

STS-85 SPACE SHUTTLE MISSION REPORT

October 1997



**National Aeronautics and
Space Administration**

**Lyndon B. Johnson Space Center
Houston, Texas**

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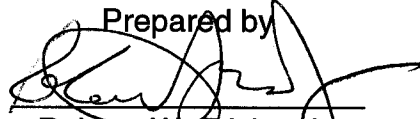
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STS-85
SPACE SHUTTLE
MISSION REPORT

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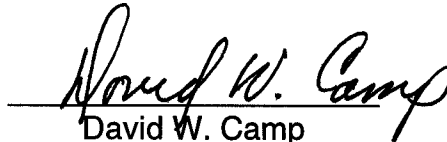
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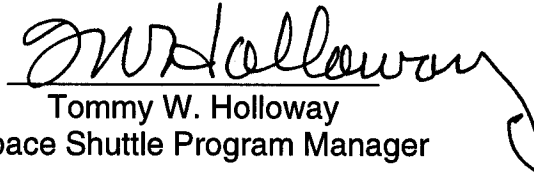
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INTRODUCTION

This Space Shuttle Program Mission Report presents a discussion of the Orbiter subsystem operation and the in-flight anomalies that were identified. The report also summarizes the activities of the STS-85 mission and presents a summary of the External Tank (ET), Solid Rocket Booster (SRB), Reusable Solid Rocket Motor (RSRM), and Space Shuttle main engine (SSME) performance during this eighty-sixth mission of the Space Shuttle Program. STS-85 was the sixty-first flight since the return to flight, and the twenty-third flight of the OV-103 (Discovery) Orbiter vehicle.

The flight vehicle consisted of the OV-103 Orbiter; an ET that was designated ET-87; three SSMEs that were designated as serial numbers (S/N) 2041 (Block 1A), 2039 (Phase IA), and 2042 (Phase IA) in positions 1, 2, and 3, respectively; and two SRBs that were designated BI-089. The two RSRMs were designated RSRM 57 with one installed in each SRB. The individual RSRMs were designated 360T057A for the left SRB, and 360T057B for the right SRB.

The STS-85 Space Shuttle Program Mission Report fulfills the Space Shuttle Program requirements as documented in NSTS 07700, Volume VII, Appendix E. The requirement is that each organizational element supporting the Program will report the results of their hardware and software evaluation and mission performance plus identify all related in-flight anomalies.

The primary objective of the STS-85 flight were to successfully accomplish science objectives by operating the Cryogenic Infrared Spectrometers and Telescopes for the Atmosphere-Shuttle Pallet Satellite (CRISTA-SPAS), to launch and operate in orbit a Manipulator Flight Demonstration (MFD), and to perform operations on the Technology Applications and Science (TAS-01). Secondary objectives were to perform the operations of the Southwest Ultraviolet Imaging System (SWUIS), the International Extreme Ultraviolet Hitchhiker (IEH-02), Bioreactor Demonstration-3 (BDS-3), Biological Research in Canisters (BRIC), the Protein Crystal Growth Single Locker Thermal Enclosure System-05 (PCG-STES-05), the Advance X-ray Astrophysics Facility-Imaging (AXAF) Charge-Coupled Device (CCD) Imaging Spectrometer (ACIS), Get-Away Special (GAS), the Midcourse Space Experiment (MSX), Solid Surface Combustion Experiment (SSCE), and the Shuttle Ionospheric Modification with Pulsed Local Exhaust (SIMPLEX).

The STS-85 mission was a planned 12-day plus 2-contingency-day mission during which experiments were to be conducted in the MSL-1. The two contingency days were available for bad weather avoidance for landing, or other Orbiter contingency operations. The STS-85 sequence of events is shown in Table I, and the Space Shuttle Vehicle Engineering Office In-Flight Anomaly List is shown in Table II. Appendix A lists the sources of data, both informal and formal, that were used in the preparation of this report. Appendix B provides the definitions of all acronyms and

abbreviations using in this report. All times are given in Greenwich mean time (G.m.t.) and mission elapsed time (MET).

The seven-person crew of the STS-85 mission consisted of Curtis L. Brown, Jr., Lt. Col., United States Air Force, Commander; Kent V. Rominger, CDR, United States Navy, Pilot; N. Jan Davis, Ph. D., Civilian, Payload Commander/Mission Specialist 1; Robert L. Curbeam, Jr., Lt. Cdr., United States Navy, Mission Specialist 2; Stephen K. Robinson, Ph. D., Civilian, Mission Specialist 3; and Bjarni V. Tryggvason, Civilian, Canadian Space Agency, Payload Specialist 1. STS-85 was the fourth space flight for the Commander; the third space flight for the Pilot and Mission Specialist 1; and the first space flight for Mission Specialist 2, Mission Specialist 3 and Payload Specialist 1.

MISSION SUMMARY

Liftoff for the STS-85 mission occurred at 219:14:41:00.013 G.m.t. (10:41 a.m. e.d.t.) on August 7, 1997, and on an inclination of 57 degrees. The ascent was nominal and the vehicle was inserted into an orbit of 160.2 by 20.6 nmi. with a 57-degree inclination. The determination of vehicle performance using vehicle acceleration and preflight propulsion data showed that the average flight-derived engine I_{sp} determined for the time period between SRB separation and start of 3g throttling was 454.0 seconds as compared to a main propulsion system (MPS) tag value of 453.55 seconds.

All SSME and RSRM start sequences occurred as expected and the launch phase performance was satisfactory in all respects. First stage ascent performance was as expected. SRB separation, entry, deceleration, and water impact occurred as anticipated with all deceleration systems operating nominally. Both SRBs were successfully recovered and returned to KSC for disassembly and refurbishment. Performance of the SSMEs, ET and main propulsion system (MPS) was normal. The data review showed that no in-flight anomalies occurred in these elements.

During prelaunch operations, the right Orbital Maneuvering Subsystem (OMS) standby yaw actuator rate was observed to be low during the OMS gimbal profile test. The actuator drive-rate has a minimum requirement of 2.9 deg/sec and is only allowed to change by a maximum of 1.0 deg/sec between comparable tests. During the prelaunch gimbal profile test, the standby drive rate differed from the previous comparable test by more than 1.0 deg/sec (Flight Problem STS-85-V-01). During subsequent testing to investigate this condition, a drive rate of 2.45 deg/sec was observed, which was below the minimum rate of 2.9 deg/sec that is specified in the Operational Maintenance Requirements and Specification Document (OMRSD). The Launch Commit Criteria (LCC) allows the loss of one channel (active or standby) on either the left or right side. After the OMS 2 maneuver, the gimbal check was performed again. At that time, the drive rate was sufficient to avoid an Redundancy Management (RM) fault message. The standby drive rate of the actuator was below nominal levels, but it was considered usable for steering during an OMS maneuver, should an active channel be lost. The ground standby gimbal-history shows erratic performance and reflects a gradual degradation of performance. The suspected causes are the lack of the lubrication improvements identified by the vendor from previous failures in the program. The actuator will be removed and replaced during its next flow.

Just prior to liftoff at 219:14:40:56 G.m.t., the right RCS pod oxidizer manifold 5 isolation valve open discrete measurement changed from 1 to 0 (loss of open indication); two seconds later (219:14:40:58 G.m.t.), the isolation valve open discrete changed back to a 1 (open). One second later, the discrete again changed to 0, and a redundancy management (RM) message was logged. At 219:14:42:35.8 G.m.t. [00:00:02:35.8 (mission elapsed time (MET))], the open indication returned for two seconds after which the open was lost until 219:15:00:40 G.m.t. (00:00:19:40 MET). Throughout ascent, the corresponding closed discrete

measurement indicated 0 (not closed) causing an RM dilemma each time. The open indication was lost again at 220:20:38:03.3 G.m.t. (01:05:57:03.3 MET). When the vehicle was powered up again on August 25, 1997, the open indication (1) was present. (Flight Problem STS-85-V-02). Three seconds after the NC4 maneuver was initiated, the right RCS oxidizer manifold 5 isolation valve-open discrete changed from 1 to 0 (loss of open indication), and it continued to indicate not-open following the maneuver. The redundancy management (RM) fault message 'RM DLMA MANF' occurred at 220:20:38:06 G.m.t. (01:05:57:06 MET). Following the NC5 maneuver, the valve position indicator (VPI) indicated not-open for the remainder of the mission. The manifold 5 isolation valve was not cycled during the postflight "RCS,OMS Valve Test" which will aid troubleshooting of the VPI by preserving as much information/evidence as possible. Troubleshooting will be performed on the hardware at KSC.

The OMS 1 maneuver was not required because the direct insertion ascent trajectory was completed nominally. The OMS 2 maneuver was satisfactorily performed at 219:15:18:06.43 G.m.t. (00:00:37:06 MET). The maneuver was 159.8 seconds in duration and the differential velocity (ΔV) was 254.3 ft/sec. The planned 160 nmi. circular orbit was achieved.

The left (port) payload bay door was opened at 219:16:01:55 G.m.t. (00:01:20:55 MET) and the right (starboard) payload bay door was opened at 219:16:03:14 G.m.t. (00:01:22:14 MET). The operation of both doors during the opening was nominal.

Commanding problems were encountered with commands being sent to the Cryogenic Infrared Spectrometers and Telescopes for the Atmosphere-Shuttle Pallet Satellite-II (CRISTA-SPAS-II), Technology Applications and Science-01 (TAS-01), and International Extreme Ultraviolet Hitchhiker-02 (IEH-02) payloads. These problems and their resolution are discussed in detail in the Communications and Tracking Subsystems section of this report.

The remote manipulator system (RMS) was powered up and the checkout was successfully completed at 219:18:24 G.m.t. (00:03:43 MET). The CRISTA-SPAS-II payload was grappled by the RMS at approximately 219:18:40 G.m.t. (00:03:59 MET), and release of the payload bay keel and longeron latches was completed at 219:21:24:06 G.m.t. (00:06:43:06 MET). CRISTA-SPAS-II was successfully deployed at 219:22:27:04 G.m.t. (00:07:46:04 MET). During the CRISTA-SPAS II deployment, the RF signal strength stabilized and the phase remained nominal throughout the deployment phase and most of the separation. The separation and rendezvous maneuvers that were performed to allow CRISTA-SPAS nominal operation and retrieval are presented in the in the Reaction Control Subsystem section of this report.

At 227:15:41:46 G.m.t. (08:01:00:46 MET), general purpose computer (GPC) 1 annunciated a cathode ray tube (CRT) built-in test equipment (BITE) 1 message that was caused by a display electronics unit (DEU) 1 memory parity error (Flight Problem STS-85-V-03). The crew performed malfunction procedure 5.4b (CRT BITE 1). At

block 12 of the procedure, the BITE status words were nominal, indicating that the BITE condition had cleared. Therefore, the crew reassigned CRT 1 to GPC 1, and the BITE did not repeat during the remainder of the mission. This occurrence did not impact the mission. The DEU will be removed and replaced during the next process flow with no post-flight troubleshooting required.

CRISTA-SPAS-II was captured at 228:15:13 G.m.t. (09:00:32 MET). The CRISTA-SPAS II was successfully berthed and latched at 228:16:30:32 G.m.t. (09:01:49:32 MET). The port longeron indicated ready-to-latch (RTL) indication was acquired at 228:16:27:22 G.m.t. (09:01:46:22 MET). The payload bay keel latch was latched at 228:16:29:46 G.m.t. (09:01:48:46 MET). Note that the starboard longeron latch RTL indication was obtained during latching. This was expected because of the location of the grapple fixture with respect to the starboard trunnion on the payload. A similar signature was seen during the STS-66 CRISTA-SPAS-II berthing.

The flight control system (FCS) checkout was performed using auxiliary power unit (APU) 1. The APU and hydraulics subsystems performed nominally during the checkout. APU 1 was started at 229:06:20 G.m.t. (09:15:39 MET) and ran for 4 minutes 19.8 seconds. The fuel consumption during this run was 14 lb. No water spray boiler operation occurred because of the short APU run time. FCS performance was nominal.

The RCS hot-fire was not required since all of the primary RCS thrusters were verified by firing during the rendezvous maneuvers earlier in the mission.

The RMS was moved from the GLO unloaded extended-park position to the pre-cradle position at 229:07:29 G.m.t. (09:16:48 MET). CRISTA-SPAS-II grapple occurred at 229:07:46 G.m.t. (09:17:05 MET) in preparation for AutoTrac Computer Vision System (ACVS) and Space Vision System (SVS) operations. The RMS was used to maneuver the CRISTA-SPAS-II for ACVS and SVS operations. Upon completion of these activities, CRISTA-SPAS-II was successfully berthed and latched at 229:11:34:06 G.m.t. (09:20:53:06 MET). The port longeron latch RTL indication was acquired at 229:11:32:12 G.m.t. (09:20:51:12 MET), and the starboard longeron latch RTL was acquired at 229:11:32:14 G.m.t. (09:20:51:14 MET). The keel latch was latched at 229:11:33:29 G.m.t. (09:20:52:29 MET).

The OMS was used to perform two orbit adjust maneuvers, height adjust (HA) 1 and HA2. The HA1 maneuver used the left OME in a 37-second firing beginning at 229:12:14 G.m.t. (09:21:33 MET), which resulted in a ΔV of 30.6 ft/sec. The HA2 maneuver used the right OME in a 37.1-second firing beginning at 229:12:56 G.m.t. (09:22:15 MET), which resulted in a ΔV of 31.2 ft/sec. The OMS performed nominally during each maneuver.

When the flash evaporator system (FES) Primary B controller was activated (both high load and topping evaporators) after the secondary FES checkout, the evaporator outlet temperature oscillated as the temperature neared the control band. There were eight prominent cycles (STS-85-V-04). Similar oscillations occurred on

STS-82, but the amplitude and number of cycles were less (only 3 cycles). On STS-85, the initial cycle peaked at approximately 46 °F. On STS-82, the initial cycle peaked at approximately 44 °F. On STS-82, the oscillations damped out after about two minutes. On STS-85, the oscillations lasted approximately six minutes. On STS-85, the oscillations did not occur at the initiation of radiator cold soak (using FES Primary B topping evaporator). This signature suggests that the condition is associated with the midpoint sensor, and is typical for a temperature sensor having poor contact with the sensor well. The poor contact is frequently caused by loss of the thermally conductive grease around the sensor.

The payload bay doors were closed at 230:07:34:38 G.m.t. (10:16:53:38 MET) in preparation for the deorbit maneuver. The planned deorbit maneuver was to be performed at 230:10:14:14 G.m.t. (010:19:33:14 MET); however, anticipated unsatisfactory weather conditions at the landing site resulted in the landing being delayed 24 hours. The payload bay doors were reopened at 230:10:17:45 G.m.t. (010:19:36:43 MET).

