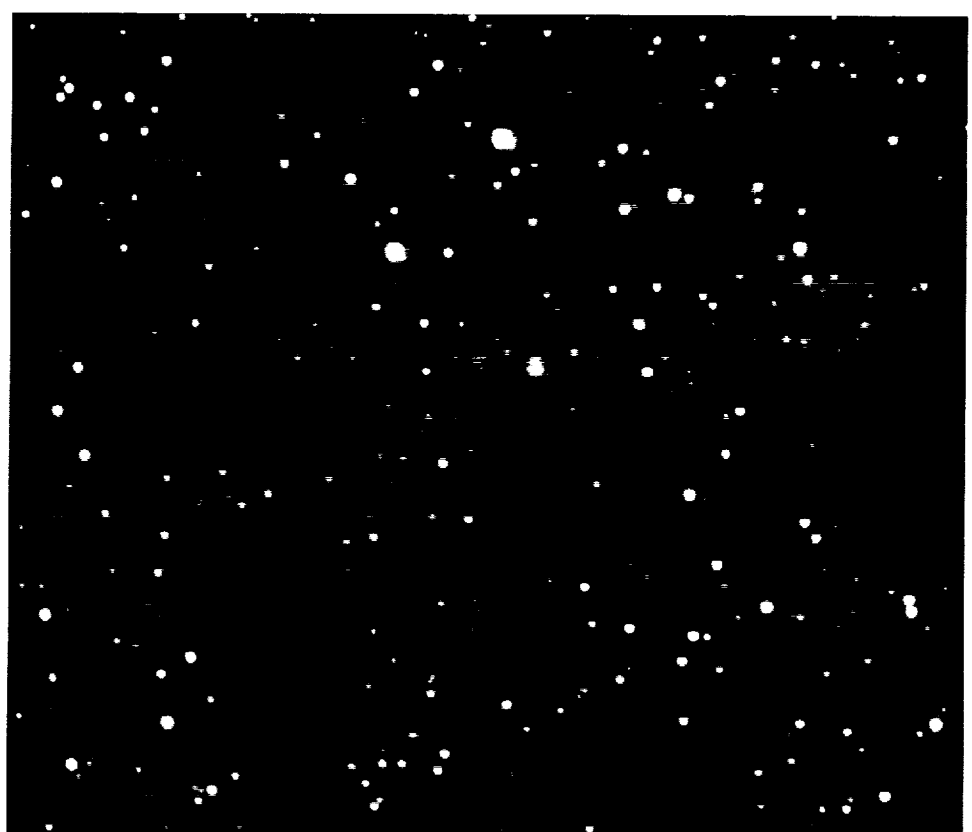
Spacelab can be used as an observation platform for remote sensing and imaging of Earth's environment and the celestial sphere. Telescopes, cameras, and sensors can be used outside the Spacelab module, in the scientific airlock, or at the high-quality window.



The atmosphere is the scene of many complex chemical and physical interactions. The delicate balance maintained there is crucial to the balance of our terrestrial environment as a whole. Scientists are interested in more detailed knowledge of the constituent atmospheric gases, their sources, concentrations, temperatures, variations and movements. Much of the information about the chemistry and physics of Earth's environment cannot be gained from the ground, because the atmosphere itself absorbs the evidence. From space, it is possible to survey Earth on a global scale and gain new insight into the processes that control our environment.

Likewise, the atmosphere filters radiation from the sun, stars, and other celestial objects. Electromagnetic radiation in the gamma ray, X-ray, ultraviolet, and infrared wavelengths is largely absorbed in the atmosphere before it can reach the ground. Consequently, much of the universe is "invisible" except to instruments placed above the atmosphere. The atmosphere also obscures our view of the visible sky; much clearer observations and sharper photographs are possible above the clouds and turbulence.

Spacelab 3 carries instruments for four atmospheric and astronomical investigations. Located outside the module on the experiment support structure, the ATMOS instrument studies atmospheric composition and the Ions instrument samples cosmic rays. The Very Wide Field Camera is mounted inside the scientific airlock and extended into space to photograph the Milky Way. Two other cameras are used by the crew to photograph auroras, the Northern Lights.



