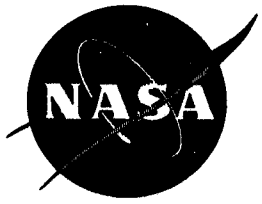
NSTS-37413

STS-82
SPACE SHUTTLE
MISSION REPORT

April 1997



National Aeronautics and Space Administration

Lyndon B. Johnson Space Center
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NOTE

The STS-81 Space Shuttle Mission Report was prepared from inputs received from the Space Shuttle Operations Engineering Office as well as other organizations. The following personnel may be contacted should questions arise concerning the technical content of this document.

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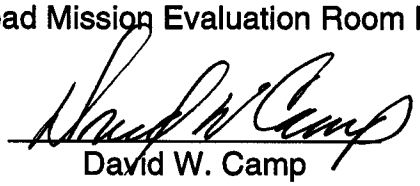

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INTRODUCTION

The Space Transportation System (STS) -82 flight was the second of four planned Hubble Space Telescope (HST) servicing missions that significantly upgraded the HST scientific capabilities. Five extravehicular activities (EVAs) were required to complete the servicing. The remaining two servicing missions are planned for mid-1999, and mid-2002.

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-82 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-second mission of the Space Shuttle Program. STS-82 was the fifty-seventh flight since the return to flight, and the twenty-second flight of the OV-103 (Discovery) vehicle.

The flight vehicle consisted of the OV-103 Orbiter; an ET that was designated ET-81; three Block 1 SSMEs that were designated as serial numbers 2037, 2040, and 2038, in positions 1, 2, and 3, respectively; and two SRBs that were designated BI-085. The two RSRMs were designated RSRM-058 with one installed in each SRB. The individual RSRMs were designated as 360T058A for the left SRB, and 360T058B for the right SRB.

The STS-82 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 objectives of the STS-82 flight were to perform the operations necessary to fulfill the second on-orbit servicing requirements for the HST. The servicing tasks included installation of the Near Infrared Camera and Multi-Object Spectrometer (NICMOS), installation of the Space Telescope Imaging Spectrograph (STIS), replacement of the Data Interface Unit (DIU) -2 as well as the Engineering/Science Tape Recorder (ESTR) -2. In addition, the HST reboost was highly desirable, depending on real-time propellant availability. A secondary objective of this flight was to accomplish requirements of the Midcourse Space Experiment (MSX) on a payload-of-opportunity basis.

The STS-82 flight was planned as a 10-day plus 2-contingency-day flight. The two contingency days were available for bad weather avoidance for landing or other Orbiter contingency operations. The sequence of events is shown in Table I, and the Orbiter In-Flight Anomaly List is shown in Table II. The Government furnished equipment/flight crew equipment (GFE/FCE) Problem Tracking List is shown in Table III, and the EVA In-Flight Anomaly List is contained in Table IV.

Appendix A lists the sources of data, both formal and informal, that were used in the preparation of this report. Appendix B provides the definition of acronyms and abbreviations used throughout this report. All times during the flight are given in Greenwich mean time (G.m.t.) and mission elapsed time (MET).

The seven-person crew of the STS-82 flight consisted of Kenneth D. Bowersox, CDR, U. S. Navy, Commander; Scott J. Horowitz, Ph. D., Lt. Col. U. S. Air Force, Pilot; Joseph R. Tanner, Civilian, Mission Specialist 1; Steven A. Hawley, Ph. D., Civilian, Mission Specialist 2; Gregory J Harbaugh, Civilian, Mission Specialist 3; Mark C. Lee, Colonel, U. S. Air Force, Mission Specialist 4 and Payload Commander; and Steven L. Smith, Civilian, Mission Specialist 5. STS-82 was the fourth space flight for the Commander, Mission Specialist 2, Mission Specialist 3, and Mission Specialist 4; and the second space flight for the Pilot, Mission Specialist 1, and Mission Specialist 5.

MISSION SUMMARY

The STS-82 mission was successfully completed on February 21, 1997. The Hubble Space Telescope (HST) was serviced during the course of five extravehicular activities (EVAs). In addition to the maintenance that was performed, the HST scientific capabilities were significantly upgraded. As of this writing, the NICMOS system camera 3 focus is presently beyond the range of the internal mechanical adjustment capability; however, cameras 1 and 2 of this instrument are functioning properly and providing excellent images in the preliminary focus tests.

The STS-82 launch occurred at 042:08:55:17.017 G.m.t. (February 11, 1997) following a nominal countdown with no unscheduled holds. The launch azimuth was 28.45 degrees. The launch was nominal in all respects with no problems noted. No in-flight anomalies or problems were identified during the ascent phase.

All SSME and RSRM start sequences occurred as expected and the launch phase performance was satisfactory in all respects. SRB performance was satisfactory in all respects. SRB separation, entry, deceleration and water impact occurred as anticipated. Both SRBs were successfully recovered. Performance of the SSMEs, ET, and MPS was normal, and no in-flight anomalies were identified.

A determination of vehicle performance was made using the vehicle acceleration and preflight propulsion prediction data. From these data, the average flight-derived engine specific impulse (I_{sp}) that was derived for the time period between SRB separation and start of 3g throttling was 453.7 seconds as compared to an main propulsion system (MPS) tag value of 452.96 seconds.

The orbital maneuvering subsystem (OMS) 2 maneuver was performed at 042:09:39:50 G.m.t [00:00:44:33 (mission elapsed time) MET]. The 172.4-second maneuver imparted a differential velocity (ΔV) of 275.3 feet per second (ft/sec) to the vehicle.

Since the payload bay doors were removed during the Orbiter Maintenance Down Period (OMDP) that preceded this flight, both doors were cycled partially open and then closed to verify acceptable door alignment. Following the satisfactory alignment check, the payload bay doors were driven to the full-open position at 042:10:37 G.m.t. (00:01:41 MET). Dual-motor operation was observed for the doors, and all operations of the door opening were nominal.

An OMS 3 maneuver was performed at 042:14:22:34 G.m.t. (00:05:27:17 MET). The dual-engine, straight-feed firing lasted 73.8 seconds and imparted a ΔV of 119 ft/sec to the vehicle. Performance was nominal.

Cabin depressurization to 10.2 psia in preparation for the planned EVAs was begun at 043:04:03 G.m.t. (00:19:08 MET) and completed at 043:04:36 G.m.t. (00:19:41 MET).

The remote manipulator system (RMS) checkout was completed at 043:04:29 G.m.t. (00:19:34 MET), and the RMS performance was nominal. Following the checkout, the RMS was used to conduct a video survey of the HST space support equipment.

Checkout of extravehicular mobility units (EMUs) 1, 2, and 3 was successfully completed. All operations were nominal.

The following table summarizes the OMS and reaction control subsystem (RCS) maneuvers that were performed to complete the rendezvous with the HST.

Maneuver	Time, G.m.t./MET	System	ΔV, ft/sec	Duration, sec
NSR	043:12:31:38.9 01:03:36:21.9	OMS	96	56.2
NC-2	043:13:57:17 01:05:02:00	RCS Primary	3.1	13.0
NH	044:02:01:21.9 01:17:06:04.9	OMS	12	8.0
NC-3	044:02:48:17 01:17:53:00	RCS Primary	3.4	14.0
NPC-2	044:03:55:41 01:19:00:24	RCS Primary	0.5	2.0
NCC	044:05:03:03 01:20:07:46	RCS Primary	1.1	1.1
TI	044:06:03:09 01:21:07:52	RCS Primary	2.8	12.0
MC-1	044:06:29:33 01:21:34:16	RCS Primary	0.4	2.0
MC-2	044:06:57:57 01:22:02:40	RCS Primary	1.5	6.0
MC-3	044:07:07:57 01:22:12:40	RCS Primary	0.9	3.0
MC-4	044:07:17:57 01:22:22:40	RCS Vernier	0.2	1.0

The HST was grappled at 044:08:43 G.m.t. (01:23:38 MET) and berthed at 044:09:06 G.m.t. (02:00:10 MET).

In preparation for EVA 1, the external airlock was depressurized at 45:02:44 G.m.t. (02:17:48 MET). During this depressurization from 10.2 to 5.0 psia, the air exhausting from the depressurization valve caused the +V2 HST solar array (on the port side of the Orbiter at the time of the event) to rotate approximately 80 degrees to the Solar Array Mechanism hard-stop and then rebound back 40 degrees before stopping. At 045:04:15 G.m.t. (02:19:19 MET), the airlock was depressurized to vacuum using the equalization valve on the airlock aft hatch. There was little or no motion of the solar arrays during the depressurization to vacuum.

As a result of the event experienced during airlock depressurization prior to EVA 1, a procedure was developed to use the aft hatch equalization valves to depressurize the external airlock for EVA 2. The circumferential inlet screen of one of the two equalization valves on each airlock hatch (aft and upper) was covered with gray tape that blocked flow through the screen. Two holes through the end plate of the valve provided the flow path, and an initial flow rate of approximately 80 lb/hr at 10.2 psia (the holes in the end plate are there to facilitate assembly). Once the airlock pressure reached 5.0 psia, the other untaped valve was used to depressurize the airlock to

vacuum (initial flow rate of approximately 80 lb/hr at 5.0 psia). The emergency position was selected on the same untaped valve to depressurize from 1 psia to vacuum. The upper hatch valves were available as a backup. When the hatch was opened, the HST solar arrays experienced a small rotation, due to the sudden release of the remaining air in the airlock, but the rotation was acceptable. The depressurization was completed nominally using this procedure during the remaining four EVAs.

The first HST EVA was successfully completed with a duration of 6 hours 42 minutes.

At approximately 045:06:00 G.m.t. (02:21:05 MET), the FES feedline A accumulator temperature began a slow downward trend (Flight Problem STS-82-V-01). Prior to that time, the temperature had been cycling between 60 and 75 °F as the accumulator heater cycled on and off. There had been no indication of a heater cycle during the previous seven hours. However, the accumulator temperature remained above 47 °F which was the lower limit. The nominal reconfiguration of this heater from system 1 to system 2 was performed at 047:02:37 G.m.t. (04:17:42 MET), and heater system 2 functioned nominally. The lower-temperature trend of the FES feedline A accumulator was confirmed to be a heater failure.

The second HST EVA was successfully completed. The EVA duration was 7 hours 27 minutes.

At the end of the second EVA, a 20-minute 41.9-second HST reboost maneuver was performed. The vernier RCS maneuver was initiated at 046:10:04 G.m.t. (04:01:18 MET) and terminated at 046:10:25 G.m.t. (04:01:39 MET). The maneuver imparted a ΔV of 6.6 ft/sec to the vehicle. The performance of the RCS thrusters was nominal with chamber pressures (P_c) remaining stable in the expected 100- to 110-psia range. Following the reboost, thruster F5L had four low-P_c pulses. These were attributed to hot propellant in the thruster valves and did not represent a concern. Normal P_c from thruster F5L was observed following these pulses.

An unscheduled 10-minute 12.6-second HST reboost maneuver was performed to avoid orbital debris. This vernier RCS maneuver was started at 046:15:02 G.m.t. (04:06:06 MET) and was terminated at 046:15:12 G.m.t. (04:06:16 MET). A total ΔV of 3.3 ft/sec was imparted to the vehicle. The RCS performance was nominal and no secondary low-P_c pulses were observed.

Prior to the start of the third EVA, extravehicular crewmember 1 (EV 1) did not have an indication that EMU 1 was on battery power after the power mode switch (PMS) had been taken from the service and cooling umbilical (SCU) position to the battery (BATT) position Flight Problem STS-82-X-01). The PMS has three separate microswitches, one of which provides a battery-on discrete to the EMU caution and warning system. In this case, the battery/SCU indicator microswitch in the PMS did not adequately throw when the switch was actuated. This microswitch not being made is a known condition involving the PMS. The EMU was actually on battery power and the EVA could have proceeded without the battery-power-on indication. The crew is trained to correct this condition by a firm recycling of the PMS. After recycling the switch, the EMU reset and the proper indication was received. No further problems were encountered during the EVA.
The third HST EVA was successfully completed. The third EVA had a duration of 7 hours and 11 minutes.

