https://ntrs.nasa.gov/search.jsp?R=19970001479 2020-06-16T03:47:18+00:00Z

NSTS-37404

STS-74 SPACE SHUTTLE MISSION REPORT

February 1996

LIBRARY COPY
FEB 9
LANGLEY RESEARCH CENTER
LIBRARY NASA
HAMPTON, VIRGINIA

National Aeronautics and
Space Administration

Lyndon B. Johnson Space Center
Houston, Texas

NOTE

The STS-74 Space Shuttle Mission Report was prepared from inputs received from the Orbiter Project Office as well as other organizations. The following personnel may be contacted should questions arise concerning the technical content of this document.

Kenneth L. Brown 713-483-3891	Orbiter and subsystems
George Harsh, MSFC 205-544-4827	MSFC Elements (SRB, RSRM, SSME, ET, SRSS, and MPS)
Dianne J. Murphy, JSC 713-483-1055	Payloads/Experiments
J. Williams, JSC 713-483-1177	DTOs and DSOs
F. T. Burns, Jr., JSC 713-483-1262	FCE and GFE

STS-74

SPACE SHUTTLE

MISSION REPORT

Prepared by

Robert W. Fricke, Jr.
LMES/Flight Engineering and Vehicle Management Office

Approved by

Kenneth L. Brown 2/5/96
STS-74 Lead Mission Evaluation Room Manager

Dennis Dillman for
David W. Camp
Manager, Flight Engineering and Vehicle Management Office

Jay H. Greene
Manager, Orbiter Project

Tommy W. Holloway
Space Shuttle Program Manager

Prepared by
Lockheed Martin Engineering and Sciences
for
Flight Engineering and Vehicle Management Office

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
LYNDON B. JOHNSON SPACE CENTER
HOUSTON, TEXAS 77058

February 1996

STS-74 Table of Contents

STS-74 Table of Contents

List of Tables

INTRODUCTION

The STS-74 Space Shuttle Program Mission Report summarizes the Payload activities as well as the Orbiter, External Tank (ET), Solid Rocket Booster (SRB), Reusable Solid Rocket Motor (RSRM), and the Space Shuttle main engine (SSME) systems performance during the seventy-third flight of the Space Shuttle Program, the forty-eighth flight since the return-to-flight, and the fifteenth flight of the Orbiter Atlantis (OV-104). In addition to the Orbiter, the flight vehicle consisted of an ET that was designated ET-74; three Phase II SSMEs that were designated as serial numbers 2012, 2026, and 2032 in positions 1, 2, and 3, respectively; and two SRBs that were designated BI-076. The RSRMs, designated RSRM-51, were installed in each SRB and the individual RSRMs were designated as 360T051A for the left SRB, and 360T051B for the right SRB.

The STS-74 Space Shuttle Program Mission Report fulfills the Space Shuttle Program requirement as documented in NSTS 07700, Volume VII, Appendix E. The requirement stated in that document 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 this flight were to rendezvous and dock with the Mir Space Station and perform life sciences investigations. The Russian Docking Module (DM) was berthed onto the Orbiter Docking System (ODS) using the Remote Manipulator System (RMS), and the Orbiter docked to the Mir with the DM. When separating from the Mir, the Orbiter undocked, leaving the DM attached to the Mir. The two solar arrays, mounted on the DM, were delivered for future Russian installation to the Mir. The secondary objectives of the flight were to perform the operations necessary to fulfill the requirements of the GLO experiment (GLO-4)/Photogrammetric Appendage Structural Dynamics Experiment Payload (PASDE) (GPP), the IMAX Cargo Bay Camera (ICBC), and the Shuttle Amateur Radio Experiment-II (SAREX-II).

The STS-74 mission was planned as an 8-day flight plus 2 contingency days, which were available for weather avoidance or Orbiter contingency operations. The sequence of events for the STS-74 mission is shown in Table I, and the Orbiter Project Office Problem Tracking List is shown in Table II. The Government Furnished Equipment/Flight Crew Equipment (GFE/FCE) Problem Tracking List is shown in Table III. Appendix A lists the sources of data, both formal and informal, that were used to prepare this report. Appendix B provides the definition of acronyms and abbreviations used throughout the report. All times during the flight are given in Greenwich mean time (G.m.t.) and mission elapsed time (MET).

The five-person crew for STS-74 consisted of Kenneth D. Cameron, Col., U. S. Marine Corps, Commander; James D. Halsell, Jr., Lt. Col., U. S. Air Force, Pilot; Chris A. Hadfield, Major, Canadian Air Force, Mission Specialist 1; Jerry L. Ross, Col., U. S. Air Force, Mission Specialist 2; and William S. McArthur, Jr. Lt. Col., U. S. Army, Mission Specialist 3. STS-74 was the fifth flight for Mission Specialist 2; the third space flight for the Commander; the second space flight for the Pilot and Mission Specialist 3, and the first space flight for Mission Specialist 1.

MISSION SUMMARY

The planned launch of STS-74 on November 11, 1995, was scrubbed because of unacceptable weather at the TransAtlantic Abort Landing (TAL) site. The launch was rescheduled for November 12, 1995, and the countdown proceeded nominally to a successful on-time launch at 316:12:30:43.013 G.m.t. (7:30:43 a.m. e.s.t.). The orbital inclination was 51.6 degrees, and the ascent was nominal.

An evaluation of vehicle performance during ascent was made using vehicle acceleration and preflight propulsion prediction data. From these data, the average flight-derived engine specific impulse (Isp) that was determined for the time period between SRB separation and start of 3g throttling was a nominal 452.29 seconds as compared to the main propulsion system (MPS) tag value of 452.70 seconds.

The auxiliary power unit (APU) 2 pump inlet pressure measurement became erratic for approximately one minute during ascent and then recovered and operated satisfactorily until APU 2 shutdown.

Two water spray boiler (WSB) problems occurred during ascent. WSB system 3 experienced a moderate under-cooling condition during which the temperature reached 279 °F prior to the start of spraying. WSB system 2 experienced an over-cooling condition during which the temperature decreased from 250 °F to approximately 194 °F after the start of cooling. The water feed-line electric heater modification was made on all three WSBs prior to this flight to mitigate spray-bar freeze-up.

The hydraulic system 2 pressure decreased to 1500 psia after APU 2 shutdown, and the pressure then rose to approximately 2550 psia and stabilized at approximately 2460 psia. The system 2 pressure then dropped as system 3 pressure decreased approximately 5 seconds later. This event is similar to an explained anomaly that occurred during STS-54 ascent in which back-driving of a speed-brake power drive unit (PDU) motor occurred. Since the speedbrake PDU motor brake was not failed, the back-driving event did not create any flight impact.

No orbital maneuvering subsystem (OMS) 1 maneuver was required as the launch performance and trajectory were satisfactory. The OMS 2 maneuver was performed at 316:13:12:35.0 G.m.t. (00:00:41:52.0 MET). The maneuver was 131.5 seconds in duration and the differential velocity (ΔV) was 213 ft/sec. The resultant orbit was circularized at 162 nmi.

The payload bay doors were opened satisfactorily at 316:13:57:23 G.m.t. (00:01:26:40 MET).

An OMS 3 maneuver was performed at 316:15:30:19.9 G.m.t. (00:02:59:36.9 MET). The maneuver, using the right-hand orbital maneuvering engine (OME), had a duration of 46.2 seconds and resulted in a ΔV of 37.6 ft/sec. The resulting orbit was 184 x 162 nmi.

The port radiator was deployed at 316:13:57 G.m.t. (00:01:26 MET) to reduce flash evaporator system (FES) water consumption. The radiator was later stowed prior to docking with the Mir.

The cabin was depressurized to 10.2 psia at 317:05:08 G.m.t. (00:16:37 MET). This allowed extravehicular activity (EVA) crewmembers to prepare for a contingency EVA in the event that the docking module was not successfully mated to the Orbiter docking system (ODS).

When the thermal impulse printer system (TIPS) was activated, it was nominally configured to receive data through the Ku-band system. When a test page was sent via the Ku-band, the printed page had lines missing. After initial troubleshooting failed to recover TIPS operation through the Ku-band system, the TIPS was successfully used when configured to receive through the S-band; however, in the S-band mode, the TIPS operates like a teleprinter and no longer had the graphics capability. Further troubleshooting isolated the problem to the front end processor (FEP) on the ground. A workaround was used that provided full TIPS capability.

Checkout of the remote manipulator system (RMS) was successfully completed, and a payload bay survey was performed using the RMS. Additionally, checkout of the extravehicular mobility units (EMUs) was successfully completed in preparation for a possible contingency extravehicular activity.

The OMS 4 maneuver occurred at 317:15:13:55.1 G.m.t. (01:02:43:12.1 MET). The maneuver, using both OMEs in straight feed, had a duration of 40 seconds and imparted a ΔV of 65.0 ft/sec. The OMS 5 maneuver occurred at 317:16:11:44.1 G.m.t. (01:03:41:01.1 MET). This 38-second firing used the left OME and imparted a ΔV of 31.3 ft/sec. Both firings had nominal performance.

The docking module was grappled at approximately 318:06:00 G.m.t. (01:17:29 MET) and unberthed from the Orbiter at approximately 318:06:40 G.m.t. (01:18:09 MET). It was then moved to the pre-install position, 12 inches above the ODS capture ring. The docking module was maneuvered to within five inches of the ODS ring in preparation for the thrusting sequence designed to force capture. Six reaction control subsystem (RCS) down-firing thrusters were fired at 318:07:16:53 G.m.t. (01:18:46:09 MET), and capture was achieved. Ring retraction occurred nominally with dual-motor operation, and the retraction was completed at 318:07:22 G.m.t. (01:18:51 MET). Hook actuation also occurred nominally with dual-motor operation. The hooks were closed at 318:07:24 G.m.t. (01:18:53 MET), completing the mating operation.

Prior to opening the ODS hatch, the crew reported that the airlock stowage bag on the ODS wall could not be removed due to two stuck actuating pins that prevented the removal of the mounting-attachment fitting system (Flight Problem STS-74-V-05). The bag was preventing the full opening of the hatch. Therefore, the contents of the ODS stowage bag were removed and placed into a launch-entry suit (LES) bag. Once the bag was emptied, the stowage bag drawstrings were drawn, and this compressed the bag and allowed the hatch to be opened without the removal of the bag. The stowage bag was utilized again at the end of the mission for stowage.

The ODS vestibule was pressurized to 10.2 psia by the Orbiter at 318:08:07 G.m.t. (01:19:36 MET) and leak-checked successfully. The ODS hatch was subsequently opened. The cabin repressurization to 14.7 psi was initiated at 318:09:19 G.m.t. (01:20:48 MET). The docking module hatch was opened at approximately 318:09:41 G.m.t. (01:21:10 MET).

The NC 4 rendezvous maneuver occurred at approximately 318:15:19 G.m.t. (02:02:48 MET). The maneuver lasted 21 seconds and yielded a ΔV of 5.0 ft/sec. RCS thrusters L3A and R3A were used primarily, with a minimal number of single pulses from the F3D, F3L, F4D, L1U, R1U and R3R thrusters.

At 318:20:02 G.m.t. (02:07:31 MET), all three fuel cell 3 substack differential voltage measurements shifted approximately 8 mV, with no significant load change on fuel cell 3 at the time. Additionally, the cell performance monitor (CPM) self-test signal, which had been indicating 48 mV, shifted to a self-test value of 56 mV. The value should be no more than 58 mV. Since the fuel cell was performing nominally, the FDA alarm was subsequently inhibited to prevent nuisance alarms. A precautionary main-B-to-main-C bus tie was established at approximately 319:15:46 G.m.t. (03:03:15 MET). The CPM was replaced during the postflight turnaround activities.

The port radiator was stowed and latched at 319:01:14 G.m.t. (02:12:43 MET) in preparation for the Mir docking.

The NC 5 (OMS 6) rendezvous maneuver, performed using the right OME, occurred at 319:01:53:04.5 G.m.t. (02:13:22:21.5 MET). The maneuver was 33 seconds in duration and imparted a ΔV of 28.0 ft/sec. The terminal phase initiation (TI) maneuver, performed using the left OME, occurred at 319:03:26:43.3 G.m.t. (02:14:56:00.3 MET). The TI maneuver lasted 9.4 seconds and imparted a ΔV of 8.6 ft/sec.

