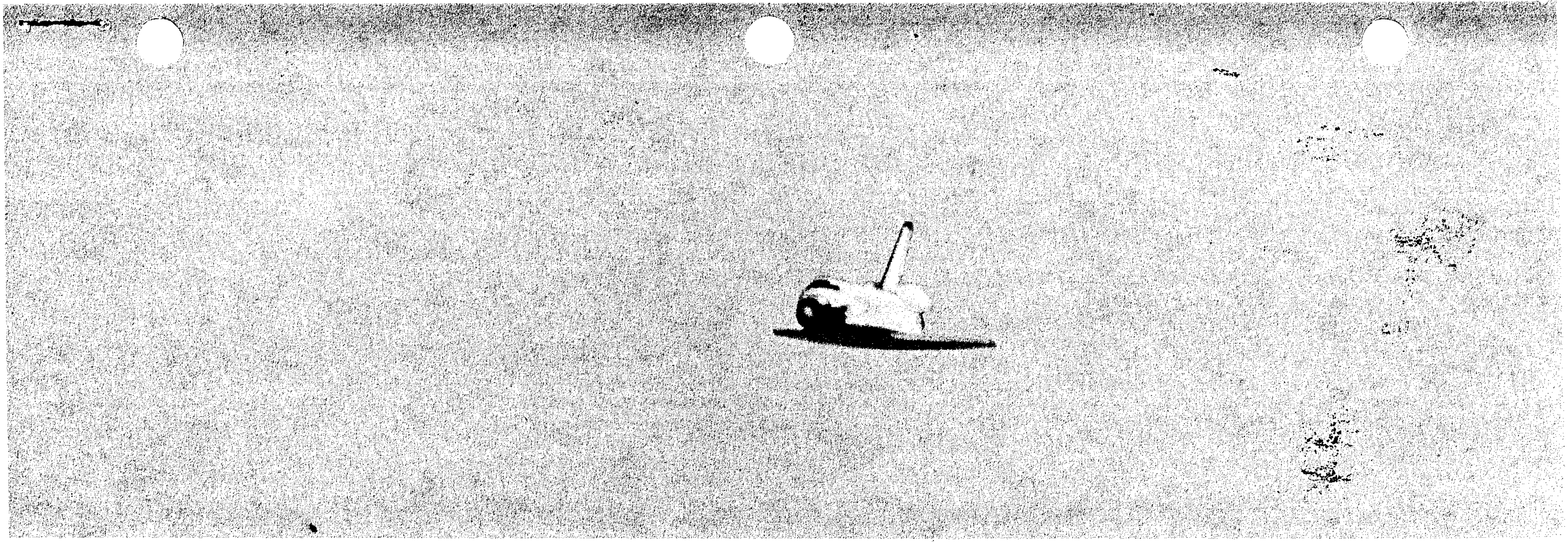


STS-4
JUNE 1982

PRESS INFORMATION

Rockwell International

Space Transportation &
Systems Group

WE THANK YOU . . . FOR THE KIND WORDS

The 1972 edition of Webster's dictionary failed to list or define the words *Space Shuttle*. The "word bible" did list "space" with variations including spacecraft, space station, space platform . . . and it defined the word "shuttle" on a preceding page.

On July 26, 1972, the National Aeronautics and Space Administration announced that Rockwell International (the company's space group in Downey, Calif.) was the prime contractor for design, development, test and evaluation of a Shuttle spacecraft—the first two phases of the contract covered 10 years.

Today, revised editions of Webster's now concisely define and list *Space Shuttle*—a two-word combination—as a transport craft carrying persons, satellites and laboratories into space and return.

Behind the definition are milestone events which started in 1976; (Constitution Day, Sept. 17) with the rollout of *Enterprise,* a full-size spacecraft test article. There were the successful Approach and Landing Test Flights of 1977. August 12, 1977 was the date *Enterprise* proved that the design of the Shuttle spacecraft provided outstanding aerodynamic control and flight features . . . the spacecraft could fly and land as a very stable airplane.

Enterprise, subsequently used for mated vibration and fit and functional ground testing, was followed by the spaceflight-qualified *Columbia*. And, behind *Columbia* is *Challenger* (to be delivered to the Kennedy Space Center in July 1982), *Discovery* (now being delivered to the Rockwell final assembly site in Palmdale, Calif.), and *Atlantis*.

Through the eyes and words of the communications media, the spacecraft *Columbia*, in the past 18 months, has become well known to the world. The photographic lenses and printed words have focused on the exploits of this heavy-bodied, delta-winged, black- and white-colored Shuttle spacecraft—detailing in-breadth its achievements. *Time* magazine editors came extremely close to selecting *Columbia* as the 1981 "Man of the Year" . . . instead of runner-up.

And, well they might.

Four times this spacecraft (appropriately becoming the gem in the ocean of space) will have been boosted by rocket propulsion into space; four times it will have flown in varying attitudes and orbits about the Earth . . . looking in all directions at the vast universe; and four times it will have returned to the atmosphere . . . gliding through friction-generated molten temperatures to a high-speed landing.

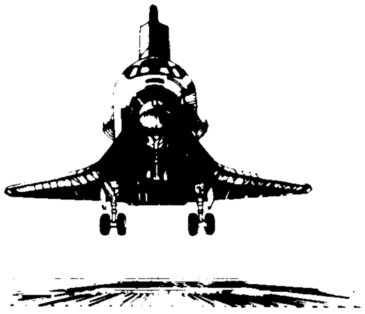
Each flight brings out additional "in-depth" performance capabilities. *Columbia*, with four separate astronaut crews, is proving that "she" performs as she was designed and built to perform.

The Shuttle spacecraft is not only a transporter; it provides an extremely stable platform for mounting even the most delicate of instrumentation, and also is adeptable to performing as a self-contained laboratory for smaller scale processing and development projects.

President Reagan, who, on his Memorial Day weekend trip, stopped off to meet with Rockwell workers in Downey—told the 7,000 space craftsmen that it was "your fingerprints on the Apollo spacecraft that enabled 'our' footprints on the moon." And, he thanked these same workers (and their off-site colleagues) for the outstanding job they have done in designing, building and testing Shuttle spacecraft.

CONTENTS

FLIGHT CREWS



NEWS ABOUT AMERICA'S SPACE SHUTTLE

...it comes from Rockwell International

A major test objective, vitally important to the long-range success of the Space Shuttle Transportation System program, is the capability of rapid turnaround from a landing to another launch.

In this developmental phase, the early turnarounds are deliberately lengthy and incorporate extensive modifications and detailed systems checkout. In the later operational phase, the time between landing and launch will be greatly reduced.

A major modification to the spacecraft *Columbia* (from STS-3 to STS-4) is the changing of experiment packages in the cargo bay. STS-3 contained the OSS-1 pallet and experiments. This has been removed and the DOD 82-1 payload has been installed.

In the following pages we have outlined the specific turnaround tasks required. The major experiments on STS-4 are described in some detail. There is also a summary of the STS-1, STS-2, and STS-3 flights.

Office of Public Relations
Space Transportation & Systems Group • 12214 Lakewood Boulevard • Downey, CA 90241
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TURN-AROUND MODIFICATIONS TO *COLUMBIA* FOR STS-4

- Install payload bay liner
  - Support brackets and retention hardware for payload bay liner and closeout attachment for inclusion of three payload purge ducts in mid-body.

- Remove two potable water tanks from the crew compartment mid-deck floor (*Columbia* for STS-4 will have four potable and one waste water tank).

- Provide necessary crossover lines with quick disconnects and manual valves for connecting waste water dump line to primary flash evaporator line.

- Addition of carbon monoxide (CO) removal device to the atmosphere revitalization system downstream of and adjacent to condensing heat exchanger. CO device to be removed and replaced after each flight.

- Coating of five tiles (three mid, two forward) for catalytic surface effect experiment.

- Removal of OSS-1 pallet and hardware.

- Remove and replace payload recorder timing cable.

- Remove and replace three main propulsion system liquid hydrogen actuator valves on the three liquid hydrogen prevalves for prevalve anti-slam and emergency shutdown capability.

- Dynamics, acoustic and thermal environment (DATE) experiment coustic changes of 38 measurements mounted on the Development Flight Instrumentation (DFI) pallet and payload bay bridge fittings including payload harness installation and signal conditioner to DFI pallet.

- Remove and replace ablators.

- Provision for payload in lieu of galley in crew compartment mid-deck. Continuous flow electrophoresis system (CFES) payload in place of galley, weight 158 kilograms (350 pounds).

- Provide drag angles on each side of vertical tail to improve load margins at aft fuselage forward attachment.

- Reconfigure partial pressure oxygen (PPO_2) sensor and amplifier installation. Provide capability for installation and removal of sensor without moving amplifier and provide capability/access to amplifier adjust provisions for "onboard" calibration.

- Add strain gages to eight payload bay centerline latch torque tubes and add temperature measurements to seals and actuators.

- Instrumentation changes.

- Installation of monodisperse latex reactor experiment in crew compartment mid-deck.

- Remove and reinstallation of induced environment contamination monitor on development flight instrumentation unit.

- Remove "getaway special" instrumented container and install "getaway special" containers with experiments in payload bay.

- Thermal protection system
  - Removal of approximately 1,043 tiles and

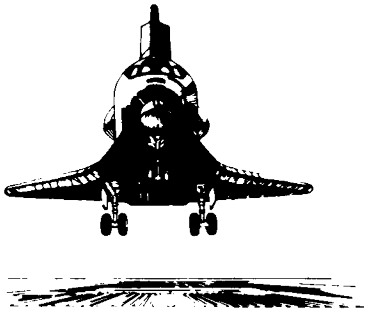
replacement with densified tiles; this includes 144 tiles damaged in flight (nicks, dings, etc.), 37 tiles lost in flight, 37 tile modifications for orbiter experiments and vertical tail work, 29 tiles due to ground damage, 19 tiles for engineering evaluation and 777 for densification.

– Refurbishment of selected thermal barriers and gap fillers.

– Re-waterproofing of tiles.

LINE REPLACEMENT UNITS (LRU'S) FOR STS-4

- Removal and replacement of H_2O (water)/Freon-21 coolant interchanger.
- Installation of ACK (acknowledge) key in aft flight station keyboard unit.
- Removal and replacement of Inertial Measurement Unit (IMU) No. 3.
- Removal of waste collection system and re-installation.
- Removal and replacement of S-Band transponder.
- Removal and replacement of MCA power AC3 forward circuit breaker.
- Removal and replacement of smoke detector 2A.
- Removal and replacement of H_2 (hydrogen) 0_2 (oxygen) heater control box No. 1 and No. 4.
- Removal of remote manipulator system (RMS) wrist television camera and reinstalation.
- Removal of payload bay television camera "C" and reinstallation.
- Remove and replace nose landing gear wheels/tires and main landing gear tires/wheel assemblies (two landings).
- Removal and replacement of all four main landing gear brake assemblies.
- Removal and replacement of low pressure oxidizer turbopump, SSME No. 2 engine.
- Removal and bench inspection of all 3 SSME high pressure fuel turbopumps. Replacement of SSME No. 1 and No. 3 high pressure fuel turbopumps and re-installation of SSME No. 2 high pressure fuel turbopump.
- Removal and replacement of rudder/speedbrake power drive unit.
- Removal and replacement of forward reaction control engine F1U, F2U, F3U, F1F, F1L and F2R and aft reaction control system engines L4U, L2U, L1U, R4U, R2U, R1U and L3L.
- Removal and replacement of Space Shuttle Main Engine No. 1 yaw actuator.



NEWS ABOUT AMERICA'S SPACE SHUTTLE

...it comes from Rockwell International

The fourth flight of *Columbia* is primarily a continuation thermal test to register the reactions of the spacecraft to the most extreme temperature differentials that could be encountered in the operational flights. Temperatures may range from 82 to 93 degrees C (180 to 200°F) on surfaces irradiated by sunlight to minus 82 to 93 degrees C (minus 180 to 200°F) on any surface out of direct sunlight or shadowed by another object. With relatively small satellites, the resulting thermal strains can be checked in advance in test chambers on earth. But such tests are not possible with the large orbiter.

STS-4 MISSION STATISTICS

Launch – Sunday, June 27, 1982
11:00 A.M. E.D.T.
10:00 A.M. C.D.T.
8:00 A.M. P.D.T.

Duration: 7 days 1 hr, 13 min., 37 sec.

Landing: Sunday, July 4, 1982
12:13:37 P.M. E.D.T.
11:13:37 A.M. C.D.T.
9:13:37 A.M. P.D.T.

Inclination: 28.5 degrees

SSME throttling: 68 to 100 percent RPL

Altitude: 130 nautical miles (149 statute miles), then to 165 nautical miles (189 statute miles) which will utilize a total of 4 OMS thrusting periods.

Payload weight up and down: Approximately 10,271 kilograms (22,645 pounds).

Entry angle of attack: 40 degrees

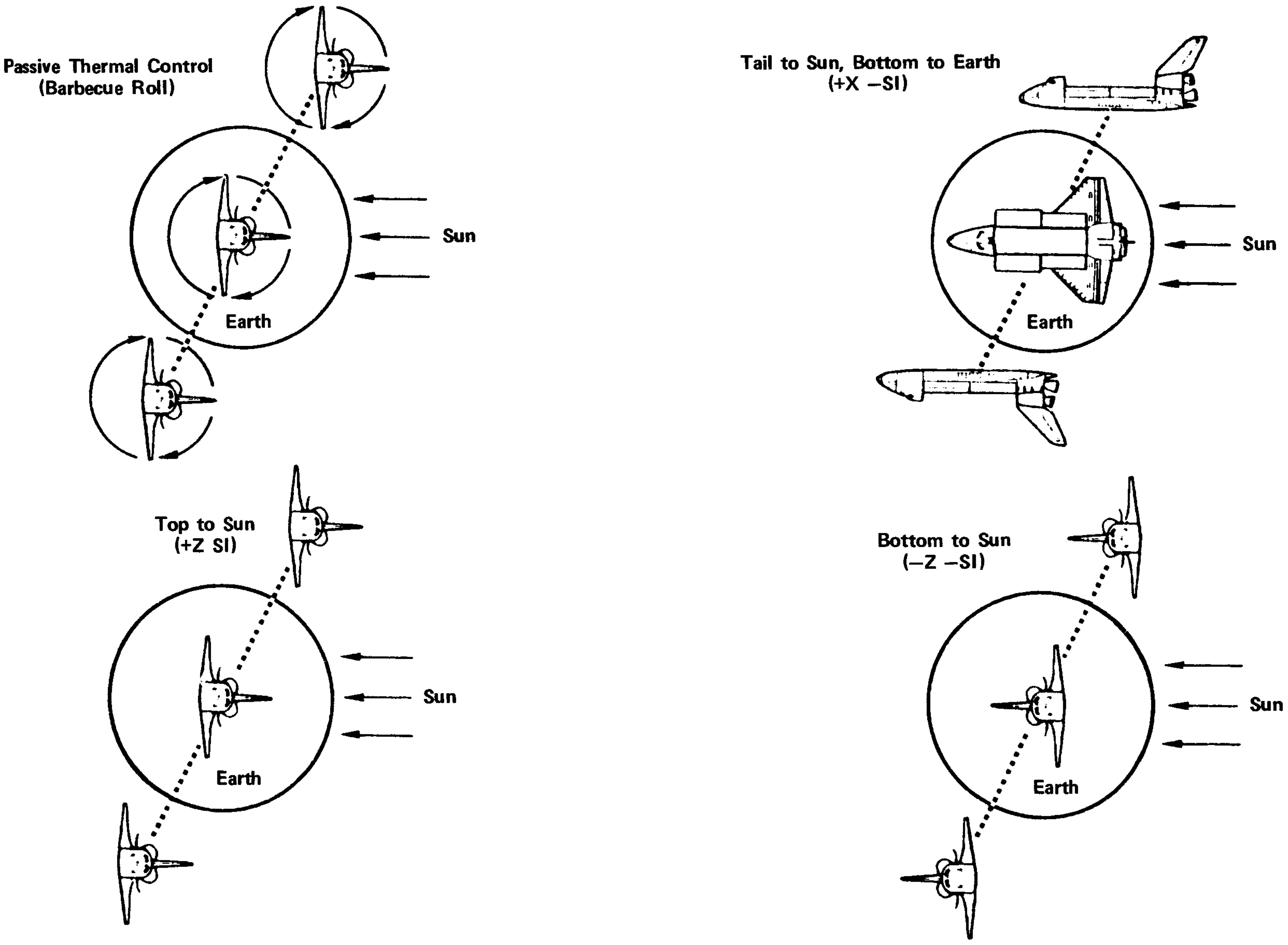
Crossrange: Less than 600 nautical miles (690 statute miles).

Autoland control mode: From MSBLS acquisition to approximately 762 meters (2,500 feet).

Runway: Edwards AFB, Calif., Lakebed runway 17 if crosswinds between 10 and 15 knots, otherwise concrete runway 22.

STS-4 MISSION OBJECTIVES

- Flutter boundary tests during ascent, elevon and rudder deflections
- Navigation base stability
- Payload bay liner performance
- Payload bay door alignment test
- Payload bay door cold case performance
- Payload bay door thermal gradient
- Radiator performance
- Main propulsion system inerting verification
- IECM (induced environment contamination monitor) mapping using RMS (remote manipulator system)
- Radiator surface inspection using RMS
- Unloaded RMS response to primary reaction control system (PRCS)
- Passive gravity gradient
- RCS plume flow field
- Forward RCS thermal soakback, pulse mode
- RCS thermal soakback
- Star tracker coldsoak
- Star tracker operation during H_2O (water) dump
- Primary RCS narrow deadband attitude hold
- On orbit TACAN (Tactical Air Navigation) test
- PRSD (power reactant storage distribution) stratification test at 15 percent level
- Backup orbital navigation
- S-Band and UHF patterns
- ACIP (Aerodynamic coefficient package) on orbit operation
- CFES (Continuous flow electrophoresis system) experiment
- NOSL (Night/Day Optical Survey of Lightning) experiment
- GAS (Get-away special) experiment
- VPC (Vapor phase compression) freezer heat exchanger dynamics for freezing samples
- Attitude hold response
- MLR (Monodisperse latex reactor) experiment
- Entry aero/structural tests
- Autoland demonstration to 762 meters (2,500 feet)
- Orbiter braking test on rollout. Demonstrate the minimum stopping distance of the orbiter on landing rollout using standard braking technique
- IECM gas release



Passive Thermal Control (Barbecue Roll)

Tail to Sun, Bottom to Earth (+X –SI)

Top to Sun (+Z SI)

Bottom to Sun (–Z –SI)

Orbiter Thermal Test Attitudes

ORBITAL THERMAL TEST ATTITUDES

The spacecraft may be maintained at any attitude in orbit–nose first (which looks right, like an airplane), tail first, broadside, and the bottom or top (payload) may face the earth or sun. The spacecraft is positioned according to needs of the payload or mission requirement. (In the direct sunlight, temperatures reach approximately 93°C (200 degrees F). In the shade they plunge to about minus 93°C (200 degrees F).

When the spacecraft has its bottom toward the sun, the payload bay remains entirely in the shade and subject to extreme cold. With the spacecraft payload bay facing the sun, the payload bay naturally is exposed to high heat.

The passive thermal control (PTC) mode is when the spacecraft rolls to equalize temperatures on all surfaces at any time required, especially before entry. This is referred to as a "barbecue mode."

	– Gravity Gradient (GG) free drift	1.9 hours
	– Plus Z Local Vertical (LV) Perpendicular to Orbital Plane (POP)	10.0 hours
	– Gravity Gradient	11.6 hours
*	– Passive Thermal Control (PTC)	11.4 hours
	– Top to sun (plus Z - SI (Solar Inertial))	3.4 hours
*	– Tail to sun (plus X - SI)	67.0 hours
*	– Bottom to sun (negative Z - SI)	33.1 hours
*	– PTC	11.1 hours

*Thermal Test Attitudes

CONTINUOUS FLOW ELECTROPHORESIS SYSTEM (CFES) EXPERIMENT

The continuous flow electrophoresis system experiment is a pharmaceutical producing device designed to demonstrate that pharmaceuticals of marketable purity can be produced in quantity in the zero gravity of space. This is the first of many steps leading to possible commercial operation in space of "space factories." It provides a processing system which can segregate biological samples using a separation process based on the relative motion of charged particles through an electric field (electrophoresis).

The U.S. materials processing in space (MPS) program is designed to accommodate applied research payloads on economically viable materials, technology, and industrial processes in space and is part of a pace processing applications program. It is hoped that this technology will develop products that cannot be produced on earth, or that can be improved greatly by being processed in space. NASA is confident that these payloads will advance new product technology and make significant contributions to American industry for many years.

On earth, people accept the pull of gravity and the atmosphere as essential elements in their existence. Weight is the balance between the earth's gravitational attraction and the centrifugal force caused by the earth's constant high-speed rotation. It is commonly thought of as a force pulling the body or object downward; we refer to it as a force of one-g at sea level. In space (earth orbit), the gravitational attraction of earth to an object is reduced as the object moves away from earth, while centrifugal force increases as it moves faster. In a stable orbit, the two forces equal and cancel each other. This is referred to as zero-g or weightlessness.

Until orbital space flights became possible, a zero-gravity environment could be produced only for very short periods in free fall. Drop towers, aircraft nose-overs, and sounding rocket coast periods could provide periods of zero or reduced gravity lasting from a few seconds to six minutes.

