

STS 51-F National Space Transportation System Mission Report

September 1985



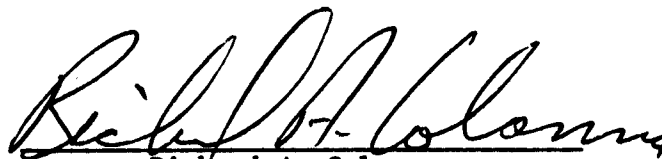
**National Aeronautics and
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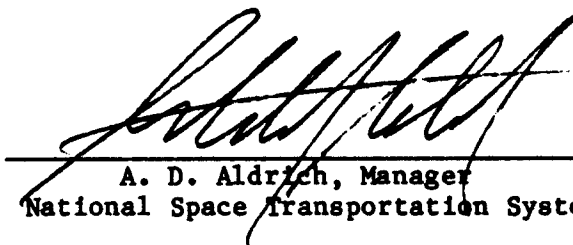
STS 51-F
NATIONAL SPACE TRANSPORTATION SYSTEM
MISSION REPORT



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INTRODUCTION AND MISSION OBJECTIVES

The STS 51-F National STS (Space Transportation System) Mission Report contains a summary of the major activities and accomplishments of the nineteenth Space Shuttle flight and the eighth flight of the OV-099 vehicle, Challenger. The problem tracking list is presented to provide a complete list of all Orbiter problems that occurred.

The primary objectives of the STS 51-F flight were to successfully conduct verification flight tests of Spacelab in the pallet-only configuration as an operational element of the STS, including the IPS (Instrument Pointing System), and to conduct normal Spacelab scientific operations within flight and remaining timeline constraints. These operations include deployment and retrieval of the PDP (Plasma Diagnostics Package) experiments. The sequence of events for this flight is shown in table I. The problem tracking lists for the Orbiter and Marshall Space Flight Center elements are presented in tables II and III, respectively.

MISSION SUMMARY

The scheduled STS 51-F launch on July 12, 1985, was aborted shortly after ignition of all three main engines. The abort was executed because the main engine-2 chamber coolant valve was slow in closing from 100-percent open to 70-percent required for startup. Other than this problem, all systems operated as planned throughout loading and prelaunch operations. Detanking operations were performed as planned for an aborted launch.

The STS 51-F mission was launched on July 29, 1985. Lift-off was delayed 1 hour 37 minutes due to an erroneous command to the BFS (backup flight system) computer. The countdown was resumed and lift-off occurred at 210:21:00 G.m.t. (5:00:00 p. m., e.d.t) from Launch Complex 39A at KSC (Kennedy Space Center). The mission was successfully concluded with a landing at Edwards Air Force Base, California, at 218:19:45:26 G.m.t., on August 6, 1985.

The crew for this nineteenth flight of the Space Shuttle and third flight of Spacelab were C. Gordon Fullerton, Col., U. S. Air Force, Commander; Roy D. Bridges, Col., U. S. Air Force, Pilot; Karl G. Henize, Ph.D., Anthony W. England, Ph.D., and F. Story Musgrave, M.D., Mission Specialists; and Loren W. Acton, Ph.D., and John-David Bartoe, Ph.D., Payload Specialists.

At 5 minutes 43 seconds after lift-off, both temperature readings for the SSME (Space Shuttle Main Engine) 1 high pressure turbopump indicated above the red-line, resulting in a premature shutdown of SSME 1 and the declaration of an ATO (abort-to-orbit) condition. This is the first such abort condition encountered during the Shuttle Program. An OMS (orbital maneuvering system) burn was initiated at 210:21:06:06.0 G.m.t., for 106 seconds and used approximately 4134 lb of propellant. At 8 minutes 13 seconds into the flight, one of two temperature sensors on SSME 3 indicated a high temperature reading and auto shutdown for the remaining two engines was inhibited to assure achieving an acceptable orbit. The OMS (orbital maneuvering system)-2 burn placed the Shuttle in a 143.1- by 108.0-nmi. orbit with an inclination of 49.57 degrees.

The first day's activities included opening the payload bay doors, checkout of the RMS (Remote Manipulator System), activation of Spacelab experiments, and deployment of the IPS. Because of the ATO decision, three additional OMS burns were required to raise the orbit to 170.7 by 169.8 nmi.

The operational phase of Spacelab began on the second day. All instruments were powered up and several had begun science operations. One experiment, SOUP (Solar Optical Universal Polarimeter) became inoperative plus some pointing problems were evident with the IPS. The IPS was stowed during the highly successful PDP operation. Good scientific data were obtained from the remaining Spacelab experiments.

The Orbiter subsystems continued to operate satisfactorily during the third day of the mission. The highlight of this third day was the successful deployment, operation, and grapple of the PDP. The majority of the crew time from both shifts was devoted to PDP operation. Successful science operations were completed for every experiment except the SOUP, which remained inoperative since shortly after activation.

Day 4, the midpoint of the planned 7-day mission, saw the successful completion of the 6-hour period of proximity operations with the free-flying PDP. The final two flyarounds were completed and the PDP was grappled and stowed. As a result of these activities, the crew was able to shift their attention to solar and astronomical observations. Operations with the IPS improved with sunpointing being quite successful; however, some of the problems experienced earlier in the mission were still present. An attempt to start the SOUP experiment was again unsuccessful. All Orbiter subsystems continued to operate satisfactorily throughout the fourth day.