The payload bay doors were closed and latched for the second landing attempt at 231:07:28:32 G.m.t. (011:1647:31 MET). The dual-engine deorbit maneuver for the landing at the Shuttle Landing Facility (SLF) runway 33 was performed on orbit 189 at 231:10:09:45.6 G.m.t. (011:19:28:45.6 MET). The maneuver was 135 seconds in duration with a ΔV of 232.4 ft/sec.

Entry was completed satisfactorily, and main landing gear touchdown occurred on KSC concrete runway 33 at 231:11:08:00 G.m.t. (011:20:27:00 MET) on August 19, 1997. The Orbiter drag chute was deployed at 231:11:08:00 G.m.t. and the nose gear touchdown occurred 9 seconds later. The drag chute was jettisoned at 231:11:08:37 G.m.t. with wheels stop occurring at 231:11:09:07 G.m.t. The rollout was normal in all respects. The flight duration was 11 days 20 hours 27 minutes 00 second. The APUs were shut down 17 minutes 20 seconds after landing.

PAYLOADS AND EXPERIMENTS

The STS-85 mission provided data for the ongoing study of natural and human-induced changes to the Earth's environment under NASA's ongoing Mission to Planet Earth enterprise. Payloads were positioned both in the payload bay and in the cabin.

CRYOGENIC INFRARED SPECTROMETERS AND TELESCOPES FOR THE ATMOSPHERE - SHUTTLE PALLET SATELLITE

The Shuttle Pallet Satellite (SPAS) carrier is a battery-powered free-flyer, flown in the payload bay, that stored data on tapes for postflight analysis, and the SPAS was flown for the fourth time. During STS-85, the Cryogenic Infrared Spectrometers and Telescopes for the Atmosphere (CRISTA) three telescopes made atmospheric observations along parallel tracks of trace constituents and temperature distributions. Examination of the STS-85 data as well as the STS-66 data that were collected in 1994, researchers from 15 countries will gain a better understanding of the ozone and its properties.

The CRISTA-SPAS measured atmospheric spectra for 183 hours, obtaining 44,000 altitude profiles of emission of up to 17 trace gases, and obtained more than 10 Gigabytes of data. The altitude range covered was from 7 km to 185 km; these were obtained by using different pointing orientation modes of the SPAS platform. The latitude range covered was from 73 degrees North to 73 degrees South; this wide range came from use of the "ping-pong" mode of the SPAS, in which it looked North in the northern hemisphere and South in the southern hemisphere. A high-resolution pointing mode was used eight times to obtain detailed information over the Indonesia region. Only 1 to 2 percent of the data was downlinked during the mission.

Among the instrument improvements made for this mission were use of more sensitive detectors in the center telescope for the far infrared wavelengths, which allowed improved determination of atomic oxygen, among other species. In addition, the ground-based program, which emphasized balloon launches from Wallops Island and the Hohenpeissenberg, rocket launches from Wallops Island and White Sands, and aircraft flights by the German Falcon, was successful with more than 26 rockets and 44 balloon flights being launched. One result obtained was detection of what appeared to be a large polar stratospheric cloud at high southern latitudes.

The SPAS global positioning system (GPS) receiver processing unit (RPU) lost acquisition of the GPS satellites through the two GPS antennas. Normally, the SPAS will automatically switch to the onboard propagated state vector if GPS is unavailable. However, at the time that this loss occurred, this software function was disabled. Consequently, the attitude control following the failed GPS data and created a "Loss of inertial reference) flag. The SPAS GPS was power cycled twice and satellite acquisition occurred.

MIDDLE ATMOSPHERE HIGH RESOLUTION SPECTROGRAPH INVESTIGATION

The Middle Atmosphere High Resolution Spectrograph Investigation (MAHRSI), located in the payload bay, focused on obtaining new vertical profile data on the distribution of hydroxyl (OH) in the mesosphere and upper stratosphere under very different conditions (both seasonal and diurnal) from the previous flight of this investigation (STS-66). This investigation also measured the nitrous oxide (NO) in the mesosphere and thermosphere and provide information on the spatial and temporal variability of nitrous acid in the atmosphere. There are 38 different working groups of researchers associated with the CRISTA/MAHRSI science team.

Over 206 hours of MAHRSI operation provided 73 orbits of OH data and 52 orbits of NO data, for a total of 4230 complete vertical profiles of the middle atmosphere. A total of 30 Gigabytes of data were obtained during the 206 hours of operation. Correlative activities included four coordinated flights of the German Falcon aircraft, and measurements of D-region electron density measured by scientists at the Arecibo Observatory in Puerto Rico. As a result of the rapid processing of data obtained during the mission, the MAHRSI team was able to prepare a map of OH between 55 and 90 km. The map showed evidence for high OH measurements at high northern latitudes in summer, with the high abundance extending all the way up to 80 to 85 km. These high values are consistent with high summer mesospheric water vapor measurements obtained by the Halogen Occultation Experiment (HALOE) flown on the Upper Atmosphere Research Satellite earlier in the Space Shuttle Program. The previous MAHRSI flight on STS-66 (November, 1994) did not obtain high latitude data, so the new results are unprecedented.

TECHNOLOGY APPLICATIONS AND SCIENCE

The Technology Applications and Science -01 (TAS-01) was a diverse Hitchhiker payload that carried eight experiments in the payload bay and weighed more than any previous Hitchhiker payload. Three of the eight experiments are a part of the Mission to Planet Earth program.

Solar Constant Experiment

The Belgian-sponsored Solar Constant Experiment (SOLCON) examined the effects of the total solar irradiance (TSI), or the Sun's total energy input into the Earth/atmosphere system, by using space-borne radiometers to locate and pinpoint within 0.01 percent the absolute value of the TSI.

Solar data acquisition was performed 17 times during the mission. For nine Sun views, the instrument operated in its normal automatic mode, exposing the left cavity five times and the right cavity four times. The second half of the measurement campaign saw the radiometer running for the first time in the passive mode, the right cavity being twice exposed to the Sun and the left cavity six times. A successful operation in the passive mode requires exposures of at least 30 minutes. This optimal condition occurred five times. The data gathered during all observing runs is being thoroughly analyzed with the objective of reaching an accuracy better than 10^{-3} on the solar irradiance.

Infrared Spectral Imaging Radiometer

The Infrared Spectral Imaging Radiometer (ISIR) tested new techniques and technology for cloud observations from space. The ISIR used the microbolometer focal plane array technology, which allowed infrared imaging without external cooling. External cooling has been used in the past, but it was very bulky and unreliable.

Upon mission completion, the ISIR had successfully acquired approximately 24 hours of low-resolution time-delay imaging by 10 (TDI-10) data, in addition to 11 hours of high-resolution TDI-40 data under zero cross track velocity (Doppler shift) (ZDS) Shuttle attitude steering. Three landmark maneuvers were also successfully completed, twice focusing on out-flow boundaries of Typhoon Winnie in the western Pacific and another for an upper-level low-pressure system west of Great Britain. In total, minimum mission data requirements were more than satisfied, and the unit operated excellently with only minor deviations.

Shuttle Laser Altimeter

The Space Laser Altimeter (SLA) -02 served as the pathfinder for both technology and science by demonstrating the potential for acquiring a globally distributed array of measurements of land-cover vertical structure, as well as high-resolution topographic transects using laser-radar (LIDAR). The SLA-02 provided direct measurements of the height of clouds, as well as acquired high-resolution profiles of land and surface vegetation canopies over land targets.

The SLA-02 on its second flight easily fulfilled its objectives; a global dataset which describes the total vertical roughness of land-cover, and in many cases, the heights of clusters of trees was obtained. The SLA-02 has demonstrated new capabilities for measuring land topography and the height of vegetation using active laser ranging and lidar technologies. The experiment also generated a unique dataset that provides the first systematic sampling of land topography and vegetation height for North America and South America, Africa, Eurasia, and Australia. These fundamental characteristics of the surface are difficult to accurately measure using traditional imaging systems in Earth orbit.

In summary, the SLA-02 met or exceeded all of the primary scientific objectives of the mission and demonstrated the tremendous versatility of orbital surface lidar sensors for measuring aspects of the Earth's land-cover and landscapes that were heretofore elusive. SLA-02 improved upon the impressive achievements of SLA-01, which flew on STS-72 (January 1996) by developing a method to circumvent surface echo saturation and by measuring the vertical character of the forest landscapes virtually everywhere on Planet Earth.

Critical Viscosity of Xenon

The Critical Viscosity of Xenon (CVX) experiment measured the viscosity of xenon under a set of conditions that cannot be achieved on Earth. A near-critical state of the fluid

was chosen because many fluid properties (such as viscosity) exhibit remarkable changes near the critical point (unique combination of temperature and density).

The CVX instrument was activated approximately 4 hours after liftoff and operated continuously for the duration of the mission (approximately 250 hours). All planned experimental activities were accomplished during the first 8 days of operation and additional scientific data were collected during the final two days of the flight. More than 10,000 measurements of viscosity were made as the sample temperature was controlled with the desired precision (approximately 30 micro-degrees) at selected temperatures near the critical temperature of xenon ($T_c =$ approximately 16.57 °C).

The CVX instrument operated nearly flawlessly for the duration of the mission. On flight day 4, the communications processor of the flight system had to be reset (the power was cycled) to regain communication with the instrument. This anomaly occurred during an extended period of isothermal soak and, therefore, no significant data were lost. All ground operations were nominal and, at mission end, a full dataset existed on the ground. The primary pre-mission concern, orbital thermal environment, proved to be very amenable to the final design of the CVX instrument. The internal canister temperature did not fluctuate beyond ± 0.5 degree even in the solar extremes. This provided an adequate environment for the required micro-degree thermostat performance. Overall, the CVX experiment is considered a success and a great leap toward understanding the behavior of Xenon.

Two-Phase Flow Experiment

The Two Phase Flow (TPF) experiment, flown in the payload bay, characterized microgravity operations as well as demonstrated the reliability of the capillary pumped loop (CPL), which contained multiple evaporators. CPL's are being developed by the Goddard Space Flight Center. CPL's are two-phase heat transfer systems that use capillary wicks to move the ammonia working fluid from the cooling interface to the radiator for rejection into space.

The TPF experiment operated for over 150 hours and ran of 50 different tests, and the experiment was a complete success. Most features of the CPL were tested and a multitude of data were obtained. The tests performed included numerous start-ups, a variety of tests with low power (down to 15 W total) on the system, some medium and higher power operation, saturation temperature (set point) changes, and several heat pipe performance tests. The high-power operations were not demonstrated because of the limited heat sink; however, the preflight-defined attitudes would have also precluded this activity. In spite of this limitation, TPF tests were performed up to 240 W for a short duration.

Cryogenic On-Orbit Long Life Active Refrigerator Flight Experiment

Long term cryogenic cooling was demonstrated by the Cryogenic On-Orbit Long Life Active Refrigerator (COOLLAR) Flight Experiment (CFE), which tested a Joule-Thomson (J-T) cycle cryocooler that provided two stages of cooling. This payload was located in the payload bay. The mission objectives were to verify cryogenic performance and

liquid management in a microgravity environment. Acquisition and distribution of oil and liquid nitrogen were demonstrated. All operating principles were proven and all performance requirements were demonstrated. The CFE exceeded all expectations.

SPACE EXPERIMENT MODULE

The Space Experiment Module (SEM) contained seven experiments, which were created by seven student organizations for their own educational benefit. These experiments were contained in seven NASA-supplied modules that were flown in the payload bay. The experiment results will be reported in separate documentation. The experiments and sponsoring organizations/schools were:

- a. Variety of passive experiments including colored sand layers, yeast, seeds, and crystal-growth medium, and this was sponsored by the Boy Scouts of America.
- b. Several active experiments measuring radiation, sound acquisition, and dispersion of paint, and these were sponsored by the CAN-DO of Charleston, SC.
- c. Variety of passive experiments including brine shrimp, "silly putty", antibiotic, cartilage, dye, film, hair, rice, graphite seeds, soap, and vinegar, and these were also sponsored by the CAN-DO of Charleston, SC.
- d. Variety of passive experiments including radiation effects on software, and black and white and X-ray films, and these were sponsored by Chesterfield County, VA., Math and Science High School.
- e. Active experiment on acceleration and seeds, and this was sponsored by the William E. Fanning Elementary School of Orange, CA.
- f. Active experiments on surface tension of immiscible and non-immiscible fluids, crystal growth, and mosquito development. Also, a variety of passive experiments including baking soda, gravel, rubber, brine shrimp eggs, yeast, seeds, beans, and salt water. These experiments were sponsored by the Glenbrook North High School of Northbrook, IL.
- g. An experiment in particle stratification that was sponsored by the Charles R. Spain Career Enrichment Center, Albuquerque, NM.

STAND ALONE ACCELERATION MEASUREMENT DEVICE AND THE WIDE BAND STAND ALONE ACCELERATION MEASUREMENT DEVICE

The Stand Alone Acceleration Measurement Device (SAAMD) and the Wide Band Stand Alone Acceleration Measurement Device (WBSAAMD) were a self-contained autonomous data acquisition system. The SAAMD and WBSAAMD measured vibrations in the low and high frequency range, respectively, during launch and landing. The results of this experiment will be reported in separate documentation.

MANIPULATOR FLIGHT DEMONSTRATION PAYLOAD

The Manipulator Flight Demonstration (MFD) evaluated the use of a small fine arm in the payload bay that was planned to be a part of the Japanese Experiment Module Remote Manipulator System (RMS) on the International Space Station. This evaluation was sponsored by the National Space Development Agency (NASDA) of Japan, and the MFD evaluation was completed with almost a 100-percent success rate.. In addition, the NASDA sponsored two additional experiments that were not related to the MFD.

Extra time was allocated on flight day 11 to complete all MFD objectives including robot arm crew-tended, robot arm ground-commanded, two-phase fluid loop experiment (TPFLEX) (piggyback) and Evaluation of Space Environment and Effects on Materials (ESEM) (piggyback). The robot arm operations were unexpectedly halted several times during the mission; however, the crew-tended portion of the robot arm operations was completed on flight day 7, and the ground-commanded portion of the robot arm operations was completed on flight day 9 with a 100-percent success rate.

TWO-PHASE FLUID LOOP EXPERIMENT

The Two-Phase Fluid Loop Experiment (TPFLEX) studied cooling systems operation in microgravity with the cooling unit circulating water from an evaporator to a condenser. The planned eight runs were completed with almost a 100-percent success rate.