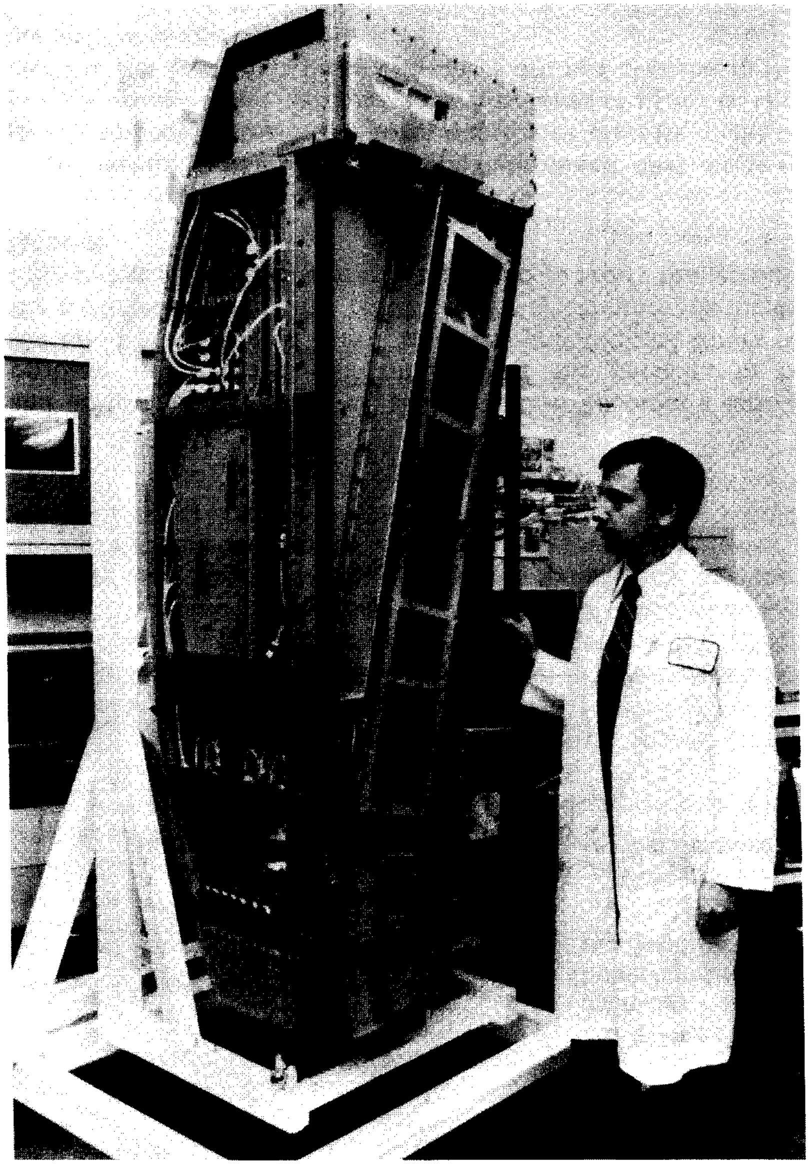
Gravity and the atmosphere often pose serious problems in the manufacturing of certain very important products. The space environment, with its zero gravity and almost perfect vacuum, offers interesting possibilities for large-scale manufacturing of products.

Space processing can provide advantages by lowering costs through the more efficient processing available in space. More frequently, it provides the capability for producing substances or devices that cannot be produced in the presence of gravity and an atmosphere.

Examples of the difference between earth and space environments are the effects of gravity on the processes of sedimentation and convection. An example of sedimentation is fruit gelatin dessert; the gelatin must be allowed to thicken to a certain extent before adding fruit or the fruit will settle to the bottom. Sedimentation is caused by the effect of gravity on mixtures of solid particles in liquids.

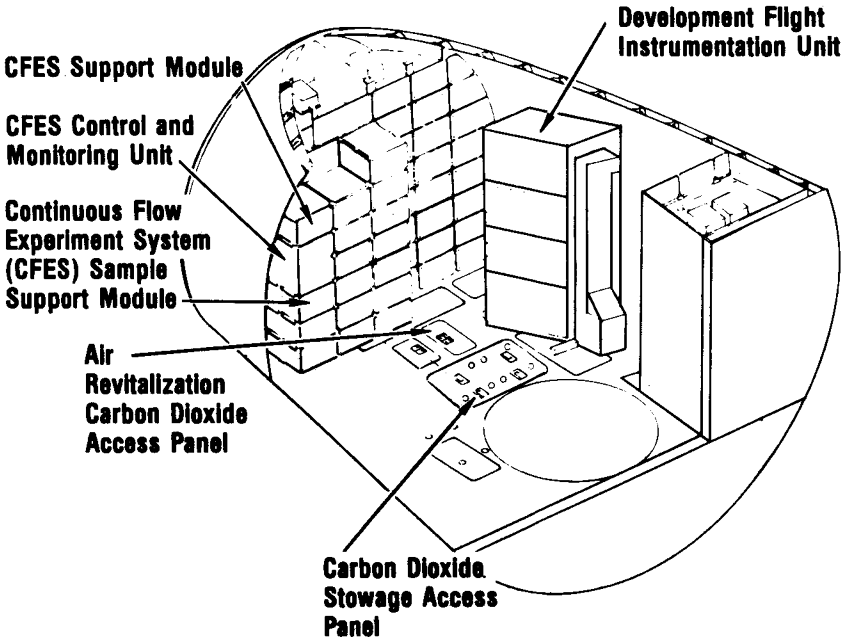
Convection is either the upward movement of part of a gas or liquid that is heated, or the downward movement of a gas or liquid that is cooled. It is caused by the difference in gravity force-weight or buoyancy—which occurs at different temperatures. Wind is an example of natural convection of the air; the currents observed in a heated glass pot of water is another example.

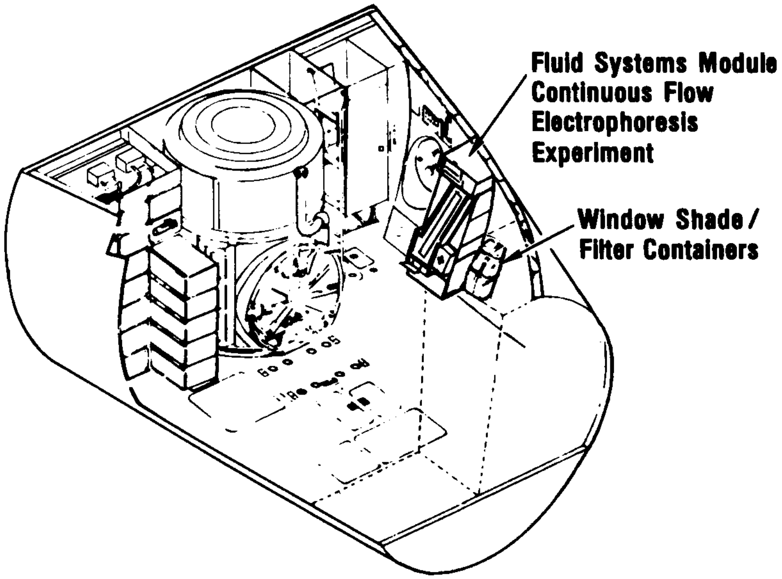
In space, sedimentation and convection are virtually absent. A liquid mixture containing materials of greatly differing densities can be solidified without the materials separating. Without convection, some parts of the liquid mixture will get much hotter or colder than on earth. This enables control of the way liquids solidify and thereby control of the product produced. The lack of gravitational forces in space also allows liquids to levitate, or float freely, so that processes can be conducted in space that are impossible on earth because the liquids to be processed would react with their containers.



Continuous flow electrophoresis system

CONTINUOUS FLOW ELECTROPHORESIS SYSTEM EXPERIMENT INSTALLATION IN ORBITER CREW COMPARTMENT MID DECK





In earth's one-g environment, it is almost impossible to process useful quantities of some pure biologicals (such as vaccines). Pharmaceutical companies are presently spending millions of dollars a year on research to improve biological processing. A method called electrophoresis may be used in zero-g to obtain quantities of highly superior, purer biological substances than those that can be produced on earth.

The electrophoresis method separates biological materials, such as human cells, by means of an electrical field (electrical voltage force). In zero-g, the cells will separate because each cell reacts in a different degree to the electrical field. Electrophoresis is not a new process. It has been widely used in blood and urine analysis. However, sedimentation becomes a serious problem in electrophoresis on earth if the particles to be separated are large and heavy, since the gravitational forces on the particles become large relative to the electrophoresis forces. Convection also causes currents that tend to remix the separate factions.

In recent years, scientists have determined that cures or greatly improved treatments for a number of diseases might be possible using certain cells, enzymes, hormones or proteins. One problem has been that these substances are not available in the quantity or purity needed.

In the electrophoresis process, gravity limits the concentration of starting material to be used and thus the output of the process itself. On earth the starting must be diluted to only about 0.1 percent by weight in order.for its density to equal that of the carrier fluid—a condition necessary for proper suspension and successful separation. In space, these concentrations can be increased to at least 10 percent and as high as 40 percent, and still remain suspended in the carrier fluid. This increased concentration means that an electrophoretic chamber in space could turn out 100 to 400 times as much as a chamber on the ground in the same length of time, thereby providing the premise that marketable quantities of the product can be obtained.

Processing in space offers the additional benefit of improved product purity. On earth, as the starting material separates into individual streams, gravity acts on the density differences between them and the carrier fluid. This phenomenon causes the streams to widen and overlap, which in turn limits the purity of the output product. Because this overlapping phenomenon does not occur as extensively in the microgravity of space, product purity will increase. Analysis indicate that product purity will increase by a factor of about five.

Extensive analytical and experimental work has been accomplished by a skilled team of engineers and scientists representing such disciplines as fluid dynamics, thermodynamics, microbiology, and biochemistry. They continued to develop improved laboratory electrophoresis units so that, by optimizing earth performance, they could understand the limitations of the process. When gravity effects are removed, they predict a significant improvement of the process and thus larger quantity and greater purity.

Thus, the start of space testing is the next step. In addition, the conceptual design of a precommercial space flight pilot plant has been initiated. Present plans call for pilot plant demonstration in 1985 or 1986. Maintaining this schedule could result in commercial operation in 1986 or 1987.

The electrophoresis program is the result of a unique joint endeavor agreement between McDonnell Douglas Corporation and NASA. In addition, McDonnell Douglas Corporation has an agreement with the Ortho Pharmaceutical Division of Johnson & Johnson to collaborate in studying the commercial feasibility of production in space.

McDonnell Douglas anticipates that following successful experimental work, approximately six more years would be necessary before commercial operations can begin; five years would encompass product research and development, space flights to verify technology and to demonstrate a scale-up pilot plant. The additional year is to obtain final Food and Drug Administration approvals.

In this flight, experiment runs will develop data related to electrophoresis separation of six (6) biological samples, each sample running for about ten minutes.

The CFES is comprised of three equipment modules in the orbiter crew compartment mid-deck.

The fluid systems module is installed in lieu of the galley location in the mid deck of the orbiter crew compartment. The fluid systems module contains all fluid systems associated with control of the electrophoretic process. The flow control/conditioning subsystem of the fluid systems module provides functional control of buffer and sample flow rates and system pressures, and is comprised of buffer pumps, flow thermal electronic cooling unit and internal cooling blower.

The buffer reservoir subsystem of the fluid system module provides a depletable supply of process buffer liquid, 35 liters (9.2 gallons) and also serves as a return loop waste tank and the other reservoir provides a fixed volume supply of process buffer 10 liters (2.6 gallons).

The separation column of the fluid system module provides the equipment item within which a sample stream of biological material is separated and contains the carrier buffer/sample separation flow chamber, electrode chambers, fluid supply manifold, sample fraction collection tubing bundle and instrumentation for sensing system parameters of temperature, pressure, differential pressures, and separation chamber voltage gradients.

The degassing subsystem of the fluid system module provides the removal of the hydrogen product of electrolysis generated within the cathode chamber of the separation column and is comprised of three membrane deaeration/degassing columns, vacuum systems, solenoid isolation valves, liquid sensors and a catalytic converter.

The fraction collecting subsystem of the fluid system module provides valving control of all effluent fractions from the separation column and the positioning control for sample cartridge collectors. The cartridge positioning mechanism is contained in a housing that isolates its interior from the interior of the fluid system module. A latched door on the front of the housing enclosure provides access for installing and removing sample collection cartridges for each separation run collection cycle.

The fluid system module structure is equipped with gasketing to contain liquids within the fluid systems module interior in the event of system leakage. The fluid system module interior tracks cabin pressurization profiles via air exchange through hydrophobic breather panels installed in the fluid systems module enclosure panels.

The sample storage module is a separate insulated enclosure mounted in the module locker area of the mid-deck equipped with a thermal electric cooling unit and shelving for stowing sample supply syringes and sample collection cartridges. The experiment command and monitoring module is a separate module from the fluid systems module located above the sample storage module, which provides autonomous control of the electrophoresis system and is comprised of dedicated experiment processor, power supplies computer peripherals, fusing, displays and electrophoresis to orbiter power interface connectors.

The flight crew will be required to operate the experiment twice during the early portion of the flight. Each operating time lasts approximately seven hours.

The total weight of all three modules and cables is 299 kilograms (660 pounds). The fluid system module is 1.8 meters (6 feet) in height and is 457 millimeters (18 inches) in width.

MONODISPERSE LATEX REACTOR (MLR) EXPERIMENT

The monodisperse latex reactor experiment flown on *Columbia* in STS-3 produced tiny plastic spheres successfully as planned. The experiment was designed to study the feasibility of making monodisperse (identical size) polystyrene latex microspheres which may have major medical and industrial research applications.

This process was discovered more than 30 years ago when Dr. J. W. Vanderhoff of Lehigh University was with Dow Chemical Company. However, since Vanderhoff discovered the process, they have been limited to a maximum size of two microns without using what chemists call "heroic measures" because gravity causes connection and other effects that limit the reaction to very small yields at great expense and effort. One micron is a millionth of a meter. One inch is 25,400 microns long.

In STS-3, the purpose of the experiment was to see whether near weightlessness in orbit would allow the polymerization reaction to continue without creaming, that is, to produce larger latex spheres without large, irregular masses of latex forming.

The examination of the product from the experiment in the STS-3 flight of *Columbia* shows that the theory was indeed correct and was 95 to 98 percent successful. Latex microspheres were made larger than scientists can produce on earth.

Possible applications for the spheres include calibrating the pores in human intestines in cancer research and the human eye in glaucoma research as a carrier of drugs and radioactive isotopes for treatment of cancerous tumors.

If there is a major difference in pores within healthy and tumor cells, then the latex microspheres could become missiles that would stick inside tumors but not healthy tissues, thus carrying a higher drug dose in malignant tissue.

The National Bureau of Standards has also indicated its interest in routine use of the beads as calibration standards in medical and scientific equipment.

Some of the material produced in the STS-3 flight of *Columbia* probably will be used as a seed in the STS-4 flight of *Columbia* to produce larger spheres, possibly up to 12 microns wide.

Each of the four reactor chambers in the experiment produced about 20 percent useable solids in the 100 cubic centimeters (almost a half-cup) of raw material, each had at the start. One chamber produced spheres that were 0.2 - 0.3 microns wide as a control to be compared with ground-based spheres. The others produced spheres about 3.5 4.5 and 5.5 - 6.0 microns wide. Even at the largest size, it would take more than 4,200 spheres to span an inch. The largest that can be produced on the ground are 2-3 microns wide "using nonheroic measures."

The experiment consists of four, 304 millimeter (12 inch) tall reactors, each containing a chemical latex forming recipe, housed in a 609 millimeter (24 inch) tall metal cylinder. The recipe is a suspension of very tiny (micron size) plastic beads in water or another liquid.

Prior to launch, each side of the reactors are loaded with 100-cubic centimeters (6.102 cubic inches) of the chemical latex-forming recipe. A small onboard computer will control the experiment after the flight crew turns it on in orbit. A recorder will store all data produced during operation of the experiment. After 14 hours, the experiment turns itself off.

The reactor is removed from the *Columbia* spacecraft at the landing site and returned to the experimenters for sample and data analysis. After a cleanup and refurbishment of the experiment hardware, it will be ready for another flight.

The MLR experiment is located in the crew compartment mid-deck. It occupies the space of three mid-deck stowage lockers. It requires electrical power from the spacecraft to maintain timing and provide intermittent stowing operations in orbit.

The principal investigator on the experiment is Dr. John W. Vanderhoff of Sehigh University. The three co-investigators are Drs. Fortunato J. Micale and Mohamed S. El-Aasser, of Lehigh University, and Dale Kornfield of the Marshall Space Flight Center, Huntsville, Ala.

Marshall Space Flight Center Materials Processing in Space Projects Office, is responsible for producing and testing the experiment.

Design support and integration of the experiment was provided by Rockwell International's Space Transportation and Systems Group, Downey, Calif. General Electric Company, Valley Forge, Penna. built the reactors.

NIGHT/DAY OPTICAL SURVEY OF LIGHTNING (NOSL)

NOSL will involve the orbiter flight crew in taking motion pictures and correlated photocell sensor signals of lightning and thunderstorm as seen from orbit. This experiment was flown on the STS-2 but due to the short duration of the mission, a limited amount of NOSL data was obtained. In order to gain additional weather data, NASA has scheduled the NOSL to fly on STS-6 as well.

The area of the Earth's surface in the view of the orbiting spacecraft is so large that lightning storms will probably be visible on almost every orbit. Because of the high speed of the orbiter, these storms will remain in view only a short time, just a few minutes for storms directly beneath the flight path, somewhat longer for storms off to either side.

During passage over the dark side of the Earth, observers in the orbiter will readily recognize nocturnal storms by their lightning flashes, which should be visible for hundreds of kilometers (miles). On the sunlit side of the Earth, the crew will recognize storms by their prior familiarization with the appearance of cumulonimbus clouds and associated anvils as viewed from above. An observer can also locate lightning storms by listening to the audio signal from the photocell detector in monitor mode (as radiation is located using a Geiger counter). The astronauts will also be sent meteorological information to alert them to possible storm locations.

When a target is in view, a crewmember will mount the camera so that it can photograph through the overhead window of the crew cabin. The tape recorder will be mounted on the aft bulkhead. Using both visual and audio clues, the observer will focus the camera on the target. The camera will film the lightning storm while audio signals corresponding to camera shutter pulses are recorded on one track of the stereo tape recorder and the photocell output is recorded on the other track.

The crew will use a motion picture camera to film the lightning flashes of nighttime thunderstorms. A diffraction grating will be attached to the camera lens during nighttime observations to provide lightning spectrographs, which can be used to determine the temperature, pressure, molecular species, electron density, and percent ionization in the lightning's path. During the day, lightning discharges will be delineated by a photo-optical system, which creates an audio pulse in response to the detection of a lightning flash. These pulses will be recorded on magnetic tape. A lightning event, which is visible as only one flash, is usually composed of many separate discharges, called strokes, which can be detected by the photocell. Thus, the photocell will also be used during the night to record lightning strokes. And the motion picture camera will be used during the day as well to film the cloud structure and the convective circulation in the storm. These techniques may be adaptable to identifying severe weather situations from meteorological satellites.

The NOSL equipment consists of the camera, the attached photocell sensor, and the connected tape recorder. During launch, boost, and reentry, this equipment will be secured in stowage lockers in the crew compartment. In orbit, the equipment will be retrieved and assembled for use in the crew cabin. Because it is both stowed and used in crew quarters, the NOSL apparatus has been designed to withstand the same pressure, temperature, humidity, and acceleration conditions that human beings can tolerate.

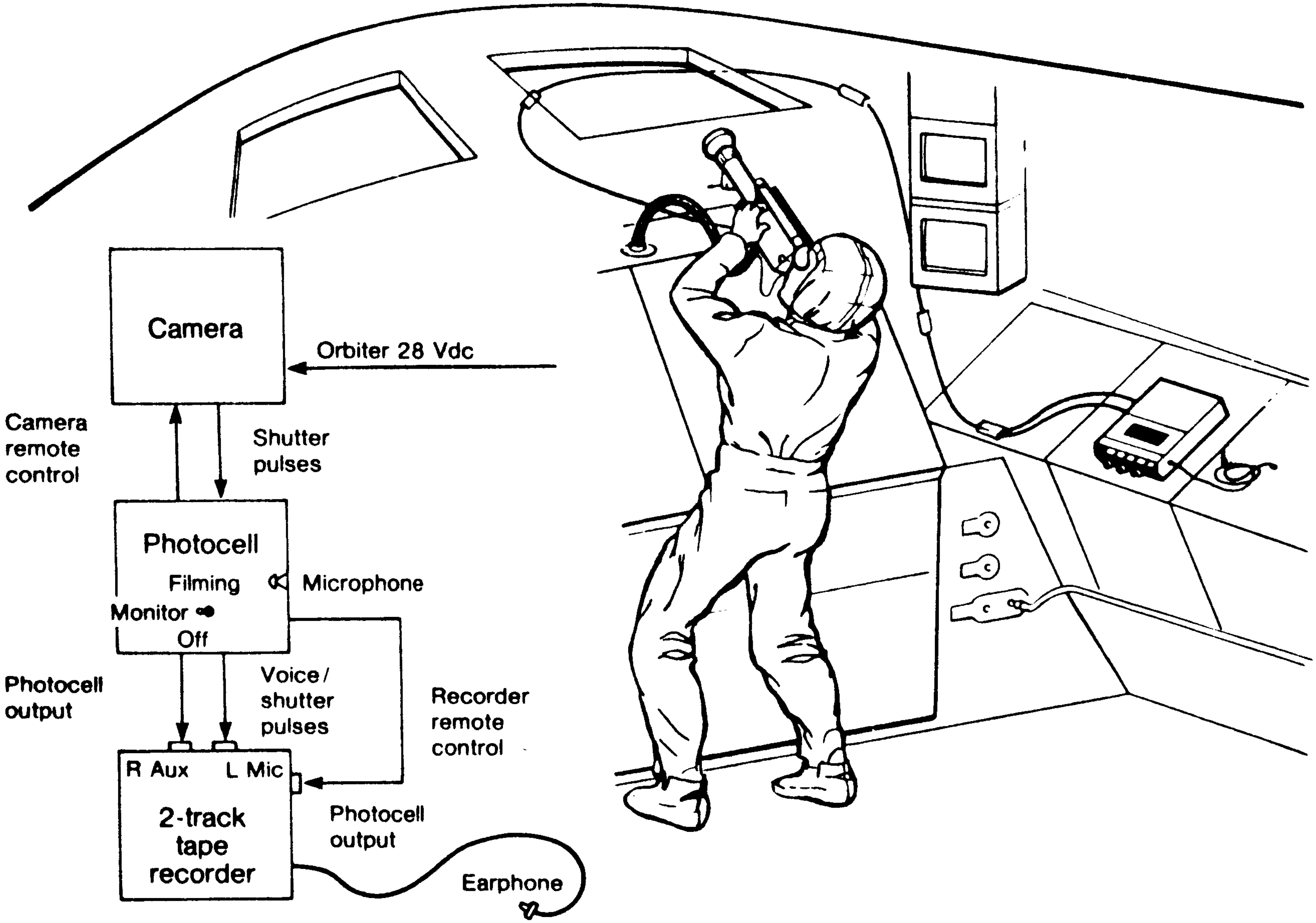
The motion picture camera is a 16-mm Data Acquisition Camera (DAC), a model which has been flight tested on Apollo and Skylab missions. The camera will run on 28 Vdc power supplied by the orbiter.