Day 5 Orbiter subsystem operations continued to be very satisfactory. Initial discussions were held on extending the mission one day since the consumables appeared to be adequate to support such an extension. The scientists received vast amounts of sun data and, with the three telescopes pointing simultaneously at the same spot and the IPS operating satisfactorily, they were able to obtain a more comprehensive picture of the Sun. In addition to these observations, most of the other Spacelab 2 experiments were operating automatically.

No new Orbiter anomalies were reported during day 6 as the vehicle subsystems continued to perform in an excellent manner. The decision was made to extend the mission 24 hours with the planned landing on August 6, 1985. A TPS (thermal protection system) tile survey was successfully conducted of the underside of the vehicle and it showed no significant damage. The Spacelab 2 mission logged another successful day as the crew completed all planned activities on schedule with a high degree of "data take". All Spacelab systems and experiments except the SOUP continued to operate properly.

The Orbiter systems operated satisfactorily during the seventh day as the vehicle continued to demonstrate its design capability to function as a platform for on-orbit scientific investigations. Following a satisfactory OMS burn in support of the Plasma Depletion experiment, the SOUP experiment responded to a ground command and began operating properly. Scientists immediately began collecting data from this telescope. The IPS reached its fully operational capability, and all Spacelab systems functioned satisfactorily during this period.

On the eighth day, the Orbiter subsystems continued their almost flawless operation. Likewise, the Spacelab was operating very satisfactorily with great amounts of data being collected on this bonus day of the mission. During the latter part of the day, Spacelab experiments were powered down. Also, stowage of items not required for entry and landing was also completed.

The 172-second deorbit maneuver was initiated at 218:18:43:00 G.m.t. Entry was nominal in all respects. Eight of ten planned PTI's (programmed test inputs) were completed. After completing the 130-degree HAC (heading alignment circle) turn angle, the Orbiter was guided to a landing on runway 23 at Edwards AFB, CA. Rollout required 8569 feet and was 55 seconds in duration.

All Orbiter DTO's (detailed test objectives) assigned to STS 51-F were accomplished either completely or to a very high degree.

TABLE I. - STS 51-F SEQUENCE OF EVENTS

<u>Event</u>	<u>Actual time, G.m.t.</u>
APU activation (1)	210:20:55:11
(2)	210:20:55:12
(3)	210:20:55:13
SRB HPU activation command (LH-A2)	210:20:59:32
MPS start command sequence (engine 3)	210:20:59:53.4
SRB ignition command from GPC (lift-off)	210:21:00:00
MPS throttle-down to 97 percent (engine 3)	210:21:00:19.7
MPS throttle-down to 65 percent (engine 3)	210:21:00:29.9
Maximum dynamic pressure	210:21:00:50
MPS throttle-up to 104 percent (engine 3)	210:21:00:55.9
SRB separation command from GPC	210:21:02:01
SSME 1 cutoff	210:21:05:43.4
OMS dump ignition	210:21:06:06.0
OMS dump cutoff	210:21:07:52.4
Main engine cutoff (MECO)	210:21:09:42
External tank separation	210:21:10:00
OMS 1 ignition (not required)	
APU deactivation (3)	210:21:13:55
OMS 2 ignition	210:21:33:00
OMS 2 cutoff	210:21:35:02
OMS 3 ignition	211:02:30:27
OMS 3 cutoff	211:02:31:02.3
OMS 4 ignition	211:03:22:18
OMS 4 cutoff	211:03:23:03.1
OMS 5 ignition	211:05:01:36.1
OMS 5 cutoff	211:05:01:51.3
APU 3 activation	218:18:38:06
Deorbit maneuver ignition	218:18:43:00
Deorbit maneuver cutoff	218:18:45:52
APU activation (1)	218:19:33:50
(2)	218:19:01:29
Entry interface	218:19:14:27
End blackout	218:19:30:56
Flight control system checkout - APU 2 start	217:13:48:16
APU 2 shutdown	217:13:53:00
Terminal area energy management (TAEM)	218:19:39:10
Main landing gear contact	218:19:45:26
Nose landing gear contact	218:19:45:35
Wheels stop	218:19:46:21
APU deactivation complete (3)	218:19:59:32

VEHICLE ASSESSMENT

SOLID ROCKET BOOSTERS

All SRB (solid rocket booster) systems performed as expected except for the RGA (rate gyro assembly) "C" yaw gyro located on the left SRB, which failed approximately 40 minutes after completion of the T-1 hour and 30 minute gyro torque checks. It was agreed to launch with this gyro deselected in the redundancy management software. Performance of both SRM's (solid rocket motor) was close to predicted value, and well within the allowed envelopes.

Propellant burn rates were near predicted values. Preliminary data indicate that the SRB separation occurred within 1 second of the predicted time.