The Orbiter/Mir docking was initiated at 319:06:27 G.m.t. (02:17:56 MET). Ring retraction was initiated at 319:06:30 G.m.t. (02:17:59 MET) and was nominal with dual-motor operation. Hook actuation also occurred nominally with dual-motor operation. The hooks were closed at 319:06:35 G.m.t. (02:18:04 MET). Docking was completed with the ring reaching its final position at 319:06:36 G.m.t. (02:18:05 MET). The hatches were opened at 319:09:02 G.m.t. (02:20:31 MET). All docking mechanical and avionics systems performed nominally. Following hatch opening, the process of repressurizing the Orbiter/Mir mated unit to 14.62 psi was initiated.

After the Orbiter/Mir docking, the crew reported that a bad data cable existed between one of the hand-held light distance and ranging (LIDAR) units and one of the payload general support computers (PGSCs). This is an RS-232 LIDAR interface cable. There are two of these cables onboard, one for each hand-held LIDAR.

At 319:18:32:09 G.m.t. (03:06:01:26 MET), the power reactant storage and distribution (PRSD) subsystem oxygen manifold 1 isolation valve failed to close when commanded. The hydrogen manifold 1 isolation valve closed successfully. The hydrogen valve was subsequently reopened, and the hydrogen and oxygen manifold 2 isolation valves were closed. This same serial number valve failed to close on OV-105 during STS-49, STS-54, and STS-57. This valve successfully passed cryogenic screening with the valve attached to the valve panel at the NASA Shuttle Logistics Depot (NSLD) in October 1993. The valve cycled successfully during STS-66 and STS-71, as well as the first time it was commanded closed on this flight.

At approximately 319:19:22 G.m.t. (03:06:51 MET), during a data dump of operations (OPS) recorder 1, the ground was unable to lock-on the modulation on track 8 of the recorder. The tape was then played in both the forward and reverse directions, and data retrieval was unsuccessful. Additional data-recovery procedures were performed, and again the ground was unable to lock-on to the modulation on track 8. As a workaround, track 8 was not used for recording data for the remainder of the flight.

The RCS was used to support the mated Orbiter/Mir structural dynamics test at 320:05:26 G.m.t. (03:16:55 MET). Thrusters F4D, L3D, R3D, L1L were all pulsed once and F3D was pulsed twice. The thruster pulse data were nominal.

The ten contingency water containers (CWC) were filled with water and transferred to the Mir. The total water transfer to the Mir was approximately 993 pounds.

The repressurization of the Mir and Orbiter crew cabin to a total pressure of 15.40 psia and an oxygen partial pressure (PPO_2) of 3.85 psia was initiated at

321:06:54 G.m.t. (04:18:23 MET). At ODS hatch closure, the Orbiter cabin pressure was 15.34 psi with a PPO_2 level of 25.52 percent. Closure of the hatch was performed at 321:17:46 G.m.t. (05:05:15 MET). Vestibule depressurization was completed at 321:18:29:44 G.m.t. (05:05:59:01 MET) and required two minutes.

At 321:09:31 G.m.t. (04:21:00 MET), the flight crew reported that both the aft port and aft starboard payload bay floodlights were not illuminated. Current signatures on the mid main bus C were indicative of a payload bay floodlight remote power controller (RPC) current limiting and tripping. The aft port payload bay floodlight is powered by the mid main bus C.

Orbiter undocking from the Mir was completed at 322:08:15 G.m.t. (05:19:44 MET). All docking mechanical and avionics systems performed nominally. Primary RCS thrusters were used in the low-Z mode during the initial separation from the Mir. The primary RCS was also used for the separation maneuver. Performance was nominal. The Ku-band radar acquired and tracked nominally during the Mir separation and flyaround.

During several Public Affairs events using a camcorder, the image went black indicating a loss of power. The crew was notified, and the battery was replaced; however, the same problem occurred between five and seven minutes later. Initial indications were that the camcorder was being left in the "record pause" mode, which would result in the camcorder being powered off after seven minutes. Discussions with the crew revealed that this was not the case. The camcorder in use was not identified (two onboard).

An OMS 8 maneuver was performed, using the left engine, at 322:15:14:19.7 G.m.t. (06:02:43:36.7 MET). The firing lasted 47 seconds, yielding a ΔV of 41.7 ft/sec. An OMS 9 maneuver was initiated, using the right engine, at 322:15:58:03.5 G.m.t. (06:03:27:20.5 MET). The firing duration was 55.4 seconds and the ΔV was 49.2 ft/sec. Both firings were satisfactory.

APU 3 was started at 323:09:06:03.486 G.m.t. (06:20:35:20.473 MET) for the flight control system (FCS) checkout. Data review indicated that the FCS, APU and hydraulic subsystems performed nominally. APU 3 was run longer than normal (11 minutes 57.755 seconds) for verification of lubrication oil cooling from WSB 3. The maximum lubrication oil return temperature reached with controller A was 266 °F. This is within the specification for start of spray cooling, which is no greater than 275 °F. A slight over-cooling condition to 249 °F occurred before the steady-state temperature of 259 °F was reached. Spray cooling was observed for about 2.5 minutes before switching to the WSB 3 controller B as planned. Nominal steady-state cooling was observed on the WSB 3 controller B.

The Plume Impingement and Contamination (PIC) test [Development Test Objective (DTO) 829] was conducted at 323:11:34 G.m.t. (06:23:03 MET). Primary RCS thruster F3U was fired in two sets of ten 0.80 msec firings, and thruster F4D was fired twice, once after each F3U test. In addition, primary RCS thruster firings for the GLO experiment were performed between 323:18:41 G.m.t. (07:06:11 MET) and 323:19:14 G.m.t. (07:06:32 MET). Primary RCS thrusters L1L, L1U, L3D, R3R, R1U, R3D, F3L, and F4L were fired.

The RCS hot-fire was performed at 324:09:43 G.m.t. (07:21:12 MET). Each RCS thruster was fired twice. Analysis indicates that all thrusters performed nominally.

All entry stowage and deorbit preparations were completed in preparation for entry on the nominal end-of-mission landing day. The Ku-band antenna was stowed at 323:20:50:21 G.m.t. (07:08:19:38 MET). The RMS was stowed for entry, and the final power-down was completed at 323:21:16 G.m.t. (07:08:45 MET). The payload bay doors were successfully closed and latched at 324:13:20:56 G.m.t. (08:00:50:13 MET). The deorbit maneuver was performed at 324:15:58:43.2 G.m.t. (08:03:28:00.2 MET) on orbit 128 for Kennedy Space Center (KSC) Shuttle Landing Facility (SLF), and the maneuver was 233.7 seconds in duration with a ΔV of 434 ft/sec. Entry interface (400,000 ft) occurred at 324:16:30:03 G.m.t. (08:03:58:19 MET).

Entry was completed satisfactorily, and main landing gear touchdown occurred on SLF concrete runway 33 at 324:17:01:29 G.m.t. (08:04:30:46 MET) on November 20, 1995. The Orbiter drag chute was deployed at 324:17:01:32.4 G.m.t. and the nose gear touchdown occurred 5.6 seconds later. The drag chute was jettisoned at 324:17:02:06.7 G.m.t. with wheels-stop occurring at 324:17:02:25 G.m.t. The rollout was normal in all respects. The flight duration was 8 days 4 hours 30 minutes and 46 seconds. The APUs were shut down 18 minutes after landing.

SPACE STATION IMPLICATIONS, RECOMMENDATIONS AND LESSONS LEARNED

REACTION CONTROL SUBSYSTEM

Analysis of the RCS data revealed the following lessons learned in addition to those discussed in the STS-71 Space Shuttle Program Mission Report with respect to Mir and International Space Station docked operations.

1. RCS vernier thruster usage during STS-74 docking was significantly higher than seen during the STS-71 docking mission, based on the evaluation of the Advanced Thruster Life Analysis System (ATLAS). Although the totals are lower, on the average and based on the total docked time with the Mir, usage was actually higher than STS-71. This was the case in all four areas shown in the following table.

THRUSTER USAGE DATA COMPARISON

Flight	Thruster No.	Thruster Firings	Firing Time, seconds	Thermal Cycles	Flight Duration, hrs
STS-74	F5L	2,580	4,192	100	N/A
STS-74	F5R	2,458	5,224	131	N/A
STS-74	L5D	3,640	6,341	152	N/A
STS-74	L5L	2,073	3,833	86	N/A
STS-74	R5D	3,354	6,659	148	N/A
STS-74	R5R	2,267	4,283	116	N/A
STS-74 Totals		16,372	30,436	733	197
STS-71 Totals		19,907	32,327	840	223

For both missions, the number of firings was well within the 500,000-cycle certification life. The firing time on the aft down-firing thrusters was very marginal for the 125,000-second certified limit (~ 19-mission equivalent). A large number of long-duration firings (> 50 seconds) were noted on the aft down-firing thrusters for attitude maneuvering, some of which approached the 125-second duration limit for steady-state firings. Also, the high duty-cycles noted during attitude-hold operations required evaluation to determine if the 1,000-cycle per hour limit was exceeded. The STS-71 and STS-74 vernier usage continues to be evaluated to assess long-term effects on the hardware.

From a certified-life standpoint, concerns primarily exist with the chamber/nozzle damage which would require chamber replacement. Coating damage is primarily driven by the number of thermal cycles. While all vernier-usage parameters vary depending on mission profile and duration, average vernier mission thermal cycles based on the ATLAS evaluation of 63 previous missions were:

1. F5L and F5R thrusters - 42 thermal cycles/mission
2. L5D and R5D thrusters - 105 thermal cycles/mission
3. L5L and R5R thrusters - 47 thermal cycles/mission

With thermal cycles on the order of 1.3 to 3 times higher than average, the chamber wear-out rate would be expected to increase if future Mir and International Space Station (ISS) docked missions resulted in similar usage. This poses a significant spares risk to the Program, and this condition requires detailed evaluation by both Engineering and Logistics. If usage can be optimized (minimized) by better digital autopilot (DAP) models and/or primary RCS thruster usage, the vernier usage may be significantly reduced from that seen on STS-71 and STS-74 missions assuming future missions of similar duration.

3. Thermal issues continue to be a concern for future ISS missions where cold vernier thrusters and hot primary thrusters are expected. The NASA-JSC Structures and Mechanics Division has been tasked to investigate the temperature concerns.

FLIGHT CONTROL SYSTEM

Analysis of the flight control system operations and data lead to the following lessons learned.

1. Vernier RCS control and stability was satisfactorily demonstrated for Space Station payloads extended over the Space Shuttle nose.

2. Alternate primary RCS performance was demonstrated to provide acceptable control while minimizing loads.

3. Improved control performance was demonstrated with the new minimum-angle thruster selection for Space-Station sized payloads.

4. Updated thruster plume impingement models were satisfactorily verified using the aft down-firing vernier RCS thrusters.

5. The patch to re-enable acceleration filter inhibit eliminated the increased propellant consumption observed on STS-71.

COMMUNICATIONS AND TRACKING

Analysis of the communications and tracking data has lead to the following conclusions concerning Space Station operations.

1. The Space Shuttle Orbiter communications coverage profiles in the docked configuration and the planned attitudes were generated during the preflight period. The coverage profiles and the attitudes were provided to the Mission Operations Directorate personnel for planning purposes. Multipath effects due to the Mir structure were included to provide realistic predictions. Analysis predictions were also verified postflight with actual flight data to ensure the validity and pedigree of the results. This same analysis method is being used to determine the Orbiter coverage when docked with the International Space Station and vise versa. Refinement of the analysis method and tool is on-going with each Mir flight in preparations for the International Space Station support. Coverage and multipath analyses are planned for ISS missions.

ATMOSPHERIC REVITALIZATION PRESSURE CONTROL SYSTEM

STS-74 data for this system has revealed the same information that was reported in Lessons Learned shown in the STS-71 Mission Report.

THERMAL CONTROL SYSTEM

Analysis of the thermal control system (TCS) data from STS-74 has led to the following concerns:

1. The thermal effects from the Mir on the Orbiter hydraulic lines in the midfuselage and main landing gear tires were observed. The use of the Shuttle Thermal Evaluation Program (STEP) (Orbiter alone) analysis data for nose-Sun type attitudes will not reliably predict temperatures for the hydraulic lines and main landing gear tires. As a result, the negative effects from the presence of the International Space Station Alpha (ISSA) for nose-Sun type attitudes needs to be assessed for ISSA missions using detailed thermal math models.

2. Violation of the vernier RCS leak detection limit of 130 °F is expected even in low-beta ISSA missions. An operational workaround is required.

