

STS-102 SPACE SHUTTLE MISSION REPORT

May 2001

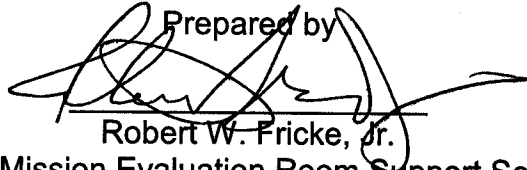


**National Aeronautics and
Space Administration**

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

STS-102
SPACE SHUTTLE
MISSION REPORT

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NOTE

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INTRODUCTION

The Space Transportation System (STS)-102 Space Shuttle Program Mission Report presents a discussion of the Orbiter subsystem operation and the in-flight anomalies that were identified during the mission. The STS-102 flight was the eighth mission to the International Space Station (ISS) to perform maintenance and logistics tasks.

The STS-102 report also summarizes the activities of the STS-102 mission, and presents a summary of the External Tank (ET), Solid Rocket Booster (SRB), Reusable Solid Rocket Motor (RSRM), and Space Shuttle main engine (SSME) performance during this one-hundred and third mission of the Space Shuttle Program. STS-102 was the seventy-eighth flight since the return to flight, and the twenty-ninth flight of the OV-103 (Discovery) vehicle. This flight delivered the Multi Purpose Logistics Module (Leonardo) to the ISS.

The flight vehicle consisted of the OV-103 Orbiter; an ET, which was the tenth Super Lightweight Tank (SLWT), and it was designated ET-107; three Block IIA SSMEs that were designated as S/Ns 2045, 2053, and 2048 in positions 1, 2, and 3, respectively; and two SRBs that were designated B1106. The two RSRMs were designated RSRM-78 with one installed in each SRB. The individual RSRMs serial numbers were 360L078A for the left SRB and 360L078B for the right SRB.

The primary objective of the STS-102 mission was to deliver and integrate the 5A.1 launch package (LP) in to the orbiting ISS Stage 5A, including ISS Expedition 1 crew rotation of three crewmembers. The LP consisted of the Multi-Purpose Logistics Module (MPLM), the Integrated Cargo Carrier (ICC), two Assembly Power Converter Units (APCU's) in the Orbiter Cargo bay and ISS equipment and supplies in the Orbiter crew compartment. The MPLM is a pressurized module that transports the U. S. Laboratory system racks, Resupply/Return Stowage Platforms (RSP's) Resupply Stowage Racks (RSR's), and the Human Research Facility (HRF) International Standard Payload Rack (ISPR) to the ISS. The ICC carried the Ammonia Servicer (AS), the Pump Flow Control Subsystem (PFCS), the Laboratory Cradle Assembly (LCA), the External Stowage Platform (ESP) and the Rigid Umbilical (RU), which was installed/attached on the ISS during the two scheduled extravehicular activities.

One passive Get-Away Special (GAS) canister was installed in the payload bay in Bay 13, starboard side and one passive GAS canister and the Wide-band Shuttle Vibration Forces Measurement (WSVFM) Experiment were installed in Bay 4, Port side of the payload bay. Should the ISS Program require Launch-On-Need (LON) capability for an ISS Program orbital replacement unit (ORU) [Direct Current Switching Unit (DCSU) or S-band Antenna Support Assembly (SASA)], the GAS canister and WSVFM could be removed, and the DCSU or SASA installed in Bay 4, Port location up to launch minus 7 days.

The STS-102 flight was planned as a 11-day, plus 2-contingency-day flight, of which six days would be spent docked to the ISS. An additional day of docked activities required a mission extension of one day, making the mission a 12-day mission. The two contingency days were available for bad weather avoidance for landing or other Orbiter contingency operations. The sequence of mission events is shown in Table I, and the Orbiter In-Flight Anomaly List is shown in Table II.

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

The seven-person crew of the STS-102 flight consisted of James D. Wetherbee, Capt., U. S. Navy, Commander; James M. Kelly, Lt Col. U. S. Air Force, Pilot; Andrew S. W. Thomas, Civilian, Mission Specialist 1; Paul W. Richards, Civilian, Mission Specialist 2; James S. Voss, Col., U. S. Army (Retired), Mission Specialist 3; Susan J. Helms, Col., U. S. Air Force, Mission Specialist 4; and Yury V. Usachev, Civilian Cosmonaut, Mission Specialist 5. Mission Specialists 3, 4, and 5, were the Expedition 2 crewmembers to the ISS, and the Expedition 1 crewmembers were being returned to Earth from their ISS mission which was over 4 months in length. The Expedition 1 crewmembers were Sergei Krikalev, Civilian Cosmonaut, who became Mission Specialist 3 when he became a member of the STS-102 crew; William M. Shepherd, Capt., U. S. Navy, who became Mission Specialist 4 when he became a member of the STS-102 crew; and Yuri P. Gidzenko, Lt. Col. Russian Air Force, who became Mission Specialist 5 when he became a member of the STS-102 crew.

STS-102 was the fifth space flight for the Commander, Mission Specialist 3 (Expedition 1 crewmember); as well as Mission Specialist 3 and 4 (Expedition 2 crewmembers). STS-102 was the fourth space flight for Mission Specialist 4 (Expedition 1 Commander), and Mission Specialist 5 (Expedition 2 Commander). STS-102 was the second space flight for Mission Specialist 5 (Expedition 1 crewmember); and the first space flight for the Pilot and Mission Specialist 2.

MISSION SUMMARY

The STS-102 mission was launched as planned with no unscheduled holds during the flawless countdown. The time of launch was 067:11:42:09.004 G.m.t. (2:42 p.m. e.s.t.) (March 8, 2001). All Orbiter subsystems performed satisfactorily during the ascent phase of the mission.

The orbital maneuvering subsystem (OMS) assist maneuver was performed at 067:11:44:23.8 G.m.t. (00:00:02:14.8 MET) following Solid Rocket Booster (SRB) separation. The maneuver was 69.5 seconds in duration, and the OMS performed satisfactorily.

The vehicle was inserted into orbit at 067:11:50:32 G.m.t. (00:00:08:23 MET) when the Space Shuttle main engines (SSMEs) were shut down. Nineteen seconds later, the External Tank (ET) was jettisoned.

A determination of vehicle performance was made using vehicle acceleration and preflight propulsion prediction data. The average flight-derived engine specific impulse (I_{sp}) was 452.9 seconds as compared to the SSME tag value of 451.87 seconds at 104.5-percent power level.

The OMS 2 maneuver was performed at 067:12:20:46 G.m.t. (00:00:38:37 MET) and was 63.8 seconds in duration. The differential velocity (ΔV) was 97.2 ft/sec, and the orbit was 85.2 by 127.1 nautical miles (nmi.) following the maneuver. The OMS performed satisfactorily throughout the maneuver.

The payload bay doors were opened at 067:13:27:33 G.m.t. (00:01:45:24 MET). All voltages were nominal and the motors opened the doors in nominal dual-motor time.

STS-102 was the first flight where all three water spray boilers (WSBs) had the water additive [Propylene Glycol Monomethyl Ether (PGME)] in the core for cooling during ascent. The auxiliary power unit (APU) 2 lubrication oil return-temperature reached 276.7 °F before cooling began. This temperature is 1.7 °F above the limit and indicates a slight under-cooling condition occurred. This is the first occurrence of an under-cooling condition when PGME was used for cooling in the WSB core.

During the post-insertion period, the crew reported that the fan in the Orbiter cabin air cleaner (OCAC) was only spinning at 60 to 70 rpm in all three speed-settings. The crew performed troubleshooting on the OCAC on the morning of flight day (FD) 2. The troubleshooting consisted of rotating the fan by hand and trying a different power cable and a different dc utility outlet. The fan spun freely when rotated by hand but still spun at only 60 to 70 rpm regardless of the speed setting. The green light emitting diode (LED) illuminated when the power was on and no red LED's illuminated at any time. An in-flight maintenance procedure was developed and performed later in the mission and nominal operation of the OCAC was recovered. A blown fuse on the diagnostic box circuit board was bypassed with a new fuse.

The NC-2 and NPC maneuvers, originally scheduled to be reaction control subsystem (RCS) maneuvers, were combined with the NC2 maneuver, and as a result, the two maneuvers were no longer required.

At 068:09:00 G.m.t. (00:23:18 MET), the data on cathode ray tube (CRT) 1 appeared garbled when powered on. While performing the malfunction procedure, a power cycle of the unit restored nominal operations. A review of the downlisted built in test equipment (BITE) status words and poll header word did not reveal that the display electronics unit (DEU) sent two expected bits to the general purpose computer (GPC) during initialization (GPC downlists BITE status words approximately every other poll). While User Notes deal with DEU Control Program (DCP Software) timing window issues, none of the User Notes explained this particular condition. Analysis indicated that if the DEU fails to transmit the expected poll header word critical BITE bit to the GPC subsequent to initialization, a transient display anomaly will occur, similar to what was seen on orbit. While the exact cause for the transient is unknown, the most probable cause lies within DEU hardware (it has been determined through code analysis that the DCP Software was most likely not the cause). More specifically, a transient in the DEU hardware may have caused the error during the final steps of the DEU initialization process of storing the critical BITE bit, or during DEU transmission of this bit. It should be noted, however, that the DEU BITE status words did not indicate that a hardware failure had occurred. A slight possibility exists that the presumed lost Critical BITE Bit occurred during the GPC's reception of the poll header word. DEU17 was powered-up several times subsequent to this transient, and the error condition was not repeated. No further action was required for this recoverable transient, and the Problem Resolution Team (PRT) recommendation, on March 15, 2001, was that DEU17 should remain flight-worthy (i.e., DEU17 will remain on OV-103 subsequent to the mission). No additional postflight testing/troubleshooting is required.

A successful checkout of extravehicular mobility units (EMU's) 1 and 2 was completed. EMU 3, which is currently on the International Space Station (ISS), was checked out following the first extravehicular activity (EVA).

Checkouts of the remote manipulator system (RMS), the Orbiter space vision system (OSVS) and the Orbiter docking system (ODS) were completed nominally. A payload bay survey, using the RMS cameras, was also performed. Upon completion of the survey, the arm was cradled and powered down.

On flight day 1, during the setup of the Proshare system for a private medical conference (PMC) videoconference, the crew reported that the video from the mini-cam would not consistently display on the Proshare local video window. The crew stated that they could make the video work by wiggling the cable, but it was still intermittent. The crew also noticed the cable between the mini-cam and the payload and general support computer (PGSC) was kinked and they reported both the cable and mini-cam were warm. For the record, the mini-cam does become warm during use. For video conferencing, the camcorder was used in place of the mini-cam for the remainder of the mission.

Shortly before 68:05:00 G.m.t. (00:17:18 MET), the flash evaporator system (FES) left topping-duct string A heater failed off. The temperature sensor showed nominal heater cycles before that time and then a cooling trend after that time, a clear deviation from normal heater operations. The system B heater was selected at 68:22:53 G.m.t. (01:11:11 MET), and the heater is performing nominally.

When ground controllers attempted to dump data from operations (OPS) recorder 2, significant data dropouts were observed on track 1. Data quality was poor and there was less-than 50-percent lock-on to the data stream. Playbacks from tracks 2, 3, and 8 were satisfactory. To troubleshoot the problem, data were recorded on tracks 1, 2, 3, 4, 7 through 10, 12 and 13 and played back in both the forward and reverse directions. All data dumps were good except the dumps from tracks 1, 10, 12 and 14. Tracks 1 and 14 are positioned in the middle of the recorder tape and indications point to a tape-degradation problem. The ground controllers avoided using OPS recorder 2 as much as possible and when it had to be used, recording was done on tracks 4 through 9 only. The recorder was removed and replaced during the postflight turnaround activities.

The following table shows the OMS as well as the RCS maneuvers that were performed to complete the rendezvous with the ISS.

Maneuver	Time, G.m.t./MET	ΔV, ft/sec	Firing time, sec	Orbit, nmi.
OMS-3 (NC-1) (Both engines)	067:15:16:32 00:03:34:23	111.7	72.8	126.4 by 148.0
OMS-4 (NC-2) (Right engine)	068:04:14:23 00:16:32:14	12.1	15.8	149.5 by 130.8
OMS-5 (NC-3) Both engines	068:14:15:17 01:02:33:08	118.2	75.6	147.8 by 198.4
OMS-6 (NC-4) (Both engines)	069:01:35:14 01:13:53:05	90.8	75.6	198.5 by 200.0
NCC (Multi-axis RCS)	069:02:14:56 01:14:32:47	2.2	6.7	198.4 by 199.5
OMS-7 (TI) (Left engine)	069:03:12:39 01:15:30:30	9.6	12.6	199.2 by 205.3
Out-of-plane null (RCS)	069:03:45:40 01:16:03:31	N/A	< 60	N/A
MC-1 (RCS)	069:03:32:38 01:15:50:29	0.4	1.5	199.2 by 205.2
MC-2 (RCS)	069:04:06:08 01:16:23:59	1.9	8.1	199.1 by 205.4
MC-3 (RCS)	069:04:23:21 01:16:41:12	1.0	4.5	199.1 by 205.2
MC-4 (RCS)	069:04:33:21 01:16:51:12	2.0	8.6	199.1 by 206.1

Orbiter/ISS capture occurred at 069:06:38:26 G.m.t. (01:18:56:17 MET). A successful ring-in and hard mating was subsequently performed at 069:06:58:23 G.m.t. (01:19:16:14 MET). During the drive-in of the ring, alignment was temporarily lost, apparently due to a stuck damper. This phenomenon has been observed in the past. Leak checks were performed and opening of the hatches was completed at approximately 069:08:51 G.m.t. (01:21:09 MET). Docking was delayed approximately one hour because of a problem on the ISS with latching one of the P6 solar arrays in the feathered position.

At the conclusion of rendezvous and docking operations, the trajectory control sensor (TCS) failed to respond to a shutdown or a shutter-close command from a PGSC.

Power was removed from the TCS with the shutter open. Upon TCS activation during the rendezvous tools checkout the day prior to undocking, telemetry showed a self-test failure on the lasers. This was followed by additional errors that implied that the TCS unit had not successfully completed the startup sequence as well as failing to generate the 'initialization complete' and 'going to standby' responses to the PGSC. The crew performed troubleshooting in accordance with the existing flight data file procedure. However, problems were still encountered, and it was verified via telemetry that the commands were received by the unit but not successfully executed. The unit was declared failed and was not used during the undocking phase of the mission.

The crew reported while changing the hardware caution and warning for the 10.2-psia depressurization, the tenths place on the limit-set volts pushbutton rotary did not work in the down position. Note that the limits-set volts switch can be nominally operated in the up and down position. There was no mission impact since the crew could use the up position to select the tenths place on the switch.

Airlock depressurization for the first EVA was initiated at 70:04:53 G.m.t. (02:17:11 MET) and was completed at 70:05:07 G.m.t. (02:17:25 MET). The EVA began at 70:05:12 G.m.t. (02:17:30 MET) when the EMU's were transferred to internal battery power. The crew completed the external activities, except for one task, the connection of the rigid umbilical cables. This task was deferred to the second EVA. The EMUs and EVA tools performed nominally.

The first EVA was successfully completed without the crew having to exit the airlock in support of the pressurized mating adapter (PMA) 3 relocation. The official time of the first EVA was 8 hours 55 minutes 56 seconds. During the PMA 3 relocation and latching operations, the EVA crewmembers were in the airlock on standby. The crewmembers were connected to the servicing and cooling umbilical (SCU) power for 2 hours and 12 minutes while awaiting completion of PMA 3 activities.

After completion of the EVA support, the RMS began maneuvering to PMA 3 for its relocation. PMA 3 was grappled and unberthed from the Node 1 Nadir active common berthing mechanism (ACBM) at 070:11:57 G.m.t. (03:00:15 MET). PMA 3 was then repositioned and successfully installed on the Node 1 Port ACBM at 070:13:50 G.m.t. (03:02:08 MET). The RMS performed nominally and was subsequently powered down.

The RMS was powered on at 071:02:10 G.m.t. (03:14:28 MET) and the Multipurpose Logistics Module (MPLM) was grappled at 071:03:36 G.m.t. (03:15:54 MET). The MPLM was successfully removed from the payload bay and installed on the Node 1 Nadir ACBM at 071:06:08 G.m.t. (03:18:46 MET). The RMS was cradled and powered down following the completion of the MPLM installation activities.