EXTERNAL TANK

All ET (external tank) systems and instrumentation performed as expected. No LCC (Launch Commit Criteria) violations were experienced and no significant ice buildup was observed. ET tumbling was tentatively confirmed. Preliminary indications are that the ET impacted at 48.9 degrees south latitude and 159.1 degrees east longitude as compared with predicted impact of 33.6 degrees south latitude and 159.9 degrees west longitude.

SPACE SHUTTLE MAIN ENGINE

All SSME parameters appeared to be normal during the prelaunch countdown and compared well with prelaunch parameters that were observed on previous flights.

During mainstage operation of SSME 1 at T+120 seconds, data from Channel A, one of two measurements of the HPFTP (high pressure fuel turbopump) discharge temperature, displayed characteristics indicative of the beginning of failure of that sensor. The measurement then began to drift. Meanwhile, the Channel B sensor apparently failed at T+221 seconds. The Channel A measurement continued its drift and exceeded the redline limit at T+343 seconds, resulting in the premature shutdown of SSME 1. All other parameters on this engine appeared satisfactory.

Also during mainstage operation of SSME 3, Channel B sensor data, one of two measurements of the HPFTP discharge temperature, began to drift upward and exceeded the redline at approximately T+493 seconds. The measurement did not at this time exceed the reasonableness limit of 2900 degree R. Drift then resumed downward and within a few seconds exceeded the reasonableness limit at T+496 seconds. The measurement of Channel A remained within prescribed limits. This measurement and other engine operating parameters indicated that the performance of SSME 3 was satisfactory. Performance of SSME 2 appeared satisfactory.

MAIN PROPULSION SYSTEM

Liquid oxygen and liquid hydrogen loading was accomplished as planned. Loads were near predicted values. There were no hazardous gas leaks of any significance.

Ascent performance of MPS (main propulsion system) before and after the premature shutdown of SSME 1 was satisfactory.

ORBITER

Auxiliary Propulsion Unit I Pressure Anomalies

During ascent, the APU (auxiliary propulsion unit) 1 gearbox nitrogen pressure and gearbox lubrication oil outlet pressure both increased by approximately 8 psia. Both pressure indications returned to normal and then began to rise again. At APU shutdown, the gearbox nitrogen pressure was off-scale high (above 30 psia versus a normal operating pressure of 20 psia), and the gearbox lubrication oil outlet pressure was 90 psia versus a normal operating pressure of 60 psia.

During descent, APU 1 was started late, at about Mach 10, to provide the most assurance of having three APU's for flight control and landing operations. APU 1 pressures recorded during descent were a repeat of the profiles observed during ascent.

Subsequent postflight investigations revealed excess water in the lubrication oil of gearbox 1. This, when exposed to operating temperatures, caused the pressure profiles experienced during the flight. The water is reported to have come from a hose that is part of common-use ground support nitrogen servicing equipment.

TPS Damage During Ascent

During the launch pad inspection following lift-off, a piece of SOFI (spray-on foam insulation) that apparently came from the external tank was found. An inspection of the beach areas near the launch pad revealed additional pieces of SOFI from the external tank.

An on-orbit tile survey was conducted to determine the extent of possible damage to the Orbiter. This inspection showed a large number of small diameter tile hits similar to the damage observed postflight on STS 51-G. No tiles were missing, and there was no concern for entry with the damage observed.

The postflight inspection showed that there was a total of 553 debris hits of which 226 were greater than or equal to 1 inch in diameter. Most of the impact craters showed the effects of entry heating. This is the largest number of debris hits on any Orbiter flown. Also, a piece of SOFI was found lodged beneath the right-hand ET door. Review of the ET separation films shows a number of large divots in the SOFI in the intertank area.

DETAILED TEST OBJECTIVES

ENTRY AERODYNAMIC TEST (DTO 0234)

A total of 10 sets of PTI's and one manual body-flap maneuver were scheduled for the DTO. The first PTI set, QBAR=35, was cancelled because of an RCS (reaction control system) PTI maneuver redline exceedance and the mach 3.4 to 2.65 PTI set was cancelled due to a bank-reversal conflict. The most important PTI set was performed at Mach 19 to 17 in conjunction with the body-flap pulse to obtain and compare elevon and body-flap pitch authority with a common center of gravity. The center of gravity was further aft than planned. In spite of the loss of the two PTI sets and the more aft center of gravity, this DTO is considered successful.

ET TPS PERFORMANCE (DTO 0312)

This DTO required photography of the external tank after ET separation. A +X RCS translation was also required to photograph the forward end of the tank. The RCS translation was cancelled due to the ATO decision. Excellent photography of the two-tone SOFI area forward of the ET forward attach point was obtained.

TACAN ON-ORBIT NAVIGATION (DTO 0780)

This DTO required that the Orbiter acquire TACAN stations and downlist the data to the MCC (Mission Control Center) to demonstrate that the MCC could generate a state vector. The DTO was considered highly successful.

"DATA ONLY" DTO'S

The following DTO's required no special test or crew activity other than operation of the instrumentation systems and recorders. Postflight data are not yet available, but no instrumentation or recorder problems are known which affect these DTO's.