The photocell sensor is mounted on top of the camera, and its field of view is aligned with the camera's. The camera/sensor package is 40 centimeters (15 inches) long, 24 centimeters (9 inches) wide, and 20 centimeters (7 inches) high. The photocell/amplifier assembly contains its own battery power supply.

The stereo cassette tape recorder, 25 centimeters (9 inches) long, 18 centimeters (7 inches) wide, and 6 centimeters (2 inches) high, is a Sony TC 124, equipped with a plug-in earphone. The tape recorder interfaces with the photocell, which in turn interfaces with the camera, via connecting wires. The recorder is battery powered.

Twenty 42 meter (140 feet) film magazines, three 60-min. tape cassettes, and spare batteries will be kept in a stowage apron mounted on the crew cabin wall.

NIGHT/DAY OPTICAL SURVEY OF LIGHTNING (NOSL)



These are a few of the existing accounts of unusual lightning phenomena. It is interesting to note that the sophisticated scientific observer finds the phenomena quite as baffling as does the layman. There are few photographs of such lightning discharges, none taken from above the storm. We need photographic and quantitative data to come to understand lightning and thunderstorms. These data and resulting knowledge may lead to the development of systems providing early warning of severe storms. Experience from the Gemini, Apollo, Skylab, and Apollo-Soyuz missions indicates that an orbiting platform several hundred kilometers (miles) above the Earth affords a view of thunderstorms and lightning that cannot be equaled on the ground or from aircraft. Thus, the Night/Day Optical Survey of Lightning (NOSL) has been designed to fly on the Space Shuttle.

"I approached a vigorous, convective turret close to my altitude 32 kilometers (20 miles) that was illuminated from within by frequency lightning. The cloud had not yet formed an anvil. When I was about 9 or 19 kilometers (6 to 12 miles) away, I was surprised to see at about 5 degrees to the right of my course a bright lightning discharge, whitish-yellow in color, that came directly out of the center of the cloud at its apex and extended vertically upwards far above my altitude. The discharge was very nearly straight, like a beam of light, showing no tortuosity or branching. Its duration was greater than an ordinary lightning flash, perhaps as much as 5 seconds." Ronald Williams, U-2 pilot NASA Ames Research Center, 1973.

"There was a line of thunderstorms that I assume was associated with frontal activity. . . .I estimate that in 2 or 3 seconds the lightning would propagate out to cover the whole line, which was probably at least 200 or 300 kilometers (124 to 186 miles) long. If you assume that it started near the middle, it went 100 to 150 kilometers (62 to 93 miles) in a couple of seconds. . . ." Paul Weitz, Skylab 1, 1973.

The tornado "was accompanied by heavy rain and intense lightning of the most unusual nature. It was brightly colored in pink, red, yellow, and some green. At times, a flash would emit red balls of fire that arched down like fireworks displays. Sometimes 10 or 15 balls would be visible. The lightning was bright enough to shut off light-operated street lights almost continuously." Kenneth Noel, of nocturnal tornadoes in Huntsville, Ala., April 2, 1974.

"I saw this tremendous flash of green light. Now, this was like a green finger of light, a green column. It was surrounded by a real pale apple green coloration, and then that had around it somewhat of a lightish blue tinge and then from that a very, very light blue, almost like a halo." Otha H. Vaughan, Jr., of the same tornadoes. April 3, 1974.

The NOSL has been planned by Principal Investigator Bernard Vonnegut of the State University of New York at Albany and by Co-Investigators Otha H. Vaughan, Jr., of NASA's Marshall Space Flight Center and Marx Brooks of the New Mexico Institute of Mining and Technology. The equipment was developed by the Experiments Systems Division at the NASA Johnson Space Center.

BIOLOGICAL STUDENT EXPERIMENTS

Two teenage girls were named winners in a nationwide experiment contest sponsored by the National Science Teacher's Association for the STS-4 mission. Amy Kusske, 15, of Long Beach, Calif., and Karla Hauersperger, 17, of Charlotte, N.C., are the two winners.

Miss Hauersperger plans to check the effects of weightlessness on levels of trivalent chromium in the body and determine whether any alterations occur in chromium metabolism during space flight. Serum levels of insulin are known to change slightly during space flight and insulin helps control body use of carbohydrates. Chromium is also a cofactor (that is, a substance which must be present in low quantities for an enzyme to work) for insulin. The food which the crew eats will be recorded, and the chromium content determined by use of U.S. Department of Agriculture computerized reference values from flight minus seven days to launch. During flight the crew will record how much they eat of what foods. The crew levels of serum glucose, insulin, and chromium and urine chromium will be measured. Blood and urine samples will be collected from the crew during physical examinations around flight minus seven, two days and launch day. Approximately 10 drops more of blood are taken on these days as well as urine samples. Analysis of these samples will be done by the Johnson Space Center Biochemical Laboratories and the results will be provided to Karla for interpretation. Trivalent chromium will be determined by atomic absorption spectrophotometry.

Miss Kusske's experiment involves a careful study of the astronauts diet and exercise programs before, during and after the mission in an effort to determine the effect of prolonged weightlessness on lipoprotein levels in the body. The high density lipoprotiens that are the focus of her study could be viewed as cholesterol "scavengers" collecting and disposing of excess cholesterol in the blood. Blood samples will be used to study changes in lipoprotein profiles and, specifically whether the type of diet and exercises performed are sufficient to maintain the desired levels of high density lipoproteins in prolonged space missions such as, permanent space facilities in which people will be living for one or two years or perhaps longer in the future. Blood samples for lipoproteins levels are scheduled to be taken of the crew at aproximately thirty, ten, and two days before flight. The flight crew will keep an accurate daily diary of what is and is not consumed of their daily diet as well as their exercise program, including the duration of each exercise period. Following their return to earth, blood samples are drawn immediately after touchdown and again after seven days. The results of pre- and post-flight blood tests for lipoproteins will be compared for determining the adequacy of existing diet and exercise programs in maintaining the desired lipoprotein levels and possibly indicate where changes are needed to increase the health safety of astronauts during extended missions.

GETAWAY SPECIAL

The getaway special (GAS), officially titled small self contained payloads (SSCPS) is offered by NASA to provide anyone who wishes the opportunity to fly a small experiment aboard the Space Shuttle.

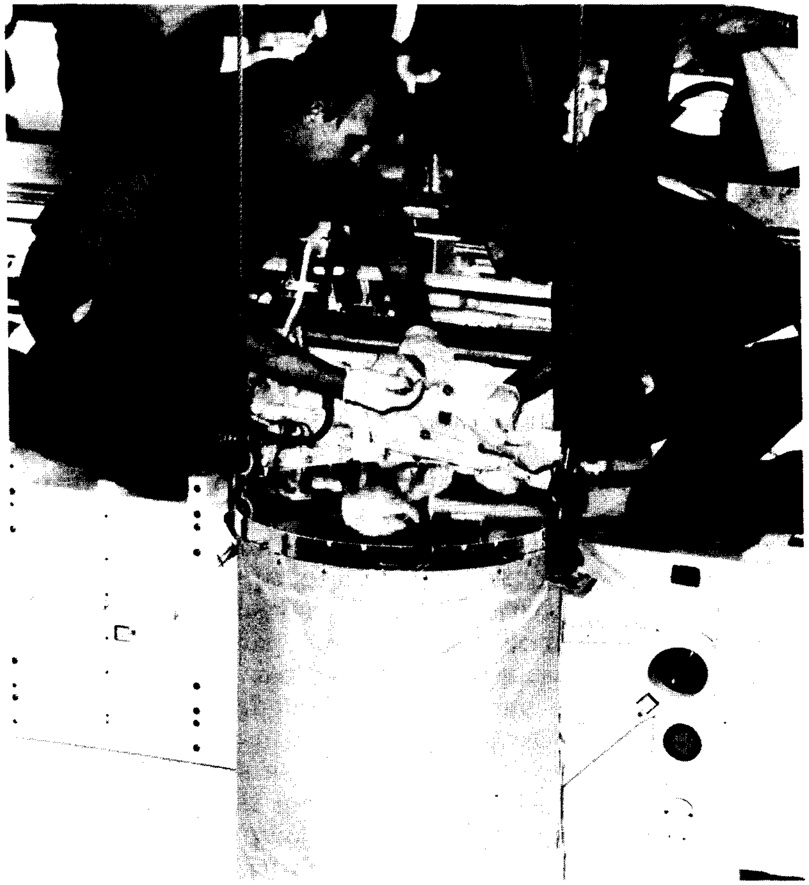
Since the offer was first announced in the fall of 1976, more than 326 GAS reservations have been made by over 197 individuals and groups. Payload spares have been reserved by several foreign governments and individuals; United States industrialists, foundations, high schools, colleges and universities; professional societies, service clubs and many others. Although many reservations have been obtained by persons and groups having an obvious interest in space research, a large number of spaces have been reserved by persons and organizations entirely outside the space community.

There are no stringent requirements to qualify for space flight, but the payload must meet safety criteria and must have a scientific or technological objective. It is noted, that a person who wishes to fly items of a commemorative nature, such as medallions for later resale as "objects that have flown in space" would be refused.

GAS requests must first be approved at NASA Headquarters, Washington, D.C. by the Director, Space Transportation Systems Utilization Office, Code OT6. It is at this point that requests for Space Shuttle space are screened for propriety, and scientific or technical aim. These requests must be accompanied or preceded by the payment of $500 earnest money.

Requests approved by the Space Transportation Systems Utilization Office are given a payload identification number and referred to the GAS Team at the Goddard Space Flight Center, Greenbelt, Maryland. The center has been designated the lead center or direct manager for the project.

The GAS Team screens the proposal for safety and provides advice and consultation for payload design. The GAS Team certifies that the proposed payload is safe, that it will not harm or interfere with the operations of the Space Shuttle, its crew,



Getaway special container in payload bay

or other experiments on the flight. If any physical testing must be done on the payload to answer safety questions prior to the launch, the expense of these tests must be borne by the customer.

In flight, the flight crew will turn on and off up to three payload switches, but there will be no opportunity for flight crew monitoring of GAS experiments, or any form of in-flight servicing.

The cost of this unique service will depend on the size and weight of the experiment; getaway specials of 90 kilograms (200 pounds) and 0.14 cubic meter (5 cubic feet) may be flown at a cost of $10,000; 45 kilograms (100 pounds) and 0.07 cubic meter (2.5 cubic feet) for $3,000, and 27 kilograms (60 pounds) and 0.07 cubic meter (2.5 cubic feet) at $3,000. These prices remain fixed for the first three years of Space Shuttle operations.

The GAS container provides for internal pressure which can be varied from near vacuum to about one atmosphere. The bottom and sides of the container are always thermally insulated and the top may be insulated or not depending on the specific experiment, an opening lid or one with a window may be required. These may be offered as additonal cost options.

The weight of the GAS container, experiment mounting plate and its attachment screws, and all hardware regularly supplied by NASA is not charged to the experimenter's weight allowance.

The GAS container is made of aluminum and the circular end plates are 15 millimeters (5/8 inch) thick aluminum. The bottom 76 millimeters (3 inches) of the container are reserved for NASA interface equipment such as command decoders and pressure regulating systems. The container is a pressure vessel capable of; evacuation prior to launch, or; evacuation during launch and repressurization during reentry, or; maintaining about one atmosphere pressure at all times; evacuation and repressurization during orbit as provided by the experimenter. The experimenters payload envelopes in the 0.14 cubic meter (5 cubic feet) container are 501 millimeters (19.95 inches) in diameter and 717 millimeters (28.25 inches) in length. The payload envelope in the 0.07 cubic meter (2.5 cubic feet) container are 501 millimeters (19.95 inches) in diameter and 358 millimeters (14.13 inches) in length.

The GAS program is managed by the Goddard Space Flight Center. Project manager is James S. Barrowman. Clarke Prouty, also of Goddard, is technical liaison officer, and queries can be addressed to him at Code 741, Goddard Space Flight Center, Greenbelt, Md., 20771. Program manager at NASA Headquarters, Washington, D.C. is Donna S. Miller.

The first GAS payload on STS-4 consists of nine educational payloads sponsored and purchased by R. Gilbert Moore in 1976, an adjunct professor of physics at Utah State. All nine experiments will be contained in the one 0.14 cubic meter (5 cubic foot) container.

DROSOPHILIA MELANOGASTER (FRUIT FLY) GROWTH EXPERIMENT

This experiment is designed to provide a means of raising and separating succeeding generations of fruit flies in orbit to study the effects of micro-gravity on their genetic structure. This will be a test of equipment that is proposed to be flown on the Long Duration Exposure Facility (LDEF).

The student investigator is Walt L. Moore, HDR Sciences Co., Santa Barbara, Calif.

ARTEMIA (BRINE SHRIMP) GROWTH EXPERIMENT

The brine shrimp will determine the genetic effects of micro-gravity on cysts hatched in space. Cysts will be injected into a saline solution upon experiment activation. The growing shrimp called nauplii, will be observed by a camera in flight. Powdered rice hulls will be fed to the shrimp by a linear actuator. The shrimp will be studied post-flight by means of electron microcopy.

The student investigator is Bruce W. Moore, Weber State College, Ogden, Utah.

SURFACE TENSION EXPERIMENT

This experiment is to study the shape of a liquid meniscus in a weightlessness environment. An aluminum block contains several holes filled with solder. Upon entering weightlessness, the block is heated, allowing the solder to flow and assume a meniscus (crescent-like) shape. The block is allowed to cool "freezing" the meniscus when the solder solidifies.

The student investigator is James Elwell, Utah State University, Ogden, Utah.

COMPOSITE CURING EXPERIMENT

This experiment will test the effect of micro-gravity on construction materials by sending up a partially cured mixture of epoxy resin-graphite composite strips. This study will complete the cure of a B-staged (partially cured) epoxy resin-graphite composite sample in micro-gravity. The composite sample will be heated to 163 degrees Celsius (325°F) and maintained at that temperature for one–half hour to allow the resin to gel. The flight sample will be compared with samples processed in one "g", and post flight laboratory analysis will determine the quality of wetting between the resin and graphite fibers and test the tensile strength of the sample.

The student investigator is Amber M. Dalley, Utah State University, Ogden, Utah.

THERMAL CONDUCTIVITY EXPERIMENT

An oil and water mixture in a one "g" environment will separate due to the density difference. The goal of the experiment is to carry oil and water into orbit and mix the two, then heat the mixture with a platinum wire. Temperatures of the heater wire, the mixture, and the air around the cylinder will be monitored. Ultimately, the thermal conductivity of the mixture will be calculated from the data.

The student investigator is Russel R. Laker, Utah State University, Ogden, Utah.

MICRO-GRAVITY SOLDERING EXPERIMENT

Another construction method is the micro-gravity soldering experiment which studies the separation of flux from solder while soldering in weightlessness. The lack of buoyancy in a non-accelerating environment could allow pockets of flux to become trapped in the solder. The experiment will melt samples of resin core and coreless solder on four heated copper foils. When the experiment is returned, the solder will be analyzed for trapped pockets of flux and compared with solder similarly processed on earth.

The student investigator is G. Christian Alford, Utah State University, Ogden, Utah.

ROOT GROWTH OF LEMNA MINOR L. (DUCKWEED) IN MICRO-GRAVITY

This experiment will photograph using a camera the root growth patterns of Duckweed. The investigation centers on the nutrient transport role played by sieve tubes in the plants' roots in response to the force of gravity in earth-grown specimens. The plants will be injected with a fixing agent before experiment deactivation. Electron microscopy will be used to compare control and flight specimens.

The student investigator is Kelly D. Hunt, Utah State University, Ogden, Utah.

HOMOGENOUS ALLOY EXPERIMENT

A metals experiment, this study will attempt to make an alloy out of two metals that won't melt together on earth due to gravity.

An aluminum chamber containing a powdered bismuth-tin mixture will be placed in the "GAS." The chamber will be heated, passing the melting points of the chemicals and allow alloying to take place. The chamber will cool down and the alloy will be returned for earth-based analysis.

The student investigator is Terrance L. Thomas, Utah State University, Ogden, Utah.

ALGAL MICRO-GRAVITY BIOASSAY EXPERIMENT

The goal of this experiment is to monitor the growth rate of Chlorella vulgaris, a unicellular green algae, in micro-gravity. Upon experiment activation, a freeze-dried sample of algae will be injected into the media-filled growth chamber. Over the duration of the experiment the culture optical density and temperature will be measured. Near the end of this experiment, a fixative will be injected into the chamber preserving the cells for post-flight analysis. Such algae could possibly be used as a source of oxygen on future space missions.

PAYLOAD ACTUATION AND CONTROL SYSTEM (PACS)

The payload actuation and control system is comprised of a computer recorder and microprocessor unit that will control all activity inside the GAS canister. It was designed by James Elwell a recent Utah State electrical engineering graduate, Brigham City, Utah.

PROJECT COORDINATION AND FACULTY ADVISOR

Utah State graduate student David Yoel is project coordinator and the faculty advisor is Rex Megill. David Yoel is from Highland Heights, Ohio.

CARGO BAY STORAGE ASSEMBLY (CBSA)

The Cargo Bay Storage Assembly contains miscellaneous tools for use in the payload bay. It is located on the starboard (right) side of the payload bay forward of the OSS-1 pallet between Orbiter Station $X_O = 636$ and $X_O = 693$.

The CBSA is approximately 1066 millimeters (42 inches) wide, 609 millimeters (24 inches) in depth and 914 millimeters (36 inches) in height. The CBSA weight is 259 kilograms (573 pounds).

ORBITER EXPERIMENTS

ORBITER EXPERIMENT (OEX) SUPPORT SYSTEMS

The support system for the orbiter experiments was developed to record the data obtained by such experiments and to provide time correlation for the recorded data. The information obtained through the sensors of the OEX instruments must be recorded during the orbiter mission because there will be no real-time or delayed downlink of OEX data. In addition, the analog data produced by certain instruments must be digitized for recording.

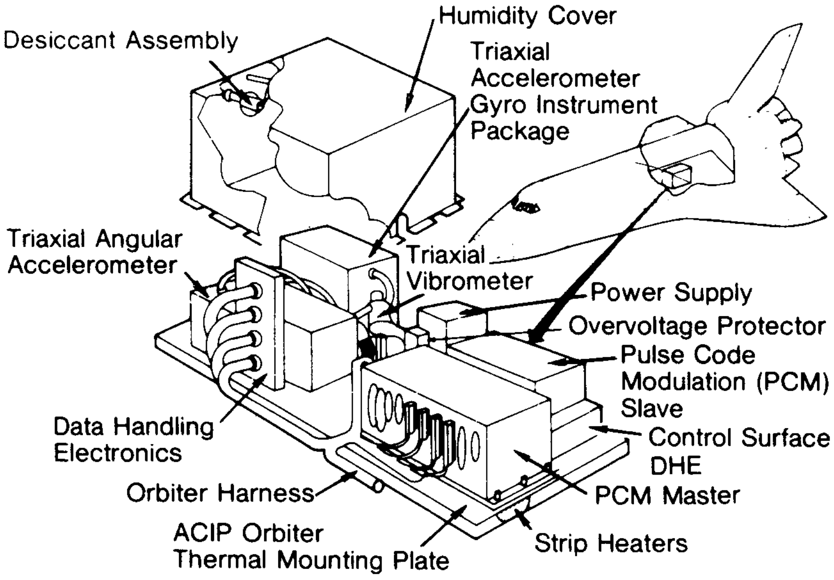
The support system for the OEX consists of five packages: the OEX recorder, the interface control module (ICM), and the pulse code modulation (PCM) master, PCM slave, and data hand handling electronics (DHE) package. The ICM is the primary interface between the OEX recorder and the experiment instruments and between the recorder and the orbiter subsystems. The ICM transmits operating commands from the orbiter MDM to the instruments and controls the operation of the recorder to correspond to the instrument operation. Time signals will be received by the ICM from the orbiter timing buffer, converted to a frequency-modulated signal, and transmitted to the recorder to provide the time information needed. The recorder will carry 2804 meters (9200 feet) of magnetic tape that will permit up to two hours of recording time at the rate of 38 millimeters (15 inches) per second. After the return of the spacecraft, the data tape will be played back for recording on a ground system. The tape will not usually be removed from the spacecraft.