Airlock depressurization for the second EVA was initiated at 72:05:04 G.m.t. (04:17:22 MET). The EVA began at 72:05:23 G.m.t. (04:17:41 MET) when the EMU's were transferred to internal battery power. The crew completed the planned activities plus the task that had been deferred from the first EVA, and the duration of the EVA was 6 hours and 17 minutes. The EMU's and EVA tools performed nominally.

The RMS was successfully powered on at 72:02:34 G.m.t. (04:14:52 MET) and used in support of the EVA. The RMS was cradled and powered down following the completion of the EVA.

The crew reported that the A-side of the middeck EMU battery charger had failed. The crew also reported that all LED's on the A-side were off and a power cycle failed to restore the charger. The B-side of the charger appeared to be operating nominally.

Development test objectives (DTOs) 257 (Structural Dynamics Model Verification) and 263 (Shuttle Automatic Reboost Tuning) were performed in support of ISS/Orbiter structural modeling verification. DTO 257 was initiated at 73:12:02 G.m.t. (06:00:20 MET) and terminated 16 minutes later. DTO 263 was initiated at 73:12:27:54 G.m.t. (06:00:45:45 MET) and lasted 16 seconds. Review of the data indicated that no changes were required for the alternate digital autopilot (DAP) or reboost algorithms.

A collision avoidance/first reboost maneuver was performed using the automatic reboost software with vernier RCS thrusters. The maneuver was initiated at 73:12:12:09 G.m.t. (06:02:30:00 MET) and was terminated 47 minutes and 22 seconds later. The reboost fired RCS thrusters F5L, F5R, L5D and L5L almost continuously. The resultant orbit was 200.1 by 210.8 nmi., and the ΔV imparted to the vehicle was 11.8 ft/sec.

The supply water-tank-C quantity transducer exhibited a quantity dropout during a water-fill period at 71:01:31:57 G.m.t. (03:13:49:48 MET). The measurement went to zero percent when the tank quantity reached approximately 39 percent. The loss of data lasted for less than one minute and was followed by a return to normal data. A second dropout period occurred at 072:17:09:28 G.m.t (05:05:27:19 MET). The second dropout lasted for about 35 seconds with the quantity also fluctuating between 39 and 0 percent. Minor contamination of the quantity gage potentiometer is believed to be the cause of the problem, and this condition did not impact supply water tank usage.

The second ISS reboost maneuver was started at 75:11:32:22.6 G.m.t. (07:23:50:13.6 MET) and completed at 75:12:30:07.1 G.m.t. (08:00:47:58.1 MET) for a total duration of 57 minutes 44.5 seconds. The maneuver was stopped approximately 2 minutes earlier than planned. The primary RCS thruster pulse durations were 160 ms with a period of 11.6 seconds (pulse start to pulse start). Breaks for attitude maintenance limited the number of pulses to 225. The vernier RCS thrusters were used for attitude maintenance with an average duty cycle of 8.03 seconds on and 3.66 seconds off. The ΔV delivered was 7.2 ft/sec and the resultant orbit was 203 by 212 nmi.

The third ISS reboost maneuver was started at 76:09:17:45.1 G.m.t. (08:21:35:36.1 MET) and completed at 76:10:16:00.6 G.m.t. (08:22:33:51.6 MET) for a total duration of 58 minutes 15 seconds. The maneuver was cut short by 1 minute 10 seconds because of the Freon coolant loop (FCL) 1 problem discussed in the following paragraph. The primary RCS thruster pulse durations and period were the same as used for the second reboost maneuver. Breaks for attitude maintenance limited the number of pulses to 249. Vernier thrusters were used for attitude maintenance with the same average duty cycle as used during the second reboost maneuver. The ΔV delivered was 7.4 ft/sec and the resultant orbit was 204.5 by 213.7 nmi.

During a flash evaporator system (FES) water dump, Freon coolant loop (FCL) 1 apparently experienced a flow blockage due to freezing in the radiator with ice collecting

in the port radiator flow controller inlet filter. This condition resulted in reduced flow rates in FCL 1. Automatic radiator bypass occurred when normal radiator temperature control was restarted and a radiator under-temperature condition occurred (< 33 °F). The condition persisted and eventually the radiator bypass mode was switched to manual, equipment was powered on to increase the heat load on the loop, and the attitude was changed to increase the heat load on the radiator. These actions recovered nominal operation of FCL 1.

During recovery from the FCL 1 flow blockage due to freezing in the radiator, one of the actions taken was to power GPCs 2 and 3. Data review indicated that GPC mode changes were made to run within 5 to 7 seconds of each other. This timing led to the concern that the primary avionics software system (PASS) was corrupted since a PASS user note indicates that the time should be greater than 10 seconds. An engineering review determined that a problem would not occur if the time was greater than 5 seconds.

To build confidence in the PASS, memory dumps of GPC's 1 and 4 were performed and the data were analyzed, and no problems were found. Additionally, a set expansion was performed by forming a redundant set with GPC's 1, 2 and 3 strung 1233 and running OPS 2 software. GPC 4 continued to run systems management (SM) software in the common set. GPC's 1, 2 and 3 were transitioned to run OPS 8 software. The cathode ray tube (CRT) 1, 2 and 4 major function switches were toggled between guidance navigation and control (GN&C) and SM to verify proper GPC interface with the GN&C and SM GPC's. Finally, GPC's 1, 2 and 3 were transitioned back to OPS 2, and the set was contracted. No problems were identified.

The dump data was revisited focusing only on the mission scenario. Based on additional code analysis and the dump results, the flight software community stated they had 100-percent confidence in the PASS GPC configuration.

The RMS was powered on at 77:07:17 G.m.t. (09:19:35 MET) and the MPLM was grappled at 77:07:59:03 G.m.t. (09:20:16:54 MET). After the MPLM was reberthed in the Orbiter payload bay, the MPLM was ungrappled at 77:12:17 G.m.t. (10:00:35 MET) and the RMS was cradled and latched at 077:13:08 G.m.t. (10:01:26 MET).

During docked operations prior to ISS and Orbiter repressurization, airlock booster fan B was powered. The fan started on ac phases A and C with only a slight increase in phase B amperes. Phase A showed an increase of 2.33 amperes and phase C had an increase of 3.72 amperes. The fan operated on two phases for 9 minutes and 28 seconds before power was removed. The crew verified that circuit breaker (CB) 24 on panel MA73C was closed. The crew was asked to cycle the CB once and no change occurred in the phase-B current. The crew then cycled the CB five times per the flight rule with no change in phase B current. The fan was powered off. The fan is designed to be able operate on two phases, if a loss of one of the phases occurs.

In preparation for undocking, the ODS hatch was closed and vestibule depressurization was begun at 78:02:48 G.m.t. (10:15:06 MET). Undocking occurred at 78:04:32 G.m.t. (10:16:50 MET), and ISS separation was initiated with a +Z pulse of the primary RCS. Prior to final separation from the ISS, a 1-1/4 revolution flyaround of the ISS was performed. The final separation maneuver was initiated at 78:05:48:00 G.m.t.

(10:18:05:51 MET), with a 12.16-second, +X pulse of primary RCS thrusters L3A and R3A. The ΔV delivered was 2.95 ft/sec, and the resultant orbit was 203 by 213 nmi.

The flight control system (FCS) checkout was performed with no problems identified. APU 1 was used to support the checkout, with a start time of 79:02:05:34 G.m.t. (11:14:23:25 MET). The run time was 5 minutes, 22 seconds, and 21 pounds of fuel were used during the APU operation. APU performance was nominal, and the total run time was too short to require the WSB to provide spray cooling.

Following FCS checkout, the RCS hot-fire was performed nominally. The hot-fire began at 79:03:10:45 G.m.t. (11:15:28:36 MET) and ended at 79:03:17:11 G.m.t. (11:15:35:02 MET). A review of thruster chamber pressure data confirmed that all of the firings were satisfactory, with each thruster performing at least two pulses of 320-millisecond duration. Data review revealed that the primary thruster R2D fuel valve closure was slow but still within specification limits. This behavior has been seen on other thrusters on previous flights and experience indicates that it is not necessarily an indication of an impending leak or failure.

An OMS orbit-adjust maneuver was performed using both OMS engines. Ignition for the maneuver occurred at 79:07:27:58 G.m.t. (11:19:45:49 MET). The maneuver was 15.9 seconds in duration, and the ΔV delivered was 26.7 ft/sec. The resulting orbit was 193.2 by 206.4 nmi.

The payload bay doors were closed and latched for the nominal end of mission landing opportunities at 080:03:50:17 G.m.t. (12:16:08:08 MET).

The first landing opportunity at Kennedy Space Center (KSC) was waived because of rain showers within 30 nmi. and crosswinds that were out of limits. The deorbit maneuver for the second KSC landing opportunity on the planned landing day, a two-engine straight-feed firing, was performed on orbit 201 at 080:06:26:06.188 G.m.t. (12:18:43:57.179 MET). The maneuver was 177.2 seconds in duration with a ΔV of 307.0 ft/sec.

At activation of the helium system for the deorbit maneuver, the right OMS vapor isolation valve 2 failed to indicate open. This condition did not impact the maneuver. Postflight testing will be performed to determine the cause of this failure.

Entry interface occurred at 080:06:59:53.77 G.m.t. (12:19:15:44.76 MET), and entry was completed satisfactorily. Main landing gear touchdown occurred on KSC concrete runway 15 at the Shuttle Landing Facility (SLF) at 080:07:31:43 G.m.t. (12:19:49:34 MET) on March 21, 2001. The nose gear touchdown occurred at 080:07:31:52 G.m.t. The drag chute was deployed at 080:07:31:54 G.m.t. The drag chute was jettisoned at 080:07:32:31 G.m.t. Wheels stop occurred at 080:07:33:06 G.m.t. The rollout was normal in all respects. The flight duration was 12 days 19 hours 49 minutes 34 seconds. The APU's were shut down 18 minutes 20 seconds after landing.

PAYLOADS AND EXPERIMENTS

The STS-102 mission, the eighth U. S. mission to the International Space Station (ISS) carried seven crewmembers up and seven crewmembers down. In the ascent portion of the mission, Mission Specialists 3, 4, and 5 were the Expedition 2 crew to the ISS, and on the entry portion of the mission, Mission Specialists 3, 4, and 5 were the Expedition 1 crewmembers being rotated back to Earth after approximately 140 days in orbit.

A successful rendezvous and docking with the ISS was completed satisfactorily, although the docking was approximately 1 hour late because of a delay in securing a latch on the ISS P6 solar array. Two extravehicular activities (EVA's) were successfully performed and all scheduled as well as additional tasks were completed. The STS-102 mission was the first flight of the Multi Purpose Logistics Module (MPLM), named Leonardo, and the fourth flight of the Integrated Cargo Carrier (ICC). The ICC provided a mounting place for external transfer items.

Once the rendezvous and docking with the ISS was completed, the first EVA was performed. During the EVA, Pressurized Mating Adapter (PMA) 3 was relocated from the Node 1 nadir location to the Node 1 port location using the remote manipulator system (RMS). Following the relocation, the MPLM was docked at the Node 1 nadir location, also using the RMS.

New challenges were encountered regarding determination of the return stowage configuration for the MPLM. As a result, an additional day was provided to completed the MPLM packing during docked operations, extending the overall mission to 13 days. During the flight day 5 to flight day 12 docked operations, all preflight planned on-orbit task priorities were completed.

ISS OPERATIONS

The ISS deemed the STS-102 mission a total success in that all of the planned mission objectives were completed successfully, including additional tasks that were added and completed during the flight. Two EVA's were performed to transfer and install equipment from the ICC to the ISS. Additional EVA tasks that were accomplished included photographic surveys to assist the ISS personnel in assessing the operations and status of ISS systems. The Shuttle performed three reboost maneuvers and raised the orbit to 205 by 214 nmi.

MULTI-PURPOSE LOGISTICS MODULE

The MPLM contents consisted of the following classes of items:

1. U. S. Laboratory System Racks;
2. Resupply/Return Stowage Platforms (RSP's);
3. Resupply Stowage Racks (RSR's);
4. Human Research Facility (HRF) International Standard; and
5. Payload Rack.

INTEGRATED CARGO CARRIER

The ICC, which was carried in the Orbiter payload bay, served as the transport carrier for the larger equipment that was to be transferred to the ISS during the two EVA's. Equipment successfully launched, transferred and externally mounted to the ISS from the ICC included:

1. Pump flow control system (PFCS) – An on-orbit spare;
2. Laboratory cradle assembly (LCA) – Will hold Spacelab pallet containing Space Station remote manipulator system (SSRMS) on ISS mission 6A;
3. External stowage platform (ESP) – For on-orbit spares; and
4. Rigid Umbilical (RU) – Provides power/data to power data grapple fixture (PDGF).

TRANSFER OPERATIONS

The transfer weight from the MPLM and to the MPLM is as shown in the following table.

Description	Weights, lb	Percentage completion
MPLM Stowage to ISS		
Total Cargo	9649	100
Racks Plus Rack Stowage Items	7145	100
Stowage Items in RSR's and RSP's	2703	100
ISS Stowage Items to MPLM	1647	63

TASK PERFORMANCE

Nominal Tasks Completed

The nominal tasks completed during the mission is as follows:

1. Performed mandatory Expedition 1 crew rotation;
2. Critical systems, maintenance and crew-related cargo transferred from middeck;
3. Ten water-filled contingency water containers (CWCs) transferred;
4. Released pressurized mating adapter (PMA) 3/Node 1 umbilicals and relocated PMA 3 to Node 1 port side;
5. Removed the port early communications (ECOMM) antenna for return to ground;
6. Berthed the MPLM to Node 1 nadir, activated and checked out the MPLM;
7. Returned the MPLM to payload bay of the Orbiter;
8. Transferred and installed DC-to-DC converter unit (DDCU) 2 rack;
9. Transferred and installed Laboratory Mobile Servicing System (MSS) rack;
10. Transferred and installed one Robotic Workstation (RWS);
11. Transferred LCA to U. S. Laboratory using the RMS to assist, install, and connect umbilicals. Activated "keep alive" power;
12. Checkout of LCA and ready-to-latch checkout;
13. Transferred PDGF RU to U. S. Laboratory. Activated 'keep alive' power;

14. Transferred and installed DDCU 1 rack;
15. Transferred and stowed second RWS;
16. Transferred and installed Cupola MSS 1 rack;
17. Rotated circuit interrupter devices (CIDs) 1 and 4;
18. Transferred MPLM cross connect jumper cable;
19. Transferred and installed U. S. Laboratory avionics rack 3;
20. Transferred and installed Crew Health Care System (CheCS) and equipment;
21. Removed the external stowage platform (ESP) from the ICC, rack 1 transferred and installed the platform on the aft port U. S. Laboratory trunnion.
22. Removed the pump flow control subassembly (PFCS) critical spare from the ICC, transferred and installed the assembly onto the ESP. Connected associated umbilicals;
23. Engaged port solar array 4-bar linkage;
24. Transferred remaining cargo per group 2, the flight 5A.1 transfer priority list from middeck and MPLM and stowed in ISS:
25. Transferred and stowed the HRF and utilization experiment unique equipment (EUE) to the ISS. Returned utilization EUE to MPLM and middeck;
26. Transferred returned cargo from ISS and stowed in the MPLM and middeck per the flight 5A.1 transfer priority list;
27. Performed the remaining Expedition 2 handover (included remaining items in Handover Phase 1 Checklist and crew preference items);
28. Activated and checked out one RWS. Verified video connectivity between RWS and Orbiter. Required activation and checkout of MSS 2 and DDCU 1 racks (DDCU activation required closure of circuit interrupt devices);
29. Provided 124 Vdc power to MPLM from ISS. Required activation and checkout of DDCU 2 and connection of MPLM to DDCU 2 cross-connect jumper. (DDCU activation required closure of CIDs (circuit interrupt devices).);
30. Performed HRF Hoffman-Reflex and Education Seed Growth Kit experiment activities during joint operations;
31. Sampled the U. S. Laboratory moderate temperature and low temperature coolant using the Coolant Quality Monitoring Kit;
32. Performed IMAX three-dimension (IMAX3D) camera operations for filming of 5A.1 activities in Russian and U. S. Segments;
33. Exchanged four charcoal filters for high-energy particulate air (HEPA) filters in Node 1;
34. Performed Development Test Objective (DTO) 257, Structural Dynamics Model Validation. DTO 261, ISS On-Orbit Loads Validation, objectives were performed along with DTO 257;
35. Performed DTO 263, Shuttle Automatic Reboost Tuning;
36. Performed three Orbiter-ISS reboost maneuvers;
37. Installed and checked out the Internal Audio Subsystem components which were the Russian Audio Interface Unit (RAIU), Docked Audio Interface Unit (DAIU) and S-band Audio Interface Unit (SAIU). This activity required activation and checkout of avionics rack 3;
38. Removed and replaced Node 1 lamp housing assembly with MPLM lamp housing assembly; and
39. Performed imagery survey of the ISS exterior during Orbiter fly-around maneuver after undocking.