- DTO 0301 Ascent Structural Capability Evaluation
- DTO 0303 RCC Life Evaluation
- DTO 0307 Entry Structural Capability
- DTO 0308 Vibration and Acoustic Evaluation
- DTO 0311 Pogo Stability Performance
- DTO 0319 Shuttle/Payload Low Frequency Environment
- DTO 0320 Elevon Trailing Edge heating Evaluation
- DTO 0758 Payload/FCS Dynamics Measurements

SPACELAB

SUMMARY

Throughout the 8-day mission, all but one of the Spacelab subsystems operated nominally. There were no problems with the command and data management, environmental control, or electrical power distribution system. The new IPS caused some frustration for the first half of the mission when it did not acquire and track the Sun through the IPS optical sensor package. However, persistent efforts on the ground and in orbit led to resolution of the operational problems and satisfactory performance throughout the last half of the mission. During troubleshooting, a number of software changes were uplinked to adjust the optical sensor package operations. As a result, the four telescopes mounted on the IPS completed most of their planned observations with the desired pointing accuracy and stability. Data and image quality varied from very good to spectacular.

Since many of the Spacelab 2 scientific instruments will be flown again on future missions, this flight provided opportunities for scientific data collection and for engineering checkout of sophisticated new equipment. Results from this mission will be important for future flights of the astronomical telescopes and superfluid helium cryogenic systems as well.

Although each experiment began the mission with clearly defined objectives and designated periods of operation, the mission plan was continuously changed. Solar observations, for example, were planned orbit-by-orbit on the basis of data gleaned during previous orbits and changing conditions on the Sun. If some orbital anomalies spoiled the chance to do a particular experiment, scientists readily shifted their resources to another objective and kept obtaining good scientific results. Data collected by the infrared telescope, for example, did not provide a survey of the sky in all the planned wavelengths, but a compendium of potentially useful information about background radiation that interfered with astronomical scanning was collected.

SCIENCE ACTIVITIES

As the mission concluded, scientists reported meeting at least half their planned objectives, and many reported 90-percent to 100-percent success. Data quantity was record-breaking and data quality was excellent.

Solar Physics

The general goal of the solar physics investigations was to understand the structure and dynamics of the Sun, its different features, energy processes, and activity cycles.

Although the Sun is currently in a fairly quiet phase of its activity cycle, the crew observed sunspots, filaments, granules, spicules, and prominences. These

solar features changed from orbit to orbit and day to day. Spacelab 2 has returned a stock of still photographs, videotapes, spectral scans, and films of solar activity, some of which were seen on downlink television during the mission.

Spacelab 2 carried a complement of 4 ultraviolet and visible light instruments that functioned together as a solar observatory mounted on the IPS. Three of these telescopes operated jointly, observing the same targets simultaneously to collect different, but complementary data.

Solar Optical Universe Polarimeter - The SOUP started its observation program late in the mission after an unexplained shutdown on the first day and an equally inexplicable startup on the sixth day of the mission. Thereafter, the instrument performed almost perfectly to observe the strength, structure, and evolution of magnetic fields in the solar atmosphere. Scientists are confident that despite the abbreviated operation, SOUP data will be the best and longest run of solar granulation data ever collected.

Coronal Helium Abundance Spacelab Experiment - The HRTS (High Resolution Telescope and Spectrograph) instrument was designed to make spectral scans and images of the solar disc and, particularly, to record rapidly changing solar features. It included one television and three still camera systems for ultraviolet and hydrogen alpha imaging. Downlink television from the instrument revealed the birth of a spicule, which has never been witnessed before. The resolution of the telescope was very good, but IPS pointing difficulties compromised early data. For part of the mission, IPS pointing was controlled by the HRTS instrument.

Atmospheric Physics

Although ultraviolet radiation constitutes about 5 percent of the energy radiated by the Sun, most of it is absorbed by the ozone layer in the upper atmosphere. However, it still has subtle, unexplained effects on the Earth's environment and possibly on global weather and climate. Scientists have already determined that solar ultraviolet radiation varies more than total solar radiation and, therefore, may be the key to weather variations. Spacelab 2 carried one instrument that operated in conjunction with the three solar telescopes to measure solar ultraviolet radiation as part of a study to determine the short-term and long-term variations in the flux.

Solar Ultraviolet Spectral Irradiance Monitor - The SUSIM made spectral scan of the Sun with excellent accuracy that have been verified by calibration and alignment checks. Some of the scanning opportunities were lost when the IPS had pointing problems and when the SUSIM team cycled the instrument off and on to avoid overheating.

Plasma Physics

Investigations of the ionized gases in the upper atmosphere are especially well-suited for Shuttle/Spacelab missions because they can use the Shuttle itself as a research tool in the vast natural laboratory of space. On Spacelab 2, three plasma physics investigations involved a variety of measurements and experiments to determine the nature of the environment around the Shuttle and the effect of the Shuttle's passage through it. Some of these experiments passively monitored the ambient environment, while others actively stimulated the environment to produce plasma waves, airglow, and other phenomena.