On flight day 1, the self heater control software did not control evaporator heaters as expected and caused higher than nominal TPFLEX evaporator temperatures. This condition resulted in more water in the accumulator than nominal. To attempt to distribute the water throughout the test loop, a checkout procedure was performed on flight day 2 to turn off the evaporator heaters and increase the pump speed through the software. On flight day 3, experiment run 1 was performed using the original software. During the analysis, the data showed that the differential pressure (ΔP) did not respond to pump movement. A clog in the capillary tube or non-condensed gas in the system was suspected as the cause of the ΔP not responding. Troubleshooting of flight day 8 appeared to clear the clog and test run 1 was attempted, and a positive indication in the main and return capillary line ΔP 's resulted. The following day, test runs 2 and 3 were successfully performed. Experiment runs 1 and 2 were successfully performed on flight day 10, and experiment runs 3, 4, and 5 were successfully performed on flight day 11.

EVALUATION OF SPACE ENVIRONMENT AND EFFECTS ON MATERIALS

The Evaluation of Space Environment and Effects on Materials (ESEM) experiment held several small samples that were exposed to the environment of low-Earth orbit and collected cosmic dust. This experiment was located in the payload bay. The STS-85 mission accumulated over 49 hours of pointing the ESEM experiments into the velocity vector. The target pointing time was 40 hours, and the success rate was 122 percent.

INTERNATIONAL EXTREME ULTRAVIOLET HITCHHIKER

This second flight of the International Extreme Ultraviolet Hitchhiker (IEH-2), which was located in the payload bay, consisted of four experiments. These experiments all had a common objective of investigating the uncertainty and long-term variation in the absolute solar extreme ultraviolet (EUV) flux and EUV emissions of the Jupiter Io plasma torus system. The four experiments were:

- a. **Solar Extreme Ultraviolet Hitchhiker** - The solar extreme ultraviolet hitchhiker (SHE-2) instrumentation produced excellent full-disk absolute solar flux data during the entire mission. All of the primary objectives were met or exceeded. The observations consisted of 13 sub-solar data sets, in addition to three at sunset, one at sunrise and one data set running from sunrise to sunset.
- b. **Ultraviolet Spectrograph Telescope for Astronomical Research** - The ultraviolet spectrograph telescope for astronomical research (UVSTAR) successfully tracked 34 targets of which 19 provided confirmed spectra, an additional 14 targets require further careful analysis and one target was not detected.

The most impressive observations were those of the stellar sources. These observations were not only scientifically important, covering the wavelengths short of Lyman to the hydrogen interstellar absorption cut-off, but were extremely useful in evaluating the instrument. Both targets, Hale-Bopp and Jupiter, have weak emission in the EUV wavelengths. These two targets were not obvious in the single short exposures, and several observations were compromised searching for a signature in short integration times. The tracker accuracy was validated with the stellar observations; however, the principal investigators (PI's) believe good data were obtained from both the Hale-Bopp and Jupiter, although this must be validated during the postflight data analysis. In summary, the mission was a success from the point of view of science and instrument performance.

- c. **Distribution and Automation Technology Advancement - Colorado Hitchhiker and Student Experiment of Solar Radiation** - Most of the mission objectives of this experiment were met. Though the Colorado Hitchhiker and Student Experiment of Solar Radiation (CHASER) was unable to obtain science data at a resolution suitable for publication, it did continue to successfully support the Distribution and Automation Technology Advancement (DATA) experiment and the primary objectives of the project. The CHASER supplementary ultraviolet science experiment was unable to obtain quality science. Unfortunately, a failure in the instrument reduced the resolution considerably; however, the instrument continued to perform well enough to fully support all of the project's primary objectives—those of the DATA experiment. The DATA-CHASER did meet each of its primary objectives, making the project a success.

- d. Arizona Air Glow Experiments -5 and -6 - The science operations of the Arizona Air Glow Experiments (GLO) -5 and -6 were a complete success. The two GLO instruments performed spectral and imagery measurements on several optical data targets. The following table provides an summary of the targets viewed.

Target	No. of Orbits	Comments
Ionospheric day glow	73	43 in preferred attitude
Ionospheric night air glow	68	All in good attitudes
Aurora Australia	12	Some ground-to-deep-space scans
Planets, stars (calibration data)	20	Pointing/detector response checks
Perseid meteor shower metals	68	Data set in night air glow
Hale-Bopp comet	5	
Cometary OH	3	
Space vehicle glow	2	
OMS engine firings	2	Two events at attitude change
Near-stereo viewing	20	One at 90° and others at 40° angle
SEH, CRISTA coordinated scans	30	

Both GLO instruments performed flawlessly, with better-than-expected thermal responses and no serious anomalies. GLO observations occurred in all of the Orbiter routine attitudes, and a total of 25 Gigabytes of Ionosphere, Thermosphere, and Mesosphere (ITM) data were recorded. This is more data than were collected on the three GLO flights in 1995. The lessons learned as well as the instrument upgrades since the 1995 flights have improved both the operation and scientific return from this experiment.

PROTEIN CRYSTAL GROWTH/SINGLE LOCKER THERMAL ENCLOSURE SYSTEM

The Protein Crystal Growth/Single-Locker Thermal Enclosure System (PCG-STES) experiment provided a facility for the growth of protein crystals for basic biological research, pharmacology and drug development. A total of 630 specimens were flown for this experiment. The PCG-STES operations continued nominally until deactivation at 229:08:24 G.m.t. (09:17:43 MET). All PCG-STES science objectives were met.

MIDCOURSE SPACE EXPERIMENT

The Midcourse Space Experiment (MSX) required no additional spacecraft hardware to be flown for the experiment to be conducted. The experiment was performed for the first time on this flight. The thruster firings of the OMS and primary RCS were scheduled and performed to enable the MSX satellite to record ultraviolet, infrared and visible data from the firings. Two OMS firings were observed by the MSX on flight day 11. Data have been given to the sponsors for correlation and evaluation to determine the success of this experiment.

SHUTTLE IONOSPHERIC MODIFICATION WITH PULSED LOCAL EXHAUST

The Shuttle Ionospheric Modification with Pulsed Local Exhaust (SIMPLEX) experiment used OMS thruster firings to create ionospheric disturbances for observation by three SIMPLEX radar sites. The SIMPLEX, like the MSX required no additional flight hardware to be flown for the conduct of the experiment. There were no SIMPLEX ground site over-flight opportunities on this flight.

SOUTHWEST ULTRAVIOLET IMAGING SYSTEMS

The Southwest Ultraviolet Imaging System (SWUIS) used a baffled ultraviolet (UV) telescope to obtain data, that was recorded, of the Hale-Bopp comet from the Orbiter middeck. The SWUIS obtained more than 300,000 useful frames in the UV range during the nine orbits of viewing opportunity. Over 90 percent of the SWUIS flight objectives were met.

BIOLOGICAL RESEARCH IN CANISTERS -10

The Biological Research in Canisters (BRIC) -10 is the latest in the series of BRIC life sciences experiments to examine the effects of microgravity on a wide range of physiological processes in higher-order plants and arthropod animals. The STS-85 experiment studied the gravitational effects on growth, development and metabolic processes in *Arabidopsis thaliana* and tobacco seeds. The only crew activity was the transfer of the sample canister to the passive GN₂ freezer. The transfer occurred at 224:16:51 G.m.t. (05:02:10 MET). The samples will be analyzed postflight and the results will be published in separate documentation.

SOLID SURFACE COMBUSTION EXPERIMENT

The Solid Surface Combustion Experiment (SSCE) was flown on the middeck and consisted of a camera module (16 mm) assembly and an experiment sample container. The chamber assembly contained one Polymethyl Methacrylate (PMMA) fuel sample internally mounted in the center of the pressurized chamber. Two windows were orthogonally mounted to enable camera viewing of the side edge and top of the PMMA sample.

At 221:11:51 G.m.t. (01:21:10 MET), the SSCE experiment was initiated and the burn of the hexan material was completed as scheduled. A complete evaluation was conducted after the flight and after the experiment hardware was returned to the sponsor and all data are examined. The initial indication of the experiment is that it was 100 percent successful.

BIOREACTOR DEMONSTRATION SYSTEM -03

The phase I (mammalian) cell growth of the Bioreactor Demonstration System (BDS) - 03 activities were successfully completed, and the cells were harvested from the

Bioreactor. Postflight analyses will be completed to determine if the change in vessel rotation rates allowed for successful sampling and fixation prior to harvest. However, the Principal Investigator (PI) received excellent video of the cells and the growth was very impressive. The phase II (fluid dynamics observation) activities were also completed successfully.

RISK MITIGATION EXPERIMENT

Risk Mitigation Experiment (RME) 1328 entitled, Microgravity Vibration Isolation Mount (MIM) System Performance Evaluation and Characterization, was flown for the first time on the STS-85 mission. The MIM performance was evaluated to determine the level of microgravity quality that is obtainable on-orbit. This results of this evaluation will assist in determining the microgravity level achievable on the ISS using locker-level motion-isolation systems. The data have been given to the sponsor for evaluation, and the results will be published in separate documentation.

The STS-85 operations were a qualified success in that it achieved its minimum success criteria for RME 1328 payloads [MIM and Fluid Physics Experiments (FLEX)] despite problems with hardware and software that delayed operations for several days.

The MIM demonstrated its flexibility as it isolated various FLEX payloads from vibration and imparted controlled vibrations into the same payload. This flight demonstrated that the MIM can reduce vibrations from 5 milli-g peak-to-peak to 50 micro-g peak-to-peak on the Orbiter. This is a vast improvement in the Orbiter microgravity environment and a ten-fold improvement in the performance over the first version of MIM currently installed on the Mir. These data prove that the MIM could provide low-cost vibration isolation on the International Space Station (ISS) for true microgravity science. The FLEX PI's received sufficient science return on the FLEX experiments to declare a success.

GET AWAY SPECIAL PAYLOADS

Two Get Away Special (GAS) payloads were flown. Data from these two investigations will be documented in other publications.

G-572 - Hearts in Space

The G-572 Hearts in Space GAS experiment gathered data in an attempt to answer the question concerning why astronauts' hearts get smaller while in space. The experiment investigated the effect of weightlessness on the physical factors that contribute to cardiac function.

G-745 - Root Growth in Microgravity

The G-745 Root Growth in Microgravity GAS experiment provided six growing chambers. After launch, the seeds were watered and allowed to germinate in a temperature-controlled environment.

VEHICLE PERFORMANCE

SOLID ROCKET BOOSTERS

Data analysis showed that the Solid Rocket Booster (SRB) performance during ascent was satisfactory, and no in-flight anomalies occurred. The SRB countdown was normal, and no SRB Launch Commit Criteria (LCC) or Operations Maintenance Requirements and Specification Document (OMRSD) violations occurred. All SRB subsystems performed properly during the prelaunch testing and countdown except for the right SRB C-band transponder battery current, which read lower than has been seen on previous missions. The C-band transponder functioned nominally and no requirements were violated; however, the reading was "out of family" and the condition is being further investigated.

Both SRBs were successfully separated from the External Tank at approximately 123.9 seconds, and recovery area reports indicate that the deceleration systems performed as designed. The SRBs were recovered and returned to Kennedy Space Center for disassembly and refurbishment.

REUSABLE SOLID ROCKET MOTORS

The Reusable Solid Rocket Motors (RSRMs) performed satisfactorily throughout ascent, and no in-flight anomalies were identified in the data or during postflight inspection. No LCC nor OMRSD violations occurred. Data show that the motor performance was well within contract end item (CEI) specification limits and was typical of the performance on previous flights. The maximum trace shape variation of pressure versus time during the 62 to 80 second time period was calculated to be 0.81 percent at 74.5 seconds for the left motor and -0.51 percent at 70 seconds for the right motor. These values were well within the 3.2 percent allowable limits.

Power-up and operation of all igniter and field-joint heaters was accomplished routinely. All RSRM temperatures were maintained within acceptable limits throughout the countdown. The RSRM propellant mean bulk temperature (PMBT) was 81 °F at liftoff, and the calculated flex bearing mean bulk temperature was also 81 °F.

The propulsion performance for the RSRMs are shown in the table on the following page.

The postflight inspection and disassembly indicated that all RSRM hardware performed as expected during the flight. The nozzle phenolic components showed normal smooth erosion performance except for the right-hand throat and forward exit cone. These two locations had 16 areas of slight pocket erosion and associated areas of wash erosion. The erosion was within the established experience base, and the nozzle operated within CEI requirements.

RSRM PROPULSION PERFORMANCE

Parameter	Left motor, 81 °F		Right motor, 81 °F	
	Predicted	Actual	Predicted	Actual
Impulse gates				
I-20, 10 ⁶ lbf-sec	65.95	66.96	66.15	66.83
I-60, 10 ⁶ lbf-sec	175.66	177.25	176.12	177.98
I-AT, 10 ⁶ lbf-sec	296.81	297.49	296.97	297.33
Vacuum Isp, lbf-sec/lbm	268.6	269.2	268.6	268.9
Burn rate, in/sec @ 60 °F at 625 psia	0.3671	0.3682	0.3676	0.3697
Event times, seconds ^a				
Ignition interval	0.232	N/A	0.232	N/A
Web time ^b	109.2	108.1	108.9	107.7
50 psia cue time	118.9	118.4	118.6	117.6
Action time ^b	121.0	120.4	120.7	119.6
Separation command	123.8	123.3	123.8	123.3
PMBT, °F	81	81	81	81
Maximum ignition rise rate, psia/10 ms	90.4	N/A	90.4	N/A
Decay time, seconds (59.4 psia to 85 K)	2.8	2.7	2.8	2.9
Tailoff Imbalance Impulse differential, Klbf-sec	Predicted		Actual	
	N/A		717.3	

Impulse Imbalance = Integral of the absolute value of the left motor thrust minus right motor thrust from web time to action time.

^aAll times are referenced to ignition command time except where noted by a ^b

^b Referenced to liftoff time (ignition interval).

EXTERNAL TANK

All objectives and requirements associated with the External Tank (ET) propellant loading and flight operations were successfully met. All electrical equipment and instrumentation operated satisfactorily. No ET LCC or OMRSD violations occurred, nor were any in-flight anomalies identified from the data.

No unexpected ice or frost formations were observed during the countdown. Also, there was no ice or frost on the acreage areas of the ET. Normal quantities of ice or frost were present on the liquid oxygen (LO₂) and liquid hydrogen (LH₂) feed lines, the pressurization-line brackets, and along the LH₂ protuberance air load (PAL) ramps. These observations were acceptable based on NSTS 08303.

The Ice/Frost "Red Team" reported that there were no anomalous thermal protection system (TPS) conditions. The recurring defect of a crack in the TPS where the foam bridges between the vertical strut tray and fitting fairing did not occur on this ET.