3. Data analysis during the flight showed that the APAS hardware thermo-optical properties provided by the suppliers was either inaccurate or insufficient or both. Prior to STS-76, a more complete survey of the flight unit is planned.

ORBITER DOCKING SYSTEM

Analysis of the docking system performance for both the docking and berthing procedures lead to the following implications and lessons learned for the ISS.

1. The berthing procedure used to install the DM onto the ODS worked very well and the analytical predictions had good correlation with flight data. This success provides confidence for the ISS assembly flight 2A where this same technique will be used to berth the U. S. Node onto the ODS, and then berth the Russian FGB onto the Orbiter/Node stack.

2. The docking system worked well and the analytical predictions correlated very well with flight data which provides confidence in the system and procedures for ISS.

3. For the second time, the crew and Orbiter demonstrated the ability to fly to the Mir very precisely, and this resulted in fairly benign contact conditions that were well within the docking system's ability to tolerate. The provides confidence for docking-related activities for the ISS.

4. Having flexibility to modify (non-real-time) the Post Contact Thrusting (PCT) sequence proved to be very useful. This feature allows tuning of the sequence to match the spacecraft mass properties and configuration to achieve good capture performance and minimize loads and post-capture dynamics. This will be very useful during the assembly of ISS as its mass properties and configuration change.

PAYLOADS

The mission objectives and joint requirements of the Phase 1 Program for the second mission of joint operations with the Russian Mir Station were completed satisfactorily. Approximately 275 resupply items were transferred from the Orbiter to the Mir, and 195 return items were transferred from the Mir to the Orbiter. The approximate weight of the transferred items to the Mir was 2132 lb. Included in the total that was transferred to the Mir was U. S and Russian consumables, science resupply items, and supplemental atmospheric gasses. The approximate weight of the return items transferred to the Orbiter was 816 lbm, and it consisted of U. S., Russian, and European Space Agency (ESA) items. A Risk Mitigation Experiment (RME) that was not performed was left on the Mir, and the experiment may be performed by the STS-76 crew in late March of 1996. In addition, the jointly developed DM, weighing 9,066 lbm, was successfully transferred from the Shuttle and mated to the Mir. The DM now provides a standard docking port on the Mir for the Shuttle and will facilitate future Shuttle docking missions as the Mir configuration is enhanced.

DOCKED ACTIVITIES

Docking Module

After the payload bay doors were opened, the DM systems were activated through the Remotely Operated Electrical Umbilical (ROEU) interface. The DM system data were transmitted to both the Mission Control Center-Houston (MCC-H) and MCC-Moscow (MCC-M) and evaluated by Russian and American specialists. All systems were operating as planned. On flight day 3, the DM was grappled by the RMS, deactivated, detached from the ROEU and lifted from the payload bay. The DM was maneuvered to a position above the ODS, and the crew prepared to join the DM to the ODS with the primary RCS thrusting procedure. Per the nominal timeline, the structural latches on the Androgynous Peripheral Assembly System (APAS) 2 and 3 achieved capture the first time the Orbiter fired the down-firing thrusters. Hard mating of the DM to the ODS was nominal. The DM was activated through the X-connector interface. After ODS and DM pressure checks were completed, the U. S. crew entered the DM to perform the tasks planned by both teams during preflight preparations. Russian specialists were prepared in MCC-M to assist the crew. The crew installed the air duct, removed the center-line camera, and disabled the negative pressure relief valve. The power switching box in the ODS was configured to operate the DM APAS 1. All DM systems operated nominally. On flight day 4, the crew maneuvered the Orbiter and the DM to dock with the Mir Space Station. Docking was successfully achieved between APAS 1 and the Krystal mechanism. After the U. S. crew removed the centerline camera and bracket and stowed the window fan, the U. S. and MIR crews opened the DM and Mir hatches to begin the joint mission activities. That same day, the joint DM power transfer procedures were performed and control of the DM was formally transferred to the Mir. The Orbiter configured the ODS switch box to control the APAS 3. Undocking between the Orbiter and the Mir occurred on flight day 7 at 322:08:13:24 G.m.t. (05:19:42:41 MET). The DM remains as the permanent Orbiter docking port on the Mir Space Station.

Science Resupply

Transfer and stowage of all Mir 21/NASA 2 U. S. science resupply items on the Mir and the transfer and stowage of all ambient science return items on the Orbiter were accomplished as planned in accordance with the pre-mission agreements. In addition, several changes to the transfer list were successfully implemented by the crew following approval by the Space Shuttle Program. The final transfer tracking log was updated and sent to KSC to assist in the destowage of the vehicle. The final science transfer tally is as follows:

a. Science Resupply to Mir - 100 items;
b. U. S. Science Return - 80 items;
c. Russian Return - 67 items; and
d. European Space Agency - 48 items.

Onboard Mir, the thermal electric freezer (TEF) lids were replaced and verified to be functioning nominally. Following transfer of frozen samples to the Orbiter, the Mir Thermal Electric Holding Freezer (TEHOF) was defrosted. Video of the Mir treadmill and ergometer was also accomplished by the Orbiter crew. The video will be used by principal investigators to identify potential locations for future U. S science hardware. A space ergometer mounting pin and a set of ergometer shoes were also transferred to the Mir for use during Mir 21 science activities. A water sample was taken from the Mir potable water tank for analysis by ground personnel. In addition, samples from the Mir EDV water containers, consisting of Mir humidity separator condensate, were obtained to assess the recent ethylene glycol leak which occurred on the Mir.

GLO EXPERIMENT/PHOTOGRAMMETRIC APPENDAGE STRUCTURAL DYNAMICS EXPERIMENT PAYLOAD

The Photogrammetric Appendage Structural Dynamics Experiment (PASDE) successfully completed all primary mission objectives, including recording the dynamic response of the Mir Kvant 2 Module solar array through Orbiter/Mir docking, and during primary RCS thruster-firing activities and terminator crossings. PASDE supplemented these activities with several secondary science data collections including a predocking RMS maneuver, an additional primary RCS thruster firing sequence, Orbiter maneuvers, and solar array tracking slews. Recorded video data were analyzed postflight to determine the structural dynamics of the Mir solar panels. The PASDE's photogrammetric method, if proven to work efficiently through the STS-74 data analysis, will be used for structural verification of the International Space Station solar panels.

The PASDE instruments were powered up and operation of all cameras and tape recorders was verified within 1.5 hours after the payload bay doors were opened. On flight day 2, a calibration using the RMS in a predetermined position verified the camera angles prior to the first data collection period. On flight day 4, the highest priority mission objective, which was recording the deflections of the Kvant module solar array during the Orbiter-Mir docking, was accomplished. PASDE also recorded the motions of the Kvant module solar array during scheduled primary RCS thruster firings. The primary RCS test was repeated because of a checklist error that placed the RMS in a position that blocked two PASDE camera fields-of-view during the first test. On flight day 6, the PASDE successfully completed the primary objectives of that payload, and also gained some additional science data for the secondary objectives. PASDE recorded two terminator events to investigate how the structural stability of array structures are affected by the thermal effects experienced during orbital sunrises and sunsets. Minor blotches were noted in the video images, and these were determined to be internal to the PASDE cameras and did not impact the mission objectives. The PASDE instrument performed flawlessly throughout the mission and was powered down prior to undocking and configured for entry. The PASDE recorded 114 of a possible 115 minutes of data collection.

The GLO-4 experiment was also verified following power-up and checkout shortly after payload bay door opening. The GLO-4 was modified for this mission to include a cold cathode pressure gauge, and this enhancement measured pressure variations in the cargo bay. These data will aid in the understanding of the interaction between the spacecraft environment and the atmospheric environment during thruster firings and while docked to the Mir. The GLO also successfully recorded Earth limb, airglow, stellar occultation's, extensive night-glow, and OMS and primary RCS thruster firings. A change in altitude from 215 to 185 nmi provided GLO with plume fluorescence data at a different altitude to aid in the understanding of the orbital environment optical effects.

On flight day 8, the GLO low-light TV camera iris failed closed and attempts to recover the use of the camera were unsuccessful. This loss of video did not seriously affect the quality of data collection as other Orbiter cameras were used as a back-up to provide video data. During sleep periods while docked with the Mir, the GLO instrument was placed in standby to avoid overheating. Data were obtained on two additional tests of a primary GLO experiment, the primary RCS fluorescence experiment, and resulted in a 100-percent successful mission for this experiment.

IMAX CARGO BAY CAMERA

All of the IMAX cargo bay camera (ICBC) film was exposed with no anomalies recorded. The main objective of this mission was to record DM unberthing, DM installation, and Shuttle/Mir docking and undocking, and all of these activities were successfully accomplished.

SHUTTLE AMATEUR RADIO EXPERIMENT-II

All planned Shuttle Amateur Radio Experiment-II (SAREX-II) contacts on STS-74, including one test pass, five school contacts (Crown Point, IN., Lake Heights, IL., Pocatello, ID., Norwalk, CT., and San Jose, CA.), and five personal contacts were completed. During these contacts, 3175 people were in attendance with rebroadcasts to local communities. Five television stations and ten newspapers covered the contacts.

Many amateur radio operators also reported making contact with the Orbiter; the SAREX-II team estimates as many as 100 contacts per flight day (over 500 for the flight). The crew operated from the Mir radio while docked, and the very high frequency (VHF) radio using the payload bay antenna onboard the Orbiter while undocked.

RISK MITIGATION EXPERIMENTS

Five Risk Mitigation Experiments (RMEs) were performed on the STS-74 mission. The following paragraphs discuss each RME.

RME 1301- Mated Shuttle and Mir Structural Dynamics Test - RME 1301 was performed shortly after docking to confirm the capability of the alternate digital autopilot (ALT DAP) to control the mated Orbiter/Mir configuration. Additional primary RCS thruster firings were performed in support of the PASDE. The Russians confirmed their acceptance of using ALT DAP should the vernier RCS fail.

RME 1305 - Assessment of Mir Space Station Sound Environment - RME 1305 was set up shortly after docking to collect data on the noise environment at several locations inside the Mir. These data were analyzed postflight for potential impact to hardware development for the International Space Station.

RME 1306 - Mir Wireless Network Experiment - RME 1306 was not performed. Extensive technical discussions with the Russians did not result in an agreement for operation during the available docked time. The Mir Wireless Network Experiment (WNE) was left onboard the Mir and may be operated during the next joint docking mission (STS-76).

RME 1308 - Photogrammetric Appendage Structural Dynamics Experiment - The PASDE was part of the GPP payload and is discussed in that paragraph of this report.

RME 1310 - Shuttle/Mir Alignment Stability Experiment - RME 1310 provided state-vector data from both the Orbiter and Mir while in the docked configuration. These data were analyzed postflight to determine the stability of the stacked configuration.

ORBITER DOCKING SYSTEM

The Orbiter Docking System (ODS) performance was nominal, and no in-flight anomalies were identified. The ODS carried a new Androgynous Peripheral Docking System (APDS) that had been modified compared to the STS-71 APDS with the addition of four interface connectors. The ODS also carried a Russian-built connector switching mechanism (CSM) mounted on the truss assembly. It was used to transfer avionics functions from the ODS APDS to the DM APDS once the DM was attached to the ODS.

During the first phase of the mating operations that occurred on flight day 3, the APDS demonstrated the ability to berth at the docking interface. The RMS unberthed and maneuvered the DM to position the docking interface at a separation of approximately five inches from the extended capture ring of the ODS APDS. The RMS was then placed in the test mode (free drift) so it would not resist the docking mechanism alignment during the berthing process. Once the alignment was verified, the crew initiated a thrusting sequence to gently push the Orbiter toward the DM and force the docking interfaces together to achieve capture. Once capture was achieved, the APDS completed the mating process by attenuating the relative motion, retracting the capture ring and then closing the structural hooks to complete the normal docking procedure. Data obtained during the berthing phase of the mission compared well with the preflight analysis that was performed for verification of the procedure. The success of this phase of the mission and the very good analytical correlation's provide confidence for the ISSA assembly 2A where the same technique will be used.

The docking phase of the mission that occurred on flight day 4 was nominal. The main difference between this docking procedure and the STS-71 procedure was that the docking interface was mounted on top of the DM, approximately 15 feet outside the payload bay, and this made viewing the docking interface more difficult. To compensate for this condition, the RMS was positioned such that its camera provided a good view of the docking interface as the docking occurred. The APDS was powered and commanded from the Orbiter using the Russian-built aft flight panel, and the nine avionics boxes which are mounted in the bottom of the airlock. After the DM was installed onto the ODS, the Russian-built CSM was used to switch power command and control from the ODS APDS to the APDS on top of the DM. Once the switching was completed, the avionics functions traveled through four ODS APDS interface connectors and along cables on the DM to reach the DM APDS.