Plasma Diagnostics Package - One of the high points of the Spacelab 2 mission was the PDP, which performed flawlessly on the pallet, on the RMS (Remote Manipulator System) arm, and as a free-flyer. The PDP had flown once on a previous Shuttle mission, but it was released as a satellite for the first time during Spacelab. While the PDP was deployed about 1/3 nmi. away, the crew maneuvered the Shuttle through a series of complex proximity operations that permitted monitoring of the vehicles' wake and observation of other plasma turbulence effects. During this period, the PDP and the VCAP (Vehicle Charging and Potential Experiment) instruments were used in successful joint operations to produce and monitor electron beams and radio waves. While it was attached to the RMS, the PDP monitored the plasma turbulence induced by the Shuttle's motion, the OMS burns, and firing of the VCAP electron beam. It also was used with the infrared telescope in a joint investigation of the Shuttle infrared glow phenomenon.

Plasma Depletion Experiment - The Plasma Depletion Experiment also used the Shuttle as a research instrument. OMS burns were scheduled over radar and radio astronomy facilities on the ground to observe the ionospheric effects of Shuttle exhaust vapor. The experiment was jeopardized by the loss of altitude and propellant during ascent, but planners managed to schedule four of the eight anticipated burns - two over Millstone Hill, Mass., and one each over Arecibo, Puerto Rico, and Hobart, Australia. Preliminary data indicate that the OMS burns did produce "holes", or troughs, of depleted plasma that persisted in the ionosphere for more than an hour. The crew observed resultant airglow after the nighttime burns, and there were reports of visual observations from the ground as well. The Hobart site reported the reception of low-frequency cosmic radio emissions through the window temporarily opened by the burn.

Vehicle Charging and Potential Experiment - The VCAP instruments were used for both passive monitoring and active experimentation. VCAP monitors gathered background information on the plasma environment, plasma turbulence and wakes, passive charging, and return currents to the Orbiter. A number of joint operations and observations were accomplished, primarily with the PDP experiment and also with the nearby Dynamics Explorer satellite. The VCAP electron generator was fired more than 200 times - 20 times by the crew during the PDP fly-around and the rest by the experiment team in the POCC (payload operations control center). Instrument performance was near perfect, and incoming data looked clean and interesting.

Infrared Astronomy

Astronomers are interested in the characteristics of the Shuttle as an observatory platform, capable of carrying telescopes and other instruments above the observable atmosphere and then bringing them back for calibration and modification. Infrared radiation reveals much of the dust and gas throughout our galaxy and others as well as distant, cool objects not observable in other wavelengths.

Small Helium-Cooled Infrared Telescope - The IRT (infrared telescope) operated well throughout the mission, but it did not achieve its primary objective of an all-sky survey in all the planned wavelengths. During the first IRT viewing period, many of the detectors were found saturated by a strong background source of mysterious origin, approximately 500 to 1000 times more intense than the natural background from dust in the solar system. In spite of the high background radiation problem, a reasonably good sky map was obtained. A section of the galaxy was mapped in shorter wavelengths, and these data represent a new and valuable complement to the IRAS (Infrared Astronomical Satellite) data. Since astronomical observations could not be performed, observing time was devoted to studying background itself. A survey of the instrument with the RMS camera just before payload deactivation revealed something that appeared to be debris within the Sun shade. During the final 1 1/2 days of operation, a number of measurements were made on the behavior of the superfluid helium cooling system of IRT. Several important results were obtained which will influence the design of future space helium systems.

High Energy Astrophysics

One goal of high energy astrophysics was to examine X-rays, gamma rays, and cosmic ray particles and to interpret the information they bear about the past and continuing development of the cosmos. Astrophysicists are also interested in the capabilities of the Shuttle/Spacelab as a platform for observations in all wavelengths.

Cosmic Ray Nuclei Experiment - The 2-ton egg-shaped CRN (cosmic ray nuclei) detector operated well throughout the mission and recorded 24 million particle events. It is the largest and most complex cosmic ray detector ever built for spaceflight. Cosmic ray particles penetrated the instrument continuously and were analyzed at a rate of about 70 events per second. The only significant interruptions were by orbital and attitude constraints; no useful data could be received during bay-to-Earth attitudes or periods of high background radiation. Cosmic ray nuclei penetrated CRN with virtually the speed of light and CRN measured the position and direction of each particle's trajectory. Quick-look analysis confirmed the capability of the instrument to determine the elemental identity and energy of each cosmic ray nucleus that entered the detector across the range from Beryllium to Nickel (atomic numbers 4 to 28). Of the total of 24 million cosmic rays collected, about 30,000 will probably be the extremely high energy variety (hundreds or thousands of giga-electron volts). These could not be explored in past experiments, thus the CRN data will yield entirely new information on the most energetic processes responsible for the generation and propagation of these particles in our galaxy.

Hard X-Ray Imaging of Cluster of Galaxies - The dual X-ray telescope operated well throughout the mission with very good image quality, detector sensitivity, and stability. Images of point sources and extended sources were successfully reconstructed from downlinked data. The total net observing time was approximately 70 hours, with long exposures of most of the prime targets, including the galactic center, Perseus, Virgo, the Coma cluster, Centaurus, A754, Vela supernova remnant, and others. A number of secondary targets and miscellaneous fields also were observed, with calibration exposures of the Crab Nebula.

Technology Research

The microgravity environment aboard the Shuttle provides a unique laboratory for investigating the basic properties and behaviors of materials. Subtle effects that are masked in normal gravity can be more readily observed in space. On Spacelab 2, scientists investigated the properties of superfluid helium, a substance that showed promise as a cryogen. Data collected in space on the performance of superfluid helium could have practical applications in the design of cooling systems for infrared detectors in telescopes.