The ET pressurization system functioned properly throughout engine start and the flight with a total of 51 LH₂ flow control valve cycles. The performance of the LO₂ flight pressurization system which uses the fixed orifices was normal. The LO₂ tank slosh baffle at X_t = 780 was removed from this and subsequent ETs. The LO₂ tank ullage pressure data indicated that the baffle removal had only a minor, if any impact on the ullage pressure slump, as predicted.

ET separation was performed nominally less than 20 seconds after main engine cutoff (MECO). The ET intact impact point was approximately 88 nmi. uprange from the preflight predicted impact point and within the predicted footprint.

SPACE SHUTTLE MAIN ENGINE

All Space Shuttle main engine (SSME) parameters were normal throughout the prelaunch countdown and were typical of prelaunch parameters observed during previous flights. There were no LCC or OMRSD violations and no in-flight anomalies occurred. Engine-Ready was achieved at the proper time, and engine start and thrust buildup were normal.

Flight data indicate that the SSME performance during mainstage, throttling, shutdown and propellant dump operations was normal. The high pressure oxidizer turbopump (HPOTP) and high pressure fuel turbopump (HPFTP) temperatures remained well within the specification throughout engine operation. Cutoff times for SSME 1, 2, and 3 were 518.47, 518.61, and 518.73 seconds, respectively. The I_{sp} was rated as 453.98 seconds based on trajectory data. Controller and software performance was satisfactory.

SHUTTLE RANGE SAFETY SYSTEM

The Space Shuttle range safety system (SRSS) performed satisfactorily through the first stage of ascent. Prelaunch closed-loop testing was completed as scheduled. All SRSS safe and arm (S&A) devices were armed and system inhibits turned off at the appropriate times. No in-flight anomalies were identified from the data.

As planned, the SRB S&A devices were safed, and the SRB system power was turned off at SRB separation. The ET system had been deleted.

ORBITER SUBSYSTEM PERFORMANCE

Main Propulsion System

The overall performance of the main propulsion system (MPS) was nominal with no OMRSD or LCC violations nor in-flight anomalies noted. The LH₂ and LO₂ loadings were performed with no stop-flows or reverts. However, the start of loading was delayed 40 minutes for two reasons. First, the secondary GO₂ vent hood heater was not operating. Testing determined that the controller was receiving power, but was not outputting power. The primary heater was operational, so loading began without a functional backup. Second, there was a slow decay in the facility GN₂ purge system

primary regulator output pressure. Both the primary and secondary regulators were reset, and no problems were experienced during the remainder of the prelaunch activity. There were no LCC violations since the regulators operated nominally once loading was initiated.

Throughout preflight operations, no significant hazardous gas concentrations were detected. The maximum hydrogen concentration level in the Orbiter aft compartment, which occurred after the start of fast-fill, was approximately 118 ppm. This value compares favorably with previous data from this vehicle.

The LH₂ loading operations were normal throughout the countdown. Based on the analysis of loading system data, the LH₂ load at the end of replenish was 231,335 lbm, which was within 3 lbm (+0.001 percent) of the predicted load and well within the required MPS loading accuracy of ±0.37 percent.

The LO₂ loading operations were normal throughout the countdown. Based on the analysis of the loading system data, the LO₂ load at the end of replenish was 1,387,889 lbm. Compared with the inventory (predicted) load of 1,388,728 lbm, this assessment yields a difference of -0.06 percent, which is well within the required MPS loading accuracy of ±0.43 percent.

Ascent MPS performance was completely normal. Data indicate that the LO₂ and LH₂ pressurization systems performed as planned, and that all net positive suction pressure (NPSP) requirements were met throughout the flight. The minimum ullage pressure during the period of ullage-pressure slump was 13.9 psid. The GH₂ system performance was nominal as was the GO₂ fixed orifice pressurization system. All three flow control valves performed normally. Helium system performance for the SSME and pneumatic helium systems was nominal, and helium usage of 62.2 lbm for entry was well within the requirements.

The Space Shuttle main engine (SSME) 3 liquid hydrogen (LH₂) inlet pressure shifted upward 4 psi during ascent. The transducer also failed to react fully to pressure changes during the propellant dumping and vacuum inerting procedures. The data signature indicates that the measurement is scaled and only responds to about 1/3 of the actual pressure change. This was the first flight of this new vapor-deposit transducer, and it will be replaced during the turnaround activities in preparation for the STS-91 mission. The failure did not impact the engine operation during ascent.

The LH₂ and LO₂ propellant dumping operations were initiated at MECO + 122 seconds as planned. Postflight data review indicates that the performance was nominal. Likewise, the MPS hydrogen and oxygen feed system vacuum inerting operations were performed as planned. Postflight data review indicates that the performance was nominal.

Reaction Control Subsystem

The reaction control subsystem performed satisfactorily throughout the STS-85 mission. One in-flight anomaly was noted during the flight and it is discussed in a later paragraph. A total of 6500 lbm of propellants were consumed by the RCS during the mission. Of this total, 1855 lbm of propellants were provided by the Orbital Maneuvering Subsystem during left- and right-pod interconnect operations. The primary RCS had a total of 4219 firings, and a total firing time of 1207.88 seconds. The vernier RCS had a total of 38,839 firings, and a total firing time of 31,202.04 seconds.

Multiple RCS maneuvers were performed in support of the rendezvous with CRISTA-SPAS-II. Eleven of the planned maneuvers (NH, NC1, NC3, NC7, NC10, NC14, NC19, MC-1, and MC-4) were canceled because they were not needed. The NC9 and NC 11 maneuvers were performed with the propulsive vent from water dumps. The performance of all primary RCS thrusters during these maneuvers and the manual firings subsequent to MC-4 was nominal. Data for these maneuvers are shown in the table on the following page.

Just prior to liftoff at 219:14:40:56 G.m.t., the right RCS pod oxidizer manifold 5 isolation valve open discrete measurement changed from 1 to 0 (loss of open indication); two seconds later (219:14:40:58 G.m.t.), the isolation valve open discrete changed back to a 1 (open). One second later, the discrete again changed to 0, and an redundancy management (RM) message was logged. At 219:14:42:35.8 G.m.t. [00:00:02:35.8 (mission elapsed time (MET))], the open indication returned for two seconds after which the open was lost until 219:15:00:40 G.m.t. (00:00:19:40 MET). Throughout ascent, the corresponding closed discrete measurement indicated 0 (not closed) causing an RM dilemma each time. Three seconds after the NC4 maneuver was initiated, the right RCS oxidizer manifold 5 isolation valve-open discrete changed from 1 to 0 (loss of open indication), and it continued to indicate not-open following the maneuver (Flight Problem STS-85-V-02) A redundancy management (RM) fault message 'RM DLMA MANF' occurred at 220:20:38:06 G.m.t. (01:05:57:06 MET). Following the NC5 maneuver, the valve position indicator (VPI) indicated not-open for the remainder of the mission. The manifold 5 isolation valve was not cycled during the postflight "RCS,OMS Valve Test" to aid in troubleshooting of the VPI by preserving as much information/evidence as possible. When the vehicle was powered up again on August 25, 1997, the open indication (1) was present. The valve connector plug was removed and some corrosion was noted on all pins and sockets; however, no corrosion was found on the exterior of the connector or valve. Evaluation of the condition is continuing as this report is being written.

The RCS hot-fire was not required since all of the primary RCS thrusters were verified by firing during the rendezvous maneuvers earlier in the mission.

SEPARATION AND RENDEZVOUS MANEUVERS

Rendezvous Maneuver	Time, G.m.t./MET	Firing time, seconds	Differential Velocity, ft/sec	Primary RCS Thrusters Fired
-X Separation 1 from CRISTA-SPAS	219:22:28 G.m.t. 00:07:47 MET	-	0.5	L1A, R1A, F4D, F2F, F3F and F1D
-X Separation 2 from CRISTA-SPAS	219:22:45 G.m.t. 00:08:04 MET	-	0.95	L1A, R1A, L1U, R2U, F4D and F1D
NC2	220:13:03 G.m.t. 00:22:22 MET	-	2.1	F3U, L2D, L4U, R1U, R2D
NC4	220:20:38 G.m.t. 01:05:57 MET	-	1.0	F1D, F1F, F2F, F3U, F4D, L2D, L4D, L4U, R4D, R1U, R2D,
NC5	221:10:51 G.m.t. 01:20:10 MET	6.0	1.5	F1U, F3L, F4R, L2D, L4L, L4U, R2D, R4D
NC6	221:19:54 G.m.t. 02:05:13 MET	1.0	0.3	F4R, L2D, R1R, R4U
NC8	222:21:25 G.m.t. 03:06:44 MET	5.0	1.3	L1U, R2U, F3U, L2D, R2D
NC12	224:19:24 G.m.t. 05:04:43 MET	1.2	0.4	F3L, F1D, F4D, F4R, F3U, L3D, L1U, L2D, L3L, R2D, R2U, R3R
NC13	225:07:46 G.m.t. 05:17:05 MET	3.0	0.8	F3U, L1U, R2U, L2D, R2D
NC15	225:20:01 G.m.t. 06:05:20 MET	4.0	1.0	F2F, F1D, F4D, F1F, L2D, L1U, L4D, R2U, R2D, R4D
NC16	226:07:24 G.m.t. 06:16:43 MET	2.0	0.6	F3U, L1U, R2U
NC17 ^b	226:18:56 G.m.t. 07:04:15 MET	12	1.3	L3A, R3A, R2D, R4D, F1D, F3L, F4D, L2D, L4D
NC18	227:08:28 G.m.t. 07:17:47 MET	4.0	0.9	F3U, L1U, R2U, L2D, L4D, R2D, R4R
NC20	227:17:19 G.m.t. 08:02:38 MET	23.0	5.8	L1A, R1A, F1D, F4D, R2U
NC21	228:08:11 G.m.t. 08:17:30 MET	4.0	1.0	F1L, F4R, L2D, R2U, R4R
NC22	228:09:51:30 G.m.t. 08:19:10:30 MET	22.0	5.6	
NC23	228:11:21:51 G.m.t. 08:20:40:51 MET	7.0	1.8	
NCC	228:11:54:23 G.m.t. 08:21:13:23 MET	2.4	0.6	
MC2	228:13:39:08 G.m.t. 08:22:58:08 MET	-	0.9	
MC3	228:13:49:08 G.m.t. 08:23:08:08 MET	-	0.5	

^a NC1, NC3, NC7, NC9 through NC11, NC14, NC19, MC1 and MC4 maneuvers were not required.

^b The final two primary thrusters that had yet to be fired this mission were fired during this maneuver and this completed all requirements for the planned passive hot-fire. Consequently, no hot-fire was required.

Orbital Maneuvering Subsystem

The Orbital Maneuvering Subsystem (OMS) performed satisfactorily throughout the mission. No LCC or OMRSD deviations occurred prior to launch, and no in-flight anomalies occurred during the mission. A total of 14,779.8 lbm of OMS propellants were consumed during the mission, and of this total, 1855 lbm was consumed by the

RCS during interconnect operations. The direct insertion ascent trajectory resulted in the orbital maneuvering subsystem (OMS) 1 maneuver not being required. The following table provides pertinent data about the five OMS maneuvers performed during the mission.

OMS FIRINGS

OMS firing	Engine	Ignition time, G.m.t./MET	Firing duration, seconds	ΔV , ft/sec
OMS-2	Both	219:15:18:06.5 G.m.t. 00:00:37:06.5 MET	158.4	254
OMS-3	Right	228:12:50:47.2 G.m.t. 08:22:09:47.2 MET	12.0	11
OMS-4 HA1	Left	229:12:14:14 G.m.t. 09:21:33:14 MET	37	31
OMS-5 HA2	Right	229:12:56:21 G.m.t. 09:22:15:21 MET	37.1	31
Deorbit	Both	231:10:07:30.1 G.m.t. 11:19:26:30.1 MET	135.5	232

The dual-engine deorbit maneuver for the landing at the Shuttle Landing Facility (SLF) runway 33 was performed on orbit 189 at 231:10:07:30.1 G.m.t. (011:19:26:30.1 MET).

Power Reactant Storage and Distribution Subsystem

The power reactant storage and distribution (PRSD) performed satisfactorily on the STS-85 mission. The PRSD subsystem supplied 2945 lbm of oxygen and 371 lbm of hydrogen to the fuel cells for the production of 4308 kWh of electrical energy. In addition, 112 lbm of oxygen was supplied to the environmental control and life support system (ECLSS) for life support to the crew. A 58-hour mission extension was possible at extension-day power levels, and a 56-hour extension capability existed at the average power level of 15.1 kW. During the mission, tank sets 4 and 5 were depleted to residual quantities. Both oxygen and hydrogen manifold isolation valves were successfully cycled during the mission. There were no PRSD in-flight anomalies or significant problems noted.

Fuel Cell Powerplant Subsystem

Performance of the fuel cell powerplant (FCP) subsystem was nominal during the mission, and no in-flight anomalies occurred. The average power level for the mission was 15.1 kW and 492 amperes. The fuel cells produced 3316 lbm of potable water during the production of 4308 kWh of electrical energy. The oxygen consumption was 2945 lbm, and the hydrogen consumption was 371 lbm.

The fuel cell reactant purge operated satisfactorily in the performance of five on-orbit fuel cell purges during the mission. The actual fuel cell voltages at the end of the mission were 0.1 volt above predicted for fuel cell 1, 0.05 volt below predicted for fuel cell 2, and as predicted for fuel cell 3.

The overall thermal performance of the fuel cell water relief, water line and reactant purge systems was nominal. The fuel cell 2 and 3 alternate water line temperatures were erratic on-orbit, indicating a slight leakage of warm fuel cell product water through the alternate water line check valves.

The cell performance monitor (CPM) reading for substack 2 on fuel cell 1 remained at 2 mV for the entire mission, from the completion of the fuel-cell-start sequence through completion of the fuel cell shut-down at the end of the mission. The CPM did not change during the load changes that occurred during various phases of the mission. Also, it did not display any sensitivity to purges, which normally occurs. The self-test function performed properly. Postflight checkout activities, using CPM vendor-provided acceptance test procedures (ATPs) showed that the CPM was operating nominally, and replacement was not required.

Auxiliary Power Unit Subsystem

The auxiliary power unit (APU) subsystem performed satisfactorily throughout the mission. No in-flight anomalies or significant problems were noted during the course of the mission. The APU run times and fuel consumption are shown in the following table.

APU RUN TIMES AND FUEL CONSUMPTION

Flight phase	APU 1 (S/N 306)		APU 2 (S/N 409)		APU 3 (S/N 408)	
	Time, min:sec	Fuel consumption, lb	Time, min:sec	Fuel consumption, lb	Time, min:sec	Fuel consumption, lb
Ascent	19:48	55	20:04	56	20:17	55
FCS checkout	04:19	11				
Entry ^a	62:06	130	82:33	156	62:28	137
Total	86:13	196	102:37	212	82:45	192

^a APUs were shut down 17 minutes 36 seconds after landing.