Real-Time Task Additions

The following tasks were added during the course of the mission:

1. Centerline berthing camera system (CBCS) checkout to troubleshoot lack of video from CBCS-to-Orbiter for MPLM berthing;
2. U. S. Laboratory water and condensate sampling;
3. Constraints for PMA 3 ingress;
4. Service Module (SM) Solar Array survey;
5. Floating Potential Probe (FPP) light emitting diode (LED) inspection task;
6. Video of U. S. Laboratory condensate venting;
7. U. S. Laboratory non propulsive vent (NPV) photography and inspection request;
8. Removed articulated portable foot restraint (APFR) thermal shield;
9. Video survey of Node 1 nadir common berthing mechanism (CBM) after 10.
10. MPLM undocking;
11. Investigated Kbar fit problem for CheCS and avionics rack 3;
12. Photography of the Treadmill Vibration Isolation System (TVIS) chassis;
13. LTA heater connector test to troubleshoot short in remote power controller (RPC);
14. Cycled manual pressure equalization valve (MPEV) during the PMA 3 relocation; and
15. Removed ECOMM antenna cables for returned them to the ground.

Mission 5A.1 Tasks Not Performed

The following tasks of this mission were not performed.

1. Node nadir hatch window cover was not closed before MPLM unberthing;
2. Video of crewmember exercise on the TVIS;
3. Downlink of internal wireless instrumentation system (IWIS) data; and
4. Upload of MACE II data and portable computer memory card international adapter (PCMCIA) card.

REAL-TIME CHANGES TO THE TRANSFER LIST

ISS-To-MPLM Changes

The following list of items reflects the changes in transfer from the ISS to the MPLM.

1. Right Kbar assembly;
2. Left Kbar assembly;
3. One-half of the central thermal bus (CTB) operations data file (ODF);
4. One and one-half of Shepherd crew preference;
5. One of the NPRV;
6. Eight of the non-collapsible Russian food containers
7. Three of the Russian KVO liners:
8. One of the Russian rubber-lined bag;
9. Thirteen dust covers;
10. One PO603 O-ring;
11. Three protective caps were not transferred;

12. Two crew provisioning bags were not transferred;
13. Twenty-four Russian collapsible food containers were not transferred;
14. Expedition 1 refurbishable items bag was not transferred;
15. IWIS PCMCIA hard drive was not transferred;
16. Braycote was not transferred; and
17. TVIS harness assembly was not transferred.

ISS-To-Shuttle Changes

The following list of items reflects the changes in transfer from the ISS to the Orbiter

1. APFR thermal shield and fasteners;
2. Seed water sample;
3. One videotape;
4. Portable computer system (PCS) removable hard disk;
5. Partially full contingency water container (CWC);
6. Three TVIS harness assemblies;
7. Three IMAX DAT boxes;
8. Four formaldehyde monitors;
9. Two micro archival bags were not transferred;
10. Two humidity condensate sample bags were not transferred;
11. One chemical archive bag was not transferred;
12. Seed Experiment watering hardware was not transferred;
13. Three grab sample containers were not transferred; and
14. EVA tethers were not transferred.

Shuttle-To-ISS Changes

The following list of items reflects the changes in transfer from the Orbiter to the ISS.

1. Shuttle portable computer system hard disk;
2. PGT RS422 card with cable and adapter;
3. Mesh bag;
4. Pin kit assembly 5-foot cable;
5. Three MAG II; and
6. Two additional unused Lithium hydroxide (LiOH) canisters.

Shuttle-To-MPLM Change

Ten used LiOH canisters were transferred from the Orbiter to the MPLM.

ISS HARDWARE ANOMALIES ENCOUNTERED DURING THE FLIGHT

The following list of ISS hardware anomalies resulted in some of the transfer changes shown in the previous lists.

1. Two PMA 3 cables could not be connected to dummy connectors because of the difficulty in removing their dust caps;
2. The Node nadir hatch window cover was not closed before MPLM unberthing;
3. The utilization operations panel (UOP) tripped during RWS checkout;

4. The CheCS and avionics 3 racks were installed with one Kbar;
5. The 4B solar array pin 2 did not lock;
6. The floating potential probe LEDs did not illuminate;
7. The PMA 3 vent was propulsive;
8. The TVIS slat failures;
9. The lower-than-expected rate in U. S. Laboratory Condensate Venting; and
10. The Node smoke detector 2 RPC trip.

IMAX THREE DIMENSION CAMERA OPERATIONS

The IMAX Three Dimension (3D) camera system objectives were all met in that all manifested film was exposed and returned for processing.

The IMAX3D camera was pre-positioned on the ISS and film/support hardware was stowed in the middeck and the MPLM to support IMAX3D photo/television operations in the ISS. No problems were encountered with the camera or any of the support equipment by either the ISS or the Orbiter crewmembers. Timeline constraints during the mission, to protect for the completion of transfer operations, limited the availability of scheduled time for either crew to perform filming. Seven rolls of interior IMAX3D film were manifested with the objective of capturing 25 scenes specified in the scene list for this flight, or scenes of opportunity. In addition, two rolls of exterior film and one roll of interior film were left onboard the ISS by STS-98 for filming the STS-98 departure, STS-102 approach and scenes of opportunity during stage operations; these rolls were scheduled for return on STS-102.

The crew reported that all seven interior rolls of IMAX3D film were exposed and transferred for return. The three rolls of film left by the STS-98 crew were all exposed and were also transferred to STS-102 for return.

SPACE VISION SYSTEM

The Space Vision System (SVS) successfully supported the mission in the relocation of PMA 3 and the MPLM.

During the PMA 3 relocation, the SVS digital indications were zeroed and PMA 3 was pushed in; however, no ready-to-latch indications (RTL) were received. The crew backed out and used the calibrated digital indications to center PMA 3, and all four RTL indications were received. The difference between the SVS and the RMS was less than 1-inch of a ± 3.5 -inch corridor. A preliminary review of the RMS data show that the SVS was probably a total of 1.3 inches off-nominal in the lateral direction out of a 3.5-inch corridor. The calibrated RMS digital data was between 0.4 and 0.8 inch off nominal in the lateral direction. The cause of the RTL indications not being received in the first attempt was most likely the result of a weak RMS configuration and insufficient applied force at a commanded rate of 0.1 ft/sec.

The SVS successfully supported the flight day 5 MPLM berthing with no problems noted. There was a short delay while the crew worked to re-route the CBCS to the RMS operator and the RMS operator to adjust the MPLM position. The SVS and CBCS both agreed that the MPLM was centered and well within the CBM corridor.

CARGO BAY PAYLOADS

Wide-Band Shuttle Vibration Forces Measurement

The Wide-Band Shuttle Vibration Forces Measurement (WSVFM) experiment, managed by the Jet Propulsion Laboratory (JPL), obtained flight measurements of the vibration forces acting between the payload and its mounting structure, as well as acceleration data at high and low frequencies. The WSVFM is battery powered and is activated by gravity (g) switches that sense the Space Shuttle main engine (SSME) ignition vibration. The experiment is designed to operate automatically for approximately 240 seconds and then remain inactive for the remainder of the mission. No data were sent to the ground; consequently, the operational success of this experiment was determined from postflight analysis.

Get-Away Special 783

The Get-Away Special (GAS) 783 consisted of 47 experiments provided by schools in the St. Louis, Missouri, area, all of which were completely passive and self-contained within the standard-sealed 2.5 cubic foot GAS canister. The payload was managed by Washington University, also in St. Louis, and did not require any power or crew interaction. There were no on-orbit operations involved with this canister.

Space Experiment Module

The Space Experiment Module-09 (SEM-09), managed by Goddard Space Flight Center (GSFC), utilized an existing GAS canister that was divided into 10 modules to accommodate small zero-gravity and microgravity experiments. The primary science objective is the quantification of extraterrestrial particles and other orbital debris present in the Orbiter payload bay. The experiment was a passive sponge that collected microscopic debris on-orbit and retains the debris for postflight evaluation by Kindergarten through University students. The experiment was completely passive and did not require any power or crew interaction.

VEHICLE PERFORMANCE

SOLID ROCKET BOOSTERS

All Solid Rocket Booster (SRB) systems performed as expected. The prelaunch countdown was normal and no SRB Launch Commit Criteria (LCC) or Operations and Maintenance Requirements And Specifications Document (OMRSD) violations occurred. No in-flight anomalies were identified from the evaluation of the data.

Power-up and operation of all igniter and field joint heaters were accomplished routinely. The heated, ground-supplied aft-skirt purges maintained the case/nozzle joint and flexible bearing temperatures within the required LCC ranges.

At liftoff, there were no stud hang-ups based on Orbiter accelerometer data. Both SRB's were successfully separated from the vehicle at approximately T+125 seconds. Visual tracking indicated a normal descent and splash down. All 48 sea-water-activated release (SWAR) links (8 links per parachute) fired satisfactorily.

Five enhanced data acquisition system (EDAS) units were installed on the left SRB forward skirt to gather baseline strain data for use in validating the repair to the forward skirt that will be flown on the STS-100 mission. Except for unit 3 experiencing a data gap beginning at 79 seconds and lasting 24 seconds, all thirty channels of data were recorded properly and the data were usable for the desired analysis.

Both SRB's were recovered and returned to KSC for inspection, disassembly and refurbishment. The inspection revealed that both SRBs were in excellent condition.

REUSABLE SOLID ROCKET MOTORS

All Reusable Solid Rocket Motor (RSRM) systems performed satisfactorily during the countdown and the ascent phase of the mission. No LCC or OMRSD violations occurred during the countdown phase. No in-flight anomalies were identified during the review of the data. All RSRM temperatures were maintained within acceptable limits throughout the countdown. The maximum trace-shape variation of pressure versus time during the 62 to 80 second time frame was calculated to be 0.332 percent at 64.5 seconds for the left motor and 0.337 percent at 63.5 seconds for the right motor. These values are well within the 3.2 percent allowable limits.

Data indicate that the flight performance of both RSRM's was within the allowable performance envelopes, and was typical of the performance observed on previous flights. The predicted propellant mean bulk temperature (PMBT) was 63 °F. Delivered burn rates were 0.3675 and 0.3678 inch/second for the left and right motors, respectively. The maximum trace shape variation of pressure versus time during the 62 to 80 second time frame was calculated to be 0.332 percent at 64.5 seconds (left motor) and 0.337 percent at 63.5 seconds (right motor). These values were well within the 3.2 percent allowable limits.

The launch pad environment showed ambient temperatures between 41 °F and 50 °F during the LCC time frame of the countdown. Field joint heaters operated for 13 hours 41 minutes during the final launch countdown. Power was applied to the heating

elements 68 percent of the time during the LCC time frame. All field joint heaters operated nominally throughout the countdown.

The igniter joint heaters operated for 18 hours 56 minutes during the final launch countdown. The igniter heaters were activated prior to L-18 hours because the ambient temperature was less 55 °F. Power was applied to the heating elements 94 percent of the time to keep the igniter joints within their normal operating range.

RSRM PROPULSION PERFORMANCE

Parameter	Left motor, 68 °F		Right motor, 68 °F	
	Predicted	Actual	Predicted	Actual
Impulse gates				
I-20, 10 ⁶ lbf-sec	64.44	64.73	64.54	45.90
I-60, 10 ⁶ lbf-sec	172.98	174.37	173.20	174.82
I-AT, 10 ⁶ lbf-sec	296.94	297.39	296.98	297.31
Vacuum Isp, lbf-sec/lbm	268.5	268.9	268.5	268.7
Burn rate, in/sec @ 60 °F at 625 psia	0.3675	0.3687	0.3678	0.3696
Event times, seconds ^a				
Ignition interval	0.232	N/A	0.232	N/A
Web time ^b	110.7	110.2	110.6	110.1
50 psia cue time	120.9	120.1	120.7	119.6
Action time ^b	123.1	122.3	122.9	122.1
Separation command	125.3	124.5	125.3	124.5
PMBT, °F	63	63	63	63
Maximum ignition rise rate, psia/10 ms	90.8	N/A	90.8	N/A
Decay time, seconds (59.4 psia to 85 K)	3.2	3.1	3.2	3.4
Tailoff Imbalance Impulse	Predicted		Actual	
differential, Klbf-sec	N/A		569.8	

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

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

^bReferenced to liftoff time (ignition interval).

The aft skirt purge was activated seven times during the 71 hours of recorded data for a total of 23 hours 46 minutes. The activation time during the final countdown was 13 hours 29 minutes. It was necessary to activate the aft skirt purge to maintain the nozzle/case joint temperatures above the minimum LCC temperature. The purge was also necessary to thermally condition the flex bearing. During the LCC time frame, the nozzle/case joint sensor temperatures ranged from 78 to 83 °F on both motors. The final flexible bearing mean bulk temperature was determined to be 79 °F.

All ground environmental instrumentation (GEI) and operational flight instrumentation performed within established requirements. All available data were recorded, transmitted and analyzed without incident.

EXTERNAL TANK

All External Tank (ET) objectives and requirements associated with propellant loading and flight operations were met. No significant oxygen or hydrogen leakage concentrations were detected in the intertank. All ET electrical equipment and instrumentation operated satisfactorily. Purge and heater operations were monitored and performed properly. No ET LCC or OMRSD violations occurred during the countdown.

The observed thermal protection system (TPS) cracks were acceptable. Crack growths and additions during loading were acceptable. All ice conditions were acceptable.

The hydrogen gas detection system (HGDS) changed beginning with STS-96. The change incorporated a sampling program for the last three minutes of the countdown. No hazard gas concentrations were measured or detected during the monitoring period.

The pressurization systems functioned properly throughout engine start and flight. The maximum LO₂ ullage pressure experienced during the ullage pressure slump was 13.75 psid.

ET separation was performed and since it occurred within expected tolerances, entry and break-up occurred within the expected footprint approximately 108 nmi. downrange from the preflight predicted impact point.

For this launch, the Orbiter was equipped with the 35mm umbilical well cameras, but there were no 16mm cameras installed for this mission. A review of the photographs revealed no anomalies, but the External Tank/Orbiter (EO)3 separation bolt on the LO₂ side of the ET was not fully retracted into the shaft of the ET ball joint.

SPACE SHUTTLE MAIN ENGINES

The prelaunch operation for the Space Shuttle main engines (SSME's) was satisfactory. The SSME's performed satisfactorily throughout ascent with no in-flight anomalies identified from the data. The flight-derived specific impulse (I_{sp}) was approximately 0.8 second higher than predicted. The Block IIA engines, which were on this vehicle, have typically delivered approximately 0.8 second higher I_{sp} than predicted from ground testing.

Main engine cutoff (MECO) occurred 501.7 seconds after SRB ignition. The commanded maximum dynamic pressure (Max $Q\alpha$) throttle-down was in a single throttle step to 72 percent.

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 appropriate times. The system operated as expected throughout the countdown and flight. As planned, the SRB S&A devices were safed and SRB system power was turned off prior to SRB separation.

During the countdown SRSS testing, the right SRB SRSS systems A and B exhibited signal strengths that were lower than usual. The low signal strengths did not affect system operation and were not observed during subsequent open-loop testing. These results indicate faulty ground support equipment.

ORBITER SUBSYSTEMS PERFORMANCE

Main Propulsion Subsystem

The main propulsion system (MPS) operated satisfactorily, and no LCC or OMRSD violations occurred during the launch countdown and flight. The overall prelaunch system performance for the two launch attempts was nominal.

No significant hazardous gas concentrations were detected prior to liftoff. The maximum hydrogen concentration level in the Orbiter aft compartment, with the normally elevated system backpressure used for fast-fill, was 97 ppm (corrected for mass spectrometer drift). This compares favorably with previous data for this vehicle.