## Atmospheric Trace Molecules Spectroscopy (ATMOS)

**Dr. C.B. Farmer**
**NASA-Jet Propulsion Laboratory**
**Pasadena, California**

***Purpose:*** The objectives of this investigation are to examine, on a global scale, the composition and variability of the upper atmosphere and to gain very precise spectral information for an atlas of the region.

***Importance:*** The chemistry and physics of the upper atmosphere influence the stability of the lower atmosphere in which we live. It is, therefore, important to understand the behavior of the atmosphere—to learn what composes it, where the various components originate, what causes them to move about and interact, and how they change over time.

Scientists have identified at least 40 molecular species that play a role in the chemistry of Earth's atmosphere and in its interaction with solar radiation. These atmospheric constituents include various compounds of nitrogen, oxygen, hydrogen, carbon, and other elements. Many are present only in very sparse, trace quantities, as low as a few parts per trillion. Some of these gases are present only as a result of human activity and are sensitive indicators of change in our environment.

***Method:*** The atmosphere can be studied by direct sampling (that is, by putting a probe in its midst) or by remote sensing from a distance outside the region. One productive method of remote sensing is absorption spectroscopy, the analysis of how different constituents absorb solar radiation. This technique is used in the ATMOS investigation for detailed measurements of three atmospheric zones—the stratosphere, mesosphere, and lower thermosphere.

ATMOS consists of four major systems: a suntracker for precise solar pointing, an input optical system that includes a telescope and a data handling system, an interferometer for wavelength measurements, and an infrared detector sensitive to radiation in the 2 to 16 micron wavelength range. The instrument package is mounted on the experiment support structure.

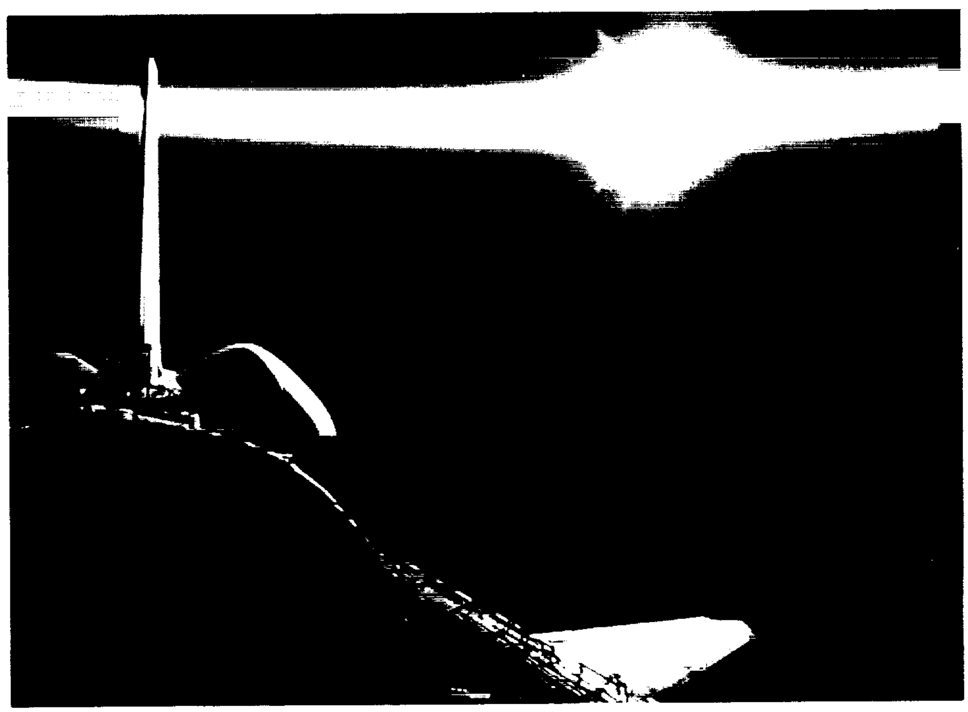
ATMOS operates during orbital sunrise and sunset, which occur 32 times a day as the Shuttle circles the globe. Observations are scheduled for about 50 such opportunities during the 7-day mission. The instruments view the sun through Earth's atmosphere just as the sun crosses the horizon. Each observation lasts about 3 minutes. Coverage by ATMOS ranges from 30° to 55° North latitude around the globe, a region well studied by instruments on balloons, and up to 20° on each side of the equator, where an upwelling effect carries molecules into the upper atmosphere. Altitude coverage ranges from 20 to 120 kilometers (12 to 75 miles).