During ascent, the auxiliary power unit (APU) 3 X-axis accelerometer failed for the entire operational time of the APU. During entry, the accelerometer output was erratic. This measurement provides engineering data, and therefore, loss of these data caused no impact on the mission. This APU will be replaced because of gas generator valve module (GGVM) wet time; therefore, the vendor will be requested to replace the accelerometer once the APU is refurbished.

The APU 1 drain-line pressure continued to decrease slowly from the prelaunch value of approximately 14 psia to 5 psia at APU pre-start for entry. The drain relief valve did not leak on the last flight of this vehicle. The pressure decay did exceed the File IX limit of 0.5 psi/day over the course of the mission; actual leakage was 0.89 psi/day. The drain relief valve was replaced during the postflight turnaround activities.

At 224:22:00 G.m.t. (05:07:19 MET), the APU 1 fuel pump/line/GGVM system B heater thermostat began cycling within a 4 °F deadband as indicated by the bypass line temperature. The deadband shifted back to about 10 °F at 225:02:40 G.m.t. (05:11:59 MET) for approximately 36 hours after which the deadband returned to 2 °F. This thermostat is located on a fuel line that is attached to the APU and previous experience has shown that a thermostat located at this position will eventually fail once it begins to dither and/or behave erratically. The vibration (g-level) environment at this location is greater than the acceptable design vibration levels for the thermostat. The signature of the thermostat did not suggest that the thermostat would fail on this flight. This heater system has an over-temperature thermostat as well as a redundant heater circuit. The thermostat was removed and replaced during the postflight turnaround processing.

The flight control system (FCS) checkout was performed using auxiliary power unit (APU) 1. The APU and hydraulics subsystems performed nominally during the checkout. APU 1 was started at 229:06:20 G.m.t. (09:15:39 MET) and ran for 4 minutes 19.8 seconds. The fuel consumption during this run was 11 lb. No water spray boiler operation occurred because of the short APU run time. FCS performance was nominal.

Hydraulics/Water Spray Boiler Subsystem

Overall hydraulics and water spray boiler (WSB) system performance was nominal, and no WSB over-cooling or under-cooling conditions occurred during ascent or entry. No in-flight anomalies were identified from the data.

During ascent, there were no unexpected decreases in reservoir quantity, indicating that no gross leaks existed in the system. Priority valve openings at APU activation were less than the 1 second specification limit, and reseating of the priority valves at engine shutdown were also within specification.

Electrical Power Distribution and Control Subsystem

The electrical power distribution and control (EPDC) subsystem performed nominally throughout the mission. No in-flight anomalies were identified from the data analysis.

Pressure Control Subsystem

The pressure control subsystem performed normally throughout the flight. During the redundant component check, the pressure control configuration was switched to an alternate system. Both systems exhibited normal operation.

Atmospheric Revitalization Subsystem

The atmospheric revitalization subsystem performed satisfactorily throughout the flight. Beginning approximately 12 hours after liftoff, the avionics bay 3A flow differential pressure (ΔP) steadily increased from 3.79 inches of water to a steady-state value of 3.89 inches of water after nine days of flight. Data from the previous flight of this vehicle, STS-82, were reviewed and the same rise in the flow ΔP was observed for avionics bay 3A. The upper limit for this ΔP is 4.30 inches of water. Data from STS-70, the last flight prior to the Orbiter Maintenance Down Period (OMDP), the flow ΔP remained constant throughout the flight. During the OMDP, five additional filtered ports/inlet ducts were added to accommodate the additional payload cooling requirements. Initial evaluations indicate that debris may have collected during the flight. The postflight inspections to determine the cause of the pressure rise will be conducted when the Orbiter returns to the Orbiter Processing Facility during the first week of November.

Active Thermal Control Subsystem

When the flash evaporator system (FES) Primary B controller was activated (both high load and topping evaporators) after the secondary FES checkout, the evaporator outlet temperature oscillated as the temperature neared the control band. There were eight prominent cycles. Similar oscillations occurred on STS-82, but the amplitude and number of cycles were less (only 3 cycles). On STS-85, the initial cycle peaked at approximately 46 °F. On STS-82, the initial cycle peaked at approximately 44 °F. On STS-82, the oscillations damped out after about two minutes. On STS-85, the oscillations lasted approximately six minutes. On STS-85, the oscillations did not occur at the initiation of radiator cold soak (using FES Primary B topping evaporator). This signature suggests that the condition is associated with the midpoint sensor, and is typical for a temperature sensor having poor contact with the sensor well. The poor contact is frequently caused by loss of the thermally conductive grease around the sensor.

Supply and Waste Water Subsystem

The supply and waste water subsystem performed normally throughout the flight, and no in-flight anomalies occurred. All in-flight checkout requirements were successfully satisfied.

Supply water was managed through the use of the flash evaporator system (FES) and the water dump system. Eight supply water dumps were performed with an average dump rate of 1.49 percent/minute (2.46 lb/min). The supply water dump line temperature was maintained between 64 °F and 96 °F during the mission using the line heater.

The first three supply water dumps were performed with the supply dump line purge assembly installed in the waste water cross-tie quick disconnect (QD). Following the second and third supply water dumps, a total of nine brief releases of water, referred to as "burps", were observed through the supply water dump valve. This phenomenon has

been seen in the past, and as a result, a device was made and flown to purge the dump line and dump valve following supply water dumps. The crew was asked if the purge device was being used and where it was connected on the contingency water cross-tie. The crew determined that the purge device had been connected to the waste-water quick disconnect (QD) and not the supply water QD. Therefore, the supply water line and dump valve were not being purged, and the purge device could not be moved to the supply water QD because of contamination concerns. Therefore, after completion of each supply water dump for the remainder of the mission, the supply water dump line was purged using the free fluid disposal wand. No supply water "burps" were observed following the completion of these dumps.

The supply water tank A and D quantity transducers exhibited several quantity dropouts during the mission. Most of the tank A dropouts occurred at a quantity of approximately 98 percent and while water was being drawn from the tank. There have been no previously observed quantity transducer dropouts on this tank. The fault detection and annunciation (FDA) limit for this measurement has been changed to off-scale-low to prevent unnecessary alarms. The tank D dropout behavior was similar to the behavior the tank exhibited when it was installed in the tank C position prior to the OMDP. There was no mission impact from these tank dropouts. It is planned to remove and replace the cover assemblies, which contain the quantity transducers, the next time the tanks are removed from the vehicle.

Waste water was gathered at approximately the predicted rate. Six waste water dumps were performed at an average rate of 1.84 percent per minute (2.89 lb/min). The waste water dump line temperature was maintained between 57 and 86 °F. The vacuum vent line temperature was maintained between 59 and 84 °F, with the vacuum vent nozzle temperature between 136 and 186 °F.

Waste Collection Subsystem

The waste collection subsystem performed nominally throughout the mission, and no in-flight anomalies were recorded.

Airlock Support System

Use of the airlock support system components was not required because no extravehicular activity (EVA) was planned or required. The active system monitor parameters indicated normal outputs throughout the duration of the flight.

Smoke Detection and Fire Suppression Subsystem

The smoke detection and fire suppression subsystem showed no indications of smoke generation during the flight. Use of the fire suppression subsystem was not required.

Flight Data Systems

The flight data systems performed satisfactorily during the mission, and no in-flight anomalies occurred during the mission. Sensor data were incorporated into the onboard

navigation state vector at the expected times. Drag measurement processing started at approximately 235,600 feet and ended at approximately 85,100 ft. TACAN station acquisition occurred at approximately 146,800 ft. The air data transducer assembly (ADTA) data incorporation began at 82,000 ft and continued to approximately 16,400 ft. All sensor measurement residuals and residual ratio values were nominal with no data editing observed. The backup flight system navigation data also exhibited similar characteristics to the primary flight system. The postflight error analysis has shown a good comparison between the primary flight system state vector and the backup flight system state vector.

At 227:15:41:46 G.m.t. (08:01:00:46 MET), general purpose computer (GPC) 1 annunciated a cathode ray tube (CRT) built-in test equipment (BITE) 1 message that was caused by a display electronics unit (DEU) 1 memory parity error (Flight Problem STS-86-V-03). The crew performed malfunction procedure 5.4b (CRT BITE 1). At block 12 of the procedure, the BITE status words were nominal, indicating that the BITE condition had cleared. Therefore, the crew reassigned CRT 1 to GPC 1, and the BITE did not repeat during the remainder of the mission. This nine-minute loss of the DEU did not impact the mission. The DEU will be removed and replaced during the next process flow with no post-flight troubleshooting required.

Flight Software

The flight software performed satisfactorily with no in-flight anomalies recorded during the flight.

Flight Control Subsystem

The flight control subsystem performed satisfactorily during the mission with no in-flight anomalies recorded. Ascent and descent navigation performed nominally during the mission.

The inertial measurement unit (IMU) performance was satisfactory throughout the mission. During on-orbit operations, only one adjustment of the onboard IMU accelerometer compensations was performed for IMU's 1 and 2.

During the countdown OMS Gimbal Profile Test, the right OMS standby yaw actuator rate was observed to be slow. The actuator drive-rate has a minimum requirement of 2.9 deg/sec and is only allowed to change by a maximum of 1.0 deg/sec between comparable tests. The standby drive rate differed from the previous comparable test by more than 1.0 deg/sec (Flight Problem STS-86-V-01). During three additional tests to investigate this condition, a drive rate as low as 2.45 deg/sec was observed, which was below the minimum rate of 2.9 deg/sec that is specified in the Operational Maintenance Requirements and Specification Document (OMRSD). The Launch Commit Criteria (LCC) allows the loss of one thrust vector control (TVC) channel (active or standby) on either the left or right engine. Since both OMS TVC channels were good on the left engine, the LCC requirements were not violated, and the vehicle was launched with the degraded condition present. After the OMS 2 maneuver, a planned gimbal check was performed. At that time, the drive rate was

sufficient to avoid an Redundancy Management (RM) fault message. The standby drive rate of the actuator was below nominal levels, but it was considered usable for steering during an OMS maneuver, should an active channel be lost. The history of the standby gimbal during previous ground tests shows erratic performance and reflects a gradual degradation of performance. The suspected causes are the lack of the lubrication improvements identified by the vendor from previous failures in the program. The actuator will be removed and replaced during its next flow. The following table presents the prelaunch and flight actuator rate data.

ACTUATOR EXTEND/RETRACT DATA

Data take	Active retract, deg/sec	Active extend, deg/sec	Standby retract, deg/sec	Standby extend, deg/sec
STS-82 Countdown	4.95	-4.93	4.11	-4.82
STS-85 Countdown	4.95	-4.95	3.86	-3.22
STS-85 Rerun 1	4.93	-4.94	2.51	-3.41
STS-85 Rerun 2			2.74	-3.38
STS-85 Rerun 3			2.45	-3.49
STS-51 Deorbit	4.981	-4.962	4.703	-4.962
STS-60 OMS 2	4.972	-4.924	4.656	-4.908
STS-63 OMS 2	4.956	-4.962	4.716	-4.908
STS-70 OMS 2	4.962	-4.943	4.640	-4.962
STS-70 Wave Off	5.000	-4.962	4.735	-4.943
STS-70 Deorbit	5.000	-5.000	4.735	-4.940
STS-82 OMS 2	4.963	-4.928	4.390	-4.488
STS-82 Deorbit	5.000	-4.981	4.564	-4.943
STS-85 OMS 2	4.943	-4.905	4.058	-4.167
STS-85 Wave Off	4.987	-4.956	4.593	-4.940
STS-85 Deorbit	4.980	-4.979	4.683	-4.930

Displays and Controls Subsystem

The displays and control performed satisfactorily during the mission with no in-flight anomalies noted.

Communications and Tracking Subsystems

The communications and tracking subsystems performed satisfactorily during the mission, and no in-flight anomalies were recorded or observed.

Commanding problems were encountered with commands being sent to the Cryogenic Infrared Spectrometers and Telescopes for the Atmosphere-Shuttle Pallet Satellite-II (CRISTA-SPAS-II), Technology Applications and Science-01 (TAS-01), and International Extreme Ultraviolet Hitchhiker-02 (IEH-02) payloads. It was reported that there were payload-throughput-command (PTC) rejects by the systems management (SM) general purpose computer (GPC) as well as payload-signal-processor (PSP) command rejects. Additionally, CRISTA-SPAS-II telemetry was momentarily lost on several occasions causing payload data interleaver/decommutator (PDI/DECOM) fail messages. To alleviate the

commanding problems, operational changes were made, such as changing the payload commanding rate from 3 to 2 commands/second and commanding the TAS-01 and IEH-02 payloads using the two-stage buffer during CRISTA-SPAS-II critical command periods. Additional PTC errors were noted after flight day 1; these included first/last word and check sum errors as well as additional PSP errors.

An evaluation team was formed to investigate the payload commanding and telemetry problems. The first troubleshooting action of the team reduced the payload commanding rate to one command/second at approximately 225:00:43 G.m.t. (05:10:02 MET). With this action, the rate of command errors dramatically decreased, and the rate of Mission Operations Computer (MOC) rejects of Payload Operations Control Center (POCC) commands dramatically increased. The team's conclusions and forward actions are summarized in the follow paragraph.

The flight day 1 payload commanding problems are explained as primarily the result of communications problems resulting from radio frequency interference (RFI). The team did not find a most probable cause for the telemetry problems with SPAS in the payload bay on flight day 1. The PTC buffer rejects commanding problems that occurred when the MOC input rate was two commands/second were caused by bad communications or the commands were exceeding the timing capability. The PSP rejects were caused by commands exceeding the timing capability. The PTC buffer rejects commanding problems that occurred when the MOC input rate was one command/second were caused by bad communications, and the PSP rejects were caused by commands exceeding the timing capability. An investigation of the MOC command input rate history is being performed, and Shuttle Avionics Integration Laboratory (SAIL) testing will be performed in late October to fully understand the onboard events and system capabilities and limitations.

The Ku-Band system failed self-test prior to the CRISTA-SPAS-II deployment because of a known condition. The Ku-Band radar successfully tracked the CRISTA-SPAS-II during deployment and separation operations.

The Ku-Band radar was used during CRISTA-SPAS-II rendezvous operations. The CRISTA-SPAS-II was acquired at a range of 151,000 feet at 228:10:21 G.m.t. (08:19:40 MET) and tracked until the system was put back in the communications mode at 228:15:52 G.m.t. (09:01:11 MET). The system did break lock during an attitude change for the Ti maneuver; however, this was expected due to the large angle off the boresight caused by the maneuver.