AERODYNAMIC COEFFICIENT IDENTIFICATION PACKAGE (ACIP)

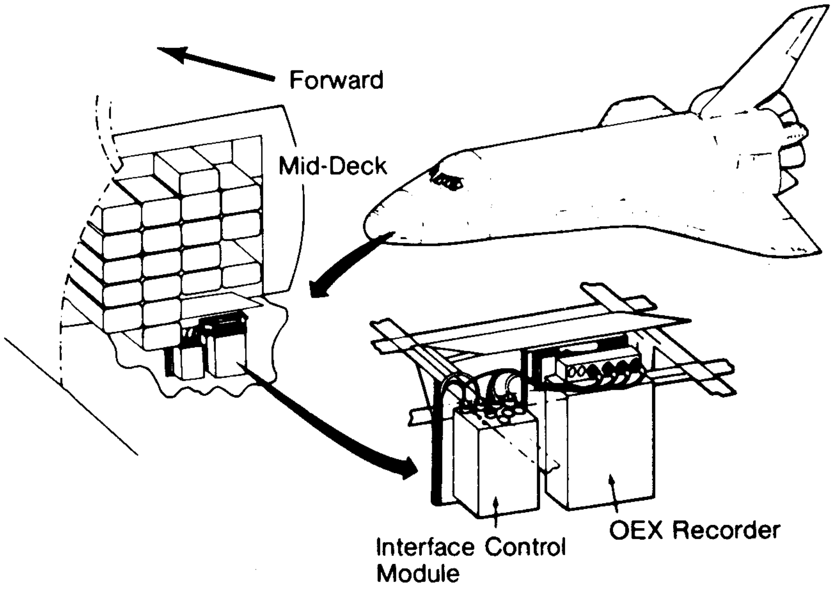
The ACIP is a sensor package installed below the payload bay area in the aft area of the mid-fuselage at station $X_0 1069$. It contains a rate gyro package, a linear accelerometer package, an angular accelerometer package, and associated electronics.

The ACIP will collect aerodynamic data in the hypersonic, supersonic, and transonic flight regimes, regions in which there has been little opportunity for gathering and accumulating practical data, to establish an extensive aerodynamic data base for verification of and correlation with ground-based test data including assessments of the uncertainties in such data. In addition, it will provide flight dynamics state and variable data in support of other technology areas, such as aerothermal and structural dynamics.

The implementation of the ACIP will benefit the Space Shuttle because the more precise data obtainable through the ACIP will enable earlier attainment of the full operational capability of the Space Shuttle. Currently installed instrumentation provides data that is sufficiently precise for spacecraft operations but not for research. The result is that constraint removal would either be based on less substantive data or would require a long-term program of gathering less accurate data.



Aerodynamic Coefficient Identification Package (ACIP) Experiment



ACIP Experiment

Although all of the generic types of data required for aerodynamic parameter identification are available from the baseline spacecraft systems, the data is not suitable for experimentation due to such factors as sample rate deficiencies, sensor ranges too large for bit resolutions, or computer cycle time/core size interactions. In addition, the baseline data compromises operational measurements and is not subject to the desired changes required for experiments. The ACIP places a sensor package on the spacecraft to obtain experiment measurements that are not available through the baseline system.

The ACIP incorporates three triaxial instruments: one of dual-range linear accelerometers, one of angular accelerometers, and one of rate gyros. Also included are the power conditioner for the gyros, the power control system, and the housekeeping components for the instruments. The ACIP is aligned to the orbiter axes to a very high order of accuracy. Mounted on the ACIP base is a triaxial vibrometer which will provide the structural vibration characteristics of the orbiter affecting the ACIP experiment necessary for baseline filtration of accelerometer data. The output signals of the instruments are recorded on the OEX tape recorder. The ACIP operates through launch and through the entry and descent phases. The internal instruments continuously sense the dynamic and performance characteristics of the orbiter through these critical flight phases. In addition, the ACIP receives indications of position of the control surfaces and converts them into higher orders of precision before recording them with the attitude data. Power is supplied from the mid-power control assembly 3 main bus C. Heaters are employed on the package and controlled by a switch on panel R11.

Weight of the ACIP is 119 kilograms (262 pounds). The principal technologist for the experiment is David Howes of NASA's Johnson Space Center.

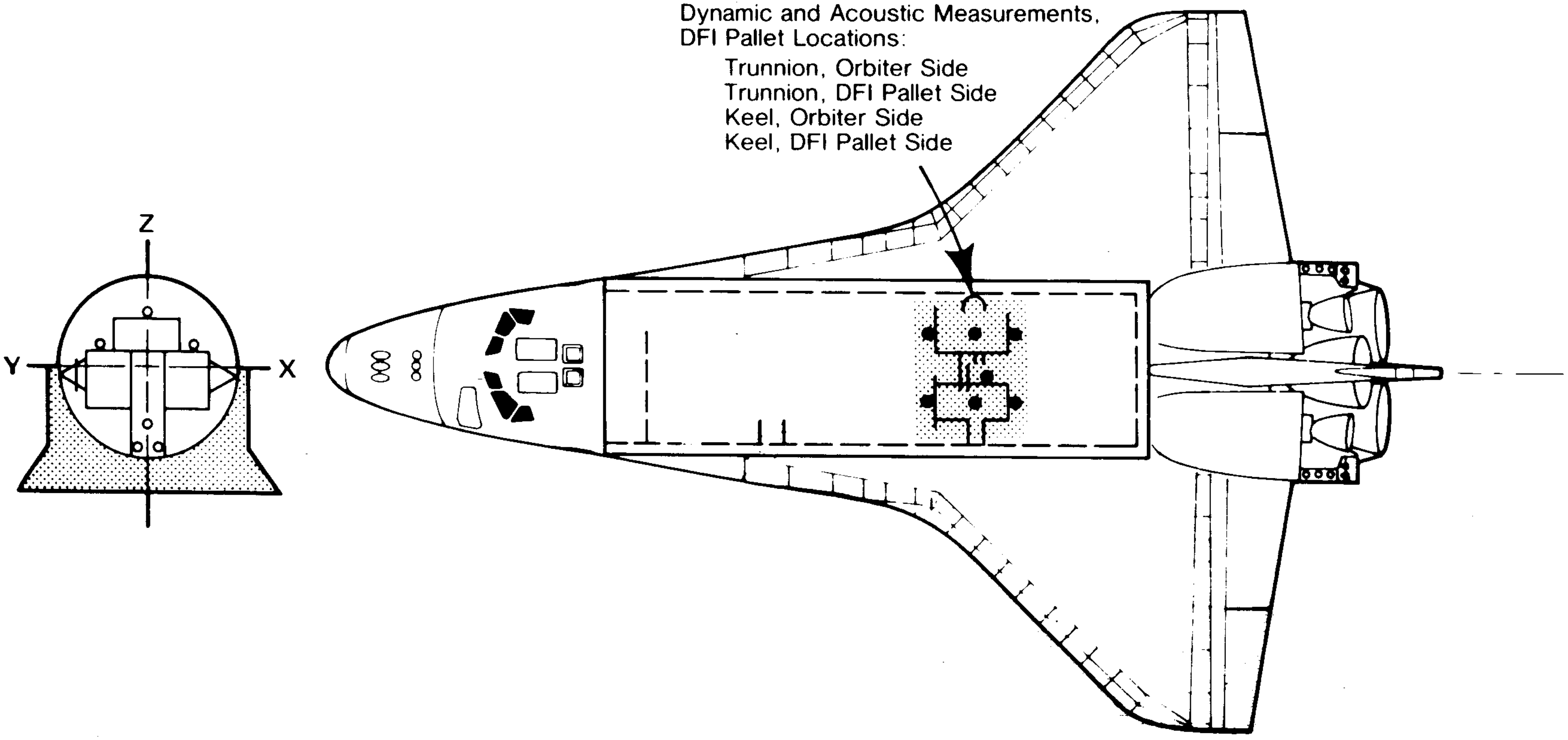
DYNAMICS, ACOUSTIC, AND THERMAL ENVIRONMENT (DATE)

The DATE exeriment is to acquire environmental response and input data for prediction of environments for future payloads. The environments are neither constant nor consistent throughout the payload bay and are influenced by interactions among cargo elements.

The DATE experiment consists of accelerometers and force gauges (for dynamic influences), microphones (for vibra-acoustic effects), and thermal sensors. These devices will be installed on both payload components and carrying structure (pallet, shelf, etc.). DATE has no commands or telemetry interfaces. This data is recorded on the OEX recorder whenever the recorder is on.

INDUCED ENVIRONMENT CONTAMINATION MONITOR (IECM)

Measurements of the Space Shuttle environment are needed to verify that contamination associated with the Space Shuttle will not interfere with the gathering of data during flight.



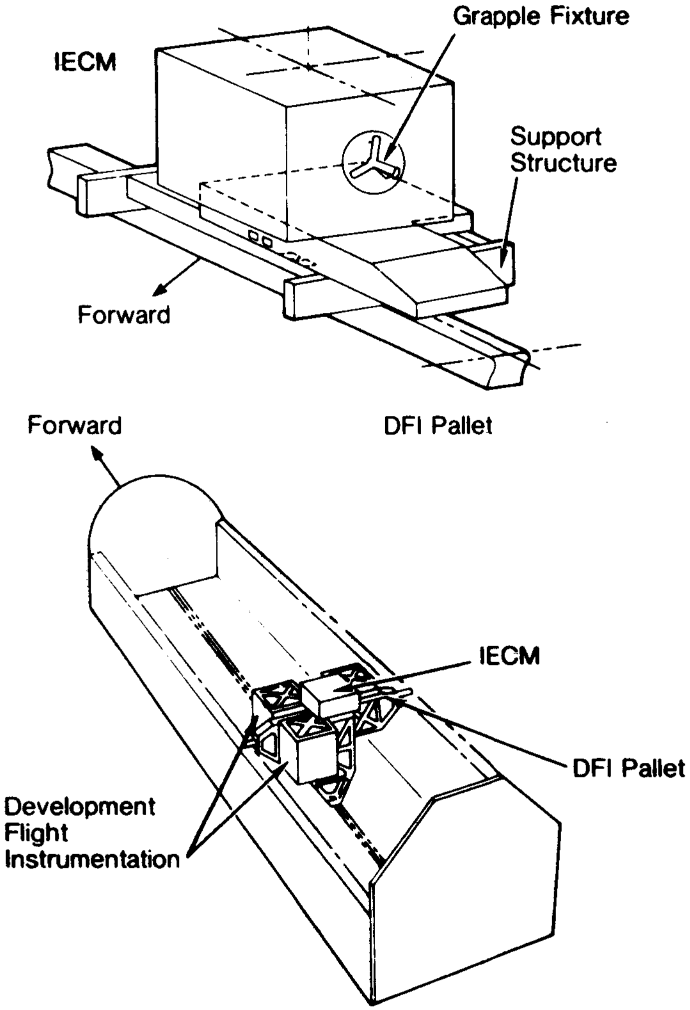
Dynamics, Acoustic, and Thermal Environment (DATE) Experiment

Definition of the Space Shuttle contamination environment will help in finding solutions to contaminant problems that may possibly arise during the Space Shuttle operational phase.

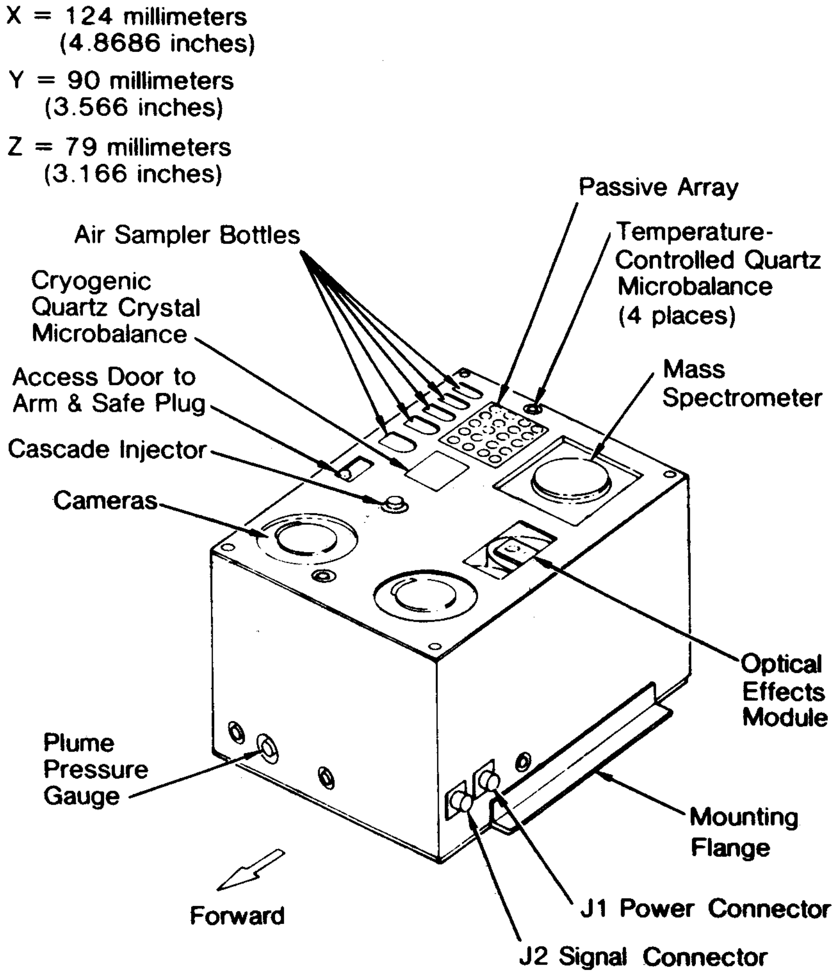
Data from the IECM in the STS-1 flight indicates that the IECM could clearly identify each type of contamination-producing orbiter activity, although the brevity of the 54-hour mission provided insufficient time to evaluate the potential breadth of contamination.

In addition, the results of STS-1 showed: humidity levels remained low in the cargo bay diving ascent and descent; particulate matter of sizes greater than five micrometers were relatively absent from the cargo bay, but particles less than five micrometers exceeded expectations; and the cargo bay was successfully sealed from engine by-products during liftoff and ascent. The flight data also indicated: water molecules and other early-mission contaminants began boiling off rapidly and there was a 90-percent reduction after approximately 35 hours in orbit; other data indicated that when the spacecraft's attitude control system is used, or a water dump is made, a temporary "cloud" of particles is generated.

Measurements of the contamination environment will be made using the integrated set of instruments designated as the IECM.



Induced Environment Contamination Monitor (IECM)



IECM Location

The IECM will measure and record concentration levels of gases and particulate contamination emitted by the Space Shuttle during all phases of the mission.

The IECM is self-contained aluminum unit and contains ten instruments and supporting systems mounted on the Development Flight Instrument (DFI) unit. The IECM weighs 360 kilograms (793.9 pounds). The instruments are: humidity monitor, dew point hygrometers, air sampler, cascade impactor, passive sample array, optical effects module, temperature controlled quartz crystal microbalance, cryogenic quartz crystal microbalance, camera/photometer, and mass spectrometer and gas.

The IECM has an internal battery for launch/deorbit and utilizes orbiter 28-Vdc power in orbit. The IECM is passively cooled via structural baffles and warmed by 28-Vdc electrical heaters. The IECM self-contained tape recorder is automatically controlled by the data acquisition control system.

The humidity monitor is in operation during prelaunch through launch, and during entry and landing. It measures the relative humidity from 0 to 70°C (32 to 158°F). An oscillator varies the frequency as a function of the amount of water present.

Dew point hygrometer is in operation during prelaunch, through launch, and entry and landing. It measures the dew point of the air surrounding the monitor. A mirror is cooled until condensation begins and a thermistor on a mirror provides the data.

Air sampler consists of five bottles. Two are open for one minute at launch. One opens for a short period after solid rocket booster staging. The remaining two are opened for a period during entry. The requirements are generally categorized into three groups: ground based sampling to detect the presence of organic and silicone polymers (such as hydraulic fluids and lubricants, paints and adhesives) which is of the most concern: ascent when the primary interest is in hydrochloric acid from the solid rocket booster plume as well as hydrocarbons and silicones; descent, when the gaseous sources of greatest concern are expected to be nitrogen compounds from the auxiliary power unit exhaust and other products from entry effects on the adhesives for the TPS (hydrocarbons and silicones can also be sampled during descent).

Cascade impactor operates before and throughout the mission. A quartz crystal microbalance system measures the concentration and particle size distribution of contaminants. The data rate varies by mission phase, such as one per minute during orbit.

Passive sample array consists of 48 optical samples which are exposed to the Space Shuttle environment throughout the mission.

The optical effects module measures light transmission and scattering sequentially on six optical samples mounted on a carousel exposed to the payload bay. Data is taken on each sample approximately every nine and one-half minutes.

Temperature controlled quartz crystal microbalances measure the amount of molecular contamination deposited on a crystal sensor periodically at various temperatures. There are five sensors, one on each of the exposed sides of the IECM. Between each data take, sensor temperature is raised to clean off deposited material. It takes 10 hours to run through a complete sequence in orbit.

The cryogenic quartz crystal microbalance measures the amount of molecular contamination deposited on the crystal sensor, plus Z only. This is similar to the temperature-controlled microbalance but uses passive radiative detector cooling.

The camera/photometer makes optical measurements of induced particulate environment and background brightness. It uses two 16 millimeter Bolex movie cameras, 24 frames per hour.

The mass spectrometer and gas identify the off-gassing and out-gassing molecules in the payload bay and define the gas cloud through which optical experiments must look. It is activated by the flight crew via the IECM switch on the flight deck display and control panel, R11. It analyzes a series of mass groups of data taken every scan, then idles for five minutes between scans. It is calibrated by gas release.

The IECM operations prelaunch uplink ascent mode multiplexer/demultiplexer resets commands and configures the IECM for ascent mode processing. The T-O disconnect initiates mode processing and at T-O plus 150 seconds completes ascent mode processing.

In this flight, the IECM will monitor for contamination in place on the DFI in the payload bay and will be deployed using the RMS to allow a contamination/plume survey of the payload capture area. The RMS end effector will engage and latch onto the IECM grapple fixture and the IECM will then be released from the DFI. The RMS will position the IECM to various locations and the IECM measures the contamination flow field. This will be accomplished with reaction control system engine thrusting periods for a minimum of 80 milliseconds and without RCS engine thrusting periods in addition to operating and not operating the flash evaporator system.

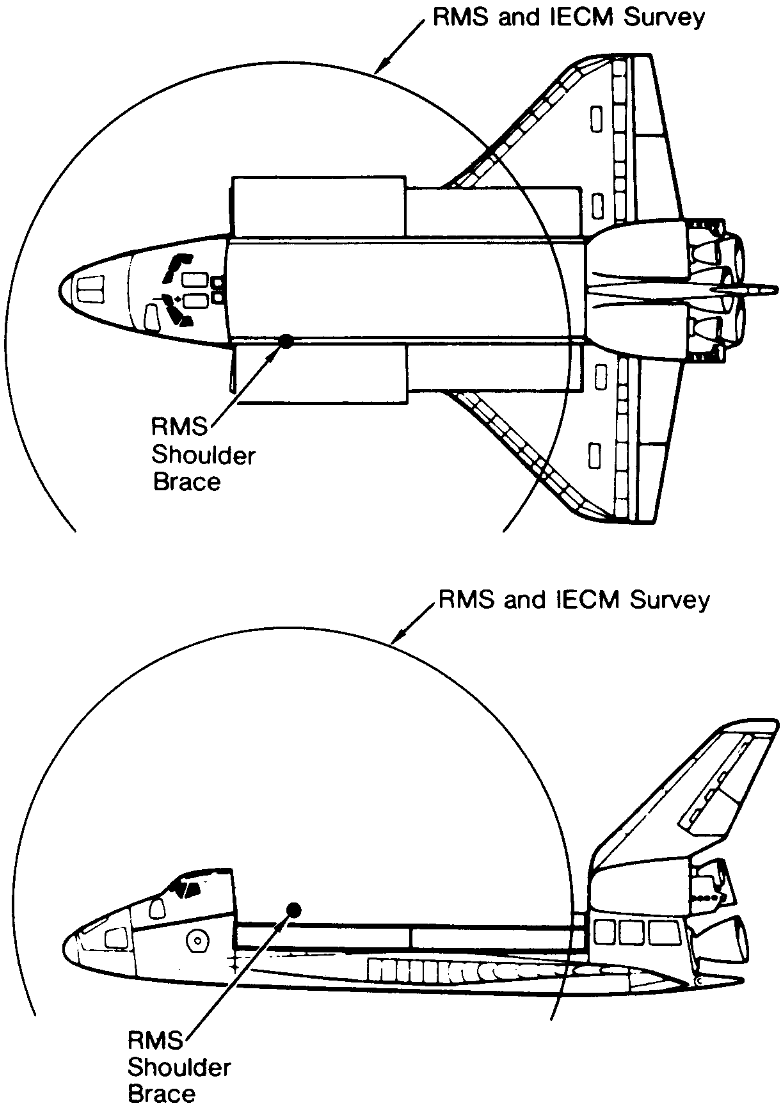
In orbit the IECM uplink orbit mode multiplexer/demultiplexer reset command initiates orbit mode processing. One to two hours after payload bay door opening on orbit 1 or 2, the IECM switch on panel R11 is moved to position 1, and the mass spectrometer is on low bit rate. At a convenient time the IECM switch on panel R11 is moved to position 2, and starts gas release and the mass spectrometer is on high bit rate. After 45 minutes, the IECM switch panel R11 is positioned to 1, and the mass spectrometer is on low bit rate. Fifteen to 45 minutes prior to final payload bay door closure, the IECM switch on panel R11 is positioned to 2, and the mass spectrometer is off. The uplink deorbit mode multiplexer/demultiplexer reset command configures the IECM for the deorbit mode.

THERMAL PROTECTION SYSTEM (TPS)

The TPS experiment is subdivided into two groups: scorched filler bar data acquisition and catalytic surface effects. These experiments will provide a better understanding of TPS heating phenomena which could lead to a TPS with greater reusability.

Scorched Filler Bar Data Acquisition: This experiment will evaluate the effects of the tile gap and step height geometry on the spacecraft TPS inter-tile gap convective heating. This panel will fly in place of the tile gap heating effects experiment.

This experiment will provide basic thermal data on the



IECM Contamination Data Points Using RMS effects of varying step heights and gaps on gap heating during entry. The experiment consists of a removable carrier panel with 11 TPS tiles of baseline material located on the underside of the spacecraft fuselage. Measurements through the tiles and in the gaps will provide temperature data during entry. This experiment will provide flight data on the effects of gap and step height variances on entry heating.