At the end of the third EVA, a 19-minute 46.9-second HST reboost maneuver was performed. The vernier RCS maneuver was initiated at 047:10:10:20 G.m.t. (05:01:15:03 MET) and was terminated at 047:10:30:05 G.m.t. (05:01:34:48 MET). The maneuver imparted a ΔV of 6.5 ft/sec to the vehicle. The data review indicated that the RCS performance was nominal.

The fourth scheduled HST EVA was successfully completed. All of the preflight planned activities were completed during this 6 hour 33 minute EVA.

A decision was made to perform an additional EVA to repair damaged multilayer insulation (MLI) on several areas of the HST. The fifth HST EVA was successfully completed including all MLI repairs. This final EVA had a duration of 5 hours 17 minutes. A total of 33 hours and 10 minutes of EVA were performed during the five EVAs. All repair activities of the HST were satisfactorily completed.

At the end of the fifth EVA, a 31-minute 53.5-second HST reboost maneuver was performed. The vernier RCS maneuver was initiated at 049:10:28 G.m.t. (07:01:33 MET) and was terminated at 049:11:00 G.m.t. (07:02:05 MET). The maneuver imparted a ΔV of approximately 10.4 ft/sec to the vehicle, and placed the vehicle a 335 by 320 nmi. orbit. The data review indicated that the vernier RCS performance was nominal. The average orbit of the HST was raised approximately eight nmi. as a result of the RCS reboost maneuvers.

At 049:03:37 G.m.t. (06:18:42 MET), the mid main A bus current signature was indicative of a floodlight failing and tripping the 10-ampere remote power controller (RPC) on mid-power controller 1 (Flight Problem STS-82-V-02). The crew confirmed that the aft starboard floodlight had failed. The floodlight power switch was taken to off and remained off for the remainder of the mission. Postflight troubleshooting showed that the floodlight electronics assembly (FEA) had an internal short.

The HST was grappled by the RMS for release at 050:03:21 G.m.t. (07:18:25 MET), unberthed at 050:05:02 G.m.t. (07:20:06 MET) and released at 050:06:41 G.m.t. (07:21:45 MET). The performance of the RMS in support of the HST operations and the five EVAs was excellent.

The following table summarizes the RCS separation (SEP) maneuvers that were performed to complete the separation from the HST.

Maneuver	Time, G.m.t./MET	ΔV, ft/sec	Duration, sec
SEP-1	050:06:42 007:21:46	1.2	4.9
SEP-2	050:07:17 007:07:17	1.2	4.8
SEP-2A	050:07:58 007:23:02	1.1	4.5

The Orbiter cabin was repressurized to 14.7 psia at 050:08:50 G.m.t. (07:23:51 MET).

The flight control system (FCS) checkout was performed using auxiliary power unit (APU) 3. FCS performance was nominal. The APU and hydraulics subsystems performed nominally during the checkout. APU 3 was started at 051:03:05:44 G.m.t. (08:18:10:27 MET) and ran for 5 minutes 56 seconds. The fuel consumption during this run was 17 lb. No water spray boiler (WSB) operation occurred because of the short APU run time.

Following FCS checkout, the LH_2 manifold was repressurized. The manifold pressure peaked at 25 psia, and leveled out to 22.5 psia at 051:06:10 G.m.t. (08:21:14 MET). The repressurization was performed as a test to evaluate a candidate enhancement on the Orbiter-upgrade list. This upgrade would add temperature instrumentation to the liquid hydrogen (LH_2) manifold so that operational data could be utilized to perform a LH_2 system mass decay test in-flight, thus eliminating the need for a test on the ground.

All RCS primary thrusters were passively hot-fired during the course of the mission; therefore, the RCS hot-fire was not required.

At 051:08:41 G.m.t. (08:23:45 MET), an RCS -X axis orbit adjust (perigee) firing was initiated. The firing duration was 52 seconds with a ΔV of 13.0 ft/sec imparted to the vehicle. The RCS performance during the firing was nominal. The perigee was lowered approximately 8 nmi. with this firing.

The payload bay doors were closed at 052:03:09:00 G.m.t. (09:18:13:43 MET) in preparation for landing. Unacceptable weather conditions at the Kennedy Space Center (KSC) Shuttle Landing Facility (SLF) resulted in the landing being waived until the second KSC landing opportunity. The dual-engine deorbit maneuver for the second landing opportunity at the SLF was performed on orbit 149 at 052:07:21:54.7 G.m.t. (09:22:26:37.7 MET). The maneuver was 298.9 seconds in duration with a ΔV of 504.5 ft/sec.

Entry was completed satisfactorily, and main landing gear touchdown occurred on KSC concrete runway 15 at 052:08:32:24 G.m.t. (09:23:37:07 MET) on February 21, 1997. The Orbiter drag chute was deployed at 052:08:32:27.3 G.m.t. and the nose gear touchdown occurred 7.7 seconds later. The drag chute was jettisoned at 052:08:32:55.8 G.m.t. with wheels stop occurring at 052:08:33:16 G.m.t. The rollout was normal in all respects. The flight duration was 9 days 23 hours 37 minutes and 7 seconds. The APUs were shut down 13 minutes 49 seconds after landing.

PAYLOADS

HUBBLE SPACE TELESCOPE

Summary

STS-82 was the second servicing mission to the Hubble Space Telescope (HST), which was launched on April 25, 1990, on STS-31. All of the HST primary and secondary objectives for the second servicing mission were fully accomplished. The Near-Infrared Camera and Multi-Object Spectrometer (NICMOS) and Space Telescope Imaging Spectrograph (STIS) instruments were installed and tested and were functioning nominally at this writing. The Fine Guidance Sensor (FGS), the Solid State Recorder (SSR), the Engineering/Science Tape Recorder (ESTR), the Reaction Wheel Assembly (RWA), the Data Interface Unit (DIU), and the Solar Array Drive Electronics (SADE) replacement units were also installed and successfully tested. The support carrier structures in the cargo bay all performed nominally. The EVA tools and crew aids were successfully used to support the servicing tasks.

As of this writing, camera 3 of the NICMOS system is beyond the range of the NICMOS internal mechanical adjustment capability and cannot be focused properly. Cameras 1 and 2 are continuing to provide excellent images in the preliminary focus tests. Analysis indicates the situation may be due to unexpected thermal contact in the dewar, which results in a slightly warmer cryogen temperature and a subsequent reduction of dewar lifetime.

The most likely explanation of the NICMOS camera 3 problem is that as the solid nitrogen warms up, it expands and exerts pressure on the internal structure of the dewar. This expansion has resulted in an unwanted physical contact between two internal structural components, providing a pathway for excess heat to travel from the warmer outer structure of the dewar to its colder internal parts, warming the solid nitrogen to a higher-than-desired operating temperature. The analysis team expects that the thermal contact might release in the future, returning NICMOS to its nominal state. If the thermal contact releases, the analysts predict that camera 3 should move back into the instrument's range of focus, and the camera will become usable. Rearrangement of the NICMOS observing schedule could allow the full implementation of the NICMOS science program.

Operations

The airlock depressurization operation for the first EVA caused an unexpected large motion of the Solar Array; however, there was no significant damage to the array and it continued to function nominally. At the initiation of the airlock depressurization, the +V2 wing of the Solar Array (SA) rotated 80 degrees to the Solar Array Drive Mechanism (SADM) hard-stop and then back 40 degrees before stopping. This condition was caused by air being vented from the airlock during the depressurization. The SADE were turned off by the HST flight computer when the array exceeded the software limits for valid range of rotation. Analysis of the first slew commanded after the anomaly as well as a visual inspection of the solar arrays indicated that no significant damage had occurred to the drive mechanism or SA geometry (bi-stem twist). Modeling of the event derived a bi-stem tip displacement of 21 inches and that is well within the bi-stems'

single-event capability. An alternate airlock depressurization procedure was developed for subsequent EVA operations with satisfactory results.

On flight day 4 during the first EVA , the crew accomplished the successful installation of the NICMOS and STIS science instruments into the HST. Each instrument passed its aliveness and functional tests.

On flight day 5 during the second EVA, the crew successfully completed the installation of the Fine Guidance Sensor 1R (FGS-1R) , the Engineering/Science Tape Recorder 2R (ESTR-2R), and the Optical Control Electronics Enhancement Kit (OCEK). Each of the instruments installed passed its aliveness and functional tests.

The first of three vernier reaction control subsystem (RCS) reboost maneuvers was completed satisfactorily at the end of the second EVA. The HST SA response to the vernier RCS thruster firings was minimal. The firing time of the thrusters was approximately 21 minutes, and the resulting orbit was 323.6 by 319.5 nautical miles.

An additional vernier RCS reboost maneuver of approximately 10 minutes duration was performed on flight day 5 for debris avoidance.

On flight day 6 during the third EVA, the crew successfully completed the installation of the Data Interface Unit 2R (DIU-2R), the Solid State Recorder 1 (SSR-2), and the Reaction Wheel Assembly 1R (RWA-1R). Each installed instrument passed its aliveness and functional tests. After completing the instrument installations, the crew performed a close visual inspection of the multi-layer insulation (MLI) on Support Systems Module (SSM) bay 7. A Kapton tape pull-test was performed to determine whether the tape would adhere well to the MLI, and the tape did not adhere well.

The third vernier RCS reboost maneuver was performed following the third EVA. The maneuver was approximately 20 minutes in duration, and the resulting HST orbital parameters were 329 by 320 nautical miles.

On flight day 7 during the fourth planned EVA, the crew satisfactorily completed the installation of the Solar Array Drive Electronics 2R (SADE-2R), the insertion of three T-fasteners to replace screws missing from SADE-1R connectors, and the installation of new covers over those installed on the original HST Magnetometer Sensing System (MSS's) installed during the first servicing mission. The two SADEs passed both the aliveness and functional test. With the installation of the SADEs, all of the tasks manifested for STS-82 were completed. Other activities completed during the EVA included collection of a sample from the damaged MLI above the +V3 High Gain Antenna (HGA), and installation of two MLI patches to cover the torn MLI on the Forward Light Shield.

During the mission, the HST MLI surfaces on the sunward side were found to be split and peeled back in several places. Available materials onboard were adapted to fashion covers for the most critical locations. During the fifth EVA, which was not scheduled prior to flight but was performed on flight day 8, the crew performed the MLI repairs to the SSM's on the sunward side. Two retaining wires were affixed across the MLI of SSM bay 7, and patches were installed to cover tears on bays 8 and 10. Each of these bays contained critical HST components whose thermal environment required protection. The components located in these areas included the HST Pointing and Safemode Electronics Assembly and its science computer.

The fourth and final reboost maneuver was approximately 32 minutes in duration and the orbit of the Orbiter and HST was raised to 335 by 320 nmi. As a result of the reboost maneuvers, the HST average orbit was raised approximately 8 nmi. higher than it was prior to retrieval and berthing in the Orbiter.

Prior to the redeployment of the HST, a photogrammetric analysis was performed of the SA wings while static and during vernier RCS thruster firings. The wing geometry appeared to be little changed from its documented position following the first servicing mission in 1993. Tip displacement during thruster firings was well within the criterion for a vernier reboost maneuver as had been established prior to the flight.

Testing was performed on the HST payload and general support computer assembly (PGSCA) and reliable support of all required telemetry rates was demonstrated. The HST PGSCA will be an important element of support for servicing mission 3 in 1999.

All pre-deployment activities progressed smoothly and deployment of the HST took place at the opening of the first release window at 050:18:41 G.m.t. (08:09:46 MET) on February 19, 12:41 a.m. c.s.t.). All post-deployment activities with the HST were also nominal.

MIDCOURSE SPACE EXPERIMENT

No Midcourse Space Experiment (MSX) activities were performed during the mission because of the lack of opportunities.