At 221:03:20 G.m.t. (01:12:39 MET), the video image from camera B was exhibiting a white horizontal band across 40 percent of the image that overlays the screen. This condition appeared to be intermittent or it only occurred in certain modes. A more detailed discussion of this problem is given in the Government Furnished Equipment/Flight Crew Equipment section of this report.

Operational Instrumentation/Modular Auxiliary Data System

The operational instrumentation (OI) and the modular auxiliary data system (MADS) performed satisfactorily throughout the mission, and no in-flight anomalies of either subsystem occurred.

Structures and Mechanical Subsystems

The structures and mechanical subsystems performed satisfactorily throughout the mission. No in-flight anomalies were noted in the review of the data and inspection of the hardware. The landing and braking parameters for the mission are shown in the following table.

LANDING AND BRAKING PARAMETERS

Parameter	From threshold, ft	Speed, keas	Sink rate, ft/sec	Pitch rate, deg/sec
Main gear touchdown	3074.1	195.0	-1.1	N/A
Nose gear touchdown	6076.8	144.7	N/A	5.20
Brake initiation speed		137.5 knots		
Brake-on time		55.6 seconds		
Rollout distance		8744.6 feet		
Rollout time		68.67 seconds		
Runway		33 (Concrete) KSC		
Orbiter weight at landing		221,184.3 lb		
Brake sensor location	Peak pressure, psia	Brake assembly	Gross energy, million ft-lb	
Left-hand inboard 1	819	Left-hand inboard	21.52	
Left-hand inboard 3	819			
Left-hand outboard 2	837	Left-hand outboard	20.31	
Left-hand outboard 4	837			
Right-hand inboard 1	773	Right-hand inboard	16.16	
Right-hand inboard 3	773			
Right-hand outboard 2	708	Right-hand outboard	13.23	
Right-hand outboard 4	708			

The left (port) payload bay door was opened at 219:16:01:55 G.m.t. (00:01:20:55 MET) and the right (starboard) payload bay door was opened at 219:16:03:14 G.m.t. (00:01:22:14 MET). The operation of both doors during the opening was nominal. The doors were also closed nominally in preparation for entry; however, the landing was delayed 24 hours because of unacceptable weather conditions and the doors were again opened nominally. The final closing of the doors for entry was performed in nominal time.

The ET/Orbiter separation devices EO-1, EO-2, and EO-3 functioned normally. No ordnance fragments were found on the runway beneath the umbilical cavities. The EO-2 retainer springs were dislodged; however, this condition has been observed on previous flights. Also, five clips were missing from the EO-3 fitting "salad bowl".

The tires were in good condition for a landing on the KSC concrete runway. Most of the wear and tear occurred on the inboard tires of both main landing gears.

Integrated Aerodynamic Heating and Thermal Interfaces

The prelaunch thermal interface purges were normal with no problems noted. The ascent aerodynamic and plume heating was normal. The entry aerodynamic heating on the SSME nozzles higher than normal (metal blued); however, the nozzles met material hardness test requirements.

Thermal Control Subsystem

The thermal control subsystem performed nominally throughout the flight. All subsystem temperatures were maintained within acceptable limits. No heater or thermal instrumentation failures occurred. The launch date and time resulted in a beta angle ranging from -33.6 degrees at orbit insertion to approximately -42 degrees at 160 hours MET to approximately -31.7 degrees at entry interface.

At 224:22:00 G.m.t. (05:07:19 MET), the APU 1 fuel pump/line/GGVM system B heater thermostat began dithering within a 4 °F deadband as indicated by the bypass line temperature. The deadband shifted back to about 10 °F at 225:02:40 G.m.t. (05:11:59 MET). This thermostat is located on a fuel line that is attached to the APU and previous experience has shown that a thermostat located at this position will eventually fail once it begins to dither and/or behave erratically. The vibration (g-level) environment at this location is greater than the acceptable design vibration levels for the thermostat. The signature of the thermostat did not suggest that the thermostat would fail on this flight. This heater system has an over-temperature thermostat as well as a redundant heater circuit. The thermostat will be removed and replaced during the next processing flow.

Entry Aerothermodynamics

The boundary layer transition was symmetrical and modular auxiliary data system (MADS) data showed boundary layer transition from laminar to turbulent flow occurred at Mach 8.6 which was 1244 seconds after entry interface. The acreage heating was normal. Local heating was also normal, but slumped tiles were noted on the chin panel region because of a tile installation problem. The OV-103 vehicle has tiles instead of a chin panel. The removal of the slumped tiles did lead to the installation of the more robust reinforced carbon carbon (RCC) chin panel on this vehicle. Tile slumping was also noted on the body flap and it was caused by impact damage.

Thermal Protection Subsystem and Windows

The thermal protection system (TPS) and windows performed nominally with no in-flight anomalies identified. Entry heating was locally higher than normal based on structural temperature rise data. The temperature rise in the aft mid-fuselage, the aft fuselage lower surfaces, and the port-side surfaces was, on the average, equal to the highest temperature rises recorded on this Orbiter, but not when compared with the flights of all Orbiter vehicles.

The Orbiter thermal protection system (TPS) sustained a total of 102 hits (damage sites) of which 13 had a major dimension of 1 inch or larger. The total number of hits, shown in the table on the following page, does not include the numerous hits on the base heat shield that are attributed to the SSME vibration/acoustics, exhaust plume recirculation, and the flame arrestment sparkler system. Based on data from the postflight debris inspection team reports as well as the comparison with statistics from 70 previous flights of similar configuration, both the total number of damage sites and the number of damage sites that were 1 inch or larger showed that the overall debris damage was less than average. No tile damage from micrometeorites or on-orbit debris was identified during the postflight inspection.

TPS DAMAGE SITES

Orbiter Surfaces	Hits > 1 Inch	Total Hits
Lower Surface	6	37
Upper Surface	7	41
Right Side	0	9
Left Side	0	5
Right OMS Pod	0	4
Left OMS Pod	0	6
Total	13	102

On the forward portion of the vehicle, a slump (melt) condition occurred on two tiles, one row aft of the nose cap. The opening was approximately 1.25 inches long, 0.25 inch wide, and between 2.5 and 3.0 inches deep (tile thickness is 3.25 inches). The captured pillow gap-filler between these tiles provided adequate protection. In addition, two nose-gear aft-edge tiles were damaged and the forward RCS vernier engine F5L thermal barrier had a tear approximately 5 inches in length.

In the mid section of the vehicle, two gap fillers were protruding near the centerline at approximately the same X-axis dimension as the left-hand and right-hand main landing gear (MLG) door. Twelve thermal barriers on the MLG doors (six on each door) were torn and frayed. A 6-inch by 8-inch piece of advanced flexible reusable surface insulation (AFRSI) outer mold line fabric was hanging from left-hand payload bay door 2.

In the aft section of the vehicle, the body flap sustained a large area of impact damage, and an adjacent tile had damage that resulted in a burrowing hole approximately 0.5-inch in diameter. Also, a base heat shield tile had a large degraded room temperature vulcanizing (RTV) material repair. Likewise, the dome heat shield blanket on SSME 1 was ripped and torn at approximately the 6 o'clock position.

An estimated 25 to 35 percent of the ceramic insulator surface area on both flash evaporator system (FES) 1 and 2 vents, which are located in the aft fuselage near the body flap hinge, was missing to a maximum depth of 1 inch. Review of the launch films showed the insulator piece from FES 2 falling aft of the Orbiter during SSME ignition. However, the missing piece from FES 1 could not be detected in the films and was most likely lost later in the flight.

Hazing and streaking of forward-facing windows was typical. Damage sites on the window perimeter tiles appeared to be average in size but more than average in quantity. The damage sites are believed to be the result of impacts from excessive RTV adhesive used in attaching paper covers to the forward RCS thrusters.

REMOTE MANIPULATOR SYSTEM

The remote manipulator system (RMS) performed satisfactorily, and no in-flight anomalies occurred. The primary task of the RMS was the deployment and retrieval of the CRISTA-SPAS satellite. Additional RMS tasks included support of the Space Vision Experiment (SVS), RMS Situational Awareness Displays (RSAD), Shuttle GLO and the Southwest Ultraviolet Imaging System (SWUIS) experiments. The RMS television camera provided video of the Technology Applications and Science (TAS) experiments in the payload bay.

The RMS was powered up and the checkout was successfully completed at 219:18:24 G.m.t. (00:03:43 MET). The CRISTA-SPAS-II payload was grappled by the RMS at approximately 219:18:40 G.m.t. (00:03:59 MET), and release of the payload bay keel and longeron latches was completed at 219:21:24:06 G.m.t. (00:06:43:06 MET). CRISTA-SPAS-II was successfully deployed at 219:22:27:04 G.m.t. (00:07:46:04 MET). During the CRISTA-SPAS II deployment, the RF signal strength stabilized and phase remained nominal throughout the deployment phase and most of the separation.

At 224:09:17 G.m.t. (04:18:36 MET), the RMS was maneuvered from the GLO unloaded extended-park position into a shading position for the SWUIS. It was returned to the GLO unloaded extended-park position at 224:12:54 G.m.t. (04:22:13 MET). At 224:15:08 G.m.t. (05:00:27 MET), the RMS was used to provide video images of the TAS-01 experiment in the payload bay. The RMS Situational Awareness Display (RSAD) unloaded operations were initiated at 224:15:34 G.m.t. (05:00:53 MET) and completed at 224:16:27 G.m.t. (05:01:46 MET). The RMS was parked with the brakes on following these activities.

As part of RMS support for the Space Vision System (SVS) Development Test Objective (DTO), the arm was maneuvered from the Sprite unloaded extended-park position to the pre-cradle position at 227:14:14 G.m.t. (07:23:33 MET). The arm was then moved to the camcorder overhead field of view position at 227:14:27 G.m.t. (07:23:46 MET) and commanded through a series of shoulder-yaw and shoulder-pitch single-joint maneuvers. Upon completion of these maneuvers at 227:14:51 G.m.t. (08:00:10 MET), the arm was moved to the RMS overhead-window characterization position to support SVS witness-plate characterization. As part of the SVS witness-plate characterization, the RMS was commanded through a series of single-joint maneuvers. Upon completion of these maneuvers at 227:16:14:37 G.m.t. (08:01:33:37 MET), the arm was maneuvered to the pre-cradle position using the single joint mode. The arm was then maneuvered to the GLO unloaded extended-park position where it was parked.

The RMS was maneuvered into the pre-cradle position at 228:09:01 G.m.t. (08:18:20 MET). It remained there until 228:13:04 G.m.t. (08:22:23 MET), when it was moved to the CRISTA-SPAS-II poise-for-capture position. CRISTA-SPAS-II was captured at 228:15:13 G.m.t. (09:00:32 MET). The CRISTA-SPAS II was successfully berthed and latched at 228:16:30:32 G.m.t. (09:01:49:32 MET). The port longeron indicated ready-to-latch (RTL) indication was acquired at

228:16:27:22 G.m.t. (09:01:46:22 MET). The payload bay keel latch was latched at 228:16:29:46 G.m.t. (09:01:48:46 MET). Note that the starboard longeron latch RTL indication was obtained during latching. This was expected because of the location of the grapple fixture with respect to the starboard trunnion on the payload. A similar signature was seen during the STS-66 CRISTA-SPAS-II berthing.

The RMS was moved from the GLO unloaded extended-park position to the pre-cradle position at 229:07:29 G.m.t. (09:16:48 MET). CRISTA-SPAS-II grapple occurred at 229:07:46 G.m.t. (09:17:05 MET) in preparation for AutoTrac Computer Vision System (ACVS) and Space Vision System (SVS) operations. The RMS was used to maneuver the CRISTA-SPAS-II for ACVS and SVS operations. Upon completion of these activities, CRISTA-SPAS-II was successfully berthed and latched at 229:11:34:06 G.m.t. (09:20:53:06 MET). The port longeron latch RTL indication was acquired at 229:11:32:12 G.m.t. (09:20:51:12 MET), and the starboard longeron latch RTL was acquired at 229:11:32:14 G.m.t. (09:20:51:14 MET). The keel latch was latched at 229:11:33:29 G.m.t. (09:20:52:29 MET). These activities completed the RMS operations for the STS-85 mission.

The RMS end effector released the CRISTA-SPAS-II at 229:11:37 G.m.t. (09:20:56 MET). The RMS was then cradled and the arm deselected at 229:12:01 G.m.t. (09:21:20 MET). The manipulator retention latches (MRL) were latched at 229:11:56:32 G.m.t. (09:21:15:32 MET). Manipulator position mechanism (MPM) stow was completed at 229:11:59:39 G.m.t. (09:21:18:39 MET). This completed all planned RMS operations for the STS-85 mission.

DEPLOYMENT, RENDEZVOUS AND RETRIEVAL OPERATIONS

The CRISTA-SPAS was deployed approximately 7 hours after liftoff, and retrieved approximately nine days later. All flight software systems for the deployment and retrieval operations functioned satisfactorily with no in-flight anomalies identified.

Rendezvous and retrieval of the CRISTA-SPAS occurred approximately nine days into the flight. The final maneuver (NCC) prior to terminal phase initiation (TI) was performed at 228:11:54:23 G.m.t. (08:21:13:23 MET). The intermediate onboard solution for the TI maneuver was completed and the Mission Control Center (MCC) confirmed that the solutions were nominal and that the navigation residuals were well within limits. The TI maneuver (OMS-3) was performed at 228:12:50:47.2 G.m.t. (08:22:09:47.2 MET) and was 12 seconds in duration with a ΔV of 11 ft/sec. At the completion of the TI maneuver, the Orbiter was nine miles behind the CRISTA-SPAS, and the orbital altitude was 159 by 152 nmi.

Seven minutes after the TI maneuver, the crew reported that the satellite was in sight. The crew-optical alignment sight (COAS) and the rendezvous radar both indicated that the CRISTA-SPAS position to be 1 degree left and 1 degree low in the COAS crosshairs. The first midcourse correction maneuver was not performed as the residuals and ratios were less than 0.2 ft/sec. The second midcourse correction maneuver was performed at 228:13:39:08 G.m.t. (08:22:58:08 MET). The maneuver was approximately 6 seconds in duration and a ΔV of 0.9 ft/sec was imparted to the vehicle. Ten minutes later, the third midcourse correction maneuver was performed with 0.6 ft/sec imparted to the vehicle.