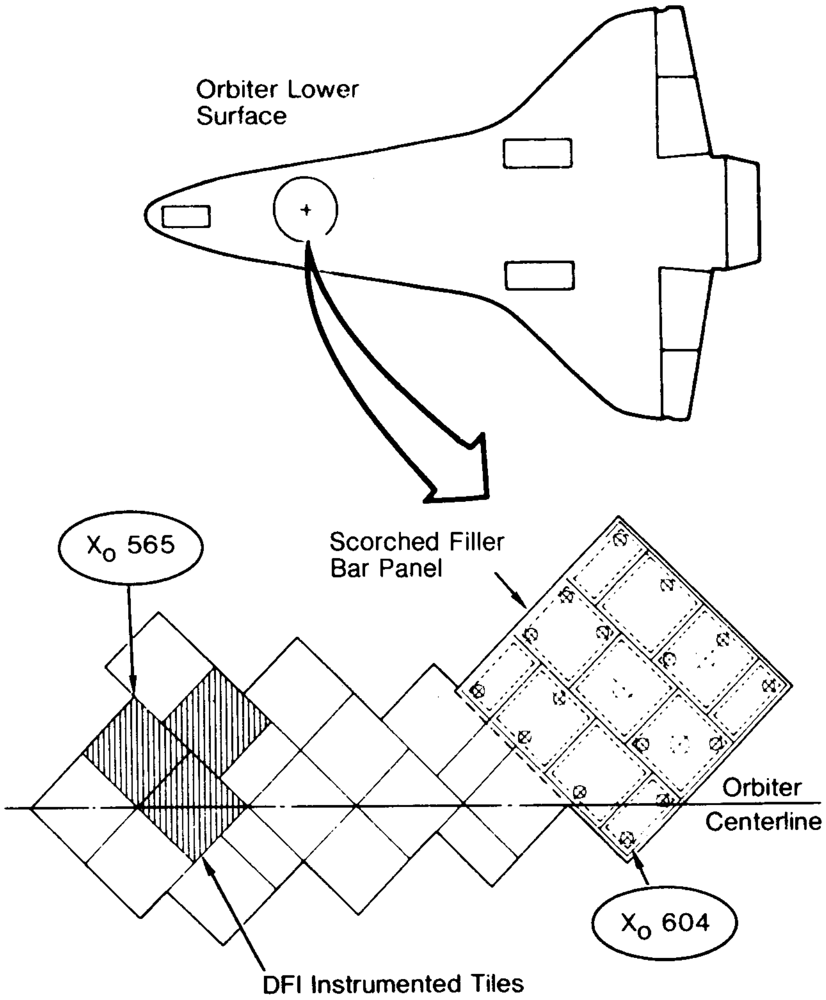
The scorched filler bar panel of the tile gap heating experiment will be conducted jointly by William Pitts of NASA Ames Research Center and Robert Dotts of NASA Johnson Space Center.

Catalytic Surface Effects. This experiment will verify predictions of the effects of surface catalytic efficiency on convective heating rates. Indications from analyses and ground test are that the design criteria for the spacecraft TPS may be overly conservative because surface catalytic efficiency was not included. To obtain flight data for comparison, this experiment was proposed.

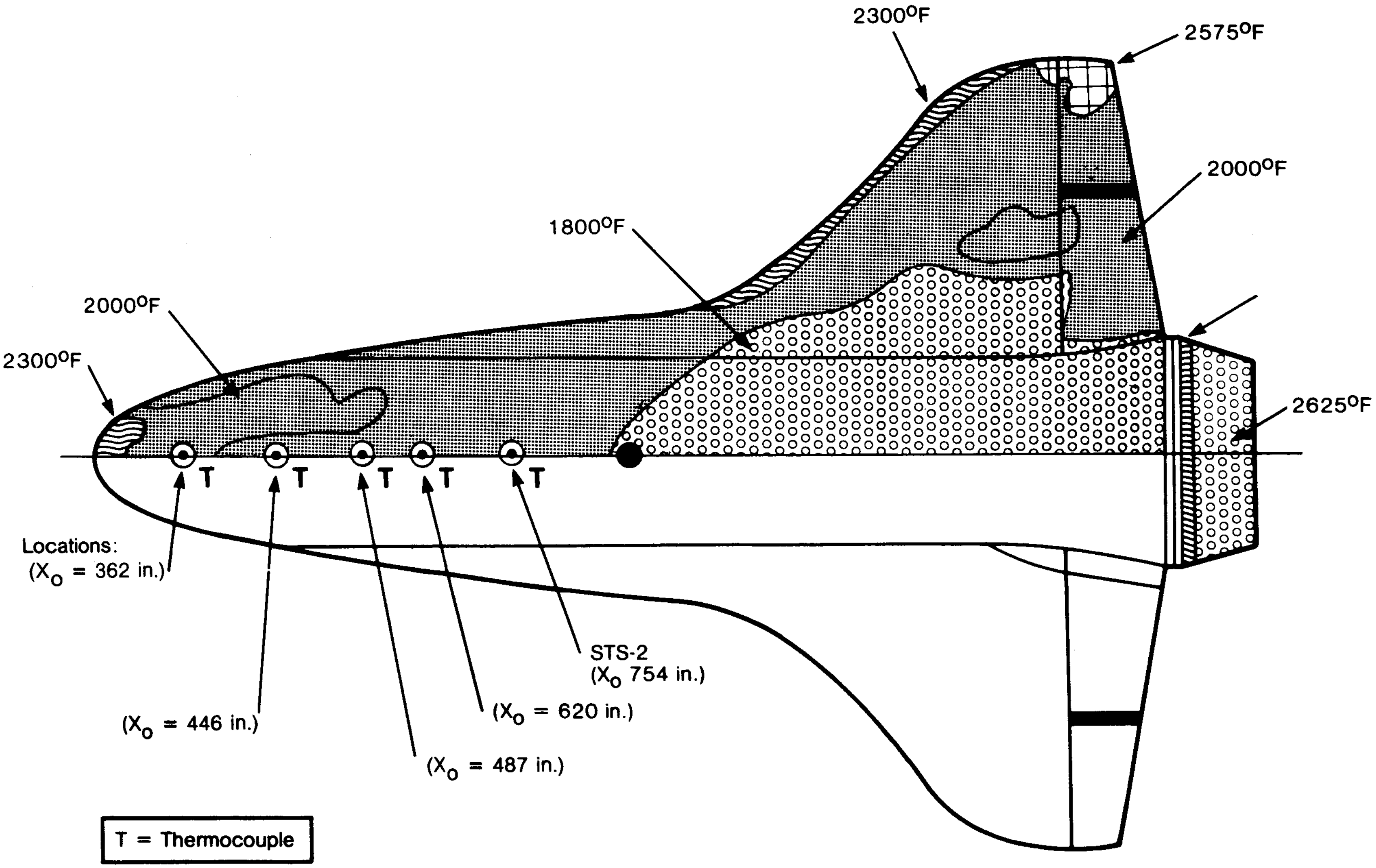
The experiment will use ten baseline tiles, having DFI thermocouples, located along the lower mid fuselage of the spacecraft. Five of these tiles will be sprayed with an overcoat consisting of iron-cobalt-chromia spinel (a highly efficient catalytic material) in a polyvinyl acetate binder. The overcoat is compatible with the existing baseline tile coating. During ascent the polyvinyl acetate will burn out of the overcoat, leaving the high emittance iron cobalt chromia spinel exposed.

During entry, beginning at 121,920 meters (400,000 feet) and continuing through landing, the thermocouple measurements will be recorded by the PCM recorder. As an aid in evaluating this data, comparisons will be made using DFI measurements recorded on baseline tiles adjacent to the tiles with the overcoat.

This experiment is conducted by principal investigator David Stewart of NASA Ames Research Center.



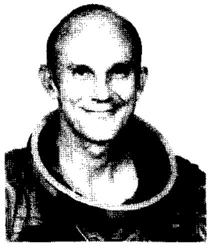
Scorched Filler Bar panel of the Tile Gap Heating Experiment



Lower Surface View

Catalytic Surface Effects Experiment

STS-4 FLIGHT CREW



THOMAS K. MATTINGLY, II is the commander for the STS-4 flight. He was the backup commander for the STS-3 flight and STS-2 flight. From 1979 to 1981 he headed the astronaut ascent/entry group. Mattingly was previously assigned as technical assistant for flight test to the manager of the Development Flight Test program. He was the head of the astronaut office support to the STS-program from 1973 to 1978. Mattingly was the designated command module pilot for the Apollo 13 flight, but was removed from flight status 72 hours prior to the scheduled launch due to exposure to the German measles. He subsequently served as command module pilot of Apollo 16, April 16 through April 27, 1972. With the completion of his first space flight Captain Mattingly has logged 265 hours and 51 minutes in space—1 hour and 13 minutes of which were spent in extravehicular activity (EVA). He has logged 6,300 hours of flight time—4,130 hours in jet aircraft. Mattingly is one of the 19 astronauts selected by NASA in April 1966. Prior to reporting for duty as an astronaut, he was a student at the Air Force Aerospace Research Pilot school. Mattingly began his naval career as an ensign in 1958 and received his wings in 1960. He was then assigned to the USS Saratoga from 1960 to 1963 flying A1H aircraft and then served aboard the USS Franklin D. Roosevelt where he flew A3B aircraft for two years. He served as a member of the astronaut support crews for the Apollo 8 and 11 missions. Mattingly is an Associate Fellow, American Institute of Aeronautics and Astronautics; Fellow, American Astronautical Society; and Member, Society of Experimental Test Pilots, and the U.S. Naval Institute. He has the NASA Distinguished Service Medal, the JSC Group Achievement Award, the Navy Distinguished Service Medal, and Navy Astronauts Wings, the SETP Ivan C. Kincheleo Award, the Delta Tau Delta Achievement Award, the Auburn Alumni Engineers Council Outstanding Achievement Award, the AAS Flight Achievement Award, the AIAA Haley Astronautics Award, and the Federation Aeronautique Internationale V.M. Komarov Diploma. Mattingly was born in Chicago, Illinois, March 17, 1936, is married and has one child. He is 5'10" and weighs 140 pounds. He has brown hair and blue eyes.

HENRY W. HARTSFIELD, JR. is the pilot for the STS-4 flight. He was the backup pilot for the STS-3 flight and the STS-2 flight. Hartsfield was a member of the Development Flight Test missions group of the astronaut office and was responsible for supporting the development of the Space Shuttle entry flight control system and its associated interface. In 1977, he retired from the U.S. Air Force with more than 22 years of service, but continues his assignment as a NASA astronaut in a civilian capacity. Hartsfield became a NASA astronaut in 1969. He was a member of the astronaut support crew for Apollo 16 and Skylab 2, 3, and 4 missions. Hartsfield was assigned in 1966 to the USAF Manned Orbiting Laboratory program as an astronaut until the program was canceled in 1969, when he was reassigned to NASA. He has logged over 5,270 flying hours—of which over 4,700 hours are in the F-86, F-100, F-104, F-105, F-106, T-33 and T-38A. Hartsfield received his commission through the Reserve Officers Training program at Auburn University. He entered the Air Force in 1955, and his assignments included a tour with the 53rd Tactical Fighter Squadron in Germany. He is also a graduate of the USAF Test Pilot school at Edwards Air Force Base, California and was an instructor there prior to his assignment as an astronaut in the USAF Manned Orbiting Laboratory program. He was awarded the Air Force Meritorious Service Medal and the General Thomas D. White Space Trophy. Hartsfield was born in Birmingham, Alabama, November 21, 1933, is married and has two children. He is 5'10" and weighs 165 pounds. He has brown hair and hazel eyes.

STS-5 FLIGHT CREW

VANCE D. BRAND is the spacecraft commander for the STS-5 flight. He has logged 217 hours and 28 minutes in space flight as command module pilot of the Apollo-Soyuz Test Project. A graduate of the University of Colorado in business (1953) and aeronautical engineering (1960), Brand was commissioned a naval aviator and served as a Marine Corps fighter pilot until 1957. He was with the Marine Reserve and Air National Guard until 1964. He joined Lockheed Aircraft as a flight test engineer in 1960, and following completion of the Navy's Test Pilot School was assigned to Palmdale, Calif., as an experimental test pilot on the F-104. He was selected as an astronaut in 1966, and was a crew member of the prototype command module in thermal-vacuum chamber program. He was a support crewman on Apollo 8 and 13, and was backup pilot for Apollo 15 and the Skylab 3 and 4 missions. Brand is a Fellow, American Astronautical Society, Associate Fellow of AIAA, and a member of SETP. He has the NASA Distinguished and Exceptional Service Medals, the JSC Certificate of Commendation, the Richard Gottheil Medal, the Wright Brothers International Manned Space Flight Award, the VFW National Space Award, the FAI Yuri Gagarin Gold Medal, the AIAA Special Presidential Citation and the Haley Astronautics Award, the AAS's Flight Achievement Award, and the University of Colorado's Alumnus of the Century award. Brand was born in Longmont, Colo., May 9, 1931, is married and has five children. He is 5'11" in height, and weighs 175 pounds. He has blond hair and gray eyes.

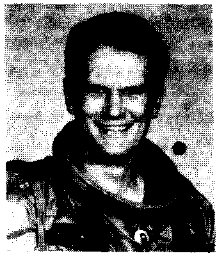
ROBERT F. OVERMYER is the pilot for the STS-5 flight. He was previously assigned engineering development duties on the Space Shuttle program and the Development Flight Test missions group of the astronaut office. His first assignment with NASA was engineering development duties on Skylab. Overmyer then served on the support crews for the Apollo 17 and Apollo-Soyuz Test Project. In 1976 he was the prime T-38 chase pilot for the Approach and Landing Test program on orbiter free flights 1 and 3. Overmyer was selected as a NASA astronaut when the U.S. Air Force Manned Orbiting Laboratory program was canceled in 1969. Colonel Overmyer entered active duty with the Marine Corps in January 1958. After flight training, several squadron tours, and graduate school, he attended the Air Force Test Pilots school in 1965. He was selected as an astronaut for the U.S. Air Force Manned Orbiting Laboratory program in 1966. He is a member of the Society of Experimental Test Pilots. Overmyer was born in Lorain, Ohio, July 14, 1936, is married and has three children. He is 5'11-3/4" and weighs 180 pounds. He has brown hair and blue eyes.

WILLIAM B. LENOIR is one of the mission specialists on the STS-5 flight. He is a graduate of the Massachusetts Institute of Technology where he received a bachelor of science degree in Electrical Engineering, and a doctor of science degree. From 1964 to 1965, he was an instructor at MIT, and in 1965 he was named assistant professor of Electrical Engineering until he was selected as a NASA scientist astronaut in 1967. He was backup science pilot for the Skylab 3 and 4 missions. From 1974 to 1976, Lenoir spent approximately one-half of his time as leader of the NASA satellite power team. Since 1976, he has supported the Space Shuttle program in the areas of payload deployment and retrieval. He has received the NASA Exceptional Service Medal and is a senior member of the Institute of Electrical and Electronics Engineers and a member of the American Geophysical Union. He has logged over 2,300 hours of flying time in jet aircraft. He is married, has two children. Lenoir was born in Miami, Fla., March 14, 1939. He is 5'10" in height and weighs 150 pounds. He has brown hair and eyes.

JOSEPH P. ALLEN is one of the mission specialists on the STS-5 flight. He received a bachelor of arts degree in math-physics from DePauw University and a master of science degree and doctorate in physics from Yale University. He was a staff physicist at the Nuclear Structure Lab at Yale from 1965 to 1966 and served as a guest research associate at Brookhaven National Laboratory from 1963 to 1967 and was a research associate in the Nuclear Physics Laboratory at the University of Washington from 1967 until he was selected as a scientist astronaut in 1967. He was a mission scientist while a member of the astronaut support crew for Apollo 15 and served as a staff consultant on science and technology for the President's Council on International Economic Policy. From 1975 to 1978, Allen served as NASA Assistant Administrator for Legislative Affairs in Washington, D.C. Allen has received two NASA Group Achievement Awards, the Yale Science and Engineering Association Award, the DePauw University Distinguished Alumnus Award, the NASA Exceptional Scientific Achievement Medal, and a NASA Exceptional Service Medal. He is a member of the American Physical Society, the American Astronomical Society, the AIAA, the American Association for the Advancement of Science, and the AAS. He has logged more than 2,400 hours of flying time in jet aircraft. Allen is married and has two children. He was born in Crawfordsville, Ind., June 27, 1937. He is 5'6" and weighs 125 pounds. He has brown hair and blue eyes.

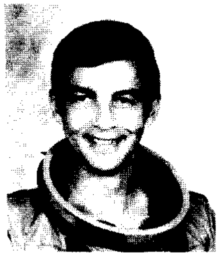
STS-6 FLIGHT CREW

PAUL J. WEITZ is the commander for the STS-6 flight. He was the pilot in the Skylab 2 mission, logging 672 hours and 49 minutes aboard the Skylab workshop in addition to 2 hours and 11 minutes in extra vehicular activities. Weitz retired from the Navy in 1976 with 22 years of service and remains with NASA as a civilian astronaut. Weitz received his commission as an Ensign through the ROTC program at Pennsylvania State University in 1954 and received his wings in 1956. He was an A-4 Tactics Instructor at the Naval Air Station in Jacksonville, Fla. from 1956 to 1960, a project officer at China Lake, Calif. in various air-to-ground delivery tactic projects from 1960 to 1962, completed the U.S. Naval Postgraduate School in 1964, was assigned to the Naval Air Station at Widbey Island, Washington in 1964 and was selected as a NASA astronaut in 1966. He received a bachelor of science degre in Aeronautical Engineering from Pennsylvania State University in 1954 and a masters degree in Aeronautical Engineering from the U.S. Naval Postgraduate School in Monterey, Calif., in 1964. Weitz was awarded the NASA Distinguished Service Medal, the Navy Distinguished Service Medal, the Federal Aviation Agency's Space Mechanic Technician Award, the Los Angeles Chamber of Commerce Kitty Hawk Award, the Robert J. Collier Trophy, the AAS Flight Achievement Award, the AIAA Haley Astronautics Award, the FAI V. M. Komarov Diploma, the Dr. Robert H. Goddard MemorialTrophy and the Harman International Trophy. He has logged more than 5,000 flying hours time, 4,700 hours in jet aircraft. Weitz is married and has two children. He was born in Erie, Pa., July 25, 1932. He is 5'10" in height and weighs 180 pounds. He has blond hair and blue eyes.



KAROL J. BOBKO is the pilot for the STS-6 flight. He was a member of the Skylab Medical Experiments Altitude Test—SMEAT - a 56 day simulation of the Skylab mission and a member of the astronaut support crew for the ASTP mission and a member of the support crew for the Space Shuttle Approach and Landing Test program. He was then involved with the ground test and checkout of the *Columbia*. He received a bachelor of science degree from the Air Force Academy in 1959 and a master of science degree in Aerospace Engineering from the University of Southern California in 1970. Bobko received his wings in 1960 and flew F-100 and F-105 aircraft from 1961 to 1965, then attended the Aerospace Research Pilots school and was assigned as an astronaut in the USAF Manned Orbiting Laboratory Program in 1966 and became a NASA astronaut in 1969. He has logged over 4,100 hours of flying time in the F-100, F-104, F-105, T-33 and T-38. Bobko was awarded the NASA Exceptional Service Medal, three JSC Group Achievement Awards and two USAF Meritorious Service Medals. He is married and has two children. He was born in New York, New York December 23, 1937. He is 5'11" in height and weighs 180 pounds. He has blond hair and blue eyes.

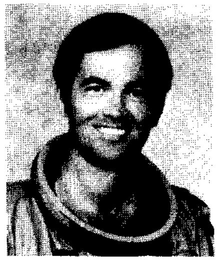
STORY MUSGRAVE is a mission specialist on the STS-6 flight. Dr. Musgrave was selected as a scientist astronaut in 1967. He worked on the design and development of the Skylab program, as a back-up science pilot for the first Skylab mission and has been participating in the design and development of all Space Shuttle extra-vehicular activity equipment. He received a bachelor of science degree in mathematics and statistics from Syracuse University in 1958, a master of business adminstration degree in Operations Analysts and Computer Programming from the University of California at Los Angeles in 1959, a bachelor of arts degree in chemistry from Marietta College in 1960, a doctorate in Medicine from Columbia University in 1964. He served his surgical internship at the University of Kentucky Medical Center in Lexington from 1964 to 1965 and continued there as a USAF post-doctoral fellow working in aerospace medicine and physiology from 1965 to 1966 and received his master of science in Physiology and Biophysics from the University of Kentucky in 1966. From 1966 to 1967, as a National Heart Institute post-doctoral fellow, Dr. Musgrave was teaching and doing research in cardiovascular and exercise physiology. He is continuing clinical and scientific training as a part-time surgeon at the Denver General Hospital and as a part-time professor of physiology and biophysics at the University of Kentucky Medical Center. He has flown 90 different types of civilian and military aircraft, logging over 10,800 flying hours, including 4,300 in jet aircraft and holds instructor, instrument instructor, glider instructor and airline transport



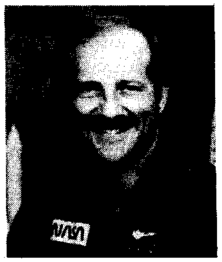
DONALD H. PETERSON is a mission specialist on the STS-6 flight. He served on the astronaut support crew for Apollo 16. He received a bachelor of science degree from the United States Military Academy at West Point in 1955 and a masters degree in Nuclear Engineering from the Air Force Institute of Technology, Wright-Patterson AFB, Ohio in 1962. His USAF assignments included 4 years as a flight instructor and military training officer with the Air Training Command and 3 years as a nuclear systems analyst with the Air Force Systems Command. He is a graduate of the Aerospace Research Pilot School and was assigned to the USAF Manned Orbiting Laboratory Program. He became a NASA astronaut in 1969. He has retired from the USAF after 24 years of active service but continues his assignment as a NASA astronaut in civilian capacity. He has logged over 4,490 hours of flying time including more than 4,180 hours in jet aircraft. He has received the Air Force Commendation Medal and the Meritorious Service Medal, and the JSC Group Achievement Award. He is married and has three children. He was born in Winona, Miss., October 22, 1933. He is 5'8" in height and weighs 147 pounds. He has blond hair and green eyes.

ratings. He has received the National Defense Service Medal, USAF Post-doctoral Fellowship, National Heart Fellowship, American College of Surgeons I. S. Ravdin Lecture, NASA Exceptional Service Medal and Flying Physicians Association Airmen of the Year Award. He has five children. He was born in Boston, Mass., August 19, 1935 but considers Lexington, Ky. his hometown. He is 5'10" in height and weighs 149 pounds. He has blond hair and blue eyes.