Properties of Superfluid Helium in Zero-Gravity - The dewar or cryostat performed up to expectation during the Spacelab 2 mission, maintaining a temperature low enough to keep the helium in the superfluid state. Temperature was readily controlled, and the cryostat recovered well from temperature increases. These findings will be of importance to the use of superfluid helium as a cryogen on future missions.

In addition to the engineering assessment of the cryostat system, the investigation included several experiments in basic fluid dynamics. The existence of low-frequency capillary waves (quantized surface waves) in thin films of helium had been theorized, but actual laboratory observations could not be made because of the effects of gravity. During this mission the existence of the waves was clearly established, and several hundred recordings were made across a range of temperatures. Comparison of the experimental and theoretical results showed many similarities and also some interesting differences.

Bulk thermal dynamics measurements of temperature variations within the dewar were quite successful, but bulk fluid dynamics measurements were foiled until late in the mission by anomalous sensor performance. The superfluid helium instrumentation also was used to monitor acceleration levels aboard the Shuttle.

Life Sciences

The Shuttle/Spacelab also was used as a microgravity laboratory for research into basic life processes and adaptation to weightlessness. An ongoing program of plant, animal, and human studies of biological and physiological processes is being conducted on Shuttle flights. This research results in greater understanding of life processes and may lead to practical applications on Earth.

Vitamin D Metabolites and Bone Demineralization - The results of this experiment will not be known until blood samples collected from the crew are processed. The purpose of the investigation was to measure the vitamin D metabolite levels of crew members in an attempt to understand the causes of mineral imbalances and bone demineralization that occur during prolonged spaceflight.

Gravity Influenced Lignification in Plants - Pine seedlings, oats, and bean sprouts grew in self-contained growth chambers during the mission. Growth unit temperatures were monitored daily, and the chambers were inspected and photographed early and late in the mission. The oats and bean seeds germinated in orbit and sprouts grew to a height of 5 to 6 inches, as expected. The pine seedlings also showed normal growth. Postflight, the plant tissues are being analyzed to determine whether there is any difference in the production rate of lignin between plants grown in space and a control group grown in the ground laboratory.

TABLE II.- STS 51-F PROBLEM TRACKING LIST.

JSC STS 51-F PROBLEM TRACKING LIST FOR OV-099 CHALLENGER FLIGHT 8		SEPT. 06, 1985	
NO.	TITLE	TIME, G.M.T.	COMMENTS
1	PAYLOAD DATA INTERLEAVER DYNAMIC WRAP TEST FAILURE.	210:15:10 PRELAUNCH	PDI DID NOT RESPOND TO EITHER PCMMU. PDI WAS NOT REQUIRED FOR SPACELAB. R&R AT KSC. H. HERNANDEZ CAR 26F006 CLOSURE IN PROCESS
2	APU 1 LUBE OIL OUTLET PRESSURE (V46P0153A) HIGH AND GEARBOX GN2 PRESSURE (V46P0151A) HIGH.	210:21:09:47	OIL PRESSURE READ OVER 25 PSI HIGH. GN2 PRESSURE WENT OFF SCALE HIGH. T/S AT KSC FOUND WATER IN LUBE OIL. OIL WAS CHANGED. W. SCOTT CAR 26F007 CLOSURE IN PROCESS
3	INSTRUMENTATION:		
A	SSME 2 GH2 OUTLET PRESSURE (V41P1260A) FAILED.	210:21:00:15	SENSOR FAILED OFF SCALE LOW ABOUT 15 SECONDS AFTER LAUNCH. REMOVE SENSOR AND PLUG. FLY AS IS. D. PREVEIT CAR 26F002
4	PAYLOAD BAY BLACK AND WHITE TV CAMERA "A" FAR FIELD FOCUS FAILED AND RMS WRIST TV CAMERA HAD A BRIGHT SPOT IN THE MIDDLE.	211:02:40	CAMERA "A" FOCUSED ONLY ON NEAR FIELD OBJECTS. UNABLE TO FOCUS ON DISTANT OBJECTS. NOTED WRIST CAMERA SPOT DURING TILE SURVEY. R&R AT KSC. B. EMBREY EE610F & 14F CLOSURE IN PROCESS
5	BACKUP FLIGHT SYSTEM LOGGED STORE PROTECT VIOLATION.	210:18:23 PRELAUNCH	BFS TMBU UPLINKED WITH INVALID ADDRESS WORD. COUNTDOWN RECYCLED, IMU'S REALIGNED AND BFS INITIAL PROGRAM RELOADED. JSC EVALUATE BFS STORE PROTECT SOFTWARE. DR TO CHANGE SOFTWARE. H. MOBLEY CLOSURE IN PROCESS
6	RIGHT RCS THRUSTER RIR INJECTOR HEATER FAILED AND JET LEAKED FUEL AFTER HOT FIRE.	212:02:00(H) 213:00:29(L)	OX/FU INJECTOR TEMPERATURES STABILIZED AT ABOUT 55 DEG F. AFTER FIRING FU INJ TEMP FELL TO 27 DEG F AND CREW DESELECTED JET. LEAK STOPPED. TEMPS STABILIZED ABOVE 50 DEG F. PLACED IN 4TH PRIORITY AND RESELECTED FOR ENTRY. GROUND INSPECTION VERIFIED NO LEAK. R&R THRUSTER AT KSC AND REPLACE HEATER AND CONTROLLER. G. GRUSH CAR 26F003 CLOSURE IN PROCESS

TABLE II.- STS 51-F PROBLEM TRACKING LIST (CONTINUED).