VEHICLE PERFORMANCE

SOLID ROCKET BOOSTERS

All Solid Rocket Booster (SRB) systems performed nominally. The SRB prelaunch countdown was normal, and no SRB Launch Commit Criteria (LCC) or Operational Maintenance Requirements and Specifications Document (OMRSD) violated occurred. No SRB in-flight anomalies occurred during the flight.

The left SRB Operational A bus voltage measurement indicated 31.12 Vdc. This value is one bit above the previous experience base high value (31.04 Vdc on STS-45). The bit value for this measurement is 0.08 Vdc. The OMRSD/LCC upper limit for bus voltages is 31.3 Vdc. The new experience base value falls within the upper limit and was attributed to Orbiter fuel cell troubleshooting being performed during this time-frame.

Both SRBs were successfully separated from the External Tank (ET) 123.8 seconds after liftoff, and reports from the recovery area indicate that all deceleration subsystems performed as designed. The SRBs were retrieved and towed to port and transferred to Kennedy Space Center where the SRBs were disassembled and refurbishment was initiated.

REUSABLE SOLID ROCKET MOTORS

Data indicate that all Reusable Solid Rocket Motor (RSRM) subsystems performed as designed. No LCC or OMRSD violations occurred during the countdown, nor were any in-flight anomalies noted during the data review and analysis.

All RSRM temperatures were maintained within acceptable limits throughout the countdown. Reconstructed propulsion performance is summarized in the table on the following page. The calculated RSRM propellant mean bulk temperature (PMBT) was 63 °F at liftoff. The maximum trace-shape variation of pressure versus time was calculated to be 1.5 percent at 71 seconds (left motor) and 0.5 percent at 62 seconds (right motor). Both values were well within the 3.2 percent allowable limits.

The preflight burn rate prediction for STS-82 (RSRM-58) was the highest in RSRM history. The right-motor delivered burn rate, although less than predicted, represents the second highest burn rate flight history in the Space Shuttle Program. This caused the web-time average pressure at 60 °F to exceed the postflight control alert (PFCA) upper limit (676 psi) by 2.5 psi. This high web-time average pressure is directly proportional to the burn rate. This high burn rate also caused an out-of-family action time (early). Analysis of this condition is continuing.

The RSRM hardware performed as expected during the flight. All nozzle phenolic erosion was within baseline requirements. All requirements were met by all components. The left-hand and right-hand nozzle plugs and adhesive beads were removed and replaced at KSC prior to launch as part of the nozzle erosion issue. All nozzle phenolic erosion was normal.

RSRM PROPULSION PERFORMANCE

Parameter	Left motor, 63 °F		Right motor, 63 °F	
	Predicted	Actual	Predicted	Actual
Impulse gates				
I-20, 10^6 lbf-sec	65.95	65.22	66.32	65.71
I-60, 10^6 lbf-sec	175.66	175.24	176.50	176.61
I-AT, 10^6 lbf-sec	296.76	296.72	296.92	297.02
Vacuum Isp, lbf-sec/lbm	268.4	268.4	268.4	268.5
Burn rate, in/sec @ 60 °F at 625 psia	0.3716	0.3710	0.3727	0.3725
Burn rate, in/sec @ 63 °F at 625 psia	0.3724	0.3718	0.3735	0.3733
Event times, seconds[a]				
Ignition interval	0.232	N/A	0.232	N/A
Web time[b]	109.2	109.3	108.6	108.6
50 psia cue time	118.9	118.7	118.3	118.3
Action time[b]	120.9	121.2	120.4	120.4
Separation command	123.8	123.7	123.8	123.7
PMBT, °F	63	63	63	63
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	3.2	2.8	2.9
Tailoff Imbalance Impulse differential, Klbf-sec	Predicted		Actual	
	N/A		1174.4	

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

[a] All 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 ET propellant loading and flight operations were met. All ET electrical equipment and instrumentation operated satisfactorily. The ET purge and heater operations were monitored and all performed properly. No LCC or OMRSD violations were identified.

No unexpected ice/frost formations were observed on the ET during the countdown. Likewise, there was no ice or frost observed on the acreage areas of the ET. Less than normal quantities of ice or frost were present on the liquid oxygen (LO_2) and LH_2 feedlines, the pressurization line brackets, and along the LH_2 protuberance air load (PAL) ramps. All observations were acceptable per NSTS 08303. The Ice/Frost Red Team also reported there were no anomalous thermal protection system (TPS) conditions.

Propellant loading was nominal. All LO_2 and LH_2 tank ullage pressures were within acceptable limits throughout loading, prepressurization and flight. Geyser prevention procedures provided excellent temperature margins throughout loading.

STS-82 was the first flight with reshimmed GH_2 flow control valves (FCVs) for this vehicle (OV-103) since shim sizes were changed to reduce the number of FCV cycles. The LH_2 tank ullage pressure was maintained within the 32 to 34 psia control band. There were 32 FCV cycles for STS-82; prior to reshim, the minimum number of FCV cycles was 43 and the average was 113.

The ET pressurization system functioned properly throughout engine start and flight. The minimum LO_2 ullage pressure experienced during the ullage pressure slump was 13.6 psid.

ET separation occurred as planned, with entry and breakup of the ET occurring approximately 68 nmi. uprange of the preflight predicted point and well within the predicted footprint for impact.

SPACE SHUTTLE MAIN ENGINE

All Space Shuttle main engine (SSME) parameters were normal throughout the prelaunch countdown and were typical of prelaunch parameters observed on previous flights with one exception. The SSME 1 main fuel valve (MFV) skin temperature was low and out-of-family, but was still within the LCC limits. Engine ready was achieved at the proper time; all LCC were met; and engine start and thrust buildup were normal.

Flight data indicate that the SSME performance during main-stage, throttling, shutdown and propellant dump operations was normal, and no in-flight anomalies were identified during the data analysis. The high-pressure oxidizer turbopump (HPOTP) and high-pressure fuel turbopump (HPFTP) temperatures were well within specifications throughout engine operation. Space Shuttle main engine cutoff (MECO) occurred 509.3 seconds after lift-off. There were no failures and significant SSME problems during the flight.

SHUTTLE RANGE SAFETY SYSTEM

The Shuttle range safety system (SRSS) performed as designed. The SRSS closed-loop testing was completed as scheduled during the launch countdown. All SRSS safe and arm (S&A) devices were armed and system inhibits turned off at the appropriate times. As planned, the SRB S&A devices were safed, and SRB power was turned off at the appropriate times. All SRSS measurements indicated that the system operated as expected throughout the flight. The SRSS was deleted from the ET.

ORBITER SUBSYSTEMS PERFORMANCE

Main Propulsion System

The overall performance of the main propulsion system (MPS) was nominal. Ascent performance was normal, and data indicate that the LO_2 and LH_2 pressurization subsystems performed as planned. Likewise, all net positive suction pressure (NPSP) requirements were met throughout the flight. Performance analyses of the propulsion systems during start, mainstage, and shutdown operations indicated that the performance was nominal and all requirements were satisfied. No in-flight anomalies occurred during the mission; however, two conditions were noted that are discussed later in this section.

The LO_2 and LH_2 loading was completed satisfactorily with no stop-flows or reverts. The initiation of tanking was delayed about 1.5 hours, however, to complete troubleshooting of a possible oxygen leak in the Orbiter mid-body. No OMRSD or LCC violations were identified during the countdown.

Throughout the period of the preflight operations, no significant hazardous gas concentrations were detected. The maximum hydrogen concentration level in the Orbiter aft compartment was approximately 65 ppm, which compares favorably with previous data for this vehicle.

A comparison of the calculated propellant loads at the end of replenish versus the inventory (planned) loads resulted in a loading accuracy of 99.8 percent for LO_2 and 99.8 percent for LH_2.

The LO_2 replenish flow-rate transducer went off-scale high during transfer line chill-down and Orbiter chill-down. However, during fast-fill, the LO_2 ullage pressure was slightly below the historical limit and had one of the earliest vent-valve cycling starts.

The gaseous hydrogen (GH_2) system in-flight performance was nominal. The gaseous oxygen (GO_2) fixed orifice pressurization system performed as predicted. Reconstruction data from engine and MPS parameters closely matches the actual ET ullage-pressure measurements. All three flow control valves operated nominally.

During the first stage of ascent, the SSME 3 LH_2 inlet pressure showed unacceptable drift. Previous flights of this vehicle showed the some amount of drift has existed and it has been increasing in magnitude since STS-64. This type of transducer also experienced unacceptable drift on STS-49 and STS-66. The transducer was removed and sent to the Orbiter contractor for troubleshooting. This transducer is used primarily for engineering data, but also provides a backup cue for dump inhibit should a premature engine shut down occurred.

All four LH_2 outboard fill and drain valve switch-to-switch timings for the close cycles were out-of-family when compared to fleet historical averages. The fleet average is between 4 and 5 seconds and the STS-82 timings were between 7 and 8 seconds. Ambient cycling of the valves was performed in the Orbiter Processing Facility (OPF) after landing. All times matched the STS-82 preflight ambient cycles. Also, low-pressure actuation tests, which evaluate the internal friction of the valves, were performed and the results were satisfactory. The slower switch-to-switch times observed during flight may have been a function of the particular build of these valves. As long as the signal-to-switch and switch-to-switch times remain consistent and do not trend toward slowing down, these valves are acceptable for flight.

Reaction Control Subsystem

The reaction control subsystem (RCS) performed satisfactorily throughout the mission. A total of 5675 lbm propellants (3462 - oxidizer, 2213 - fuel) were used during the rendezvous mission with the HST. In addition, 190 lbm of propellants were consumed from the orbital maneuvering subsystem (OMS) during interconnect operations. The primary RCS thrusters had 4,123 firings and a total firing time of approximately 1,196.7 seconds. The vernier RCS thrusters had 14,393 firings and a total firing time of

25,015.3 seconds. No in-flight anomalies were noted during the data review and analysis.

In addition to the rendezvous maneuvers performed, four reboost maneuvers, three separation maneuvers, and an orbit adjustment maneuver were performed.

RENDEZVOUS, SEPARATION, AND ORBIT ADJUST MANEUVERS

Maneuver	Time, G.m.t./MET	System	ΔV, ft/sec	Duration, sec
NC-3	044:02:48:17 01:17:53:00	RCS Primary	3.4	14.0
NPC-2	044:03:55:41 01:19:00:24	RCS Primary	0.5	2.0
NCC	044:05:03:03 01:20:07:46	RCS Primary	1.1	1.1
TI	044:06:03:09 01:21:07:52	RCS Primary	2.8	12.0
MC-1	044:06:29:33 01:21:34:16	RCS Primary	0.4	2.0
MC-2	044:06:57:57 01:22:02:40	RCS Primary	1.5	6.0
MC-3	044:07:07:57 01:22:12:40	RCS Primary	0.9	3.0
MC-4	044:07:17:57 01:22:22:40	RCS Vernier	0.2	1.0
-X SEP 1	050:06:42:07 07:21:46:50	RCS Primary	1.2	4.9
-X SEP 2	050:07:17:22 07:22:22:05	RCS Primary	1.2	4.8
-X SEP 2A	050:07:57:46 07:22:27:14	RCS Primary	1.1	4.5
-X ORBIT ADJUST	051:08:41:34 08:13:46:17	RCS Primary	13.0	52

The four reboost maneuvers raised the HST orbit an average of 8 nmi. The reboost maneuvers are shown in the table on the following page.

During attitude-control activities following the HST separation maneuvers, thruster priorities were changed to allow firings of several RCS primary thrusters which had not been previously fired. During the first firing of primary thruster R2R, following a slow ramp-up, the P_c peaked at 69 psia (normal P_c is 150 psia). The thruster performed adequately and was not declared failed; however, this behavior was suspicious. In a second firing of thruster R2R, a nominal P_c was observed. This thruster had been flushed at the White Sands Test Facility (WSTF) prior to this mission. In an effort to determine whether the phenomenon seen on the first pulse was merely transitory, thruster R2R was placed in first priority during entry to exercise the thruster to the fullest extent possible. The thruster functioned satisfactorily for the 290 firings during the remainder of the mission.