The pneumatic outlet pressure decay was approximately 3.3 psi/min, which violates the File IX requirement. The maximum allowable pressure decay is 2.4 psi/min. During the Orbiter Processing Facility (OPF) turnaround activities, the leakage was measured as 2.75 psi/min. This amount of leakage can be attributed to four solenoids in the pneumatic leg. Postflight testing will be performed to determine the source of the leakage.

Data indicate that the LO₂ and liquid hydrogen (LH₂) pressurization systems performed as planned. Engine inlet net positive suction pressure (NPSP) requirements were met throughout the flight. All three flow-control valves performed nominally, and all pneumatic valve cycles were within the timing requirements.

The gaseous oxygen (GO₂) fixed orifice pressurization system performed as predicted. Reconstructed data from engine and MPS parameters closely matched the actual ET ullage pressure measurements. Helium system performance for the SSME and pneumatic helium systems was nominal. Entry helium usage was 60.1 lbm, a value that is within the requirements. All other parameters were nominal.

Reaction Control Subsystem

The reaction control subsystem (RCS) performed satisfactorily throughout the mission. No in-flight anomalies were noted in the evaluation of the data.

The RCS was used to perform nine translation firings in support of the rendezvous with the ISS, a collision avoidance/first reboost maneuver and two additional RCS reboost maneuvers. The overall altitude increase delivered during the three separate maneuvers was approximately 6.5 nmi. The following table reflects the maneuvers performed to complete the rendezvous with the ISS.

RCS RENDEZVOUS MANEUVERS

Maneuver	Time, G.m.t./MET	ΔV , ft/sec	Firing time, sec	Orbit, nmi.
NCC (Multi-axis RCS)	069:02:15:56 01:14:33:47	2.2	6.7	198.4 by 199.5
Out-of-plane null	069:03:45:40 01:16:03:31	N/A	< 60	N/A
MC-1	069:03:32:38 01:15:50:29	0.4	2.0	199.2 by 205.2
MC-2	069:04:06:08 01:16:23:59	1.9	8.1	199.7 by 205.4
MC-3	069:04:23:21 01:16:41:12	1.0	4.5	199.1 by 205.2
MC-4	069:04:33:21 01:16:51:12	2.0	8.6	199.1 by 206.1
Collision avoidance/first reboost	073:14:12:09 04:02:30:00	11.8	Four +X axis 4.64-second pulses	200.1 by 210.8
Second reboost maneuver	075:11:32:22.6 07:23:50:13.6	11.6	225 pulses	203 by 212
Third reboost maneuver	076:09:17:45.1 08:21:35:36.1	7.4	249 pulses	204.5 by 213.7

A total of 5754.1 lbm propellants (3518.8 lbm - oxidizer, 2235.3 lbm - fuel) were used from the RCS during the rendezvous mission with the International Space Station. In addition, a total of 2045.2 lbm of the orbital maneuvering subsystem (OMS) propellants were used by the RCS during interconnect operations. The primary RCS thrusters had 3391 firings and a total firing time of approximately 9425.19 seconds. The vernier RCS thrusters had 9203 firings and a total firing time of 38567.27 seconds.

The first ISS reboost maneuver, originally planned for flight day 8, was moved up 12 hours and used as a collision avoidance maneuver. The maneuver was performed as a vernier/vernier automatic reboost, the first time a reboost has been performed in this configuration. The reboost, planned for one hour of thrusting, was stopped at 50 minutes because of over-performance. Thrusters F5L, F5R, L5D and L5L were fired nearly continuously for 47 minutes 22 seconds.

The second ISS reboost maneuver used thrusters L3A and R3A. The maneuver was 57 minutes 44.45 seconds in length. The primary thruster pulse widths were 160 ms, with a firing period of 11.6 seconds from the start of a pulse until the next firing. The number of pulses was limited to 225 because the regimen was interrupted to perform attitude maintenance with the vernier thrusters. The aft down-firing vernier thrusters had an average duty cycle of 8.03 seconds on and 3.66 seconds off.

The third ISS reboost maneuver used thrusters L3A and R3A. The maneuver was 58 minutes 15 seconds in length. The maneuver began 35 seconds late and ended 1 minute 10 seconds earlier than planned. The primary thruster pulse widths were 160 ms, with a firing period of 11.6 seconds from the start of a pulse until the next firing. The number of pulses was limited to 249 because the regimen was interrupted to

perform attitude maintenance with the vernier thrusters. The aft down-firing vernier thrusters had an average duty cycle of 8.03 seconds on and 3.66 seconds off.

The RCS was used in support of DTO 257 following the second EVA and with the Orbiter docking system (ODS) unpressurized. A maneuver was begun with a 320 ms pulse of the L3D and R3D thrusters. A 17.2-second firing of the primary F5L and F5R thrusters, and three 180 ms pulses of the F5L thruster for attitude hold and rate damping followed these pulses.

The undocking and fly-around maneuver were nominal. The final separation maneuver was a 12.16-second +Z axis pulse using the L3A and R3A thrusters.

The RCS hot-fire was performed nominally. The hot-fire began at 79:03:10:45 G.m.t. (11:15:28:36 MET) and ended at 79:03:17:11 G.m.t. (11:15:35:02 MET). A review of thruster chamber pressure data confirmed that all of the firings were satisfactory, with each thruster performing at least two pulses of 320-millisecond duration. Data review revealed that the primary thruster R2D fuel valve closure was slow but still within specification limits. This behavior has been seen on other thrusters on previous flights and experience indicates that it is not necessarily an indication of an impending leak or failure.

Orbital Maneuvering Subsystem

The OMS performed satisfactorily throughout the mission. One in-flight anomaly, which is discussed in a following paragraph, was identified from the evaluation of the data. The OMS inlet pressures, chamber pressures and regeneration jacket temperatures for both engines were as predicted, verifying nominal engine performance. All nine OMS maneuvers were performed accurately, and OMS operation was nominal during all the maneuvers.

A total of 23078 lbm (14,414 lbm - oxidizer and 8,664 lbm - fuel) of OMS propellants were consumed during the mission. Of this total, the OMS provided 2045.2 lbm of propellants to the RCS during interconnect operations.

When the crew configured the OMS helium valves, the right OMS vapor isolation valve 2 did not indicate open for either the OMS-8 maneuver or the deorbit maneuver (Flight Problem STS-102-V-02). The valve did not indicate movement either when the cockpit switch was manually placed in the open position or when the valve-open commands were sent by the general purpose computer (GPC) OMS fire-sequence during the maneuvers. A review of the main bus currents during the maneuvers for this flight and the previous flight of this vehicle shows no change in the current signature, and this seems to indicate the valve did receive power. A multiplexer/demultiplexer (MDM) built-in test equipment (BITE) check did not reveal any anomaly within the MDM; however, this test is not conclusive. There is a single capacitor, which if it fails can prevent the valve position signal from being detected. Further troubleshooting is being performed during the turnaround activities at Kennedy Space Center (KSC).

The following table lists the OMS maneuvers performed during the flight.

OMS MANEUVERS

Maneuver	Time, G.m.t./MET	ΔV , ft/sec	Firing time, sec	Orbit, nmi.
Assist Maneuver (Both engines)	067:11:44:23 00:00:02:14	-	69.6	N/A
OMS-2 (Both engines)	067:12:20:46 00:00:38:37	97.0	63.8	85.2 by 127.1
OMS-3 (NC-1) (Both engines)	067:15:16:32 00:03:34:23	111.7	72.8	126.4 by 148.0
OMS-4 (NC-2) (Right engine)	068:04:14:23 00:16:32:14	12.1	15.8	149.5 by 130.8
OMS-5 (NC-3) Both engines	068:14:15:17 01:02:33:08	118.2	75.6	147.8 by 198.4
OMS-6 (NC-4) (Both engines)	069:01:35:13 01:13:53:04	90.8	75.6	198.5 by 200.0
OMS-7 (TI) (Left engine)	069:03:12:51 01:15:30:42	9.6	12.6	199.2 by 205.3
OMS-8 (Orbit adjust) (both engines)	079:07:27:58 11:19:45:49	26.7	15.9	193.2 by 206.4
Deorbit (Both engines)	051:19:27:20 12:20:14:18	317.9	164.2	-

Power Reactant Storage and Distribution Subsystem

The power reactant storage and distribution (PRSD) subsystem performance was nominal throughout the STS-102 mission. No LCC or OMRSD violations occurred during the countdown and mission, and no in-flight anomalies were noted during the analysis of the data. The PRSD subsystem supplied the fuel cells with 2884 lbm of oxygen and 363 lbm of hydrogen for the production of 4243 kW of electrical energy. In addition, the environmental control and life support system (ECLSS) was supplied 243 lbm of oxygen for life support.

The Orbiter landed with 787 lbm of oxygen and 94 lbm of hydrogen remaining in the PRSD subsystem. A 54-hour mission extension capability existed at landing, based on the PRSD oxygen (limiting reactant) tank landing quantities and an average power level of 13.8 kW. At an extension-day power level of 12.1 kW, a 60-hour mission extension capability was available.

Oxygen tank 4 was depleted to residual quantities, and the heaters were deactivated when the oxygen fluid temperature reached 160 °F. The fluid temperature continued to rise after the heater deactivation. The fluid temperature reached 167 °F and remained above 160 °F for 34 minutes. The Shuttle Operational Data Book (SODB) states that the heaters will be deactivated when the heater temperature reaches 350 °F or the fluid temperature reaches 160 °F. The heater temperature is the more critical and it did not approach the 350 °F. The higher than desired fluid temperature did not impact the operation of the system or the integrity of the tank.

Fuel Cell Powerplant Subsystem

The overall performance of the fuel cell powerplant (FCP) subsystem was nominal during the mission. There were no OMRSD or LCC violations, nor were any in-flight anomalies found during the analysis of the data. The average power level and load was 13.8 kW and 445 amperes. The fuel cells produced 3247 lbm of potable water and 4243 kWh of electrical energy while using 2884 lbm of oxygen and 363 lbm of hydrogen.

Four purges of the fuel cells were performed, all of which achieved nominal results. The actual fuel cell voltages at the end of the mission were 0.15 V above the predicted for fuel cell 1, 0.20 V above predicted for fuel cell 2, and 0.15 V above the predicted for fuel cell 3. The voltage margin above the minimum performance curve at 200 amperes at the end of the mission was 1.2 V for fuel cell 1, 1.4 V for fuel cell 2, and 1.1 V for fuel cell 3.

The overall thermal performance of the fuel cell water relief, water line, and reactant purge heater systems was normal. System A was used during the countdown, ascent and through 5.7 days of the mission. The B system was selected at that time and it operated for the remainder of the mission.

The fuel cell 3 alternate water line temperature was high and erratic for most of the mission, indicating leakage past the check valve. Leakage on this check valve has occurred on previous flights. The valve did exhibit normal operation for two intervals of about 24 hours during the flight. During entry, the valve reseated and indicated normal operation through the end of the mission.

The fuel cell 1 hydrogen flow meter output became slightly erratic after launch. It became more erratic and biased high about 4 days into the mission. The flow meter responded to purge flow rates, except for the last purge, and continued to exhibit a bias. The erratic performance and bias continued until entry interface at which time it returned to nominal indications through landing. The hydrogen flow meter indicated a flow rate of 0.272 lb/hr after fuel cell 1 was shut down, and it should have indicated zero. Initial indications were that a hydrogen leak existed.

The fuel cell monitoring system (FCMS) was used to monitor individual cell voltages during the prelaunch period as well as during the mission and after landing. Full-rate on-orbit data were recorded for 12 minutes during the mission. No problems were identified from the analysis of the data. All of the cell performance monitor (CPM) values remained stable throughout the mission.

Auxiliary Power Unit Subsystem

The auxiliary power unit (APU) subsystem performance was nominal throughout the STS-102 mission. No in-flight anomalies were identified during the review of the data.

The flight control system (FCS) checkout was performed nominally, with no problems identified. APU 1 was used to support the checkout, with a run time was 5 minutes, 22 seconds, and a fuel consumption of 11 pounds during the APU operation. APU performance was nominal and the total run time was too short to require the water spray boiler (WSB) to provide spray cooling.

The following table presents the APU run times and fuel consumption for the mission.

APU RUN TIMES AND FUEL CONSUMPTION

Flight phase	APU 1 (S/N 405)		APU 2 (S/N 303)		APU 3 (S/N 409)	
	(a) (b) Time, Min:sec	Fuel consumption, lb	(a) Time, Min:sec	Fuel consumption, lb	(a) Time, min:sec	Fuel consumption, lb
Ascent	19:06	48	19:25	51	19:36	51
FCS checkout	05:22	11				
Entry ^a	62:31	122	88:40	171	62:52	140
Total	86:59	181	108:05	222	82:28	191

^a APUs were shut down 18 minutes 20 seconds after landing.

Hydraulics/Water Spray Boiler Subsystem

The hydraulics/WSB subsystem performed satisfactorily throughout the mission. No in-flight anomalies were identified from the analysis of the data. STS-102 was the sixth flight in which the new WSB water additive (PGME) was used to preclude ascent freeze-ups. The STS-102 mission was the first flight in which the additive was loaded into all three WSB system cores during the turnaround flow at KSC to preclude ascent under-cooling conditions from occurring.

WSB 2, operating on the A controller, experienced a minor under-cooling condition with a maximum APU 2 lubrication oil return temperature of 276.7 °F. During the previous flight of this vehicle (STS-92), WSB 2 failed to provide spray cooling during ascent and APU 2 was shut down at a lubrication return oil return temperature of 317 °F. WSB 2 did not use the PGME/water additive for the STS-92 mission. For this flight, the WSB 2 core was loaded with approximately 5.0 lb of the additive mixture. The mixture was 53 percent water and 47 percent PGME.

APU 2 was started prior to ignition for the deorbit maneuver with the WSB 2 system configured on the A controller. WSB 2 spray cooling was initiated at a lubrication oil return temperature of 272 °F. Following verification of spray cooling on WSB 2 A controller, the system was configured to the B controller, and this occurred about 12 minutes after the start of APU 2. The WSB 2 lubrication oil return temperature stabilized at 254 °F while operating on the B controller. The signature in the data is indicative of a temperature sensor problem, which will be corrected during the upcoming Orbiter Maintenance Down Period (OMDP).

During the course of the mission, the hydraulic system 3 reservoir quantity decayed a total of 3 percent with no corresponding decay in system temperatures or pressures. During ascent, hydraulic system 3 performed nominally with no evidence of a leak. The absence of a leakage signature while the main pump was running at high pressure suggests that no dynamic leakage exists on the high pressure side of the main pump. Since the leak rate is very small, the leak is suspected to be in the return (low pressure) side of the system. Hydraulic system 3 performed nominally during entry. Postflight troubleshooting was performed during the turnaround activity for this vehicle.

Electrical Power Distribution and Control Subsystem

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

The crew reported that the fan in the Orbiter Cabin Air Cleaner (OCAC) was spinning at only 60 or 70 rpm in all three speed-settings. The crew performed troubleshooting on the OCAC on flight day 2. The fan spun freely when rotated by hand but still spun at only 60 to 70 rpm regardless of the speed setting. The fan was connected to a different DC utility outlet, and the green light emitting diode (LED) illuminated when the power was on but the red LED's did not illuminate at any time. An in-flight maintenance procedure was developed and troubleshooting later in the mission recovered nominal operation of the OCAC. A blown 0.5 ampere slow-blow fuse on the OCAC diagnostic box circuit board was bypassed with a new 1 ampere fast-blow fuse.

At 077:12:15:42 G.m.t. (10:00:33:33 MET), the Airlock tunnel fan B was powered on to augment the fan A flow. Fan B started and ran on two phases (phases A and C). The phase B circuit breaker was cycled 6 times with no joy on regaining phase B. The switch was not cycled. At 077:12:25:10 G.m.t. (10:00:43:01 MET), the power was removed from Airlock tunnel fan B.

Orbiter Docking System

The Orbiter Docking System (ODS) performed satisfactorily throughout the mission. No significant problems or in-flight anomalies were identified from the mission operations or the evaluation of the data. The active system monitor parameters indicated normal outputs throughout the duration of the flight. Checkouts of the ODS were completed nominally.

Orbiter/ISS capture occurred at 069:06:38:26 G.m.t. (01:18:56:17 MET). A successful ring-in and hard mating was subsequently performed. During the drive-in of the ring, alignment was temporarily lost, apparently due to a stuck damper. This phenomenon has been observed in the past. Leak checks were performed and opening of the hatches was completed at approximately 069:08:51 G.m.t. (01:21:09 MET). Docking was delayed approximately 1 hour because of a problem on the ISS with latching one of the P6 solar arrays in the feathered position.