The ATMOS system makes very rapid and precise measurements of solar radiation passing through the atmosphere. In absorption spectroscopy, dark lines appear in spectral scans where particular wavelengths of solar radiation are being absorbed or blocked from the instrument's view. Since different elements absorb energy selectively at different wavelengths, the spectra can be read to determine which molecular species are present in the area scanned. In the ATMOS instrument, incoming light is split, recombined, and focused to produce interferograms, which yield information about the amount of radiation at each wavelength. These measurements are made every second during the 3-minute observation periods. The ATMOS collection of solar spectra will contribute to the compilation of an "atlas" of the atmosphere.

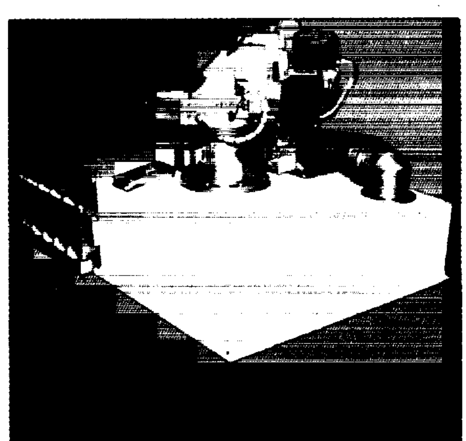
ATMOS observations are largely automated, with coarse solar pointing commands from the onboard Spacelab computer and precise pointing by the ATMOS suntracker, a sensor that "locks on" to the sun for each observing sequence. Control commands normally will be issued from the ground. The flight crew also can alter and fine-tune ATMOS operations via a data display unit keyboard. Changeable parameters include field of view, elevation angle, and filters. Data are transmitted real-time via satellite to the Payload Operations Control Center.

On Spacelab 3, ATMOS is the only investigation with science requirements that influence launch window time and duration. The launch window has been calculated to provide the maximum number of viewing opportunities for the ATMOS target latitudes. The gravity gradient attitude is well-suited for this investigation.

Co-investigators for the ATMOS investigation include Reinhard Beer, James Breckenridge, Monstafa Chahine, Robert Norton, Odell Raper, Rudolf Schindler and Robert Toth of the Jet Propulsion Laboratory; John Harries of the Rutherford Laboratory in England; James Russell of the NASA-Langley Research Center; John Shaw of the Ohio State University; Joel Susskind of the NASA-Goddard Space Flight Center; Fred Taylor of Oxford University; Steven Wofsy of Harvard University; and Rudolphe Zander of the University of Liege.



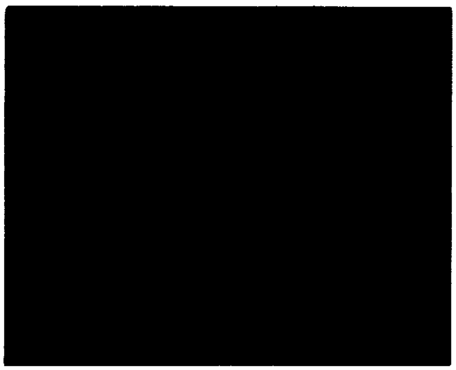
*The ATMOS instrument views the Earth's atmosphere as the sun crosses the horizon at sunrise and sunset.*



*The ATMOS instrument scans the atmosphere to determine which gases are present.*

# Studies of the Ionization of Solar and Galactic Cosmic Ray Heavy Nuclei (also called Ions or Anuradha)

**Dr. Sukumar Biswas**
**Tata Institute of Fundamental Research**
**Bombay, India**



*Solar flares may cause giant eruptions that send energetic solar particles speeding toward Earth.*

***Purpose:*** For this investigation, a newly designed detector system, which uses the most sensitive solid state nuclear track detector presently available, is used to determine the composition and intensity of energetic ions streaming from the sun and other galactic sources toward Earth's atmosphere.