VERNIER REBOOST MANEUVERS

Maneuver	Time, G.m.t./MET	System	Duration, min:sec
Reboost 1	046:10:04:45 04:01:09:28	RCS Vernier	20:41.9
Reboost $1A_a$	046:15:02:21 04:06:07:04	RCS Vernier	10:12.6
Reboost 2	047:10:10:20 05:01:15:03	RCS Vernier	19:46.9
Reboost 3	049:10:28:17 07:01:33:00	RCS Vernier	31:53.5

Note: a - Maneuver required for space debris avoidance.

The passive RCS hot-fire (no dedicated hot-fire time) was used this mission, and all thrusters were fired satisfactorily.

During entry, thruster F1D fuel injector temperature exceeded the temperature limit of 255 °F for approximately 3 minutes, and the temperature was estimated to have peaked at 256 °F. This temperature is attributed to the hot entry. No thruster damage was found during postflight inspections, and the thruster will be flown as-is on the next mission.

Orbital Maneuvering Subsystem

The OMS performed satisfactorily in every aspect of the subsystem throughout the mission. Pertinent data concerning the OMS maneuvers is shown in the following table.

Maneuver	Time, G.m.t./MET	ΔV, ft/sec	Duration, sec
OMS 2	042:09:39:50.9 00:00:44:33.9	275.3	172.4
OMS 3	042:14:22:35.1 00:05:27:18.1	119.0	73.8
OMS 4 (NSR)	043:12:31:39.1 01:03:36:22.1	96	56.2
OMS 5 (NH)	044:02:01:22.3 01:17:06:05.3	12	8.0
Deorbit	052:07:21:54.7 09:22:26:37.7	504	298.9

No deviations from the OMRSD or LCC requirements occurred during prelaunch operations. No in-flight anomalies were identified from the data review and analysis. The five OMS maneuvers, which were all dual-motor firings, plus interconnect operations consumed 22,958.8 lbm of propellants during the mission.

Power Reactant Storage and Distribution Subsystem

The performance of the power reactant storage and distribution (PRSD) subsystem was nominal during the STS-82 mission. No in-flight anomalies were identified from the data analysis and review. The PRSD subsystem supplied a total of 2507 lbm of oxygen and 316 lbm of hydrogen to the fuel cells for electrical energy production. In addition, the PRSD supplied 140 lbm of oxygen to the environmental control and life support system (ECLSS) for life support. The oxygen/hydrogen manifold isolation valves were cycled each day to support the crew sleep periods. A 51-hour mission-extension capability existed at landing based on the oxygen (limiting reactant) remaining at an average power level of 15.3 kW. However, at an extension-day power-level of 11.8 kW, a 66-hour mission-extension capability existed.

Modifications to the PRSD subsystem of this vehicle during the OMDP included adding a fifth tank set and the change from 5 ampere to 10 ampere fuses in all the tank heater circuits. Both modifications performed nominally with no problems identified.

Fuel Cell Powerplant Subsystem

Performance of the fuel cell powerplant (FCP) subsystem was nominal throughout the STS-82 mission. The average electrical power level and load was 15.3 kW and 497 amperes. During the 239.6-hour flight, the fuel cells produced 2,823 lbm of water and 3,676 kWh of electrical energy from 2,507 lbm of oxygen and 316 lbm of hydrogen. Four purges of the fuel cells were performed during the flight, and both the automatic and manual modes were demonstrated. The actual fuel cell voltages at the end of the mission were 0.2 V above the predicted value for fuel cells 1 and 2, and 0.1 V above the predicted value for fuel cell 3.

At 043:15:10 G.m.t. (01:06:14 MET), the fuel cell 3 alternate product water line temperature increased rapidly from 77 °F to 128 °F indicating leakage through the check valve and possibly into water tank C. The leak subsequently stopped at 044:02:01 G.m.t. (01:17:06 MET) coincident with the height adjust (NH) rendezvous maneuver. There was no other mission impact associated with this condition.

At 043:15:10 G.m.t. (01:06:14 MET), the fuel cell 3 alternate product water line temperature increased rapidly from 77 °F to 128 °F indicating leakage through the check valve and possibly into water tank C. The leak subsequently stopped at 044:02:01 G.m.t. (01:17:06 MET) coincident with the NH rendezvous maneuver. To minimize the amount of hydrogen that may have been introduced into tank C during the time that the fuel cell 3 alternate-water-line check valve was leaking, two supply water dumps were performed through the flash evaporator system (FES) to provide ullage. Water was then transferred from tank A to tank C. The tank C water was used for the EMU water servicing. . For the remainder of the mission, the alternate product water line temperature was intermittently erratic, indicating that a small quantity of water was occasionally leaking through the check valve, although the temperature never approached the level initially experienced. There was no other mission impact associated with this condition.

For about a 40-minute period beginning at 044:11:26 G.m.t. (02:02:31MET), the fuel cell 2 calculated-performance plot showed to a step change downward by 0.1 V. Review of the data showed that the fuel cell 2 voltage toggled one data bit below the

main bus B voltage when the fuel cell was in the 128 to 130 ampere range. As the mission progressed, the voltage deviation was noted at other current levels; however, the deviation never exceeded one bit and was often zero. Analysis indicated that the instrumentation subsystem was causing this observed deviation and not fuel cell 2. Data taken at the end of the mission showed good correlation (zero deviation) between fuel cell 2 voltage and main bus B voltage.

Auxiliary Power Unit Subsystem

The auxiliary power unit (APU) subsystem performed nominally throughout the STS-82 mission. No APU in-flight anomalies were recorded. The run times and fuel consumption for the APUs are summarized in the following table.

APU RUN TIMES AND FUEL CONSUMPTION

Flight phase	APU 1 (a) (b) (S/N 306)		APU 2 (a) (S/N 409)		APU 3 (a) (S/N 408)	
	Time, min:sec	Fuel consumption, lb	Time, min:sec	Fuel consumption, lb	Time, min:sec	Fuel consumption, lb
Ascent	18.50	48	19:12	52	19:29	48
FCS checkout					05:54	17
Entry[a]	57:30	122	89:01	167	57:58	128
Total	76:20	170	108:13	219	83:21	193

[a] APUs were shut down 13 minutes 49 seconds after landing.
[b] APU 3 was used for the FCS checkout.

During the prelaunch period, the APU 1 injector temperature indicated 437 °F for approximately 20 minutes, exceeding the 436 °F LCC limit. Throughout the majority of the prelaunch period, the indicated temperature was 431°F. The gas generator (GG) bed temperature was 386 °F during the same period. This temperature difference is greater than that typically seen on other APUs; however, it was consistent with the past performance of this APU. The intent of the LCC is to determine the condition of the APU GG bed heater, and it was determined that the GG bed heater was functioning nominally. The LCC limit was changed to accommodate this particular measurement.

The APU 3 exhaust gas temperature (EGT) 2 measurement became erratic for approximately 5 minutes at landing. This measurement is redundant to EGT 1 and, as a result, will not be changed until after its next flight.

Hydraulics/Water Spray Boiler Subsystems

The overall hydraulics and water spray boiler (WSB) subsystem performance was nominal. There were no WSB over-cooling or under-cooling conditions noted during ascent or entry. Likewise, no in-flight anomalies were identified from the data.

All three WSBs operated nominally throughout the flight. No leakage was noted in the system. Priority valve openings at APU activation were within the 1-second specification value, and reseats in all three systems at APU shutdown were also within the specification value of >2675 psia.

FCS checkout was performed with system 3, and APU 3 ran for 5 minutes 54 seconds. Because of the short operating time of the APU, no WSB cooling was noted. Hydraulic performance was nominal during entry. Hydraulic heat exchanger mode was achieved on all three systems. Systems 1 and 2 achieved heat exchanger mode during entry and system 3 postlanding.

Electrical Power Distribution and Control Subsystem

The data review and analysis of all available electrical power distribution and control (EPDC) subsystem parameters revealed nominal values throughout the flight. No in-flight anomalies were identified, and all file IX requirements were fulfilled.

Atmospheric Revitalization Pressure Control Subsystem

The atmospheric revitalization pressure control subsystem (ARPCS) performed normally throughout the flight. The redundant component check of the pressure control system was performed normally, and the alternate system performed nominally.

Cabin depressurization to 10.2 psia in preparation for the planned extravehicular activities (EVAs) was begun at 043:04:03 G.m.t. (00:19:08 MET) and completed at 043:04:36 G.m.t. (00:19:41 MET). Cabin repressurization to 14.7 psia was initiated at 050:08:27:11 G.m.t. (07:23:31:54 MET) and was completed satisfactorily.

Atmospheric Revitalization Subsystem

All atmospheric revitalization subsystems (ARS) performed nominally during STS-82, which was the first flight of the vehicle following the Orbiter Maintenance Down Period (OMDP) modifications.

At liftoff, the cabin temperature was 70 °F, the humidity was 36 percent, and the cabin heat exchanger outlet temperature was 52.5 °F. The heat exchanger outlet temperature peaked at 73.7 °F at launch plus two minutes, and the humidity peaked at 42 percent at liftoff plus 30 minutes, while the cabin temperature remained at the liftoff value. The peak cabin temperature was 80 °F on flight day 8, and the peak humidity level was 57.7 percent on flight day 10. Also, the peak cabin heat exchanger temperature was 56.3 °F on flight day 10.

Active Thermal Control Subsystem

The active thermal control subsystem (ATCS) operation was satisfactory throughout the mission. During the mission, there were a total of 11 FES water dumps with a total duration of 76 hours.

One in-flight anomaly was noted in the failure of heater 1 for the FES feedline accumulator (Flight Problem STS-82-V-01). At approximately 045:06:00 G.m.t. (02:21:05 MET), the FES feedline A accumulator temperature began trending low. Prior to that time, the temperature had been cycling between 60 and 75 °F as the accumulator heater cycled on and off. The last indication of a heater cycle on system 1 was at 044:22:57 G.m.t. (02:14:02 MET). After the last heater system 1 cycle, the accumulator temperature remained above 45 °F. The plan was to take no action unless

the accumulator temperature dropped below 40 °F. The nominal heater reconfiguration was performed at 047:02:37 G.m.t. (04:17:42 MET). The redundant heater was activated during the scheduled mid-mission heater reconfiguration and the redundant heater system 2 functioned nominally for the remainder of the mission.

The radiator cold-soak provided cooling during entry and through touchdown plus 10 minutes when ammonia boiler system (ABS) A was activated using the secondary controller. The ABS operated satisfactorily until it was deactivated when external cooling was provided.

Supply and Waste Water Subsystem

The supply and waste water subsystems performed nominally throughout the mission, and all file IX requirements were satisfied prior to landing. No in-flight anomalies were identified from the data analysis and review.
Supply water was managed through the use of the FES. The supply water dump line temperature was maintained between 64 and 96 °F with the operation of the line heater.

The tank D quantity transducer experienced several dropouts. This tank was installed as tank C prior to the OMDP and experienced similar dropouts on this vehicle's previous mission (STS-70). Current planning is to replace the cover assembly which contains the quantity transducer during the STS-97 flow when the tanks are scheduled to be removed from the vehicle for an avionics bay 3 fan modification.

Data indicating possible flow of water through the fuel cell 3 auxiliary water line raised a concern that the water in tank C may have contained excessive free hydrogen. To allay this concern, tank C was dumped overboard through the FES and tank C was refilled from tank A.

Waste water was gathered at about the predicted rate. Four waste water dumps were performed at an average rate of 1.75 percent/minute (2.89 lb/min). The waste water dump line temperature was maintained between 57 and 86 °F through the use of a line heater. The vacuum vent line temperature was maintained between 59 and 84 °F with the vacuum cent nozzle maintained between 140 and 180 °F.

Waste Collection Subsystem

The waste collection subsystem performed normally throughout the mission with no in-flight anomalies or problems identified.