The actual docking occurred on November 15, with the ODS being powered up at 319:05:53:47 G.m.t. (02:17:23:04 MET). The docking contact conditions were well within the allowable limits. The closing velocity was very near the targeted 0.1 ft/sec, and the misalignments were small. Post-contact thrusting (PCT) was initiated with approximately two inches of separation. The PCT used for this mission was modified from STS-71 to compensate for the large mass properties change. Capture occurred at 319:06:27:40 G.m.t. (02:17:56:57 MET). Docking loads were reconstructed from flight data and showed a maximum axial load of 850 kg, compared to an allowable of 1900 kg.

The ODS avionics activated the automatic docking sequence after receiving the initial capture signal. The electromagnetic dampers were activated at 5 seconds after capture and remained on for 30 seconds. The ring-extend command occurred at 60 seconds after capture. The crew depressed the "Power On" switch to interrupt the automatic sequence, as planned, to allow further damping. After the ring alignment signal was received, the crew initiated the ring-in command to drive the ring to the final position. The structural hooks were activated with the ready-to-hook signal and closed within about 2.5 minutes. Docking was completed at 319:06:36:14 G.m.t. (02:18:05:31 MET), and the normal system pressurization followed.

At the end of the docked phase of the mission, the structural hooks were opened after the vestibule was depressurized. Once open, four spring-loaded plungers separated the two spacecraft at a low velocity. Unlike STS-71, the Orbiter's predicted separation rate correlated very well with the measured values. Undocking was completed at 322:08:15:44 G.m.t. (05:17:45:01 MET).

VEHICLE PERFORMANCE

The overall performance of all elements of the vehicle was satisfactory with only five Orbiter in-flight anomalies defined. The following paragraphs provide a more detailed discussion of individual subsystem performance as well as the in-flight anomalies.

SOLID ROCKET BOOSTERS

All Solid Rocket Booster (SRB) systems performed as expected. The SRB prelaunch countdown was normal, and no SRB Launch Commit Criteria (LCC) or Operational Maintenance and Requirements and Specification Document (OMRSD) violations occurred. No in-flight anomalies were noted from the data review.

Both SRBs were successfully separated from the External Tank (ET) at T+123.004 seconds, and reports from the recovery team indicate that the deceleration subsystems performed as designed. Both SRBs were returned to Kennedy Space Center for disassembly and refurbishment.

REUSABLE SOLID ROCKET MOTORS

All Reusable Solid Rocket Motor (RSRM) systems performed satisfactorily. Power-up and operation of all igniter and field joint heaters was accomplished routinely. All RSRM temperatures were maintained within acceptable limits throughout the countdown. For this flight, the low-pressure heated ground purge in the SRB aft skirt was used to maintain the case/nozzle joint temperatures within the required LCC ranges. At T-15 minutes, the purge was changed to high pressure to inert the SRB aft skirt.

Data indicate that the flight performance of both RSRMs was well within the allowable performance envelopes. The performance was typical of that observed on previous flights, and within the contract end item (CEI) specification limits. The RSRM propellant mean bulk temperature (PMBT) was 75 °F at liftoff. The maximum trace shape variation of pressure vs. Time was calculated to be a very nominal 1.4 percent at liftoff plus 72 seconds (left motor), and 1.1 percent at liftoff plus 69.5 seconds (right motor). The trace shape variation for both motors was well within the 3.2 percent allowable limit.

Field joint heaters operated for a total of 25 hours, which includes operation during the scrubbed launch attempt. Power was applied to the igniter heating elements an average of 36 percent of the time during the LCC time frame.

The igniter joint heaters operated for 23 hours 27 minutes total including the scrubbed launch attempt. Power was applied to the igniter joint heating elements an average of 52 percent during the LCC time frame.

The aft skirt purge operated for 24 hours 30 minutes and the nozzle/case joint temperatures in the aft skirt were maintained within the minimum LCC limits. The calculated flex bearing mean bulk temperature was 83 °F. The following table shows the significant propulsion parameters from the flight.

RSRM PROPULSION PERFORMANCE

Parameter	Left motor, 74 °F		Right motor, 74 °F	
	Predicted	Actual	Predicted	Actual
Impulse gates				
I-20, 10^6 lbf-sec	66.33	66.27	66.22	66.23
I-60, 10^6 lbf-sec	176.53	176.63	176.30	176.52
I-AT, 10^6 lbf-sec	297.20	296.52	297.23	296.05
Vacuum Isp, lbf-sec/lbm	268.6	268.0	268.6	268.4
Burn rate, in/sec @ 60 °F at 625 psia	0.3694	0.3705	0.3690	0.3700
Burn rate, in/sec @ 81 °F at 625 psia	0.3734	0.3745	0.3730	0.3740
Event times, seconds[a]				
Ignition interval	0.232	N/A	0.232	N/A
Web time[b]	108.7	108.2	108.9	108.5
50 psia cue time	118.4	118.2	118.6	118.1
Action time[b]	120.5	120.4	120.7	120.5
Separation command	123.5	123.0	123.5	123.0
PMBT, °F	75	75	75	75
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	3.0	2.8	3.4
Tailoff Imbalance Impulse differential, Klbf-sec	Predicted		Actual	
	N/A		344.7	

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 ET propellant loading and flight operations were met satisfactorily, and the performance of the subsystems was excellent. All ET electrical equipment and instrumentation operated satisfactorily. The ET purge and heater operations were monitored and all performed properly. No ET LCC or OMRSD violations were identified.

Typical ice/frost formations were observed on the ET during the countdown. No ice or frost were observed on the acreage areas of the ET. Normal quantities of ice or frost were present on the liquid oxygen (LO_2) and liquid hydrogen (LH_2) feed-lines and on the pressurization line brackets, and some frost or ice was present along the LH_2 protuberance air load (PAL) ramps. These observations were acceptable based on NSTS 08303. The ice/frost Red Team reported that no anomalous thermal protection system (TPS) conditions existed. The umbilical mounted camera film showed successful performance of the redesigned jack-pad closeouts.

The ET pressurization system functioned properly throughout engine start and flight. The minimum LO_2 ullage pressure experienced during the ullage pressure slump was 13.4 psid.

ET separation occurred as planned with the postflight predicted ET entry impact point 19 nmi. Up-range of the preflight prediction.

SPACE SHUTTLE MAIN ENGINE

All Space Shuttle main engine (SSME) parameters appeared to be normal throughout the prelaunch countdown and were typical of prelaunch parameters observed on previous flights. Engine ready was achieved at the proper time; all LCC were met; and engine start and thrust buildup were normal.

Flight data indicate that SSME performance during main-stage, throttling, shutdown, and propellant dumping operations was normal. High pressure oxidizer turbopump (HPOTP) and high pressure fuel turbopump (HPFTP) temperatures were well within specification throughout engine operation. The specific impulse (Isp) was rated as 452.29 seconds based on trajectory data. Space Shuttle main engine cutoff (MECO) occurred at T+512.6 seconds after engine start. No in-flight anomalies or significant problems were noted during the countdown or flight.

SHUTTLE RANGE SAFETY SYSTEM

The Shuttle Range Safety System (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 were turned off at the appropriate times. All SRSS measurements indicated that the system operated as expected throughout the countdown and flight. No in-flight anomalies were noted from the data analysis.

As planned, the SRB S&A devices were safed, and the SRB system power was turned off prior to SRB separation. The ET system remained active until ET separation from the Orbiter.

ORBITER SUBSYSTEMS PERFORMANCE

Main Propulsion System

The overall performance of the main propulsion system (MPS) was nominal with no in-flight anomalies identified. The LH_2 loading was performed as planned with no stop-flows or reverts. The LO_2 loading experienced a revert because of the failure of the primary facility liquid oxygen pump. The failure was caused by an over-voltage condition and lasted for 18 minutes until the backup pump was brought on-line. No OMRSD or LCC violations were noted during the countdown.

Throughout the period of preflight operations, no significant hazardous gas concentrations were detected. The maximum hydrogen concentration level in the Orbiter aft compartment was approximately 120 ppm, and it occurred shortly after the start of the fast-fill process. This concentration level compares favorably with previous data from 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 0.004 percent for LH_2 and 0.004 percent for LO_2. These values are well within the required accuracy of $\pm$ 0.37 percent for the LH_2 and 0.43 percent for the LO_2.

Ascent MPS performance was completely nominal with no in-flight anomalies identified. Data indicate that the LO_2 and LH_2 pressurization systems performed as planned, and that all net positive suction pressure (NPSP) requirements were met throughout the flight. The gaseous hydrogen flow control valve performance was nominal. The manifold repressurization for entry was satisfactory with helium usage totaling 59.3 lbm.

The gaseous oxygen (GO_2) fixed orifice pressurization system performed as predicted. Reconstructed data from the SSME and MPS parameters closely matched the actual ET ullage pressure measurements. The minimum LO_2 ullage pressure experienced during the period of ullage pressure slump was 13.43 psid.

STS-74 was the first flight of the gaseous helium pressurization system modifications. The manifold was reoriented and new flow control valves were installed during the STS-74 flow. All three flow control valves performed nominally. These valves are being removed during the STS-76 flow as part of the second phase of the gaseous helium pressurization system modification during which new lines and filters will be installed. Helium system performance and pneumatic helium systems operated nominally.

Reaction Control Subsystem

The reaction control subsystem (RCS) performed nominally throughout all phases of the STS-74 mission with no anomalies identified. A total of 4,840 lbm of propellants were used from the RCS tanks during the mission. In addition, RCS interconnect to the orbital maneuvering subsystem (OMS) provided 3,013.3 lbm (23.26 percent) of OMS propellants for RCS use.

Docking with the Mir was supported with satisfactory RCS thruster performance. While docked with the Mir, the RCS vernier thrusters provided the primary means of attitude control. Planned operations while docked also were supported with satisfactory performance. These operations included the Structural Dynamics test, the Risk Mitigating Experiment (RME) 1301 performance, and the Shuttle/Mir Structural Dynamics test. Also, the RCS was used to perform the undocking and fly-around maneuvers.

Orbital Maneuvering Subsystem

The orbital maneuvering subsystem (OMS) was used for a total of nine maneuvers during the STS-74 mission, and no in-flight anomalies were identified. The left OMS engine was fired for 499.6 seconds and the right OMS engine was fired for 539.8 seconds. A total of 23,209.4 lbm of OMS propellant were consumed during the mission; and of this total, the RCS used 3,013.3 lbm (23.2 percent) during interconnect operations. The table on the following page lists all of the OMS maneuvers and the pertinent data concerning each maneuver.

Power Reactant Storage and Distribution Subsystem

The power reactant storage and distribution (PRSD) subsystem performed nominally throughout the mission with one in-flight anomaly recorded. The consumables remaining at landing would have provided a mission extension capability of 116 hours at an average power level of 15.9 kW. A total of 2296 lbm of oxygen and 271 lbm of hydrogen was consumed during the mission. Oxygen supplied for environmental control (82 lbm) and to resupply the Mir (59 lbm) totaled 141 lbm.

OMS FIRINGS

OMS firing	Engine	Ignition time, G.m.t./MET	Firing duration, seconds	ΔV, ft/sec
OMS-2	Both	316:13:12:35.0 G.m.t. 00:00:41:52.0 MET	131.4	213.0
OMS-3	Right	316:15:30:19.9 G.m.t. 00:02:59:36.9 MET	46.2	37.6
OMS-4	Both	316:15:18:55.1 G.m.t. 01:02:48:12.1 MET	40.0	65.0
OMS-5	Left	316:16:11:44.1 G.m.t. 01:03:41:01.1 MET	38.0	31.3
OMS-6	Right	319:01:53:04.5 G.m.t. 02:13:22:21.5 MET	33.0	28.0
OMS-7	Left	319:03:26:43.3 G.m.t. 02:14:56:00.0 MET	9.4	8.6
OMS-8	Left	322:15:14:19.7 G.m.t. 06:02:43:36.7 MET	47.0	41.7
OMS-9	Right	322:15:58:03.5 G.m.t. 06:03:27:20.5 MET	55.4	49.2
Deorbit	Both	324:15:58:43.2 G.m.t. 08:03:28:00.2 MET	233.7	434.0

At 319:18:32:09 G.m.t. (03:06:01:26 MET), the PRSD subsystem oxygen manifold 1 isolation valve failed to close when commanded (Flight Problem STS-74-V-02). After the first failed attempt, the switch was held in the CLOSE position for 10 seconds with no valve response. The hydrogen manifold 1 isolation valve closed satisfactorily. The hydrogen valve was subsequently reopened, and the hydrogen and oxygen manifold 2 isolation valves were closed. This same serial number valve failed to close on OV-105 during STS-49, STS-54, and STS-57. This valve successfully passed cryogenic screening with the valve attached to the valve panel at the NSLD in October 1993. The valve cycled successfully during STS-66 and STS-71, as well as the first time it was commanded closed on this flight. The valve also closed satisfactorily on the ground during postlanding operations.