In preparation for undocking, the ODS hatch was closed and vestibule depressurization was begun at 78:02:48 G.m.t. (10:15:06 MET). Undocking occurred at 78:04:32 G.m.t. (10:16:50 MET), and ISS separation was initiated with a +Z pulse of the primary RCS.

The ODS valves were used during the docked operation and for the EVAs. The Orbiter was docked to the ISS PMA 2 and the vestibule was pressurized from the ISS. The post-docking vestibule leak check was nominal. The vestibule depressurization valves were used to depressurize the vestibule to vacuum before undocking and the post-undocking vestibule leak check was nominal.

The external airlock waterline heater reconfiguration from string A heaters to String B heaters was performed as part of the in-flight checkout. String C heaters were not required.

Atmospheric Revitalization Pressure Control Subsystem

The ARPCS system performed normally throughout the duration of the flight. The active system monitor parameters indicated normal output throughout the duration of the flight.

The Orbiter equalized the internal pressure with the ISS and the hatches between the ISS and the Orbiter were opened at 069:08:51 G.m.t. (01:21:09 MET). Pressure in the ISS/Orbiter stack was raised to 14.7 psia by electronically taking the cabin pressure regulators out of the circuit.

The first depressurization to 10.2-psia to support the first EVA was initiated at 069:11:44 G.m.t. (02:00:02 MET) and the cabin pressure was reduced to 10.4 psia. The pressure was maintained at 10.4 psia until after the first EVA crewmembers had egressed the cabin, after which the cabin pressure was increased back to 14.7 psia. At the completion of the EVA, the airlock was repressurized, and the first EVA crewmembers ingressed the cabin. After the first EVA, the cabin pressure was returned to 14.7 psia, and PCS 1 maintained the pressure control. Hatches between the ISS and the Orbiter were opened for the transfer of equipment at 71:26:52 G.m.t. (03:15:10 MET).

The crew reported that while changing the hardware caution and warning for the 10.2-psia depressurization, the tenths place on the limit-set value pushbutton rotary did not work in the down position. Note that the limit-set value switch can be nominally operated in the up and down position. There was no mission impact since the crew could use the up position to select the tenths place on the switch. The switch was replaced during the postflight turnaround activity.

In preparation for the second EVA, the hatches between the ISS and the Orbiter were closed at 71:15:27 G.m.t. (03:23:45 MET). Cabin depressurization to support the second EVA was secured at 071:12:58 G.m.t. (04:01:16 MET) and the cabin pressure was 10.4 psia. During the second EVA, the cabin pressure was returned to 14.7 psia. Pressure was returned to 14.7 psia after airlock repressurization, and normal pressure control began using pressure control system (PCS) 2. The cabin pressure was equalized with the ISS and the hatches were opened. A stack repressurization with oxygen was performed at 077:12:36 G.m.t. (010:00:54 MET). The hatches between the ISS and Orbiter were closed at 078:02:33 G.m.t. (010:14:51 MET). Normal operation of the PCS system was used for the remainder of the mission.

Atmospheric Revitalization Subsystem

The ARS system performed nominally throughout the duration of the flight, with one exception.

The Orbiter Condensate Separation hardware was manifested on this flight. This was the first flight of the hardware installation on this vehicle. The hardware is the two-piece configuration, consisting of an adapter hose assembly and a water dispenser valve assembly (WDVA). The hose was installed on the vehicle and pressure checked for leakage during the OPF turnaround flow. The on-orbit installation of the hardware did not occur because of the contamination found in the waste collection system (WCS) following the STS-97 flight. It is believed the Solid Urine Pretreat Assembly (SUPA) may

have been the contributing factor/cause of the contamination. Therefore, no condensate collection occurred on this flight.

At 077:12:41 G.m.t. (10:00:59 MET), the airlock booster fan B started on two phases. The airlock booster fan was powered to assist with the oxygen mixing during the repressurization of the ISS/Orbiter stack with oxygen. The fan started on two phases, phases A and C, and continued to operate for approximately 9 minutes and 22 seconds. The crew was asked to verify that circuit breaker (CB) 24, located on panel MA73C, was pushed in. The crew confirmed that the CB was in; however the crew cycled that CB one time. The crew was asked to reset the CB five times, and the phase B current was still not present. The B fan continued to operate on two phases. The fan manufacturer indicated that the fan could continually be powered on two phases for up to 165 hours without damaging the fan.

During the launch phase, the crew compartment temperature peaked to 75.21 °F and climbed to 80.61 °F at approximately 2 hours and 30 minutes into the flight. Cabin humidity peaked to 40.78 percent 5 minutes and 13 seconds after launch. The heat exchanger outlet air temperature peaked to 73.68 °F approximately 3 minutes 33 seconds into the flight.

At 078:06:02 G.m.t. (010:18:20 MET), the partial pressure carbon dioxide (ppCO₂) peaked to 9.14 mmHg while the cabin pressure was at 14.7 psia. This occurred approximately 3.5 hours after hatch closure, which occurred at 078:02:33 G.m.t. (10:14:51 MET). The crew awakened that same day at 77:22:42 G.m.t. (10:11:00 MET), and no lithium hydroxide (LiOH) change occurred at that time, as the ppCO₂ when the crew awakened was approximately 3.1 mmHg. At 78:04:50 G.m.t. (10:17:08 MET), the ppCO₂ climbed through the 7.6 mmHg limit and did not decrease below 7.6 mmHg for approximately 1 hour and 23 minutes. Some of the crewmembers experienced mild symptoms related to elevated ppCO₂ exposure.

During 10.2-psia cabin pressure operations, the ppCO₂ peaked to 6.0 mmHg for a short period. This occurred during the period of the second cabin depressurization and just after the cabin had been depressurized.

Cabin Humidity averaged 30.0 percent for the flight, peaking to 45.2 percent during the power up of the primary water coolant loop during the radiator panel icing incident. The primary loop was powered on to increase the cabin heat load into the Freon loop.

During the landing phase of the flight, the heat exchanger outlet temperature peaked to 60.56 °F 10 minutes after wheel stop; with the cabin air temperature peaking to 74.07 °F 29 minutes 51 seconds after wheel stop. The cabin humidity peaked near 46.7 percent approximately 36 minutes 35 seconds after wheel stop.

Active Thermal Control Subsystem

The active thermal control subsystem (ATCS) performed well during the ascent phase of STS-102. No pre-evaporative cooling was observed and that indicates no evidence of condensate existed in the flash evaporator subsystem (FES) cores prior to launch.

Shortly before 68:05:00 G.m.t. (00:17:18 MET), the FES left topping-duct string A heater failed off. The temperature sensor showed nominal heater cycles before that time and

then a cooling trend after that time, a clear deviation from normal heater operations. The system B heater was selected at 68:22:53 G.m.t. (01:11:11 MET), and the heater is performing nominally.

The FES behavior that was notable was the irregular FES outlet-temperature profile that occurred during main engine cutoff (MECO). There was a temperature rise of 2 °F from 38 °F about six seconds before MECO. The outlet temperature cooled back down to 38 °F and then began to rise by about 6 °F by six seconds after MECO. The temperature then returned to 38 °F. The rising slope of the temperature to 44° F was also irregularly shaped as shown in the data. Normally, the FES outlet temperature would begin to rise about 6 to 7° F by 6 seconds after MECO and then cool back down to the FES control temperature of 38 ± 2 °F in a smooth curve as observed in the previous flight, which was STS-92. However, this FES behavior for STS-102 is not anomalous because the FES duct temperatures, feedline temperatures, and water pressures showed no excess carryover nor were there any anomalous feedline parameters. Furthermore, no limits were violated. No further unexpected behavior from the FES was observed for the rest of the mission.

At about 068:05:47 G.m.t. (00:18:05 MET), the FES left duct heater began to show non-cyclic heater behavior and a cool-down trend. Evaluation of data over the next several hours confirmed that the FES steam and environmental effects were the only factors affecting duct temperatures and that the heater string A on zone F for the left topping duct had failed. At 68:22:58 G.m.t. (01:11:16 MET), the crew switched the FES topping duct heater from the A string to the B string. The data for the left topping duct began to show a response within minutes. This further confirmed that the string A heater had failed. The topping duct temperatures remained nominal for the rest of the flight on heater string B. Postflight examination of the heater A system for the zone F revealed a bad thermostwitch. Additional troubleshooting of the thermostwitch is in work.

During a FES water dump, Freon coolant loop (FCL) 1 apparently experienced a flow blockage due to freezing in the radiator with ice collecting in the port radiator flow controller inlet filter (Flight Problem STS-102-V-01). At about 076:09:37 G.m.t. (08:21:55 MET), the FCL 1 flow rates began to degrade and eventually dropped from about 2900 lb/hr to 940 lb/hr. Automatic radiator bypass occurred when normal radiator temperature control was restarted and a radiator under-temperature condition occurred (< 33 °F). The condition persisted and eventually the radiator bypass mode was switched to manual, equipment was powered on to increase the heat load on the loop, and the attitude was changed to increase the heat load on the radiator. These actions recovered nominal operation of FCL 1. The flow degradation was caused by an accumulation of ice in the inlet filter to the FCL 1 radiator flow control valve. The radiator panel outlet temperature on FCL 1 had dropped to -75 °F. This cold condition was caused by a combination of the FES water dump and the reboost attitude that placed the Orbiter in a bay-to-space orientation.

Supply and Waste Water Subsystem

The Supply Water and Waste Management Systems performed nominally throughout the mission and all of the scheduled in-flight checkout requirements were satisfied. Supply water was managed through the use of the FES, water transfer to the International Space Station and the overboard dump system. Three supply water nozzle

dumps were performed at a nominal dump rate of 1.63 percent per minute (2.68 lb/min). The line heater maintained the supply water dump line temperature between 64 °F and 93 °F throughout the mission.

Six wastewater dumps were performed at an average rate of 1.89 percent/minute (3.11 lb/min). The first waste dump lasted only for 12 minutes, and was video taped and monitored to confirm a nominal waste-dump plume. The waste water dump line temperature was maintained between 58 °F and 85 °F throughout the mission. Vacuum vent line temperature was maintained between 60 °F and 83 °F.

Ten Contingency Water Containers (CWC's) were filled and transferred to the ISS, for a total of 974.4 lb. Seven of the CWC's transferred were potable water and three were technical water. Calculated average fill rate was 95 lb/min. Initially, CWC fill number 7 was not scheduled to be sampled, but sampling was performed as a result of a Russian request after they have detected cadmium contamination in their water tank. It was reported that tank SVO-ZV has been filled with CWC water from STS-106, bags 4 and 8.

During the fill and drain of supply water tanks on this mission, the potable water tank "C" quantity measurement had a non-uniform increase. There was a flat spot in the fill and drain signature that could be indicative of a bellow-stiction (not moving) problem. The bellows performance during fill and drain of the water tank has been identified and is well understood. This condition did not impact the mission or the water system operation. Corrective action for this condition has been deferred to the next OMDP.

At 68:13:47:57 G.m.t. (01:02:05:48 MET), the tank C quantity sensor started oscillating between 6 and 68 percent for 12 minutes and then recovered to the nominal reading. The tank quantity was 6 percent during this occurrence. Additionally, at 071:01:32 G.m.t. (03:01:50 MET), the quantity sensor exhibited a quantity dropout at a tank quantity of 39 percent during a water-filling period. The tank quantity dropped to zero percent for less than one minute and recovered. A second dropout period occurred at 072:17:09:28 G.m.t. (05:05:27:19 MET) and lasted for about 35 seconds with the quantity fluctuating between 39 and zero percent. Such dropouts have been experienced in previous flights and the problem is believed to be associated with minor contamination that intermittently interrupts the output signal of the potentiometer. These dropouts are understood problems and are deferred for repair when the vehicle is in the OMDP.

Waste Collection Subsystem

The waste collection subsystem (WCS) performed satisfactorily throughout the mission. The crew noted no anomalous performance.

Airlock Support System

The airlock support system provided all of the support required for the EVA activities in a satisfactory manner.

During docked operations prior to ISS and Orbiter repressurization, airlock booster fan B was powered. The fan started on ac phases A and C with only a slight increase in phase B amperes. Phase A showed an increase of 2.33 amperes and phase C had an increase of 3.72 amperes. The fan operated on two phases for 9 minutes and 28 seconds before power was removed. The crew verified that circuit breaker (CB) 24 on panel MA73C was closed. The crew was asked to cycle the CB once and no change

occurred in the phase-B current. The crew then cycled the CB five times per the flight rule with no change in phase B current. The fan was powered off. The fan is designed to be able operate on two phases, if a loss of one of the phases occurs.

Smoke Detection and Fire Suppression Subsystem

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

Flight Data System

The flight data system provided satisfactory support throughout the STS-102 mission. No in-flight anomalies were noted in the data, and the minor problems are discussed in the following paragraphs.

At 068:09:00 G.m.t. (00:23:18 MET), the data on cathode ray tube (CRT) 1 appeared garbled when the CRT was initially powered on. While performing the malfunction procedure, a power cycle of the unit restored nominal operations.

A review of the downlisted BITE status words and poll header word did not reveal that the display electronic unit (DEU) sent two expected bits to the general purpose computer (GPC) during initialization (GPC downlists BITE status words approximately every other poll). While User Notes deal with DEU Control Program (DCP Software) timing window issues, none of the User Notes explain this particular condition. Analysis indicates that if the DEU fails to transmit the expected poll header word critical BITE bit to the GPC subsequent to initialization, a transient display anomaly will occur, similar to what was seen on orbit. While the exact cause for the transient is unknown, the most probable cause lies within DEU hardware (it has been determined through code analysis that the DCP Software was most likely not the cause). More specifically, a transient in the DEU hardware may have caused the error during the final steps of the DEU initialization process of storing the critical BITE bit, or during DEU transmission of this bit. It should be noted, however, that the DEU BITE status words did not indicate that a hardware failure had occurred. A slight possibility exists that the presumed lost Critical BITE bit occurred during the GPC's reception of the poll header word (i.e., single event upset in IOP Local Store). DEU17 has been powered-up several times subsequent to this transient, and the error condition has not repeated. No further action is required for this recoverable transient, and the Problem Resolution Team (PRT) recommendation, on March 15, 2001, is that DEU17 should remain flight-worthy (i.e., DEU17 will remain on OV-103 subsequent to the mission). No additional postflight testing/troubleshooting is required.

During recovery from the FCL 1 flow blockage due to freezing in the radiator, one of the actions taken was to power general-purpose computers (GPC's) 2 and 3. Data review indicated that GPC mode changes were made to run within 5 to 7 seconds of each other. This timing lead to the concern that the primary avionics software system (PASS) was corrupted since a PASS user note indicates that the time should be greater than 10 seconds. An engineering review determined that a problem would not occur if the time were greater than 5 seconds.

To build confidence in the PASS, memory dumps of GPC's 1 and 4 were performed and the data were analyzed, and no problems were found. Additionally, a set-expansion was

performed by forming a redundant set with GPC's 1, 2 and 3 strung 1233 and running OPS 2 software. GPC 4 continued to run SM software in the common set. GPC's 1, 2 and 3 were transitioned to run OPS 8 software. The CRT 1, 2 and 4 major function switches were toggled between guidance navigation and control (GN&C) and systems management (SM) to verify proper GPC interface with the GNC and SM GPC's. Finally, GPC's 1, 2 and 3 were transitioned back to OPS 2 and the set was contracted. No problems were identified.

The dump data was revisited focusing only on the mission scenario. Based on additional code analysis and the dump results, the flight software community stated they had 100-percent confidence in the PASS GPC configuration.

Flight Software

The flight software performed as expected during the mission.

Flight Control Subsystem

The flight control subsystem performance was nominal throughout the mission.

The entry inertial guidance, navigation and control performance was nominal. The navigation sensors (drag, TACAN, ADTA and MLS) data were incorporated into the onboard navigation state vectors at the expected regions of operations. No navigation editing was observed.

The inertial measurement unit (IMU) performance was nominal throughout the mission. Only on in-flight adjustment of the onboard IMU accelerometer compensation values was required, and that occurred on IMU 3.

Displays and Controls Subsystem

The displays and controls subsystem performed satisfactorily throughout the mission.

Communications and Tracking Subsystem

The communications and tracking subsystem performed nominally. One minor problem was noted early in the flight and it is discussed in the following paragraph.