Airlock Support System

The airlock support system performed satisfactorily in the support of five EVAs. The active system monitor parameters indicated normal outputs throughout the remainder of the flight.

In preparation for EVA 1, external airlock depressurization began at 45:02:44 G.m.t. (02:17:48 MET). During this depressurization from 10.2 to 5.0 psia, the air exhausting from the depressurization valve caused the +V2 HST solar array (on the port side of the Orbiter at the time of the event) to rotate approximately 80 degrees to the Solar Array Mechanism hard-stop, then rebound back 40 degrees before stopping and also shutting

down the SADE. Almost 1½ hours later at 045:04:15 G.m.t. (02:19:19 MET), the airlock was depressurized to vacuum using the equalization valve on the airlock aft hatch. There was little or no motion of the solar arrays during the depressurization to vacuum.

As a result of the propulsive event experienced during airlock depressurization prior to EVA 1, a procedure was developed to use the aft hatch equalization valves to depressurize the external airlock for EVA 2 and subsequent EVAs. The caps on the two aft hatch equalization valves were removed, and the circumferential inlet screen of one of the two equalization valves on each airlock hatch (aft and upper) was covered with gray tape that blocked flow through the screen. Two holes through the end plate of the valve provided the flow path and an initial flow rate of approximately 80 lb/hr at 10.2 psia (the holes in the end plate are there to facilitate assembly). Once the airlock pressure reached 5.0 psia, the other untaped valve was used to depressurize the airlock to vacuum (initial flow rate of approximately 80 lb/hr at 5.0 psia). The emergency position was selected on the same untaped valve to depress from 4 psia to vacuum. The upper hatch valves were available as a backup. When the hatch was opened, the HST solar arrays experienced a small rotation, due to the sudden release of the remaining air in the airlock, but the rotation was at acceptable levels. The depressurization was completed nominally using this procedure during the remaining EVAs.

Smoke Detection and Fire Suppression Subsystem

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

Flight Data Systems

The flight data systems performed satisfactorily throughout the STS-82 mission. No in-flight anomalies were identified during the review and analysis of the data.

Flight Software

The flight software performed flawlessly throughout the mission. No in-flight anomalies or problems were identified in the data review and analysis.

Flight Control Subsystem

Flight control system performance was satisfactory throughout the duration of the mission. The vernier RCS reboost procedures worked very well. Solar array tip deflection caused by the vernier RCS firings was apparently small, on the order of less than four inches and usually less than two inches. The total ΔV from the four vernier RCS reboost maneuvers was 9.9 ft/sec which raised the orbit to 335 by 320 nmi.

The inertial measurement unit (IMU) performance was nominal during prelaunch operations and during the mission. Only one adjustment to the onboard IMU accelerometer compensations was performed for each IMU during the mission. Drift performance for this ship's set of IMUs showed no signs of degradation from the previous mission's signatures. Two of the three IMUs had on-orbit drift trends of less than 0.0002 deg/hr/day, while the third IMU had a drift trend of less than 0.0008 deg/hr/day. A mission extension would have required an update of approximately one and one-half sigma to the latter IMU before entry.

Descent navigation performed nominally with no hardware failures of deselections by the redundancy management (RM). All external sensor data were incorporated in the onboard navigation state vectors at the expected region of operations. All external sensor measurement residuals and residual ratio values were nominal with no navigation-measurement data editing observed.

The backup flight system (BFS) navigation data exhibited similar characteristics to the primary flight system. Postflight error analysis has shown good comparison between the primary flight system state vectors and the BFS state vectors.

Displays and Controls Subsystem

The displays and controls subsystem performed nominally throughout the mission. One in-flight anomaly was identified and it is discussed in the following paragraph.
At 049:03:37 G.m.t. (06:18:42 MET), a mid main bus A current signature was observed that was indicative of a floodlight failing and tripping the 10-ampere remote power controller (RPC) in mid power controller (MPC) 1. The crew confirmed that the aft starboard floodlight had failed. The floodlight power switch was taken to off, and remained there for the remainder of the mission. The characteristic arcing indication in the current data for a failed floodlight was not present during this failure. The current ramped up slightly from 16.5 to 17.6 amperes over 0.7 second, then spiked to 24 amperes and remained at that value for 2.3 seconds, and finally dropped to 10 amperes (total spike of 13.6 amperes). Troubleshooting at KSC determined that the floodlight electronic assembly (FEA) 1 had an internal short. The FEA was removed and replaced.

Communications and Tracking Subsystems

The communications and tracking subsystems performed nominally. No in-flight anomalies were identified. Minor problems were noted, but none had any impact on the successful completion of the mission.

At 049:02:45 G.m.t. (06:17:49 MET), the HST Payload Operations Control Center (POCC) was unable to reliably send commands to the HST after switching from payload communications system 1 to system 2. While on system 2, dropping lock and sweeping the forward-link frequency improved the performance; however, a reliable forward link could not be established. The downlink telemetry was not affected while using system 2. Payload communications system 1 was used to send commands to HST for the remainder of the time that the HST was in the payload bay. Preliminary data review indicates that problems on communications system 2 were most probably caused by blockage and poor "off the nose" communications.

At approximately 047:07:00 G.m.t. (04:22:04 MET), spots were observed in the image received from payload bay camera C. These cameras are susceptible to burn spots if allowed to view bright objects for extended periods of time. This condition did not impact the mission operations.

Operational Instrumentation/Modular Auxiliary Data System

The operational instrumentation (OI) subsystem performed satisfactorily, except that no pulse code modulation (PCM) data (mainly strain and temperature measurements) were recorded on the Modular Auxiliary Data System (MADS) after liftoff. Twelve minutes of the PCM data were recorded prior to liftoff; however, a failure occurred at liftoff that prevented any further recording of PCM data. Data from the frequency-division multiplexing (FDM) system (mainly SSME vibration and HPOTP strain measurements) was recorded throughout ascent by the MADS recorder. As this report was being written, troubleshooting of the recorder and associated wiring had not isolated the cause of the failure.

The operations (OPS) recorder 2 experienced data dropouts of 1 to 2 seconds duration on tracks 1, 2, and 4. Track 1 dropouts were at the 3, 10 and 75 percent locations on the tape. Track 2 dropouts were at the 2 and 6 percent locations and track 4 dropout was at the 65-percent location. The pattern of dropouts indicates that the most probable cause involves the tape rather than the recorder heads. No data were lost because of these dropouts.

Structures and Mechanical Subsystems

The structures and mechanical subsystems performed satisfactorily throughout the mission. Landing data are presented 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	2607.4	191.5	-2.12	N/A
Nose gear touchdown	5595.6	140.0	N/A	5.7

Brake initiation speed	98.6 knots
Brake-on time	30.77 seconds
Rollout distance	7,073 feet
Rollout time	52.0 seconds
Runway	15 (Concrete) KSC
Orbiter weight at landing	213,710 lb

Brake sensor location	Peak pressure, psia	Brake assembly	Gross energy, million ft-lb
Left-hand inboard 1	792	Left-hand inboard	15.59
Left-hand inboard 3	845		
Left-hand outboard 2	753	Left-hand outboard	13.19
Left-hand outboard 4	726		
Right-hand inboard 1	872	Right-hand inboard	16.74
Right-hand inboard 3	938		
Right-hand outboard 2	740	Right-hand outboard	12.22
Right-hand outboard 4	925		

Integrated Aerodynamics, Heating and Thermal Interfaces

The prelaunch thermal interface purges were nominal. The ascent aerodynamics and plume heating was also normal.

The entry aerodynamic heating to the SSME nozzles was nominal. The lack of MADS data during entry significantly affected the understanding of the heating on the SSME nozzles. The heating that was caused by the forward center-of-gravity (c.g.) as well as data from the early transition was to be used to update the nozzle heating models. The lack of these data may affect the extended forward c.g. efforts.

Thermal Control Subsystem

The performance of the thermal control subsystem (TCS) was satisfactory throughout the mission. All Orbiter subsystem temperatures were maintained within acceptable limits. The FES feed-water primary accumulator heater system A failed off during flight day three operations. This heater loss did not impact mission operations.

During the prelaunch period, the APU 1 injector temperature sensor indicated 437 °F, which exceeded the LCC limit by 1 °F. A 45 °F gradient existed between the injector temperature and the GG bed. This problem did not impact the countdown and it is discussed in greater depth in the Auxiliary Power Unit Subsystem section of this report.

The new external airlock TCS hardware performed nominally. As a result of the observations made during the mission, a potential need for an under-temperature thermostat on the liquid cooling garment (LCG) line is indicated. Recommendations are being developed on this subject as this report was written.

Aerothermodynamics

Boundary layer transition is suspected to have occurred earlier than usual, occurring at Mach 15 instead of approximately Mach 8. This condition was caused by protruding gap filler at approximately 20 percent of the windward centerline. Because of the lack of MADS data during entry, this suspicion of early transition cannot be verified.

Acreage heating was above normal as a result of the early transition. Local heating was nominal.

Thermal Protection Subsystem and Windows

The TPS performed satisfactorily. Entry heating was significantly higher than expected based on lower-surface structural temperature response data. Boundary layer transition from laminar flow to turbulent flow cannot be determined as there was no MADS data from entry which could be used to confirm the transition. The bondline temperature data indicate a higher-than-usual temperature rise, which may indicate the occurrence of early transition. There was a protruding gap-filler approximately half-way between the centerline and the left-hand side that may have caused an early transition.

The postlanding inspection of the Orbiter TPS identified a total of 103 impacts of which 18 had a major dimension of 1-inch or larger. This total does not include the numerous

damage sites on base heat shield that are attributed to the flame arrestment sparkler system. A comparison of the number of damage sites with statistics from previous missions indicates that both the total number of hits and the number of hits 1-inch or larger was less than average.

Based on data from the debris inspection team, overall debris damage was minimal. Of the 53 impacts on the lower surface, 15 were greater than one-inch in diameter. The largest damage site on the lower surface was located on the left chine about midway between the nose landing gear door and the left main landing gear door. The site measured 2 inches long by ¼ inch wide by 1/16 inch maximum depth.

TPS DAMAGE SITES

Orbiter Surfaces	Hits > 1 Inch	Total Hits
Lower Surface	14	53
Upper Surface	4	39
Right Side	0	3
Left Side	0	3
Right OMS Pod	0	2
Left OMS Pod	0	3
Total	18	103

Several outer mold-line (OML) thermal barriers were breached. The protruding gap filler discussed in the first paragraph of this section was protruding 0.2 inch over a 6-inch length. In addition, several main landing gear door thermal barriers were breached and required replacement during turnaround activities. A protruding gap filler was also evident approximately four feet forward and two feet outboard of the right-hand elevon gap hinge line.

Tiles on the upper body flap where the black RTV material had been removed for this mission were damaged as expected. The reaction cured glass (RCG) coated toughened unified fibrous insulation (TUFI) tiles showed no damage or degradation.

Tile damage sites aft of the LH_2 and LO_2 ET/Orbiter umbilicals were typical. The damage was most likely caused by impacts from umbilical ice or shredded pieces of umbilical purge barrier material flapping in the air stream, both of which were observed in the launch films.

No tile damage from micrometeorites or on-orbit debris was identified during the inspection.

Bent metal that was approximately 1 inch in length by ¼ inch wide was visible on the trailing edge of a spacer between two bolt heads on the inside surface of the LO_2 ET door near the forward outboard corner.

The SSME 2 and 3 dome mounted heat shield (DMHS) closeout blankets were in excellent condition. The SSME 1 blanket was slightly frayed at the 5:00 o'clock position.

Damage to the base heat shield tiles appeared to be somewhat more than usual. Two adjacent tiles close to the SSME 1 and 3 base-mounted heat shields exhibited a cluster

of seven large damage sites. A similar cluster of six damage sites spanning four tiles occurred in a mirror-image area outboard of the SSME 1 and 2 base-mounted heat shields. A base-mounted heat shield tile at the SSME 2 4:00 to 5:00 o'clock position was missing a 4-inch by 2-inch by 1-inch deep corner piece. The opposite corner of this same tile sustained a three-inch crack.