The hydrogen manifold 1 isolation valve, S/N CRP0020, gave a false-close indication at 324:12:39:46 G.m.t. (08:00:09:03 MET), setting off an FDA alarm. The crew reported that the valve went closed on its own and that no one touched the switch. The valve was commanded open without any change in the position indicator. The malfunction procedure was followed, and the switch was first commanded closed and then open. The position indicator immediately changed to open at 324:12:44:38 G.m.t. (08:00:13:55 MET). The two hydrogen manifold pressure curves did not diverge on the downward slope of the pressure cycle during the five-minute period that the indication was closed, confirming that this was a false-closed indication. The same anomaly occurred on STS-71, the last flight of this vehicle, when six false-closed indications occurred.

Fuel Cell Powerplant Subsystem

The fuel cell powerplant (FCP) subsystem performed nominally. The fuel cells generated 3120 kWh of electrical energy at an average power level of 15.9 kW and 521 amperes. The fuel cells consumed 271 lbm of hydrogen and 2155 lbm of oxygen and produced 2426 lbm of water. The actual fuel cell voltages at the end of the mission were 0.10 volt above predicted for fuel cells 1 and 2, and 0.15 volt above the predicted for fuel cell 3. The overall performance degradation for the entire mission was 0.10 volt for fuel cell 1 and 0.15 volt for fuel cells 2 and 3. Fuel cell 1 (S/N 117) was removed and replaced since the performance of this fuel cell is close to the end-of-life curve as it had 2298 operational hours when shut down at the end of the mission. One in-flight anomaly was noted, and it did not impact the mission.

At 318:20:02 G.m.t. (02:07:31 MET), all three fuel cell 3 substack differential voltage measurements shifted approximately 8 mV, and there was not a significant load change on fuel cell 3 at the time (substack 1 shifted down and substacks 2 and 3 shifted upward). Additionally, the cell performance monitor (CPM) self-test signal, which had been indicating 48 mV, shifted to a self-test value of 56 mV (Flight Problem STS-74-V-02). The value should be no more than 58 mV. Since the fuel cell was performing nominally, the FDA alarm was subsequently inhibited to prevent nuisance alarms. A precautionary main-B-to-main-C bus tie was established at approximately 319:15:46 G.m.t. (03:03:15 MET). The CPM will be replaced during the postflight turnaround activities.

The fuel cell 2 hydrogen flow-meter was biased low. This flow-meter was installed on this fuel cell in September of 1989, and it flew the first five flights of OV-105 with no bias. The fuel cell was sent to the vendor after STS-61 because of a diagnostic test anomaly. During the acceptance test procedure (ATP) at the vendor, the output of the flow-meter was detected to be biased low and exceeded the error limits. A waiver was written on this component and the fuel cell was placed in the spares inventory. The fuel cell was installed in the OV-104 vehicle following the STS-66 mission and was flown with the low bias on STS-71. This condition did not impact operations as the instrument provides a gross leak detection capability as well as confirmation of purge operations.

Auxiliary Power Unit Subsystem

The auxiliary power unit (APU) subsystem performed nominally. The following table shows the APU's by serial number, position, run time, fuel consumption and flight phase.

APU RUN TIMES AND FUEL CONSUMPTION

Flight phase	APU 1 (S/N 208)		APU 2 (S/N 406)		APU 3 (S/N 310)	
	Time, min:sec	Fuel consumption, lb	Time, min:sec	Fuel consumption, lb	Time, min:sec	Fuel consumption, lb
Ascent	25:58	57	26:03	57	26:10	59
FCS checkout					11:59	26
Entry[a]	61:57	114	85:36	142	62:06	115
Total	87:55	171	111:39	199	100:15	200

[a] The APUs ran for approximately 18 minutes after landing.

One in-flight anomaly was noted during ascent when the APU 2 fuel pump inlet pressure operated erratically and repeatedly failed to 0 psia for a 1-minute 15-second period after which the measurement operated properly for the rest of the mission (Flight Problem STS-74-V-01).

All of the requirements of Development Test Objective (DTO) 414 - APU Shutdown Test have been fulfilled, and the DTO was not performed on this flight nor will it be on any future flight of any vehicle.

Hydraulics/Water Spray Boiler Subsystem

The hydraulics/water spray boiler (WSB) subsystem performance throughout the mission was nominal. No in-flight anomalies were identified; however, two WSB problems occurred during ascent, and are discussed in the following paragraphs.

WSB system 3 experienced a moderate under-cooling condition during which the temperature reached 279 °F prior to the start of spraying. This under-cooling condition was similar to those seen on other flights. The water feed-line electric heater modification was made on all three WSBs prior to this flight to mitigate spray-bar freeze-up. Also, STS-74 was the second flight in which an electric heater was powered and an under-cooling condition was observed.

WSB system 2 experienced an over-cooling condition during which the temperature decreased from 250 °F to approximately 195 °F after the start of cooling. Control was switched from controller 2A to 2B; however, data show that spraying had already stopped when the switchover was made. Water usage was nominal throughout ascent.

APU 3 was started at 323:09:06:03.486 G.m.t. (06:20:35:20 MET) for the flight control system (FCS) checkout. Data review indicated that the FCS, APU and hydraulic subsystems performed nominally. APU 3 was run longer than normal (total of 11 minutes 57.755 seconds) for verification of lubrication oil cooling from WSB 3. The maximum lubrication oil return temperature reached with controller A was 266 °F. This is within the specification for start of spray cooling, which is no greater than 275 °F. A slight over-cooling condition to 249 °F occurred before the steady-state temperature of 259 °F was reached. Spray cooling was observed for about 2.5 minutes before switching to the WSB 3 controller B as planned. Nominal steady-state cooling was observed on the WSB 3 controller B.

The hydraulic system 2 pressure decreased to 1535 psia after APU 2 shutdown following ascent, and the pressure then rose to above 2400 psia after which it stabilized at approximately 2460 psia. The system 2 pressure then dropped as system 3 pressure decreased approximately 5 seconds later. This event is similar to an explained anomaly that occurred during STS-54 ascent in which back-driving of a speed-brake PDU motor occurred. Since the speed-brake PDU motor brake was not suspected to be failed, the back-driving event did not create any flight issues.

Postlanding, the WSB 3 regulator outlet pressure transducer operated erratically (Flight Problem STS-74-V-06). Intermittent pressure fluctuations were noted from 0 psia to 39.9 psia and back to 0 psia. The pressure transducer was checked during turnaround operations, and the erratic operation was duplicated.

Electrical Power Distribution and Control Subsystem

The electrical power distribution and control (EPDC) subsystem performed satisfactorily throughout the mission. No in-flight anomalies or problems were noted.

Environmental Control and Life Support System

The environmental control and life support system (ECLSS) performed satisfactorily throughout the mission.

The active thermal control system (ATCS) performance was satisfactory throughout the mission. Flash evaporator system B was used prior to docking with the Mir to support Mir water transfer from supply water tanks A and B. There were no actively cooled payloads in the payload bay, and, as a result, both Freon loops remained in the interchanger position for the entire mission. The port radiator was deployed at 316:13:57 G.m.t. (00:01:26 MET) to reduce flash evaporator system (FES) water consumption. The radiators were stowed prior to docking.

The radiator coldsoak provided cooling during entry through touchdown plus 11 minutes when ammonia system A was activated using the secondary controller at 324:17:11 G.m.t. (08:04:41 MET). Ammonia system A operated for 29 minutes when it was turned off in preparation for ground-cooling connection.

The atmospheric revitalization system (ARS) air and water coolant loops performed normally.

At 318:00:43:39 G.m.t. (01:12:12:56 MET), the pump for WCL 1 was commanded on by the GPC for a water loop cycle. The WCL 1 pump runs 6 minutes every 4 hours. The crew was asleep at the time of this cycle and the cabin heat-load was low. As a result, WCL 2 was flowing at only 660 lb/hr to maintain the WCL 2 pump outlet temperature at 63 °F. When the WCL 1 pump was turned on, the WCL 1 water was warmer than that in WCL 2, and as a result, temperature transients were induced throughout WCL 2. The WCL 2 pump outlet temperature initially increased to 64.7 °F during this transient, and the controller increased the WCL 2 interchanger flow-rate to 760 lb/hr to bring the temperature back down. With this increase in flow and other transients in the loop, the WCL 2 pump outlet temperature decreased to 60.4 °F and caused the controller to decrease the interchanger flow to approximately 490 lb/hr, which was below the 550 lb/hr FDA alarm limit. The resulting alarm woke the crew. The WCL system performed nominally, and this phenomenon was not considered a problem other then being a nuisance alarm.

The carbon dioxide partial pressure was maintained below 7.96 mmHg. The cabin air temperature and relative humidity peaked at 83.0 °F and 51.2 percent, respectively. Avionics bays 1, 2, and 3 air outlet temperatures as well as water coldplate temperatures were maintained within satisfactory limits throughout the mission.

The atmospheric revitalization pressure control system (ARPCS) performed normally throughout the flight. The cabin was depressurized to 10.2 psia at 317:05:08 G.m.t. (00:16:37 MET) using the airlock depressurization valve. This allowed EVA crewmembers to prepare for a contingency EVA in the event that the DM had not successfully mated to the ODS. However, the DM/ODS mating was satisfactory and no EVA was required.

After the DM was installed on the ODS, the ODS vestibule was pressurized to 10.2 psia by the Orbiter at 318:08:07 G.m.t. (01:19:36 MET) and leak-checked successfully. The pressure was then equalized between the Orbiter and DM at

14.68 psia at 318:09:19 G.m.t. (01:20:48 MET). After docking with the Mir, the DM/Mir hatch equalization valves were opened and the Mir and Shuttle volumes were equalized at a total pressure of 13.20 psia. The docking module hatch was opened at approximately 318:09:41 G.m.t. (01:21:10 MET). After the Mir transfer hatches were opened, the entire Shuttle/Mir volume pressure was raised to 14.62 psia using the Shuttle ARPCS. Total oxygen and nitrogen consumables transferred to the Mir was 44.16 lb of nitrogen and 58.97 lb of oxygen. The nitrogen was used for Mir pressurization, and the oxygen was used for the additional crew metabolic consumption during the docked phase and for raising the total pressure and PPO_2 of the Shuttle/Mir. The repressurization of the Mir and Orbiter crew cabin to a total pressure of 15.40 psia and an PPO_2 of 3.85 psia was initiated at 321:06:54 G.m.t. (04:18:23 MET). At ODS hatch closure [321:17:46 G.m.t. (05:05:15 MET)], the Orbiter cabin pressure was 15.34 psi with a PPO_2 level of 25.52 percent. Vestibule depressurization was completed at 321:18:29:44 G.m.t. (05:05:59:01 MET) and required two minutes.

The supply water system performed normally throughout the mission. Supply water was managed through the use of the FES, the overboard dump system, and water transfer to the Mir. One supply water dump was performed at a rate of 1.73 percent/minute (2.858 lb/min). The higher-than-normal dump rate resulted from the simultaneous FES operations. A single burp was seen following the dump, and this was caused by the purge assembly not being used at that time. The supply water dump line temperature was maintained between 67 and 99 °F throughout the mission with the operation of the line heater. The string A heaters experienced a dithering thermostat, as expected from the previous flight data.

Ten contingency water containers (CWCs) were used for Mir water transfer. Each CWC fill required approximately 25 minutes to complete with a total of 993 lb of water transferred in the 10 CWCs to the Mir. Five CWCs had only silver biocide added, while the other five had silver biocide and minerals.

Waste water accumulated at the predicted rate. Four waste water dumps were performed at an average rate of 1.91 percent/minute (3.16 lb/min). The waste-water dump-line temperature was maintained between 55 and 75 °F throughout the mission. The vacuum vent line temperature was maintained between 58 and 76 °F, with the vacuum vent nozzle maintained between 88 and 185 °F.