Following the handover from Merritt Island Launch Area (MILA) at launch plus 1 minute through launch plus 2 minutes 30 seconds, the real time down-link telemetry received from the ground tracking stations was unusable at the Mission Control Center (MCC) in Houston. Following the handover back to MILA at 2 minutes 30 seconds, the telemetry dropouts observed at MCC decreased significantly. However, telemetry dropouts continued until loss of signal (LOS) at MILA. As a result, 1 minute 30 seconds of non-recoverable data during powered flight was lost.

At 067:16:38 G.m.t. (00:04:56 MET), the crew reported that broken communications were being received between the ground and the flight deck when using the hand-held microphone connected to the multiple headset adapter. The crew bypassed the multiple headset adaptor and went directly into a flight deck crew communications umbilical. As a result, better communications were present. On the following day, the crew noted that

a switch on the mission specialist audio terminal unit was not in the correct position. The switch was placed in the correct position (PTT/PTT) and there were no more problems with the multiple headset adapter and the hand-held microphone interface.

During entry, the heads-up display (HUD) was extremely faint and on some TV monitors the image was not detectable. On final approach, the runway was very dark and difficult to discern. The video could not be used by KSC Public Affairs. Postflight troubleshooting was required to determine the source (Orbiter or ground) of the problem.

Operational Instrumentation/Modular Auxiliary Data System

When ground controllers attempted to dump data from operations (OPS) recorder 2, significant data dropouts were observed on track 1. Data quality was poor and there was less-than 50-percent lock-on to the data stream. Playbacks from tracks 2, 3, and 8 were satisfactory. To troubleshoot the problem, data were recorded on tracks 1, 2, 3, 4, 7 through 10, 12 and 13 and played back in both the forward and reverse directions. All data dumps were good except the dumps from tracks 1, 10, 12 and 14. Tracks 1 and 14 are positioned in the middle of the recorder tape and indications point to a tape-degradation problem. The ground controllers avoided using OPS recorder 2 as much as possible and when it had to be used, recording was done on tracks 4 through 9 only. The recorder was removed and replaced during the postflight turnaround activities.

Structures and Mechanical Subsystems

The structures and mechanical subsystems performed satisfactorily throughout the mission. No in-flight anomalies were identified in the data. The landing and braking parameters are shown in the following table.

The payload bay doors were opened at 067:13:27:31 G.m.t. (00:01:45:22 MET). All voltages were nominal and the motors opened the doors in nominal dual-motor time.

The landing gear tires were reported to be in good condition. There was no ply undercutting on the main landing gear tires.

The ET/Orbiter (EO) separation devices (EO-1, EO-2 and EO-3) functioned normally. No ordnance fragments or other debris were found beneath the LO₂ and LH₂ umbilicals after the umbilical doors were opened. The EO-2 and EO-3 fitting retainer springs appeared to be in nominal configuration; however, one of the "salad bowl" clips was missing from EO-3. A small piece of umbilical closeout foam was adhered to the umbilical plate near the LO₂ disconnect.

No flight hardware was found during the postlanding walkdown of the runway. All components of the drag chute were recovered and appeared to have functioned normally. Both reefing and line-cutter pyrotechnic devices were expended.

LANDING AND BRAKING PARAMETERS

Parameter	From Threshold, Ft	Speed, Keas	Sink rate, ft/sec	Pitch rate, deg/sec
Main gear touchdown	2952.2	201.9	-0.82	N/A
Nose gear touchdown	6192.4	159.3	N/A	-5.4
Brake initiation speed		96.3 knots		
Brake-on time		53.2 seconds		
Rollout distance		14361.58 feet		
Rollout time		83.77 seconds		
Runway		15 (Concrete) KSC		
Orbiter weight at landing		218,304 lb		
Brake sensor Location	Peak Pressure, Psia	Brake assembly	Gross energy, million ft-lb	
Left-hand inboard 1	898.3	Left-hand inboard	18.16	
Left-hand inboard 3	898.3			
Left-hand outboard 2	885.6	Left-hand outboard	14.55	
Left-hand outboard 4	885.6			
Right-hand inboard 1	648.6	Right-hand inboard	4.18	
Right-hand inboard 3	648.6			
Right-hand outboard 2	594.4	Right-hand outboard	3.25	
Right-hand outboard 4	594.4			

Integrated Aerodynamics, Heating and Thermal Interfaces

The prelaunch thermal interface purges were normal with no problems noted. Likewise, the ascent aerodynamic heating and plume heating was nominal with no problems noted. The entry aerodynamic heating on the SSME nozzles was also normal with no bluing of the closure metal noted during the postflight inspection.

Thermal Control Subsystem

The thermal control subsystem performed nominally. All temperatures were maintained within nominal limits. The heaters operated nominally and the temperatures and entry interface as well as the main landing gear tire pressures were within acceptable limits.

Three ISS reboost maneuvers were performed. The first reboost maneuver was performed in the -XLV -ZVV (tail to the Earth, top of vehicle on velocity vector). There were no thermal issues from this maneuver. The second and third reboost maneuvers were performed in +ZLV +XVV (bottom of vehicle to Earth, nose on velocity vector). Following the third maneuver, the RCS L5D thruster oxidizer inlet temperature reached 169 °F while the R5D oxidizer inlet temperature only reached 158 °F. By comparison, the oxidizer inlet temperatures soaked back to within 2 °F of each other after the first two maneuvers and remained under 150 °F.

The FES topping duct heater A (zone H) failed approximately 18 hours into the mission. After selection of the B heater by the crew, the duct temperature returned to the nominal range.

The FES accumulator feedline temperature violated its upper fault detection and annunciation (FDA) limit of 150 °F. Prior to the period of loss of signal (LOS), the temperature indicated 102 °F. During the LOS, water tanks A and B reached their maximum volume causing the water system pressure to rise. The differential pressure caused water to move through the FES system A feed-lines to the accumulator. A hot slug of water moved past the temperature sensor during the LOS period. Upon acquisition of signal (AOS), a master alarm message was received for violating the 150 °F FDA limit. This condition did not impact the mission.

During the two EVAs, the external airlock service line temperatures remained well within their operational limits throughout the EVA timeframe.

Aerothermodynamics

Surface thermocouple temperature data, aileron deflection data, and yaw thruster firings all indicated an asymmetric boundary layer transition that was also early. The surface data on the centerline and left wing locations indicate transition onset from laminar flow to turbulent flow starting at Mach 13.4 (1070 seconds after entry interface). The single data point from the right wing recorded an unstable transition onset at Mach 10.6.

The acreage heating data indicate that the vehicle experienced higher than normal entry heating. The vehicle at entry weighed approximately 218,000 lb and it was entering from a high inclination orbit with boundary layer transition occurring early. The combined effect of these conditions was that both the maximum temperature and temperature-rise data on the skin (structural) were higher than normal along the lower surface mid-body. The wing skin temperature rise was on the high side, but not as much as the fuselage centerline. The difference between the left and right wing skin temperatures was 6.9 °F, which is normal. These data indicate that the area affected by early transition may be confined to the center and left-hand portion of the fuselage.

Local heating resulted in some damage to one of the left-hand radial carbon carbon (RCC) panels. Also charred filler-bar was reported and it requires the removal of one tile approximately two feet outboard of the left-hand ET door.

Thermal Protection Subsystem and Windows

The thermal protection subsystem (TPS) performed satisfactorily. Entry heating was higher-than-normal based on lower-surface structural temperature response data. Boundary layer transition from laminar flow to turbulent flow occurred 1070 seconds after entry interface (EI).

The postlanding inspection of the Orbiter TPS identified a total of 100 impacts of which 14 had a major dimension of 1-inch or larger. The distribution of these impacts on the vehicle is shown in the following table. This total does not include the numerous damage sites on the base heat shield that are attributed to the flame arrestment sparkler system, SSME vibration/acoustics and exhaust plume recirculation.

The Orbiter lower surface sustained 44 hits of which 10 had a major dimension of 1-inch or larger. Approximately 12 damage sites (two larger than 1-inch) were located in the area from the nose landing gear to the main landing gear wheel wells. The amount and size of the damage in this region was less than average. The majority of the damage sites were concentrated in an area of the LH₂ umbilical.

TPS DAMAGE SITES

Orbiter Surfaces	Hits > 1 Inch	Total Hits
Lower Surface	10	44
Upper Surface	0	0
Window Area	4	44
Right Side	0	4
Left Side	1	3
Right OMS Pod	0	1
Left OMS Pod	0	4
Total	14	100

Numerous damage sites around the LH₂ ET/Orbiter umbilical were most likely caused by pieces of the umbilical purge barrier flapping in the airstream and contacting tiles before pulling loose and falling aft.

The largest damage site on the lower surface was located inboard of the LH₂ umbilical, and it measured 1 inch long by 2 inches wide by 0.125 inch deep.

COMPARISON OF LOWER SURFACE DAMAGE SITE DATA FROM LAST TEN FLIGHTS

Parameter	STS -95	STS -88	STS -96	STS -93	STS -103	STS -101	STS -92	STS -97	STS -98	STS1 02
Lower surface total hits	139	80	160	161	84	70	86	78	73	44
Lower surface Hits > 1 in.	42	21	66	42	13	19	14	10	8	10
Longest damage Site, in.	4.0	4.5	4.0	6.0	1.5	8	2	3	3	1
Deepest damage Site, in.	0.4	0.5	0.5	0.5	0.25	0.75	0.75	0.5	0.5	0.125

The left-hand RCC panel 10 had a large damage at the leading edge, below the apex curve and adjacent to the T-seal. The damage is 2 inched long by 0.120 inch wide by 0.100 inch deep. Carbon substrate is exposed. The same panel also had what appears to be a surface degradation in the middle lower region of the panel that is approximately 0.5 inch in diameter. Investigation is continuing into the source of this damage.

No unusual tile damage occurred on the leading edges of the OMS pods. Only four small hits were noted on the leading edge of the left OMS pod and one small hit on the leading edge of the right OMS pod. One protruding-tile gap filler was found on the right OMS pod, and it was approximately two inches long.

Four vertical tail leading edge tile damage sites were observed. One site on the leading edge of the rudder/speedbrake measured 1.75 inches long by 1.25 inches long by 0.25 inch deep.

Damage sites on the window perimeter tiles were more than usual in quantity. There were a total of 44 damage sites on window perimeter tiles with four having dimensions greater than one inch. The hazing and streaking on the forward windows was moderate.

The tile damage on the base heat shield was less than usual. Less than the usual amount of tile damage occurred on the base heat shield. The SSME 1 dome heat shield blanket has minor damage at the 6 o'clock position.

Gas Sample Analysis

The STS-102 mission was a successful flight for the gas sample bottles. The hardware provided five excellent gas samples. One bottle leaked and therefore, provided no useful data for the gas sample analysis. The data obtained during ascent in the five gas-sample bottles system was all in the acceptable range. The five bottle-pressures were in the expected range. The oxygen data was within the bands of error as determined by the argon measurement, and the amount detected can be attributed to air.

The analysis was performed using an AeroVac Mass Spectrometer and the backup analysis was accomplished using a Finnegan 9001 Gas Chromatograph with Discharge Ionization Detection.

Computations to determine the amount of hydrogen contributed by the pyrotechnic, used to open and close the sampling bottle, assumed the composition would match that of experimental values obtained under controlled conditions. These conditions indicated that the ratio of hydrogen to carbon monoxide was 0.54. The percent air and the oxygen from air is calculated from the amount of argon in the sample. The calculations assume normal air to be 78.08 percent nitrogen, 20.95 percent oxygen and 0.934 percent of hydrogen and 0.934 percent argon.

EXTRAVEHICULAR ACTIVITY

A successful checkout of extravehicular mobility units (EMU's) 1 and 2 was completed. EMU 3, which is currently on the International Space Station (ISS), was checked out following the first extravehicular activity (EVA).

All planned and get-ahead extravehicular activity (EVA) tasks were completed within the two scheduled EVAs. The official length of the first EVA was 8 hours 55 minutes; however, the EVA tasks were completed in 6 hours 42 minutes with an additional 1 hour 58 minutes spent in the airlock so the crew could provide visual support for the relocation of pressurized mating adapter (PMA) 3, if required. All of the scheduled and additional tasks EVA 2 tasks were completed in 6 hours 21 minutes.

FIRST EXTRAVEHICULAR ACTIVITY

The major tasks completed during the first EVA are listed as follows:

1. Removal and stowage of pressurized mating adapter (PMA) 3-to-Node 1 umbilicals. The P608 connector could not be installed to the deadface panel because a connector cover could not be dislodged;
2. Removal of the Node 1 early communications (ECOMM) antenna and the disconnect of the antenna cables;
3. Laboratory Cradle Assembly (LCA) transfer and installation; and Rigid Umbilical (RU) transfer and installation. This task required the pistol grip tool (PGT) to be in the manual mode to break the torque on the bolts. The RU cable connection task was moved to EVA 2.

The following anomalies occurred during the first EVA.

1. Gold Salt (Hydrazine Detection) Kit was lost and then recovered following a few minor remote manipulator system (RMS) maneuvers;
2. Following retrieval of the portable foot restraint (PFR) attachment device (PAD) from the U. S. Laboratory, it stuck on the RMS. The PAD was released and then re-engaged. Later in the EVA, the PAD came loose and was not recovered. A spare unit was located in the Node bag and it was retrieved and used during the EVA; The EVA crew reported winch pin problems with the second PAD. The unit was brought to the middeck after the second EVA was completed; and
3. Two of three bolts for the Rigid Umbilical could not be untorqued with the PGT. The PGT was then placed in the manual ratchet mode and the bolts were successfully untorqued.

SECOND EXTRAVEHICULAR ACTIVITY

The major tasks completed during the second EVA are listed as follows:

1. Connect RU cables (Deferred from EVA 1);
2. Remove and install external stowage platform (ESP);
3. Remove the pump flow control subsystem (PFCS) from the integrated cargo carrier (ICC) and install on ESP;
4. Four-bar latch (tapping the latch only, no PRD attachment);

5. Floating potential probe (FPP) photography;
6. U. S. Laboratory NPV evaluation and photography;
7. Service Module Solar Array photography from P6; and
U. S. Laboratory LTA heater RPC trip response.

The following anomalies occurred during the second EVA.

1. During the setup for MPLM berthing, the centerline berthing camera subsystem (CBCS) video signal was not received on the Orbiter. The ISS crew made a work-around by using the battery-powered speaker microphone unit (BPSMU) video cable from the Orbiter to the Node;
2. Pressurized mating adapter 3 connector problems:

During STS-97, the PMA 3 APCU power cables (P607, and P608) were demated from the Node while insight into the connector was available to confirm power inhibits were in place. Since the two power cables were each only one part of a four-connector bundle and could not reach the PMA 3 deadface panel without releasing the other three connectors in the bundle, the released connectors were tied off to structure and dust caps were installed. During STS-102, the other connectors in the bundles were released, and all four connectors of each bundle were attached to their respective deadface plugs on the PMA 3 for stowage. The EVA crew was unable to remove the dust cap from the P608 cable and the cable was not mated to the deadface panel connector. The dust cap remained in place and the cable was tied off to nearby structure. No plans exist for the use of this cable in the future, so this action did not impact operations or future missions.

At the completion of the first EVA, the EV1 crewmember reported a burning sensation in his eyes during airlock repressurization. The crew reported that the burning sensation began when the service and cooling umbilical (SCU) was attached to the suit. The crewmember also reported the smell of lithium hydroxide (LiOH) like when changing out a LiOH canister. The crew thoroughly cleaned the interior of the helmet with lint-free wipes after applying anti-fog solution prior to EVA 2.

While attempting to mate PMA 3 cable P601 to its PMA 3 deadface connector, the EVA crew was unable to throw the bail to complete the connection. As a workaround, the crew tied off the cable to nearby structure. No dust cap was installed on the P601 cable. No plans exist to use this cable in the future, so this action did not impact the mission or future operations.

The crew reported that the A-side of the middeck EMU battery charger had failed. The crew also reported that all LED's on the A-side were off and a power cycle failed to restore the charger. The B-side of the charger appeared to be operating nominally. On flight day 7, the crew reported that the light emitting diodes (LEDs) on the A side were never lit when the charger was initiated on the prior flight day. The crew reported several hours later that the middeck EMU battery charger on the A side was complete. Later that day, the crew made a final report that the red LED on the B side must have been burned out. The crew left a battery on the B side overnight, then moved it to the A side and received a green LED within 10 minutes. The hardware was shipped to JSC for troubleshooting and repair.