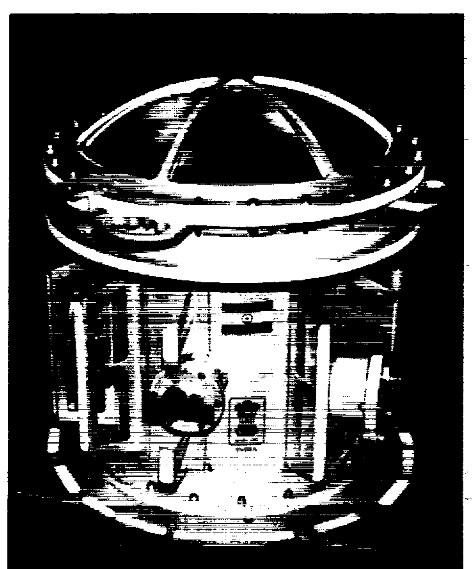
***Importance:*** Cosmic rays are energetic nuclear particles that bombard Earth's upper atmosphere at velocities close to the speed of light and penetrate into the atmosphere in which we live. These atomic nuclei of helium and heavier elements up to uranium are the only available samples of matter from outside the solar system. During the Spacelab 3 mission, these particles will race through a detector exposed to space, and scientists will measure their specific traits.

A new population of energetic ions was discovered in measurements of low-energy cosmic rays (particles with energies from 5 to 100 MeV) during the Skylab mission. Investigators have not been able to identify these irregular new components of low-energy cosmic rays and have designed the Spacelab 3 detector specifically to study them. High-energy cosmic rays (containing particles with energies greater than 100 MeV) have different properties than low energy cosmic rays, and scientists can use the detector to distinguish between them.

If the abundance and ionization states of low-energy galactic cosmic rays can be defined, it may be possible to identify their origin. Some scientists have speculated that exploding stellar objects called novas, which hurl matter through space, may be the source of low-energy cosmic rays. The Spacelab 3 cosmic ray experiment may provide new clues to their origin, which has remained obscure because of their irregular journeys through the galaxy for millions of years before they reach our solar system.

Scientists are also interested in the energetic particles that speed toward Earth after large solar flares, tremendous explosions on the sun. Measurements of the energy levels of these particles give insight into acceleration processes on the sun.

*Photomicrograph of uranium 238 nuclei tracks in the cosmic ray experiment detector sheets.*



*Detectors located in the top of the Ions instrument sample and identify energetic particles from the sun and other celestial sources.*

***Method:*** A detector 100 times more sensitive than the best previously used will be placed on the experiment support structure for direct exposure to space. As cosmic ray particles pass through the detector, their identity, charge, energy, and abundance will be measured.

The detector system consists of stacks of thin sheets of special plastics in a cylindrical module. There are two distinct stacks: a major lower stack that rotates slowly (4 degrees per hour) and a thin, fixed upper stack. An energetic particle entering through the top stack and stopping in the bottom stack leaves a path on the plastic that can be revealed by chemical treatment. By studying the shape and range of the track, the time of the rotation, and the position of the Shuttle, scientists can determine the arrival direction, arrival time, nuclear mass, and charge of each of the cosmic ray ions. This information may be used to determine the identity and abundance of each particle and to deduce its path of travel through space. These data will give scientists clues to the point of origin of the particles.

The experiment will operate continuously until the lower electron detector completes a 360 degree rotation, which is estimated to take 90 hours. The operation of the instrument is controlled by a computer on board Spacelab, which can be commanded either by the crew or from the Payload Operations Control Center. Data on the instrument's operating condition will be sent directly to the ground, but science data will be analyzed after the instrument is returned.

If a major solar flare occurs during the mission, experiment operations can be modified to take advantage of the opportunity to measure the enhanced abundance of high-energy solar particles. The principal investigator will receive solar "weather reports" from the National Oceanic and Atmospheric Administration (NOAA). If notified of flare activity, the investigator will change the experiment protocol to rotate the stack faster for optimal data capture.

Co-investigators from India include Dr. J.N. Goswami and Devendra Lal of the Physical Research Laboratory in Ahmedabad; Ramanath Cowsik, Dr. N. Durgaprasad, P.J. Kajarekar, Dr. M.N. Vahia, and Dr. J.S. Yadav of the Tata Institute of Fundamental Research in Bombay.