Tiles on the upper surface of the body flap near the outboard edges sustained greater than usual damage from the down-firing RCS thrusters.

Tiles on the vertical stabilizer and "stinger" were intact and mostly undamaged. One small damage site was attributed to a launch debris impact rather than contact from the drag chute risers. No significant damage was noted on the OMS pods, though a total of six gap fillers protruded from leading edge tiles.

Hazing and streaking of forward-facing Orbiter windows was typical. Damage sites on the window perimeter tiles appeared to be average in size and number. A somewhat unusual finding consisted of a cluster of 14 hits, including four larger than 1 inch, in the black-tiled area between windows 3 and 4. These damage sites are believed to be the result of impacts from the forward RCS thruster paper covers/RTV adhesive.

EXTRAVEHICULAR ACTIVITY OPERATIONS

Four scheduled EVA's and one unscheduled EVA were performed during the second HST reservicing mission. All of the STS-82 EVA mission objectives were successfully completed. The EVA tools operated nominally during the EVA's with only one occurrence of a safety-tether binding. One extravehicular mobility unit (EMU) in-flight anomaly was recorded for the incomplete actuation of the power mode switch on EMU 1 prior to exiting the airlock during the third EVA.

The EMUs used on STS-82 included enhancements for on-orbit resizing and incorporated glove heaters that were powered by a remote power source located away from the EVA gloves. STS-82 was the first mission to incorporate on-orbit resizing of the EVA suits that was performed between EVA's. Because of Orbiter center of gravity (c.g.) constraints, only three EMU's were manifested for the four EVA crewmembers. The EV2 and EV4 crewmembers shared a short EMU [upper torso and primary life support subsystem (PLSS)] and changed out the lower arms and lower torso assemblies (LTA's) between EVAs. The resizing was made possible with the incorporation of enhanced suit assembly quick disconnect sizing rings and components that did not require any lacing or sewing. These modifications enabled the use of EMU 2 for five consecutive EVAs.

EVA 1

The EV1 (Mark Lee) and EV2 (Steve Smith) crewmembers completed all planned tasks of the first EVA with no EMU problems. However, during airlock depressurization to 5 psia, the airlock vented to the port side of the Orbiter payload bay and caused solar array movement. This condition is discussed in more detail in the Payloads section of this report. As a result of the solar array movement, the two crewmembers remained in the airlock for approximately 1 hour 45 minutes at 5 psia while the solar array stabilized and HST engineers evaluated the condition of the solar array. Approval was given to begin the EVA and the airlock was depressed to vacuum at a slower rate, and no solar array fluctuations were noted. The official time of the EVA was 6 hours 42 minutes.

EVA 2

The EV3 (Greg Harbaugh) and EV4 (Joe Tanner) completed all planned tasks for the second EVA and no EMU problems were noted. The depressurization of the airlock for EVA 2, as well as the remaining EVAs, was performed using a modified procedure to prevent possible movement and damage to the solar arrays. The aft hatch-equalization valve was used to depressurize the airlock. One of the two equalization valves on each hatch was taped to cover the circumferential inlet screen upper hatch-equalization valve and thereby block flow through the screen. The flow path was through the end plate at a rate of approximately 80 lb/hr. One minor problem occurred early in the EVA when a safety tether reel became bound up, and this was a known problem which was corrected immediately. There were no other EVA hardware problems during the EVA, and the total time of the EVA was 7 hours 27 minutes.

EVA 3

All tasks planned for the third EVA were completed with only one minor EMU problem that occurred as the EVA was about to begin. At the end of the airlock depressurization procedure and prior to the start of the EVA, the EV1 crewmember did not have an indication that EMU 1 was operating on battery power even though the switch was in the battery-power position. The crewmember recycled the power mode switch, and the EMU reset to the proper configuration. The total time for the EVA was 7 hours 11minutes.

The power mode switch contains three separate microswitches. During the throw of this switch, each of these microswitches is activated independent of the others. If the throw is not complete, only two of the three microswitches might be activated. In the case discussed in the previous paragraph, the battery/service and cooling umbilical (SCU) indicator microswitch did not make contact when moved from the SCU to the BATT position. The ground data showed that the battery power was off and the vehicle power was off. It should have read battery power on and vehicle power off. This malfunction was only a battery-on discrete to the EMU caution and warning system and would not have terminated the EVA. Previous power mode switch experience has shown that the described condition can be corrected by a firm recycle of the switch. Also, the crew is trained during chamber tests for this particular situation.

EVA 4

The EV3 and EV4 crewmembers performed the fourth EVA satisfactorily with all planned tasks completed. No EMU problems occurred during the EVA. The total time of the EVA was 6 hours 33 minutes.

EVA 5

The EV1 and EV2 crewmembers completed the fifth EVA, which was unscheduled prior to flight. The crewmembers repaired MLI that had been observed during previous EVAs to be damaged (torn). The crewmembers remained in the payload bay for approximately 1 hour after completion of the repair tasks awaiting a decision on whether the HST reaction wheel assembly was to be changed out. A decision was made not to replace the reaction wheel assembly and the EVA was concluded with payload bay closeout. The total time of the EVA was 5 hours 17 minutes.

REMOTE MANIPULATOR SYSTEM

The remote manipulator system (RMS) performed in an excellent manner throughout the mission with one in-flight anomaly noted. The anomaly is discussed later in this section.

STS-82 was the forty-seventh flight of an RMS and the fifteenth flight of this particular arm (-301). For this mission, the special purpose end effector (SPEE) connector was removed and replaced with an EVA camera bracket on which a closed circuit television (CCTV) camera was installed. The camera was used to record and broadcast visual inspections inside the compartments of the HST as well as assist in the various surveys that were performed.

The RMS checkout was completed at 043:04:29 G.m.t. (00:19:34 MET), and the RMS performance was nominal. Following the checkout, the RMS was used to conduct a video survey of the Hubble Space Telescope (HST) space support equipment, which concluded the RMS flight day 1 activities.

On flight day 2, the RMS was used to capture and berth the HST. After berthing was complete, a visual inspection of the HST exterior and solar arrays was performed using the wrist camera.

The RMS was used during each EVA in the performance of the servicing tasks. During the first EVA, the RMS supported the first EVA, and the first task was to grapple the manipulator foot restraint (MFR) with the end effector as the EVA began. The MFR served as a mobile work platform in the performance of the servicing tasks, which included:

a. Replacement of the Goddard High Resolution Spectrograph with the Space Telescope Imaging Spectrograph (first EVA); and,

b. Replacement of the Faint Object Spectrograph with the Near Infrared Camera and Multi-Object Spectrometer (first EVA);

c. Replacement of the Fine Guidance Sensor with an upgraded unit (second EVA);

d. Changeout of one of the Engineering/Science Tape Recorders (second EVA);

e. Installation of an Optics Control Electronics Enhancement Kit (second EVA);

f. Changeout of a faulty Data Interface Unit (third EVA);

g. Changeout of a suspect Reaction Wheel Assembly (third EVA);

h. Replacement of one of the Engineering/Science Tape Recorders with a Solid State Recorder (third EVA);

i. Changeout of the Solar Array Drive Electronics unit no. 2 (fourth EVA); and,

j. Installation of a cover on the Magnetic Sensing Systems unit (fourth EVA).

During the second EVA, it was noted that several of the MLI blankets on the HST were torn, and a visual inspection of the damaged areas was performed using the RMS wrist camera. After completion of the planned tasks during EVA 3, a more detailed inspection of the MLI blankets was performed using the EVA hand-held camera. One MLI blanket was repaired during the fourth EVA. Following the EVA, a survey, using the RMS wrist camera, was made of the work site that was used during the fifth EVA. The RMS was used during the fifth EVA to maneuver the EVA crewmember to the three repair work sites on HST bays 7, 8, and 10. At the end of the final EVA, the MFR was released and stowed.

On flight day 8, the RMS was used to satisfactorily unberth and deploy the HST. Approximately one hour after the release, the RMS arm was cradled for a last time.

GOVERNMENT FURNISHED EQUIPMENT/FLIGHT CREW EQUIPMENT

The Government furnished equipment/flight crew equipment (GFE/FCE) performed nominally throughout the mission. Four in-flight anomalies were identified and these are discussed in the following paragraphs.

At approximately 047:07:00 G.m.t. (04:22:04 MET), spots were observed in the image received from payload bay camera C (Flight Problem STS-82-F-04). These cameras are susceptible to burn spots if allowed to view bright objects for extended periods of time. This condition did not impact the mission operations. Postflight action will include removal of the camera. The camera was sent to the TV laboratory in Houston.

On flight day 2, the incorrect packet number was discovered in the initialization file for the 10.2 cabin depressurization payload general support computer (PGSC) application, and this caused the application to not receive PCMMU data. A corrected file was created, tested, and provided to the controller team for uplink. The corrected file was sent up as part of the standard "SPOC updates" that are sent every day. However, the update was performed, the Orbiter Communications Adapter (OCA) data diskette was not in the OCA PGSC drive A. This resulted in the update files being placed on drive C. Because the data was on drive C, it was necessary for these data to be copied to drive A. However, the instructions to the crew on the necessary action required were unclear. As a result, the wrong hard-disk was used and it contained none of the files required to perform the 10.2 cabin depressurization application, and when the crew ran the 10.2 cabin depressurization application, they reported that it "did not run correctly" (Flight Problem STS-82-F-01). Efforts to resolve this anomaly are continuing.

The crew sent a message down that reported difficulty in powering up the STS-1 PGSC (Flight Problem STS-82-F-02). The crew stated, "Tried several power cord/power source combinations: no joy". The PGSC was powered up outside of the docking station using a power converter, and the PGSC worked satisfactorily. The docking station fuse was checked with a multimeter and the fuse was good. The PGSC was reassembled in the docking station and tried again without success. The PGSC was demated and remated several times and the fuse was removed and replaced several times, and the PGSC operated correctly thereafter. The crew was advised not to use docking station power, and the PGSC power switch was to be used if a reboot was required.

The postflight testing hardware checkout showed that one of the pins on the power connector on the expansion chassis was recessed, and this was the cause of the difficulty. The preflight hardware processing procedures will be reviewed to ensure that the connector pins are checked prior to flight.

The crew sent down an OCA message that described the following STS-3 PGSC problem. "Tried to run PCDECOM got the following error: 110 00000 (S). The crew tried the PCDecom application several times with similar results" (Flight Problem STS-82-F-03). After using the Think-Pad off the chassis as a world map overnight, the crew remated the Think-Pad to the chassis and got an error message and the screen went blank. After updating the machine, and attempt was made to fire up PCDECOM again. The application worked properly with no cables attached; however, when the data cable was attached, the 110 error was received. Consequently, the crew used the STS-2 PGSC as the PCDECOM machine.

Postflight loop-back testing showed the 422 serial card to be faulty. The card was removed and installed in a ground support computer where it worked without any problems. Re-installation in the flight computer resulted in again receiving the failed indication. The card was reseated and the tests were completed with satisfactory results. Further investigation showed that the 422 card was misaligned with the expansion chassis card slot. The alignment was corrected and the system passed the loopback test consistently.

Review and analysis of the pictures taken with the electronic still camera (ESC) revealed an unusually large number of radiation hits on the detector. These hits were the result of the extreme Orbiter altitudes flown. The many dots which appeared on the photographs as a result of the radiation hits were processed out of the pictures.

CARGO INTEGRATION

Integration hardware performance was nominal throughout the mission. As a result of the airlock venting problem that occurred immediately prior to the beginning of the first EVA, the Orbiter-to-Cargo Core Interface Control Document (ICD-2-19001) will be revised to reflect airlock venting effects in the Orbiter payload bay.