REMOTE MANIPULATOR SYSTEM

The remote manipulator system (RMS) performed satisfactorily throughout the mission. No problems or in-flight anomalies were identified from the review of the data.

Checkout of the RMS was completed nominally. A payload bay survey, using the RMS cameras, was also performed. Upon completion of the survey, the arm was cradled.

After completion of the support the first EVA, the RMS began maneuvering to pressurized mating adapter (PMA) 3 for its relocation. PMA 3 was grappled and unberthed from the Node 1 Nadir active common berthing mechanism (ACBM) at 070:11:57 G.m.t. (03:00:15 MET). Two attempts were made to berth the PMA 3 to the Node 1 port ACBM. On the first attempt, the operation failed to obtain the four ready-to-latch (RTL) indications using the Space Vision System (SVS). The payload was maneuvered away from the mating interface approximately 8 inches and corrective commands were issued using a calibrated RMS digital technique that was developed prior to the mission. Once these adjustments were completed, PMA 3 was commanded to the RTL position and the proper indications were achieved. PMA 3 was successfully installed on the Node 1 Port ACBM at 070:13:50 G.m.t. (03:02:08 MET). The RMS performed nominally and was subsequently powered down.

The RMS was powered on at 071:02:10 G.m.t. (03:14:28 MET) and the Multipurpose Logistics Module (MPLM) was grappled at 071:03:36 G.m.t. (03:15:54 MET). The MPLM was successfully removed from the payload bay and installed on the Node 1 Nadir ACBM at 071:06:08 G.m.t. (03:18:46 MET). The RMS was cradled and powered down following the completion of the MPLM installation activities.

The RMS was successfully powered on at 72:02:34 G.m.t. (04:14:52 MET) and used in support of the EVA. The RMS was cradled and powered down following the completion of the EVA.

The RMS was powered on at 77:07:17 G.m.t. (09:19:35 MET) and the MPLM was grappled at 77:08:04 G.m.t. (09:20:22 MET). After the MPLM was reberthed in the Orbiter payload bay, the MPLM was ungrappled at 77:12:17 G.m.t. (10:00:35 MET) and the RMS was cradled and latched at 077:13:08 G.m.t. (10:01:26 MET). The RMS was powered down at 077:13:11 G.m.t. (10:01:29 MET), and not used for the remainder of the mission.

GOVERNMENT FURNISHED EQUIPMENT/FLIGHT CREW EQUIPMENT

The Government furnished equipment/flight crew equipment (GFE/FCE) performed nominally throughout the mission. No in-flight anomalies were identified; however, a number of minor problems were encountered, and these are discussed in the following paragraphs.

During the post-insertion period, the crew reported that the fan in the Orbiter cabin air cleaner (OCAC) was only spinning at 60 to 70 rpm in all three speed-settings. The crew performed troubleshooting on the OCAC on the morning of FD 2. The troubleshooting consisted of rotating the fan by hand and trying a different power cable and a different DC utility outlet. The fan spun freely when rotated by hand but still spun at only 60 to 70 rpm regardless of the speed setting. The green light emitting diode (LED) illuminated when the power was on and no red LED's illuminated at any time. An in-flight maintenance procedure was developed and troubleshooting on flight day 9 recovered nominal operation of the OCAC. A blown fuse on the diagnostic box circuit board was bypassed with a new fuse.

At 067:16:38 G.m.t. (00:04:56 MET), the crew reported that broken communications were being received between the ground and the flight deck when using the hand-held microphone connected to the multiple headset adapter. The crew bypassed the multiple headset adapter and went directly into a flight deck crew communications umbilical. As a result, better communications were present. On the following day, the crew noted that a switch on the mission specialist audio terminal unit was not in the correct position. The switch was placed in the correct position (PTT/PTT) and there were no more problems with the multiple headset adapter and the hand-held microphone interface.

On flight day 1, during the setup of the Proshare system for a private medical conference (PMC) videoconference, the crew reported that the video from the mini-cam would not consistently display on the Proshare local video window. The crew stated that they could make the video work by wiggling the cable, but it was still intermittent. The crew also noticed the cable between the mini-cam and the payload and general support computer (PGSC) was kinked and they reported both the cable and mini-cam were warm. For the record the mini-cam does become warm during use. The crew disconnected the cable and for video conferencing, the camcorder was used in place of the mini-cam for the remainder of the mission.

The crew reported at 069:07:24 G.m.t. (01:19:41 MET) that the hand-held microphone (HHM) had failed. A spare HHM was onboard and it was substituted for the failed unit.

The trajectory control sensor (TCS) began acquiring the target at a range of approximately 10,000 ft. The TCS started tracking the target on pulse power at a range of 4,470 ft. At the approximate range of 963 ft., the TCS unit switched to high continuous wave (CW) power and at a range of 645 ft., the TCS switched to high CW power. The unit switched back to low CW power at a range of approximately 10 ft. The International Space Station (ISS) capture of the Orbiter occurred about one minute later at a range of 5.1 ft. At the conclusion of rendezvous and docking operations, the trajectory control sensor (TCS) failed to respond to a shutdown or a shutter-close command issued from a payload and general support computer (PGSC). Power was removed from the TCS with the shutter open. Upon TCS activation during the

rendezvous tools checkout the day prior to undocking, telemetry showed a self-test failure on the lasers. This was followed by additional errors that implied that the TCS unit had not successfully completed the startup sequence as well as failing to generate the 'initialization complete' and 'going to standby' responses to the PGSC. The crew performed troubleshooting in accordance with the existing procedure that is in the flight data file. However, problems were still encountered, and it was verified via telemetry that the commands were received by the unit but not successfully executed. The unit was declared failed and was not used during the undocking phase of the mission.

The crew reported that one of the Hasselblad cameras jammed while taking pictures. The crew changed out the lens, motor drive and batteries while trying to recover the camera. The camera settings were reported as f/2.8, one-second shutter speed and a viewfinder showing A, 8 and 6 both before, during and after each attempt to shoot a frame. The crew was asked to mark the camera as failed and stow it. The crew reported a short time later that the camera had been recovered. The crew marked the camera as suspect and continued to use it. The camera troubleshooting will occur at JSC.

During private medical conferences on flight days 8 and 10, the videoconference did not have an audio signal. The video was acceptable on both the ground and onboard the vehicle. The quality of the simultaneous air-to-ground and Orbiter communications adapter (OCA) video was degraded because the timing is not synchronized between the two sources. All of the associated hardware was placed on the early destowage list. The equipment will be tested during postflight activities to determine the cause of the loss of audio.

When the RMS end effector television camera was activated at 069:22:47:00 G.m.t. (03:11:17:52 MET), the color subcarrier phase appeared to be skewed, resulting in a magenta hue in the downlinked video. The color remained that way for about 12 hours when the camera power was recycled. The color was correct when the camera was reactivated. Postflight troubleshooting will be performed.

The crew reported that one of the Hasselblad cameras jammed while taking pictures. A series of troubleshooting steps were performed using the written malfunction procedures in the photo/TV checklist, using a different lens, using a different motor drive and finally changing batteries. The camera was to be marked failed and stowed; however, the crew subsequently reported that the camera was again operating properly. The crew marked the camera as suspect, but the crew continued to use the camera.

CARGO INTEGRATION

Integration hardware performance was nominal throughout the mission.

POSTLAUNCH PAD INSPECTION

The postlaunch inspection of the main launch platform (MLP) -3, Launch Pad B, Fixed Service Structure (FSS) and Rotating Service Structure (RSS) was successfully completed approximately 4 hours after the launch. No flight hardware was found. The inspection was delayed because of the loss of one hardware interface module (HIM).

The Orbiter liftoff lateral acceleration data to predict stud hang-ups indicated that a hang-up had not occurred. The HIM card failure prevented the Debris Team from performing a close-up inspection of the holddown posts on the zero level as nitrogen was flowing. Erosion was typical for the north posts. North holddown post blast covers and the T-0 umbilical exhibited typical exhaust plume damage. Both SRB aft skirt gaseous nitrogen purge lines were intact, however, the protective tape layering was partially eroded.

The LO₂ and LH₂ tail service masts (TSMs) appeared undamaged and the LO₂ bonnet was closed properly. The MLP deck was in generally good shape.

The GH₂ vent line latched in the third of eight teeth of the latching mechanism. The ground umbilical carrier plate (GUCP) 7-inch quick disconnect (QD) sealing surface exhibited no damage, but the lip had a dent at the bottom-most location. The spool weldment strut had contacted the left-hand latch assembly and the latch was bent slightly. The left-hand side of the GH₂ vent line arresting cable was noticeably frayed on the outer surface of the cable.

The Orbiter Access Arm (OAA) appeared to be intact with no evidence of plume impingement. All slide-wire baskets were secured with no evidence of damage.

The gaseous oxygen vent arm, hood, ducts and structure appeared to be in good shape with no indications of plume damage.

Three areas of damage (missing material) were noted on the North flame deflector. No flight debris was found on the pad apron or adjacent grass. No unusual debris items were found on the FSS.

Overall, the damage to the FSS/RSS and Main Launch Platform appeared to be minimal. Minimal debris was noted of the pad apron and FSS.

DEVELOPMENT TEST OBJECTIVES/DETAILED SUPPLEMENTARY OBJECTIVES

DEVELOPMENT TEST OBJECTIVES

Development test objectives (DTOs) 257 (Structural Dynamics Model Verification) and 263 (Shuttle Automatic Reboost Tuning) were performed in support of International Space Station (ISS)/Orbiter structural modeling verification. DTO 257 was initiated at 73:12:02 G.m.t. (06:00:20 MET) and terminated 16 minutes later. DTO 263 was initiated at 73:12:27:54 G.m.t. (06:00:45:45 MET) and lasted 16 seconds. Review of the data indicated that no changes were required for the alternate digital autopilot (DAP) or reboost algorithms.

DTO 257 - Structural Dynamics Model Verification and DTO- 263 Shuttle Automatic Reboost Tuning -These two DTOs were performed flawlessly by mission operations. Good quality flight data were recovered and processed. The data from the two parts of DTO's 257 and 263 were used to provide authorization for Shuttle primary thruster use for attitude control and reboost maneuvers when required by mission operations. The engineering results indicated no retuning of preflight developed criteria or procedures for either capability was required.

DTO 261 - ISS On-Orbit Loads Validation - The On-Orbit Loads Validation Tasks was a DTO of opportunity for the STS-102 mission. The evaluation showed that this DTO was successful in that the DTO could use the DTO 257 data to obtain valuable frequency and damping information for the primary stack modes of the mated configuration. Although crew time limitations prevented the recording of Internal Wireless Instrumentation System (IWIS) data during reboost, Shuttle payload bay cameras collected photogrammetry data of the U. S. port solar array. The solar array data will provide a valuable assessment of any dynamic changes in the solar array motion that may have resulted from the final latching of the beta gimbal assembly (BGA) 4-bar mechanism.

DTO 700-14 - Single String Global Positioning System - The STS-102 mission was very successful for the miniature air-to-ground receiver (MAGR) DTO 700-14. All planned operations were performed with nominal and expected results. The tests performed included:

Operations 2 test after main engine cutoff (MECO), in which several commands were issued and the receiver power was cycled. One receiver 'TILT' condition was recorded during on-orbit operations. The condition was not unexpected, and was caused by a known firmware bug. The bug has been corrected and will be incorporated in the next MAGR firmware link, scheduled for November of this year. During flight control system (FCS) checkout, operations were nominal. During OPS 8 operations, a commanded self test was performed nominally. During entry, the initial data indications are that the MAGR performed nominally. The figure of merit (FOM) remained mostly at 1 (5 or less are acceptable) following the plasma blackout region.

DTO 805 - Crosswind Landing Performance - This crosswind DTO, a DTO of opportunity, was performed as a result of the crosswind present at landing. The delayed drag parachute procedure was followed in preparation for the crosswind DTO. The flight

control community is still evaluating the crosswind data to determine if the DTO objective was achieved. The results of this DTO will be published in separate documentation.

DETAILED SUPPLEMENTARY OBJECTIVES

DSO 493 - Monitoring Latent Virus Reactivation and Shedding in Astronauts -

Samples for this DSO were 4 taken during flight and are being assessed during the postflight operations. The results will be published in separate documentation.

DSO 496 - Individual Susceptibility to Post Spaceflight Orthostatic Intolerance -

Data were taken during the preflight and postflight period. The evaluation results will be published in separate documentation.

DSO 498 - Space Flight and Immune Functions -

Samples were collected during the preflight and postflight periods. The evaluation results will be published in separate documentation.

PHOTOGRAPHY AND TELEVISION ANALYSIS

LAUNCH PHOTOGRAPHY AND VIDEO DATA ANALYSIS

The launch photograph and video were reviewed and no anomalous conditions were noted.

ON-ORBIT PHOTOGRAPHY AND VIDEO DATA ANALYSIS

No on-orbit films were reviewed during the mission. During the postflight period, the External Tank (ET) imagery was reviewed. The ET appeared to be in excellent condition with no anomalies observed in the film. One special interest item was observed and is reported in the following paragraph.

The ET separation bolt in the ET/Orbiter (EO) -3 fitting (aft), on the LO₂ side of the ET, was observed not to be fully retracted into the shaft of the ET ball joint on the 35mm umbilical well camera film. The comparison of successive frames appears to show a lateral motion of the bolt. The EO bolt appeared similar to the protruded EO-3 bolt seen in the STS-106 umbilical well camera film. An attempt to measure the length of the unretracted bolt using a parallax method with pairs of images showing the bolt at slightly different angles was being made at the time of publication. A Space Shuttle Program investigation of the STS-106 bolt extension was previously conducted in October 2000.

The 35 mm crew handheld camera film and well as the video were also evaluated. The 35mm handheld camera film produced 36 excellent quality frames of the ET. The first picture was taken 19 minutes 1 second after liftoff. The handheld video was also of good quality. No anomalous conditions were noted in the handheld photography or video.

LANDING PHOTOGRAPHY AND VIDEO DATA ANALYSIS

The video from landing was reviewed and no anomalous conditions were noted during the review.