# Auroral Imaging Experiment


## Dr. Thomas J. Hallinan
## Geophysical Institute
## University of Alaska
## Fairbanks, Alaska


***Purpose:*** In this investigation, the visual characteristics of pulsating and flickering auroras are observed and recorded. After the mission, the three-dimensional form of various auroras can be reconstructed through innovative photographic techniques.

***Importance:*** Viewed from the ground, auroras appear as dazzling displays of light that dance across the night sky. Auroras typically occur in an oval region around the north and south magnetic poles, where charged particles from the sun that have been accelerated by Earth's magnetic field collide with air molecules in the upper atmosphere. The resultant discharge of energy, visible as auroral light, is a useful indicator of more distant events deep in the Earth's magnetic field, the magnetosphere.

Some physical processes associated with auroral activity are not yet well understood. Of special interest are pulsating auroras, in which brightness increases and decreases in a quasi-periodic fashion, and flickering auroras, a special type of pulsating aurora in which brightness flickers at a high frequency. These types of auroras and others have been observed and photographed from ground observatories and satellites.

Typically, scientists are able to photograph only small sections of an aurora. These images are not detailed enough for the study of systematic variations in pulsating auroras. From the Shuttle, however, scientists can photograph expanses of auroras and record large-scale changes. They also can examine the relationship of flickering auroras to auroral substorms, the quiet, steadily glowing auroras that explode into a sequence of displays, reach a peak, and subside.

During the Spacelab 3 mission, the Shuttle will make a number of passes in darkness near the auroral zone, the region where auroras are most likely to be visible. The crew will take advantage of these opportunities to view and photograph auroras. Scientists on the ground can then use the information, like pieces in a puzzle, to construct a photographic atlas of auroral structure and form as seen from space.

***Method:*** Auroral displays over the Northern Hemisphere (primarily North America) will be visible at a distance of 3200 kilometers (2000 miles) from the Shuttle. During more than 40 prime observation opportunities over the auroral zone, the Shuttle will pass within 800 kilometers (500 miles) of the auroras. The path of the Shuttle will allow observations of hundreds of miles of auroras in just a few minutes. The auroral observations will occur in periods of 10 minutes or less and in groups of up to 10 consecutive orbits each day.

A sensitive black and white television camera, which is standard flight equipment mounted in the payload bay, will be used to observe and record the changing auroras. Video images will be supplemented with color still photographs taken through the orbiter windows by crew members. Because different colors in auroral light represent different interactions, the color images will contain useful information about auroral chemistry and physics.

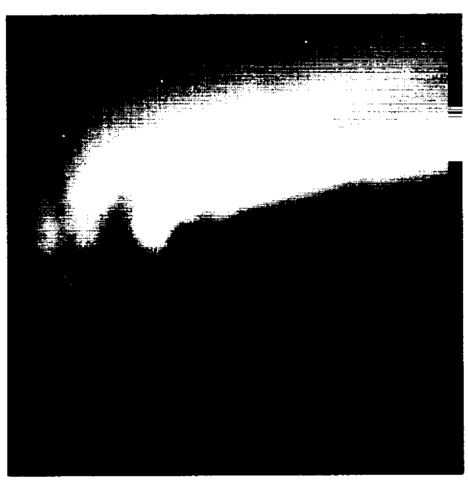
The motion of the Shuttle will allow three-dimensional movies to be constructed from the black and white video tapes when they are processed on the ground. The orbital velocity of Spacelab 3 is sufficiently rapid that pictures of the aurora taken a fraction of a second apart form stereo pairs from which the three-dimensional structure and form of most parts of the aurora can be constructed. This new observational technique may allow scientists to separate apparently overlapping forms and distinguish individual features of auroras.

For maximum scientific results from this investigation, automated equipment cannot be used; human judgment is needed to select viewing targets and adjust the cameras. The principal investigator, working in the Payload Operations Control Center, will provide the crew with information from ground observatories and satellites on predicted auroral activity, types of observations with highest priority for the day, and evaluations of previously transmitted video data.