The waste collection system performed normally throughout the mission.

Smoke Detection and Fire Suppression Subsystems

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

Airlock Support System

The airlock support system performed normally with no problems identified. The active system monitor parameters indicated normal outputs throughout the flight. The airlock depressurization valve was used to depressurize the cabin from 14.7 psia to 10.2 psia should a contingency EVA have been required in support of the DM being docked with the ODS. After the DM was docked to the ODS, the external airlock-to-vestibule hatch equalization valve was used to equalize the DM and Space Shuttle habitable volume pressures.

Avionics and Software Support Subsystems

The integrated guidance, navigation and control subsystem performed nominally during all phases of the mission.

An "I/O ERR CRT 1" fault message was annunicated by the guidance, navigation and control (GNC) general purpose computers at 322:08:03 G.m.t. (05:19:32 MET). The crew reported no anomalous indications on the cathode ray tube (CRT) 1 other than the fault message. A explanation of this condition is described in User Note D027, "DEU Poll Response Checksum Anomalies."

At 322:18:39 G.m.t. (06:06:09 MET), while the crew was attempting to take a checkpoint to mass memory unit (MMU) 2, two fault messages, "S60 CHECKPT FAIL" and "OFF/BUSY MMU2", were annunciated. As indicated by the messages, the checkpoint was unsuccessful. A second attempt to perform the checkpoint was initiated and was successful. Discrepancy Report (DR) 107971, which documents a software timing issue for checkpoint operations, explains this fault message.

The flight control system performance was nominal. All on-orbit flight control mission objectives were accomplished. A new minimum-angle thruster-selection algorithm was used for the first time and performance was nominal. The software patch to re-enable acceleration filter inhibit eliminated the increased propellant consumption that was observed on STS-71. The mated aft down-firing vernier thruster acceleration matched updated thruster plume predictions.

The Mir control performance were nominal based on data analysis.

The mated primary RCS structural dynamics test (RME 1301) was completed nominally three times. The results validated the preflight model predictions within the given uncertainties. As a result, the alternate primary RCS digital autopilot (ALT DAP) was available for control of the combined stack, had a vernier RCS thruster failed.

The closed-loop alternate primary RCS control test was completed and nominal performance was demonstrated. Attitude hold, maneuver capability and control of a large space-station sized payload were satisfactorily demonstrated. Star tracker performance was nominal as was the performance of the inertial measurement units. The data processing system (DPS) hardware and software performed satisfactorily.

Displays and Controls Subsystem

The displays and control subsystem performed nominally. No in-flight anomalies were noted; however, two items of interest were noted.

The hydrogen manifold 1 isolation valve, S/N 20, gave a false-close indication at 324:12:39:46 G.m.t. (08:00:09:03 MET). Approximately 5 minutes later, the valve indicated open after the close command, and the open command was given at that time. The same anomaly occurred on STS-71, the last flight of this vehicle, when six false-close indications occurred.

At 321:09:31 G.m.t. (04:21:00 MET), the flight crew reported that both the aft port and aft starboard payload bay floodlights were not illuminated. Current signatures on the mid main bus C were indicative of a payload bay floodlight RPC current limiting and tripping. The aft port payload bay floodlight is powered by the mid main bus C.

Communications and Tracking Subsystems

The performance of the communications and tracking subsystem was nominal. One in-flight anomaly and a number of minor problems were noted, and these are discussed in the following paragraphs.

During prelaunch preparations, a transmit/receive relay for the Merritt Island Launch Area (MILA) TELTRAC ultrahigh frequency (UHF) air-to-ground voice system failed. An alternate UHF system was used for ascent with nominal performance. The TELTRAC system was repaired, and operation during landing was nominal.

During the communications activation prior to launch, the frequency modulation (FM) system 1 did not modulate the carrier with the expected frequency deviation (0.75 Hz vs. 1.6 Hz to 2.5 Hz). The decision was made to launch using FM system 2. The operations recorder was dumped on-orbit to evaluate the performance of the FM system 1. All dumps were nominal.

A smudge was noted in the middle of the closed circuit television camera C (S/N 212) downlink video. Attempts to burn off the smudge by closing the iris and pointing the camera toward the Sun were ineffective. Video from this camera remained degraded but was usable.

At 323:01:07 G.m.t. (06:12:37 MET), during downlink of a multiplexed (split-screen) combination of views from payload bay cameras A and D, the right half of the multiplexed video was noted to have incorrect chroma, although video from all cameras downlinked separately was nominal. To troubleshoot the condition, various combinations of the payload bay cameras (A, B, C and D) and video switching unit multiplexers (1 and 2) were viewed. Depending on the combination selected, the incorrect chroma was present either on the right side, on both sides, or on neither side. No obvious pattern was noted. This phenomenon occurred previously on this vehicle during STS-71, and is attributed to the video cameras having cables of different lengths to the video switching unit. This introduces color phasing differences in the split-screen configuration. Single camera downlink video was not affected.

When the TIPS was activated, it was nominally configured to receive data through the Ku-band system. When a test page was sent via the Ku-band, the printed page had lines missing. After initial troubleshooting failed to recover TIPS operation through the Ku-band system, the TIPS was successfully used when configured to receive through the S-band; however, in the S-band mode, the TIPS operates like a teleprinter and no longer has the graphics capability. Further troubleshooting isolated the problem to the FEP on the ground. A workaround was used that provided full TIPS capability.

Trajectory control sensor (TCS) 1 and 2 operated nominally for rendezvous. However, TCS 1 did not perform the short and long calibrations at the proper times. This condition did not impact the rendezvous operations. TCS 1 operated satisfactorily throughout the undocking and separation phase.

TCS 2 failed the self-test two consecutive times during the power-up for thermal conditioning on the day before the undocking. In both cases, the power was cycled, and the third self-test was satisfactory. TCS 2 failed self-test again just prior to Mir separation, and the unit was not available until separation had been completed. Consequently, a test to determine whether the TCS could lock on the wrong reflectors on the Mir was not performed.

Operational Instrumentation/Modular Auxiliary Data System

The operational instrumentation (OI) subsystem performed nominally with one exception. At approximately 319:19:22 G.m.t. (03:06:51 MET), during a data dump of operations (OPS) recorder 1, the ground was unable to lock on to the modulation on track 8 of the recorder. The tape was then played in both the forward and reverse directions, and data retrieval was unsuccessful. Additional data-recovery procedures were performed, and again the ground was unable to lock on to the modulation on track 8. As a workaround, track 8 was not used for recording data for the remainder of the flight. This condition did not cause the loss of any significant amount of data from the mission.

The modular auxiliary data system (MADS) performed satisfactorily and all data on the recorder was successfully dumped postflight.

Structures and Mechanical Subsystems

All mechanical systems performed satisfactorily with no in-flight anomalies noted. Drag chute performance was also nominal. The tires and brakes were in good condition for a landing on the SLF runway. Landing and braking 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	2564	201.3	~ 2.2	N/A
Nose gear touchdown	5567	157.3	N/A	~5.8

Brake initiation speed	73.2 knots
Brake-on time	24.4 seconds
Rollout distance	8,598 feet
Rollout time	57.8 seconds
Runway	33 (Concrete) KSC SLF
Orbiter weight at landing	202,898 lb

Brake sensor location	Peak pressure, psia	Brake assembly	Energy, million ft-lb
Left-hand inboard 1	768	Left-hand outboard	6.75
Left-hand inboard 3	696	Left-hand inboard	7.74
Left-hand outboard 2	708	Right-hand inboard	9.84
Left-hand outboard 4	708	Right-hand outboard	9.89
Right-hand inboard 1	852		
Right-hand inboard 3	864		
Right-hand outboard 2	840		
Right-hand outboard 4	780		

Integrated Aerodynamics, Heating, and Thermal Interfaces

Ascent and entry aerodynamics were nominal.

Aerodynamic and plume heating were nominal during ascent and entry. No anomalous conditions have been identified.

Thermal interface temperatures were nominal.

Thermal Control System

Performance of the thermal control system was nominal during all phases of the mission. All subsystem temperatures were maintained within acceptable limits. It was determined during the mission that the APAS hardware thermal-optical properties were either inaccurate or insufficient. Prior to STS-76, a more complete survey of the flight unit will be completed.

Aerothermodynamics

The acreage heating was nominal based on structural temperature data. Also, the structural temperature rise rate on the left and right wing was symmetrical and within the experience base. Local heating was also nominal.

Thermal Protection Subsystem and Windows

The thermal protection subsystem (TPS) performed satisfactorily. Based on structural temperature response data (temperature rise), the entry heating was nominal. Boundary layer transition from laminar flow to turbulent flow was symmetrical and occurred at 1151 seconds after entry interface on the aft centerline and right-hand side of the vehicle, and about 10 seconds later on the later on the aft left side of the vehicle. Thermocouple data are not available to determine transition on the forward centerline of the vehicle.

The postlanding inspection of the TPS identified 116 damage sites (hits) of which 21 had a major dimension of 1 inch or greater. This total does not reflect the numerous hits on the base heat shield attributed to the flame arrestment sparkler system. A comparison of these numbers to statistics from 57 previous missions of similar configuration indicates that the number of hits 1-inch or larger was average while the total number of hits was less than average. The distribution of the hits on the Orbiter is shown in the table on the following page.

The largest lower-surface tile damage site occurred near the Orbiter centerline immediately forward of the ET/Orbiter umbilicals. The damage site measured 3.5 inches long by 1.5 inches wide by 0.25 inch deep. Many tile damage sites were located to the right of the centerline on the lower surface. Hits in this area along a line from nose to tail are attributed to ice impacts from the ET liquid oxygen feed-line bellows and support brackets.

TPS DAMAGE SITES

Orbiter Surfaces	Hits > 1 Inch	Total Hits
Lower Surface	17	78
Upper Surface	1	31
Right Side	0	0
Left Side	0	0
Right OMS Pod	1	2
Left OMS Pod	2	5
Total	21	116

Tile damage sites aft of the LH_2 and LO_2 ET/Orbiter umbilicals was typical. The damage was most likely caused by impacts from umbilical ice or shredded pieces of umbilical purge barrier material flapping in the airstream. No tile damage sites was attributed to micrometeorites or on-orbit debris.

All three dome-mounted heat shield (DMHS) closeout blankets were in excellent condition with no missing material. The DMHS blanket at the SSME 1 six o'clock position was slightly torn and frayed. No body-flap hinge stub tiles were missing or damaged. Tiles on the vertical stabilizer stinger and around the drag chute door were intact and undamaged.

A total of seven tile damage sites, including three sites larger than 1-inch in size, were observed on the leading edge tiles of the OMS pods. A flexible reusable surface insulation (FRSI) blanket repair patch and the leading edge corner of a FRSI blanket were peeled back at two locations on the upper side of the left OMS pod.

Orbiter windows 3 and 4 exhibited moderate hazing and streaking. A light haze was present on all the other windows. Damage to the window perimeter tiles was less than usual and concentrated between windows 3 and 4. The damage sites were caused by impacts from forward RCS paper cover pieces and room temperature vulcanizing (RTV) material.

FLIGHT CREW EQUIPMENT/GOVERNMENT FURNISHED EQUIPMENT

The flight crew equipment (FCE)/Government furnished equipment (GFE) performed nominally. Two in-flight anomalies were noted, neither of which impacted flight operations or meeting flight objectives.

Prior to opening the ODS hatch, the crew reported that the airlock stowage bag on the ODS wall could not be removed due to two stuck actuating pins that prevented the removal of the mounting-attachment fitting system (Flight Problem STS-74-V-05). The bag was preventing the full opening of the hatch. Therefore, the contents of the ODS stowage bag were removed and placed into a LES bag. Once the bag was emptied, the stowage bag drawstrings were drawn, and this compressed the bag and allowed the hatch to be opened without the removal of the bag. The stowage bag was utilized again at the end of the mission for stowage.

During several Public Affairs events using a camcorder, the image went black indicating a loss of power. The crew was notified, and the battery was replaced; however, the same problem occurred between five and seven minutes later (Flight Problem STS-74-F-02). Initial indications were that the camcorder was being left in the "record pause" mode, which would result in the camcorder being powered off after seven minutes. Discussions with the crew revealed that this was not the case. Based on these discussions, the problem appears to be either insufficiently charged batteries or a camcorder that is drawing unusually high amounts of power. The camcorder in use was not identified (two onboard).