JSC STS 51-F PROBLEM TRACKING LIST FOR OV-099 CHALLENGER FLIGHT 8		SEPT. 06, 1985	
NO.	TITLE	TIME, G.M.T.	COMMENTS
7	LEFT SRB YAW AXIS RATE GYRO ASSEMBLY 3 FAILED.	210:17:28:00 PRELAUNCH	WENT HARDOVER DURING SRB TORQUE CHECK. FAILED RGA DESELECTED IN PASS AND BFS DURING PRELAUNCH COUNTDOWN. SRB'S RECOVERED. T/S OF RGA AT KSC REPEATED HARDOVER FAILURE. FOUND FAILED CAPACITOR. R&R AT KSC. FLY LCC RED LINE AS IS.
8	GPC BODY RATE DATA TRANSFER INCOMPATIBLE WITH SPACELAB.	212:18:37	COORDINATE AXIS ORDER XYZ (ROLL, PITCH, YAW) IN GPC SM BUT YZX IN SPACELAB. UPLINKED PATCH TO GPC. OPERATION NORMAL IN SPACELAB. JSC EVALUATE GPC SOFTWARE. DR FOR STS 61-B.
9	CCTV MONITOR 1 PICTURE QUALITY POOR AND MONITOR 2 HAD A WHITE SPOT IN THE MIDDLE.	213:00:39	POOR PICTURE NOTED BEFORE LAUNCH AND AT HIGH CONTRAST POSTFLIGHT. COULD NOT FIND WHITE SPOT ON MONITOR 2; CHECKOUT NORMAL, FLY AS IS. R&R MONITOR 1 AT KSC.
10	PAYLOAD BAY COLOR TV CAMERA "D". LOSS SYNC.	212:18:00	BINARY GMT DISPLAY A WHITE LINE, OVER TEMP HIGH, GAMMA AND ALC CYCLED EVERY SECOND, AND IRIS DID NOT FULLY CLOSE. CLEARED BY POWER CYCLE AND OPERATION NORMAL. R&R AT KSC.
11	SMOKE DETECTOR "B" IN AVIONICS BAY 2 FAILED SELF TEST.	214:04:37	REDUNDANT SENSOR 2A OPERATION NORMAL. DETECTOR 2B OUTPUT SHIFTED DOWNWARD AT 213:08:00 WHEN AV BAY 2 WAS POWERED DOWN. R&R AT KSC.
12	RIGHT OMS CROSSFEED LEG "B" FUEL OPEN MICROSWITCH FAILED.	214:14:08	CABIN DISPLAY BARBER POLE WITH AFT MCA 2 STATUS 1 OFF. SWITCH PLACED IN GPC CONTROL AND STATUS 1 READ ON. R&R ACTUATOR AT KSC. REPLACED ALL 4 B LEG OMS CROSSFEED VALVE ACTUATORS USING PIND TESTED SWITCHES.
13	OPERATIONS RECORDER 2 TRACK 6 MALFUNCTION.	213:18:06	DATA DUMPS ON TRACK 6 UNREADABLE. DATA GOOD ON TRACKS 5 AND 7. TRACK 6 DATA READABLE WHEN DUMPED ONE TO ONE. R&R AT KSC.

TABLE II.- STS 51-F PROBLEM TRACKING LIST (CONTINUED).