The fourth midcourse correction maneuver was not required. The Orbiter crossed the Rbar at a distance of 2100 feet and maintained a closure rate of 0.75 ft/sec until the Vbar was reached at a range of 330 feet. The closure rate had been reduced to 0.2 ft/sec by the time the Vbar was reached. The crew completed the rendezvous with the satellite and positioned the Orbiter to grapple the satellite. Seven minutes after grappling the satellite, the crew disabled the rendezvous navigation program and returned to the original flight plan. In summary, the flight system was better than expected and the navigation software performed well within the criteria guidelines.

GOVERNMENT FURNISHED EQUIPMENT/FLIGHT CREW EQUIPMENT

At 221:03:20 G.m.t. (01:12:39 MET), the video image from camera B was exhibiting a white horizontal band across 40 percent of the image that overlays the screen. This condition appeared to be intermittent or it only occurred in certain modes. The video that has been analyzed indicates that the condition may only occur in the night gain-control mode and not the day mode. The condition may also be temperature dependent as the video with the band showed the camera temperature to be -9 °C, whereas in other video when the band was not present the camera temperature was +19 °C. Postflight testing will be performed at the Flight Crew Equipment Laboratory at JSC.

A smudge was noted on camera C of the closed circuit television (CCTV) system. This condition is known to occur occasionally when the internal camera paint outgasses, and material is deposited on the lens. This camera will be removed from the vehicle during the postflight turnaround activities.

When powering on the STS-2 payload general support computer (PGSC), a blue screen appeared with an error code that indicated a bad track-point device. The track point was disabled, and operation of the PGSC was recovered for the remainder of the mission. This PGSC had successfully passed the preflight checkout.

When powering on the STS-3 PGSC, a blue screen appeared with an error code that indicated a failed keyboard. The PGSC was rebooted a number of times and the error code disappeared. The error appears to be transient in nature, and the initial indication was a loose connection between the keyboard and the base of the laptop. The PGSC apparently operated properly for the remainder of the mission with no reinitialization attempts required. This PGSC had successfully passed the preflight checkout.

The Pilot's private family conference (PFC) via the Orbiter communications adapter (OCA) video teleconference failed twice - one time due to the loss of audio, and the second time because a green downlink light was not illuminated (downlink not being received). Troubleshooting consisted of checking configurations, changing very lightweight headset (VLHS) units, and performing loop-back tests, which were successful. The PFC's on flight day 8 were successful and the audio problem had been solved. There were no further occurrences of failing to receive the downlink signal.

CARGO INTEGRATION

The cargo integration hardware performance was nominal throughout the mission, and no issues or in-flight anomalies were identified.

DEVELOPMENT TEST OBJECTIVES/DETAILED SUPPLEMENTARY OBJECTIVES

DEVELOPMENT TEST OBJECTIVES

DTO 255- Wraparound Digital Autopilot Flight Test Verification - STS-85 was the seventh flight of Development Test Objective (DTO) which verified the in-flight stability and control of the digital autopilot (DAP). The first four flights used programmed test inputs to execute flight test maneuvers. The next two flights actually enabled the wraparound DAP while flying the nominal end-of-mission trajectory. When operational, the wraparound DAP will result in a significant savings of RCS propellant during entry. The data from this DTO have been given to the sponsor for analysis. The results of that analysis will be reported in separate documentation.

DTO 312 - EXTERNAL TANK THERMAL PROTECTION SYSTEM PERFORMANCE, METHOD 3 - Photography of the External Tank (ET) was acquired using the 35 mm camera and a 400 mm lens. The +X translation maneuver following ET separation was not planned nor performed. The umbilical well cameras were not flown.

A total of 37 views of the ET were acquired, and the film exposure and focus were good. The first photograph was taken approximately 21 minutes after liftoff, and the last picture was taken 5 minutes 12 seconds later. The ET was measured to be approximately 2.3 kilometers from the Orbiter on the first image of the ET. The photographic analysis did not reveal any damage to the ET. The normal aerodynamic heating marks, and SRB separation motor burn scars were seen on the thermal protection system (TPS).

DTO 700-10 - ORBITER SPACE VISION SYSTEM FLIGHT VIDEO TAPING - STS-85 was the ninth flight of this Orbiter Space Vision System (SVS) flight video taping DTO, which provides precise relative position, attitude and rate cues in a concise graphical and digital format. These data are then used to perform RMS operations and/or proximity operation. A minimum of three flights of good data for this DTO were required. The two primary objectives of this DTO were to conduct SVS assessments from the Mission Control Center (MCC) during crew sleep periods, and record video of the CRISTA-SPAS during the Orbiter separation and approach. The SVS crew-sleep objectives were accomplished during the flight day 1 and 2 activities, despite heavy competition for use of Ku-band channel 3 for video downlink. During flight day 1 activities, the low-light-level intensified television camera (ITVC) illuminator was configured to obtain video data during night passes, a condition that was not available on previous flights.

The video data of targets on the SPAS during separation and approach was only recorded onboard and was not downlinked during the flight. The recording objectives for this activity are assumed to have been completed. The data were given to the sponsor for evaluation. The report of the flight results will be published in separate documentation.

DTO 700-11 - ORBITER SPACE VISION UNIT FLIGHT UNIT TESTING - STS-85 was the third flight of the DTO with a minimum of four flights of good data required. The

space vision unit flight unit testing uses existing payload bay hardware to provide precise relative position data for RMS operations. The primary flight testing objectives were to use the SVS as a primary cue for a payload berthing and to simulate International Space Station (ISS) 2A FGB Installation and 3A PMA 3 Installation tasks. These tasks were performed, including the first simulation of a ISS assembly task at night using only the lighting from the ITVC illuminator. In the postflight debriefing, the crew reported that inconsistencies were observed between SVS data and RMS data during these operations. Analysis of the flight video was performed in an effort to identify the cause.

Secondary objectives included RMS witness plate evaluations of SVS target materials, ITVC performance with the illuminator, camcorder field-of-view verifications, overhead window characterizations, and simulation of an ISS assembly task. Most of these objectives were accomplished; however, two were not completed because of timeline requirements by other payloads/systems. Those not accomplished were:

- a. Dynamic movement portion of the RMS Witness Plate material evaluation; and
- b. Simulation of the 3A Z1 Installation task.

The data collected for this DTO have been given to the sponsor for evaluation. The results of the evaluation will be reported in separate documentation.

DTO 700-14 - SINGLE-STRING GLOBAL POSITIONING SYSTEM - STS-85 was the fourth flight of this DTO, and its purpose was to demonstrate the performance and operation of the Global Positioning System (GPS) receiver during all phases of a flight. The data have been given to the sponsor for analysis and evaluation. The results of the evaluation will be reported in separate documentation. The system operated nominally from activation through deactivation.

DTO 805 - CROSSWIND LANDING PERFORMANCE - This DTO was not performed as the crosswind component at landing was insufficient to fulfill the minimum requirements of this DTO.

DTO 842 - AUTOTRAC COMPUTER VISION SYSTEM - STS-85 was the first flight of this DTO whose purpose was to demonstrate a space vision system concept that can be used that can be used to support cargo element berthing and proximity operations for Space Station assembly flights 2A through 6A.

At 228:17:36:00 G.m.t. (09:02:55:00 MET), the crew set up the Autotrac Computer Vision System (ACVS) primary mini keel camera (MKC) for a test of the system. The video downlinked was of good quality and synchronous with the Shuttle remote closed circuit television (CCTV) system remote control unit (RCU). Also, the G.m.t. was inserted properly in the vertical blanking interval. The secondary MKC was then downlinked and synchronization problems were noted. In addition, the G.m.t. was floating through the frame, and poor light emitting diode (LED) flashing performance was noted.

The major objectives of this DTO were accomplished on flight day 11 when the system was used to unberth the CRISTA-SPAS satellite. Between the unberth and berth operations on flight day 11, the light emitting diode (LED) brightness evaluation procedures were performed and recorded to evaluate the camera, LED illumination, and target performance for the lighting conditions encountered. The recorded data from these operations have been obtained, and the analysis indicates that there were no lighting conditions encountered that the system could not handle. The LED systems on both MKC's were capable of delivering adequate illumination to the target. The target elements as produced by the camera were of high contrast and the recorded video that has LED's flashing can be processed. The data and video from the conduct of this DTO have been given to the sponsor for evaluation. The results of that evaluation will be reported in separate documentation.

DTO 843 - V-bar Proximity Operations Demonstration for International Space Station - STS-85 was the first flight of this DTO, which demonstrates piloting techniques and Space Shuttle performance during a V-bar approach to a small payload target. The ACVS MKC for DTO 842 was also successfully used on flight day 10 as an aid for the rendezvous of the Orbiter with the CRISTA-SPAS satellite. This support was provided for DTO 843 which simulated the proximity operations for a typical Orbiter rendezvous with the ISS. The results of this DTO have been given to the sponsor for evaluation, and the results of that evaluation will be reported in separate documentation.

DTO 844 - Remote Manipulator System Situational Awareness Displays - On this first flight of DTO 844, the Remote Manipulator System (RMS) Situational Awareness Displays (RSAD) were demonstrated. These displays are planned for use on ISS assembly flights to determine the position and attitude of payloads. These data have been given to the sponsor for evaluation, and the results of that evaluation will be reported in separate documentation.

DETAILED SUPPLEMENTARY OBJECTIVES

DSO 331 - Interaction of the Space Shuttle Launch and Entry Suit and Sustained Weightlessness on Egress Locomotion - This DSO collected data on the effect of the launch and entry suit (LES)/advanced crew escape suit on egress locomotion as well as directly assessing the emergency egress capacity of crew members at wheel stop. The data from the DSO have been given to the sponsor for evaluation, and the results of that evaluation will be reported in separate documentation.

DSO 484C - Assessment of Sleep Quality and Circadian Rhythms in Astronauts by Bright Light - This DSO was performed during the preflight and postflight periods to assess the efficacy of bright light in facilitating preflight circadian shifting in astronauts who undergo atypical work-rest cycles during space flight. The data from this DSO have been given to the sponsor for evaluation, and the results of that evaluation will be reported in separate documentation.

DSO 485 - Inter-Mars Tissue Equivalent Proportional Counter - Data were collected throughout the flight on the ability of hardware to withstand the radiation environment of

space flight. The data have been given to the sponsor for evaluation. The results of that evaluation will be reported in separate documentation.

DSO 493 - Monitoring Latent Virus Reactivation and Shedding in Astronauts - Saliva were collected for this DSO on a daily basis throughout the flight. These specimens have been given to the sponsor for evaluation, and the results of the evaluation will be reported in separate documentation.

DSO 802 - Educational Activities - Video of various educational activities was collected as well as downlinked throughout the flight. These videos will be used in schools throughout the United States to teach students about space flight.

PHOTOGRAPHY AND TELEVISION ANALYSIS

LAUNCH PHOTOGRAPHY AND VIDEO DATA ANALYSIS

The launch photography consisted of 24 videos and twenty 16 mm and 35 mm cameras. Film from one camera, E-224, was not received. A review of all of these films showed no anomalies or significant events. Initial reports from the vehicle contractor indicated threshold-level lateral accelerations that were attributed to possible holddown post stud hang-up. A detailed review of the stud releases showed no evidence of stud hang-up.

ON-ORBIT PHOTOGRAPHY AND VIDEO DATA ANALYSIS

No requirements or requests for review and analysis of on-orbit photography were made.

LANDING PHOTOGRAPHY AND VIDEO DATA ANALYSIS

Twelve videos of landing were reviewed and no anomalous conditions or events were noted during the review.

STS-85 SEQUENCE OF EVENTS

Event	Description	Actual time, G.m.t.
APU Activation	APU-1 GG chamber pressure APU-2 GG chamber pressure APU-3 GG chamber pressure	219:14:36:11.022 219:14:36:12.121 219:14:36:13.145
SRB HPU Activation ^a	LH HPU System A start command LH HPU System B start command RH HPU System A start command RH HPU System B start command	219:14:40:32.153 219:14:40:32.313 219:14:40:32.473 219:14:40:32.633
Main Propulsion System Start ^a	ME-3 Start command accepted ME-2 Start command accepted ME-1 Start command accepted	219:14:40:53.458 219:14:40:53.577 219:14:40:53.704
SRB Ignition Command (Liftoff)	Calculated SRB ignition command	219:14:41:00.013
Throttle up to 104 Percent Thrust ^a	ME-3 Command accepted ME-1 Command accepted ME-2 Command accepted	219:14:41:03.973 219:14:41:03.985 219:14:41:03.989
Throttle down to 67 Percent Thrust ^a	ME-3 Command accepted ME-1 Command accepted ME-2 Command accepted	219:14:41:30.693 219:14:41:30.705 219:14:41:30.709
Maximum Dynamic Pressure (g)	Derived ascent dynamic pressure	219:14:41:49
Throttle up to 104 Percent ^a	ME-3 Command accepted ME-1 Command accepted ME-2 Command accepted	219:14:42:00:134 219:14:42:00:146 219:14:42:00:150
Both RSRM's Chamber Pressure at 50 psi ^a	RH SRM chamber pressure mid-range select LH SRM chamber pressure mid-range select	219:14:42:57.653 219:14:42:58.493
End RSRM ^a Action ^a Time	RH SRM chamber pressure mid-range select LH SRM chamber pressure mid-range select	219:14:42:59.893 219:14:43:00.633
SRB Physical Separation ^a	LH rate APU B turbine speed - LOS RH rate APU A turbine speed - LOS RH rate APU B turbine speed - LOS LH rate APU A turbine speed - LOS	219:14:43:03.493 219:14:43:03.493 219:14:43:03.533 219:14:43:03.533
SRB Separation Command	SRB separation command flag	219:14:43:04
Throttle Down for 3g Acceleration ^a	ME-2 command accepted ME-3 command accepted ME-1 command accepted	219:14:48:28.275 219:14:48:28.302 219:14:48:28.315
3g Acceleration	Total load factor	219:14:49:06.6
Throttle Down to 67 Percent Thrust ^a	ME-2 command accepted ME-3 command accepted ME-1 command accepted	219:14:49:25.875 219:14:49:25.904 219:14:49:25.916
SSME Shutdown ^a	ME-2 command accepted ME-3 command accepted ME-1 command accepted	219:14:49:32.155 219:14:49:32.184 219:14:49:32.196
MECO	MECO command flag MECO confirm flag	219:14:49:33 219:14:49:33
ET Separation	ET separation command flag	219:14:49:52