STS-7 FLIGHT CREW

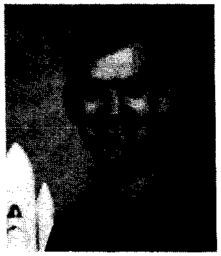


ROBERT L. CRIPPEN is the commander for the STS-7 flight. He was the pilot in the 54-1/2 hour STS-1 flight. He has logged more than 4,980 hours of flying time—most of it in jet-powered aircraft—as a U.S. Navy pilot and astronaut. A graduate of the University of Texas in aerospace engineering, Crippen entered naval service and was a carrier pilot. He completed the U.S. Air Force's Aerospace Research Pilot School at Edwards AFB and remained as an instructor until he was selected for the Manned Orbiting Laboratory program in 1966. He transferred to the NASA Astronaut Office in 1969 and was a crew member of the Skylab Medical Experiments Altitude Test—a 56-day simulation of the Skylab mission. He was a member of the support crew for Skylab 2, 3, and 4, and the ASTP mission. He has been awarded the NASA Distinguished Service Medal and Exceptional Service Medal and the JSC Group Achievement Award. Crippen was born in Beaumont, Tex., September 11, 1937, is married and has three children. He is 5'10" in height, weighs 160 pounds, and has brown hair and eyes.



FREDERICK H. HAUCK is the pilot for the STS-7 flight. He was a member of the support crew for STS-1 and capsule communicator during reentry for the STS-2 flight. He was selected as an astronaut candidate by NASA in 1978. Hauck received a bachelor of science degree in Physics from Tufts University in 1962 and a master of science degree in Nuclear Engineering from MIT in 1966. He was a Navy ROTC student at Tufts University and was commissioned upon graduation and served as communications officer and CIC officer on the USS Warrington. In 1964 he attended the U.S. Naval Postgraduate School, Monterey, Calif., in math and physics and studied Russian at the Defense Language Institute in Monterey. He was then selected for the Navy's Advanced Science Program. He received his wings in 1968. He flew 114 combat and combat support missions in the Western Pacific aboard the USS Coral Sea. He graduated from the U.S. Naval Test Pilot School in 1971. Hauck then served as a project test pilot for automatic carrier landing systems in the A-6, A-7, F-4 and F-14 aircraft. In 1974 he was assigned to the USS Enterprise flying A-6, A-7 and F-14 aircraft. He was an executive officer in February 1977 until he was selected as an astronaut. He was born in Long Beach, Calif., April 11, 1941 but considers Winchester, Mass., and Washington, D.C. as his hometown. He is married and has two children. He is 5'9" in height and weighs 175 pounds. He has blond hair and blue eyes.

SALLY K. RIDE is a mission specialist for the STS-7 flight. She was selected as an astronaut candidate by NASA in 1978. Dr. Ride received a bachelor of arts in English from Stanford University in 1973, a bachelor of science, a master of science, and doctorate degrees in Physics in 1973, 1975, and 1978, respectively from Stanford University. Dr. Ride has held teaching assistant and research assignments while a graduate student in the Physics Department at Stanford University. Her research includes one summer with the low-temperature group working in experimental general relativity and three years in X-ray astrophysics. She was born in Los Angeles, Calif., May 26, 1951 and considers Encino, Calif. her hometown. Dr. Ride is 5'5" in height and weighs 115 pounds. She has brown hair and blue eyes.



JOHN M. FABIAN is a mission specialist for the STS-7 flight. He was selected as an astronaut candidate in 1978. He received a bachelor of science degree in Mechanical Engineering from Washington State University in 1962, a master of science in Aerospace Engineering from the Air Force Institute of Technology in 1964 and a doctorate in Aeronautics and Astronautics from the University of Washington in 1974. Fabian was an Air Force ROTC student at Washington State University and was commissioned in 1982. He had various assignments in the Air Force Institute of Technology at Wright-Patterson Air Force Base, Ohio, aeronautical engineer at San Antonio Air Material Area, Kelly AFB, Tx, then attended flight training at Williams AFB, Ariz., and spent five years as a KC-135 pilot at Wurtsmith AFB, Mich., and flew 90 combat missions in Southeast Asia. Following additional graduate work at the University of Washington, he served four years on the faculty of the Aeronautics Department at the USAF Academy in Colo. He has logged 2,800 hours flying time, including 2,300 hours in jet aircraft. He is a member of AIAA. He is married and has two children. He was born in Goosecreek, Tx., January 28, 1939, but considers Pullman, Wash., his hometown. He is 6'1" in height and weighs 175 pounds. He has brown hair and green eyes.

STS-8 FLIGHT CREW

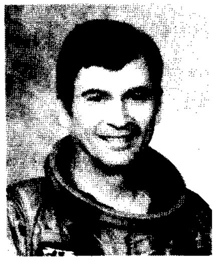
RICHARD H. TRULY is the commander for the STS-8 flight. He was the spacecraft pilot for the STS-2 flight. He was an orbiter pilot during the successful Approach and Landing Test program, and as a naval pilot and astronaut has logged nearly 6,000 hours in jet aircraft. He graduated from the Georgia Institute of Technology in aeronautical engineering and entered naval flight training. Following service as a carrier pilot, Truly completed the USAF Aerospace Research Pilot School at Edwards and was subsequently assigned there as an instructor. In 1965 he was assigned to the Manned Orbiting Laboratory program and in 1969 was assigned to the NASA Astronaut Office. Truly was a member of the Skylab support crew and served in a similar capacity for the ASTP flight. He has been awarded two NASA Exceptional Service Medals, the JSC Superior Achievement Award and Special Achievement Award, the SETP Iven C. Kincheloe Award, the AFA's David C. Schilling Award, the American Astronomical Society's Flight Achievement Award, the Navy Distinguished Flying Cross, and the AIAA's Haley Space Flight Award. Truly was born in Fayette, Miss., Nov. 12, 1937, is married and has three children. He is 5'8" in height, weighs 150 pounds, and has brown hair and eyes.

DANIEL C. BRANDENSTEIN is the pilot for the STS-8 flight. Brandenstein was selected as an astronaut candidate in 1978. He was a member of the STS-1 and STS-2 astronaut support crew and served as ascent capcom. He received a bachelor of science degree in Mathematics and Physics from the University of Wisconsin in 1965. He entered the Navy in 1965 and designated a naval aviator in 1967. He flew 192 combat missions in Southeast Asia from the USS Constellation and Ranger. He graduated from the U.S. Naval Test Pilot School. He then served aboard the USS Ranger in the Western Pacific and Indian Ocean flying A-6 aircraft. He has logged 3,400 hours flying time in 19 different types of aircraft and has 400 carrier landings. Brandenstein is married and has one child. He was born in Watertown, Wisc., January 17, 1943. He is 5'11" in height and weighs 185 pounds. He has brown hair and blue eyes.

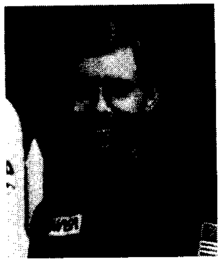
GUION S. BLUFORD JR. is a mission specialist for the STS-8 flight. He was selected as an astronaut candidate in 1978. He received a bachelor of science degree in Aerospace Engineering from Pennsylvania State University in 1964, a master of science degree with distinction in Aerospace Engineering from the Air Force Institute of Technology in 1974, and a doctor of philosophy in Aerospace Engineering with a minor in Laser Physics from the Air Force Institute in 1978. Bluford was an Air Force ROTC graduate at Penn. State University and attended pilot training at Williams AFB, Ariz., and received his wings in 1965. He was assigned to F-4C combat crew training and subsequently flew 144 combat missions. He was assigned then as a T-38A instructor pilot at Sheppard AFB, Tx., and served as a standardization/evaluation officer and as an assistant flight commander. In 1972 he entered the Air Force Institute of Technology at Wright-Patterson AFB, Ohio, and upon graduating in 1974, he was assigned to the Air Force Flight Dynamics Laboratory at Wright-Patterson AFB as a staff development engineer. He then served as Deputy for Advanced Concepts for the Aeromechanics Division and as Branch Chief of the Aerodynamics and Airframe Branch in the Laboratory. He has logged over 2,700 hours jet flight time in the T-33, T-37, T-38, F-4C, C-135, and F-5A/B, including 1,300 hours as a T-38 instructor pilot. Bluford also has an FAA commercial license. He is married and has two children. He was born in Philadelphia, Pa., November 22, 1942. He is 6' in height and weighs 180 pounds. He has black hair and brown eyes.

DALE A. GARDNER is a mission specialist for the STS-8 flight. He was selected as an astronaut candidate in 1978. He received a bachelor of science degree in Engineering Physics from the University of Illinois in 1970. Gardner entered the U.S. Navy in 1970 upon graduation from college and was assigned to Aviation Officer Candidate School. In 1970 he attended basic naval officer training and was graduated with the highest academic average ever achieved in the 10-year history of the squadron. He proceeded to the Naval Aviation Technical Training Center for advanced naval flight officer training and received his wings in 1971. From 1971 to 1973 he was assigned to weapons system test division at the Naval Test Center in F-14A development test and evaluation as project officer for testing inertial navigation system. He then flew F-14A aircraft and participated in two WESTEC cruises while deployed aboard the USS Enterprise. From 1976 until reporting to NASA, Gardner was with the Air Test and Evaluation Squadron in the operational test and evaluation of fighter aircraft. Gardner is married and has one child. He was born in Fairmont, Minn., November 8, 1948, but considers Clinton, Iowa, his hometown. He is 6' in height and weighs 160 pounds. He has brown hair and eyes.

STS-9 FLIGHT CREW



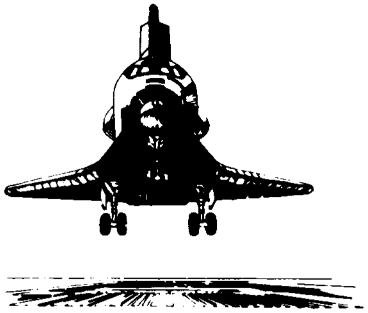
JOHN W. YOUNG, veteran of five space flights, is the commander of the STS-9 flight and was commander for the 54-1/2 hour STS-1 flight. He has logged 588 hours in space flight on the Gemini 3 and 10 missions, the Apollo 10 and 16 flights to the moon, and the STS-1 flight. A graduate of Georgia Institute of Technology in aeronautical engineering, Young entered U.S. Naval service and after a year of destroyer duty he was accepted and completed flight training. He is a graduate of the Navy's Test Pilot School and was stationed at the Naval Air Test Center for three years prior to entering the Astronaut Corps in 1962. He retired from the Navy in 1976. Young was assigned responsibility for the Space Shuttle Branch of the Astronaut Office in 1973, and in 1975 was named as chief of the Astronaut Office. Young is a Fellow of the American Astronautical Society (AAS), and the Society of Experimental Test Pilots (SETP) and associate fellow of the American Institute of Aeronautics and Astronautics (AIAA). He was awarded the Congressional Medal of Honor, the Department of Defense Distinguished Service Medal, three NASA Distinguished Service Medals, two NASA Exceptional Service Medals, the JSC Certificate of Commendation, two Special Achievement Awards, the Navy Astronaut Wings, two Navy Distinguished Service Medals, three Navy Distinguished Flying Crosses, the Georgia Tech Distinguished Alumni Award (1965) and the Distinguished Service Alumni Award (1972), the SETP Iven C. Kincheloe Award, the AAS Flight Achievement Award, the FAI Yuri Gagarin Gold Medal, and the AIAA Haley Astronautics Award. Young was born in San Francisco, Calif., Sept. 24, 1930, is married and has two children. He is 5'9" in height, weighs 165 pounds, and has green eyes and brown hair.



BREWSTER A. SHAW is the pilot for the STS-9 flight. Shaw was selected as an astronaut candidate in 1978. He received a bachelor and master of science degrees in Engineering Mechanics from the University of Wisconsin in 1968 and 1969 respectively. Shaw entered the Air Force in 1968 and after completing Officer Training School, attended undergraduate pilot training, receiving his wings in 1970 and was assigned to the F-100 at Luke AFB, Ariz., and was subsequently assigned to the Republic of Vietnam. He returned to the U.S. in 1971 and was assigned to the F-4 and subsequently reported to Thailand, where he flew the F-4. In 1973 he returned to George AFB, Calif., for F-4 instructor duties. From 1976 to 1976 he attended the USAF Test Pilot School and remained at Edwards AFB, Calif., as an operational test pilot. He then served as an instructor at the USAF Test Pilot School from 1977 until selected as an astronaut candidate. Shaw is married and has three children. He was born in Cass City, Mich., May 16, 1945. He is 5'8" in height and weighs 135 pounds. He has brown hair and blue eyes.

ROBERT ALLAN RIDLEY PARKER is a mission specialist for the STS-9 flight. Parker was a member of the astronaut support crews for the Apollo 15 and 17 missions and served as program scientist for the Skylab Program Director's Office during the three manned Skylab flights. He received a bachelor of arts degree in Astronomy and Physics from Amherst College in 1958 and a doctorate in Astronomy from the California Institute of Technology in 1962. Parker was an associate professor of astronomy at the University of Wisconsin prior to his selection as an astronaut. Dr. Parker was selected as a scientist-astronaut in 1967. He has logged over 2,225 hours flying time in jet aircraft. He was awarded the NASA Exceptional Scientific Achievement Medal and the NASA Outstanding Leadership Medal. He is married and has two children. He was born in New York City, December 14, 1936, but grew up in Shrewsburg, Mass. Parker is 5'10" in height and weighs 160 pounds. He has brown hair and blue eyes.

OWEN K. GARRIOTT is a mission specialist for the STS-9 flight. Dr. Garriott was the science pilot for the Skylab 3, 59-1/2 day mission. He logged 1,427 hours and 9 minutes in space in the Skylab 3 mission and also spent 13 hours and 43 minutes in three separate extravehicular activities outside the Skylab workshop. Since the Skylab 3 flight, Garriott has served as Deputy and then Director of Science and Applications and as the Assistant Director for Space Science at JSC. Dr. Garriott was selected as a scientist astronaut in 1965. Prior to his selection as an astronaut, he taught electronics, electromagnetic theory, and ionspheric physics as an associate professor in the Department of Electrical Engineering at Stanford University. He has performed research in inospheric physics since obtaining his doctorate. Garriott remains a consulting professor at Stanford University. He has logged over 3,900 flying hours—including over 2,100 hours in jet aircraft and the remainder in spacecraft, light aircraft, and helicopters, in addition he holds FAA commercial pilot and flight instructor certification for instrument and multi-engine aircraft. He has received the NASA Distinguished Service Medal, the City of Chicago Gold Medal, the Robert J. Collier Trophy, the FAI V. M. Komarov Diploma, and elected to the International Academy of Astronautics. He is a Fellow of the AAS and a member of the IEEE. He is married and has four children. Garriott was born in Enid, Okla., November 22, 1930. He is 5'9" in height and weighs 140 pounds. He has brown hair and blue eyes.



NEWS ABOUT AMERICA'S SPACE SHUTTLE

...it comes from Rockwell International

STS-1 SUMMARY

"The Space Shuttle did more than prove our technological abilities, it raised our expectations once more; it started us dreaming again..."

– President Ronald Reagan,
Address to Joint Session of
Congress, April 28, 1981.

The success of the first Space Shuttle flight (STS-1) was marked by superb systems performance of the Rockwell-built orbiter *Columbia*.

The 54-hour mission (April 12-14, 1981) began with a flawless and spectacular launch from Pad 39A at NASA's Kennedy Space Center in Florida. After two days of orbital activities, the STS-1 crew of Commander John W. Young and Pilot Robert Crippen brought the 99-ton *Columbia* to a textbook-perfect landing on a dry lake-bed runway at Edwards Air Force Base, California, before a crowd of more than 100,000.

Assessment of flight test results shows all major objectives were accomplished. A problem with the on-board data recorder which developed early in the flight caused loss of some data.

The STS-1 crew described *Columbia's* maiden flight as nominal and said the spacecraft performed superbly.

Astronaut Young, at the crew's post-flight press conference (April 23), said, "The first Space Shuttle flight can truly be called nominal, although I think we can do away with the word nominal. You can call it phenomenal."

According to the crew, the five major test areas and performance in each were:

- Propulsion systems... "went super."
- Mechanical systems... "worked great."
- Man/machine interface... "was superb."
- Thermal tests checked out... "very well."
- Avionics systems test... "were just terrific."

Of the 135 test objectives, Young said that, except for the loss of some data through recorder malfunctions, "we got them all."

MISSION SUMMARY

Liftoff Through OMS-2 Maneuver. Liftoff of STS-1 occurred at 1:12:00:03.8 GMT on April 12, 1981. The trajectory was as planned with all events up through payload bay door opening and radiator deployment occurring normally. The orbital parameters after the OMS (orbital maneuvering system)-2 firing were an apogee of 133.7 nautical miles (153 statute miles) and a perigee of 132.7 n.mi. (152 statute miles), as expected.

The main propulsion system performed normally.

The APU's (auxiliary power units) operated as expected with no apparent problems. The hydraulics systems also operated normally, although all three water boiler and vent temperatures were higher than expected. These conditions are thought to have been caused by freezing of boiler water.

The fuel cells, cryogenics, and electrical power distribution systems all performed satisfactorily with no anomalies. The liftoff electrical loads were about 23 kW, some 5 to 7 kW lower than predicted.

4 Hours Through 24 Hours–April 13, 1981. The OMS-3 and OMS-4 maneuvers were completed as planned, raising the orbit to a 145-n.mi. (166 statute miles) apogee by a 144-n.mi. (165 statute miles) perigee. The propellant remaining after the maneuvers was at the predicted levels, indicating satisfactory system performance.

Orbiter temperatures remained within acceptable limits. The flight control systems checks, using one auxiliary power unit, went as planned.

During the first television pass at approximately 13:53 GMT, the flight crew directed the onboard TV camera at the OMS pods, showing some TPS damage on both pods.

24 Hours Through 48 Hours–April 14, 1981. An assessment of the thermal and structural loads for the area of the TPS damage on the OMS pods was completed. The over-all assessment for the tile damage was that the orbiter was safe for reentry.

Three planned RCS firings were performed with the expected results.

The APU gas generator injector bed temperatures dropped to 236°F (normal range–350°F to 410°F) at 1:23:30 GMT, indicating the loss of the APU 2 gas generator heater B. The heater was switched from the B to the A system and the temperatures began increasing. Approximately 4-1/2 hours later, the gas generator injector bed temperatures were again decreasing. The heater was switched to the B system, but no increase was noted; it was then returned to system A, again with no increase in temperature. It was determined through a real-time ground test that APU 2 would start satisfactorily at bed temperatures as low as 21°C (70°F).

During the flight control system checkout, the horizontal situation indicator (HSI) compass card did not respond properly. The indicator was off 5 degrees during the "low" test and did not drive at all during the repeated "high" test. A test procedure was performed by the crew and the indicator again failed to respond, with the card appearing stuck. Later, during the Ops 8 checkout, the crew reported normal HSI function.

The -Y star tracker experienced an anomaly at 1:16:53 GMT. Bright object protection was being provided by an interim backup circuit which senses light in the field of view and was latching the shutter closed. The crew opened the shutter via an override command for subsequent alignments.

The on-orbit electrical loads were about 15 to 25-1/2 kW, some 2 kW lower than predicted.

48 Hours Through Landing–April 14, 1981. Entry preparation was accomplished according to the crew activity plan and without problems. A nominal reentry was flown, and touchdown occurred at 104:18:20:56 GMT. Post-rollout operations were accomplished without incident, and ground cooling was connected about 16 minutes after landing. The flight crew left the orbiter 1 hour and 8 minutes later. This occurred after a delay for the ground crew to clear hazardous vapors indicated in the vicinity of the orbiter side hatch.

Entry Loads and Consumables. Structural, power, and heat rejection entry loads were generally lower than predicted, as were the APU, RCS, and active thermal control subsystem (ATCS) consumables usage. Orbiter structure backface temperatures also were lower than expected.

Solid Rocket Booster Recovery. SRB recovery was accomplished after some difficulty with the nozzle plugging operations. Divers were able to plug the nozzles using backup procedures and hardware and the solid rocket motor cases, frustums, and remaining hardware was returned to KSC for inspection and processing.

External Tank Reentry. The external tank reentry and disposal process began and proceeded as planned, until the external tank rupture occurred at a higher altitude than expected. Verbal reports from the ET tracking ship indicate that the debris footprint was also larger than expected. Tracking data was returned on an expedited basis for in-depth evaluation.

STS-1 MISSION FACTS

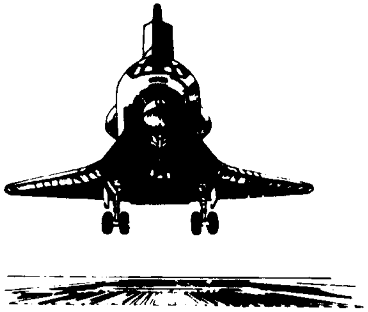
Commander: John W. Young
Pilot: Robert L. Crippen
Mission Duration–54 hours, 21 minutes, 57 seconds
Miles Traveled–approximately 1,074,567 nautical miles (933,757 statute miles)
Orbits of Earth–36
Orbital Altitude–145 nautical miles (166 statute miles)
Landing Touchdown–853 meters (2,800 feet) beyond planned touchdown point
Landing Rollout–274 meters (8,993 feet) from main gear touchdown
Orbiter Weight at Landing–Approximately 89,014 kilograms (196,500 pounds)
Landing Speed at Main Gear Touchdown–180 to 185 knots (207 to 212 mph)

All of the 135 flight test objectives assigned to STS-1 were accomplished based on data available as of this date.