JSC STS 51-F PROBLEM TRACKING LIST FOR OV099 CHALLENGER FLIGHT 8		SEPT. 06, 1985	
NO.	TITLE	TIME, G.M.T.	COMMENTS
14	RIGHT OMS CROSSFUEL LEG "A" FUEL OPEN MICROSWITCH FAILED.	218:19:55 POSTLANDING	OPEN MICROSWITCH READ "ON" WHEN VALVE WAS CLOSED. SUSPECT CONTAMINATED MICROSWITCH. R&R ACTUATOR AT KSC. REPLACED WITH ACTUATOR USING PIND TESTED MICROSWITCHES. J. HOOPER CAR 13F001 CLOSED 08/28/85
15	THERMAL PROTECTION SYSTEM DAMAGED BY ET INTERTANK FOAM INSULATION DURING ASCENT.	ASCENT	ABOUT 50 DEBRIS HITS FORWARD OF ET DOOR. LARGE PIECE OF SOFI WEDGED IN ET DOOR CAVITY. ABOUT SAME NUMBER OF HITS AS LAST FLIGHT, BUT SMALLER IN SIZE. ET INSULATION DEBONDED. SEE PROBLEM STS51G+11. J. SMITH CLOSURE IN PROCESS
16	RIGHT OMS ULLAGE PRESSURE HIGH.	ON ORBIT	AT START OF OMS+6 HOBART BURN, PRESSURE INCREASED FOR ABOUT 10 SECONDS UP TO 266 PSI THEN STARTED DECREASING. SUSPECT PRIMARY AND SECONDARY "B" LEG HE PRESSURE REGULATORS. R&R HE REGULATORS AT KSC. J. HOOPER CAR 26F008
17	ALL OMS BURNS HAD A ROUGH START TRANSIENT EXCEPT DEORBIT BURN.	ON ORBIT	CREW POSTFLIGHT REPORT. STANDARD KSC BOROSCOPE TEST OF OMS INJECTORS FOUND NO PROBLEM. ATTACH FITTINGS OK. REINSTALL AT KSC. J. HOOPER
18	PAYLOAD BAY FORWARD BULKHEAD FLOODLIGHT FAULTY START.	ON ORBIT	CREW REPORTED SEEING LIGHT FLASH ON VIDEO DURING FIRST START. LIGHT WORKED PROPERLY ALL SUBSEQUENT TIMES. FLY AS IS. T. LEWIS CLOSURE IN PROCESS
19	AIRLOCK HATCH "A" DIFFICULT TO LATCH FOR ENTRY.	PRE DEORBIT	CREW REPORTED 2 PIP PINS WERE PULLED TO ALLOW HATCH TO BE ALIGNED FOR DEORBIT STOWAGE. FOUND BENT GUIDE PIN. R&R HINGE STOP ASSEMBLY, POINTER & GUIDE PIN. RERIC WITH GSE PER OMSRD PROCEDURE. N. JEVAS CAR 26F009
20	DIGITAL AUTO PILOT DOWNMODED TO MANUAL DURING MANEUVER TO ENTRY INTERFACE ATTITUDE.	ENTRY	PILOT'S RHC WAS BUMPED CAUSING DOWNMODE DURING MANEUVER TO EI+5 ATTITUDE. ANALYSIS CONFIRMED PROPER TRANSDAP OPERATION. E. KUBIAK CLOSURE IN PROCESS
21	RIGHT DISPLAY DRIVER UNIT GOOD BIT TOGGLED.	ENTRY	BITE MESSAGE TOGGLED SEVERAL TIMES FOR ABOUT 10 MINUTES. REVIEW OF ONBOARD TAPE DATA ISOLATED PROBLEM TO R DDU. R&R AT KSC. T. LEWIS CLOSURE IN PROCESS

TABLE II.- STS 51-F PROBLEM TRACKING LIST (CONCLUDED)

JSC STS 51-F PROBLEM TRACKING LIST FOR OV-099 CHALLENGER FLIGHT 8		SEPT. 06, 1985	
NO.	TITLE	TIME, G.M.T.	COMMENTS
22	CREW DEBRIEFING ITEMS FOR KSC:		
A	GALLEY DOOR LATCH PIN FELL OUT.	ON ORBIT	KSC REPLACE PIN. R. TRABANINO
B	OVERHEAD IMU FILTER ACCESS PANEL M04258F RETAINER SCREW SHEARED.	ON ORBIT	KSC REPLACED SHEARED SCREW. F. McALLISTER
C	VOLUME G DOOR UNDER AFT LOCKERS OPENED.	LAUNCH	KSC ENSURED CLOSURE OF VOLUME G DOOR. F. McALLISTER
D	VELCRO DEBONDED ON WINDOW 9 & 10 SHADES.	ON ORBIT	KSC REBONDED VELCRO IN PLACE. C. McCULLOUGH
E	LEFT AIR DATA PROBE SWITCH LOOKED OUT OF DETENT PRIOR TO PROBE DEPLOYMENT.	ENTRY	KSC ENSURE LEVER LOCK HOLDS SWITCH IN AFT POSITION. C. McCULLOUGH
F	FILTERS CLOGGED BEHIND PANELS L 10, 11 & 12.	ON ORBIT	KSC ENSURE ALL FILTERS CLEANED AGAIN BEFORE NEXT LAUNCH. C. McCULLOUGH

PREPARED BY: /s/RJW
ROBERT J. WARD

09/06/85
DATE

APPROVED BY: /s/JEM
JOSEPH E. MECHELAY

09/06/85
DATE

TABLE III - STS 51-F ANOMALY AND FAILURE LIST

ELEMENT	ITEM	RESPONSIBILITY
SRB	RATE GYRO ASSEMBLY (RGA) "C" YAW GYRO LOCATED ON THE LEFT SRB FAILED DURING COUNTDOWN.	USBI/JSC
SRB	ONE RH SRB MAIN CHUTE FAILED AT 372 SECONDS.	ISBI
SSME	ME-1 (2023) WAS PREMATURELY SHUTDOWN DUE TO CHANNEL B AND CHANNEL A HPFTP DISCHARGE TEMPERATURE MEASUREMENTS FAILING AT T+221 AND T+353 SECONDS, RESPECTIVELY.	RKDN
SSME	ME-3 (2021) HPFTP DISCHARGE TEMPERATURE (CH B) BEGAN TO DRIFT UPWARD AND EXCEEDED THE REDLINE AT APPROXIMATELY T+493 SECONDS.	RKDN