^aMSFC supplied data

STS-85 SEQUENCE OF EVENTS

Event	Description	Actual time, G.m.t.
APU Deactivation	APU-1 GG chamber pressure APU 2 GG chamber pressure APU 3 GG chamber pressure	219:14:55:59.855 219:14:56:16.489 219:14:56:30.863
OMS-1 Ignition	Left engine bi-prop valve position Right engine bi-prop valve position	Not performed - direct insertion trajectory flown
OMS-1 Cutoff	Left engine bi-prop valve position Right engine bi-prop valve position	
OMS-2 Ignition	Left engine bi-prop valve position Right engine bi-prop valve position	219:15:18:06.5 219:15:18:06.7
OMS-2 Cutoff	Right engine bi-prop valve position Left engine bi-prop valve position	219:15:20:44.9 219:15:20:45.1
Payload Bay Doors (PLBDs) Open	PLBD right open 1 PLBD left open 1	219:16:01:57 219:16:03:16
CRISTA-SPAS Unberthing	Payload SEL 1 Latch 2A Release	219:21:24:07
CRISTA-SPAS Deployment	Payload Captured	219:22:27:05
OMS-3 Ignition	Left engine bi-prop valve position Right engine bi-prop valve position	N/A 228:12:50:47.2
OMS-3 Cutoff	Right engine bi-prop valve position Left engine bi-prop valve position	N/A 228:12:50:59.2
CRISTA-SPAS Capture	Payload Captured	228:15:13:30
CRISTA-SPAS Berthing	Payload SEL 1 latch 2A Ready-to-Latch	228:16:30:29
CRISTA-SPAS Latching	Payload SEL 1 latch 1A Latched	228:16:30:32
Flight Control System Checkout APU 1 Start APU 1 Stop	APU 1 GG chamber pressure APU 1 GG chamber pressure	229:06:20:23.804 229:06:24:52.624
CRISTA-SPAS Unberthing	Payload Select 1 Latch 2A Release	229:07:54:18
CRISTA-SPAS Berthing	Payload SEL 1 Latch 3A Ready-to-Latch	229:11:33:27
CRISTA-SPAS Latching	Payload SEL 1 Latch 1A Latched	229:11:34:06
Payload Bay Doors Close	PLBD left close 1 PLBD right close 1	230:07:33:00 230:07:34:38
Payload Bay Doors Reopen	PLBD right open 1 - BFS PLBD left open 1 - BFS	230:10:16:24 230:10:17:45
Payload Bay Doors Close	PLBD left close 1 PLBD right close 1	231:07:25:52 231:07:27:32
APU Activation for Entry	APU-2 GG chamber pressure APU-1 GG chamber pressure APU-3 GG chamber pressure	231:10:02:31.748 231:10:22:46.218 231:10:22:47.663
Deorbit Burn Ignition	Left engine bi-prop valve position Right engine bi-prop valve position	231:10:07:30.1 231:10:07:30.2
Deorbit Burn Cutoff	Left engine bi-prop valve position Right engine bi-prop valve position	231:10:09:45.6 231:10:09:45.7
Entry Interface (400K feet)	Current orbital altitude above	231:10:35:46
Blackout end	Data locked (high sample rate)	No blackout
Terminal Area Energy Mgmt.	Major mode change (305)	231:11:01:19
Main Landing Gear Contact	RH main landing gear tire pressure 2 LH main landing gear tire pressure 2	231:11:07:59 231:11:07:59
Main Landing Gear Weight on Wheels	LH main landing gear weight on wheels RH main landing gear weight on wheels	231:11:08:00 231:11:08:00

STS-85 SEQUENCE OF EVENTS

Event	Description	Actual time, G.m.t.
Drag Chute Deployment	Drag chute deploy 1 CP volts	231:11:08:00.7
Nose Landing Gear Contact	NLG LH tire pressure 2	231:11:08:08
Nose Landing Gear Weight On Wheels	NLG weight on wheels	231:11:08:09
Drag Chute Jettison	Drag chute jettison 1 CP Volts	231:11:08:36.7
Wheel Stop	Velocity with respect to runway	231:11:09:07
APU Deactivation	APU-1 GG chamber pressure	231:11:24:51.975
	APU-2 GG chamber pressure	231:11:25:05.100
	APU-3 GG chamber pressure	231:11:25:16.211

TABLE II.- SPACE SHUTTLE VEHICLE ENGINEERING OFFICE IN-FLIGHT ANOMALY LIST

No.	Title	Reference	Comments
STS-85-V-01	Right OMS Standby Yaw Actuator Slow Drive Rate	219:04:34 G.m.t. Prelaunch 85RF01 IPR 91V-0003	<p>During prelaunch operations, the right OMS standby actuator rate was observed to be low during the OMS Profile Test. The actuator drive rate has a minimum requirement of 2.9 deg/sec and is only allowed to change by a maximum of 1.0 deg/sec between comparable tests. During the profile test, the standby drive rate differed from the previous comparable test by more than 1.0 deg/sec. During subsequent testing to investigate this condition, a drive rate of 2.45 deg/sec was observed, which was below the minimum rate of 2.9 deg/sec that is specified in the OMFSD. The LCC allows the loss of one channel (active or standby) on either the left or right side. After the OMS 2 maneuver, the gimbal check was performed again, and the drive rate was sufficient to avoid a fault detection and annunciation (FDA) message. The standby drive rate of the actuator was below nominal levels, but was considered usable for steering during an OMS maneuver, should an active channel be lost.</p> <p>KSC: The actuator will be removed and replaced during postflight turnaround activities with no further troubleshooting.</p>
STS-85-V-02	Right RCS Oxidizer Manifold 5 Loss of Open Position	219:14:37 G.m.t. Prelaunch CAR 85RF02 IPR 91V-0004	<p>Immediately prior to liftoff, the right RCS oxidizer manifold 5 isolation valve open-discrete measurement began toggling. Data shows that the open discrete changed from a 1 to 0 (loss of open indication) at 219:14:40:56 G.m.t. (T-4 seconds), changed back to 1 approximately one second later, and changed back to 0 at T-2 seconds. At 219:14:42:31 G.m.t. (00:00:01:31 MET), the open indication returned for six seconds after which the open indication was lost for 17 1/2 minutes. Throughout ascent, the corresponding closed discrete measurement indicated 0 (not closed). The toggling open-discrete measurement caused an RM dilemma and master alarm on two occasions during ascent. The measurement continued to indicate open until 220:20:38:03 G.m.t. (01:05:57:03 MET), when the open discrete measurement again changed from 1 to 0 following initiation of the NC 4 maneuver. The RM fault message (RM DLMA MANF) occurred three seconds later. Following the NC 5 maneuver, the valve position indicator continued to indicate not-open. The right RCS manifold 5 status was over-ridden open and vernier operation resumed. There was no change in the loss of the Open indication of this valve during entry and landing. This problem was not an impact to the mission.</p> <p>KSC: The RCS oxidizer manifold 5 isolation valve was not cycled during the postflight "RCS OMS Valve Test", which aided in troubleshooting of the VPI by preserving as much information/evidence as possible. After fuel cell power down and ground power-up of the vehicle, the open discrete started to toggle. Postflight inspection revealed that connector LY358 had corrosion around the valve connector receptacles. No other anomalies were found.</p>
STS-85-V-03	Transient DEU 1 Memory Parity Error	227:15:41 G.m.t. 08:01:00 MET PR DIG-3-24-0309	<p>At 227:15:41:46 G.m.t. (08:01:00:46 MET) GPC 1 announced a CRT BITE 1 message. The DEU BITE status words and poll header word indicated a critical BITE due to a DEU 1 (S/N 19) memory parity error. The crew reassigned CRT 1 to GPC 1 and the BITE indication returned because this action doesn't clear the BITE status register (BSR). The crew worked the malfunction procedure 5.4b (CRT BITE 1, and at</p>

TABLE II.- SPACE SHUTTLE VEHICLE ENGINEERING OFFICE IN-FLIGHT ANOMALY LIST

No.	Title	Reference	Comments
STS-85-V-03 (Continued)	Transient DEU 1 Memory Parity Error (Continued)	227:15:41 G.m.t. 08:01:00 MET PR DIG-3-24-0309 (Continued)	block 12, the BITE status works were nominal, indicating that the BITE condition had cleared. Therefore, the crew reassigned CRT 1 to GPC 1 and the BITE has not repeated. KSC: No postflight troubleshooting required. The DEU was removed and replaced.
STS-85-V-04	FCL Evaporator Outlet Temperature Oscillations on FES Primary B Controller	230:07:26 G.m.t. 10:16:45 MET CAR 85RF05 PR-ECL-3-24-1250	When the FES Primary B controller was activated (both high load and topping evaporators) after the secondary FES checkout, the Freon coolant loop (FCL) evaporator outlet temperatures oscillated as the temperature neared the control band. There were eight prominent cycles. Similar oscillations occurred during STS-82 (OV-103/22), but the amplitude and number of cycles were less (only 3 cycles). On STS-85, the oscillations lasted for approximately six minutes. On STS-85, the oscillations did not occur at the initiation of radiator cold soak (FES primary B topping evaporator). This signature suggests that the problem is associated with the midpoint sensor, and is typical for a temperature sensor having poor contact with the sensor well. The poor contact is frequently caused by loss of thermal grease around the sensor. KSC: Troubleshooting of this condition will be performed.

DOCUMENT SOURCES

In an attempt to define the official as well as the unofficial sources of data for this mission report, the following list is provided.

1. Flight Requirements Document
2. Public Affairs Press Kit
3. Customer Support Room (CSR) Daily Science Reports, and Final CSR Report
4. Mission Evaluation Room (MER) Daily Reports
5. MER Mission Summary Report
6. MER Problem Tracking List
7. MER Event Times
8. Subsystem Manager Reports/Inputs
9. MOD Systems Anomaly List
10. MSFC Flash Report
11. MSFC Event Times
12. MSFC Interim Report
13. Crew Debriefing comments
14. Shuttle Operational Data Book
15. STS-85 Summary of Significant Events
16. Contractor Reports of Subsystem Operation

ACRONYMS AND ABBREVIATIONS

The following is a list of the acronyms and abbreviations and their definitions as these items are used in this document.

ALPHA	American Loop Heat Pipe with Ammonia
APU	auxiliary power unit
ARS	atmospheric revitalization system
ASA	aerosurface servo amplifier
ATCS	active thermal control system
ATVC	ascent thrust vector control
BDND	Bubble and Drop Non Linear Dynamics
CFDHP	Cryogenic Flexible Diode Heat Pipe
CHT	Capillary-driven Heat Transfer
CPM	cell performance monitor
CRYOFD	Cryogenic Flexible Diode Experiment
CSLM	Coarsening in Solid-Liquid Mixtures
CSR	Customer Support Room
DAP	digital autopilot
DCE	Droplet Combustion Experiment
DMHS	dome-mounted heat shield
DSO	Detailed Supplementary Objective
DTO	Developmental Test Objective
ΔP	differential pressure
ΔV	differential velocity
ECLSS	Environmental Control and Life Support System
ECOS	Experiment computer operating system
EDO	extended duration Orbiter
e.d.t.	eastern daylight time
EO	ET/Orbiter
EPDC	electrical power distribution and control
ET	External Tank
ETA	External Tank attachment
EVA	extravehicular activity
EXPRESS	Expedite the Processing of Experiments to the Space Station
FCE	flight crew equipment
FCL	Freon coolant loop
FCP	fuel cell powerplant
FCS	flight control system
FDA	fault detection and annunciation
FES	flash evaporator system
FM	frequency modulation
FPV	flow proportioning valve
FSDC	Fiber Supported Droplet Combustion Experiment
ft/sec	feet per second
g	gravity
GFE	Government furnished equipment
GH ₂	gaseous hydrogen
G.m.t.	Greenwich mean time

GO ₂	gaseous oxygen
GPC	general purpose computer
H ₂	hydrogen
HI-PAC DTV	High-Packed Digital Television
HPFTP	high pressure fuel turbopump
HPOTP	high pressure oxidizer turbopump
HRM	high-rate multiplexer
IFFD	Internal Flows in a Free Drop Experiment
IFM	in-flight maintenance
I _{sp}	specific impulse
JSC	Lyndon B. Johnson Space Center
kbps	kilobits per second
KOH	potassium hydroxide
KSC	Kennedy Space Center
kW	kilowatt
kWh	kilowatt/hour
lbm	pound mass
lb/min	pound per minute
LCC	Launch Commit Criteria
LH ₂	liquid hydrogen
LIF	Large Isothermal Furnace
LMSMS&S	Lockheed Martin Space Mission Systems and Services
LO ₂	liquid oxygen
LSP	Laminar Soot Process
MECO	main engine cutoff
MER	Mission Evaluation Room
MET	mission elapsed time
MFD	Methane Flexible Diodes
MGBX	Middeck Glovebox
MLG	main landing gear
MMA	Microgravity Measurement System
MOD	Mission Operations Directorate
MPS	main propulsion system
MSFC	Marshall Space Flight Center
MSL-1	Microgravity Science Laboratory-1
MSX	Midcourse Space Experiment
mV	millivolts
NASA	National Aeronautics and Space Administration
NCU	network communication unit
nmi.	nautical mile
NPSP	net positive suction pressure
NSTS	National Space Transportation System (i.e., Space Shuttle Program)
O ₂	oxygen
OARE	Orbital Acceleration Research Experiment
OCA	Orbiter Communications Adapter
OFD	Oxygen Flexible Diode
OMRSD	Operations and Maintenance Requirements and Specifications Document
OMS	orbital maneuvering subsystem
OPF	Orbiter Processing Facility

OPS	Operations
PAL	protuberance air load
PCAM	Protein Crystallization Apparatus for Microgravity
PGBA	Plant Generic Bioprocessing Apparatus
PGSC	payload general support computer
pH	parts hydrogen
PHaSE	Physics of Hard Spheres Experiment
PM	phase modulation
PMBT	propellant mean bulk temperature
ppm	parts per million
PRSD	power reactant storage and distribution
psi	pounds per square inch
psia	pound per square inch absolute
psid	pound per square inch differential
QSAM	Quasi-Steady Acceleration Measurement
RCS	reaction control subsystem
RF	radio frequency
RIC	rack interface controller
RME	Risk Mitigation Experiment
RPC	remote power controller
RSRM	Reusable Solid Rocket Motor
RTLS	Return to Launch Site (abort)
RTV	room temperature vulcanizing (material)
S&A	safe and arm
SAMS	Space Acceleration Measurement System
SAREX-II	Shuttle Amateur Radio Experiment-II
scim	standard cubic inch(es) per minute
SLF	Shuttle Landing Facility
S/N	serial number
SOFBALL	Structure of Flame Balls at Low Lewis-numbers
SRB	Solid Rocket Booster
SRSS	Shuttle range safety system
SSME	Space Shuttle main engine
STS	Space Transportation System
TDRS	Tracking and Data Relay Satellite
TEMPUS	Electromagnetic Containerless Processing Facility
TPS	thermal protection system/subsystem
WCS	Waste Collection System
WDAS	Wireless Data Acquisition System
WSB	water spray boiler