STS-102 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	067:11:37:19.964 067:11:37:21.037 067:11:37:22.393
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	067:11:41:41.004 067:11:41:41.164 067:11:41:41.324 067:11:41:41.484
Main Propulsion System Start ^a	ME-3 Start command accepted ME-2 Start command accepted ME-1 Start command accepted	067:11:42:02.457 067:11:42:02.572 067:11:42:02.696
SRB Ignition Command (Liftoff)	Calculated SRB ignition command	067:11:42:09.004
Throttle up to 104.5 Percent Thrust ^a	ME-2 Command accepted ME-3 Command accepted ME-1 Command accepted	067:11:42:14.353 067:11:42:13.358 067:11:42:13.377
Throttle down to 72 Percent Thrust ^a	ME-2 Command accepted ME-3 Command accepted ME-1 Command accepted	067:11:42:44.553 067:11:42:44.558 067:11:42:44.577
Throttle up to 104.5 Percent Thrust ^a	ME-2 Command accepted ME-3 Command accepted ME-1 Command accepted	067:11:42:57.833 067:11:42:57.838 067:11:42:57.858
Maximum Dynamic Pressure (q)	Derived ascent dynamic pressure	067:11:43:08
Both RSRM's Chamber Pressure at 50 psi ^a	RH SRM chamber pressure mid-range select LH SRM chamber pressure mid-range select	067:11:44:08.404 067:11:44:09:084
End RSRM ^a Action ^a Time	RH SRM chamber pressure mid-range select LRH SRM chamber pressure mid-range select	067:11:44:11.364 067:11:44:11:554
SRB Physical Separation ^a	LH rate APU turbine speed - LOS	067:11:44:13.604
SRB Separation Command	SRB separation command flag	067:11:44:14
OMS Assist Ignition	Left engine bi-prop valve position Right engine bi-prop valve position	067:11:44:23.8 067:11:44:23.8
OMS Assist Cutoff	Left engine bi-prop valve position Right engine bi-prop valve position	067:11:45:33.2 067:11:45:33.3
Throttle Down for 3g Acceleration ^a	ME-2 command accepted ME-3 command accepted ME-1 command accepted	067:11:49:30.639 067:11:49:30.645 067:11:49:30.668
3g Acceleration	Total load factor	067:11:50:09
Throttle Down to 72 Percent Thrust ^a	ME-2 command accepted ME-3 command accepted ME-1 command accepted	067:11:50:25.360 067:11:50:25.366 067:11:50:25.389
SSME Shutdown ^a	ME-2 command accepted ME-3 command accepted ME-1 command accepted	067:11:50:31.800 067:11:50:31.807 067:11:50:31.829

^aMSFC supplied data

**TABLE I.- STS-102 SEQUENCE OF EVENTS
(Continued)**

Event	Description	Actual time, G.m.t.
MECO	MECO command flag MECO confirm flag	067:11:50:32 067:11:50:34
ET Separation	ET separation command flag	067:11:50:51
APU Deactivation	APU-1 GG chamber pressure APU 2 GG chamber pressure APU 3 GG chamber pressure	067:11:56:23.086 067:11:56:42.279 067:11:56:55.942
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	Not performed
OMS-2 Ignition	Left engine bi-prop valve position Right engine bi-prop valve position	067:12:20:46.2 067:12:20:46.2
OMS-2 Cutoff	Right engine bi-prop valve position Left engine bi-prop valve position	067:12:21:50.2 067:12:21:50.2
Payload Bay Doors (PLBDs) Open	PLBD right open 1 PLBD left open 1	067:13:26:14 067:13:27:33
OMS-3 Ignition	Left engine bi-prop valve position Right engine bi-prop valve position	067:15:16:32.7 067:15:16:32.8
OMS-3 Cutoff	Right engine bi-prop valve position Left engine bi-prop valve position	067:15:17:45.7 067:15:17:45.8
OMS-4 Ignition	Left engine bi-prop valve position Right engine bi-prop valve position	N/A 068:04:14:23.0
OMS-4 Cutoff	Left engine bi-prop valve position Right engine bi-prop valve position	N/A 068:04:14:39.0
OMS-5 Ignition	Left engine bi-prop valve position Right engine bi-prop valve position	068:14:15:17.3 068:14:15:17.4
OMS-5 Cutoff	Left engine bi-prop valve position Right engine bi-prop valve position	068:14:16:33.3 068:14:16:33.4
OMS-6 Ignition	Right engine bi-prop valve position Left engine bi-prop valve position	069:01:35:14.2 069:01:35:14.3
OMS-6 Cutoff	Right engine bi-prop valve position Left engine bi-prop valve position	069:01:36:12.1 069:01:36:12.2
OMS-7 Ignition	Left engine bi-prop valve position Right engine bi-prop valve position	069:03:12:39.31 N/A
OMS-7 Cutoff	Left engine bi-prop valve position Right engine bi-prop valve position	069:03:12:51.9 N/A
Initial ISS Contact	Initial contact	069:05:37:13
Docking with ISS	Docking ring final position	069:06:58:23
Cabin Depressurization (end)	Cabin pressure	069:12:10:41
Airlock Depressurization (end)	Airlock differential pressure no. 1	070:05:07:16
Begin First Extravehicular Activity	Airlock differential pressure no. 1	070:05:12
Cabin Repressurization (start)	Cabin pressure	070:07:34:57
PMA 3 Grappled	End effector rigidized	070:11:24:27
PMA 3 Ungrapped	End effector extended	070:14:00:45
Airlock Repressurization (start)	Airlock differential pressure no. 1	070:14:07:47
End First Extravehicular Activity	Airlock differential pressure no. 1	070:11:56
Cabin Depressurization (end)	Cabin pressure	070:14:15:54

**TABLE I.- STS-102 SEQUENCE OF EVENTS
(Continued)**

Event	Description	Actual time, G.m.t.
Cabin Repressurization (start)	Cabin pressure	070:14:52:06
MPLM Grapple	End effector rigidized	071:03:36
MPLM Ungrapple	End effector extended	071:06:27:47
Cabin Depressurization (end)	Cabin pressure	071:12:55:13
Airlock Depressurization (end)	Airlock differential pressure no. 1	072:05:19:53
Begin Second Extravehicular Activity	Airlock differential pressure no. 1	072:05:23
Cabin Repressurization (start)	Cabin pressure	072:11:00:57
Airlock Repressurization (start)	Airlock differential pressure no. 1	072:11:44:17
End Second Extravehicular Activity	Airlock differential pressure no. 1	072:11:40
Airlock Depressurization (end)	Airlock differential pressure no. 1	072:11:54:14
Airlock Repressurization (start)	Airlock differential pressure no. 1	072:12:10:14
Cabin Depressurization (end)	Cabin pressure	072:12:19:18
Cabin Repressurization (start)	Cabin pressure	072:12:45:51
First Reboost and Collision Avoidance Maneuver (start)	As reported	073:12:12:09
Second Reboost Maneuver (start)	As reported	075:11:32:23
Third Reboost Maneuver (start)	As reported	076:09:17:45
MPLM Grappled	End effector rigidized	077:07:59:03
MPLM Ungrappled	End effector extended	077:12:17:02
Undocking from ISS	Undock complete	078:04:31:53
Flight Control System Checkout		
APU Start	APU 1 GG chamber pressure	079:02:05:33.475
APU Stop	APU 1 GG chamber pressure	079:02:10:53.214
OMS-8 Ignition	Left engine bi-prop valve position	079:07:27:58.3
	Right engine bi-prop valve position	079:07:27:58.4
OMS-8 Cutoff	Left engine bi-prop valve position	079:07:28:14.5
	Right engine bi-prop valve position	079:07:28:14.6
Payload Bay Doors Close	PLBD left close 1	080:03:47:22
	PLBD right close 1	080:03:49:17
APU Activation for Entry	APU-2 GG chamber pressure	080:06:21:10.369
	APU-1 GG chamber pressure	080:06:47:07.476
	APU-3 GG chamber pressure	080:06:47:08.434
Deorbit Burn Ignition	Left engine bi-prop valve position	080:06:26:06.2
	Right engine bi-prop valve position	080:06:26:06.3
Deorbit Burn Cutoff	Left engine bi-prop valve position	080:06:29:02.7
	Right engine bi-prop valve position	080:06:29:02.8
Entry Interface (400K feet)	Current orbital altitude above	090:06:59:54
Blackout end	Data locked (high sample rate)	No blackout
Terminal Area Energy Management	Major mode change (305)	080:07:35:08
Main Landing Gear Contact	LH main landing gear tire pressure 1	080:07:31:41
	RH main landing gear tire pressure 2	080:07:31:43

**TABLE I.- STS-102 SEQUENCE OF EVENTS
(Concluded)**

Event	Description	Actual time, G.m.t.
Main Landing Gear Weight on Wheels	LH MLG weight on wheels RH MLG weight on wheels	080:07:31:43 080:07:31:45
Nose Landing Gear Contact	NLG LH tire pressure 1	080:07:31:52
Nose Landing Gear Weight On Wheels	NLG weight on wheels 1	080:07:31:52
Drag Chute Deployment	Drag chute jettison 1 CP Volts	080:07:31:54.7
Drag Chute Jettison	Drag chute jettison 1 CP Volts	080:07:32:31.0
Wheel Stop	Velocity with respect to runway	080:07:33:06
APU Deactivation	APU-1 GG chamber pressure	080:07:49:35.586
	APU-2 GG chamber pressure	080:07:49:47.799
	APU-3 GG chamber pressure	080:07:49:57.733

TABLE II- STS-102 SPACE SHUTTLE VEHICLE ENGINEERING OFFICE IN-FLIGHT ANOMALY LIST

No.	Title	Reference	Comments
STS-102-V-01	Degraded Freon Coolant Loop 1 Due to Radiator Icing	076:09:40 G.m.t. 08:21:58 MET	<p>During a flash evaporator system (FES) water dump, Freon coolant loop (FCL) 1 apparently experienced a flow blockage due to freezing in the radiator with ice collecting in the port radiator flow controller inlet filter. This condition resulted in reduced flow rates in FCL 1. Automatic radiator bypass occurred when normal radiator temperature control was restarted and a radiator under-temperature condition occurred (<33 °F). The condition persisted and eventually the radiator bypass mode was switched to manual, equipment was powered on to increase the heat load on the loop, and the vehicle attitude was changed to increase the heat load on the radiator. These actions recovered nominal operation of FCL 1.</p> <p>KSC: Postflight troubleshooting will consist of a Freon sample from loop. Also, JSC is performing a thermal analysis of the event is being performed.</p>
STS-102-V-02	Right OMS Vapor Isolation Valve 2 Did Not Indicate Open	078:07:27 G.m.t. 011:19:44 MET	<p>When the crew configured the OMS helium valves, the right OMS vapor isolation valve 2 did not indicate open. The valve also did not indicate open at the start of the deorbit maneuver when the computer sent out open commands. This could be either an actual switch failure or a limit switch failure. There is no close indicator because the valves are spring loaded closed. Data review indicates the valve did not give an open indication during the prior orbit adjust maneuver; the valve had worked all previous times it was commanded to open. This is the second flight for this particular valve; it is the replacement for a valve whose position indicator had been intermittent.</p> <p>KSC: Postflight troubleshooting will be performed.</p>

DOCUMENT SOURCES

In an attempt to define the official as well as the unofficial sources of data for the STS-102 Mission Report, the following list is provided.

1. Flight Requirements Document
2. Public Affairs Press Kit
3. Customer Support Room (CSR) Daily Reports and Final CSR Report
4. MER Daily Reports
5. MER Mission Summary Report
6. SSVEO In-Flight Anomaly List
7. MER Funny/Problem Tracking List
8. MER Event Times
9. Subsystem Manager Reports/Inputs
10. MOD Systems Anomaly List
11. MSFC Flash and Executive Summary Reports
12. MSFC Event Times
13. MSFC Interim Report
14. Crew Debriefing comments
15. Shuttle Operational Data Book
16. STS-102 Summary of Significant Events
17. Contractor Reports of Subsystem Operation

ACRONYMS AND ABBREVIATIONS

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

ACBM	active common berthing system
ADTA	?
AOS	acquisition of signal
APCU	Assembly Power Converter unit
APFR	articulated portable foot restraint
APU	auxiliary power unit
ARPCS	atmospheric revitalization pressure control system
ARS	atmospheric revitalization system
AS	Ammonia Servicer
ATCS	active thermal control system
BITE	built-in test equipment
BPSMU	battery-powered speaker/microphone unit
CB	circuit breaker
CBCS	centerline berthing camera system
CBM	common berthing mechanism
CID	circuit interrupt device
CheCS	Crew Health Care System
CPM	cell performance monitor
CRT	cathode ray tube
CSR	Customer Support Room
CTB	central thermal bus
CW	continuous wave
CWC	contingency water container
DAP	digital autopilot
dc	direct current
DCP	DEU control program
DCSU	Direct current switching unit
DDCU	DC-to-DC converter unit
DEU	display electronics unit
DSO	Detailed Supplementary Objective
DTO	Developmental Test Objective
ΔV	differential velocity
ECOMM	Early Communications
ECLSS	environmental control and life support system
EI	entry interface
EMU	extravehicular mobility unit
EO	ET/Orbiter
EPDC	electrical power distribution and control
ESP	External Stowage Platform
e.s.t.	Eastern standard time
ET	External Tank
EUE	experiment unique equipment
EV1	extravehicular crewmember designation
EVA	extravehicular activity

FCE	flight crew equipment
FCL	Freon coolant loop
FCMS	fuel cell monitoring system
FCP	fuel cell powerplant
FCS	flight control system/subsystem
FD	flight day
FDA	fault detection and annunciation
FES	flash evaporator system
FOM	figure of merit
FPP	Floating Potential Probe
FSS	Fixed Service Structure
ft/sec	feet per second
GAS	Get-Away Special
GEI	ground environmental instrumentation
GFE	Government furnished equipment
G.m.t.	Greenwich mean time
GN&C	guidance navigation and control
GO ₂	gaseous oxygen
GPC	general purpose computer
GSFC	Goddard Space Flight Center
GUCP	ground umbilical carrier plate
HEPA	high efficiency particulate accumulator
HHM	hand-held microphone
HIM	hardware interface module
HRF	Human Research Facility
HUD	heads-up display
ICC	Integrated Cargo Carrier
IMAX3D	Three-Dimension Camera system
IMU	inertial measurement unit
I_{sp}	specific impulse
ISPR	International Standard Payload Rack
ISS	International Space Station
IWIS	Internal Wireless Instrumentation System
JPL	Jet Propulsion Laboratory
JSC	Johnson Space Center
keas	knots estimated air speed
KSC	Kennedy Space Center
KVO	?
kW	kilowatt
kWh	kilowatt/hour
lb/hr	pound per hour
lbm	pound mass
lb/min	pound per minute
LCA	Laboratory Cradle Assembly
LCC	Launch Commit Criteria
LED	light emitting diode
LH ₂	liquid hydrogen
LiOH	Lithium Hydroxide
LMSO	Lockheed Martin Space Operations
LO ₂	liquid oxygen

LON	launch-on-need
LOS	loss of signal
LP	Launch Package
LTA	?
MAGR	Miniature Air to Ground Receiver
Max $q\alpha$	maximum dynamic pressure
MC	midcourse correction (rendezvous maneuver)
MCC	Mission Control Center
MDM	multiplexer/demultiplexer
MECO	main engine cutoff
MET	mission elapsed time
MILA	Merritt Island launch area
MLP	Mobile Launch Platform
MLS	microwave landing system
mmHg	millimeter mercury
MPEV	manual pressure equalization valve
MPLM	Multi-Purpose Logistics Module
MPS	main propulsion system
MSS	Mobile Servicing Platform
NASA	National Aeronautics and Space Administration
NC, NC2, NCC	circularization maneuvers (rendezvous maneuver)
NC3, NC4	circularization maneuvers (rendezvous maneuver)
nmi.	nautical mile
NPC	plane change maneuver
NPRV	?
NPSP	net positive suction pressure
NPV	non-propulsive vent
OAA	Orbiter Access Arm
OCA	Orbiter communications adapter
OCAC	Orbiter Cabin Air Cleaner
ODF	operational data file
ODS	Orbiter Docking System
OMDP	Orbiter Maintenance Down Period
OMRSD	Operations and Maintenance Requirements and Specifications Document
OMS	orbital maneuvering subsystem
OPF	Orbiter Processing Facility
OPS	operations
ORU	orbital replacement unit
OSVS	Orbiter Space Vision System
OV	Orbiter Vehicle
PAD	PFR attachment device
PASS	primary avionics software system
PCMCIA	portable computer memory card international adapter
PCS	portable computer system/pressure control system
PDGF	power and data grapple fixture
PFCS	pump flow control subsystem
PFR	portable foot restraint
PGME	Propylene Glycol Monomethyl Ether
PGSC	payload and ground support computer
PGT	pistol grip tool

PMA	pressurized mating adapter
PMBT	propellant mean bulk temperature
PMC	private medical conference
ppCO ₂	partial pressure carbon dioxide
ppm	parts per million
PRSD	power reactant storage and distribution
PRT	Problem Resolution Team
psia	pound per square inch absolute
psid	pound per square inch differential
PTT	push-to-talk
QD	quick disconnect
RAIU	Russian Audio Interface Unit
RCC	radial carbon carbon
RCS	reaction control subsystem
RMS	Remote Manipulator System
RPC	remote power controller
rpm	revolutions per minute
RSP	Resupply/Return Stowage Platforms
RSR	Resupply Stowage Rack
RSRM	Reusable Solid Rocket Motor
RTL	ready to latch
RSS	rotating service structure
RU	Rigid Umbilical
RWS	Robotics Workstation
S&A	safe and arm
SAIU	S-band audio interface unit
SASA	S-band antenna support
SCU	service and cooling umbilical
SEM	Space Experiment Module
SLF	Shuttle Landing Facility
SLWT	super lightweight tank
SM	service module/systems management
S/N	serial number
SODB	Shuttle Operational Data Book
SRB	Solid Rocket Booster
SRSS	Shuttle range safety system
SSME	Space Shuttle main engine
SSRMS	Space Station Remote Manipulator System
STS	Space Transportation System
SUPA	Solid Urine Pretreat Assembly
SVS	Space Vision System
SWAR	Sea water activated release
TACAN	Tactical Air Navigation
TCS	trajectory control sensor
TI	transfer initiation (rendezvous maneuver)
TPS	thermal protection system/subsystem
TV	television
TVIS	treadmill vibration isolation system
TSM	tail service mast
UOP	utilization operations panel

V	Volts
WCS	waste collection system
WDVA	water dispenser valve assembly
WSB	water spray boiler
WSVFM	Wide-Band Vibration Forces Measurement