STS-1 TIMELINE

Day of Year	GMT* Hr-Min-Sec	Event
102	12:00:03	Liftoff
	12:00:47	Initiate throttle down of the main engines to 65%
	12:00:56	Max q (maximum dynamic pressure)
	12:01:05	Initiate throttle up of the main engines to 100%
	12:02:14	Solid Rocket Booster separation
	12:07:36	3 "g" acceleration limit
	12:08:38	MECO (main engine cutoff)
	12:09:02	External Tank separation
	12:10:38	OMS-1 (Orbital Maneuvering System-1) ignition
	12:14:57	Orbiter APU deactivation
	12:44:06	OMS-2 ignition
	13:43:07	Payload bay door open close/open tests
	18:20:50	OMS-3 ignition
	19:05:36	OMS-4 ignition
		RCS-1 test
		RCS-2 test
103	14:48:00	Payload bay doors closed, deorbit rehearsal RCS-3 test
	16:47:00	Payload bay doors open
104	14:29:55	Payload bay doors closed
	17:17:23	Orbiter APU No. 2 and No. 3 activation
	17:21:35	Deorbit-OMS ignition
	17:43:16	Orbiter APU No. 1 activation
	17:49:05	Entry interface 121,920 meters (400,000 feet)
	18:08:30	Exit blackout
	18:14:34	Terminal area energy management
	18:20:00	Landing gear deployment
	18:20:51	Main landing gear contact
	18:21:11	Nose landing gear contact
	18:21:57	Wheel stop
	18:22:39	Orbiter APU deactivation
	19:28:00	Crew egress

*GMT–Subtract 5 hours for EST
6 hours for CST
7 hours for MST
8 hours for PST



NEWS ABOUT AMERICA'S SPACE SHUTTLE

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STS-2 SUMMARY

The planned 124-hour mission began with a flawless and spectacular launch from pad 39A at NASA's Kennedy Space Center in Florida on November 12, 1981. At approximately 2 hours and 35 minutes into the mission, a ph high indication was observed on Fuel Cell 1. Two hours later, a drop of 0.8 volt on Fuel Cell 1 occurred over a very short interval. This voltage drop after two hours of a high ph reading confirmed the loss of one or more cells in Fuel Cell 1. The decision was made to shut down and secure Fuel Cell 1. Because of the loss of Fuel Cell 1, mission plans were reviewed and refined for a 54-hour minimum mission and power levels reduced to compensate for the loss of the fuel cell. After two days in orbit, the STS-2 crew of Commander Joe Engle and Pilot Richard Truly brought the *Columbia* to a landing on the dry lakebed runway at Edwards Air Force Base, California, 54 hours, 13 minutes, and 11 seconds after liftoff, on November 14, 1981.

With the shortened flight, approximately 90 percent of the major mission objectives was successful (233 of 258) and 60 percent (38 of 63) of the tests requiring in-orbit crew involvement was completed.

Sixty-four of 94 desired OSTA-1 science data takes were completed and about 73 hours of data were acquired on the various sensors. The scientists evaluating the initial OSTA-1 science data takes are ecstatic with the results of the data and stated that the Space Shuttle is a magnificent flying platform for the experiment package.

The STS-2 crew described *Columbia's* second flight as a magnificent flying machine.

MISSION SUMMARY

Prelaunch, Nov. 4, 1981. The terminal countdown for the initial attempt to launch STS-2 was conducted on November 4, 1981. The countdown proceeded normally until T-9 minutes when the ground launch sequencer stopped the count for a launch commit criteria violation of the liquid oxygen (LOX) mass quantity redline. The automatic sequencer resumed the countdown approximately two minutes later, when the LOX mass quantity redline was cleared.

The three orbiter auxiliary power units (APU's) were started on time and in sequence and a "Go" was given on all three units even though the lube oil outlet pressures on No. 1 and No. 3 APU were higher than anticipated. The countdown continued normally until T-31 seconds, when the sequencer halted the count due to a violation of the spacecraft's power reactant storage distribution (PRSD) oxygen (O_2) tank pressure limits (800 psia). A real-time decision had been made to lower the O_2 tank pressure limits to 775 psia and continue the count, but the sequencer operator was unable to clear the limits.

The spacecraft APU's were turned off at approximately 12:48:12 GMT, and planning was begun for a recycle at T-9 minutes. After further analysis and discussion by Rockwell and NASA of the higher than expected lube oil outlet pressures on APU's 1 and 3, it was determined to scrub the launch, as there was no APU test data available for mission duty cycles with a possible clogged filter and contaminated oil. The spacecraft's APU gearbox was flushed, reserviced, and the filters were changed on APU's No. 1 and No. 3.

Prelaunch, Nov. 12, 1981. The second launch countdown for STS-2 was conducted on November 12, 1981.

The planned launch time was delayed on November 11, 1981, approximately three hours, due to a malfunction in one of the MDM's (multiplexer/demultiplexer) that provided critical telemetry information. The malfunction was corrected with a replacement unit from Orbiter Vehicle 099, the *Challenger.*

The countdown for the second launch attempt of STS-2 proceeded as planned until T-9 minutes. At that point, the solid rocket booster hydraulic power unit (HPU) gas generator bed temperature fell below the minimum redline value of 190°F. The countdown resumed after it was determined that the violation had resulted from procedural difficulty with the HPU heater.

Liftoff Through OMS-2 Maneuver. Liftoff of STS-2 occurred at 15:10:00 GMT on November 12, 1981.

The trajectory was as planned with all events up through payload bay door opening and radiator deployment occurring normally. The orbital parameters after the OMS-2 maneuver indicated an apogee of 125.0 nautical miles (143 statute miles) and a perigee of 120.1 n.mi. (138 statute miles).

The avionics system operated well and very little data were lost during the solid rocket booster operations because of plume interference.

The main propulsion system performed normally, and the propellant dump and vacuum inerting were completed successfully.

The flash evaporater system started normally but shut down after main engine cutoff before temperature control could be regained. This type of shutdown was suspected to be due to a logic problem in the flash evaporator system controller. The system was cycled off/on by the flight crew and temperature control reestablished on primary system A.

The *Columbia's* APU's operated well, but APU No. 3 was shut down manually one minute early due to a higher than expected lube oil temperature. The high lube oil temperature was due to freezing in water spray boiler No. 3. Water spray boiler No. 3 later thawed without further problems. After shutdown of APU No. 1, System A cooling apparently failed and did not cool the pump and valve properly.

The fuel cells, cryogenics, and electrical power distribution systems all performed satisfactorily with no anomalies. The liftoff electrical loads were about 23 kW, very similar to STS-1.

The reaction control, structural, and mechanical systems all performed well.

A preliminary review of pad and vehicle-mounted sensors to monitor for spacecraft overpressure indicates that overpressures and vehicle responses to vehicle overpressure were both approximately 20 to 30 percent of those experienced on STS-1. Approximately 2 hours and 35 minutes into the mission, a ph high indication was observed on Fuel Cell 1. Two hours later, a drop of 0.8 volt on Fuel Cell 1 occurred over a very short interval. This voltage drop after two hours of a high ph reading confirmed the loss of one or more cells in Fuel Cell 1. The decision was made to shut down the fuel cell. A procedure was developed and implemented to secure Fuel Cell 1.

4 Hours Through 24 Hours, Nov. 12, 1981. The OMS-3A, OMS-3B, and OMS-4 maneuvers were completed, raising the orbit to a 144-n.mi. apogee and a 139-n.mi. (159 statute mile) perigee. During the OMS-3B burn, the left OMS oxidizer quantity read approximately 6 percent higher than predicted. Two thermal measurements (OMS high point bleed lines) violated the 50°F lower limit, causing an onboard fault message. The onboard limits were changed to 40°F. Data review indicated nominal OMS performance for the three burns.

The APU data were thoroughly reviewed to eliminate the concern for bubbles forming in the fuel due to the high soakback temperatures following launch. APU No. 2 was selected for the flight control system (FCS) checkout run and the entry restart sequence established: APU 3, APU 2, and APU 1.

Because of the loss of Fuel Cell 1, mission plans were reviewed and refined for a 54-hour minimum mission and power levels reduced to compensate for the loss of the fuel cell.

OSTA-1 pallet system activation was completed and coolant loop and pallet structure temperatures were slightly higher than expected. The remote manipulator system (RMS) was activated, and RMS temperatures were as expected.

24 Hours Through 48 Hours, Nov. 13, 1981. With the decision to perform a minimum mission of approximately 54 hours, the major activities of the second day consisted of RMS checkout, data-gathering with the OSTA experiments, and other primary test objectives.

The majority of the RMS minimum mission objectives were accomplished except for berthing in the backup mode. Several TV camera failures were experienced during RMS operations but caused no difficulty. Near the end of Day 2, a problem was noted by the crew in the RMS shoulder joint drive (yaw) in the backup mode. The crew returned to primary and secured the RMS for entry. This problem was determined to be a broken wire connection.

OSTA-1 pallet system activation was completed and coolant loop and pallet structure temperatures were slightly higher than expected. The remote manipulator system (RMS) was activated, and RMS temperatures were as expected.

OSTA-1 activities continued with some minor constraints due to loss of the fuel cell. Pallet data continued to confirm flow restrictions in the pump package. The DFI coolant loop remained stable with low delta pressure from the pump across the system coldplate. Troubleshooting plans were developed but deferred until after landing.

Cathode Ray Tube 1 failed at approximately 22:30:00 GMT. The flight crew replaced it using CRT 4.

The Fuel Cell 3 oxygen flow meter was erratic, with the reading switching from off-scale high to off-scale low. O_2 cryo tank quantity did not confirm excessive usage, and a sensor malfunction was suspected.

Entry procedures for two fuel cells and the possibility of another fuel cell failure were assessed and refined. Current loads for Fuel Cells 2 and 3 ranged from 200 to 275 amperes, with Fuel Cell 2 carrying a slightly higher load.

The flash evaporator system continued to stay in standby after nightside operations. The port (left side) radiators were stowed to maintain a higher heatload on the evaporator during nightside operations so that the evaporator would operate normally. A flash evaporator test was planned for entry day.

All hydraulic parameters remained within expected and acceptable ranges. A modified test was performed to obtain empirical data for hydraulic orbital thermal certification. Temperature responses require more detailed analysis to assess thermal adequacy for the STS-3 cold mission.

48 Hours Through Landing, Nov. 14, 1981. Flash evaporator system diagnostic tests were performed to verify satisfactory full-up operation on primary A and primary B controllers. Following the test, flash evaporator system operation was initiated on primary A, and operation was normal.

The theodolite measurements for payload bay door deflections could not be accomplished because of bracket movements. The crew reported each time the unit was touched, readings were disturbed and further tests were deleted.

Flight control system checkout was performed using APU No. 2 for 4 minutes. All operating parameters were normal.

The main propulsion system helium system was configured for entry with the left and pneumatic helium isolation valves in the open position instead of being controlled by the general-purpose computer. Helium pressurized the propellant line manifolds early, causing the loss of approximately 45 pounds of helium through the engine high pressure oxidizer turbopump seals before the oxygen prevalves were closed. As a result, the Space Shuttle Main Engine (SSME) oxygen lines were not purged during entry. Oxygen prevalves were operated as soon as practical after rollout until helium depletion to purge any moisture from the system.

The forward RCS dump was successfully completed at entry interface minus 18 minutes, using RCS engines F1L, F3L, F2R, and F4R.

All *Columbia's* APU's were started and run successfully through entry. There were no indications of gearbox, filter, or lubrication jet plugging. The APU's were run for 15 minutes after rollout and the hydraulic load test and SSME repositioning completed satisfactorily.

Just before entry, the OEX recorder would not respond to ground uplink commands. Ground commands were sent several times to initiate Aerodynamic Coefficient Package data recording.

All planned preprogrammed test inputs and aerodynamic stock inputs were completed.

The air data system functioned well and air data was introduced into the navigation as planned at Mach 2.5. Lift-to-drag ratios, as well as vehicle trim positions after blackout, were as predicted.

Performance of Fuel Cells 2 and 3 was as predicted throughout the entry phase. Entry loads ranged from 8.6 kW to a peak of 10.6 kW of Fuel Cell 2, for an average power level of approximately 9.1 kW. Fuel Cell 3 entry loads ranged from 7.8 to 8.8 kW for an average power level of approximately 8.3 kW.

STS-2 landed at 21:23:11 GMT at the Dryden Flight Research facility. All spacecraft systems operated satisfactorily during entry. The landing was switched to runway 23 instead of runway 15 because of high crosswinds.

Solid Rocket Booster Recovery. SRB recovery was accomplished after considerable difficulty because of severe weather in the recovery zone. Solid rocket motor cases, frustums, and remaining hardware were returned to KSC for inspection and processing.

External Tank Reentry. The external tank reentry and disposal process began and proceeded as planned, and the external tank rupture occurred very close to nominal based on the initial estimate of engine cutoff conditions. Tracking data is being evaluated.

Experiment Results. In the STS-2 mission of the Space Shuttle, the office of Space and Terrestrial Applications pallet in the cargo bay of the *Columbia* spacecraft carried instruments that took radar pictures of earth that highlighted the earth's terrain in sharp relief. The radar waves penetrated the trees to reveal the contours of the naked land to the eye of the geologist. These contours can reveal deeply buried oil reserves hidden until now. These discoveries, which cost pennies per square mile were made from the radar carried aboard the *Columbia*. The oil companies still need to send ground crews, but it is the radar that shows the crews the promising places to look.

Another instrument on the pallet in the cargo bay of *Columbia* in the STS-2 flight used ten wavelengths or colors, some of which were sensitive to different kinds of minerals in rocks and to the eye of a geologist, the minerals betray areas that are likely to contain valuable deposits of ore. The same many-hued-images can pinpoint indications of underground oil, too subtle to be seen by the human eye or ordinary cameras. Ten oil companies have seized upon this new technique and hired an airplane to fly over parts of the United States carrying an instrument similar to the one of the STS-2 flight of *Columbia*. However, an airplane's altitude provides a fairly small field of view and covering large areas of the globe would be prohibitively expensive.

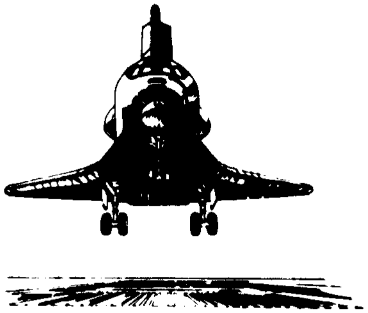
STS-2 MISSION FACTS

Commander: Joe Engle
Pilot: Richard Truly
Mission Duration–54 hours, 13 minutes, 11 seconds
Miles Traveled–Approximately 1,074,567 nautical miles (933,757 statute miles)
Orbits of Earth–36
Orbital Altitude–137 nautical miles (157 statute miles)
Landing Touchdown–Approximately 304 meters (1,000 feet) earlier than planned touchdown point
Landing Rollout–Approximately 2,133 meters (7,000 feet) from main gear touchdown
Orbiter Weight at Landing–Approximately 92,534 kilograms (204,000 pounds)
Landing Speed at Main Gear Touchdown–Approximately 195 knots (224 miles per hour)

STS-2 TIMELINE

Day of Year	GMT* Hr:Min:Sec	Event
316	15:09:59	Liftoff
	15:10:44	Initiate throttle-down of main engine to 68%
	15:10:52	Max. q (maximum dynamic pressure)
	15:11:04	Initiate throttle up of main engines to 100%
	15:12:13	Solid rocket booster separation
	15:17:36	Throttle main engines down for 3-g acceleration limit
	15:18:33	MECO (main engine cutoff)
	15:18:57	External tank separation
	15:20:33	OMS (orbital maneuvering system) 1 ignition
	15:23:27	Orbiter auxiliary power unit deactivation
	15:51:50	OMS-2 ignition
	17:42:39	Payload bay doors close/open tests–complete
316	19:10:00	OSTA (Office of Space and Terrestrial Applications) 1 experiment activation
	22:54:59	OMS-3A ignition
	22:59:14	OMS-3B ignition
	23:43:19	OMS-4 ignition
317	14:25:00	Remote manipulator system (RMS) group 1 tests
318	14:26:00	OSTA-1 experiment deactivation
	14:58:51	APU No. 2 start, flight control system checkout
	16:35:00	OSTA-1 pallet deactivation
	16:47:33	Payload bay doors closed–port
	17:05:19	Payload bay doors closed–starboard
	20:18:15	APU No. 3 activation
	20:23:15	Deorbit–OMS ignition
	20:37:36	APU No. 2 and No. 1 activation
	20:50:36	Entry interface 121,920 meters (400,000 feet)
	21:09:40	Exit blackout
	21:16:30	Terminal area energy management (TAEM)
	21:23:11	Main landing gear contact
	21:23:27	Nose landing gear contact
	21:24:04	Wheel stop
	21:38:14	Orbiter auxiliary power unit deactivation

*GMT–Subtract 5 hours for EST
6 hours for CST
7 hours for MST
8 hours for PST



NEWS ABOUT AMERICA'S SPACE SHUTTLE

...it comes from Rockwell International

STS-3 SUMMARY

The third flight of *Columbia* began on Monday, March 22, 1982 from launch pad 39A at NASA's Kennedy Space Center, Fla. with a flawless and spectacular launch. Spacecraft Commander Jack Lousma said *Columbia* "performed magnificently" and Pilot Gordon Fullerton said "It's an unbelievable flying machine."

Prior to launch of *Columbia* for its third flight, on March 18, Northrup Strip at the White Sands Missile Range, New Mex. was selected as the landing site due to heavy rains at Edwards Air Force Base, Calif. which rendered the dry lakebed runways unusable. Necessary ground support equipment for postlanding operations was dispatched by special train from the Dryden Flight Research Center, Calif. on March 19 and arrived at Northrup Strip on March 20. All equipment was in place and operationally ready by March 21.

The planned STS-3 mission was 171 hours in duration. However, due to high winds, gusts, and blowing dust at Northrup Strip, the landing was deferred one day to Tuesday, March 30, 1982. Commander Jack Lousma and Pilot Gordon Fullerton brought *Columbia* to a landing on Northrup Strip runway 17 at 192 hours (8 days), 4 minutes and 46 seconds after liftoff.

This third flight of *Columbia* was an excellent demonstration of the reusable transport concept. The spacecraft provided highly satisfactory transportation for the relatively complex OSS (Office of Space Science) –1 scientific payload.

Approximately 99 percent of the planned test objectives were accomplished on STS-3. One hundred percent of the planned scientific objectives were completed satisfactorily during the STS-3 flight. The electrophoresis equipment verification will probably be reflown since frozen test samples were lost due to a ground freezer failure.

The STS-3 provided a unique test of the flexibility of Space Shuttle System operations and performance. Changes of landing site requiring transportation of ground support recovery equipment and personnel from Edwards Air Force Base in California to the White Sands Missile Range in New Mexico, changes to some of the recovery operations, flight techniques of the deorbit plane, alignment turn to the runway (right hand turn instead of left hand turn) together with high winds, sheers and gusts, stressed the descent performance to an unexpected extreme.

On-orbit testing was completed for four thermal attitudes during STS-3. The tail-sun top-space orbital rate, the nose-sun twice orbital rate, and the top-sun solar inertial attitudes provided cooling and thermal gradient conditions for the spacecraft systems and structure.

The tail- and nose-sun inertial attitudes provided Orbiter forward, aft, and mid-fuselage cold cases to evaluate the thermal control system heater performance and the Orbiter hydraulics subsystem environment. Thermal control system heater systems maintained all temperatures within the required ranges. As expected, most heater duty cycles were less than predicted due to warmer structural temperatures and the slower structural thermal response that had been demonstrated on flights 1 and 2. Twelve heater system thermostats exhibited "dither," yet system temperatures were adequately maintained. This was experienced on the previous two flights. On-orbit operation of the hydraulic system circulation pumps maintained acceptable temperatures for all test cases.

The plus Z top solar inertial attitude provided a successful demonstration of payload bay door (PLBD) operation when a thermal gradient was induced by a cold spacecraft fuselage bottom and a hot payload bay. The spacecraft response when changing from a cold to a warm condition was as expected.

All payload bay door closings were successful except for the tail-sun orbital rate attitude test. This situation cleared after reorienting *Columbia* to the top-sun attitude for approximately 15 minutes, followed by a short period of passive thermal control. Only the payload bay door seals, as compared to latches and motors, experienced large temperature increases, but remained within acceptable limits.

The RCS engine test firings scheduled and completed on STS-3 were part of an overall test protocol during the orbital flight test program which will determine the soakback effects from various combinations of RCS engine firings on the Orbiter subsystems. An aft RCS engine test and a vernier RCS engine test were completed successfully.

The remote manipulator system (RMS) completed approximately 48 hours of test operations during the STS-3 flight. This was within one hour of the premission test plans.

Temperature response tests were initiated on flight day 1 and accumulated approximately 23 hours during the mission. Approximately 11 hours of thermal testing were completed with the RMS in an uncradled stationary position and the remainder with the RMS cradled, but active electrically.

Dynamic tests of the RMS were completed in the loaded and unloaded configurations. Approximately 6 hours were utilized to maneuver the unloaded RMS to verify ground simulation operations. About 19 hours of loaded RMS operations were completed. These control systems tests, with a real but small payload, achieved all fight test objectives. Also during this time, the payload was maneuvered through a wide variety of automatic RMS sequences to perform scientific data gathering tasks. The RMS was also used to support the spacecraft TPS tile inspection.

The only problem was the loss of the RMS wrist closed-circuit television camera. This failure resulted in the decision to utilize the lighter 149 kilogram (330 pound) plasma diagnostics package (PDP) for the loaded RMS tests, instead of the heavier 360 kilogram (794 pound) induced environmental contamination monitor (IECM). An operational wrist TV system was a requirement for berthing the IECM.