DEVELOPMENT TEST OBJECTIVES/DETAILED SUPPLEMENTARY OBJECTIVES

DEVELOPMENT TEST OBJECTIVES

DTO 255 - Wraparound Digital Autopilot (DAP) Flight Test Verification (Part 4) - This Development Test Objective (DTO) was performed during entry using programmed test inputs (PTIs). The results of these PTIs (maneuvers) will be obtained from an analysis of the data and will be reported in separate documentation.

DTO 312 - External Tank Thermal Protection System Performance (Method 4) - The ET was acquired after separation using the 35 mm camera with a 400 mm lens and a 2X extender. The OMS 2 pitch attitude maneuver was performed early to assist the crewmembers in acquiring the ET visually. Twenty-nine views of the ET were acquired. In addition, four views of an irregular shaped piece of debris (probably ice) were acquired. The ET nose and all sides of the ET were imaged, although the view angle did not always provide a good picture. The first picture was taken about 25 minutes after liftoff, and the last picture was taken 12 minutes 16 seconds later. No anomalies were noted on the ET. The normal SRB separation-motor burn scars and aerodynamic heating marks were visible on the ET thermal protection system (TPS).

The ET was calculated to be approximately 3.2 kilometers from the Orbiter in the first picture, and 9.7 kilometers in the last view. The ET separation rate was calculated to be approximately 9 meters/second. The separation velocity was greater than typical previous mission measurements since the pictures were taken later and over a longer period of time than usual. The tank tumble rate was approximately 1.6 deg/sec and the roll rate was too small to be measured.

DTO 416 - Water Spray Boiler Quick Restart Capability - STS-82 was the fifth flight of seven planned flights for this DTO. The results of the data gathered for this DTO will aid in determining the capability of the WSB to support a revolution 2 deorbit or Abort-Once-Around condition. The results of this DTO will be published in separate documentation.

DTO 684 - Radiation Measurements in Shuttle Crew Compartment - The tissue equivalent proportional counter (TEPC) hardware was deployed on flight day 1 as required by the Flight Plan. An analysis will be performed on the measurements, and the results of that analysis will be published in separate documentation.

DTO 700-9A - Orbiter Evaluation of TDRS Acquisition in Despreader Bypass Mode - The Instrumentation and Communications Officer (INCO) uplinked commands for execution over two separate Tracking and Data Relay Satellite System (TDRSS) hand-over times. Both tests were successful with TDRSS acquisition achieved in four seconds or less.

DTO 805 - Crosswind Landing Performance - This DTO was not accomplished on this flight because of an insufficient crosswind component at landing.

DETAILED SUPPLEMENTARY OBJECTIVES

DSO 331 - Interaction of the Space Shuttle Launch and Entry Suit and Sustained Weightlessness on Egress Locomotion - The only flight activity for this Detailed Supplementary Objective (DSO) was donning of biomedical instrumentation prior to the deorbit maneuver and entry. Data obtained from this DSO will be analyzed and reported in separate documentation.

DSO 487 - Immunological Assessment of Crewmembers - This DSO had no in-flight activities assigned and the postflight assessment was performed as planned. The analysis of the assessment results will be reported in separate documentation.

DSO 493 - Monitoring Latent Virus Reactivation and Shedding in Astronauts - The post-sleep activities required for this DSO were accomplished each day of the flight. The data were provided to the sponsor for evaluation. The results of the evaluation will be reported in separate documentation.

PHOTOGRAPHY AND TELEVISION ANALYSIS

LAUNCH PHOTOGRAPHY AND VIDEO DATA ANALYSIS

On launch day, 24 of 24 expected launch videos were reviewed, and no anomalous conditions were noted. Following launch day activities 21 additional films were screened. Twenty-two additional films were received for contingency support and anomaly resolution, but were not screened as there were no major launch/ascent issues. No anomalies that could threaten vehicle safety were seen in the launch imagery.

ON-ORBIT PHOTOGRAPHY AND VIDEO DATA ANALYSIS

No unplanned on-orbit analysis were performed. Pre-planned real-time analysis support was provided to the Hubble Space Telescope capture, repair and deployment. Measurements made on Solar Array twist and motion were provided to the Goddard Space Flight Center after each EVA. Results of that analysis will be published under separate documentation.

LANDING PHOTOGRAPHY AND VIDEO DATA ANALYSIS

Ten videos and seven films of landing were received and screened. No major anomalies were noted in the approach, landing, and roll-out video and film views screened. All observations were nominal.

TABLE I.- STS-82 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	042:08:50:25.687 042:08:50:26.479 042:08:50:27.166
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	042:08:54:49.107 042:08:54:49.267 042:08:54.49.327 042:08:54:49.587
Main Propulsion System Start[a]	ME-3 Start command accepted ME-2 Start command accepted ME-1 Start command accepted	042:08:55:10.458 042:08:55:10.577 042:08:55:10.678
SRB Ignition Command (Liftoff)	Calculated SRB ignition command	042:08:55:17.017
Throttle up to 104 Percent Thrust[a]	ME-1 Command accepted ME-3 Command accepted ME-2 Command accepted	042:08:55:20.998 042:08:55:21.017 042:08:55:21.018
Throttle down to 68 Percent Thrust[a]	ME-1 Command accepted ME-3 Command accepted ME-2 Command accepted	042:08:55:47.239 042:08:55:47.258 042:08:55:47.258
Maximum Dynamic Pressure (q)	Derived ascent dynamic pressure	042:08:56:09
Throttle up to 104 Percent[a]	ME-1 Command accepted ME-3 Command accepted ME-2 Command accepted	042:08:56:17.479 042:08:56:17.498 042:08:56:17.499
Both RSRM's Chamber Pressure at 50 psi[a]	RH SRM chamber pressure mid-range select LH SRM chamber pressure mid-range select	042:08:57:15.417 042:08:57:15.697
End RSRM [a] Action[a] Time	RH SRM chamber pressure mid-range select LH SRM chamber pressure mid-range select	042:08:57:17.697 042:08:57:18.477
SRB Physical Separation[a]	LH rate APU turbine speed - LOS RH rate APU turbine speed - LOS	042:08:57:20.737 042:08:57:20.737
SRB Separation Command	SRB separation command flag	042:08:57:22
3g Acceleration	Total load factor	042:09:02:45.4
Throttle Down for 3g Acceleration[a]	ME-1 command accepted ME-2 command accepted ME-3 command accepted	042:09:02:45.486 042:09:02:45.507 042:09:02:45.509
Throttle Down to 67 Percent Thrust[a]	ME-1 command accepted ME-2 command accepted ME-3 command accepted	042:09:03:39.887 042:09:03:39.908 042:09:03:39.911
SSME Shutdown[a]	ME-1 command accepted ME-2 command accepted ME-3 command accepted	042:09:03:46.367 042:09:03:46.388 042:09:03:46.391
MECO	MECO command flag MECO confirm flag	042:09:03:47 042:09:03:48
ET Separation	ET separation command flag	042:09:04:06

[a]MSFC supplied data

TABLE I.- STS-82 SEQUENCE OF EVENTS
(Continued)

Event	Description	Actual time, G.m.t.
APU Deactivation	APU-1 GG chamber pressure APU 2 GG chamber pressure APU 3 GG chamber pressure	042:09:09:15.507 042:09:09:38.092 042:09:09:55.343
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	042:09:39:50.9 042:09:39:50.9
OMS-2 Cutoff	Right engine bi-prop valve position Left engine bi-prop valve position	042:09:42:43.1 042:09:42:43.3
Payload Bay Doors (PLBDs) Open	PLBD right open 1 PLBD left open 1	042:10:33:04 042:10:37:38
OMS-3 Ignition	Right engine bi-prop valve position Left engine bi-prop valve position	042:14:22:35.1 042:14:22:35.3
OMS-3 Cutoff	Right engine bi-prop valve position Left engine bi-prop valve position	042:14:23:48.7 042:14:23:48.9
Cabin Depressurization to 10.2 psia	Cabin pressure	043:04:35:51
OMS-4 Ignition	Right engine bi-prop valve position Left engine bi-prop valve position	043:12:31:39.1 042:12:31:39.3
OMS-4 Cutoff	Right engine bi-prop valve position Left engine bi-prop valve position	043:12:32:35.3 043:12:32:35.3
OMS-5 Ignition	Left engine bi-prop valve position Right engine bi-prop valve position	044:02:01:22.3 044:02:01:22.3
OMS-5 Cutoff	Right engine bi-prop valve position Left engine bi-prop valve position	044:02:01:30.3 044:02:01:30.5
Hubble Space Telescope Grapple	Payload captured	044:08:33:53
Hubble Space Telescope Berth	Payload latch 1A latched indication	044:09:12:13
Airlock Depressurization 1 (End)	Airlock differential pressure no. 1	045:04:29:53
Airlock Repressurization 1 (Start)	Airlock differential pressure no. 1	045:11:16:32
Airlock Depressurization 2 (End)	Airlock differential pressure no. 1	046:03:23:11
Hubble Space Telescope Reboost Maneuver 1 (Start)	RCS L5D thruster chamber pressure	046:10:04:45.5
Hubble Space Telescope Reboost Maneuver 1 (End)	RCS L5D thruster chamber pressure	046:10:25:27.4
Airlock Repressurization 2 (Start)	Airlock differential pressure no. 1	045:10:53:01
Hubble Space Telescope Reboost Maneuver 1A (Start)	RCS L5D thruster chamber pressure	046:15:02:19.4
Hubble Space Telescope Reboost Maneuver 1A (End)	RCS L5D thruster chamber pressure	046:15:12:32.0
Airlock Depressurization 3 (End)	Airlock differential pressure no. 1	047:02:50:56

TABLE I.- STS-82 SEQUENCE OF EVENTS (Continued)

Airlock Repressurization 3 (Start)	Airlock differential pressure no. 1	047:10:03:37
Hubble Space Telescope Reboost Maneuver 2 (Start)	RCS L5D thruster chamber pressure	047:10:10:16.9
Hubble Space Telescope Reboost Maneuver 2 (End)	RCS L5D thruster chamber pressure	047:10:30:03.8
Airlock Depressurization 4 (End)	Airlock differential pressure no. 1	048:03:43:24
Airlock Repressurization 4 (Start)	Airlock differential pressure no. 1	048:10:19:32
Airlock Depressurization 5 (End)	Airlock differential pressure no. 1	049:03:12:42
Airlock Repressurization 5 (Start)	Airlock differential pressure no. 1	049:08:31:28
Hubble Space Telescope Reboost Maneuver 3 (Start)	RCS L5D thruster chamber pressure	049:10:28:16.5
Hubble Space Telescope Reboost Maneuver 3 (End)	RCS L5D thruster chamber pressure	047:11:00:10.0
Hubble Space Telescope Grapple	Payload captured	050:03:21:09
Hubble Space Telescope Unberth	Payload latch 1A released indication	050:05:02:56
Hubble Space Telescope Release	Payload captured	050:06:41:21
Cabin Repressurization to 14.7 psia	Cabin pressure	050:08:27:11
Flight Control System Checkout APU Start APU Stop	 APU 3 GG chamber pressure APU 3 GG chamber pressure	 051:03:05:43.242 051:03:11:37.375
Payload Bay Doors Close	PLBD left close 1 PLBD right close 1	052:03:03:54 052:03:08:00
APU Activation for Entry	APU-2 GG chamber pressure APU-1 GG chamber pressure APU-3 GG chamber pressure	052:07:16:55.260 052:07:48:12.469 052:07:48:14.441
Deorbit Burn Ignition	Left engine bi-prop valve position Right engine bi-prop valve position	052:07:21:54.7 052:07:21:54.8
Deorbit Burn Cutoff	Left engine bi-prop valve position Right engine bi-prop valve position	052:07:26:43.5 052:07:26:43:6
Entry Interface (400K feet)	Current orbital altitude above	052:08:01:15
Blackout end	Data locked (high sample rate)	No blackout
Terminal Area Energy Management	Major mode change (305)	052:08:25:49
Main Landing Gear Contact	LH main landing gear tire pressure 1 RH main landing gear tire pressure 2	052:08:32:24 052:08:32:24
Main Landing Gear Weight on Wheels	LH MLG weight on wheels RH MLG weight on wheels	052:08:32:24 052:08:32:24
Drag Chute Deployment	Drag chute deploy 1 CP volts	052:08:32:27.3
Nose Landing Gear Contact	NLG LH tire pressure 1	052:08:32:35