After the Orbiter/Mir docking, the crew reported that a bad data cable existed between one of the hand-held LIDAR and one of the PGSCs (Flight Problem STS-74-F-01). This was an RS-232 LIDAR interface cable. There were two of these cables onboard, one for each hand-held LIDAR.

REMOTE MANIPULATOR SYSTEM

The primary remote manipulator system (RMS) activity during the flight was the installation of the 5-meter long Docking Module onto the Orbiter Docking System (ODS) to enable docking of the Orbiter with the Mir. The RMS was also configured to provide camera views (elbow and wrist) of the final Orbiter/Mir docking maneuver. In addition, the RMS supported several experiments.

The RMS was powered up and initialized approximately 4 hours into the flight. Checkout of the RMS was successfully completed on flight day 2, and a payload bay survey was performed using the RMS. The arm was then maneuvered to the "poise for docking" position which provided the Orbiter Commander two views of docking.

On flight day 3, the RMS performed its primary task of STS-74, when the DM was grappled at approximately 318:06:00 G.m.t. (01:17:29 MET) and unberthed from the Orbiter at approximately 318:06:40 G.m.t. (01:18:09 MET). The DM was moved to the pre-install position, 12 inches above the ODS capture ring. The docking module was then maneuvered to within 5 inches of the ODS ring in preparation for the thrusting sequence designed to force capture. Docking was successfully completed on flight day 4 at 322:08:13:24 G.m.t. (02:17:56:57 MET).

On flight day 7 at 322:10:46:00 G.m.t. (05:22:15:17 MET) during a maneuver to the precradle position, a "PDRS CNTL POR" error message was annunciated. The was due to the trajectory deviating by more than 8 inches from commanded trajectory when a full translation hand controller (THC) reversal was executed in coarse rates. This message is expected when hardover hand-controller commands of this type occur. This problem caused no impact to RMS operations.

The RMS was powered down during the undocking activities. Following the undocking, the RMS was powered up and during the process of uncradling the arm, it was noted that the wrist roll joint was rotated 5.5 degrees prior to elbow pitch uncradle. As would be expected, the other joints in the arm were slightly back-driven and the POR at the end effector was moved up approximately 0.9 inch to accommodate the wrist roll position. The arm was successfully uncradled with no signs of jamming. This condition should not have impacted the RMS as the arm is designed to accommodate this movement. However, the postflight inspection will focus on the areas where possible damage could occur.

The RMS was powered down on flight day 8 after very successful operations in support of the mission, and with all RMS objectives met.

CARGO INTEGRATION

Integration hardware performance was nominal throughout the mission with no anomalies identified.

DEVELOPMENT TEST OBJECTIVES/DETAILED SUPPLEMENTARY OBJECTIVES

Twelve Development Test Objectives (DTOs) and seven Detailed Supplementary Objectives (DSOs) were assigned to the mission.

DEVELOPMENT TEST OBJECTIVES

DTO 301D - Ascent Structural Capability Evaluation - Data were recorded on the MADS recorder, and the data were dumped postflight and given to the sponsor for evaluation. The results of the evaluation will be reported in separate documentation.

DTO 307D - Entry Structural Capability - Data were recorded on the MADS recorder, and the data were dumped postflight and given to the sponsor for evaluation. The results of the evaluation will be reported in separate documentation.

DTO 312 - ET TPS Performance - No hand-held photographs of the ET were taken on this mission as the +X maneuver was performed. The crew reported that the ET was not seen.

Two rolls of umbilical well photography of the ET were acquired: the 35-mm film from the LO_2 umbilical and one 16 mm film (5 mm lens) from the LH_2 umbilical. The 16 mm camera with the 10 mm lens did not run. The separation velocity of the ET was 1.76 meters/second. A number of conditions were noted, but none were anomalous.

DTO 624 - Radiator Performance - Some data were obtained for this DTO-of-opportunity as the radiators were deployed throughout the mission. However, the specific attitudes were not achieved for the desired duration because of attitude requirements and constraints to the main objectives of the mission. The data were given to the sponsor for evaluation, and the results of that evaluation will be issued in separate documentation.

DTO 700-10 - Orbiter Space Vision System Video Taping - Orbiter Space Vision System (OSVS) video of the Docking Module target as well as Mir configuration data for postflight model development were recorded. These data will be used in support of future software for this DTO. The data have been given to the sponsor for evaluation, and the results will be reported in separate documentation.

DTO 700-11 - Orbiter Space Vision System Flight Unit Testing - Flight unit testing of the DM during installation on the ODS used photogrammetric techniques for tracking the DM. Success of this operation was determined postflight through data collection and crew comments. During checkout, Advanced Space Vision Unit (ASVU) system 1 experienced several video processor error messages. After an unsuccessful reboot, the unit was reloaded with a fresh flight database, but further troubleshooting and checkout were not performed. ASVU 2 was used as the primary unit for DM installation.

DTO 805 - Crosswind Landing Performance - This DTO-of-opportunity was not performed as the minimum-required weather conditions were not present at the time of landing.

DTO 829 - Plume Impingement and Contamination - The primary objective of this DTO was to record data on a plate mounted on the RMS during the firing of the Mir 13-kg thrusters. Additional data were collected during primary RCS thruster firings after a cold-soak to aid in expanding the data base. These data have been given to the sponsor and an evaluation of the data will be reported in separate documentation.

DTO 832 - Target of Opportunity Navigation Sensors - Data were acquired from the star tracker during the approach and flyaround of the Mir. The data have been given to the sponsor for evaluation to determine the success of using the Target of Opportunity Navigation Sensors (TONS) as a rendezvous tool.

DTO 1118 - Photographic and Video survey of Mir Space Station - The electronic still, video, and Hasselblad cameras recorded data on the exterior of the Mir. These data showed the condition of the Mir and were used to detect micrometeoroid or orbital debris impacts; to document the Orbiter approach, docking, and separation; to assess relative motion of the Mir and the Orbiter; and to analyze plume impingement effects. The Orbiter executed two Mir flyarounds for documentation purposes after separation. The data have been given to the sponsor for evaluation, and the report of the results will be in separate documentation.

DTO 1120 - Mated Shuttle and Mir Free Drift Experiment - This DTO was not performed because of the high beta angles and resulting thermal conditioning, which did not allow Mir to operate in the free drift configuration for the required duration.

DTO 1122 - APAS Thermal Data - The guide ring on the ODS was extended when in a cold attitude for seven hours and when in a hot attitude for seven hours to obtain APAS data for thermal model verification. These data have been given to the sponsor for evaluation, and the results of the evaluation will be reported in separate documentation. These data will be used to further correlate and refine thermal mathematical models for use in future Mir and International Space Station missions.

DETAILED SUPPLEMENTARY OBJECTIVES

Seven Detailed Supplementary Objectives (DSOs) were assigned to the STS-74 mission. Data were collected for each of these DSOs, and these data have been given to the sponsor for evaluation. The results of the evaluation will be reported in separate documentation. The seven DSOs were as follows:

a. DSO 485 - Inter Mars Tissue Equivalent Proportional Counter;
b. DSO 487 - Immunological Assessment of Crewmembers;
c. DSO 604 - Visual Vestibular Integration as a Function of Adaptation;
d. DSO 621 - In-Flight Use of Florinef to Improve Orthostatic Intolerance Postflight;
e. DSO 901 - Documentary Television;
f. DSO 902 - Documentary Motion Picture Photography; and
g. DSO 903 - Documentary Still Photography.

PHOTOGRAPHY AND TELEVISION ANALYSIS

LAUNCH PHOTOGRAPHY AND VIDEO DATA ANALYSIS

On launch day, 24 of 24 expected videos of launch were received and reviewed. In addition to the videos that were screened, thirty-three 16 mm films and nineteen 35 mm films of launch were screened. No anomalous conditions were noted in any of the data reviewed.

ON-ORBIT PHOTOGRAPHY AND VIDEO DATA ANALYSIS

No screening or evaluating of on-orbit photography was requested during this mission.

LANDING PHOTOGRAPHY AND VIDEO DATA ANALYSIS

On landing day, 13 videos were received and screened. No anomalous conditions were noted.

TABLE I.- STS-74 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	316:12:25:56.063 316:12:25:56.749 316:12:25:57.431
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	316:12:30:15.083 316:12:30:15.243 316:12:30.15.403 316:12:30:15.563
Main Propulsion System Start[a]	ME-3 Start command accepted ME-2 Start command accepted ME-1 Start command accepted	316:12:30:36.458 316:12:30:36.577 316:12:30:36.679
SRB Ignition Command (Liftoff)	Calculated SRB ignition command	316:12:30:43.013
Throttle up to 104 Percent Thrust[a]	ME-1 Command accepted ME-3 Command accepted ME-2 Command accepted	316:12:30:46.920 316:12:30:46.939 316:12:30:46.946
Throttle down to 67 Percent Thrust[a]	ME-1 Command accepted ME-3 Command accepted ME-2 Command accepted	316:12:31:08.680 316:12:31:08.698 316:12:31:08.706
Maximum Dynamic Pressure (q)	Derived ascent dynamic pressure	316:12:31:34
Throttle up to 104 Percent[a]	ME-1 Command accepted ME-3 Command accepted ME-2 Command accepted	316:12:31:42:281 316:12:31:42.297 316:12:31:42.307
Both SRM's Chamber Pressure at 50 psi[a]	RH SRM chamber pressure mid-range select LH SRM chamber pressure mid-range select	316:12:32:40.773 316:12:32:41.133
End SRM [a] Action[a]	LH SRM chamber pressure mid-range select RH SRM chamber pressure mid-range select	316:12:32:43.623 316:12:32:43.753
SRB Physical Separation[a]	LH rate APU turbine speed - LOS RH rate APU turbine speed - LOS	316:12:32:46.013 316:12:32:46.013
SRB Separation Command	SRB separation command flag	316:12:32:47
Throttle Down for 3g Acceleration[a]	ME-3 command accepted ME-1 command accepted ME-2 command accepted	316:12:38:12.685 316:12:38:12.688 316:12:38:12.716
3g Acceleration	Total load factor	316:12:38:14.6
Throttle Down to 67 Percent Thrust[a]	ME-3 command accepted ME-1 command accepted ME-2 command accepted	316:12:39:09.323 316:12:39:09.329 316:12:39:09.357
SSME Shutdown[a]	ME-3 command accepted ME-1 command accepted ME-2 command accepted	316:12:39:15.683 316:12:39:15.689 316:12:39:15.718
MECO	MECO command flag MECO confirm flag	316:12:39:16 316:12:39:17
ET Separation	ET separation command flag	316:12:39:35

[a]MSFC supplied data

TABLE I.- STS-74 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	316:12:51:53.994 316:12:51:59.848 316:12:52:07.173
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	316:13:12:35.1 316:13:12:35.1
OMS-2 Cutoff	Right engine bi-prop valve position Left engine bi-prop valve position	316:13:14:46.5 316:13:14:46.5
Payload Bay Doors (PLBDs) Open	PLBD right open 1 PLBD left open 1	316:13:56:04 316:13:57:23
OMS-3 Ignition	Left engine bi-prop valve position Right engine bi-prop valve position	N/A 316:15:30:19.9
OMS-3 Cutoff	Left engine bi-prop valve position Right engine bi-prop valve position	N/A 316:15:31:06.1
OMS-4 Ignition	Left engine bi-prop valve position Right engine bi-prop valve position	316:15:18:55.1 316:15:18:55.3
OMS-4 Cutoff	Left engine bi-prop valve position Right engine bi-prop valve position	316:15:19:35.1 316:15:19:35.1
OMS-5 Ignition	Left engine bi-prop valve position Right engine bi-prop valve position	317:16:11:44.1 N/A
OMS-5 Cutoff	Left engine bi-prop valve position Right engine bi-prop valve position	317:16:12:22.1 N/A
Port Radiator Stow	Port radiator stow 1 Port radiator stow 2	319:01:12:56 319:01:12:56
Port Radiator Latch	Port radiator latch no. 1-6 Release 1 Port radiator latch no. 1-6 latch 1	319:01:13:21 319:01:13:44
OMS-6 Ignition	Left engine bi-prop valve position Right engine bi-prop valve position	N/A 319:01:53:04.5
OMS-6 Cutoff	Left engine bi-prop valve position Right engine bi-prop valve position	N/A 319:01:53:37.5
OMS-7 Ignition	Left engine bi-prop valve position Right engine bi-prop valve position	319:03:26:43.3 N/A
OMS-7 Cutoff	Left engine bi-prop valve position Right engine bi-prop valve position	319:03:26:52.7 N/A
Docking - Initial Contact	Initial contact	319:06:27:40
Docking - Complete	Docking ring final position	319:06:36:04
Initiation of Undocking	Actuation of hooks no. 1 drive	322:08:13:24
Undocking - Complete	Undock completell	322:08:15:44
OMS-8 Ignition	Left engine bi-prop valve position Right engine bi-prop valve position	322:15:14:19.7 N/A
OMS-8 Cutoff	Left engine bi-prop valve position Right engine bi-prop valve position	322:15:15:06.7 N/A
OMS-9 Ignition	Left engine bi-prop valve position Right engine bi-prop valve position	N/A 322:15:58:03.5