There were also failures of all six data acquisition cameras in the payload bay, and this affected the post-flight analysis of the dynamics of the RMS.

STS Services

STS services were adequately provided to the Office of Space Science experiment (OSS-1) and get away special payloads located in the *Columbia* cargo bay and for crew module science activities during the STS-3 mission.

MISSION SUMMARY

Prelaunch, March 22, 1982. Day Zero. The terminal countdown for STS-3 was conducted on March 22, 1982. The planned launch time was delayed 1 hour due to a problem with a ground gaseous nitrogen Space Shuttle Main Engine (SSME) purge heater. The gaseous nitrogen heater over-temperature sensor failed. It was electrically by-passed for launch, but due to the delay in ET propellant loading, the decision was made to delay lift-off 1 hour.

Earlier in the countdown two other problems occurred and the corrective actions are described.

On Saturday, March 20, 1982, at approximately 11:00 a.m., e.s.t., the Orbiter H_2 tank 1 cryo heater B was selected for automatic operation, yet heater B indicated "ON" via telemetry. In the automatic mode, heater B should have been "OFF." Heater B was deactivated by changing the crew procedure to utilize system A only. Orbiter H_2 cryo heater usage can be manually controlled by monitoring the H_2 tank pressure. Since only one heater per cryo tank was required for flight, STS-3 was completed using heater system A in H_2 tank 1.

At approximately 10:30 a.m., e.s.t., Sunday, March 21, 1982, AC Bus 3, three phase circuit breaker (CB11) failed to latch when activated. A circuit breaker guard was modified to mechanically latch the circuit breaker.

Liftoff Through OMS-2 Maneuver. The SSME performance was normal during first and second stages. Main engine number 3 maintained 82% thrust after hydraulic lockup until main engine cutoff (MECO). Hydraulic lockup occurred due to the premature shutdown of auxiliary power unit (APU) number 3 by the flight crew.

Orbiter water spray boiler number 3 did not cool the lube oil in APU number 3 and lube oil temperature increased to approximately 177°C (352°F) requiring early shutdown of APU number 3. Water spray boiler number 3 thawed and was cleared for use during entry after checkout during the Orbiter flight control system test on flight day 7.

The ascent profile for flight 3 was changed from missions 1 and 2. Missions 1 and 2 used predicted, rather than observed, vehicle characteristics as the loads for the command loop in *Columbia's* general purpose computers (GPC's). The nominal STS-3 launch trajectory followed a continually ascending line into orbit. Trajectories on the first two missions were lofted early in the profile to allow the excess performance available to be used in the event of a return-to-launch-site (RTLS) abort. This option was not available for flight 3 due to the heavier vehicle lift-off weight.

The spacecraft payload bay lift-off acoustic environment was similar to that experienced on STS flights one and two.

OMS-1 and OMS-2 maneuvers were completed as planned.

Following the OMS-2 circularization thrusting period and reconfiguration of the data processing system, orbit operations were initiated. All test activities including payload bay door operations, four hours of passive thermal control, main propulsion system inerting, two hours of gravity gradient attitude operation and the start of the spacecraft tail-to-sun thermal attitude were accomplished.

The OSS-1 pallet was activated and operated normally. Power was applied to the remote manipulator system (RMS) in the temperature monitor mode. All RMS temperatures remained within allowable limits. Special orbital thermal conditioning tests were also initiated.

Approximately 82:18:00 GMT, excessive gaseous nitrogen usage, .45 to .68 kilogram per hour (1.0 to 1.5 pound per hour) was detected in the atmospheric revitalization primary control system when *Columbia* was in the initial cold tail-to-sun attitude. During passive thermal control warming, the leakage stopped. Gaseous nitrogen leakage recurred during the cold nose-to-sun attitude. The leakage was isolated to system 2 downstream of the regulator inlet valve and outside the Orbiter cabin. This leak did not pose any problems for continuing the mission. A long-term decay check was completed at the Kennedy Space Center in the Orbiter Processing Facility (OPF) and there was no leak. The decision was made to fly the system as is for STS-4.

Day One March 23, 1982. During the initial air-ground voice exchange with the Mission Control Center on flight day 2, the flight crew reported some white Orbiter tiles missing from the top forward fuselage area. Plans were refined to utilize the RMS for tile inspection.

The Debris Team at KSC reported white as well as black tile segments as a result of their launch complex walkdown inspection. Working together, the Debris and Mission Evaluation Teams thoroughly analyzed the recovered tile segments. The television survey of the nose tile damage utilizing the RMS and the thorough analysis by the ground teams of the recovered white and black tile segments, confirmed there was no structural or thermal concern for *Columbia* during entry and landing. The STS-3 mission was continued.

The RMS was activated and portions of six flight test objectives were completed. During these activities, attempts were made to operate the RMS wrist and elbow cameras, but the circuit breaker opened. Troubleshooting isolated the problem to the wrist camera which resulted in the RMS activities being shortened. The end effector grapple was cancelled, as was the deployment of the IECM. The deployment of the IECM was not attempted because if camera B also failed, the IECM could not be restowed.

RMS activities from flight day 4 were swapped with flight day 3 to reduce crew work load and provide time for simulations of the RMS with the attendant camera failures. These simulations provided refined procedures for deployment and berthing of the lighter PDP instead of the IECM.

At 82:23:10:34, the payload bay door cold case performance was initiated. The radiator was stowed and latched and the port payload bay door closed. The ready-to-latch indications were received and the forward bulkhead latches were latched. The aft bulkhead latches did not complete the latch cycle. The door was reopened and the spacecraft attitude changed to top-to-sun. When the door was opened, the forward ready-to-latch indication failed to go off, indicating the door engagement or switch assembly mechanism was jammed. The warming top-to-sun attitude returned the switch to the door open position. The doors were then closed without any problems. A review of the bus current indicates the actuator stalled near the on-center position. Postflight inspection revealed cracked actuator mounting lugs and possible linkage damage. The actuator and linkage were removed for evaluation and replaced. The payload bay door structure was inspected for damage and no problems were discovered. Passive thermal control was initiated prior to the flight crew sleep period.

Day Two March 24, 1982. The STS-3 mission continued to progress satisfactorily and flight day 3 was devoted primarily to crew module science activities and OSS-1 science data collection.

The OSS-1 tape recorder 2 telemetry indicated that the unit probably sustained a belt failure; therefore, no restarts were attempted. Plans were developed for recording up to 14 hours of data on the Orbiter payload recorder in addition to the planned record and dump activities. Payload recorder 1 telemetry indicated elevated temperatures. This was evaluated and recorder operations were allowed to continue without recorder degradation.

Troubleshooting procedures continued with the data acquisition cameras (DAC's), resulting in operation of only one of the six cameras.

The flight crew reported the waste management slinger was turning at 60 RPM's instead of a normal 250 RPM's and was slowing down. The waste management system continued to be used even after the slinger stopped turning on flight day 6.

The nose-to-sun atitude thermal attitude was established after 11 hours of passive thermal control.

The monodisperse latex reactor (MLR) experiment was activated and deactivated and the electrophoresis equipment verification test (EEVT) experiment was for three tests. Other tests consisted of the cryogenic tank heat leak test.

Day Three, March 25, 1982. The STS-3 Mission continued into flight day 4 which consisted primarily of RMS test operations and crew module science activities. At approximately 85:01:17, S-band transponder 2 failed in the low power downlink mode. A procedure was developed to recover the uplink in the event of further loss and provided to the flight crew. S-band transponder 2 was operational in the high power mode. About three hours later, S-band transponder 1 failed in both high and low power downlink modes. A management decision was made to continue the mission utilizing S-band transponder 2 high power mode, UHF air-to-ground, and the newly developed procedures in the event of additional failures. The flight continued without further S-band failures. Troubleshooting of the S-band system after *Columbia* landed at Northrup Strip completely restored S-band systems 1 and 2. Post-flight analysis revealed numerous debris particles in the suspect RF switches as the cause of the problem.

The RMS activities of grappling and handling the PDP (Plasma Dragnostics Package) including unberthing and berthing operations, control system evaluation, RMS/PRCS interaction tests and PDP automatic sequences. The spacecraft and RMS performed flawlessly throughout the range of operations.

Other tests included completion of the cryogenic tank heat leak cold case initiation of the flash evaporator topping duct and feed water lines thermal response, continuation of the nose-to-sun thermal attitude and OSS-1 data science collection.

Day Four March 26, 1982. The aft RCS L2U engine 100-second thrusting thermal soakback tests were accomplished and additional PDP activities utilizing the RMS was also accomplished. The RMS was cradled utilizing the backup control made.

Day Five March 27, 1982. The OMS cold restart thrusting test was accomplished in addition to the vernier RCS pulse mode thermal soakback test, payload bay door performance and the completion of the 80-hour nose-to-sun thermal attitude and the initiation of the top-to-sun thermal attitude.

All systems were maintained within acceptable operating temperatures throughout the long duration nose-to-sun attitude with many of the spacecraft structural areas reaching temperature equilibrium conditions for a sufficient time to obtain system heater performance data.

Day Six, March 28, 1982. The cryogenic tank heat leak warm case, the flight control system checkout, the aft station COAS alignment and verification, the vernier RCS minimum deadband test and the payload bay door performance test were accomplished during the top-to-sun thermal attitude. Spacecraft passive thermal control was initiated upon successful completion of the top-to-sun thermal attitude prior to the flight crew sleep period.

The on-orbit flight control system and APU number 3 checkout was completed successfully. APU 3 operated properly using about 13 kilograms (30 pounds) of propellant, and water spray boiler (WSB) number 3 cooled APU number 3 adequately during the checkout. The post-shutdown cooling system also functioned satisfactorily, and APU number 3 and WSB number 3 were cleared for entry use.

The avionics systems were all operating properly except for a problem with the left input keyboard. While the flight crew was making a SPEC request from the left keyboard, a continuous input to display electronics unit number 1 (DEU) from the SPEC key on the left keyboard was observed. The problem was isolated to a stuck contact in the SPEC key. The crew replaced the inoperative SPEC key with the ACK key from the aft keyboard, exchanged the lens caps, and the left keyboard operated normally for the remainder of the mission.

The crew began cabin cleanup in preparation for entry scheduled for the next day.

Day Seven, March 29, 1982. The nominal end-of-mission deorbit preparations including tail-to-sun and top-to-sun thermal conditioning was accomplished. Due to the high wind conditions at Northrup Strip, a deorbit wave-off and flight extension of 21 hours was called approximately 20 minutes prior to the planned deorbit maneuver.

The remainder of the day was spent reestablishing on orbit configuration for the spacecraft and conducting additional payload science and photography. The spacecraft attitude was maintained in a passive thermal control mode.

As a result of this extension, an Orbiter powerdown to conserve energy was completed by the flight crew. Future flights will include an additional two days of crew consummables to allow for mission extensions.

Day Eight, March 30, 1982. All deorbit preparations were repeated from the previous day except for the APU runs. The attitude maneuvers for pre-deorbit thermal conditioning of the spacecraft were repeated.

An early opportunity to deorbit was selected so that the time of day landing at Northrup Strip would be earlier than the previous day and that the high winds that prevailed on the previous day might be avoided.

At deorbit time, the winds at Northrup Strip were increasing with a high probability of gusts in excess of 15 knots at touchdown time. The crosswind landing objective was cancelled and the Autoland objective was selected.

Deorbit was performed as planned and entry was flown as planned. Seven of the eight scheduled test maneuvers to acquire aero data were performed as planed. The maneuver at M=4.0 was not executed due to conflicts with the guidance bank reversal. Preprogrammed test input (PTI) 2 instead of PTI 1 was accomplished at M=8.4. All other maneuvers were completed as planned.

Measured winds aloft were unusually strong with a peak value of 110 knots tailwind at 10,058 meters (33,000 feet). This wind level was known from simulations to severely stress the terminal area energy management (TAEM) guidance phase and possibly result in excessive normal accelerations during the final turn around the heading alignment cylinder (HAC). Accordingly, the flight crew was advised to fly in control stick steering (CSS) mode and fly a non-standard right hand turn to the final and to use 100 percent speedbrake below Mach 9 until intercepting the glide slope and then fly in Autoland to approximately 60 meters (200 feet) altitude above ground level.

Autoland was utilized to approximately 60 meters (200 feet) and commander Jack Lousma switched from Autoland to CSS for the landing. Touchdown was at a slightly higher speed than expected, about 234 knots true speed.

After main gear touch down, the nose began to pitch down earlier than anticipated. The commander inserted a slight pitch up stick input to bleed off the additional velocity, and *Columbia* completed a safe landing. The nose wheel steering objective was accomplished after decelerating below 50 knots.

Several minutes after landing, ammonia boiler system "A" failed to maintain adequate control and system "B" failed to operate when activated. There were no thermal problems due to these failures since the ground cooling carts had been connected.

The flight crew egressed *Columbia* about 45 minutes after landing.

Postlanding Operations. Turnaround operations for STS-3 at Northrup Strip had been planned for seven days. Actual turnaround time was six days, due primarily to rescheduling of certain serial operations to parallel operations.

Several spacecraft troubleshooting procedures were completed at Northrup Strip prior to ferry flight and verified problems noted during on-orbit operations. This provided valuable information for Kennedy Space Center (KSC) turnaround planning in the OPF and will be continued for subsequent flights.

During the postlanding operations, OV-102 was subjected to some gypsum dust intrusion. At KSC, all spacecraft cavities were inspected, wiped, and vacuumed. Critical lines received a reverse purge, and disconects were wiped and flushed with freon. The only remaining hardware concerns were RCS thrusters. Thirteen thrusters were removed and replaced. Three of the removed forward RCS engines were test fired successfully and the RCS system was cleared for STS-4.

Hypergolic deservicing was not accomplished at Northrup Strip as it was on STS-1 and STS-2 at Dryden Flight Research Center. Instead, this was completed at KSC after ferry flight.

Ferry Flight Operations. The Shuttle Carrier Aircraft/Spacecraft departed Northrup Strip, White Sands Missile Test Range, New Mexico, at 096:13:00:00 GMT, April 6,1982, and landed at the KSC Shuttle Landing Facility at 096:21:00:00 GMT, completing the return of the *Columbia* (OV-102) to KSC to begin preparations for the STS-4 launch. A three-hour enroute refueling stop was accomplished at Barksdale AFB, Louisiana.

Solid Rocket Booster Recovery (SRB). SRB recovery was accomplished without difficulty and the equipment was returned to KSC for inspection and processing.

One of the three main parachutes on the right-hand SRB failed to deploy and the RH SRB impacted on two main chutes at an expected vertical velocity of 33 meters per second (109 feet per second). This chute was recovered and the failure analysis has not been completed.

One of the main chutes on the RH SRB that had deployed properly was not recovered, apparently as a result of flotation system damage. After analysis, it was decided that the flotation system would be removed for STS-4, and the main chutes would remain attached to the SRB after water impact. Water impact damage to the SRB aft skirt was less severe than on previous flights.

External Tank Reentry. Tracking coverage from sensors obtained during ET entry indicates that a rupture event occurred between 69,494 meters (228,000 feet) and 85,344 meters (280,000 feet) altitude and breakup between 56,388 meters (185,000 feet) and 78,638 meters (258,000 feet). The ET tumble valve arm signal was verified, and tumble valve thrust of 244 to 266 newtons (55-60 pounds) provided ET tumble and impact very close to the preflight prediction.

Experiment Results of the Space Shuttle. In the STS-3 mission, the Office of Space Sciences pallet in the cargo bay of the *Columbia* spacecraft carried instruments that were oriented to space. On the last night of the STS-3 mission, the Solar Flare Experiment was able to observe a large, dramatic X-flare. Solar flare studies are eventually expected to have practical applications in areas such as meteorology and communications. The Contamination Monitor Package experiment found very little molecular contamination in the vicinity of the pallet at cold temperatures, but as the *Columbia* warmed up, the amount of molecular contamination increased slightly. Measurements of molecular contamination are valuable in preparing for future Space Shuttle missions.

The first two astronomy experiments carried on the pallet in the cargo bay of *Columbia* were the Induced Environment Contamination Monitor and the Microabrasion Foil Experiment. Both were concerned with comet dust. According to one of the principle investigators, 10,000 tons of dust are dropped on earth every day. The Microabrasion Foil Experiment collected samples of the dust which will be studied in England to determine the size, shape and chemical composition of the dust from the craters made by the particles impacting on the foil. The Induced Environment Contamination Monitor experiment studied the particles with optics, discovering difficult lighting conditions around *Columbia*. The investigator stated that the lighting conditions around *Columbia* for astronomical remote sensing were more difficult than lighting conditions on Skylab or unmanned vehicles.

STS-3 MISSION FACTS

Commander: Jack Lousma
Pilot: Gordon Fullerton
Mission Duration–192 hours (8 days), 4 minutes, 46 seconds
Miles Traveled–Approximately 3.3 million nautical miles (3.9 million miles)
Orbits of Earth–130
Orbital Altitude–128 nautical miles (147 statute miles)
Landing Touchdown–Approximately 359 meters (1,180 feet) from threshold
Landing Rollout–Approximately 4,185 meters (13,732 feet) from main gear touchdown
Orbiter Weight at Landing–Approximately 94,122 kilograms (207,500 pounds)
Landing Speed at Main Gear Touchdown–Approximately 220 knots (253 miles per hour)

STS-3 TIMELINE

Day of Year	GMT* Hr:Min:Sec	Event
81	16:00:00.02	Liftoff
81	16:00:30.78	Throttle SSME's (Space Shuttle Main Engine's) down to 68 percent thrust
81	16:00:53	Throttle SSME's up to 100 percent thrust level
81	16:01:03	Max. q (maximum dynamic pressure)
81	16:02:07.67	SRB (solid rocket booster) separation
81	16:07:38	Throttle down SSME's for 3 "g" limit
81	16:08:03	APU (auxiliary power unit)-3 deactivation
81	16:08:33.15	MECO (main engine cutoff)
81	16:08:51.29	External tank separation
81	16:10:33.35	OMS (orbital maneuvering system)-1 ignition
81	16:11:58.55	OMS-1 engine cutoff
81	16:15:00	APU-1 deactivation
81	16:15:02	APU-2 deactivation
81	16:40:50.35	OMS-2 engine ignition
81	16:42:18.35	OMS-2 engine cutoff
81	17:39:15	Enable payload bay door opening
81	18:10:13	Starboard door open
81	18:11:34	Port door open
81	18:13:53	Port door closed
81	18:17:03	Starboard door closed
81	18:37:12	Starboard door open
81	18:38:32	Port door open
81	18:41:34	Radiators deployed
81	18:55:59.78	OSS (Office of Space Science)-1 pallet activation
81	19:08:00	Maneuver to PTC (passive thermal control) attitude
81	20:25:59.78	OSS-1 experiment activation
81	23:43	Start gravity gradient free drift
82	01:19:20	End gravity gradient free drift
82	02:50	Tail to sun attitude
82	23:02:59	Radiators stowed
82	23:12:28	Port door closed–payload bay door cold performance test
82	23:57.58	Starboard door closed
83	00:15:05	Starboard door open
83	00:19:53	Port door open
83	00:40:04	Radiators deployed
83	02:01:52	Top to sun for payload bay door closure
83	02:32	PTC
83	02:42:48	Radiators stowed
83	02:48:30	Port door closed
83	02:51:48	Port door open
83	02:54:15	Radiators deployed
83	13:33	Nose to sun attitude
83	15:21	RMS (remote manipulator system) operations start
84	02:10	RMS test operations, stop
84	14:15	RMS test operations, start

Day of Year	GMT* Hr:Min:Sec	Event
85	00:28:03	RMS test operations, stop
85	14:35:00	Aft RCS (reaction control system) L2U engine thrusting, thermal soakback tests
85	14:47:20	RMS test operations, start
85	23:01:25	RMS test operations, stop
86	01:19	End nose to sun attitude
86	20:20	Radiators stowed
86	20:23	Port door closed
86	20:44	Starboard door closed
86	21:12	Starboard door open
86	21:16	Port door open
86	21:42	Radiators deployed
86	22:00	Top to sun attitude
86	22:00:00	OMS-3A cold engine restart ignition
86	22:00:02.19	OMS-3A cold engine cutoff
86	22:04:04	OMS-3B cold engine restart ignition
86	22:04:18	OMS-3B cold engine cutoff
87	14:42:28	APU-3 activation
87	14:42:30	Flight control system checkout
87	14:53:10	APU-3 deactivation
87	22:46:33.64	Radiators stowed
87	22:49:59.40	Port door closed
87	23:16:15.12	Starboard door closed
87	23:27:52.40	Starboard door open
87	23:30:19.40	Port door open
87	23:40:51.60	Radiators deployed
88	00:26:53.64	Radiators stowed
88	00:30:20.08	Radiators deployed
88	01:00:00	Start PTC
88	13:01	Start tail to sun
88	13:38:07.80	Radiators stowed
88	14:15	Crew module science activities secured
88	14:30	OSS-1 deactivation
88	14:43	Port door closed
88	14:57	Starboard door closed
88	18:00	Mission extension decision
88	18:37	Starboard door open
88	18:39	Port door open
88	18:45	Radiators deployed
89	11:20:11	Radiators stowed
89	12:13:17.40	Port door closed
89	12:15:15.40	Starboard door closed
89	14:55	Maneuver to deorbit attitude
89	15:08:39	APU-1 activation
89	15:13:30	Deorbit thrusting—OMS engines start
89	15:15:57.19	Deorbit thrusting OMS engine cutoff
89	15:22	APU-2 and -3 activation
89	15:34:34	Entry interface
89	15:34:44	Begin blackout
89	15:38:09	End blackout
89	15:58:56	TAEM (terminal area energy management)
89	16:04:44.84	Main landing gear contact
89	16:04:59.70	Nose landing gear contact
89	16:06:09	Wheels stop
89	16:44:00	Flight crew egress

*GMT–Subtract 5 hours for EST
6 hours for CST
7 hours for MST
8 hours for PST