TABLE I.- STS-82 SEQUENCE OF EVENTS
(Concluded)

Event	Description	Actual time, G.m.t.
Nose Landing Gear Weight On Wheels	NLG weight on wheels 1	052:08:32:35
Drag Chute Jettison	Drag chute jettison 1 CP Volts	052:08:32:55.8
Wheel Stop	Velocity with respect to runway	052:08:33:16
APU Deactivation	APU-1 GG chamber pressure APU-2 GG chamber pressure APU-3 GG chamber pressure	052:08:45:43.337 052:08:45:58.392 052:08:46:12.993

TABLE II.- STS-82 ORBITER IN-FLIGHT ANOMALY LIST

No.	Title	Reference	Comments
STS-82-V-01	FES Feedline A Accumulator Temperature Trending Low	045:06:00 G.m.t. 02:21:05 MET CAR 82RF05 IPR 85V-0003	At approximately 045:06:00 G.m.t. (02:21:05 MET), the FES feedline A accumulator temperature began trending low. Prior to that time, the temperature had been cycling between 60 and 75 °F as the accumulator heater cycled on and off. The last indication of a heater cycle on system 1 was at 044:22:57 G.m.t. (02:14:02 MET). After the last heater system 1 cycle, the accumulator temperature remained above 45 °F. The plan was to take no action unless the accumulator temperature dropped below 40 °F. The nominal heater reconfiguration was performed at 047:02:37 G.m.t. (04:17:42 MET). Heater system 2 functioned nominally. KSC: Troubleshooting will be performed.
STS-82-V-02	Aft Starboard Payload Bay Floodlight Failed	049:03:37 G.m.t. 06:18:42 MET CAR 82RF06 IPR 85V-0006	At 049:03:37 G.m.t. (06:18:42 MET), a mid main bus A current signature was observed that was indicative of a floodlight failing and tripping the 10 ampere remote power controller (RPC) in mid power controller (MPC) 1. The crew confirmed that the aft starboard floodlight had failed. The floodlight power switch was taken to off, and remained there for the remainder of the mission. The characteristic arcing indication in the current data for a failed floodlight was not present during this failure. The current ramped up slightly from 16.5 to 17.6 amperes over 0.7 seconds, then spiked to 24 amperes and remained at that value for 2.3 seconds, and finally dropped to 10 amperes (total spike of 13.6 amperes). Analysis of available data indicate that the most probable cause of the current spike was a failure in floodlight electronics assembly (FEA) 1. KSC: Troubleshooting will be performed.

TABLE III.- STS-82 GOVERNMENT FURNISHED EQUIPMENT PROBLEM TRACKING LIST

No.	Title	Time	Comments
STS-82-F-01	PGSC 10.2 Cabin Depressurization Application Failed to Run Correctly	043:14:12 G.m.t. 01:05:17 MET	On flight day 2, a typographical error was discovered in the initialization file for the 10.2 PGSC application. A corrected file was created, tested, and provided to the Flight Control Room (FCR) for uplink. The corrected file was sent up as part of the standard "SPOC updates" that are sent every day. The crew reported no difficulties incorporating this update. However, when the crew ran the 10.2 application, they reported that it "did not run correctly". Some minor troubleshooting was performed in real-time involving the crew switching communications ports with no success. The PGSC 10.2 application was not required for cabin depressurization, and the application was not used again during the mission. From the data sent down by the crew, it is apparent that the "update" did not get incorporated. KSC: No action is required. Troubleshooting will be performed in Houston, and the problem will be discussed with the crew during postflight debriefings.
STS-82-F-02	STS-1 PGSC Power-up Problem	043:15:00 G.m.t. 01:06:05 MET	The crew sent a message down that reported difficulty in powering up the STS-1 PGSC. The crew stated, "Tried several power cord/power source combinations: no joy. The PGSC was powered up outside of the docking station using a power converter, and the PGSC worked satisfactorily. Checked docking station fuse with multimeter and it checked good. Reassembled the PGSC in the docking station and tried again; no joy. Demated/remated several times and removed and replaced the fuse several times. Worked correctly thereafter. No mission impact. The crew was advised not to use docking station power, and the PGSC power switch was to be used if a reboot was required. KSC: No action required. The PGSC community suspects a possible docking station connector problem. Troubleshooting of the hardware will be performed postflight.

TABLE III.- STS-82 GOVERNMENT FURNISHED EQUIPMENT PROBLEM TRACKING LIST

No.	Title	Time	Comments
STS-82-F-03	STS-3 PGSC Error Messages	043:15:14 G.m.t. 01:06:19 MET	The crew sent down an OCA message that described the following STS-3 PGSC problem. "Tried to run PCDECOM got the following error: 110 00000 (S). Tried several times with similar results. Used computer out of the docking station as world map overnight. After updating the machine, and attempt was made to fire up PCDECOM again. This time an error was received during ped_com.exe.ini, and then the screen went blank. Tried again with no 422/232 cables attached and software executed properly. As soon as the 422 cable was connected to communications port 2, the original 110 ..... message was displayed. Consequently, the crew is using the STS-2 PGSC as the PCDECOM machine. KSC: No action required. IBM representatives confirmed that these error messages indicated a problem with communications port 2 on the 422 card. The crew was informed that communications port 2 on STS-3 was suspect. Troubleshooting will be performed postflight in Houston.
STS-82-F-04	Camera C Image Burn Spots	047:07:00 G.m.t. 04:22:05 MET	During on-orbit operations, spots were observed in the image received from payload bay camera C. These cameras are susceptible to burn spots if allowed to view bright objects for extended periods of time. Postflight action will include removal of the camera. The camera will be sent to the TV laboratory in Houston.

TABLE IV.- STS-82 EVA IN-FLIGHT ANOMALY LIST

No.	Title	Time	Comments
STS-82-X-01	EMU 1 Power Mode Switch Incomplete Actuation	047:02:57 G.m.t. 04:18:02 MET	Prior to the start of the third EVA, EV1 did not have an indication that EMU 1 was on battery power after the power mode switch (PMS) had been moved from the SCU position to the BATT position. The PMS has three separate microswitches, one of which provides a battery-on discrete to the EMU caution and warning system. In this case, the batter/SCU indicator microswitch in the PMS did not adequately throw when the switch was actuated. The microswitch not being made is a known condition involving the PMS. Note that the EMU was actually on battery power, and the EVA could have proceeded without the battery power-on indication. The crew was trained to correct this condition by a firm recycling of the PMS. After recycling the switch, the EMU reset and the proper indication was received. No further problems were encountered during the EVA or subsequent EVAs. The current switch design will be replaced during EMU display and control module (DCM) retrofits that are due for completion in mid-1998, with the first flight as early as STS-86. KSC: No KSC action is required.

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. 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-82 Summary of Significant Events

ACRONYMS AND ABBREVIATIONS

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

ABS	ammonia boiler system
APU	auxiliary power unit
ARPCS	atmospheric revitalization pressure control system
ARS	atmospheric revitalization system
ATCS	active thermal control system
BATT	battery
BFS	backup flight system
CCTV	closed-circuit television
c.g.	center of gravity
DIU	Data Interface Unit
DMHS	dome-mounted heat shield
ΔP	differential pressure
deg/sec	degree per second
DSO	Detailed Supplementary Objective
DTO	Developmental Test Objective
ΔV	differential velocity
ECLSS	environmental control and life support system
EGT	exhaust gas temperature
EMU	extravehicular mobility unit
EPDC	electrical power distribution and control
ESC	electronic still camera
e.s.t.	eastern standard time
ESTR	Engineering/Science Tape Recorder
ET	External Tank
EVA	extravehicular activity
EV 1 - EV 4	extravehicular crewmember identification
FCE	flight crew equipment
FCP	fuel cell powerplant
FCR	Flight Control Room
FCS	flight control system
FCV	flow control valve
FEA	floodlight electronics assembly
FES	flash evaporator system
FGS	Fine Guidance Sensor
ft/sec	feet per second
g	gravity
GFE	Government furnished equipment
GG	gas generator
GH_2	gaseous hydrogen
G.m.t.	Greenwich mean time
GO_2	gaseous oxygen
HGA	high gain antenna
HPFTP	high pressure fuel turbopump
HPOTP	high pressure oxidizer turbopump

HST	Hubble Space Telescope
ICD	Interface Control Document
IMU	inertial measurement unit
INCO	Instrumentation and Communications Officer
I/O	input/output
I_{sp}	specific impulse
ISS	International Space Station
KSC	Kennedy Space Center
kW	kilowatt
kWh	kilowatt/hour
lbm	pound mass
lb/min	pound per minute
lb/hr	pound per hour
LCC	Launch Commit Criteria
LCG	liquid cooling garment
LH_2	liquid hydrogen
LMSMS&S	Lockheed Martin Space Mission Systems and Services
LO_2	liquid oxygen
LTA	lower torso assembly
MADS	modular auxiliary data system
MC	midcourse correction (maneuvers)
MICU	manipulator controller interface unit
MECO	main engine cutoff
MET	mission elapsed time
MFR	manipulator foot restraint
MFV	main fuel valve
MLI	multilayer insulation
MPC	mid power controller
MPS	main propulsion system
MSS	Magnetometer Sensing System
MSX	Midcourse Space Experiment
NASA	National Aeronautics and Space Administration
NC2 - 3	rendezvous maneuvers (two)
NCC	corrective combination maneuver
NH	height adjust maneuver
NICMOS	Near Infrared Camera and Multi-Object Spectrometer
nmi.	nautical mile
NPC	rendezvous maneuver
NPSP	net positive suction pressure
NSR	rendezvous maneuver
NSTS	National Space Transportation System (i.e., Space Shuttle Program)
OCA	Orbiter Communications Adapter
OCEK	Optical Control Electronics Enhancement Kit
OI	operational instrumentation
OMDP	Orbiter Maintenance Down Period
OML	outer mold line
OMRSD	Operations and Maintenance Requirements and Specifications Document
OMS	orbital maneuvering subsystem
OPS	Operations

OPF	Orbiter Processing Facility
PAL	protuberance air load
P_c	chamber pressure
PFCA	postflight control alert
PGSC	payload general support computer
PGSCA	payload general support computer assembly
PLSS	primary life support system
PMBT	propellant mean bulk temperature
PMS	power mode switch
POCC	Payload Operations Control Center
ppm	parts per million
PRSD	power reactant storage and distribution
psia	pound per square inch absolute
psid	pound per square inch differential
psi	pound per square inch
PTI	programmed test inputs
RCG	Reaction Cured Glass
RCS	reaction control subsystem
RM	redundancy management
RMS	Remote Manipulator System
RPC	remote power controller
RTV	room temperature vulcanizing (material)
RSRM	Reusable Solid Rocket Motor
RWA	Reaction Wheel Assembly
SA	solar array
S&A	safe and arm
SADE	Solar Array Drive Electronics
SADM	Solar Array Drive Mechanism
SCU	service and cooling umbilical
SEP	separation
SLF	Shuttle Landing Facility
SM-02	second HST servicing mission
SPEE	special purpose end effector
SRB	Solid Rocket Booster
SRSS	Shuttle range safety system
SSM	support systems module
SSR	Solid State Recorder
SSME	Space Shuttle main engine
STIS	Space Telescope Imaging Spectrograph
STS	Space Transportation System
TCS	thermal control subsystem/trajectory control sensor
TDRSS	Tracking and Data Relay Satellite System
TEPC	Tissue Equivalent Proportional Counter
TI	terminal phase initiation maneuver
TPS	thermal protection system/subsystem
TUFI	toughened unified fibrous insulation
V	Volt
Vdc	Volt, direct current
WSB	water spray boiler
WSTF	White Sands Test Facility