After the mission, the data will be analyzed at the University of Alaska Geophysical Institute's digital video analysis facility, where elaborate programs can be used to extract specific data from the video images. Using this facility, scientists can determine when and where flickering auroras occur and can measure the frequency of pulsating auroras.

Spacelab 3 mission specialist Dr. Don Lind is the co-investigator for this experiment.

*Viewed from space, the aurora appears to crown the globe in light.*

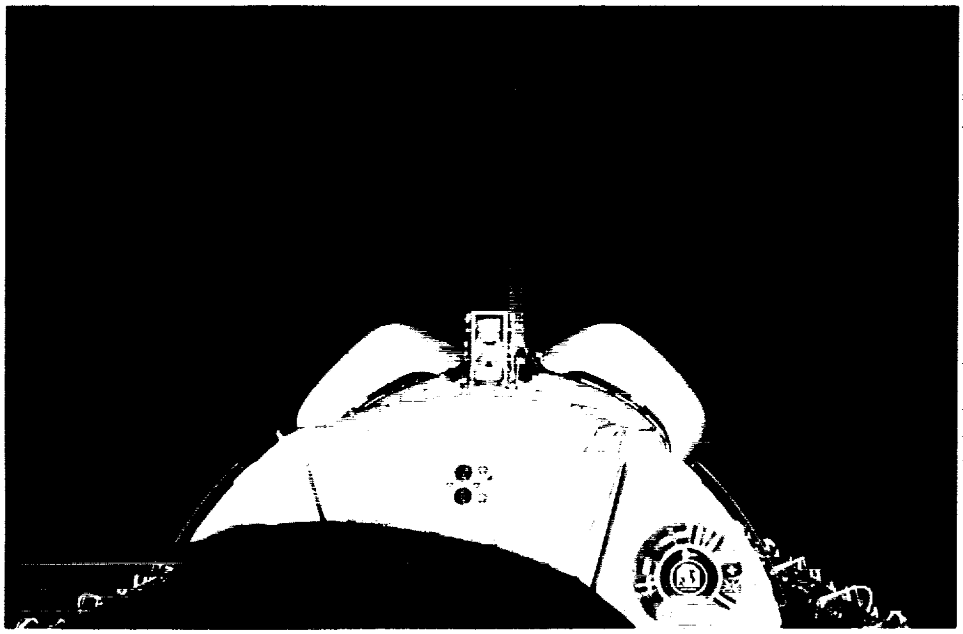


*From the ground, auroras appear as swirls of ghostly light, pulsating, flickering or hanging quietly in the sky.*

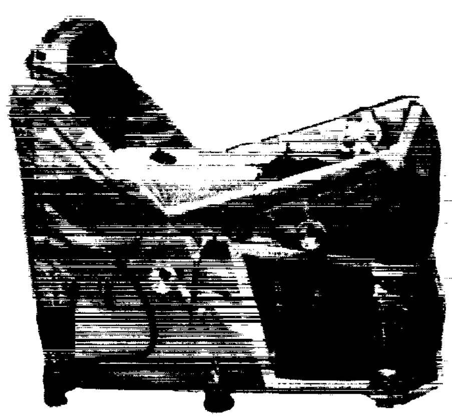
## Very Wide Field Camera

### Dr. Georges Courtes
### Laboratoire d'Astronomie Spatiale
### Marseilles, France

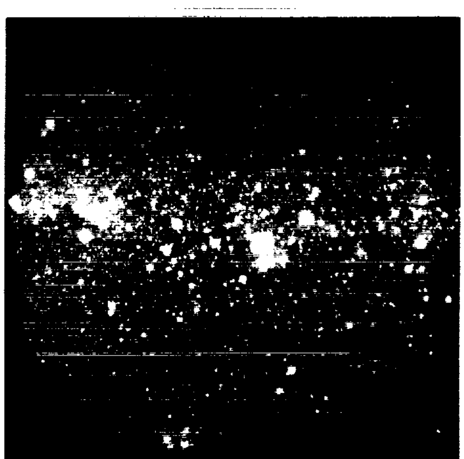
***Purpose:*** The Very Wide Field Camera is used to make a general ultraviolet survey of the celestial sphere in a study of large-scale phenomena, such as clouds within our galaxy.