TABLE I.- STS-74 SEQUENCE OF EVENTS (Concluded)

Event	Description	Actual time, G.m.t.
OMS-9 Cutoff	Left engine bi-prop valve position Right engine bi-prop valve position	N/A 322:15:58:58.9
Flight Control System Checkout APU Start APU Stop	 APU-3 GG chamber pressure APU-3 GG chamber pressure	 323:09:06:03.486 323:09:18.01.241
Payload Bay Doors Close	PLBD left close 1 PLBD right close 1	324:13:17:17 324:13:19:55
APU Activation for Entry	APU-2 GG chamber pressure APU-1 GG chamber pressure APU-3 GG chamber pressure	324:15:53:48.598 324:16:17:22.248 324:16:17:25.139
Deorbit Bum Ignition	Left engine bi-prop valve position Right engine bi-prop valve position	324:15:58:43.2 324:15:58:43.3
Deorbit Bum Cutoff	Left engine bi-prop valve position Right engine bi-prop valve position	324:16:02:36.9 324:16:02:37:0
Entry Interface (400K feet)	Current orbital altitude above	324:16:30:02
Blackout end	Data locked (high sample rate)	No blackout
Terminal Area Energy Mgmt.	Major mode change (305)	324:16:55:14
Main Landing Gear Contact	LH main landing gear tire pressure 1 RH main landing gear tire pressure 2	324:17:01:28 324:17:01:28
Main Landing Gear Weight on Wheels	LH main landing gear weight on wheels RH main landing gear weight on wheels	324:17:01:29 324:17:01:32
Drag Chute Deployment	Drag chute deploy 1 CP Volts	324:17:01:32.4
Nose Landing Gear Contact	NLG LH tire pressure 1	324:17:01:37
Nose Landing Gear Weight On Wheels	NLG weight on wheels 1	324:17:01:38
Drag Chute Jettison	Drag chute jettison 1 CP Volts	324:17:02:06.7
Wheel Stop	Velocity with respect to runway	324:17:02:25
APU Deactivation	APU-1 GG chamber pressure APU-2 GG chamber pressure APU-3 GG chamber pressure	324:17:19:19.074 324:17:19:25.209 324:17:19:30.622

TABLE II.- ORBITER PROBLEM TRACKING LIST

No.	Title	Time	Comments
STS-74-V-01	APU 2 Fuel Pump Inlet Pressure Erratic Level III Closure	316:12:39:31 G.m.t. 00:08:48:31 MET CAR 74RF03 IPR 76V-0006	The APU 2 pump inlet pressure (V46P0210A) became erratic for slightly over a minute and then recovered satisfactory until APU 2 shut down. KSC: Troubleshooting is planned.
STS-74-V-02	Fuel Cell 3 Cell Performance Monitor Shift	318:20:02 G.m.t. 02:07:31 MET CAR 74RF04 IPR 76V-0005	All three fuel cell 3 substack ΔV measurements shifted approximately 8 mV. There was not a significant load change on fuel cell 3 at that time. The CPM self-test signal, which had been indicating 48 mV, shifted to a self-test value of 56 mV (value should be no more than 58mV). KSC: Vendor will remove and replace CPM while fuel cell is installed on the vehicle.
STS-74-V-03	PRSD 0_2 Manifold 1 Isolation Valve Failed to Close	319:18:32 G.m.t. 03:06:01 MET CAR 74RF05 IPR-76V-0007	The PRSD O_2 manaifold 1 isolation valve (p/n MC284-0429-4110, S/N CRP0029) failed to close when the crew performed the cryo valve reconfiguration prior to the sleep period. The H_2 manifold 1 valve closed successfully. The H_2 manifold 1 valve was subsequently reopened, and the H_2 and O_2 manifold 2 valves were closed at 319:18:54 G.m.t. (03:06:23 MET) for the crew sleep period. S/N 29 successfully passed cryo screening at NSLD with the valve attached to the valve panel on 10/93. The valve cycled successfully during STS-66 and STS-71 after being installed in OV-104. The valve cycled properly earlier on STS-74. KSC: The valve panel will be removed and replaced.
STS-74-V-04	OPS Recorder 1 Track 8 Data Degradation	319:19:22 G.m.t. 03:06:51 MET CAR 74RF06 IPR 76V-0008	During an acquisition of signal (AOS) data dump of OPS recorder 1, the ground was unable to lock on modulation of track 8. The data were played in the forward and reverse directions, and both were unsuccessful. Newly recorded data playback was performed, and again the ground was unable to lock onto the modulation. During both attempts, the data were recorded at 15 ips. Data were then dumped at 24 ips, again without success. A 1:1 dump at VTS was performed without success for track 8. However, track 7 was locked on. KSC: Troubleshooting will be performed.

TABLE II.- ORBITER PROBLEM TRACKING LIST

No.	Title	Time	Comments
STS-74-V-05	Unable To Remove ODS Stowage Bag	319:00:00 G.m.t. 02:11:29 MET	Prior to opening the ODS hatch, the crew reported that they could not remove the airlock stowage bag from the ODS wall due to two stuck actuating pins which prevented the removal of the mounting attachment fitting system. The bag was preventing the full opening of the hatch. Therefore, the contents of the ODS stowage bag were removed and placed into an LES suit bag. The hardware is produced by RI-Houston. The drawing number is SJD32104522 entitled ODS STWG BAG, EDV KIT/FLEX DUCT HOSE. During CEIT, the crew found that the bag had to be forced down into the dovetail fitting. It should drop in smoothly. A 0.005-inch shim was fabricated for the forward and aft locations to move the fitting further away from the wall. This action allowed the bag to be installed smoothly and not cause paint to be removed from the ODS wall. This bag was flown on STS-71. A new larger bag is being designed by RI-Houston and is scheduled to be flown on STS-76 and subsequent.
STS-74-V-06	WSB 3 GN_2 Regulator Outlet Pressure Erratic	324:17:15 G.m.t. 08:04:44 MET CAR 74RF07 IPR 76V-0009	After landing, WSB 3 GN_2 regulator outlet pressure (V58P0304A) became erratic and eventually went to 0 psia. A few minutes later, the measurement returned to the appropriate value. KSC: Troubleshooting will be performed.

TABLE III.- GOVERNMENT FURNISHED EQUIPMENT PROBLEM TRACKING LIST

No.	Title	Time	Comments
STS-74-F-01	Bad Data Cable From LIDAR to PGSC	319:06:45:43 G.m.t. 02:18:15 MET	After the Orbiter/Mir docking, the crew reported that during rendezvous, one of the PGSCs stopped receiving hand-held LASER (LIDAR) data. This cable interfaces with the PGSC RS-232 port. The LIDAR interface cable is P/N SED 39123055-303. There are two of these cables onboard, one per hand-held LIDAR.
STS-74-F-02	Rapid Camcorder Battery Discharge	321:13:40 G.m.t. 02:18:09 MET	During several PAO events using the camcorder, the image was observed to go black indicating a loss of power. The crew was notified and the battery was replaced and the same problem recurred 5 to 7 minutes later. It was believed that the camcorder was being left in the "record pause" mode, which would result in the camcorder being automatically powered off in 7 minutes. However, the crew stated that this was not the case. The problem appears to be either insufficiently charged batteries or a camcorder that is drawing unusually high power. The camcorder is use was not identified. Two of these camcorders were flown.

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 Daily Reports
4. MER Daily Reports
5. MER Mission Summary Report
6. MER Quick Look Report
7. MER Problem Tracking List
8. MER Event Times
9. Subsystem Manager Reports/Inputs
10. MOD Systems Anomaly List
11. MSFC Flash Report
12. MSFC Event Times
13. MSFC Interim Report
14. Crew Debriefing comments
15. Shuttle Operational Data Book

ACRONYMS AND ABBREVIATIONS

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

ALT DAP	alternate digital autopilot
APAS	Androgynous Peripheral Assembly System
APU	auxiliary power unit
ARPCS	atmospheric revitalization pressure control system
ARS	atmospheric revitalization system
ASVU	Advanced Space Vision Unit
ATCS	active thermal control system
CPM	cell performance monitor
CRT	cathode ray tube
CWC	contingency water carrier
DAP	digital autopilot
DEU	display electronics unit
DM	Docking Module
DMHS	dome-mounted heat shield
DPS	data processing system
DR	Discrepancy Report
DSO	Detailed Supplementary Objective
DTO	Developmental Test Objective
ΔV	differential velocity
ECLSS	Environmental Control and Life Support System
EDV	Russian water bottle
EMU	extravehicular mobility unit
EPDC	electrical power distribution and control subsystem
ESA	European Space Agency
ET	External Tank
EVA	extravehicular activity
FCE	flight crew equipment
FCP	fuel cell powerplant
FCS	flight control system
FDA	fault detection and annunciation
FEP	front end processor
FES	flash evaporator system
FM	frequency modulation
FRSI	flexible reusable surface insulation
ft/sec	feet per second
GFE	Government furnished equipment
GLO	Spacecraft Glow Experiment
G.m.t.	Greenwich mean time
GNC	guidance, navigation and control
GN_2	gaseous nitrogen
GPC	general purpose computer
GPP	GLO Experiment/Photogrammetric Appendage Structural Dynamics Experiment Payload

HPFTP	high pressure fuel turbopump
HPOTP	high pressure oxidizer turbopump
Hz	Hertz
ICBC	IMAX cargo bay camera
IMAX	Canadian camera system
Isp	specific impulse
KSC	Kennedy Space Center
kW	kilowatt
kWh	kilowatt hour
LCC	Launch Commit Criteria
LES	launch/entry suit
LMES	Lockheed Martin Engineering and Science
LH_2	liquid hydrogen
LIDAR	light distance and ranging
LO_2	liquid oxygen
MADS	modular auxiliary data system
MCC	Mission Control Center
MCC-M	Mission Control Center-Moscow
MECO	main engine cutoff
MET	mission elapsed time
MILA	Merritt Island Launch Area
Mir	Russian Space Station
MMU	mass memory storage unit
MPS	main propulsion system
NASA	National Aeronautics and Space Administration
nmi.	nautical mile
NPSP	net positive suction pressure
NSLD	NASA Shuttle Logistics Depot
NSTS	National Space Transportation System (i.e., Space Shuttle Program)
O_2	oxygen
ODS	Orbiter Docking System
OI	operational instrumentation
OME	orbital maneuvering engine
OMRSD	Operations and Maintenance Requirements and Specifications Document
OMS	orbital maneuvering subsystem
OPS	operations
OSVS	Orbiter Space Vision System
PAL	protuberance air load
PASDE	Photogrammetric Appendage Structural Dynamics Experiment
PDU	power drive unit
PGSC	payload general support computer
PIC	Plume Impingement and Contamination
PMBT	propellant mean bulk temperature
ppm	parts per million
PPO_2	partial pressure oxygen
PRSD	power reactant storage and distribution
RCS	reaction control subsystem
RME	Risk Mitigation Experiment
RMS	Remote Manipulator System

ROEU	Remotely Operated Electrical Umbilical
RPC	remote power controller
RSRM	Reusable Solid Rocket Motor
RTV	room temperature vulcanizing
S&A	safe and arm
SAREX-II	Shuttle Amateur Radio Experiment-II
SLF	Shuttle Landing Facility
S/N	serial number
SRB	Solid Rocket Booster
SRSS	Shuttle range safety system
SSME	Space Shuttle main engine
TAL	transatlantic Abort
TCS	trajectory control system
TEF	Thermal Electric Freezer
TEHOF	Thermal Electric Holding Freezer
THC	translation hand controller
TI	terminal phase initiation
TIPS	Thermal Impulse Printer System
TONS	Target Opportunity Navigation Sensors
TPS	thermal protection subsystem
UHF	ultrahigh frequency
Vdc	Volts, direct current
VHF	very high frequency
WCL	water coolant loop
WNE	Wireless Network Experiment
WSB	water spray boiler