*Thrust into space through the scientific airlock, the Very Wide Field Camera gazes at the stars during the Spacelab 1 mission.*



*Very Wide Field Camera*



*This ultraviolet image of the Milky Way was made by the Very Wide Field Camera during the Spacelab 1 mission.*

***Importance:*** Astronomical observation with wide field-of-view instruments is relatively new. This technique is faster and easier to interpret than scanning of many points over a large area, and it allows constant comparison with the sky background and reference stars. Wide-angle photography is well-suited for large-scale studies of zodiacal light, diffuse galactic light, interstellar clouds, and other sources.

Ultraviolet radiation is a signature of high-temperature stars – both very young, massive stars and aging stars near the end of their evolution. Because this radiation is reflected by surrounding dust and gas clouds, ultraviolet astronomy gives us insight into the distribution of matter in the universe. Scientists are especially interested in the extent of matter within and near our galaxy.

The Very Wide Field Camera investigation demonstrates the unique capability of Spacelab for repeated research opportunities in space. This instrument was used successfully on the Spacelab 1 mission. An opportunity for a quick reflight arose because the Spacelab 3 orbit offers favorable night-time viewing conditions.

***Method:*** A camera-telescope mounted in the Spacelab scientific airlock by the crew will take wide-angle pictures of the sky in ultraviolet wavelengths. The instrument will be used to study the large-scale structure of the Milky Way and the remnants of large explosions that occurred eons ago near the sun.

The 54° field-of-view instrument can operate in two modes to photograph the sky through three different filters and to measure wavelength distribution across the ultraviolet band (from 1300 to 3000 Angstroms). All scientific data are recorded on film and returned to investigators after the mission. Film cartridges are inserted and removed by the crew as needed; about 100 exposures (one cartridge) will be made on this flight. Operations can be controlled from the Payload Operations Control Center, where scientists receive "housekeeping" data on the status of the instrument.

After Spacelab activation early in the mission, the Shuttle will move into a celestial viewing attitude. Maneuvers will be made to point the camera at different areas of the sky during each orbital night in a 10-hour period (6 orbits). Upon completion of the wide field observations, the gravity gradient attitude will be established and maintained for the rest of the mission. The camera will then be removed from the airlock and stowed.

Co-investigators for this investigation include Dr. Rudolph Decher and Dr. Allen Gary of the NASA-Marshall Space Flight Center, and J.P. Sivan and M. Viton of the Laboratoire d'Astronomie Spatiale.

# Investigations Summary

| INVESTIGATIONS | TITLE | PRINCIPAL INVESTIGATOR |
|---|---|---|
| **Materials Science** | Solution Growth of Crystals in Zero-Gravity<br>*Fluid Experiment System* | Dr. Ravindra Lal *(United States)* |
| | Mercuric Iodide Growth<br>*Vapor Crystal Growth System* | Mr. Wayne F. Schnepple *(United States)* |
| | Mercury Iodide Crystal Growth | Dr. Robert Cadoret *(France)* |
| **Life Sciences** | Ames Research Center Life Sciences Payload<br>*Rodent Facility Verification Test*<br>*Primate Facility Verification Test*<br>*Dynamic Environment Measurement System*<br>*Biotelemetry System* | Dr. Paul Callahan *(United States)*<br>Dr. John Tremor *(United States)* |
| | Autogenic Feedback Training | Dr. Pat Cowings *(United States)* |
| | Urine Monitoring Investigation | Dr. Howard Schneider *(United States)* |
| **Fluid Mechanics** | Dynamics of Rotating and Oscillating Free Drops<br>*Drop Dynamics Module* | Dr. Taylor Wang *(United States)* |
| | Geophysical Fluid Flow Cell Experiment | Dr. John Hart *(United States)* |
| **Atmospheric and Astronomical Observations** | Atmospheric Trace Molecules Spectroscopy (ATMOS) | Dr. C.B. Farmer *(United States)* |
| | Studies of the Ionization of Solar and Galactic Cosmic Ray Heavy Nuclei (Ions or Anuradha) | Dr. Sukumar Biswas *(India)* |
| | Auroral Imaging Experiment | Dr. Thomas Hallinan *(United States)* |
| | Very Wide Field Camera | Dr. Georges Courtes *(France)* |